MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER

LITERARY & PHILOSOPHICAL SOCIETY.

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NOTE.

The authors of the several papers contained in this volume are themselves accountable for all the statements and reasonings which they have offered. In these particulars the Society must not be considered as in any way responsible.

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MEMOIRS.

PROCEEDINGS.

ERRATA.

In Mr. Cameron's paper on *Hymenoptera Orientalis*. In the penultimate paragraph of the Introduction on p. 92

for Sittaghui *read* Tittaghur.
,, Ishapue *read* Ishapore.
,, Serampue *read* Serampore.
,, Chandauague *read* Chandanagore.
,, Gusery *read* Goosery.
,, Port Cauumy *read* Port Canning.
,, Mussourie *read* Mussoorie.
,, Nischindepue *read* Nischindipore.
,, North-West Province *read* North-West Provinces.

On p. 138 for *Tachytes Virchu* read *T. vischnu.*

In Dr. Bottomley's paper on "The Dissolution of an Isotropic Solid":—

Page line
163, 1, *for* CD *read* GD.
163, 11, *for* $\left(\frac{b^2a^2}{c}\right)$ *read* $\left(\frac{b^2a^2}{c}\right)^{\frac{2}{3}}$.
165, 23, The expression in this line should be multiplied by 2.
166, 2, *for* dz *read* dZ.
167, 1, *for*

$$\frac{X-\frac{d\phi}{cdX}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}} \text{ read } X-\frac{\frac{cd\phi}{dX}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}}$$

Page line
167, 2, *for*

$$\frac{Y-c\frac{d\phi}{dY}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}} \text{ read } Y-\frac{\frac{cd\phi}{dY}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}}$$

Page line
167, 3, *for*

$$\frac{Z-c\frac{d\phi}{dZ}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}} \text{ read } Z-\frac{\frac{cd\phi}{dZ}}{\sqrt{\left(\frac{d\phi}{dX}\right)^2+\left(\frac{d\phi}{dY}\right)^2+\left(\frac{d\phi}{dZ}\right)^2}}$$

Page line
167, 24, *for* $\frac{dz}{dx}$ *read* $\frac{dZ}{dX}$.
168, 3, *for* r^2 *read* c^2.
173, 15, *for* y_0-y_0+x, read y_0-x_0+x.
174, 15, *for* $x=x$ *read* $x=x_0$.
176, 9, *for* xd *read* dx.
179, 1, *for* 750 *read* 760.

MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 2nd, 1888.

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

Reference was made by the PRESIDENT to the death of Professor Rudolph Clausius of Bonn, elected an honorary member of the Society in 1886, to whom, with Rankine and Sir William Thomson, following Dr. Joule, belonged the honour of developing the dynamical theory of heat.

Mr. R. F. GWYTHER, M.A., gave an account of Hertz's experiments, showing the propagation of electrical vibrations in direct accordance with Maxwell's theory of light as an electro-magnetic phenomenon.

Professor H. B. DIXON, F.R.S., read a paper on "Incompleteness of Combustion in Gaseous Explosions."

Incompleteness of Combustion in Gaseous Explosions.

By Prof. Harold B. Dixon, F.R.S., and H. W. Smith, B.Sc., Dalton Chemical Scholar, Owens College.

(Received October 26th, 1888.)

In the course of an investigation, in which we were engaged, on the rate of propagation of gaseous explosions, it was noticed that when a mixture of hydrogen and oxygen, in the proportions in which they combine to form water, was exploded, there remained an explosive residue in addition to the unavoidable slight excess of one or the other gas due to inaccuracy in mixing. The mixture was exploded in a leaden tube 100 metres long and 9 mm. in diameter; after the explosion the tap at one end was opened, and air allowed to rush in. Air was then pumped in by a bellows, and the other tap was then opened. On applying a light to the out-rushing gases, for the purpose of determining whether the hydrogen or the oxygen was in excess in the original mixture, the gas at first driven out proved to be rich in oxygen—supporting combustion vividly—and then the succeeding gas burnt with a series of sharp cracklings, and finally there was a flash down the tube.

From this, it appeared that even in a mixture of hydrogen and oxygen, containing a slight excess of oxygen, the hydrogen was not completely burnt. If the mixture had contained an excess of hydrogen it might have been reasonably supposed that the explosive residue was made up of the excess of hydrogen and the air admitted after the explosion. This explanation could not be admitted in the present instance, as the mixture contained an excess of oxygen. A similar phenomenon was observed when a slight excess of hydrogen was employed, and the residue was swept out of the tube by a stream of carbonic acid gas.

Led by these experiments we began the investigation, an account of which is given in the following paper. Our object was to determine the conditions affecting the amount of this explosive residue—especially the influence of the surface exposed to the exploding gases.

Mixtures containing slight excess, 1st of hydrogen, and 2nd of oxygen were employed, and in all cases the residues were collected and analysed. The first series of experiments was made with the tube mentioned above, which was 100 metres long and 9 mm. in diameter, the surface exposed to the gases being about 29,000 sq. cm. After each explosion CO_2 was admitted at one end of the tube until the pressure was equal to that of the atmosphere, and then 1 litre was driven out and collected over caustic soda solution at the other end of the tube. It was found that the first litre driven out contained practically all the gas left after explosion. The amount of residue varied from 100 to 250 cc., according to the accuracy of the mixture and the amount of nitrogen as impurity in the original gas, and of air in the CO_2. We give below the mean results of analysis of a considerable number of residues; those given under A resulting from a mixture containing an excess of hydrogen, whilst in those given under B and C, the original gas contained oxygen in excess.

I.

Explosions of Hydrogen and Oxygen.

(Capacity of tube 8,100 cc.; diam. 9 mm.; internal surface 29,000 sq. cm.).

Mean composition of residue:—

Average Residue.		A.	B.	C.
A – 150 cc.	H_2	54·3 (H₂ + CO)	29·5	20·5
B – 160 cc.	CO......		5·1	5·8
C – 220 cc.	O_2	19·4	38·1	32·7
	N_2	26·3	27·3	41·0
		100·0	100·0	100·0

% of original detonating gas unburnt:—

Maximum ...	1·08	·92	1·07
Minimum... ...	·69		
Mean	·88		

With regard to the calculation of the amount of unburnt detonating gas, a slightly different method is employed, according as the original gas contains excess of oxygen or hydrogen. All the residues contain a certain percentage of nitrogen, part of which is due to inleakage of air, and to air in the CO_2, used for sweeping out the tube, whilst part exists as impurity in the original gas, being chiefly derived from the water in the gas-holder. It is, however, impossible to determine accurately how much is due to each cause. In calculating the percentage of unburnt detonating gas, a maximum and minimum are taken in the following way. Firstly, assume all the nitrogen was present in the original gas, and calculate all the oxygen as belonging to the unburnt residue. This gives a maximum value for the percentage unburnt. Secondly, assume that all the nitrogen got in (as air) after the explosion, and from the percentage of oxygen, deduct the amount of oxygen corresponding to the nitrogen (as air). In this way we get a minimum value for the amount of unburnt detonating gas, and the true percentage must lie between these limits. If there is a sufficient excess of oxygen, we get only one value for the unburnt residue, viz., 1½ times the residual hydrogen. It will be observed that each of the residues contains a small percentage of carbonic oxide. Part of this is probably due to the grease used for the taps, and part may be due to hydrocarbons derived from the zinc, used in the preparation of the hydrogen (except in cases where electrolytic gas was used). The carbonic oxide, being a combustible gas, must be taken into account in calculating the residual detonating gas. When there is an excess of oxygen, the carbonic oxide is liable to get burnt, and therefore should be considered as a portion of the detonating gas left unburnt. When there is a deficiency of oxygen, the carbonic oxide may be classed with the excess of hydrogen left over, and whether it affects the amount of unburnt detonating gas depends upon the quantity of oxygen remaining.

To determine the influence of the amount of surface exposed to the gases, a tube 4 mm. in diameter was next employed. The length was about 170 metres, and the internal surface 25,000 sq. cm. the capacity being 2,750 cc. The method of procedure was the same as before. Under A, in the following table, is given the mean of several analyses of residues from mixtures containing an excess of hydrogen, and under B, the mean result from mixtures containing an excess of oxygen.

II.

	A.	B.
H_2	46·1	38·6
CO	14·9	12·4
O_2	16·3	25·4
N_2	22·7	23·6
	100·0	100·0
Average Residue ...	75 cc.	82 cc.
% of original detonating gas unburnt :—		
Max.	1·34	2·27
Min.	·84	1·55
Mean	1·09	1·91

The % unburnt, under A, does not differ much from that obtained with the wider tube. Under B we see a rather larger percentage. In the next tables are given the means of analyses of residues obtained with a tube 19 mm. in diameter (III.), and lastly (IV.), with an iron bomb made out of an ordinary mercury bottle attached to a firing tube. In the latter, there are only about 1,600 sq. cm. of surface exposed for a volume of 3,075 cc.; that is to say, a surface only $\frac{1}{15}$ as great as that exposed in the 4 mm. tube, the capacities being, however, nearly equal. From the analyses it would appear that although the amount of surface exposed to the gases has some influence on the amount unburnt, the influence is not very great, and therefore it seems improbable that the incompleteness of combustion is due to the cooling action of the surface of the vessel.

	III.	IV.
	C = 14,000 cc.	C = 3,075 cc.
	d = 19 mm.	d = 100 mm.
	S = 28,000 sq. cm.	S = 1,600 sq. cm.
Average residue	235 cc.	100 cc.
Mean composition of residue:—		
H_2	44·2	8·2
CO	18·0	1·2
O_2	22·7	31·1
N_2	15·1	59·5
	100·0	100·0
% of detonating gas unburnt:—		
Max.	1.16	
Min.	·86	·46
	1·01	

A number of experiments were made with a mixture of carbonic oxide and oxygen.

In the first series of experiments the 9 mm. tube was employed, and in the second series the iron bomb. The mean results are given below.

Carbonic Oxide and Oxygen.

	I.	II.
	$C=8{,}100$ cc.	$C=3{,}075$
	$d=9$ mm.	$d=100$ mm.
	$S=29{,}000$ sq. cm.	$S=1{,}600$ sq. cm.
Average residue	205 cc.	55 cc.
Mean composition of residue :—		
CO	26·0	41·4
H_2	1·7	6·7
O_2	30·2	27·1
N_2	42·1	24·8
	100·0	100·0
% unburnt :—		
	1·06	Max. 1·17
		Min. 1·01
		Mean 1·09

In this case, therefore, we have also about 1% of the original detonating gas left unburnt. The surface here does not appear to have much influence, the percentages unburnt being almost the same, although the surface exposed to the gases was, with the tube, about 3½ sq. cm. for each 1 cc. of gas burnt, against ·5 sq. cm. per 1 cc. of gas burnt with the bomb.

The fact that the incompleteness of combustion is characteristic of the explosive wave, and is not observed in the ordinary combustion in a Eudiometer, has an important bearing on the theory proposed by Berthelot, to explain the mode of propagation of the explosive wave, and also seems to confirm the observation made by Mallard and Le Chatelier, that the rate of cooling in this method of combustion is much more rapid than in the ordinary combustion.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, October 8th, 1888.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section, in the Chair.

Mr. J. ARTHUR HUTTON was elected a member of the Section.

Mr. THOMAS ROGERS exhibited a small collection of shells from the neighbourhood of Brisbane, Queensland, Australia.

Mr. P. CAMERON, F.E.S., communicated some notes on the excessive abundance of *Aphis dianthi*, in the neighbourhood of Manchester in September.

He also read a paper describing ten new species of Hymenoptera.

Ordinary Meeting, October 16, 1888.

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

Mr. JOHN BOYD communicated the following note by Mr. P. Cameron on "The excessive abundance of *Aphis dianthi*, Schr., round Manchester in September, 1888":—

The extreme abundance of *Aphis dianthi* in the Manchester district in September, calls for some remark. My own experience of it has been chiefly in Cheshire, where it occurred in such numbers as to be a perfect nuisance, through getting into the eyes of travellers. Near Wilmslow I came across a swarm which formed a black cloud. In various places I have noticed them congregating in heaps on plants and walls, so as to blacken the surface on which they rested. In the city they appeared in great swarms on many days. It does not, of course, follow that these were bred in the city or suburbs; for, when these insects appear in such dense clouds, they are driven about by the wind in all directions and to great distances. Great numbers, too, must have been brought into town on the market garden waggons, on the clothes of passengers, and in other ways. This is not the first occasion on which *Aphis dianthi* has come forth in swarms. Gilbert White, in one of his letters, alludes to them under the name of "smother flies," and notes them as forming clouds which "almost obscured daylight." In 1834 they spread over Belgium in countless swarms, and Morren, who records their presence, states his belief that they were blown over from England. The species feeds on a very large number of plants. In this country it is always more or less injurious to turnips (hence it was named *Aphis rapi* by Curtis), potato, cabbage, and mangold.

Frequently it damages garden plants, such as crocus, fuchsia, oleander, Dianthus, &c., &c. In the autumn it has been known to infest the peach and nectarine. Altogether it is known to feed on over sixty plants, not even passing over *Atropa belladonna.* As for the origin of the Cheshire and Lancashire swarms, my own observations lead me to believe that the vast bulk came from the turnip and mangold fields. At the same time the aphides were undoubtedly injurious to many garden plants; and in my own garden they were abundant on the sun flowers. Not unfrequently, when aphides are excessively numerous, the lady birds (*Coccinella*), which feed on them, also swarm; but I did not notice any unusual quantity of these useful creatures. A species of *Aphidius* (an ichneumon which destroys aphides) was, however, exceedingly abundant.

A discussion ensued, during which it was suggested that the phenomenon might have a causal relation with the excessive rainfall of the year, or the early migration of the birds.

Mr. JOHN BOYD also communicated a memoir by Mr. P. CAMERON on "A decade of new Hymenoptera."

A decade of new Hymenoptera. By P. Cameron., F.E.S. Communicated by John Boyd, Esq.

(Received October 16th, 1888.)

PROCTOTRUPIDÆ.

EPYRIS BREVIPENNIS, *sp. nov.*

Niger, fere apterus, mandibulis, thorace, geniculis tarsisque, rufis. Long.: 6 mm.

Hab. Gibraltar (*J. J. Walker*, R.N.)

Basal joint of the antennæ, curved, longer than the second and third joints united; the second joint more than three-fourths the length of the third and longer than the fourth. The scape piceous and thickened towards the middle, tapering towards the apex. Head sparsely haired, strongly punctured; the eyes rather small, oblong, and situated a little behind the middle of the head; the antennal tubercles and mandibles rufous. Prothorax rather broad, longer than broad, obscurely punctured, the sides slightly excavated; the furrow in the centre deep, complete. Mesonotum finely punctured; scutellum shining, impunctate; parapsidal furrows broad and deep, sharply converging posteriorly. Metanotum finely rugose, with a very stout central and two lateral keels in the centre; the sides keeled; the apical tubercles blunt, short; metapleuræ shining, longitudinally striolated. Apical segments of abdomen sparsely covered with longish white hair. Legs covered rather closely with stiff, white hair; the femora incline to dull rufous on the underside.

A rather closely allied species to *E. hispanicus*, Cam. (*Mem. & Proc. Manch. Lit. & Phil. Soc.*, 1888, p. 169), but that differs from it in having the metathorax black, the apex convex, with the sides projecting into stout teeth; the vertical part rugosely punctured; while in *Walkeri* the apex is concave, with indistinct lateral tubercles, the perpendicular part not rugosely punctured. The wings hardly reach to the end of the metathorax, and seem to be infuscated in the middle.

BETYLA, *gen. nov.*

Eyes hairy. Antennæ 15-jointed; the basal joint as long as the six following united; joints 2—7 longer than broad; joint 8 thicker than 7th, nearly longer than broad; the 9th still thicker; 9—14 much broader than long; the 15th twice longer than broad; sharply conical. Head forming a broad snout before the antennæ; narrowed before and behind the eyes. Thorax narrow, ant-like, narrowed between the meso- and metathorax; the former bearing in front a stout tooth on either side, the scutellum not defined; parapsidal furrows absent; metanotum without keels or furrows.. Apterous. Abdomen much broader than the thorax, the petiole longer than broad, stout; the second segment very large, occupying dorsally the greater part of the entire abdomen, and with a distinct margin at its junction with the ventre. The third and fourth segments together the length of the petiole. There are apparently five ventral segments. Petiole on lower side projecting into a large, stout, tooth-like process. Femora clavate.

This genus belongs to the *Belytidæ*. The only genus with which it could be confounded is *Miota*, which has an abdomen with three dorsal segments, of which the second is very much lengthened, and reaches near to the tip. *Miota* is winged, has only three dorsal segments, and no mention is made of any peculiarity in the form of the thorax; nor of the absence of ocelli. In fact, Foerster's analytical tables are hardly capable of being used for the identification of the extra European genera; and so far as I know the type of *Miota* has never been described.

BETYLA FULVA, *sp. nov.*

Fulva; nitida, impunctata, capite abdomineque longe albo hirtis; thorace sparse fusco hirto. Long.: fere 4 mm.

Hab. Greymouth, New Zealand (*Helms*).

The mesothorax is almost glabrous, and much more shining than the rest of the body. The abdomen is haired all over, but not very thickly, and the hair is longish, and whiter towards the apex. The tibiæ and tarsi are covered with short, stiff white hairs, the femora more sparsely with longer, soft hair. At the apex the metanotum is convex, projecting into sharp teeth at the sides, and is very closely united to the petiole, which is longer and a little narrower than it.

MALVINA, *gen. nov.*

Metanotum with a spine; parapsidal furrows obsolete; scutellum bifoveate at base; third, fourth, and fifth abdominal segments subequal. Antennæ 13-jointed, the club 6-jointed; the second joint not much shorter than the third, and longer than the fourth. Petiole as long as the hind coxæ. Wings reaching to the apex of the petiole, fringed with long hair.

The only genus of *Belytidæ* with a spine on the metanotum is *Oxylabis*, Foerster. It differs, however, from the genus here described in having the antennæ 15-jointed, and in the parapsidal furrows being distinct.

MALVINA PUNCTATA, *sp. nov.*

Nigra; fortiter punctata, sparse pallida hirta; antennarum articulis 1—7 *pedibusque, rufis.* ♀. Long. 3½ mm.

Hab. Greymouth, New Zealand (*Helms*).

The front is shining, impunctate, and broadly keeled; the occiput clearly margined. Pro- and mesopleuræ shining, impunctate, slightly convex and narrowed towards the sternum, metapleuræ rugose. Apex of metanotum ending in a spine on either side. Petiole shining, keeled, and densely haired. Abdomen shining, impunctate, the apical segments pilose. Legs covered sparsely with pale hair; the coxæ usually black; sometimes the femora are more or less fuscous; these are clavate. The joints of the club are broader than long and become gradually broader to the penultimate; the last narrower than preceding and broadly rounded at the apex.

CYNIPIDÆ.

EUCOILA CLARIPENNIS, *sp. nov.*

Nigra, flagello antennarum pedibusque, rufis; alis clare hyalinis, nervis pallide fuscis. ♂. Long.: 3·5 mm.

Hab. Mexico, Vera Cruz: in January. (*H. H. Smith*),

Antennæ one half longer than the body, the third and fourth joints nearly equal in length, straight. Pronotum raised into a sharp margin, projecting in the middle above. Scutellar foveæ large, wide, and deep; sides of scutellum rugosely punctured; the cup horse-shoe shaped, shallow, depressed at the apex. Apex of metanotum semi-perpendicular, bicarinate, hardly pilose. Abdomen shorter than the thorax; compressed, the hair fringe narrow, griseous.

EUCOILA MEXICANA, *sp. nov.*

Nigra, nitida; pedibus testaceis, alis griseo hyalinis, nervis fuscis. ♂. Long.: 1¼ mm.

Hab. Mexico, Orizaba, in December (*H. H. Smith and F. D. Godman*).

Antennæ about one-fourth longer than the body; rather stout; the third joint thickened and curved, and about one-fourth longer than the fourth. Cup of scutellum distinctly raised; the centre excavated rather deeply; the apex projecting; sides of scutellum finely rugose. Edge of pronotum margined. Abdominal hair fringe slight, dull griseous. Radial cellule twice longer than broad; the second abscissa straight, three-fourths of the length of the third, which becomes curved towards the apex ; the costal nervure thick. Cubitus complete. The femora are lined with black towards the middle ; the hind tibiæ are tinged with fuscous.

EUCOILA MARGINICOLLIS, *sp. nov.*

Nigra, nitida, pedibus rufis ; alis clare hyalinis, nervis pallide fuscis. ♂ Long. : 1·5 mm.

Hab. MEXICO, Orizaba, in December (*H. H. Smith and F. D. Godman*).

Antennæ longer than the body ; the four basal joints dull rufous ; the joints becoming gradually but slightly thicker towards the apex ; the third and fourth joints the longest and thickest ; the third a little longer than the fourth. Pronotum distinctly raised above the mesonotum having a clear broad margin ; the centre slightly depressed. Scutellar cup shallow, oval, the apex flat, not projecting ; sides of scutellum rugose. Abdominal hair fringe slight, fuscous. Radial cellule wide ; the second abscissa of radius about one-fourth shorter than the third, which is roundly curved towards the apex ; cubitus completely obsolete.

GRONOTOMA GRACILICORNIS, *sp. nov.*

Nigra, nitida ; pedibus rufis ; alis hyalinis, nervis fuscis. Long. 1½ mm.

Hab. MEXICO, Orizaba, in December (*H. H. Smith* and *F. D. Godman*).

Antennæ slender, longer than the body, becoming but very slightly thickened towards the apex ; the apical three joints shorter than the preceding, but not forming a club ; the third joint slightly curved, and a little longer than the fourth. Pronotum not distinctly margined. Scutellar foveæ large, deep ; the cup without a very distinctly raised margin, oval, moderately deep. Metapleuræ densely covered with long white hair; metanotum oblique. Abdomen compressed, somewhat lenticular. Wings pilose; the radial cellule twice longer than broad, the third abscissa of the radius about three-fourths longer than the second; cubitus completely obsolete.

In having converging parapsidal furrows, a closed radial cellule and no abdominal hair fringe, this species agrees with *Gronatoma*, but the pleuræ are finely aciculated and the metapleuræ glabrous.

LARRIDÆ.

Piagetia fasciatiipennis, *sp. nov.*

Nigra; ore, antennis (basi et apice flagelli nigris), prothorace, tegulis, metapleuris, petiolo, pedibusque, rufotestaceis; clypeo bidentato; alis hyalinis, fascia substigmatili fusca. ♂. Long. 7 mm.

Hab. Ceylon (*George Lewis*).

Head opaque, granular, covered with a short microscopic pile. Eyes at the top separated by about the length of the second and third antennal joints united. Vertex broadly depressed, a wide, but not deep, furrow leading down from the centre of the depression. Front and clypeus covered with short silvery pubescence; three broad furrows on the former. Clypeus projecting, broadly carinate in the middle; the apex ending in two large projecting, somewhat triangular, teeth. Tips of mandibles black. Scape of the antennæ as long as the following two joints united; the third three times the length of the second, and a little longer than the fourth. Thorax opaque, almost granular, covered with a microscopic pile, the apex of metathorax with longish white hair; the metanotum finely transversely rugose; the apex irregularly striolated, and with a wide furrow (narrowed at the base and apex in the centre). Abdomen shining, the apex whitish pubescent; pygidial area rufescent; margined distinctly at base and apex; the latter transverse. The apical ventral segment is also margined laterally, and is for the greater part rufescent. Tibiæ and tarsi covered with a silvery pile. The base of the four hind coxæ, a line on the femora beneath, the greater part of the four hind tibiæ behind, the calcaria and the basal two tarsal joints, more or less black. The tibial spines are few in number and pale in colour; the metatarsal brush is short and whitish; the apices of the tarsal joints end in stiff white stout, sharply pointed bristles. The longer spur of the hind tibiæ is more than three-fourths of the length of the metatarsus. Femoral spine at the base nearly as broad as the total length; the apex ending in a blunt tooth.

Three species of *Piagetia* have been described, namely:

P. Ritsemæ, Ritzema, *Ent. M. Mag.* IX., p. 120. Java.

P. odontostoma, Kohl, *Verh. z.-b. Ges.*, Wien, 1883, p. 31. Arabia.

P. Woerdeni, Ritzema, *l.c.*, p. 121. Congo, South West Africa.

P. Ritsemæ differs from it in the wings having a cloud which extends from the second cubital cellule to the apex; the flagellum of the antennæ is entirely black, this being also the case with the metathorax, and the base of the abdomen is not fulvous; there is also a central longitudinal line on the metanotum, which is absent in *fasciatiipennis*. The form of the clypeus and spine in hind femora is quite different, but as this may be a sexual character (the ♂ of *Ritsemæ* is unknown) no great reliance can be placed on these points. *P. odontostoma* differs in the clypeus having four teeth, and no central keel; the body is almost entirely black, and the wings are clear hyaline. The African *Woerdeni* has not the clypeus ending in two large teeth, and differs in the colour of the body, &c.

CRABRONIDÆ.

RHOPALUM BUDDHA, *sp. nov.*

Nigrum, opacum, flavo-maculatum; metathorace rugoso; alis hyalinis. Long. 9 mm.

Hab. Poona, India. (*R. C. Wroughton.*)

Scape clear yellow, flagellum closely covered with a silvery pubescence. Head opaque, alutaceous, the vertex sparsely pilose; the antennal depression and clypeus densely covered with silvery hair. Ocelli in a curve; the clypeus carinate in the middle; mandibles clear yellow, the tips blackish. Eyes with very course facets. Thorax opaque, alutaceous; the excavated side of the pronotum coarsely obliquely striolated; the metathorax obliquely rugosely punctured, sparsely covered with a silvery pile, especially thick and close on the pleuræ; two broad lines on the pronotum, two below the tegulæ, and two on the scutellum, clear yellow; tegulæ piceous. Basal part of the petiole shining, covered with long white hair, the apial part opaque. The rest of abdomen almost opaque, with a plumbeous hue; the sides and apex covered with a white pubescence; an interrupted band on the base of the third segment, and a short lateral band on the succeeding segments, clear yellow. Legs covered with long white soft hair; the apex of coxæ, the trochanters beneath, a broad band on the lower side of the four anterior femora, and the tibiæ and tarsi, yellow; there is a black line behind on the tibiæ, and the tarsi are reddish towards the apex.

The North Indian *Rhapalum flavopictinum*, Smith, differs from the present species in having "an impressed oblique channel running down from each of the posterior ocelli," the first scutellum and the petiole are yellow; there is "an enclosed shining subcordate space at the base of the metathorax, which has a longitudinal impressed line from the base to the apex," &c.

ANTHOPHILA.

STELIS JAPONICA, *sp. nov.*

Niger, abdomine rufo, basi niger; alis violaceis, basi fere hyalinis; apice scutelli excisa. Long. fere 12 mm.

Hab. Japan. (*George Lewis*).

Scape sparsely covered with pale hair, the flagellum microscopically pilose; the tip obscure rufous. Head rugosely punctured; the sides of the face thickly covered with long white hair; the vertex and mandibles more sparsely haired; mandibles rugosely punctured, but not so coarsely as the head, the apex shining, impunctate. Thorax rugosely punctured; the scutellum with larger punctures than the mesonotum; shortly pilose; the metanotum covered with long white hair. Mesonotum with a distinct furrow down the centre. Scutellum with the apex projecting over the metathorax, margined, with a slight but distinct waved incision; at the base there is a deep curved furrow in the middle. Abdomen shining; punctured, rugosely punctured towards the apex; the segments impunctate at their junction, and depressed at base and apex; the apial dorsal segment with a distinct raised margin and slightly incised in the middle. The femora coarsely punctured, closely covered with pale to blackish hair; the tarsi thickly covered with fulvous hair on the lower side; and sparsely with pale hair above; calcaria brownish.

The late Mr. F. Smith records (*Trans. Ent. Soc.*, 1873, p. 204) *Stelis abdominalis*, a species described by himself from Celebes (*Proc. Lim. Soc.*, 1858, p. 7), from Japan. It is of course possible that he may have had the true *Stelis abdominalis* from Japan, but it appears to me that the species I have just described cannot be *abdominalis*, in as much as the latter differs from it in several respects; namely, in being nearly two lines smaller; in the abdomen being entirely ferrugineous, in the "posterior margin of the scutellum being rounded," and the wings are uniformly coloured.

[*Physical and Mathematical Section.*]

Ordinary Meeting, October 24th, 1888.

Dr. JAMES BOTTOMLEY in the Chair.

Mr. FARADAY read extracts from a letter from George Harvey, F.R.S.L. & E., communicated to the British Association, at its first meeting fifty-seven years ago, on "the very remarkable circumstance of the geometrical analysis of the ancients having been cultivated with eminent success in the northern counties of England, and particularly in Lancashire." So far as Mr. Harvey was aware, the true cause of this singular phenomenon of men in humble life, surrounded by conditions which might have been expected to develope a taste for exclusively mechanical combinations, becoming familiar with Porisms and Loci, Sections of Ratio and Space, Inclinations and Tangencies, subjects confined amongst the ancients to the very greatest minds, was not known. Mr. Faraday suggested that the Section should endeavour to collect information with a view to the full historical elucidation of the phenomenon. Men in advanced years, who might be able to furnish information, are constantly passing away, and as their knowledge on the subject is unrecorded, it is lost. Mr. Faraday urged that a circular letter should be issued, asking for information, and that the materials thus collected should be arranged by a committee, or some one mathematician nominated by the Section, and presented as a memoir to the parent society.

Dr. BOTTOMLEY made some remarks on a problem of maxima and minima values.

Ordinary Meeting, October 30th, 1888.

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

A paper on "A new system of Logical Notation," by Mr. J. J. Murphy, communicated by the Rev. ROBERT HARLEY, M.A., F.R.S., was read.

Mr. W. W. HALDANE GEE, B.Sc., gave an account of some experiments that he, in conjunction with Mr. Henry Holden, M.Sc., had made on "Electrolysis under Pressure." The experiments were begun with the view, firstly, of ascertaining the influence of high pressures on electrolytic polarisation, and secondly of designing a method whereby high pressures could be readily produced by means of electrolysis. The experiments were at first conducted in sealed glass tubes in which dilute sulphuric acid was electrolysed, the electrodes used consisting of platinum. As the evolved oxygen and hydrogen gases accumulated, the pressure gradually increased up to the explosion of the tubes, which took place generally at pressures between 50 and 100 atmospheres. Under these conditions the polarisation was found to be very little affected. On attempting to obtain pressures as high as 500—600 atmospheres by use of a very strong *gun metal** cylinder, the authors encountered the difficulty arising from the violent explosive combination of the mixed gases. Accordingly, in the latter experiments the pressure was produced by means of a hydrostatic pump, and dangerous accumulations of the mixed gases were thus prevented. Determinations of the polarisation with this apparatus are as yet incomplete, but they show, so far as they have been conducted, that the influence of pressure on polarisation is but small.

*As the apparatus was in the first instance designed to study some magnetic effects under pressure, which the late Prof. Balfour Stewart wished the authors to examine, the cylinder was constructed of gun-metal instead ot steel.

A New System of Logical Notation. By Joseph John Murphy.—Communicated by the Rev. Robert Harley, M.A., F.R.S., Corresponding Member.

(*Received October 23rd, 1888.*)

In the present state of the science, no apology is needed for offering a new system of logical notation. The use of notation in logic is not to work problems, but to illustrate principles ; and for this purpose the more systems of notation we have the better, so long as they are not absurd, and not mere reproductions of other systems.

The chief feature of the notation now proposed is that the signification of all the literal symbols is purely qualitative, unless they are expressly quantified ; so that x does not mean "all x" or "every x," but only "some x" or "an x." Consequently the equation

$$x=y$$

means "some x (or some one x) is y," provided that both x and y are the names of things having real existence :—if either is non-existent, the proposition has no significance.

For *all*, Boole's symbol 1 is used ; consequently $1x$ is the expression for "all (or every) x"; and "all x is y" is written

$$1x=y.$$

The inverse of this is given by transposing the coefficient of quantity and assigning to it a negative index, when we get

$$1^{-1}y=x,$$

that is to say "only y is x," or "nothing but y is x." The expression

$$1x=1^{-1}y$$

would mean "all x is nothing but y," and would be true, but redundant in this place, though we shall find occasion for it further on.

The form

$$1x = 1y$$

asserts the equivalence of x and y, and is Sir William Hamilton's equation "all x is all y," which he regards as the fundamental form of proposition. A possible expression for equivalence in this notation would be

$$1^0x = y, \text{ or } x = 1^0y.$$

Contraposition is expressed with equal facility, by changing the signs of the terms and transposing the coefficient without change of index:—thus, all the following four forms of proposition are equivalents of each other. The inverses are one above the other, and the contrapositives in the same line—

$$1x = y. \qquad 1\bar{y} = \bar{x}.$$

$$1^{-1}y = x. \qquad 1^{-1}\bar{x} = \bar{y}.$$

These are in language:—

All x is y.	All not y is not x.
Only y is x.	Only not x is not y.

It will be noticed that the equation

$$1^{-1} = 1,$$

which is true in arithmetic, is not generally true here.

The most important application of this notation is to the "logic of relatives," that is to say the theory of propositions containing terms which signify relations. In what follows, "absolute terms" or the terms between which relations subsist—the terms of the old logic—are expressed by Roman capitals, and relative terms by Italic capitals; and the corresponding negatives are expressed by the corresponding small letters, as in De Morgan's notation. "Of" is expressed by the sign of multiplication; thus, let A and B be the names of individuals, and let R mean the relation of teacher, then

$$\mathrm{A} = R \times \mathrm{B}$$

will mean that A is a teacher of B; or let B mean boys, then its meaning will be that A is a teacher of a boy or boys. According to Boole's plan of indicating the co-existence of attributes by the juxtaposition of their literal symbols, RB means a teacher who is a boy.

The conversion of such a proposition as the above is effected by transposing the relative term with change of index, when, if both A and B are the names of individuals, the transposed form

$$B = R^{-1} \times A$$

means that B is a pupil of A. Let A:B mean the relation of A to B, then the following four propositions are mutually equivalent;

$$A:B = R \qquad B:A = R^{-1}$$
$$A = R \times B \qquad B = R^{-1}A.$$

The same is true if R be a numerical ratio, and A:B means the ratio of A to B.

In converting a compound relative, the order of the terms is reversed, thus

$$(R \times S)^{-1} = S^{-1} \times R^{-1}.$$

For instance: if R means husband and S daughter,

$$R \times S$$

will be the symbol for son-in-law, and its converse

$$S^{-1} \times R^{-1}$$

for father or mother-in-law. This rule for conversion is well known, but we have to show that it is true of our coefficients of quantity as well as of symbols of relation. If A and B are individuals as before, and R means teacher, then "A is the only teacher of B" (or, as it might be expressed, logically though not quite grammatically, "A is all the teacher of B") will be written in symbols

$$A = 1R \times B$$

and the converse of this is

$$B = R^{-1} \times 1^{-1}A,$$

that is to say "B is a pupil of none but A," or "of A only." Let S mean child, then

$$A = R \times 1S \times B$$

will mean "A is a teacher of all the children of B," and its converse

$$B = S^{-1} \times 1^{-1}R \times A$$

will mean "B is the parent of none but pupils of A." Thus 1 means "all," or "only" with an adjective sense:— 1^{-1} means "none but," or "only" with an adverbial sense.

The simplest forms of this kind occur when A and B are individuals. When they are classes—if for instance the A's are the teachers and the B's the pupils of a particular school—the proposition

$$A = R \times B$$

asserts only that "some A's teach B's," and is a partial proposition. In the present essay, nothing more is said on the theory of partial propositions. The proposition

$$1A = R \times B$$

is singly total; it asserts that "all A's teach B's," or, what is better English, "every A teaches a B or B's." The proposition

$$1A = R \times 1B$$

asserts that "every A teaches every B," and is doubly total. A doubly total proposition is defined in the system here expounded as one where the two terms A and B are both quantified by the coefficient 1 or 1^{-1}. In a singly total proposition only one of them is so quantified; in a partial proposition, neither. A doubly total proposition, however, as De Morgan has remarked,* is one proposition, not the resultant of two propositions. "Every A teaches every B,"

* "On the syllogism, No. IV., and on the logic of relations."—*From the transactions of the Cambridge Philosophical Society*, Vol. X. Part II.

and "every B learns from every A," which is thus expressed in our notation

$$1A = R \times 1B, \quad 1B = R^{-1} \times 1A$$

is manifestly only one proposition in two equivalent and converse forms. Its doubly total character is visible to the eye as printed above, but this is not so under all its transformations. It may be stated in the form

$$a = 1r \times B$$

i.e. "not-As are the only not-teachers of Bs;" but this again is shown to be doubly total by writing below it the equivalent form

$$b = 1r^{-1} \times A$$

i.e., "not = Bs are the only not-pupils of As."

De Morgan, in the paper already quoted, states three elementary forms of proposition containing a single relative term. These are, when stated in our notation and with our examples :—

$$1A = R \times B, \qquad 1A = R \times 1B,$$
$$1A = R \times 1^{-1}B,$$

that is to say :—

Every A teaches a B, Every A teaches every B,
Every A teaches none but Bs.

But as Prof. Peirce has shown,* the symmetry of the system requires a fourth form, which in our notation is thus supplied.

A teacher of every B is necessarily a not-teacher of none but not-Bs; and the converse is also true. This is expressed by the equation

$$1R \times 1B = 1r \times 1^{-1}b;$$

* "On the Algebra of Logic," by C. S. Peirce, reprinted from the American *Journal of Mathematics*, Vol. III.

Consequently, we may write the second and third of the above three forms thus :—

$$\begin{aligned} 1A &= R \times 1B, \\ &= r \times 1^{-1}b, \\ 1A &= R \times 1^{-1}B, \\ &= r \times 1b. \end{aligned}$$

The fourth form, obviously, ought to be related to the third as the first to the second ; so that the completed system is constituted by the following four propositions, whereof two are singly and two doubly total.

$1A = R \times B,$	$1A = R = 1B,$ $= r \times 1^{-1}b,$
$1A = r \times b,$	$1A = R \times 1^{-1}B,$ $= r \times 1b.$

That is to say,

Every A is a teacher of some Bs.	Every A is a teacher of every B, and a not-teacher of none but not-Bs.
Every A is a not-teacher of some not-Bs.	Every A is a teacher of none but Bs, and a not-teacher of all not-Bs.

The two forms of proposition

$$\begin{aligned} 1A &= R \times 1B, \\ &= r \times 1^{-1}b, \end{aligned}$$

may be called the complements of each other, or complementary to each other. Their equivalence is self-evident ; nevertheless it is worth while to show it symbolically.

$$1A = R \times 1B$$

becomes by conversion

$$1B = R^{-1} \times 1A,$$

which becomes by contraposition and inversion

$$1^{-1}b = r^{-1} \times 1A,$$

and this again by conversion

$$1A = r \times 1^{-1}b.$$

It is to be observed that, somewhat as in the common logic a total proposition, such as "every A is B," contradicts and is contradicted by a corresponding partial proposition, such as "some A's are not B"; so that one of the pair must be true and the other false,—so in the logic of relative terms the same relation of contradiction subsists between a doubly total proposition such as "every A is a teacher of every B" and a singly total proposition, such as "every A is a not-teacher of some B."

The proposition

$$1A = R \times 1B$$

admits of the following equivalent forms. It will be observed that they arrange themselves in pairs of converses.

$$1A = R \times 1B \qquad 1B = R^{-1} \times 1A$$
$$1^{-1}a = r \times B \qquad 1^{-1}b = r^{-1}A$$
$$1A = r \times 1^{-1}b \qquad 1B = r^{-1} \times 1^{-1}a$$
$$a = 1r \times B \qquad b = 1r^{-1} \times A$$
$$1Ar \times B = o \qquad 1Br^{-1} \times A = o$$
$$1AR \times 1^{-1}b = o \qquad 1BR^{-1} \times 1^{-1}a = o$$

All that has been yet stated is equally true, whether the relation is transitive or not. A transitive relation is such a one that

$$\text{if } A = R \times B \text{ and } B = RC, \text{ then } A = RC,$$

or more briefly

$$R \times R = R, \text{ or } R^2 = R.$$

This is the algebraic expression of the common "syllogism in Barbara." But it expresses nothing except the transitiveness of the relation, and is not restricted to relations of identity and co-existence. As De Morgan says in the paper already quoted, "The law which governs every possible case (of Syllogism) . . . is this:—Any relation of X to Y, compounded with any relation of Y to Z, gives a relation of X to Z." The following is a valid syllogism:—"Abraham was the father of Isaac; Isaac was the father of Jacob; therefore Abraham was the grandfather of Jacob."

The notation explained in the present paper is appropriate to a set of propositions stated by De Morgan in the paper already quoted, but without detailed demonstration. The present writer, trying to improve on De Morgan, is but a dwarf on a giant's shoulders, or rather a dwarf with his feet on the shoulders of two giants, De Morgan and Boole; but it may be maintained with much plausibility that giants were made in order to carry dwarfs; and I think it will be found that, for the present purposes at least, my notation is clearer, less arbitrary, and more appropriate than De Morgans. The theorems are as follows;—they arrange themselves in pairs of converses.

Every ancestor is an ancestor of all descendants (of his descendants), and a descendant of none but their ancestors; a non-ancestor of none but their non-descendants, and a non-descendant of all their non-ancestors.

Every descendant is a descendant of all ancestors (of his ancestors), and an ancestor of none but their descendants; a non-descendant of none but their non-ancestors, and a non-ancestor of all their non-descendants.

Every non-ancestor is a non-ancestor of all ancestors, and an ancestor of none but non-ancestors.

Every non-descendant is a non-descendant of all descendants, and a descendant of none but non-descendants.

Writing ancestors E, and descendants conversely E^{-1}; non-ancestor e, and non-descendant conversely e^{-1}; these theorems are thus written in our notation :—

1.	$1E = E \times 1E^{-1}$,	$1E^{-1} = E^{-1} \times 1E$.
2.	$= E^{-1} \times 1^{-1}E$,	$= E \times 1^{-1}E^{-1}$.
3.	$= e \times 1^{-1}e^{-1}$,	$= e^{-1} \times 1^{-1}e$.
4.	$= e^{-1} \times 1e$,	$= e \times 1e^{-1}$.
5.	$1e = e \times 1E$.	$1e^{-1} = e^{-1} \times 1E^{-1}$.
6.	$= E \times 1^{-1}e$,	$= E^{-1} \times 1^{-1}e^{-1}$.

These are very simple, and are self-evident as soon as understood, yet very unfamiliar; they are like no generally recognised logical forms. They are, however, easily deducible from the property of transitiveness, by application of the principles already stated.

It will be observed that the two sets of converse propositions are identical in their formal properties, differing only in the indices being reversed. It will consequently be necessary to give the demonstrations of those of the first column only.

Proposition 1 is proved by combining the definition of a relative term with that of transitiveness. It belongs to the definition of any possible relative, that it stands in the specified relation to all its correlatives. Thus any ancestor E' is ancestor of all his own descendants; which is expressed in our notation by

$$E' = E \times 1E^{-1} \times E';$$

combining this with

$$1E \times E = E,$$

we get

$$1E \times E' = E \times 1E^{-1} \times E'.$$

that is to say every ancestor of E' is ancestor of all the descendants of E'; or, more briefly,

$$1E = E \times 1E^{-1},$$

which asserts that every ancestor (of any man) is an ancestor of all descendants (of that man).

Proposition 2 is directly derived from

$$1E \times E = E,$$

which may be written

$$1E \times E = 1^{-1} E,$$

whence by transposition

$$1E = E^{-1} \times 1^{-1} E.$$

Propositions 3 and 4 are the complements of 1 and 2 respectively. Proposition 5 is obtained by the contraposition of

$$1E \times E = E$$

for, as we have seen above, the negative of $E \times E$—ancestor of *any* ancestor—is $e \times 1E$—non-ancestor of *every* ancestor; so that the contra-position of the above equation gives

$$1e = e \times 1E.$$

And Proposition 6

$$1e = E \times 1^{-1}e$$

is the complement of proposition 5.

We have worked these out with De Morgan's examples, derived from the relation of ancestor and descendant. But they are true of any transitive relation whatever, such as before and after, and cause and effect (if we so define cause that a cause of the cause is a cause of the effect); and among others, of the relation of whole and part, which is the fundamental relation of the common logic when the terms are interpreted in extension; so that if E is taken to mean the relation of a part to the whole,

$$E \times E = E,$$

means that a part of a part is a part of the whole; or, as I propose to express it, an enclosure of an enclosure is an enclosure; and conversely

$$E^{-1} \times E^{-1} = E^{-1},$$

or, an includent of an includent is an includent. Then

$$e \text{ and } e^{-1}$$

will mean respectively non-enclosure and non-includent; and the expressions

$$\text{A} = E\text{B}, \qquad \text{B} = E^{-}\text{A},$$
$$\text{A} = e\text{B}. \qquad \text{B} = e^{-1}\text{A},$$

will mean respectively

A is (included in) B. B includes A.

Some A is not (included in) B. B does not include all A.

Consequently, all De Morgan's theorems, as stated above, admit of interpretations in the common logic.

The old logic, as perfected by the schoolmen and revived by Whately, appeared to be a complete science, though lying in a very narrow compass. But, as Mill remarks, quoting from some unnamed writer, "on all great subjects much remains to be said"; and the science of logic is no exception to this. The old, or common logic, is only one corner of a vast and probably infinite field.

General Meeting, November 13th, 1888.

Professor ARTHUR SCHUSTER, F.R.S., Vice-President, in the Chair.

Dr. G. H. BAILEY, of Owens College, and Mr. A. C. ADAMS, of the Hulme Grammar School, were elected ordinary members.

Ordinary Meeting, November 13th, 1888.

Professor ARTHUR SCHUSTER, F.R.S., Vice-President, in the Chair.

Professor W. C. WILLIAMSON, LL.D., F.R.S., opened a discussion on "The Permanence of Oceanic Basins," by pointing out the fundamental ideas of some modern geologists, viz., that our large oceanic areas had been much like what they now are, throughout all geological times; that our continents were chiefly built up by the accumulation of shore deposits, formed in what were virtually shallow waters. He was not prepared to accept these as postulates. In the first instance there could be no doubt that the hills and hollows of the earth's surface were primarily the result of the cooling of its crust, and as a result of that cooling, shrinkage in the size of the sphere: not being elastic, such shrinkage must have produced ridges and furrows on various scales of magnitude. These changes, being accompanied by a corresponding reduction of the temperature of the earth's atmosphere, in which much heated vapour must have been held in suspension, would be followed by the deposition of water on the earth's surface, which, flowing down to the lowest levels, would form streams, lakes, and seas; and these, by their erosive action, would produce the earliest sedimentary deposits,—resting upon the hollow depressions of the hardening crust. There is no reason to suppose that these agencies did not operate in varying degrees on every part of the globe. But further. Some geologists believe that the thirty thousand feet of Archaian Laurentian rocks in Canada, and the smaller layers of rocks of apparently the same age in the Hebrides, represent the cooled and hardened crust to which reference has been made; in other words, that these never were aqueous deposits, like the more modern strata occurring everywhere on the Continent. In all probability we can now identify no part of the ancient and primeval crust. Whatever it was, it has most probably been melted and re-melted by the subterranean heat which has also fused the older stratified beds; the primitive line of junction between the two being thus wholly obliterated. The contraction of the earth's crust, due to the causes already referred to, has probably not entirely ceased even now. The marvellous inflections of the contorted strata of the Alleghanies and of the Alps, affecting Cretaceous and Oolitic rocks, have in all probability been due to similar agencies, causing lateral pressure; we find that these disturbing forces have operated more or less throughout every portion of what is now dry land, all of which has been more or less frequently under water; this has been the case with even the mountainous parts that now rise thirty thousand feet above the sea-level from which they have been uplifted; hence it is difficult to believe that whilst such changes, due to cosmical causes, were taking place on the great continents, the corresponding areas now occupied by our largest oceans were resting in a state of undisturbed tranquillity. Dr. Williamson said it seemed to him that whilst two-fifths of the globe were thus being alternately raised and depressed, the remaining three-fifths must have been similarly affected; the deepest seas thus finally balancing the loftiest elevations, and producing the equilibrium of the earth's crust which we now observe.

But further. In the countless ages that have passed away since the commencement of the earth's consolidation, aqueous rocks, many miles in vertical thickness, have been deposited. These rocks contain the remains of the successive forms of life that have tenanted both land and sea during these successive epochs. According to the modern theory under discussion, if these great oceans were then such as they are now, representative strata corresponding to the now known vertical series seen on the land must underlie the present ocean beds. The oceans under which the known strata were formed must have opened into these larger and supposed persistent ones; and though accumulations may have taken place in the latter more slowly than elsewhere, they cannot have been absent. In like manner organic remains must exist in them. How far they became sufficiently shallow to be the home of our terrestrial plants and shore-loving animals may be a question. But just as our modern sharks and huge Cetaceans now traverse the deepest oceans, so the huge Saurians and primeval Cephalopods must have done the same. In like manner the innumerable Foraminifera, which flourish chiefly, if not wholly, near the surface of the sea, exist independent of depth. We know that they lived in primeval time, and doubtless under the same conditions as now. We have proof in the Nummulitic beds, which in some places accumulated to a thickness of several thousand feet, that such was the case, just as the Foraminiferous ooze, or that which is a Foraminiferous residuum, can now be found in most parts of our deep oceans. These few fundamental facts suggest that, whilst lofty mountains and seas of corresponding depths may, and probably did, always exist during the past geological epochs—it does not follow that the one always stood and the other flowed where they now do. In the case of the former we know that this was not the case. The recent periods at which the Alps, the Andes, and the Himalayas were upraised is now well known. It is not impossible that similar mountain ranges may have sunk into and now repose in the undulating depths of the Pacific Ocean.

Prof. BOYD DAWKINS held that the doctrine of the permanence of oceanic areas is only true in a very restricted sense, and as applying to such deep areas as those over 4,000 fathoms north of the Island of St. Thomas in the North Atlantic, and off the coast of Japan in the North Pacific. As the surface of the cooling globe followed the contracting nucleus it must have been thrown into folds, in which the re-entering folds would be the primeval oceans, and the salient folds the land. And this folding of the surface would only be intensified along the old lines by a still further shrinkage of the nucleus. From these *a priori* considerations he held that the main centres of the land and the sea had been where they are now through all geological time. The evidence of a considerable change in the relations of land to sea is proved both by the marine soundings and the history of the stratified rocks. The soundings made by the "Dacia," in 1883, off the mouth of the Congo, reveal the existence of a vast cañon plunging from the 100 fathom line into depths greater than the 1,000 fathom line (see *Journ. Soc. Telegr. Engineers* XVI., p. 479). It is a submerged cañon of the same order as that of the Colorado river, and has been cut by the river Congo at a time when the West Coast of Africa in that district stood more than 6,000 feet above its present level. This is merely one out of a vast number of cases which might be cited in proof that the submarine contours, to a depth of 1,000 fathoms, are due to the operation of sub-aerial agencies, by which the hills, and valleys, and ravines now submerged have been carved out of the rock. On the other hand, the witness of the rocks practically amounts to this—that there are no deposits now forming dry land which could not have been formed in depths of 1,000 fathoms. Most of these have been accumulated in shallow water close to the ancient land.

It is to be remarked also that the ancient land on the margins of which the stratified rocks were laid down in the northern hemisphere is the polar continent which Prof. Dawkins has termed Archaia, now represented by the Archaian rocks of Labrador and Canada, Greenland, Scandinavia, and the western highlands of Scotland, and that this has been land from the close of the Cambrian age to the present time. The impression left on his mind by these facts is that the great depths of the sea have probably been where they are now from the very beginning, and that the central nucleus of the continents has also been in existence also from the beginning. It may also be noted, as Agassiz and others have observed, that the low temperature of the ocean at great depths would lower the temperature of the rock on which they rest, and therefore tend to stereotype the oceanic depths.*

* At the depths of 4,000 fathoms the temperature is a little above freezing, at a depth of 24,000 feet the temperature of the rock is about 422° Fahr.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, November 19, 1888.

Mr. J. COSMO MELVILL, M.A., President of the Section, in the Chair.

Mr. THEO. SINGTON exhibited an abnormal growth, or concretion of some hard substance, found outside the bowels of a hen.

Mr. P. CAMERON, F.E.S., read a paper "On the British species of *Allotrinæ*, with descriptions of other new species of parasitic *Cynipidæ*."

Dr. ALEX. HODGKINSON showed a new form of electric lamp, and explained the diffraction spectra, and the advantage of parallel rays of light in microscopical research.

Mr. E. PYEMONT COLLETT exhibited a specimen of *Trifolium suffocatum* from the sandy sea shore at Hastings.

Ordinary Meeting, November 27th, 1888.

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

Mr. F. J. FARADAY, F.L.S., gave "An historical account of the spectroscopic evidence in support of the hypothesis that oxygen exists in the sun, with special reference to M. Janssen's recent researches on telluric oxygen and aqueous vapour lines and bands," in the course of which he pointed out that the two absorption spectra of Janssen, obtained with oxygen in long tubes at different pressures, added to the four luminous spectra obtained by various spectroscopists at different temperatures and pressures, apparently made a total of six spectra of this one gas. Janssen states that the two absorption spectra are producible separately and independently, one being the line spectrum in the A, B, and α region, that is, in the red and orange-red, and the other a spectrum of bands in the red, orange-green, and blue. The intensity of the former spectrum varies simply with the product of the thickness of gas traversed by the light, and the density ; whereas the intensity of the band spectrum varies according to the thickness and the square of the density. From the fact that the assumed corresponding dark lines and bands observed in the solar spectrum seemed to obey these laws, when examined from the Grands Mulets station on Mont Blanc, at an altitude of 10,000 feet, the bands being absent and the lines weakened proportionately, Janssen infers that their presence and relatively greater intensity in the solar spectrum when observed at lower levels are undoubtedly due to the greater thickness and density of the atmospheric oxygen traversed, and hence that they are telluric lines and bands and in no way indicative of the existence of solar oxygen. Referring to the statement that Janssen's absorption bands occur in the red, orange-green, and blue, Mr. Faraday pointed out that Plücker's bright oxygen spectrum, which has been called the "compound line" spectrum, of which a corresponding reversal spectrum has been, it is believed, identified in the solar spectrum, occurs in the red, green, and blue. Professor Henry Draper's supposed bright band solar oxygen spectrum was photographed in the blue, and there also are the dark absorption lines by which these bright bands were subsequently found to be traversed, and which Professor J. C. Draper suggested might be the reversal lines of oxygen. Finally in the red and orange-green the absorption lines due to the presence of aqueous vapour are most abundant, and with regard to these lines it must be noted that Janssen's observations on the Grands Mulets were made under exceptionally favourable conditions, the air being remarkably dry and the sky unusually clear. For all these reasons Mr. Faraday suggested that it would be interesting to test the spectroscopic evidence of the existence of oxygen in the sun hitherto advanced, by means of the photographs of what might be spoken of as the purified solar spectrum which M. Janssen stated that he had obtained at the Grands Mulets.

Ordinary Meeting, December 11, 1888.

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

Dr. JAMES BOTTOMLEY read the following "Note on the behaviour of Iodine in the presence of Borax":—

In the journal of the Chemical Society for this month there is an abstract of a paper on Boric acid by P. Georgievic (*J. for Chem.* [2], 38, 118-120). The paper treats of the position of boron in the classification of the elements. In reference to the acid character of boracic acid it is stated in the abstract that boric acid will not liberate iodine from a mixture of potassium iodide and iodate or nitrite. Also that boric acid is liberated from borax by the action of iodine, sodium iodide and iodate being formed. Some years since I read before this Society a Note entitled "On a case of reversed chemical action" (*Proceedings Lit. and Phil. Soc.*, Vol. XIV., p. 65), treating of the action of iodine on a solution of borax; my experience was as follows: A solution of borax dissolved iodine, forming sodic iodide and iodate ; but on concentrating the solution the reversed action took place, free iodine being formed. Also, on the addition of sodium iodate to a boiling solution of sodium iodide and boracic acid, iodine was set free.

Prof. W. C. WILLIAMSON, F.R.S., referred to the recently published report of the Royal Society Committee on the Krakatoa eruption, and a discussion on the meaning of the term "smoke" in the report ensued.

Mr. WILLIAM THOMSON, F.R.S.E., F.C.S., read a paper on "The crystalline structure developed on ordinary glass by the solvent action of fluorine compounds, with notes on Prince Rupert's drops."

Mr. P. CAMERON read a paper on "The British species of *Allotrinæ* with descriptions of other new species of parasitic *Cynipidæ*."

Notes on Some of the Peculiar Properties of Glass. By William Thomson, F.R.S.Ed., F.I.C., F.C.S.

(Received February 22nd, 1889.)

1.—On the Crystalline Forms produced on Glass by the action on it of Hydrofluoric Acid and the Acid Salts of the Alkali Fluorides.

At the Southport Meeting of the British Association (1883) I read a paper on this subject, and there shewed pieces of glass on which very distinct hexagonal pyramids, cubical, and other crystalline forms had been produced by the action of solutions of the acid fluorides of potassium, sodium, and ammonium, and anhydrous hydrofluoric acid on the glass. Different crystals are produced on different kinds of glass, depending on whether it contains potash, soda, lime, or other base. Tessié de Mothay and Maréchal examined these crystals and mention that they are composed of the fluorides of calcium and lead, by the separation of which the surface is rendered more opaque. F. Reinitzer in a paper on the same subject, 1886 (*Dingl. Polyt. J.* 262, pp. 312–320) gives sketches of the same crystals, and offers the explanation that they are the silico-fluorides of calcium sodium or potassium.

The Rev. Professor T. G. Bonney examined my specimens, and, whilst he would not venture on any distinct theory, suggested that they might possibly be due to the crystallization of free silica produced by the action of the fluorides on the glass. Professor Bonney microscopically examined them, and both he and I failed by the ordinary means to find that they polarized light, although they were sufficiently large to be seen by an ordinary pocket lens.

Both Professor Bonney and Professor Zirkel, with whom I also conversed respecting them, were of opinion that if they did not polarize light, and were not of the regular system, they could not be regarded as crystals, however perfect in form they might be.

Lately, I have given more attention to this subject, and by the aid of Dr. Alexander Hodgkinson, of Manchester, I have been able to demonstrate that these crystalline forms actually do polarize light. The most distinct effect produced on them was by the employment of circularly polarized light. When the microscope stage was rotated with one of these crystals in focus, the regular changing of colours was very distinctly seen on each crystal, thus proving that the crystalline forms developed by the alkaline fluorides possessed also the polarizing properties of the irregular system to which most of them belong.

It is remarkable that these crystals are only seen near the edges of etchings by the alkaline fluorides, or only where the immediate surface of the glass has been removed. In the deeper parts of the etchings an irregular surface is presented, resembling to the naked eye a crop of small crystals, but on microscopical examination shewing no distinct crystalline form. It was somewhat difficult to determine whether the crystals were indentations in the glass or whether they stood in elevation, but after careful microscopical examination both Dr. Hodgkinson and I came to the same conclusion, that they stood in elevation. In a large thick glass vessel, capable of holding ten gallons, I placed six or seven gallons of fluosilicic acid solution containing a little hydrofluoric acid. After some months the vessel became deeply etched and, viewed from the outside, the surface seemed to be covered by a crop of well-formed crystals of considerable size. This vessel cracked in different places, which I find usually results in time from dissolving the inner surface of a glass vessel by hydrofluoric acid or the fluorides. On breaking this vessel I found the inner surface to be very irregularly etched, shewing what appeared to be irregular crystalline forms of an average of a quarter of an inch across and ⅛ to ¼ inch deep from apex to bottom of rough crystals, but on carefully examining these by the naked eye, by a pocket lens, and by the microscope, no *distinct* and definite crystalline forms could anywhere be discovered. The observations which strike one regarding these are :—*First*, if glass possess that absolutely homogeneous or colloid or gelatine structure which it is generally supposed to have, why does it develope these curious irregularities when submitted to a slow solvent action. One would expect it to dissolve like a surface of gelatine when slowly acted upon by water if it were so absolutely colloid in its structure. On the other hand, if it be presumed to have a crystalline structure, one would expect that the surface would present such irregularities as it actually gives when the surface is thus removed.

With regard to the distinct crystalline forms produced on glass by the action of the alkali acid fluorides, Tessié de Mothay, Maréchal, and F. Reinitzer seem satisfied that the crystals have been *produced* by the solvent itself combining with some of the constituents of the glass and depositing crystals therefrom. The following is an extract from Reinitzer's paper :—

" Fig. 1 represents the edge of an etched plate. The " crystals are hexagonal, and agree with those of silicon- " sodium fluoride. There are also a few of a longish shape, " which are very like those of silicon-calcium fluoride. It is " believed that alkali fluoride and hydro-fluoric acid act on " the glass, forming sodium-silicon fluoride and silicon- " calcium fluoride which are set free in a crystalline form ; " whereas, hydro-fluoric acid etches the spaces between the " crystals. Silicon and calcium are derived from the glass, " sodium partly from the etching bath and partly from the "glass. On etching potash glass, tesseral crystals of silicon "potassium fluoride can be observed, and this suggests a "simple method for the detection of potash glass."

There is, however, a simple method by which this theory of Reinitzer, and also of de Mothay and Maréchal can be tested, and that is, that sodium-silicon fluoride, calcium-silicon fluoride, potassium-silicon fluoride, and also lead and calcium fluorides are all easily acted upon by sulphuric acid. If, then, these crystals be composed of the above-named compounds, it is evident they should be dissolved and removed, or destroyed by the action of sulphuric acid, which attacks with facility those compounds. I have made the experiment by boiling pieces of glass on which these crystals had been developed in sulphuric acid of different strengths up to prolonged boiling with strong vitriol, but on washing the glasses after such treatment, none of the crystals were destroyed or dissolved, and even their edges were not in the faintest degree affected. Whatever, therefore, these crystals may be, they are *not* crystals of the sodium, calcium or potassium silico fluorides, or of lead or calcium fluoride. But assuming that they are so, then one would expect to find them in the deeper parts of the etchings as well as near the surface and edges; which is not the case.

I am of opinion that these crystals existed originally in the glass, and that the action of the solvent developed them just as hydrochloric acid developes the crystalline structure on tin when a weak solution is washed over a bright and smooth surface of it. It is not suggested that the hydrochloric acid combines with and produces the crystals, it merely dissolves away the surface of the tin at some parts more than at others, so as to develope the metallic crystals; and if the etching with the acid is continued, the crystals which are at first developed disappear, which is just what happens with the glass.

I am of opinion that the crystals developed from the glass are the potassium sodium and calcium silicates, which are not acted upon by the strong sulphuric acid above mentioned, and which are developed from the surface of the glass by the slow solvent action of the fluorides, just as the metallic tin crystals are developed from the surface of tin by the solvent action of dilute hydrochloric acid upon its surface.

The objection to this theory is that glass does not polarize light; but it cannot be deduced from that that glass is not crystalline, because Pasteur proved that although paratartaric acid does not polarize light it is still crystalline, and is composed of crystals of the irregular system, but that the crystals or molecules are so arranged that the polarizing influence of one is neutralized by the reverse action of another always found in juxtaposition with it. Is it not possible, then, that glass crystals may be similarly arranged to each other so that the polarizing influence of one crystal may be neutralized by the reverse polarizing influence of the other? And this seems to be borne out by the fact that whilst small sodium and potassium silico fluoride crystals shew distinct polarization when viewed simply by two Nicol's prisms, the crystals on the glass do not shew polarization by that means, and it was only by the employment of circularly polarized light, produced by passing the light through a quartz plate, that a distinction could be observed between the crystals in question and ordinary glass. I believe that these crystals are then silicates of potassium, sodium and calcium, etc., and that they are not produced by the combination of the solvent with some of the constituents of the glass. Ammonium fluoride, when heated on the surface of glass, developes a beautiful fern-like structure on it resembling hoar-frost on a window pane.

II.—On Prince Rupert's Drops.

In the seventeenth century Prince Rupert astonished and amused the people of the English Court by producing drops of glass with long tails attached, which burst into small pieces the moment the tail was broken. Since his time Robert Hooke and others have made experiments upon them. It is believed that the explosive power of these drops depends on an internal tension in the glass of the drop due to the red hot, and consequently expanded, glass being suddenly cooled and solidified, whilst the internal contents have to adapt themselves to the rigid and expanded envelope. These drops are produced by allowing drops of molten glass to fall into cold water, a long tail being left as the highly viscid molten glass falls. As a rule, Rupert's drops contain a number of bubbles, which are due to vacuous spaces, but there are some drops which are free from such bubbles, and when the tail of one of these is broken it bursts with greater force than a drop containing bubbles.

That these bubbles are vacuous I proved by heating the drop to redness, when the bubbles disappeared, and after cooling the drop of glass appeared quite solid and transparent.

To determine whether the Rupert's drop was less dense than the drop after annealing, I took a large Rupert's drop quite solid and transparent (free from bubbles) which weighed in air 170·30 grains, and in water 102·66 grains. It was laid on a piece of platinum, placed in a muffle furnace, heated to redness, and allowed to cool gradually. It then weighed in air 170·36 grains, and in water 102·960 grains. The specific gravity of the Rupert's drop was, therefore, 2·5177, whereas the specific gravity of the drop, after the strain had presumably been removed by annealing, was 2·5276, in other words, 100 volumes of ordinary glass produced 100·392 volumes of Rupert's drop glass, or the volume of the glass of the Rupert's drop may be represented as having increased the $\frac{1}{255}$th part of the original glass.

The specific gravity of a second Rupert's drop *without bubbles*, made from a different kind of glass, was taken before and after heating to redness and allowing to cool slowly, the results obtained were—

Sp. gr. of the Rupert's drop	2·4762
Sp. gr. of the Rupert's drop after heating to redness and allowing to cool slowly ...	2·4859

100 volumes of the ordinary glass used for making this Rupert's drop produced 100·3902 volumes of Rupert's drop, equal to an increase in volume of $\frac{1}{256}$th part of the original glass.

I determined the specific gravity of a Rupert's drop containing bubbles.

	Grains.
The weight in air previous to the removal of the bubbles by heating was	34·830
Weight in water ...	20·536
After the removal of the bubbles by heating and allowing to cool slowly it weighed ...	32·948
Weight in water ...	19·700
(A piece of glass was broken off in removing it from the platinum.)	
Specific gravity before heating	2·4366
After heating	2·4870

100 volumes of ordinary glass produced therefore 102·027 volumes of Rupert's drop with bubbles.

The Rupert's drops with bubbles may therefore be represented as having expanded rather more than $\frac{1}{49}$th part of their volume.

In other experiments I determined the specific gravity of a glass rod and found it to be 2·5029.

I then produced a number of Rupert's drops from it by melting before the blowpipe, allowing the drops to fall into water and then determining the specific gravities of the drops so produced.

	Specific gravity.		100 volumes of of original glass became of Rupert's drop glass.		Equal to increase of volume.
(*a*)	2·451	......	102·073	......	$\frac{1}{48}$
(*b*)	2·460	......	101·714	......	$\frac{1}{58}$
(*c*)	2·473	......	101·194	......	$\frac{1}{84}$

One drop was made by allowing to fall into heavy mineral oil, heated to 80° C., instead of cold water, a fused portion of the rod. It produced a drop with one large bubble in the centre. Its specific gravity was 2·4475. 100 volumes, therefore, became 102·213. One drop of molten glass from the rod was allowed to fall into carbon tetrachloride. The liquid seemed to assume the spheroidal condition around the drops, so that it remained red hot for a long time under the liquid. The drop thus formed was free from bubbles and its specific gravity was 2·520, thus shewing that under those conditions 100 volumes of the original glass *contracted* to 99·317 volumes. This drop possessed none of the properties of the Rupert's drop, and neither did the ones dropped into oil, into carbon tetrachloride, or into ether.

The drop produced in ether had a specific gravity of 2·5018, whilst the original glass had a specific gravity of 2·4910, thus shewing that a contraction in volume had resulted from the use of ether.

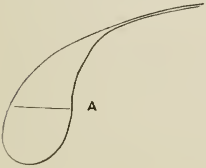
To find whether glass altered in volume on being heated to redness several times, I took a small piece of glass rod and heated it to redness, and allowed it to cool slowly in the air on three different occasions, the specific gravity being taken after each heating. The following are the results obtained :—

Specific gravity of original glass	2·4954
After first heating... ...	2·4964
„ second „	2·4981
„ third „	2·4986
The same glass was then fused and dropped into cold mineral oil, and its specific gravity was...	2·4694

The drop in oil contained vacuous spaces or bubbles, but the drops formed in carbon tetra-chloride, chloroform, or ether, were all free from vacuous spaces. The drop in water ceased to shew red-hot after 1 to 2 seconds, whilst in ether it remained red hot for 5 to 6 seconds, and in air for about 20 seconds.

I placed a Rupert's drop in hydrofluoric acid till all the outer skin was removed; when the tail was then broken the drop remained intact, and it was not till the thick part of the drop was broken in a vice that the whole drop broke into pieces, but the pieces into which it broke were much larger than when broken in the usual manner.

A small drop was placed in hydrofluoric acid, and, after a certain amount of the skin had been dissolved, an even layer of about $\frac{1}{16}$th of an inch was found broken into small pieces equally all round the drop, these pieces remaining *in situ*, and could be easily removed by the fingers, whilst a bead of glass which formed the core came out clear and transparent, and when this was broken in a vice it did not break throughout into small pieces, but acted like an ordinary piece of glass.



Two drops were taken, one was dipped in molten paraffin, so that the part from the line A, shewn in the figure, to the point was coated with paraffin, the other was dipped so that the part from the line A to the bottom was thus coated.

Both were placed in hydrofluoric acid, with the result that the acid dissolved away the surface in the first, whilst, in dissolving away the surface from the bottom the whole drop became disintegrated and was found in small pieces.

The experiment was repeated, and this time both top and bottom surfaces were removed respectively to a depth of about $\frac{1}{16}$th of an inch and the drops remained intact. When the tail of the first with the top surface removed was broken off, the drop remained intact, and it was only when the glass was broken near the point A in a vice that the bottom part became disintegrated.

In the second drop, when the lower surface only was removed, the breaking of the tail burst the whole drop, but the lower part broke into much larger pieces than it would have done if the surface had not been removed.

According to Robert Hooke you may grind away the bottom of the drop without producing disintegration, but if this be attempted from the point downwards the drop invariably bursts. From the above experiments one is led to believe that the drop might be ground from either end if the necessary care were taken, which would no doubt require to be much greater from the point downwards than from the bottom upwards.

The explanation of the bubbles in the drops seems to be that there are very minute bubbles of air in the glass, which form nuclei for the formation of the vacuous spaces, and where none of these nuclei exist the drop appears to form as a solid transparent mass under greater tension than those in which the bubbles have formed ; but the curious thing is that whilst the Rupert's drops containing bubbles had increased in volume over 2 per cent, those free from bubbles had only increased by about $\frac{1}{3}$ per cent. One would suppose that if a drop of molten glass were thrown into cold water its external surface would be solidified at once and that, whether or no, bubbles formed afterwards in the centre of the drop it would have somewhere about the same specific gravity. This, however, is not the case, and the bubbles form such a very considerable volume of the whole drop that it is difficult to imagine it possible that the molecules of glass could, as it were, stretch so as to accommodate themselves to filling such spaces with a continuous solid mass of glass. What seems to take place therefore is, that in the drops in which the bubbles occur, the solid contents and surface of the drop are forced outwards simultaneously with the cooling. It seems curious, however, that drops cooled in oil, although increasing in volume about as much as those cooled in water, should not possess the bursting properties peculiar to the drop formed in water. It is true that the drop cools more rapidly in water than in oil, and a remarkable thing is that one often finds bubbles formed from the surface inwards in drops formed in oil, whilst I have never observed that in water-cooled drops.

I have to thank my assistants, Mr. H. Bowes and Mr. J. P. Shenton, for much of the work contained herein.

On the British Species of Allotrinæ, with descriptions of other new species of Parasitic Cynipidæ. By P. Cameron. Communicated by John Boyd, Esq.

(*Received November 22nd, 1888.*)

Neither in this country nor abroad have the Parasitic Cynipidæ attracted much attention, and thus our knowledge of the species is comparatively limited. That the group is numerous in species there can be no doubt, but their correct determination is a work of some difficulty, chiefly owing to the shortness of the descriptions of Hartig, who is the entomologist who first studied the species to any extent. Until his types have been examined by the aid of the works of Thomson and other writers, there must be always some doubt regarding many of them. The Allotrinæ will probably be found to be more difficult of specific discrimination than any other section of Parasitic Cynipidæ, from the absence of much difference in sculpture or great variation in structure, while also they are very numerous in species, and mainly distinguished by differences in colour, in the form of the antennæ and in the alar neuration. As a sub-family they are to be known by the broad radial cellule, the areolet not being situated opposite its base: the first and second cubital cellules are never complete and the cubitus (when indicated) issues from the middle of the transverse basal nervure; the abdomen has the second segment the largest; the body (including the scutellum) is impunctate, and the hind tibiæ have only one spur. One of the most recent writers on the subject (Mr. W. H. Ashmead, *Trans. Am. Ent. Soc.*, XIII., p. 64) includes *Ægilips* Hal. in the *Allotrinæ*; but the entire structure of that genus comes so near the *Figitinæ* and especially *Anacharis*, that I cannot look upon *Ægilips* as having any affinity with *Allotria*, from which it differs in the rugose scutellum, in the shorter second abdominal segment (which is not half the length of the abdomen) and in the cubitus issuing from below the middle of the transverse basal nervure. It is however very probable that *Ægilips* Ashmead is different from *Ægilips* Hal. Certainly that genus has a transverse groove before the scutellum, the second abdominal segment is not " longer than the others," and the parapsidal furrows are not parallel, as stated by Mr. Ashmead to be the case with his *Ægilips*.

According to our present knowledge the *Allotrinæ* are attached to aphides, either as parasites or hyper-parasites of the ichneumons which destroy the plant lice. So far I am acquainted with thirty-three British species of *Allotria*. Those with the wings fully developed may be known by the following table :—

1 (31) Radial cellule closed.
2 (10) Thorax (and head) more or less red.
3 (4) Thorax entirely red ; wings large, antennæ and legs entirely clear yellow. *Megaptera*, Cam.
4 (3) Thorax not entirely red, antennæ not entirely yellow.
5 (6) Pleuræ entirely, and base of abdomen broadly rufous ; legs clear yellow, nervures yellow ; antennæ with the apical three-fourths dark fuscous. *Pleuralis*, Cam.
6 (5) Pleuræ not entirely, and base of abdomen but slightly rufous ; nervures fuscous.
7 (8) Lower part of pleuræ piceous-red ; legs rufo-testaceous ; radial cellule small, one half longer than wide. *Ruficeps*, Cam.
8 (7) Pleuræ rufous, the centre broadly blackish, legs yellow ; radial cellule large, twice longer than wide. *Ruficollis*, Cam.
9 (1) Thorax, head and basal half of abdomen castaneous ; legs testaceous ; radial cellule elongated, three times longer than wide. *Collina*, sp. nov.
10 (21) Thorax black.
11 (16) Head red.
12 (13) Antennæ uni-colorous yellow ; legs clear yellow. *Flavicornis*, Htg.
13 (12) Antennæ fuscous, yellow at the base.
14 (15) Head entirely red ; radial cellule elongate. *Victrix*, West.
15 (14) Head with the vertex castaneous ; radial cellule moderate. *Tscheki*, Gir.

16 (11) Head for the greater part black (entirely or with the oral region piceous-red).
17 (20) Legs clear yellow.
18 (19) Radial cellule large, elongated, more than twice longer than wide; the femora slightly infuscated. *Circumscripta*, Htg.
19 (18) Radial cellule small, not twice longer than wide; femora clear yellow. *Minuta*, Htg.
20 (17) Legs more or less fuscous-testaceous.
21 (28) Radial cellule elongated; the second abscissa of the radius at least one half longer than the first.
22 (23) Head piceous-red, radial cellule wide, the basal abscissa of radius a little more than half the length of the second. *Curvicornis*, Cam.
23 (22) Head black, radial cellule elongate, basal abscissa of radius more than half the length of the second.
24 (25) Length scarcely 1 mm.; basal joints of the antennæ clear yellow. *Dolichocera*, sp. nov.
25 (24) Length over 1 mm.; basal joints of antennæ fuscous or black.
26 (27) Head piceous, black on top; the 4th and 5th joints of antennæ deeply curved. ♂. *Ancylocera*, Cam.
27 (26) Head black; the 4th and 5th joints of the antennæ but slightly curved. *Longicornis*, Htg.
28 (21) Radial cellule minute, not much longer than wide, the 3rd abscissa of radius curved.
29 (30) Head black; the abdomen strongly compressed, broadly piceous, as long as the thorax. *Microcera*, Cam.
30 (29) Head reddish, castaneous on top; abdomen shorter than thorax, not compressed. *Mullensis*, Cam.
31 (1) Radial cellule open.
32 (49) Thorax black.
33 (40) Head red.
34 (35) Radial cellule greatly elongated. *Macrophadnus*, Htg.
35 (34) Radial cellule not greatly elongate.
36 (37) Collar broadly red. *Maculicollis*, Cam.
37 (36) Collar entirely black.
38 (39) Base of abdomen red; antennæ thickened towards the apex, broadly and darkly infuscated; legs reddish-testaceous. *Basimacula*, Cam.
39 (38) Base of abdomen black; antennæ hardly infuscated at the apex, legs yellowish testaceous. *Filicornis*, sp. nov.
40 (33) Head black.
41 (44) Radial cellule minute, more or less trapezoidal, legs clear yellow.
42 (43) Antennæ clear citron-yellow, hardly infuscated towards the apex; radial cellule twice longer than broad; the third abscissa of the radius not distinctly curved. *Citripes*, Thoms.
43 (42) Antennæ blackish, yellow at the base; radial cellule not twice longer than broad; the third abscissa of radius roundly and distinctly curved. *Trapezoidea*, Htg.

44 (41) Radial cellule elongated, much longer than broad; legs and antennæ not citron-yellow.

45 (46) Legs and base of antennæ clear testaceous-red; radial cellule elongated, the first abscissa of radius more than twice the length of the second. *Ullrichi*, Gir.

46 (45) Legs testaceous with the femora infuscated; radial cellule not elongated, the first abscissa of radius scarcely twice the length of the second.

47 (48) Legs reddish-testaceous, the femora lined with fuscous; the second abscissa of the radius twice the length of the third; length 1¼ mm. *Perplexa*, sp. nov.

48 (47) Legs pale testaceous; the femora fuscous; the joints pallid. *Crassa*, sp. nov.

49 (32) Thorax piceous-red or reddish-testaceous (head reddish or castaneous).

50 (51) Legs and antennæ fuscous-testaceous, the femora infuscated; head castaneous, abdomen broadly rufous. *Caledonica*, Cam.

51 (50) Legs clear yellow, the femora not infuscated.

52 (53) Head castaneous, abdomen black, reddish at the extreme base; radial cellule elongate. *Piceomaculata*, Cam.

53 (52) Head reddish, abdomen broadly reddish, black at the apex or base.

54 (55) Length 1½ mm.; abdomen reddish, black at the base; radial cellule elongate, narrow, the third abscissa of the radius not distinctly roundly curved. *Testaceus*, Htg.

55 (54) Length 1 mm.; abdomen black, reddish at base; radial cellule short, wide, the third abscissa of radius with a distinct rounded curve. *Nigriventris*, Thoms.

Allotria dolichocera, *sp. nov.*

Black; the mouth, the base of the antennæ (joints 1—4) and legs pallid testaceous; castaneous or infuscated broadly in the middle; wings hyaline, the nervures fuscous. Antennæ longer than the body, very slightly thickened towards the middle; the third and fourth joints subequal and a little longer than the second; the last joint fully one-half longer than the penultimate. Radial cellule wide; the second abscissa fully one and a half times the length of the second, almost straight. ♀.

Length ¾ mm.

What is probably the ♂ has the antennæ filiform, one fourth longer than the body; the third joint curved; the base of the abdomen rufous.

A. brevis Thomson comes very near this species, but it has the antennæ only the length of the thorax.

Hab. Cadder Wilderness near Glasgow, Dumfries, Peckham (*T. R. Billups*).

ALLOTRIA COLLINA, *sp. nov.*

Black; the oral region, the thorax and base of abdomen, castaneous; the basal four joints of the antennæ and legs pallid testaceous; the femora inclining to castaneous. Wings hyaline, the nervures fuscous. Antennæ nearly one-half longer than the body, thickened gradually (but not strongly) towards the apex; the third joint not much longer than the second; the last longer than the penultimate. Radial cellule elongate; the third abscissa of radius two and a half times the length of the second. ♀.

Length ¾ mm.

Most nearly related to *A. dolichocera*, but readily known by the castaneous thorax and base of abdomen, by the more slender and, if anything, longer antennæ, by the clear colour of the legs, and by the more elongated radial cellule.

Hab. Mugdock.

ALLOTRIA FILICORNIS, *sp. nov.*

Black; the head red, castaneous on the top; the legs and five basal joints of the antennæ clear yellow; joints 6—13 fuscous; wings hyaline, the nervures testaceous; metathorax and base of abdomen covered with long pale hair. Antennæ filiform, not thickened towards the apex; the third joint a little longer than the fourth, and both are longer than the fifth; the last joint is fully one-fourth longer than the penultimate. Radial cellule elongate, wide, twice longer than wide; the first abscissa of radius three-fourths of the length of the second; the third roundly curved, two and a half times the length of the second. The ♂ has the fourth and fifth joints curved; the third is as long as the fourth; the two last are subequal.

Length nearly 1½ mm.

Most nearly related to *A. macrophadna*; but it is smaller, the colour of the legs is yellow, not reddish or reddish-testaceous; the wings are shorter, the radial cellule is shorter and narrower. In the ♂ the curvature in joints 4 and 5 is better marked, and the third joint is longer.

It is a larger species than *A. basimacula*; the antennæ are of a paler and clearer yellow, not dark fuscous, and much stouter and with the fourth and fifth joints thicker and more curved; the legs are clear yellow, not reddish testaceous; the abdomen is longer compared to the thorax and the radial cellule is wider.

Hab. Cladich, Loch Awe, Clydesdale, Manual, Linlithgowshire, Moffat, Dumfries.

Allotria perplexa *sp. nov.*

Black; joints 1—5 of the antennæ and legs testaceous, the femora broadly black or infuscated in the middle; wings hyaline, the nervures pale fuscous. Antennæ as long as the body, distinctly thickened towards the apex; the third joint one-fourth longer than the fourth; the last one-half longer than the penultimate. Radial cellule moderate in length, broad; the first abscissa of radius half the length of the second, which is a little more than twice the length of the third, the third slightly curved. The hair on base of abdomen and metathorax very dense. The ♂ has the antennæ filiform, longer than the body, the third joint longer than the body, curved.

Length 1¼ mm.

There are two species described which have the femora darkened and with the tibiæ and tarsi testaceous as in *perplexa* and *crassa*, namely *A. aperta*, Htg., and *A. fuscipes*, Thomson; but both differ from *perplexa* and *crassa* in having the antennæ shorter; *fuscipes* having them scarcely longer, and *aperta* almost shorter than the thorax.

Hab. Sutherlandshire, Kingussie, Clydesdale, New Galloway, Dumfries.

ALLOTRIA CRASSA, *sp. nov.*

Black; the scape fuscous, joints 2—5 of the antennæ, the apex of femora and tibiæ more or less and the tarsi, testaceous; the rest of the legs are fuscous; wings hyaline, the nervures fuscous. Radial cellule elongate, narrow; the basal abscissa of the radius about one-third the length of the second; cubitus short, obscure. Antennæ as long as the body, thickened towards the apex, the third joint one-half longer than the fourth; the last a little longer than the penultimate.

What is probably the ♂ has the antennæ filiform, longer than the body, the basal three joints pale testaceous, the others dark fuscous.

Length 1 mm.

A smaller species than *A. perplexa*; the antennæ are shorter, the head inclines to piceous in colour; the radial cellule is more elongated and has the second abscissa of the radius fully three times the length of the third; and the legs are pale testaceous, not reddish and are especially pallid at the joints.

Hab. Sutherlandshire, Cladich, Loch Awe, Dumfries.

KLEDITOMA LONGIPENNIS, *sp. nov.*

Black, shining; the knees, apex of femora and base of tibiæ, piceous; wings hyaline, the nervures piceous. Antennæ as long as the body; the third joint scarcely one-half longer than the fourth; the 3—8 joints thin, twice longer than broad, fully half the width of the club, which is nearly as long as the preceding six joints united; the 5-jointed club distinct, abrupt, its basal joint not much narrower than the second and nearly one-half shorter than it. Scutellum distinctly striated, the cup lanceolate. Sides of metathorax opaque, finely punctured; the metanotum with a gradual slope, the keels distinct. Abdomen shorter than the thorax, compressed; the hair fringe dense, dull griseous. Wings ample; the radial cellule elongate, its width twice the length of the widest part; the second abscissa of radius twice the length of the first; apical margin of wings incised, densely ciliated. ♀.

Length 1¾ mm.

Hab. Clober Moor, near Glasgow.

KLEDITOMA ELEGANS, *sp. nov.*

Black; the trochanters, apex of femora, tibiæ, and tarsi, testaceous; wings hyaline, the nervures testaceous. Antennæ a little longer than the body; the third joint nearly as long as the fourth and fifth joints united, the 4—7 equal in length and thickness, the eighth one-half longer than the seventh and distinctly thicker than it; the 5-jointed club abrupt, the ninth joint thicker and longer than the eighth; the joints bear some moderately long hairs. Wings ample; the apex waved, almost truncate, but very slightly incised; radial cellule wide, moderately elongate; in length nearly twice the width of the widest part; the second abscissa of radius three-fourths longer than the first. Abdomen as long as the thorax, looked at from the side almost triangular; hair fringe dense, griseous. ♀.

Length nearly 1¾mm.

Allied to *K. longipennis*, but easily known from it by the clear testaceous tibiæ and tarsi, by the incision in the wings being very much less deep, and by the eighth joint of the antennæ being clearly longer and thicker than the seventh.

Hab. Mugdoch Wood, near Glasgow.

KLEDITOMA TRUNCATA, *sp. nov.*

Black; the legs testaceous, the coxæ for the greater part black, the femora black in the middle; wings hyaline, the nervures obscure testaceous. Antennæ a little shorter than the body; the third joint twice the length of the fourth; the 4—8 subequal, but becoming very slightly longer, and of equal width, and about one-half longer than broad. The 5-jointed club sub-abrupt, the ninth joint being distinctly thinner than the tenth, and shorter than it. Scutellum indistinctly striolated laterally; metapleuræ opaque, pubescent. Abdomen shorter than the thorax; the hair fringe dense, griseous. Wings large, the apex hardly incised; the radial cellule elongate, more than twice longer than wide; the second abscissa of radius twice the length of the first.

Length 1½ mm.

Compared with *longipennis* the antennæ are shorter and stouter, the club sub-abrupt and the wings can scarcely be said to be incised.

Hab. Bishopton.

KLEDITOMA MARSHALLI, *sp. nov.*

Black; the legs testaceous, the coxæ and base of femora lined with black; wings clear hyaline, the nervures testaceous; the apex incised but not deeply. Antennæ as long as the head and thorax united; the second joint sub-globose, thick; the third one-half longer than the fourth; the rest broader than long; the 3-jointed club abrupt, the basal joint nearly as long as the three preceding joints united, and a little shorter than the second; the third joint nearly as long as the two preceding joints united and sharply conical at the apex; the club nearly as long as the rest of the flagellum. Scutellum strongly longitudinally striolated; the cup small, acutely pointed at the base. Abdomen longer than the thorax, the hair fringe interrupted on the top, clear white. Radial cellule elongate, narrow, more than twice longer than broad; closed at the base and apex; the second abscissa of radius one-fourth shorter than the third; the apical incision broad, short but distinct; the fringe long.

The ♂ has the antennæ one half longer than the body, the third joint curved, not much longer than the fourth.

Length ♀ 2 mm.; ♂ 1½ mm.

The great length of the club render this (for the group) large species easily recognisable.

Hab. Barnstaple. *(Rev. T. A. Marshall.)*

KLEDITOMA FILICORNIS, *sp. nov.*

Black; the legs pale testaceous, piceous towards the base; wings clear hyaline, the apex cordate, with a long hair fringe; the nervures testaceous. Antennæ filiform, as long as the body; all the joints of the flagellum twice longer than broad, distinctly separated; the club subabrupt, the joints narrow at base and apex; the apical one-fourth longer than the penultimate. Abdomen not much longer than the thorax: piceous on ventral surface, the hair fringe large, white. Radial cellule narrow, elongate; the second abscissa of radius two-thirds the length of the third.

Length 1 mm.

May be known from *K. psiloides* by the longer and thinner antennæ of which the joints are all twice longer than broad, by the thinner less abrupt club, and by the longer and thinner radius.

Hab. Bishop's Teignton. *(Rev. T. A. Marshall.)*

KLEDITOMA LONGICORNIS, *sp. nov.*

Black; the trochanters, femora, tibiæ and tarsi, testaceous; the femora broadly lined with black above; wings hyaline, the nervures dark fuscous. Antennæ as long as the thorax and abdomen united; the basal part of the flagellum thin; the third joint not much larger than the fourth; the tenth joint longer and thinner than the ninth and about one-fourth narrower than the eleventh; the 3-jointed club distinct; the joints moderately elongate; the last sharply conical at the apex and longer than the others. Scutellum laterally opaque, closely, longitudinally striolate; the foveæ deep, wide, distinctly separated; the apical fovea small, shallow, circular; at the apex the scutellum broadly projects, narrowing towards the bottom, but not forming a beak as in the section *Rhyncacis*; abdomen longer than the head and thorax united; the hair fringe dense, large, griseous. Radial cellule an elongate triangle, closed at base and apex; the nervures straight, the second abscissa fully one-fourth shorter than the third; cubitus traced; apex of wing roundly incised. ♀

Length slightly over 2 mm.

In general coloration this species comes nearest to *K. filicornis*, but differs from it in its much greater size; in the projecting apex of the scutellum (forming a transition to *Rhyncacis*) in the longer abdomen and in the clearly indicated cubitus.

Hab. Barnstaple. *(Rev. T. A. Marshall.)*

KLEDITOMA GRACILICORNIS, *sp. nov.*

Black; the knees and tarsi piceous; wings clear hyaline, the nervures piceous. Antennæ thin, twice the length of the thorax; the third joint one-half longer than the fourth, the 4—8 wider than long; the ninth oblong, thicker and nearly twice longer than the eighth, and three-fourths of the width of the tenth; the 4-jointed club not very abrupt, the three basal joints of nearly equal thickness and length, oval; the last longer and sharply conical at the apex. Radial cellule subtriangular; the second and third abscissæ of the radius subequal. Scutellum aciculate; the basal foveæ longer than wide. Abdomen longer than the thorax and head united; the hair fringe moderate, whitish. Apical incision in wings slight. ♀.

Length 1 mm.

The much smaller size, the thinner and longer antennæ, the smaller and whiter abdominal hair fringe, sufficiently distinguish this species from *K. tetratoma.*

Hab. Munton. (*Rev. T. A. Marshall*).

KLEDITOMA AFFINIS, *sp. nov.*

Black, shining; the trochanters, knees and tarsi piceous; wings hyaline, the nervures dark piceous. Antennæ longer than the head and thorax united; the third joint not one and a half times longer than the fourth; joints 4—8 dilated towards the apex, longer than broad; the apices truncated; the ninth distinctly broader than the eighth and a little longer than it; the 4-jointed club abrupt, distinctly separated; the joints of nearly equal thickness and becoming gradually longer towards the apex; the tenth a little narrower than the eleventh. Radial cellule rather elongated, closed at base and apex; the second abscissa of radius distinctly longer than the first. Pro- and metanotum slightly pilose; abdominal hair fringe, dense, griseous; abdomen as long as the head and thorax united; scarcely petiolated. Scutellum laterally finely striolated.

Length 1¾ mm.

Very similar to *K. tetratoma*, Thoms., but may be easily known from it by the third antennal joint not being twice the length of the fourth and by the shorter abdomen.

Hab. Bonar Bridge, Sutherlandshire.

TRYBLIOGRAPHA CRASSICORNIS, *sp. nov.*

Black; the flagellum of antennæ and legs red; the coxæ, the trochanters above and a line on the upper side of the femora towards the base, black; wings hyaline, the nervures dull testaceous. Antennæ fully one-half longer than the head and thorax united; the third joint one-fourth longer than the fourth, which is as long as the fifth; the 8-jointed club abrupt; the sixth joint as long as the seventh and equal in breadth to it, moniliform. Scutellum rugose at its sides and apex; the basal foveæ deep and wide. Metapleuræ densely covered with griseous hair. Abdomen compressed laterally, lenticular, longer than the head and thorax united; piceous towards the base and apex; the hair fringe moderately broad, brownish, griseous at the apex. The first abscissa of the radius curved, fully one-half the length of the second, which is also curved and three-fourths of the length of the third; the latter straight; the cubitus reaches quite close to the apex of the wings.

Length 4½ mm.

May be known from *T. scutellaris* by the shorter antennæ, which are also thicker, with the club more distinctly abrupt; the third joint is not one-half longer than the fourth; the sixth not longer than the seventh; the wings shorter and clear hyaline; the abdomen longer, being longer than the head and thorax united.

Hab. Cambuslang on the Clyde.

EUCOILA SCOTICA, *sp. nov.*

Black; the knees, four fore-tibiæ and tarsi, piceous-red; the hinder tibiæ piceous-black; wings clear hyaline, but slightly pilose; the nervures fuscous. Antennæ nearly twice the length of the thorax, with an 8-jointed club not clearly separated; the third joint not very much longer than the fourth; the sixth longer than the seventh, twice longer than wide; the other joints not much thicker than it, but shorter compared to the width. Cup of scutellum rather small; the foveæ at apex round, deep; apex of cup projecting; scutellum coarsely punctured; the depression at base large. Cubitus indistinct, not much traced beyond the angle of the radial cellule, which is short and broad; the first abscissa of radius slightly curved, one fourth shorter than the second. Abdomen a little shorter than the head and thorax united; the hair fringe moderate. Pubescence on the metapleuræ sparce.

The ♂ has the antennæ longer than the body; the third joint thin, more than twice the length of the second, and longer than the fourth, which is thicker than the third.

Length 2—3 mm.

Hab. Clydesdale, Dumfries, Colvend, Carruber Glen, Dalry, Ayrshire.

A larger and stouter species than *T. cubitalis*; differing from it in having the antennæ quite black, stouter, and with a less clearly defined club, and with the third joint not much longer than the fourth. The radial cellule also is shorter and much broader, it being not very much longer compared to the greatest width; the second abscissa is only about one fourth longer than the third, and the nervures are dark fuscous.

EUCOILA FORTINERVIS, *sp. nov.*

Black; trochanters, base and apex of femora, tibiæ and tarsi, red; hinder tarsi inclining to fuscous; wings hyaline, with a decided fuscous tinge; the nervures dark fuscous; spurious nervures and cubitus stout, testaceous. Antennæ one-half longer than the body; the third joint a little longer than the fourth and thinner than it. Prothorax striolated in front, rather densely covered with fuscous hair. Scutellum coarsely rugosely punctured; the cup twice longer than broad; its base and apex depressed, narrowed and rather sharply pointed at the base, the apex rounded, pitted along the sides; the apical foveæ round, deep. Scutellar foveæ wide, deep, extending backwards nearly to the middle of the cup, and not completely separated in the middle. Metapleuræ densely pubescent; the metapleural keels stout, straight. Abdomen shorter than the thorax, the hair fringe, dense, griseous. Legs densely pilose. Radial cellule twice longer than wide; the first abscissa of radius about one-fourth shorter than the second, which is straight and nearly half the length of the third;

the latter is curved near the apex ; cubitus thick, extending to the apex. ♂

Length 3½ mm.

Hab. Gloucester.

EUCOILA PROXIMA, *sp. nov.*

Black, shining ; the flagellum inclining to fuscous ; the apex of coxæ, trochanters, femora, tibiæ and tarsi, rufous ; the base of femora lined with black ; wings clear hyaline, pubescent, ciliated, the nervures clear testaceous. Antennæ nearly as long as the thorax and abdomen united, without a club ; the joints becoming very gradually and slightly thickened towards the apex ; the third joint a little longer than the fourth, which is of the same length as the fifth. Scutellar foveæ longer than broad, deep, truncated at base and apex ; the sides of scutellum punctured ; the cup depressed at the base ; and apex not projecting much, with a shallow fovea above. Metapleuræ densely covered with griseous hair. Abdomen a little longer than the thorax, compressed, lenticular ; the hair fringe dense, griseous. Radial cellule elongate ; the second abscissa curved, fully three-fourths of the length of the third, which is nearly straight ; cubitus not extending beyond the radial cellule.

Length 3 mm.

Comes nearest to *E. glottiana*, but stouter ; has the antennæ stouter, shorter, and quite black ; the scutellar foveæ are longer and separated by a stout keel ; the cup is somewhat more raised ; the apex of the scutellum, looked at laterally, projects more and is rounded, while in *glottiana* it is truncated. The wings, too, are clear hyaline.

Hab. Benfleet (*T. R. Billups*).

DIASTROPHUS (?) APHIDIVORUS, *sp. nov.*

Black ; the antennæ testaceous ; the legs rufo-testaceous ; the tips of the tarsi black ; wings almost hyaline, the nervures fuscous, thick. Antennæ stout, a little longer than the body, stout; the third joint attenuate, a little longer than the fourth. Head large, a little wider than the thorax; shining, impunctate. Prothorax large, finely rugose; semi-perpendicular in the middle. Mesonotum shining, obscurely striated at the base; the parapsidal furrows distinct at the base. Scutellum rugosely punctured, depressed in the centre; the basal foveæ large, wider than long, curved, united. Metapleuræ rugosely punctured. Abdomen shining, the second and third segments subequal, apical ventral segment bluntly plough-share-shaped, not projecting beyond the apex. Hind tibiæ curved, the metatarsus twice the length of the second joint; claws apparently simple, wings ample; the radial cellule open at base and apex and in front; narrow elongate; the third abscissa of the radius curved; cubitus nearly complete. ♂

Length nearly 1¾ mm.

On the whole, this species agrees fairly well with *Diastrophus*, and it is certainly distinct from either of the two described species, but these are true gall-makers, forming galls on *Rubus* and *Potentilla*, while the present species was bred from the aphis of the nettle, by the Rev. T. A. Marshall. The difference in habit probably indicates a generic difference, but in the absence of the ♀ one is hardly justified in forming a new genus for its reception. The simple claws, the confluent scutellar foveæ (which form a curved furrow), and the depression in the centre of the scutellum, are three points of distinction between it and *Diastrophus*.

Bred from the Nettle aphis by the Rev. T. A. Marshall at Barnstaple.

The following new species of *Eucoila* has been taken in Trinidad by the Rev. T. A. Marshall, M.A., F.L.S.

Eucoila rufiventris, *sp. nov.*

Black, shining, impunctate; the legs fulvous-red; the ventral surface of the abdomen rufous; wings almost hyaline; the nervures dark testaceous. Antennæ three-fourths of the length of the body, without a defined club, the joints becoming gradually thickened from the second joint to the apex; the third joint about one-fourth longer than the fourth; the fifth and sixth subequal; the other joints moniliform, longer than broad; the last conical at apex, one-half longer than the penultimate; the basal joints piceous on the lower side. Prothorax in the middle in front raised above the mesonotum, and clearly margined above and at the sides, the top being semi-circular; at the sides of the pronotum is a thick tuft of white hair. Scutellum large, the apex rugosely punctured; the cup large, oval, its apex projecting, and with a shallow transverse, oval fovea; the basal foveæ large, deep, wider than long, distinctly separated; there is a well marked transverse furrow in front of them. Metanotum excavated deeply in the centre, without keels, the apex punctured; the metapleuræ densely covered with white hair. Abdomen a little longer than the thorax, compressed; the hair fringe gray, narrow, distinct; the apex and ventral surface widely rufous. Radial cellule elongate, twice longer than wide; completely closed; the second abscissa of radius distinctly curved, three-fourths of the length of the third, which is only slightly curved at the apex; the cubitus complete.

The ♂ has the antennæ somewhat more than twice the length of the body; the third joint curved and a little longer than the fourth.

This is a true *Eucoila*, intermediate as regards most structural points between *Eucoila* and *Psichacra*, Foerster.

Length ♂ 2, ♀ nearly 3 mm.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, December 17th, 1888.

Mr. J. COSMO MELVILL, M.A., President of the Section, in the Chair.

Dr. ALEX. HODGKINSON exhibited under the microscope, crystals of chlorate of potash, showing iridescent colours, and explained the cause of these colours.

Mr. STIRRUP exhibited a fruit of a silver fir, *Abies Douglasii*, from Sir U. Kay Shuttleworth's estate in North Lancashire.

Mr. P. CAMERON made a communication on *Pyrethrum*, and its use as an insecticide; describing its cultivation in California, and its manner of use in America.

Ordinary Meeting, December 27th, 1888.

Dr. JAMES BOTTOMLEY, B.A., F.C.S., in the Chair.

The following communication from Mr. JAMES NASMYTH, F.R.A.S., &c., was read :—

"HAMMERFIELD, PENSHURST, KENT,
"*December 21st, 1888.*

"DEAR SIR,

"Under the impression that the accompanying photograph, taken from my original drawing of a group of sun-spots may interest the members of the Manchester Philosophical Society, I have much pleasure in sending it for their acceptance.

"The remarkable objects seen in the photograph which form the light-giving constituents of the solar surface, were discovered by me on June 5th, 1864, when the condition of our atmosphere happened to be in a most favourable condition for my observation of such comparatively minute details of the sun's surface.

"My discovery of them has been amply verified by Sir George Airey, the then Astronomer Royal, as also by Mr. Stone, Chief Assistant at the Royal Observatory, Greenwich, and by Mr. Warren de la Rue, and others.

"Believe me, I am,
"Yours very respectfully,
"JAMES NASMYTH.

"*To the Secretary of the*
"*Manchester Philosophical Society.*"

Dr. BOTTOMLEY introduced the subject of the death-rate and recent correspondence in the local newspapers on smoke abatement. In the discussion which ensued it was suggested that if the adoption of smoke-consuming furnaces were to be accompanied by the abolition of tall chimneys, the advantages of diminished smoke might possibly be off-set by the invisible deleterious gases being concentrated in the lower part of the atmosphere, instead of being diffused at an altitude where they would be unlikely to be injurious. Mr. R. F. Gwyther raised the question whether a smoke-less fire might not give off carbon monoxide, and asked how this gas would be eliminated from the atmosphere. Mr. John Angell argued that the apparently perfect combustion in well-arranged smokeless furnaces implied the absence of the monoxide from the products, but admitted that in the case of smokeless house fires or stoves the danger alluded to by Mr. Gwyther might exist.

General Meeting, January 8th, 1889.

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

Mr. T. W. BROWNELL, of Manchester; Mr. CHARLES JAMES HEYWOOD, of Pendleton; and Mr. JAMES RAIT BEARD, of Longsight, were elected ordinary members.

Ordinary Meeting, January 8th, 1889.

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

The President mentioned that he had found by a calculation that the quantity of water passed per hour through the condensers of the steamship "City of New York," with 18,000 horse-power, equalled the average consumption of water per hour in Manchester.

Mr. F. J. FARADAY, F.L.S., communicated a paper by M. C. Tondini de Quarenghi, of the Bologna Academy of Sciences, on "The unification of the measure of time, with special reference to the contest on the initial meridian."

On the unification in the measure of time, with special reference to the contest on the initial meridian. By C. Tondini de Quarenghi. Communicated by F. J. Faraday, F.L.S.

(Received December 27th, 1888.)

I.

As early as the year 1862, the International Statistical Congress held at Berlin, impressed by the many inconveniences and delays resulting from the simultaneous existence of different calendars, approached the Imperial Government of Russia with the following representations :—

"The International Statistical Congress professing that "the principal object of its meeting is the improvement of "statistical publications undertaken by the several States, as "well as the unification of the same, in order that their "results may be actually compared ;

"Considering that uniformity and unification in the "measure of time is a desideratum of the highest importance "for many weighty points of science, such, for instance, as "the assessment of births and deaths for every month of "the year ; meteorological observations ; the date of the "appearance of epidemics, and their exact duration ; many "and various medical observations, and the like ;

"Considering also that the importance of that measure "is equally evident for every kind of international relations; "for commerce and the several branches of industry ; for "railways, and the simplification of many computations ;

"Most respectfully expresses a wish that the Govern- "ment of His Majesty the Emperor of Russia, and, in "general, all Christians belonging to the Greek rite, may "adopt for the measuring of time the Calendar generally "used in Europe."*

If the writer is correctly informed, an Imperial decree had been actually drawn up ordering, in compliance with the request of the Berlin Statistical Congress, the general adoption of the Gregorian Calendar throughout the empire, but other considerations prevailed. It is only just, however, to observe that, in 1862, the year of the emancipation of the serfs, the attention of Russia was diverted by more urgent reforms, which that of the Calendar might possibly have endangered.

II.

On January 26, 1888, the Royal "Instituto lombardo di Science e Lettere" of Milan, received a communication "On the advantages and possibility of the general adoption of the Gregorian Calendar," and appointed a special committee to report on the same.†

In March of the same year the Paris Academy of Sciences allowed a Note "On the Unification of the Calendar" to be read, appointed a committee to study the question, and published the note in the *Comptes-rendus*.‡ Subsequently several other communications, bearing on the same subject, were brought before the French Academy.

The Paris Geographical Society, besides receiving at their meeting of April 6th a first communication: "On the general adoption of the Gregorian Calendar in its relation to the universal hour" and, on March 18th, in the presence of General Tcheng-ki-tong, the Chinese envoy in Paris, a second paper: "On the Chinese Calendar, à propos of the Unification of the Calendar," which were printed,

* See the original French text of this important document in the *Comptes-rendus des séances de l'Académie des Sciences de Paris*, 19 March, 1888, p. 813.

† *Rendiconti del R. Instituto lombardo*, Serie II., Vol. XXI., fasc. II.

‡ Séance du 19 mars, 1888. T. CVI. No. 12, p. 813.

together with the General's Reply, in their *Comptes-rendus** went so far as to call by a special circular letter, dated June 2nd, 1888, the attention of all other geographical societies to the above communications, expressing the wish that they would support the unification of the calendar, "as a useful simplification, a real advance, both from a practical and a scientific point of view, and a step towards the desired general adoption of one initial meridian and the same unit of time." As far back as the beginning of April, 1888, this same Society, by a special letter, congratulated the Bologna Academy of Sciences, on their intention to profit by the festival of the eighth centenary of the Bologna University, to give a strong impulse to the unification of time and promised them: "tout le concours des moyens dont elle dispose."

An analogous step was taken by the Royal Academy of Belgium, as may be seen in the report of M. Folie, the Director of the Brussels Observatory, headed: "On the unification of the Calendar, proposed by the Royal Academy of Sciences of the Institute of Bologna," inserted in the Belgian Academy's *Bulletin*. Speaking of Russia, "There "is a nation," says the Belgian Astronomer Royal, "whose "assent in the matter would constitute the most valuable "scientific gift made, in our century, to science."†

Coming back to the Bologna Academy of Science, as early as February 19, 1888, a special committee was appointed to consider how the approaching festival of the University jubilee might be turned to the advantage of science. Professor Santagata's report was, on April 15th, unanimously approved, and a special memorandum bearing the title "Unification du Calendrier," was consequently

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* *Comptes-rendus des Séances de la Société de Géographie*, 1888, pp. 218 and 307.

† *Bulletin de l'Académie royale de Belgique*, 3me série, T. XVI. No. 7, 1888.

printed and addressed "Aux savants réunis à Bologne pour la commémoration du huitième centenaire de son Université." A little later the same Academy addressed to all Universities and scientific bodies which had been represented at the festival of the centenary a note, dated August 2, on the progress of the question in its relation to the universal hour,* and as soon as their attention was called to the impending Bath meeting of the British Association for the Advancement of Science, I was requested to profit by the international character of that meeting, and, as the Academy's delegate, to do all I could "to give a strong impulse to the studies connected with the unification of the Calendar."

III.

The Bologna Academy of Science, fully aware that the first condition of success is to propose to one's self things reasonable, has declared that the desired unification of the Calendar ought to be urged "within wise limits." "This Academy," they say, "beg to remark that the Universal "Calendar, *being merely intended to serve international "relations and scientific purposes,* will no more impede "the maintenance and use of national calendars, with their "own particular divisions, than the universal hour will be "likely to impede the maintenance and use of the local "hours. The abolition of the national calendars, provided "they be correct, is by no means aimed at by our Academy, "and the very circumstance of the festival in celebration of "the eighth jubilee of our University witnesses to our "respect for, and profound attachment to, the traditions of "the past. Simplification is not levelling, and it would "indeed be a poor service rendered to science to deprive "people of the means of understanding their past history. "The very fact, moreover, that all Christian countries employ

* *Sur les derniers progrès de la question de l'unification du Calendrier, dans ses rapports avec l'heure universelle.* Bologne, Gamberini, 1888.

"two calendars, the one solar for civil usages and the other "lunar for determining the epoch of movable feasts as well as "of many national feasts and customs, is a sufficient caution "against unfounded or purposely excited alarms. As long "as there shall be on earth Israelites, tracing the origin of "their rites to Moses and Sinai, the Israelite calendar will "not cease to exist; as long as there shall be Christians "considering the Synagogue as an image and preparation of "the Church, and anxious to keep, in the distribution of their "solemnities, the order of those of the ancient law, the lunar "calendar of the Jews will always be used. Let the same "be said of the religious and national feasts of Musselmans, "Chinese, and other people, distributed according to lunar "calendars. Experience alone will by and by lead them to "consider in what measure it would be for them more "advantageous to adopt for civil usages the universal "calendar. But before deciding on this point they must "be led to feel its necessity or, at least, become aware of "its utility, and this of course depends on local circum- "stances and concerns every State in particular. No "reflecting man will ever expect from a Chinese labourer "who, living in the interior of the Empire, does not come "into contact with foreigners, and who also feels thoroughly "satisfied with the national civilisation, that with regard to "the unification of time he should partake of the ideas of an American or an Englishman."*

IV.

The wisest course to be taken for hastening the said unification is to support the general existing movement in favour of the so-called "universal hour" or "universal day." A Calendar equally universal will come as the necessary result of the adoption of a universal unit of time.

"The Fifth Resolution of the Washington International

* Unification du Calendrier.—pp. 14–15.

"Conference of 1884,"—thus again the Bologna Academy of Sciences—"proposes as 'universal day' the mean solar "day, submultiple of our solar year. But neither in the "notation of dates, nor in international relations, nor in the "determination of the moment of scientific phenomena, can "that 'universal day' be isolated from a month and a year "perfectly designated. We are consequently and forcibly "in presence of the question whether, in order to indicate "that month and that year, a new chronology and a new "calendar should be created, or we should resort to a "chronology and a Calendar already in use. No one, we "believe, will seriously think of creating anything new: the "least inconvenience of such a scheme would be, if not "entirely to break with the past, to augment, without any "advantage, the difficulty of recurring to it. Far from "hailing such a creation of a new calendar as an advantage "for science, we should consider it as disastrous. Now, the "choice among the existing calendars cannot be doubtful. "Hence, the Bologna Academy of Sciences do not hesitate "to express their conviction that, everything taken into "account, and considering the advantage not merely of one "particular science only, but of the whole *humanum scibile*, "the frank and entire adoption of the Gregorian Calendar "is the measure which would best serve the interests both "of science and humanity. A more regular division of the "number of days for every month should be, at any rate, "the *maximum* reform applied to our Calendar."*

The same opinion is expressed as the result of a critical examination of our Calendar by Prof. Förster, the Superintendent of the Berlin Observatory, with the only additional remark—which, of course, is already admitted by the Bologna Academy of Sciences—that the intercalary day of every leap year, should be assigned to the month of December, and Dr. Förster seems also inclined to recommend

* Sur les derniers progrès, etc.—p. 11-12.

what he calls "this last desirable simplification of our way of measuring time" as a "compensation (Gegengabe)," offered to the members of the Greek Church for their giving up their special calendar, and thus entering into a complete agreement with the civilised world in their way of dating time.* Alluding, moreover, to the many projects for a more perfect way of intercalation, Prof. Förster makes the following truly scientific remark :—"The agreement of the Gregorian year with the course of the sun is now sufficient, and secured for a length of time beyond which our present knowledge of the constant alterations in the duration of the solar year is not able to reach." In other words: it would be unscientific, as well as unwise, to make provisions to secure the above agreement for a time before the coming of which we may be obliged to alter our intercalary arrangement again.

It is indeed satisfactory to have to announce such a perfect agreement between the representatives of science in different countries†, and to make it, as it were, even more satisfactory, owing to the special importance of the question. Prof. Förster, speaking in another pamphlet, of the "universal day," besides assuming as needing no proof, that it will be dated according to the Gregorian Calendar, remarks, by the way, that "Russia will thus gain the advantage of having her Julian date absorbed (*absorbirt*) by the Gregorian one."‡

V.

That Russia had a prominent part in stirring up the

* FÖRSTER (Wilh.). *Zur Beurtheilung einiger Zeitfragen, insbesondere gegen die Einführung einer deutschen Normalzeit.* Inserted in the *Deutsche Revue* of 1881, Berlin. I. Band, p. 365.

† See also: *Bulletin of the Philosophical Society of Washington;* Meeting of January 30, 1875, Vol. II., pp. 29, 30. *Boletin de la Sociedad de geografia estadistica de la Republica Mexicana. Teriera epocha,* Febrero 28, 1873. T.I. p. 143, *etc., etc.*

‡ FÖRSTER (Wilh.). *Ortzeit und Weltzeit,* Berlin, 1884, p. 20.

question of the universal hour, is a well-known fact; and no Power gave more support to Mr. Sandford Fleming's initiative, through the Canadian Institute, than Russia herself. As far back as February 4th, 1870, Dr. Struve read before the Imperial Geographical Society of St. Petersburg a most important paper concerning the initial meridian,* and his verdict was so authoritative that Prof. Förster and other scientific authorities referred to it as settling the question. Unfortunately the International Geographical Congress of Venice (1881), the International Geodetic Association of Rome (1883), and, finally, the International Meridian Conference, held at Washington in October, 1884, proved equally fruitless, chiefly for want of agreement on the initial meridian.

That things are now no more advanced than before the Geographical Congress of Venice, is demonstrated by the message of the late President of the United States to the Congress, dated January 9, 1888, recommending the Government "to take action to *approve* the resolutions passed in 1884, and to invite the Powers to accede to the same." These resolutions are consequently not approved yet, not even by the Washington Government, nor have the other Powers acceded yet to them. Moreover, the delegates of the different Powers represented at Washington declared from the very beginning that their presence there was only *ad referendum*, and could not in any way bind their respective Governments. What *these*, consequently, really think on the subject of the initial meridian is unknown, and they are, at any rate, still at liberty to give or refuse their adhesion to the Greenwich meridian. Other Governments not represented at Washington, say China, Montenegro, Servia, or Roumania, may claim a right to

* STRUVE (Dr. Otto) *O pervom meridiane* in the *Geographicheskia Investia, etc.*, No. 1, March 15, 1870, pp. 1 and foll.

give advice which may equally result either in diminishing or increasing the opposition to Greenwich.*

It is alleged that the Greenwich meridian is now used almost everywhere even for geographical purposes, and that, consequently, the best course to be taken is to let things go their own way, until France, who opposed the adoption of the Greenwich meridian, be morally compelled in the interest both of science and humanity to give in. As for the assertion that the Greenwich meridian is now used almost everywhere, *even for geographical purposes*, it should be carefully verified. At any rate exceptions are to be found almost everywhere. This said, I venture to advance that, paradoxical as it may appear, no Power is more anxious that, with regard to the international initial meridians now in use, no change be made, and that things should be allowed to "go their own way" than France herself. What is in fact, now-a-days, the general practice concerning international meridians? That every nation is at liberty to choose for their marine the meridian they like best, and to make use either of the *Nautical Almanac* or of the *Connaissance des Temps*, or of any other ephemerides, just as they choose. Now, what was the respective attitude of France, on the one side, and of the Powers dissenting from her on the other, at the Washington Conference? While France advocated for navigation and astronomy the maintenance of the *status quo*, urging the application of a neutral international meridian to matters to which an international meridian had not been applied yet, the Powers advocated the exclusive use for the marine of all nations, of the Greenwich meridian and the *Nautical Almanac* of Greenwich. On which side was the proposal of a change?

* The following are the names of the twenty-six States represented at Washington in 1884: Austria-Hungary, Brazil, Chili, Columbia, Costa Rica, Denmark, France, Germany, Great Britain, Guatemala, Hawaïs, Italy, Japan, Liberia, Mexico, Netherlands, Paraguay, Russia, San Domingo, Salvador, Spain, Sweden, Switzerland, Turkey, United States, Venezuela.

Consult the proceedings of the Washington Conference,* and the official Report on the same by Dr. Janssen, the President for 1888 of the Paris Academy of Sciences.†

It is customary to attribute the failure of the Conference to a wounded national susceptibility of France. That France had, after all, *some* reason for feeling wounded, is the impression which one cannot help having when carefully perusing the above documents; yet the evidence of facts goes to prove that the failure was not due to this, but to a motive of a purely scientific nature and preceding in point of time the debates of the Washington Conference.

In August, 1884, consequently two months *before* the Conference, the French Minister of Public Instruction appointed a special committee composed of standard representatives of science and men having a special competence to give advice on the practical side of the question, charging them carefully to consider the proposals which were to be brought before the Conference. The conclusions of the committee are given in a remarkable report by M. Caspari, one of its members:‡ "For navigation the question is "extremely simple; it does not find the least inconvenience "in the *statu quo*; it would find very great inconveniences "in its modification. . . . We may say in conclusion that,

* *House of Representatives. Executive Document*, No. 14; Forty-eighth Congress, Second Session, December 4th, 1884.

† *Comptes-rendus hebdomadaires des Séances de l'Académie de France.* 9 Mars, 1885, pp. 706—726.

‡ Here are the names of the members of that Committee: MM. Faye, *President*, d'Abbadie, Bouquet de la Grye, Senator Dupuy de Lôme, Janssen, Vice-Admiral Jurien de la Gravière, Ferd. de Lesseps, Liewy, Contre-Admiral Mouchez, Perrier, Vice-Admiral Pâris, Tisserand, Wolff, all members of the Institute of France. Moreover: MM. Blavier, director of the Superior Telegraph School; Cäel, director ingénieur of telegraphs; Caspari, hydrographer ingénieur of the marine; Charmes, director of the Secretaryship at the Ministry of Public Instruction; de Chancourtois, General Mines Inspector; Clavery, minister plenipotentiary director at the Ministry of Foreign Affairs; Colonel Goulier, of the French *Génie*; Colonel Laussedat, of the French *Génie*, and director of the *Conservatoire des arts et métiers*; Noblemaire, director of the Railway Paris-Lyon-Méditerranée.

"generally speaking, the unique initial meridian is rejected "by astronomers, geodetists, and navigators; that is by all "those for whom the origin of longitudes ought to be traced "with a great precision." On the other hand, "For general "geographical cartography, especially for usage in the schools ". . . for meteorology, physics, geology, and the telegraph "service (provided it be without prejudice to the local hour) "there are only advantages in trying to have a common "initial meridian. . . . France, who in many respects has "already opened the way to such international agreements, "cannot stand aloof in the present case; she can and must "give her support to reforms wisely directed."*

In compliance with the instructions of the Committee, and acting, moreover, on his own scientific convictions, Dr. Janssen, the delegate of France at Washington, did all he could to obtain that the Conference would previously discuss the above important distinction. "Whilst there is advan-"tage," he said, "in increasing the number of Observatory "meridians, it is necessary to reduce as far as possible the "origines of geographical longitudes.† Now it is evident

* The original French runs as follows:—"Pour la marine la question est des plus simples; elle ne trouve pas le moindre inconvenient au *statu quo*, elle en verrait de très-graves à le changer. . . . Nous pourrons dire que, d'une façon générale, le méridien initial unique est repoussé par les astronomes, les géodésiens et les navigateurs, c'est-à-dire, par tous ceux pour qui l'origine des longitudes a besoin d'être définie avec une grande précision. . . .

"Pour la cartographie géographique générale, et surtout pour l'enseignement, il n'y aura que des avantages à tendre vers un méridien initial commun. . . Nous avons fait valoir plus haut ces considérations ainsi que celles relatives à l'heure universelle pour les météorologistes, les physiciens et les géologues. Pour le service télégraphique aussi, s'il est bien entendu que l'heure locale sera conservée et si l'on obtient la transmission d'office de l'heure universelle sans préjudice de l'heure locale. . . La France qui, à bien des égards, a ouvert la voie à ces ententes internationales, ne peut donc se désintéresser dans le cas présent; elle peut et doit prêter son concours à des réformes sagement conduites."—(*Rapport fait au nom de la Commission de l'unification des longitudes et des heures*, par M. CASPARI, ingénieur hydrographe de la marine. Août 1884, pp. 5, 6 et 17.)

† Quoted in the above report on the Washington Conference, l. c. p. 712. "Tandis qu'il y a intérêt à multiplier les méridiens d'Observatoires, il y a nécessité de réduire, autant qu'on le peut, les origines des longitudes en géographie."

that Dr. Janssen went to the very root of the question at issue, and that a statement like his raised a doubt which ought previously to have been dissipated by a fair discussion. Instead of this, the choice of Greenwich, for all international purposes, was carried, as it were, by acclamation. Moreover, whilst Sir G. B. Airy, late Astronomer Royal of Greenwich, in a letter dated June 18, 1879, to the Secretary of State for the Colonies, said: "Nearly all navigation is based on the *Nautical Almanac*, which is based on Greenwich observations and refer to Greenwich meridian. . . . . I, as Superintendent of the Greenwich Observatory, entirely repudiate the idea of founding any claim on this"; and whilst, as it was also acknowledged during the Conference, "a law relative to the unification of time notation is of less relative importance to the navigator,"* the preference given at Washington to Greenwich was almost entirely based on the argument disclaimed by Sir G. B. Airy. It is not to be wondered at, after all this, if Dr. Janssen, consistent with his scientific convictions, wrote in the above Report: "The failure is not for France but for science," and "The proposal of France (of a neutral international meridian except for astronomy and navigation) still represents the impartial, *scientific*, and definitive solution of the question, and we think it honourable for our country to have defended that cause."†

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* These are the very words of Dr. Struve, in his Report on the Washington Conference. It is to be found, together with the letter of Sir G. B. Airy, a great amount of useful information and most valuable documents on the question in Mr. SANDFORD FLEMING'S (C.E., C.M.G.), *Universal or Cosmic Time. Proceedings of the Canadian Institute*, Toronto, July, 1885, Vol. XXI., No. 143.

† "Si notre avis, tout *scientifique* et désintéressé, n'a pas rallié la majorité, l'échec n'est pas pour la France, il est pour la science," l. c. p. 724.

"Le méridien proposé par la France reste toujours comme représentant la solution impartiale, *scientifique*, définitive de la question. Nous pensons qu'il y a honneur pour notre pays d'avoir défendu cette cause," p. 715.

VII.

On both sides, then, an appeal is made to science. Now, the well-known Italian writer, Alessandro Manzoni, remarks somewhere, in his *Promessi sposi*, that when, in a contest, each party is only repeating its own argument, the contest is likely to go on for a long series of generations. To prevent this being the case with the initial meridian, the Bologna Academy of Science has recently made an attempt to conciliate every interest. At the last meeting of the British Association, held at Bath, I made, as delegate, and in the name of that academy, the following suggestion :—

"That *navigators and astronomers being at liberty to go* "*on using their own initial meridians*, another truly "international meridian be chosen for all other "purposes for which the unification of time is "required.

"That, moreover, since the Jerusalem meridian has "already the suffrages of scientific authorities, its "appropriateness to serve as the universal initial "meridian be seriously taken into consideration."*

This suggestion I was most kindly allowed to defend before the committee of Section A (Mathematical and Physical Science), and I am only too happy to express my thanks for the way in which I was listened to and the encouragements I there received in my endeavour, not indeed to have the proposals carried through by all means, but merely to have them carefully considered. A special committee was appointed to report on them.

It is hardly necessary for me to remark that, had there been any serious probability at hand that the Greenwich

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* This suggestion was already to be found in the above-quoted Note of the Bologna Academy of Science. "*Sur les derniers progrès de la question de l'unification du Calendrier dans ses rapports avec l'heure universelle,*" dated August 2, 1888. pp. 12—14.

meridian might be universally adopted, the Bologna Academy of Science would never have thought of making the proposals, nor would I have accepted a mission, which, owing to the unavoidable misrepresentations usual in matters of that kind, makes me appear as advocating, "the *suppression* of the Greenwich meridian!" More than enough, and I speak by experience, to make me regarded in England as a kind of *bête noire.*

As regards the choice of Jerusalem, "where every form of religion, every nationality of East and West is represented at one time,"* the Ottoman Government, which has been already applied to, has shown the most favourable disposition.† Moreover, the Jerusalem antimeridian would cross the land of Alaska, where the change of date was already in use,‡ whilst should, as it was suggested, the meridian of Behring Straits have the preference, the interests of science, requiring a series of Observatories of various kinds and at different latitudes along the initial meridian, would cause the Behring one to be, practically, but a fiction, and the real initial meridian to be its antimeridian. Now the Behring antimeridian would constitute a German, Hamburg or Halle, initial meridian—a circumstance deserving consideration. Let it also be observed, by the way, that the present Jewish Calendar, reformed in the ivth century by Rabbi Hillel Hanassi, is based on the Jerusalem meridian.§

* CONDER (Claude Reignier, lieutenant), R.E. *Tent work in Palestine.* London, 1885, p. 162.

† See in the *Nouvelle Revue* of November 15, the report of COUMBARY EFFENDI, Director of the Meteorological Observatory at Constantinople, p. 440: *La Turquie, le Calendrier universel, et le méridien initial.*

‡ See *Bulletin of the Washington Philosophical Society*, Jan. 30, 1875, p. 38.

§ See, on the present Jewish Calendar, IDELER (Ludwig) *Handbuch der mathematischen und technischen Chronologie,* 2nd edit., Breslau, 1883, and MAHMOUD, *sur les Calendriers judaïque et musulman*, in the *Mémoires des savants étrangers, couronnés par l'Académie royale de Belgique.* T. XXVI. and XXVII.

The longitude of Jerusalem was first taken by Niebuhr, then by Seetzen* and Vignes.† Lieutenant Conder, well known for his survey of Palestine, says. in the *Encyclopædia Britannica* :‡ "The geographical situation of Jerusalem has now been determined by trigonometry to be 31° 46′ 45″ N., and 35° 13′ 25″ E. long. of Greenwich, taken at the dome of the Holy Sepulchre church." Now, that of the French *Connaissance des Temps* is 32° 52′ 51″ E. Paris, which would make 35° 13′ 7″ E. Greenwich. The difference is too great to be overlooked, and it would be important to ascertain whence it comes.

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* See ZACH (Baron von) *Monatliche Correspondenz* XVIII. Gotha, 1808, p. 537.

† See *Connaissance des Temps*, 1868. Additions, p. 130. *Sur la table des positions géographiques*, par M. Darondeau.

‡ *Encyclopædia Britannica*. T. XIII., p. 636. Art. *Jerusalem*.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, January 14th, 1889.

Mr. CHARLES BAILEY, F.L.S., Vice-President of the Section, in the Chair.

Mr. C. J. HEYWOOD was elected a member of the Section.

Mr. GEORGE NASH SKIPP was elected an Associate of the Section.

Mr. H. HYDE exhibited specimens of wood and stone, perforated by *Pholas*.

Mr. F. NICHOLSON exhibited Pallas' Sand Grouse, both sexes, and made a communication on its recent appearance in England.

Mr. H. C. CHADWICK showed a specimen of a rare star-fish, *Goniaster phrygianus*, taken by a North Sea trawler.

Mr. P. CAMERON read a paper entitled "Hymenoptera orientalis, or contributions to a knowledge of the hymenopterous fauna of the Oriental zoological region."

General Meeting, January 22nd, 1889.

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

Dr. GEORGE BOWMAN, of Old Trafford, was elected an ordinary member.

Ordinary Meeting, January 22nd, 1889.

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

Mr. W. H. JOHNSON called attention to the fact that commercial copper is now apparently being produced of greater purity than laboratory "pure" copper, and a discussion ensued.

Mr. P. CAMERON read a paper entitled "*Hymenoptera Orientalis*, or contributions to a knowledge of the hymenopterous fauna of the Oriental zoological region."

During the discussion which followed, Mr. CHARLES BAILEY commented on the fact that the number of entomologists has steadily decreased all over the world, there being now very few left; a circumstance, Mr. Bailey pointed out, which is the more surprising as no department of natural history, not even botany, offers so wide a field of research and so rich a reward in the discovery of new facts.

Hymenoptera Orientalis; or Contributions to a knowledge of the Hymenoptera of the Oriental Zoological Region. By P. Cameron. Communicated by John Boyd, Esq.

(*Received March 11th, 1889.*)

PART I.

INTRODUCTION.

Notwithstanding the large number of our countrymen who reside in our East Indian possessions, our knowledge of their insect fauna, even of the Hindostan peninsula, is exceedingly meagre and fragmentary. A good beginning has been made towards the study of the Lepidoptera, but the same can hardly be said of the other orders. As regards the Hymenoptera, excellent work has been done by our distinguished countryman, Mr. A. R. Wallace, more particularly in the Islands; and his labours have been recorded in numerous papers by my late friend, Mr. Frederick Smith, of the British Museum. But, with all that, very much remains to be done before our knowledge of the Oriental Hymenoptera can be fairly stated to be at all adequate. The fact that less than 2,000 species have been recorded from the Oriental region is sufficient evidence of the truth of this statement; and of the need of the attention of Indian residents being directed to such a promising field of entomological study.

My own attention was drawn to the inquiry by Mr. G. A. James Rothney offering to place at my disposal for study the beautiful and extensive collection formed by him during many years' residence in India, chiefly in the Calcutta district. This valuable source of information has been supplemented by Mr. E. C. Cotes, lending me the material in the Calcutta Museum ; by a large collection belonging to the Bombay Natural Society, formed by Mr. R. C. Wroughton, District Forest Officer at Poona; and by various small collections, including a small, but very interesting one, made by Mr. George Lewis, in Ceylon.

In order to make this paper as useful as possible, more particularly to Indian residents, I have given :—

(1) A catalogue of all the known species, with their localities, synonyms, habits, &c.

(2) Descriptions of rare or imperfectly known species.

(3) Descriptions of the new species.

(4) A list of all the works and papers relating to the Oriental Hymenoptera, and

(5) Observations on their geographical relations.

Mr. Rothney's collecting was chiefly in the Calcutta district, namely, in the neighbourhood of the City; in Barrackpore, Sittaghui, Samnugga, Ishapue, Serampue, Chandauague, Gusery; at Port Cauumy to the south, Burdwan to the north ; Nischindepue to the north-east. Also in Tirhoot, Bengal ; Mussourie, North-west Province (in September and October), in Allahabad, North-west Province; and a few species from Dargeeling, Madras, Bombay, and Ceylon.

Mr. Wroughton's collecting is principally from Poona (Dekhan) and Bombay.

SPHEGIDÆ.

AMMOPHILA.

Ammophila, Kirby, *Trans. Linn. Soc.* IV., p. 195.

Psammophila, Dahlbom, *Hym. Ent.* I., p. 16.

Parapsammophila, Taschenberg, *Zeits. f. d. ges. Naturw.* in Halle, XXXIV.

List of species of *Ammophila* known from the Oriental region.

(i.) *Petiole 2-jointed*:

1. ATRIPES, Smith, *Ann. and Mag., Nat. Hist.* IX., 1852, p. 46; *Cat. Hymen. Ins.*, IV., p. 217, 43.
   Hab. India. Common in Calcutta district (*Rothney*). Khandala (Smith), Sumatra, China, Shanghai.

2. BASALIS, Smith, *Cat. Hymen. Ins.* IV., 214, 37.
   Hab. North India, Punjaub.

3. BUDDHA, Cam., *infra.*
   Hab. Calcutta district, not uncommon.

4. DIMIDIATA, Smith, *l. c.* 216, 40.
   Hab. India (Bombay, Madras, N. Bengal).

5. ELEGANS, Smith, *l. c.* 216, 42.
   Hab. North India (Punjaub).

6. FUSCIPENNIS, Smith, *Trans. Linn. Soc. Zool.* VII., p. 187 (1870).
   Hab. Mainpuri, North-west Province.

7. HUMBERTIANA, Saussure, *Reise d. Novara, Hym.* 25.
   Hab. Ceylon.

8. LÆVIGATA, Smith, *l. c.* 215, 39, de Saussure, *Reise d. Novara, Hym.* 23.
   Hab. India (Madras, Guzerat), Barrackpore (*Rothney*), Ceylon (Cutchevilly).

9. LONGIVENTRIS, Saussure, *l. c.*
   Hab. Ceylon.

10. NIGRIPES, Smith, *l. c.* 215, 38.
    Hab. India (Madras), Barrackpore (*Rothney*).

11. PUNCTATA, Smith, 218, 46.
    Hab. Northern India.

12. ORIENTALIS, Cam., *infra.*
    Hab. Barrackpore, Allahabad (*Rothney*).

13. SMITHI (Baly), Smith, *l. c.* 217, 45.
Hab. India.

14. SUPERCILLIOSA, Saussure, *l. c.* 24.
Hab. Philippines (Manila).

15. TASCHENBERGI, Cam. *Ammophila erythropus*, Taschenberg, *Zeits. f. d. gesammte Naturw.* XXXIV. 434 (*non* Smith).
Hab. Java.

16. VAGABUNDA, Smith, *l. c.* p. 218, 47.
Hab. North China, North India, Sumatra.

17. VISCHU, Cam., *infra.*
Hab. Mussoorie Hills, North-west Province.

(ii.) *Petiole with one joint* (*Psammophila*).

18. HIRTICEPS, Cam., *infra.*
Hab. Gilgit (Mus. Calcutta).

(iii.) *Tarsal claws with two teeth at the base* (*Parapsammophila*).

19. VIOLACEIPENNIS, Cam., *infra.*
Hab. Sambhalpur, Poonah (*Wroughton*).

20. ERYTHROCEPHALA, Fabricius. *Sphex erythrocephala. Fab. Ent. Syst.* II., 204, 23.
Ammophila erythrocephala, St. Fargeau, *Hist. Nat. Ins. Hym.* III., 385, 26.
Hab. North India (Punjaub), Poona (*Wroughton*).

A. *Mesothorax transversely striolated.* (*Ammophila*, *sensu str.*)

AMMOPHILA BUDDHA, *sp. nov.*

Nigra, fusco hirta, petiolo, scapo, femoribus, tibiis tarsisque, rufis, abdomine cæruleo; alis flavo-hyalinis, apice fere fumatis, nervis testaceis. Long. 25 mm.

Antennæ short, thick; the second joint two-and-a-half times the length of the fourth. Head broad, retreating behind the eyes, which are large and almost parallel; covered with a short sparse white down, and sparsely with longish black hairs; front and vertex obliquely aciculated, the former only excavated immediately above the antennæ and without a longitudinal furrow; clypeus sparsely punctured; its apex almost transverse in the middle, the sides somewhat oblique; the centre slightly incised; mandibles obscure reddish towards the centre, the outer side broadly at the base striolated. Thorax covered with a fuscous pubescence; the tubercles and a spot on either side of the median segment silvery. Pro- and mesonotum strongly transversely striolated, the striolations rather widely separated; propleuræ obliquely striolated; meso- and metapleuræ longitudinally rugosely punctured; metanotum transversely rugosely punctured; scutellum longitudinally striolated; mesonotum with a shallow channel in the centre; metanotum not elevated in the centre; a shallow indistinct furrow below the spiracles. Petiole longish; the second joint usually blackish at the base. Coxæ covered with a dense moderately long silvery pile; the trochanters, tibiæ and tarsi, with a shorter and thinner one; hind coxæ coarsely punctured; tarsal spines black; fore calcaria red; hinder black, reddish at base; apex of tarsi black. Second cubital cellule at top a little wider or a little narrower than the space bounded by the recurrent nervures; third cubital cellule a little wider at top than at bottom, the second transverse cubital nervure bent outwardly at the bottom; tegulæ blackish to piceous.

A. humbertiana, Saus. from Java, seems to be the nearest ally of this species, but it has the metanotum "postice oblique in V-formam elevato-strigato," and the trochanters are not black. *A. basalis* is also nearly related to it, but is smaller (15-17 mm.), has the face silvery pilose, densely so on the clypeus; the head smooth, impunctate, wings hyaline, &c. Barrackpore; Allahabad, N. W. Province.

AMMOPHILA ORIENTALIS, *sp. nov.*

Nigra, argenteo hirta; femoribus, tibiis, tarsis, petiolo, abdominisque segmento 1° fere toto, rufis, alis hyalinis vel fusco-hyalinis, apice fumatis, costa testacea; nervis nigris; abdomine cæruleo. ♀. Long. 17—19 mm.

Similar to the preceding species, but smaller, with the pubescence shorter and sparser, and of a more silvery tint; the wings without such a decided yellowish tinge, and with the nervures blackish; the first abdominal segment is red, except at the apex, and the third antennal joint is shorter, not being twice the length of fourth. Mandibles broadly red at the base, which is striated; clypeus punctured, densely covered with a silvery pubescence; its apex with a broad shallow sinuation; front and vertex shagreened, sparsely and shortly pilose. Antennæ with the base of first joint testaceous, the flagellum covered with a pale pile. Pro- and mesonotum strongly transversely striolated; metanotum more closely and not so strongly; scutellum strongly longitudinally striolated; propleura perpendicularly striolated, meso- and metapleura obliquely rugosely striolated; the raised part of the metanotum shield-shaped. The tubercles and the sides of the middle segment densely silvery pilose. The second joint of the petiole is black above at the base; the apex has a silky pile; the hind coxæ are white with a dense silvery white pubescence; the trochanters are red, blackish towards the base and apex, the anterior broadly black at the base; the tips of four anterior tarsi and the posterior from the base of the second joint blackish; spurs blackish. Alar cellules pretty much as in *A. buddha.* The ocelli do not form a triangle; the anterior not being placed very far in front of the posterior.

The clypeus and tegulæ in some specimens are testaceous; the apex of the second joint of the petiole may be black; the basal joint of the antennæ may be testaceous, and the middle joints may show a tendency towards fuscous coloration. In size there is some variation.

Ammophila nigripes, *Smith.*

A specimen from Barrackpore agrees with Smith's description so far as it goes. It is fully one line longer; the hair on the thorax is longish and tolerably thick; the clypeus is broadly transverse at the apex, the sides being angled; the mesonotum is furrowed in the centre; the legs are thickly pruinose; the second cubital cellule at the top is about one-fourth shorter than the third, and about equal in length to the space bounded by the second recurrent and second transverse cubital nervures; the third cubital cellule is almost equal in length at top and bottom, and the third transverse cubital nervure is sharply elbowed a little below the middle.

Ammophila atripes, *Smith.*

The Barrackpore specimens of this species, as named by Smith, are uniform in coloration—black, the second joint of petiole is red beneath, the first joint black, the other segments steel-blue; the wings more or less fuscous, the nervures black. Face and clypeus densely covered with silvery white pile; apex of clypeus transverse, the sides rounded; vertex and front with scattered punctures, shining. Pro- and mesonotum strongly transversely striolated; metanotum more closely and not so strongly; scutellum and post scutellum longitudinally striolated; pleuræ rugose. The pubescence on the thorax is short and cinereous; the abdomen is thickly pruinose. At the top the second cubital cellule is about one-half the length of the third, and a little more than the space bounded by the second recurrent and second transverse cubital nervures; the third cubital cellule is nearly equal in length at top and bottom; the third transverse cubital nervure is elbowed near the middle. The female agrees in coloration, punctuation, and clothing with the male.

Differs from *A. nigripes* in being longer, in having the hair on the thorax less dense and shorter, the clypeus more rounded at the apex, the mesonotum with the central furrow less distinct, the wings darker, and with black nervures.

Barrackpore—common.

B. *mesonotum punctured.*

AMMOPHILA VISCHU, *sp. nov.*

Nigra, nitida, punctata; apice petioli, abdominisque segmentis 1—2, rufis; alis fuscis. Long. 22—24 mm.

Antennæ stout, microscopically pilose. Face and clypeus covered with a silvery white pubescence; the front and vertex bear long fuscous hair. Clypeus broad, flat, the apex margined, truncated; sparsely punctured. Front depressed; a distinct furrow down the centre; rather strongly punctured; the vertex with the punctures more widely separated. Thorax strongly punctured, the pleuræ and metanotum rugose; scutellum with the punctures larger and closer than on the mesonotum; post-scutellum rugose. Mesonotum with a distinct furrow, which becomes wider towards the apex, where it is nearly filled up by a keel. The pubescence is long and cinereous, long and dense on the pleuræ; sparser above. The tubercles, an oblique stripe on the pleuræ and the middle segment laterally, densely covered with silvery pubescence. Second segment of petiole stout; the extreme base black. Second segment above wider than the space bounded by the first recurrent and first transverse cubital nervures; the third cellule much narrowed at the top, usually there not one-fourth of the length of the bottom. Tegulæ black.

The male has the clypeus produced and rounded at the apex, and is, as well as the face, densely covered with silvery pubescence.

A. punctata, Smith, is apparently closely allied to this species; but no mention is made of the mesonotum being furrowed, and the metanotum is said to have a longitudinal carina in the centre; the collar has "a minute tubercle in the middle," and the wings are hyaline.

Petiole composed of one joint (*Psammophila*).

AMMOPHILA HIRTICEPS, *sp. nov.*

Nigra; longe nigra hirta; abdominis segmentis 2—4 rufis; alis fere hyalinis, apice fumatis, nervis nigris. Long. fere 15 mm.

Antennæ stout; pilose; the third joint about one quarter longer than the fourth. Head hardly punctured; covered with long and black hair; the face and clypeus densely covered with silvery pubescence; apex of clypeus broadly rounded, almost sinuated in the middle; ocelli nearly in a triangle; the posterior separated from the eyes by about the length of the third antennal joint; front hardly depressed. Thorax somewhat punctured; the scutellum apparently indistinctly longitudinally striolated; metanotum obliquely striolated, furrowed down the centre, and with a keel in the centre of the furrow. The one-jointed petiole is a little longer than the second segment, and is covered with long black hair, the fifth segment is red at the base. Above the second and third cubital cellules are sub-equal, and the former above is about three-fourths of the space bounded by the recurrent nervures; the third cellule below is about half the length of the second, and is rounded at the apex below; the third transverse cubital nervure bulges outwardly on the lower half, then retreats towards the second cubital nervure, thus making the third cubital cellule wider below than above. Claws reddish.

Owing to the matting of the hair on the head and thorax, I am unable to make out the sculpture of these parts clearly. The species is a true *Psammophila*.

Ammophila erythrocephala, *Fab.*

This large and striking species is a *Parapsammophila.* The head is large; the eyes reach only exactly opposite the level of the hind ocelli, the vertex being much more developed behind them than usual; they are quite parallel, not converging at the bottom as in *A. violaceipennis*; the antennæ issue from nearly opposite their middle, and not so high up as in the latter species; the clypeus does not project in the middle, and is truncated at the apex. The mandibles are very large and projecting, almost as in *Ampulex.* The neuration of the wings is very much as in *Violaceipennis.* Antennæ black, pilose; the 3—4 basal joints red, the third is nearly twice the length of the fourth.

Ammophila violaceipennis, *sp. nov.*

Nigra; scapo antennarum, petiolo pedibusque, rufis; coxis apiceque tarsorum nigris, alis violaceis. ♂ Long. 29 mm.

Head shining, sparsely punctured; the clypeus and face covered with silvery pubescence; the front and vertex with longish, blackish hair; clypeus somewhat projecting; the apex with a distinct margin, a little sinuated; mandibles broadly red in the middle. The antennæ incline to fuscous beneath, especially at the base; the third joint is longer than the first and second joints united, and about one-fourth longer than the fourth. Thorax densely covered with blackish hair; coarsely punctured; the mesonotum rugosely striolated in the middle at the apex; scutellum coarsely rugosely striolated; metanotum coarsely rugosely punctured in the middle, at the sides obliquely striolated; the pleuræ coarsely rugosely striolated. Pygidium broadly rounded, pilose. Second and third cubital cellules above subequal; the transverse cubital cellules elbowed towards the middle, thus making the third cubital cellule wider in the middle than at top or bottom; the first recurrent nervure is received before the middle of the cellule; the second at nearly the length of the third cubital cellule at the bottom from the apex; at the top the second cubital cellule is as wide as the space bounded by the recurrent nervures.

This species belongs to *Parapsammophila*, Taschenberg, which is chiefly distinguished from *Ammophila* and *Psammophila* by the tarsal claws being bidentate at the base.

PELOPOEUS.

Pelopoeus, Latreille, *Hist. Nat. Ins.* XIII.
Chalybion, Dahlbom, *Hym. Ent.* I., p. 21.

Catalogue of the oriental species of *Pelopoeus*:—

1. P. BENIGNUS, Smith, *Proc. Linn. Soc.* II., 101, 1 *nec P. Javanus, l. c.* Vol. III., 15, note.
Hab. Borneo, Singapore, Java.

2. P. BENGALENSIS, Dahlbom, *Hym. Eur.* I., 433, 2.
Hab. India, Philippines, China, Mauritius.

3. P. BILINEATUS, Smith, *Ann. and Mag. Nat. Hist.* IX., 47 (1852).
Hab. Bombay.

4. P. COROMANDELICUS, St. Fargeau, *Nat. Hist. Ins. Hym.* III., 302, 2.
P. fuscus, St. Fargeau, *l. c.* 311, 9.
Hab. Coromandel, Bengal, Central India.

5. P. CURVATUS, Smith, *Trans. Linn. Soc. Zool.* VII., p. 187.
Hab. Mainpuri, North-west Provinces.

6. P. FERVENS, Smith, *Proc. Linn. Soc.* II., 101, 2.
Hab. Java, Borneo.

7. P. JAVANUS, St. Fargeau, *Nat. Hist. Ins. Hym.* III., 306, 9.
Hab. Java, Malacca.

8. P. MADRASPATANUS, Fabricius, *Syst. Piez.* 203, 3.
Hab. Bengal, Madras.

9. P. PICTUS, Smith, *Cat. Hym. Ins.* IV., 231, 22.
Hab. India.

10. P. SEPARATUS, Smith, *Ann. and Mag. Nat. Hist.* IX., 47 (1852).
Hab. Bombay.

11. P. SOLERI, St. Farg., *Nat. Hist. Ins. Hym.* III., 318, 18.
Hab. India, (Smith). St. Fargeau gives Guadeloupe as the Habitat of this species.

12. P. SPINOLÆ, St. Farg. *l. c.* 307, 4.
Hab. Bombay, Ceylon.

13. P. SUMATRANUS, Kohl, *Verh. z.-b. Ges., Wien* 1883, p. 375.
Hab. Sumatra.

14. VIOLACEUS, Fab., (*Sphex*) *Ent. Syst.* II., p. 201, 12; Lep., *Nat. Hist. Hym.* III., p. 321; André, *Species d. Hym.* III., p. 101.
Pepsis violaceo, Fab., *Syst. Piez.* p. 211, 16.
Chalybion violaceum, Dbm., *Hym. Ent.*, p. 432, 1.
Pelopoeus flebilis, Lep., *l. c.*, p. 321, 22.
Hab. Southern and Eastern Europe, "India," Java.

PÉLOPOEUS BENGALENSIS.

This is an external builder, erecting its nests on rough walls, or corners, on grass, or on leaves. When on a grass stem the mud is continued far up, thus breaking the outline of the cell, which is in consequence not so readily observed. A solitary cell may be built, or over a dozen may be placed side by side, the whole being then covered well over with mud. (Horne, *Trans. Linn. Soc.* VII. p. 163).

Pelopeous madraspatanus.

Of this abundant species (commonly called the mud-dauber) an interesting account is given by Horne (*Trans. Linn. Soc.* VII., p. 161—163). In May, June and July the females are found congregating by small puddles near wells, treading the mud into little pellets of about the size of buck-shot, which, when ready, are brought in the mouth of the insect to the place where the nest is to be constructed. This is in the most various situations. In window-sills, in hollows in walls, in locks, in any cavity between the wall and door-frame ; in a depression on the floor, anywhere, in fact, inside or near a house. Horne relates how one individual commenced to build in the corner of a door-frame, where it was crushed every time the door was opened. Six times did the industrious creature commence its habitation only to have it crushed every time. It takes about a day to complete a cell ; two, or three, or five are built together, the whole being then covered over with a smooth coating of mud, so that it looks like a dab of mud accidentally left on the wall. When the cell is finished it is filled with small spiders to the number of twenty. Spiders are the regular prey of the *Pelopoeus*, but Horne has also seen it store small green caterpillars.

In the pupa state it remains from one to six months according to the season.

Pelopeous bilineatus.

Unlike *P. Madraspatanus*, this form does not frequent houses, but builds on hedges and trees, a favourite position being a fork in the bough of *Lawsonia spinosa.* As a consequence of the more exposed situation chosen for its nests, these are much more solidly built.

Smith thinks that *P. bilineatus* is only a form of *Madraspatanus.*

PELOPOEUS JAVANUS.

Wallace states (*Jour. Linn. Soc. Zool.* XI., p. 296) that this species enters houses where it constructs small earthen cells, which it stores with paralysed spiders as food for its young. According to Maurice Maindron (*Ann. Soc. Ent. Fr.* 1878, p. 390) the largest nests are 7 centimetres long by 5 in breadth; contain five cells and are made of treaded mud, almost black in colour, but covered in parts by a layer of white earth. The largest and external cell is incomplete and is formed of a whiter earth than the others. In form the nests are irregular and arched; and Wallace (*l. c.*) mentions that they may be plastered over with mud in an irregular manner, so that the shape is completely hidden. The cocoon is $\frac{7}{10}$ of an inch in length, and of a delicate brown colour.

P. COROMANDELICUS.

This species has frequently the scutellum and metanotum without the reddish spot. The clypeus is reddish towards the apex, which is incised in the middle. The mesonotum is transversely striated; the scutellum finely longitudinally striated, but not nearly so strongly as the mesonotum; the pronotum is depressed in the middle; the second cubital cellule is not much narrowed above compared to the bottom, and is broad compared to the length; the first recurrent nervure is received a little before the middle.

SPHEX.

Sphex, Fabricius, *Ent. Syst.* II., p. 198.

Chlorion, Latreille, *Hist. Nat. Crust. et Ins.* IV., p. 57 (*partim*).

Pronæus, Latreille, *loc. cit.* IV., p. 56; Saunders, *Trans. Ent. Soc.* III., p. 58.

Priononyx, Dahlbom, *Hym. Ent.* I., p. 28.

Harpactopus, Smith, *Cat. Hym. Ins.* IV., p. 264.

I. *Tarsal claws with a single tooth near the middle.* = *Chlorion*, pt. Latr., *Hist. Nat. des Crust. et Ins.* III.; *Pronæus*, Saunders, *Trans. Ent. Soc.* III., p. 58 (1841).

1. Sphex chrysis.

Sphex cærulea, Christ, (*non* Drury) *Naturg. Ins.* p. 308, tab. 30, fig. 6.

Sphex chrysis, Christ, *l. c.*, p. 310, tab. 30, fig. 7; Kohl, *Termés. Füzetek.* IX., p. 173.

Chlorion lobatum, Fab., *Ent. Syst.* II., p. 206, 30; *Syst. Piez.*, p. 217, 1; Dahlbom, *Hym. Eur.* I., p. 24, 1; St. Fargeau, *Nat. Hist. Hym. Ins.* III., p. 330, 3; Smith, *Cat. Hym.* IV., p. 237.

Chlorion azureum, Lep. et Serv., *Encycl. Méth.* X., p. 451, 2; Lep., *Nat. Hist. Hym. Ins.* III., p. 329.

Common in India all over; also in Burmah, Singapore, Ceylon, China (Hong Kong) Penang and South Africa.

2. Sphex splendida.

Chlorion splendidum, Fabricius, *Syst. Piez.*, p. 218, 5; Smith, *Ann.* and *Mag. Nat. Hist.* VII., p. 32 (1851).

Sphex pulchra, Lep., *Nat. Hist. Hym. Ins.* III., p. 355.

Pronæus Campbelli, Saunders, *Trans. Ent. Soc.* III., p. 58, tab. 5, fig. 1.

Hab. North India, Burmah, Bombay (Mus. Calcutta), Poona (*Wroughton*).

3. Sphex Melanosoma.

Chlorion melanosoma, Smith, *Cat. Hym. Ins.* IV., p. 238; Magretti, *Bull. Ent. Ital.* XI., p. 578.

Hab. Pondicherry; Kassala (Magretti).

4. Sphex rugosa.

Chlorion rugosum, Smith, *Cat. Hym. Ins.* IV., p. 239.

Hab. Sumatra.

II. *Tarsal claws bidentate; second cubital cellule narrowed towards the radial, higher than long.—Harpactopus.*

5. SPHEX ÆGYPTIA.

Sphex ægyptia, Lep., *Nat. Hist. Ins. Hym.* III., p. 181; Kohl, *Termés. Füzetek* IX., p. 181; Taschenberg, *Zeits. f. d. ges. Naturw.* XXXIV., p. 412; André, *Species d. Hym.* III., p. 147.

Sphex soror, Dahlbom, *Hym. Ent.* I., p. 436.

Sphex grandis, Radosz., *Hor. Ent. Ross.* XII., p. 132, 2.

Harpactopus crudelis, Smith, *Cat. Hym. Ins.* IV., p. 264, i., pl. vi., fig. 4.

Hab. Eastern Europe, Syria, Egypt, Mauritius, Madras.

6. SPHEX NIVOSA.

Harpactopus nivosus, Smith, *Cat. Hym. Ins.* IV., p. 265, 4.

Hab. North India.

III. *Tarsal claws with three teeth—Enodia.*

7. SPHEX ALBISECTA.

Sphex albisecta, Lep., *Nat. Hist. Ins. Hym.* III., p. 358; Kohl, *Termés. Füzetek*, p. 185; André, *Species d. Hym.* III., p. 130; J. H. Fabre, *Souvenirs Entomologiques* (1879) p. 174.

Sphex albisecta, Lep. et Serv., *Encycl. Méth.* X., p. 462, 2.

Sphex trichargyra, Spinola, *Am. Soc. Ent. Fr.* VII., p. 466, 11.

Enodia albisecta, Dahlbom, *Hym. Ent.* I., p. 28 and 438; Costa, *Fauna Reg. Napoli* p. 12, Pl. 1, fig. 3.

Hab. South and Eastern Europe; Africa, from Algiers to the Cape. India.

8. SPHEX PUBESCENS.

Sphex fervens, Fab., *Syst. Ent.* I., p. 346 (*nec* Linné).

Pepsis pubescens, Fab., *Ent. Syst.* II., p. 205.

Enodia canescens, Dahlbom, *Hym. Ent.* IV., p. 28.

Enodia fervens, Dahlbom, *l. c.* p. 439.

Parasphex fervens, Smith, *Cat. Hym. Ins.* IV., p. 267.

Sphex pubescens, Kohl, *Termés.* p. 188; André, *Species d. Hym.* III., p. 130.

Hab. Eastern Europe, Algeria, Guinea, Sierra Leone, Gambia, Cape of Good Hope; India, Madras, Tirhoot (*Rothney*), and North Bengal; China.

IV. *Tarsal claws with two teeth.* (*Sphex sensu str.*).

9. SPHEX. APICALIS.

Sphex apicalis, Smith, *Cat. Hym. Ins.* IV., p. 253 (*non* Smith, *l. c.* p. 262).

Hab. Sumatra.

10. SPHEX ARGENTATA.

Sphex. argentifrons, Lep. *Nat. Hist. Ins. Hym.* III., p. 337; Kohl, *Termés Füzetek* IX., p. 196.

Sphex argentata, Fab. *Ent. Syst.* II., p. 196; Dahlbom, *Hym. Ent.* I., p. 25. André, *Species d. Hym.* III., p. 143; Smith, *Jour. Linn. Soc.* (1869), p. 361.

Sphex albifrons, Lep. *Nat. Hist. Ins. Hym.* III., p. 337, ♂.

Sphex metalica, Taschenberg, *Zeits. f. d. ges. Nat., Hallé.* XXXIV., p. 414.

Hab. Eastern Europe, North Africa, China, Japan, India (all over), Ceylon, Java, Amboina, Celebes, New Guinea, Aru, Ceram, Morty Island; Africa, from Egypt to Senegal, Sierra Leone, Angola, Gaboon, Guinea.

11. SPHEX AURIFRONS.

Sphex aurifrons, Smith, *Proc. Linn. Soc.* III., p. 1577, 3.

Hab. Java, Celebes, Aru, Africa.

12. SPHEX AURULENTA.

Sphex aurulenta, Fab., *Ent. Syst.*; Kohl, *Termés. Füzetek* IX., p. 194.

Pepsis sericea, Fab., *Syst. Piez.*, p 211.

Sphex sericea, Dahlbom, *Hym. Ent.* I., p. 26, 7; Lep., *Nat. Hist. d. Ins. Hym.* III., 341, 12.

Sphex fabrecii, Dahlbom, *l. c.* p. 27 and 438.

Sphex ferruginea, Lep., *Nat. Hist. Ins. Hym.* III., p. 345, 18.

Sphex lineola, Lep. *l. c.* p. 353, 27, ♂.

Sphex ferox, Smith, *Jour. Linn. Soc.* IV., p. 55.
Sphex Lepeletierii, Saussure, *Reise d. Novara, Hym.* p. 40, 8.
Sphex Godeffroyi, Saussure, *Stett. Ent. Zeit.* XXX., p. 57.
Hab. China, India, very common in Bengal (*Rothney*), Poona (*Wroughton*), Ceylon, Java, Borneo, Sumatra, Celebes, Amboina, Manilla, Malacca, Ternate, Waigion, Bachian, Ceram, Aru, Timor, Floris, Australia, Cape York.

13. Sphex erythropoda, Cam., *infra.*
Hab. India (*Mus. Cal.*).

14. Sphex flavo-vistata.
Sphex flavo-vistata, Smith, *Cat. Hym. Ins.* IV., p. 253, 56.
Hab. India.

15. Sphex nigripes.
Sphex nigripes, Smith, *Cat. Hym. Ins.* IV., p. 253, 56; Kohl. *Termés.* IX., p. 197, 32.
Hab. Hong Kong, Java, Kaschmir.

16. Sphex Rothneyi, Cam., *infra.*
Hab. Allahabad; Mussourie Hills.

17. Sphex rufipennis.
Sphex rufipennis, Fab., *Ent. Syst.* II., p. 201, 10; Kohl, *Termés Füzek.*, p. 198, 33; André, *Species d. Hym.* III., p. 149; Lep., *Nat. Hist. Ins. Hym.* III., p. 334, 1; Dahlbom, *Hym. Ent.* I., p. 436, 6; Taschenberg, *Zeits. f. d. g. Naturw., Halle*, XXXIV., p. 411.
Pepsis rufipennis, Fab., *Syst. Piez.*, p. 210, 12.
Sphex diabolicus, Smith, *Proc. Linn. Soc.* II., p. 100, 3.
Sphex fulvipennis, Mocsary, Magy. Ak. *Term. Értek.* XIII.
Hab. North Africa, India; not uncommon in Bengal.

18. Sphex vicina.
Sphex vicina, Lep., *Nat. Hist. Ins. Hym.* III., 343, 16.
Hab. India.

19. Sphex zanthoptera, Cam., *infra*.
Hab. Barrackpore, Mussourie Hills (*Rothney*).

Sphex splendida, Fab.

Rufa, abdomine negro-cœruleo ; alis flavo-hyalinis, apice fumatis, nervis rufo-testaceis. Long. 17 mm.

Scape of antennæ on lower side bearing short black, bristly hairs ; the second joint curved inwardly on the inner side ; the third thin, more than one-half longer than the fourth. Head almost shining, sparsely covered with black hairs ; the front and vertex closely punctured ; the face and clypeus more shining, imperceptibly punctured ; the labrum and clypeus fringed with short black hairs, the latter with two short stumpy teeth on either side of the middle ; a thin furrow runs down from the vertex to the ocelli ; the central part of the vertex slightly raised, but not forming a distinct field. Mandibles bearing long black hairs ; and some stout furrows towards the middle tooth ; the apex is black. Palpi reddish. Thorax shining, sparsely covered with short black hair ; the pronotum strongly striolated ; the top shining, impunctate, and with a wide and deep furrow in the centre. Mesonotum with scutellum very shining, almost glabrous, sparsely and minutely punctured. Median segment striolated, depressed in the centre and with a furrow along the sides above ; the apex rounded, semi-perpendicular, and bearing long black hair ; the oblique furrow on pleura is wide and deep, and is divided at the top by an oblique raised projecting part. Abdomen shining ; sparsely punctured ; pygidial area covered with long black hairs. Legs longish ; the hinder row of spines on the hind tibiæ black ; the others reddish, and there is a tuft of black spiny hair on the apex of the hinder femora. Tarsal spines thick and stout ; metatarsal brush short, thick, reddish. There are some stiff black hair on the hinder tarsi before the claws. Second cubital cellule a little wider at the bottom than at the top, which is a little longer than the top of the third cellule, the latter being very much narrowed at the top, the bottom being more than twice the length of the second cellule, and its apex reaches near to the apex of the radial cellule. The first recurrent nervure is received a little beyond the middle of the cellule; the second quite close to the second transverse cubital nervure.

SPHEX AURULENTA, Fab.

A variable species. The commonest Bengal form is the var. *aurulenta* Fab. = *Fabricii*, Dbm. = *ferruginea*, Lep. = *godeffroyi*, Saussure. The var. *sericea*, Lep. = *Lepeletierii*, Sauss. also occurs; but I have not seen any Indian specimens that could be referred to the var. *sericca* Fab. = *ferox* Smith, a form chiefly distinguishable from var. *Lepeletierii* by the hair on the pleuræ and middle segment being blackish-brown. The ♂ from Bengal is the typical *lineola* Lep. The hair on the head and thorax is hoary white; the wings are hyaline, smoky at the apex; the abdomen black, the base and the segments at the apices above and beneath reddish; the tegulæ and legs are blackish. A ♂ var. also is met with; it has the legs red, except at the base and the tarsi: the tegulæ are red; the hair cinereous; and the abdomen may be red from the petiole, or red only at the base as in the typical *lineola*. This does not quite agree with the description of *S. velox*, Smith, which has the hair fulvous.

SPHEX ERYTHROPODA, *sp. nov.*

Nigra, fusco pubescens; pedibus rufis; basi apiceque tarsorum, nigris; alis flavo-hyalinis, apice fumatis. Long. 15—18 mm.

Antennæ of the usual length; covered with a sericeous pile; the third joint not much shorter than the fourth and fifth united. Head shining, bearing a scattered punctuation ; the front and vertex sparsely covered with longish blackish hair ; the cheeks, face, and clypeus densely covered with silvery pile and with longish fuscous hair. Eyes slightly converging beneath ; the ocelli hardly forming a triangle ; a furrow along their side, the furrows meeting into a V-shaped depression, which has a sharp raised projection in its centre. Clypeus broadly rounded, the apex depressed and with a short incision in the centre. Thorax sparsely covered with a fuscous to black pubescence ; the pubescence on the middle segment dull fulvous. Pronotum with a distinct and broad depression in its centre ; the mesothorax is also slightly depressed in the centre, and the scutellum and post scutellum are distinctly and broadly furrowed. Median segment transversely and regularly striolated ; a wide and deep furrow in its centre at the apex, and there is an elongated pear-shaped depression on the upper part. Abdomen shining, with a plumbeous tint ; the petiole covered with long black hair, and a little longer than the coxæ ; the pygidial area shagreened, and with a few scattered punctures. Legs with the coxæ, trochanters and four apical joints of the tarsi and the spines on the hinder tibiæ, blackish.

In the colour of the body and pubescence this species comes nearest to *S. rufipennis*, but is readily known from it by the reddish legs. It can hardly, I think, be an extreme variety of *S. aurulenta*, from which, apart from the difference in coloration of the head and thorax and their pubescence (comparing the females), it differs in having the pronotum more distinctly raised above and separated from the mesonotum, besides being broadly furrowed in the centre ; the mesonotum and scutellums are also broadly furrowed, and the median segment, instead of having three or four raised ridges, is uniformly and regularly striolated.

The amount of black on the tarsi varies, as does also the colour of the spines and wings, the latter in one specimen having the yellow tint very feebly developed. The tegulæ are for the greater part black.

I have seen four females in the Calcutta Museum collection.

SPHEX RUFIPENNIS, *Fab.*

This species appears to be a common one in India. The colour of the wings varies, the base, especially in the form *diabolicus*, Smith, being more or less blackish, and the yellow tint is something suffused with fuscous.

S. rufipennis has been recorded from South America, but inasmuch as the ♂ genitalia differs considerably from that of the Indian form, it is probable that the American form, notwithstanding its almost identity in coloration, size, &c., really represents a different species, which I have provisionally named *S. erythroptera* (*Biol. Cent. Am. Hym.* II., p. 30). The form of the scutellum varies in being more or less deeply furrowed. The *S. rufipennis*, Kohl (*Termés. Fuzetek*, IX., p. 198), is, as I am informed by Kohl, a different species from *rufipennis. Fab.* = *luteipennis*, Mocsáry, the latter differing from *rufipennis*, Kohl in having the post scutellum bituberculate, the antennæ thinner, and the wings black at the base.

SPHEX ARGENTATA.

This large species is common all over the Oriental region, extending also into the Australian Islands of the Malay Archipelago. It is stated by Wallace (*Jour. Linn. Soc.*, XI., p. 296) to be common in the sandy streets of Dobbo, in the Aru Islands, and also at flowering shrubs in Celebes.

SPHEX ROTHNEYI, *sp. nov.*

Nigra; capite et thorace dense et longe argenteo pilosis; abdomine pedibusque rufis; coxis, trochanteribus basique femorum, rufis; alis hyalinis, apice fumatis; clypeo inciso. Long. 22—24 mm.

The face is densely covered with long silvery white hair; the front and vertex densely pubescent and covered sparsely with long gray hair; clypeus rounded. The central incision narrow; eyes slightly converging towards the bottom; mandibles reddish; black at base and apex. Antennæ pubescent; the third joint fully one-half longer than the fourth, which is a little longer than the fifth. Thorax densely covered with a silvery pile; the pronotum above, the metathorax and the pleuræ thickly covered with cinereous hair; a thick line of silvery hair along the tegulæ on the mesonotum; finely punctured; the scutellum shining, bearing distinct punctures, and furrowed down the centre. Median segment with some stout transverse furrows, opaque; rounded and narrowed at the apex and nearly as long as the mesothorax. Petiole black, covered with grey hair; and one-half longer than the hind coxæ. Abdomen shining, indistinctly punctured, elongate, sharply punctured at base and apex; the apical segments more distinctly punctured. Legs longish; broadly black at the base; the tibial spines red; the tarsal reddish in part; the calcaria black, red at the extreme apex. The second cubital cellule is oblique, of equal width at top and bottom and receives the recurrent nervure a very little beyond the middle; the third cellule is longer at the bottom than the second, but at the top is less than one-fourth of the length; the recurrent nervure is received before the middle of the cellule.

The ♂ does not differ in coloration or sculpture from the ♀. The tegulae are reddish. The form of the cubital cellules and the position of the recurrent nervures vary.

In form this species approaches closely to *S. pubescens*; but the black legs of that insect distinguish it at once.

SPHEX XANTHOPTERA, *sp. nov.*

Nigra, argenteo sericeo pubescens; facie, pleuris, pronoto metathoraceque, longe cinereo pilosis; alis flavo-hyalinis, apice fumatis. Long. 17—18 mm.

Head closely and minutely punctured ; the pile close ; the hair on the face and clypeus long and thick ; clypeus projecting in the middle, not incised ; roundly arched in the male, which has the hair golden ; the hair on vertex and front longish, sparse and pale. Mandibles reddish in the middle. Thorax finely punctured ; the metanotum transversely striated. The pile is close and dense ; on the pronotum above ; the mesonotum at the sides ; and on the metathorax the hair is longish and dense ; on the mesopleuræ it is scarcely so thick. Petiole a little longer than the hind coxæ, densely covered with silvery white hair of moderate length ; abdomen sericeous, bluish towards the apex. Legs : coxæ densely covered with long silvery hair ; the femora and tibiæ sericeous ; the latter thickly spinose ; the claws armed at the base with two stout longish teeth. The tibiæ with some stout spines. The second cubital cellule is a little longer at the top than at the bottom, and receives the first recurrent nervure at its extreme apex ; the third cubital cellule at the top is one half of the space bounded by the first transverse cubital nervure and the second recurrent.

The male differs in having the hair longer and the pile denser ; the clypeus more projecting and broadly rounded at the apex ; the abdomen is longer.

TRIROGMA.

Trirogma, Westwood, *Trans. Ent. Soc.* III., 223.

1. *Trirogma cærulea*, Westwood, *l. c.*, 225, t. 12, f. 3 ♂ ; *Arc. Ent.* II., 66, t. 65, f. 4 ♀.

Hab. Barrackpore (*Rothney*), Poona (*Wroughton*), Northern India, Madras.

AMPULICIDÆ.

RHINOPSIS.

Rhinopsis. Westwood, *Arcana Ent.* II., 68.

Rhinopsis is chiefly distinguished from *Ampulex* by the wings having only three cubital cellules, the first and second being confluent, and by the body not being metallic green or blue.

RHINOPSIS RUFICORNIS, *sp. nov.*

Niger, antennis, ore, thorace, petiolo, tarsisque, rufis; alis hyalinis, fusco bifasciatis; nervis sordide testaceis. ♀ Long. 10 mm.

Antennæ shorter than the thorax; the basal joint curved, as long as the third, which is two-thirds longer than the fourth. Head coarsely alutaceous, almost punctured; the front keeled, but not distinctly, the keel being interrupted at the base and apex; eyes parallel. The keel on the clypeus projects at the apex into a stout sharp tooth, and there is a shorter and blunter tooth on either side of this. Prothorax a little shorter than the head; the top part raised, narrowed and separated from the lower, and deeply furrowed in the centre; the prosternum and extreme base of pronotum black. Mesonotum shorter than the prothorax, parapsidal furrows slightly diverging at the base, and there is an indistinct furrow between them. Meta- longer than the meso-thorax; the metanotum with a broad, shallow, somewhat oblique, depression on either side; in the centre (between the depressions) are three keels, the central straight, the lateral converging towards the apex; but none of them reach the apex of the metanotum. The metapleuræ are smooth, shining, impunctate; the rest of the metathorax strongly transversely striolated, running in parts into reticulations. The apex is rounded, margined; a blunt tooth on either side, and the apex roundly and shallowly incised. The apex is almost perpendicular, broadly furrowed in the centre, and covered with a moderately long white pubescence. Pro- and mesonotum coarsely aciculated, sparsely covered with a white pubescence. Petiole smooth, shining, clavate at the apex; second abdominal segment as long as all the succeeding segments united ; the latter above (especially at their junction), as well as the sides of all, covered with a short pale pubescence. Legs covered with a white pubescence, the femora thickened in the middle, the second cubital cellule is narrowed towards the top ; the transverse cubital nervures are straight. Wings not much longer than the thorax.

This species is closely related to the European *R. rufi-collis*, Cam., but is much larger, the antennæ and tarsi are red, the metanotum is entirely red, the wings are shorter and not so broadly infuscated in the middle, and with the nervures for the greater part testaceous ; and the apex of the petiole is much narrower, thinner, and more club-like.

1. AMPULEX COMPRESSA.

Ampulex, Jurine, *Hym.* 134.
Sphex compressa, Fab., *Ent. Syst.* II., 206, 32.
Ampulex compressa, Dahlbom, *Hym. Eur.* I., p. 29 ; Lep. *Nat. Hist. Ins. Hym.* III., p. 325, 1 ; Smith, *Proc. Linn. Soc.* (1869) p. 363.
Chlorion compressum, Fab., *Syst. Piez.* p. 219, 7 ; Westwood, *Trans. Ent. Soc.* III., p. 227.
A common species, generally distributed over the region. It preys on Blattidæ.

2. AMPULEX HOSPES.

Ampulex hospes, Smith, *Cat. Hym. Ins.* IV., p. 272, 12 ; *Proc. Linn. Soc.* II., p. 981.
Hab. Borneo.

3. AMPULEX SMARAGDINA.

Ampulex smaragdina, Smith, *Proc. Linn. Soc.* II., 19, 3.
Hab. Singapore.

4. AMPULEX INSULARIS.

Ampulex insularis, Smith, *Proc. Linn. Soc.* II., p. 99, 4.
Hab. Borneo, Malacca.

5. *Ampulex* (?) *annulipes*, Motsulsky, *Bull. Mosc.* XXXVI., (1863).
Hab. Ceylon.

Waagenia.

Waagenia, Kriechbaumer, *Ztett. Ent. Zeit.* XXXV., 1874, p. 51.

1. Waagenia sikkimensis, Kriechbaumer, *l. c.*
Hab. Sikkim.

LARRIDAE.

The specific discrimination in this family is at the best a work of some difficulty, and the identification of Smith's species is rendered, in many instances, almost impossible from the absence in his descriptions of any details of structure. Pending an opportunity of studying his types I have left over for future study various species of *Notogonia* and allied genera.

Pison.

Pison, Spinola, *Ins. Lig.*, II., 255; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 180.

1. P. (Parapison) agile.
Parapison agilis, Smith, *Trans. Ent. Soc.*, 1869, 300, 4.
Hab. Ceylon.

1. P. (Parapison) erythropus, Kohl.
Parapison rufipes, Smith, *Trans. Ent. Soc.*, 1869, 299, 2; *Trans. Zool. Soc.*, VII., 188, pl. XXI., fig. 1a. (*non* Shuck.)
Hab. Mainpuri, North-west Prov. (*Horne*).

2. P. (Parapison) obliteratum,
Pisonoides obliteratus, Smith, *Jour. Proc. Linn. Soc. Zool.*, XII., 1857, 104.
Hab. Borneo (*Wallace*).

3. P. PUNCTIFRONS, Shuckard, *Trans. Ent. Soc.* II., 1837, p. 77, 5.
   Hab. "India or St. Helena."

4. P. (PISONITUS) RUGOSUM, Smith, *Cat. Hym. Ins.*, IV., 313, 3.
   Pisonites rugosus, Smith, *Trans. Zool. Soc.*VII., 188, pl. XXI., fig. 5a. ♀.
   Hab. Mainpuri, North-west Province (*Horne*), Calcutta (*Rothney*), Poona (*Wroughton*).

5. P. SUSPICIOSUM.
   Pison suspiciosus, Smith, *Jour. Linn. Soc. Zool.* II. (1857), 104.
   Hab. Singapore (*Wallace*).

TRYPOXYLON.

Trypoxylon, Latreille, *Préc. Car. Gen. Ins.;* Kohl, *Verh. z.-b. Ges. Wien.* (1884), 190.

1. TRYPOXYLON ACCUMULATOR, Smith, *Trans. Ent. Soc.* (1875), p. 38.
   Hab. Barrackpore (*Rothney*).

2. T. BICOLOR, Smith, *Cat. Hym. Ins.* IV., p. 377.
   Hab. Singapore, Java.

3. T. BUDDHA, Cam. *infra.*
   Hab. Barrackpore (*Rothney*).

4. T. CANALICULATUM, Cam. *infra.*
   Hab. Barrackpore, Mussourie Hills.

5. T. COLORATUM, Smith, *Jour. Linn. Soc. Zool.* II., (1857), 106,
   Hab. Borneo (*Wallace*).

6. T. GENICULATUM, Cam. *infra.*
   Hab. Barrackpore.

7. T. INTRUDENS, Smith, *Trans. Zool. Soc.* VII., 188.
   Hab. Mainpuri, North-west Provinces (*Horne*), Allahabad (*Rothney*), Ceylon (*Lewis*).

8. T. JAVANUM, Taschenberg, *Zeits. f. d. ges. Naturw.* XLV., 378, 13.
   Hab., Java.

9. NIGRICANS, Cam., *infra.*
   Hab., Barrackpore (*Rothney*).

10. T. PETIOLATUM, Smith, *Jour. Linn. Soc. Zool.* 1857, 105.
    Hab. Borneo (*Wallace*).

11. T. PILIATUM, Smith, *Cat. Hym. Ins.* IV., 377.
    Hab., Madras.

13. T. REJECTOR, Smith, *Trans. Zool. Soc.* VII., p. 189.
    Hab., Mainpuri, North-west Provinces.

14. T. TINCTIPENNE, Cam. *infra.*
    Hab. Barrackpore.

TRYPOXYLON REJECTOR.

The habits of this species are but imperfectly known. Horne found the cells, which are formed of arenaceous mud, and appear very delicate and fragile, but from the strength of the cement used are really tenaceously held together. They are attached to straws usually under cover and constructed chiefly in September.

TRYPOXYLON BUDDHA, *sp. nov.*

Nigrum; fusco pilosum; punctatum; fronte fortiter punctata; metanoto transverse striolato; alis hyalinis; Long. 9—5 mm.

Hab. Barrackpore (*Rothney*).

Antennæ subclavate; covered with a close pile; the third and fourth joints subequal. Head fully broader than the thorax; the front shining, almost bare; the clypeus and lower part of cheeks densely covered with silvery hair. Front raised, furrowed down the centre, bearing large, distinct punctures, narrowed before the antennæ into a wedge. The eyes at top are separated by the length of the second and third antennal joints united; ocelli rather widely separated; clypeus with a raised margin, sharply rounded at the apex. Mandibles reddish beyond the base. Thorax shining, covered with long fuscous hair; mesonotum rather strongly punctured; the scutellum and fore part of the mesopleuræ slightly punctured; the hinder part of the latter impunctate. Metanotum strongly transversely striolated, the striæ wide apart; there is a wedge-shaped depression in the centre of the upper part; the depression with a keel down its edges; there are two lateral keels and the posterior part of the metanotum is widely excavated in the centre; this portion having a gradual rounded curved slope. Petiole as long as the mesothorax, clavate; fully one-third longer than the second segment; the latter is a little longer than the third, and both have an elongate fovea on the top at the apex. At the apex the abdomen is sparsely pilose. Femora sparsely haired; tibiæ and tarsi closely pilose; spurs pale testaceous.

Trypoxylon accumulator.

In this species the front is not much raised on either side of the central furrow, which is wide but shallow; the eyes at the top are separated by about the length of the third antennal joint, at the bottom below the antennæ by fully more than the length of the third. The third joint of the antennæ is nearly one-half longer than the fourth. Clypeus broadly carinate, the apex projecting, broadly rounded. Petiole longer than the thorax, rather abruptly dilated towards the apex; the second segment distinctly shorter than the third.

TRYPOXYLON TINCTIPENNIS, *sp. nov.*

Nigrum; abdominis segmentis 2° et 3° rufis; calcaria albis; clypeo et facie dense argenteo pilosis; thorace longe albo piloso; alis fere hyalinis, apice late fuscis. ♀. Long. 12 mm.

Hab. Barrackpore.

Antennæ covered with a silvery down, the third joint about one-fourth longer than the fourth; the fourth and fifth slightly curved on the lower side. Front and vertex opaque, finely punctured. Front ocellus situated in a pit; the front before it raised on either side into a roundish elevation, the two being separated by a furrow, at the end of which is a fine straight keel, which reaches near to the base of the antennæ. Eyes at the top separated by the length of the third and fourth joints united; below reaching to the edge of the clypeus; below the antennæ they are separated by about the length of the second and third joints united; clypeus slightly concave, the apex scarcely rounded, being straight to near the centre. Palpi testaceous at apex; mandibles rufous at tips. The pubescence on the front and vertex is fuscous and very short, on the rest of the head long and silvery white, being especially close and thick below the antennæ. Thorax shining, almost impunctate and with a plumbeous tinge; the mesonotum bears a sparse short pubescence; the pleuræ and sternum are more densely covered with longer silvery white hair. At the end of the metanotum there is, in the middle, a bell-shaped depression; the median segment is deeply depressed in the middle, the depression being widest at the base and continuous with that at apex of metanotum; its sides are striated. Petiole dilated at the apex and nearly as long as the thorax, and considerably longer than the second and third segments united. The second segment is a little shorter than the third. Legs pruinose, the coxæ bearing longish silvery hair; the femora are sparsely haired.

TRYPOXYLON CANALICULATUM, *sp. nov.*

Nigrum; palpis, trochanteribus, geniculis, calcaria, tarsisque anterioribus, flavo-albis, tibiæ anticis fulvis; alis hyalinis, apice fere fumatis; tegulis rufo-testaceis; apice petioli abdominisque segmentis 2 et 3 rufis. Long. 9—10 mm.

Antennæ covered with a hoary down; the scape testaceous beneath; the flagellum more or less fuscous; the third joint nearly one-half longer than the fourth. Head opaque, closely punctured; the clypeus, face, cheeks, and eye incision covered with short silvery hair, only visible in certain lights. Front slightly raised, furrowed in the centre; a not very distinct keel at the end of the furrow. Clypeus bluntly carinate in the centre; the apex gaping the margin slightly curved before the middle, which is rounded. Eyes at the top separated by fully the length of the third antennal joint; below the antennæ, by hardly the length of the third. Mandibles rufous. Pro- and meso-thorax shining, impunctate; the sides and breast covered with longish white hair. Metanotum shining; a wide depression in the centre, the depression becoming gradually widened to near the apex, which is rounded; on either side of this is a narrow furrow, of nearly equal width and converging towards the apex; both are transversely ribbed; metapleuræ finely obliquely punctured. Median segment widely furrowed in the middle, and covered with white hair. Petiole as long as the thorax, broadly dilated at the apex, and tuberculated at the basal fourth; the second segment distinctly shorter than the third; sides of apical segment distinctly margined laterally; indistinctly keeled in the middle. Legs pruinose; the coxæ bearing white hair.

Hab. Barrackpore, Tirhoot, Mussoorie Hills (*Rothney*).

TRYPOXYLON PILIATUM.

Several specimens from Barrackpore are probably referrable to this species. The antennæ bear a short white pile, and have the third joint less than one-fourth longer than the fourth. The cheeks, eye incision, and clypeus are densely covered with silvery pubescence; the front and vertex are shining, minutely punctured; and there is in the latter a large depression, rounded behind, triangular in front, with a distinct raised margin; from the middle (at the angle) a short keel runs to the eye incision; and from the apex a stout keel runs to the antennæ. At the top the eyes are separated by the length nearly of the second and third joints united. The two hinder ocelli are placed in round depressions, and are separated by a margin; the front ocellus is placed in the large frontal area. The metanotum is strongly transversely striolated; at the base in the centre there is a wide furrow, twice longer than broad, surrounded by a broad margin; and on either side of this is a broad furrow which unites into a broad furrow running down the centre to the apex. The metapleuræ are much more finely and closely striolated. The mesonotum is finely punctured, and is of almost an olive hue. The abdomen is more than twice the length of the head and thorax united. The petiole is nearly twice the length of the second joint. The calcaria are pale.

The peculiar shield-shaped depression separates this species readily from the others.

Trypoxylon intrudens.

Smith has named doubtfully some specimens in Mr. Rothney's collection as this species. They have the head rather strongly punctured; the front furrowed in the centre; the eyes at the top separated by the length of the third antennal joint; there is a wide furrow in the centre of the metanotum, with a curved narrower furrow on either side of it, meeting at the central apical furrow. The furrows transversely striolated; the rest of the metanotum finely punctured. The petiole is more than half the length of the abdomen, and is dilated not far from the base, and clavate at the apex.

On the whole the specimens agree fairly well with Smith's description, except in what he says about the metanotum, which has "a deep central longitudinal impression ; a semicircular enclosed space at the base of the metathorax, which is transversely striolated."

T. intrudens was bred from cells constructed by *Parapison rufipes.*

LARRA.

Larra, Fabricius, *Ent. Syst.* II., 220 ; Kohl, *Verh. z.-b. Ges., Wien* 1884, 233 (*non* Smith, which = *Stigmus*).

Larrada, Smith, *Cat. Hym. Ins.* IV., 274.

Smith included in *Larrada*, at least three genera, namely, *Larra*, *Notogonia*, and *Liris* ; probably also *Tachysphex*. From his description it is impossible to make out to which of these groups the majority of his species belong, as he does not mention the structural details on which the genera mentioned are grounded. In these circumstances I have been compelled to leave over for future examination, by means of Smith's types, several species of *Notogonia*. At the best the species are exceedingly difficult to discriminate, the points separating the species being usually minute structural details, most of which are not mentioned by Smith at all.

The following is a list of *Larra sensu lat., i.e.*, of those species which cannot, without an examination of the types, be referred to their precise genus, and which may belong to *Larra*, *Notogonia*, *Liris*, or *Tachysphex*.

1. LARRA ALECTO, Smith, *Jour. Linn. Soc. Zool.* II., 103, 6.

Hab. Singapore.

2. L. CARBONARIA, Smith, *l. c.* 102, 2.
Hab. Singapore.

3. L. CONSPICUA, Smith, *Cat. Hym. Ins.* IV., 276, 7.
Hab. "India."

4. L. EXILIPES, Smith, *Cat. Hym. Ins.* IV., 278.
Hab. Northern India.

5. L. EXTENSA, Walker, *Ann. Mag. Nat. Hist.* (3) V., 504.
Hab. Ceylon.

6. L. LABORIOSA, Smith, *Cat. Hym. Ins.* IV., 278, 12.
Hab. Philippines.

7. L. MAURA, Fab., *Ent. Syst.* II., 212, 55, Smith, *Cat. Hym. Ins.* IV., 277, 9.
Hab. Tranquebar.

8. L. POLITA, Smith, *Jour. Linn. Soc. Zool.* II., 102, 4.
Hab. Borneo, Sarawak.

9. L. SYCORAX, Smith, *Jour. Linn. Soc. Zool.* II., 102, 3.
Hab. Borneo.

10. L. TISIPHONE, Smith, *Jour. Linn. Soc. Zool.* II., 103, 5.
Hab. Borneo.

11. L. TRISTIS, Smith, *Cat. Hym. Ins.* IV., 277, 10.
Hab. Borneo.

12. L. VESTITA, Smith, *Am. Mag. Nat. Hist.* XII., 11.
Hab. North India.

1. LARRA SIMILLIMA.

Smith, *Cat. Hym. Ins.* IV., 275, 5.

The eyes on the top are separated by the length of the second and third antennal joints united; the vertex has a broad curved depression behind the ocelli and along the sides of the eyes, the centre being raised ; there is an indistinct longitudinal furrow in the centre behind ; the clypeus is margined, broadly transverse in the middle ; the front excavated. The antennæ are stout ; covered with a whitish pile ; the second joint is half the length of the third. The pronotum has a slight incision in the middle behind ; obliquely excavated laterally; shining and finely punctured. The meta- is as long as the mesothorax, and is strongly transversely punctured ; the puncturing being much stronger than on the mesothorax ; the sides of the metanotum are somewhat depressed ; the pleuræ becoming narrowed from the top to the bottom. Pygidial area shining, polished, with a few indistinct scattered punctures along the sides and apex ; the sides with a raised margin and with a furrow on the inner side of this margin ; the apex broadly rounded, almost truncate.

Of *Larra personata*, Sibi, from Celebes, Smith remarks, "This is probably merely a variety of *L. simillima*, wanting the black apex to the abdomen."

Hab. Tirhoot, Bengal (*Rothney*) ; "Africa" (Smith *l. c.*).

2. LARRA, SUMATRANA.

Kohl, *Verh. z.-b. Ges. Wien*, 1888, 354.

Hab. SUMATRA.

3. LARRA FUSCIPENNIS, *sp. nov.*

Nigra, argenteo pilosa, abdominis dimidio basali rufo, medio nigro, alis fusco-fumatis, basi sub hyalinis.

Long. 12—13 mm.

Hab. Tirhoot (*Rothney*).

Antennæ short, thick, tapering perceptibly towards the apex ; the second joint nearly three-fourths of the length of the third, which is fully one-fourth longer than the fourth. Head shining, strongly punctured ; the punctures distinctly separated. Ocellar region not raised and separated ; a broad, transverse curved furrow behind it ; above the front there is a broad margin. Eyes almost parallel ; at the top separated by the length of the third and fourth antennal joints. Clypeus not, or hardly, projecting in the middle; the apex broadly projecting, and with a distinct incision in the middle. Thorax half shining, coarsely punctured; the metathorax more closely punctured than the mesothorax, and densely covered with white hair; pleuræ and sternum shining, the punctures widely separated. Pro- and meso-thorax closely covered with dull whitish pubescence. Pronotum in the middle projecting into the mesonotum, which is thus incised broadly. Meta- longer than the mesothorax, the apex perpendicular, indistinctly furrowed in the centre. Abdomen as long as the thorax; covered closely with white pubescence (sparsely on the top of the second and third segments), the apex rather acutely pointed. Pygidial area punctured; covered with a soft white pubescence; the sides not keeled, the apex incised. The basal two segments are red, broadly black in the middle; the ventral segments are pale at their junction, Legs covered with soft cinereous pubescence, tibial and tarsal spines white; calcaria black; metatarsal brush pale. The second cubital cellule at the top is half the length of the third and hardly the length of the space bounded by the current nervures.

Hab. Tirhoot, Bengal (*Rothney*).

4. LARRA NIGRIVENTRIS, *sp. nov.*

Nigra, fere nitida, pruinosa, metathorace opaco, striolato, fere longiore quam mesothorace; alis fere flavo-hyalinis; apice fuscis, nervis flavo-testaceis. Long. 12 mm.

Antennæ the length of the thorax, rather stout, covered with a silvery pile; the second joint one-third of the length of the third, which is hardly one-fourth longer than the fourth. Head wider than the thorax; opaque, alutaceous; eyes at the top separated by more than the length of the third antennal joint; vertex depressed, a wide furrow along either side, close to the eyes; a shallow and less distinct furrow in the centre, leading to and from the ocellus round which it bifurcates, becoming wider and more distinct after leaving it; the presence of the hinder ocelli is not indicated, and the anterior is elongated, being longer than broad, and sharply pointed at base and apex. Face, cheeks, and clypeus densely covered with silvery pubescence. The clypeus slightly projects towards the apex, and is indistinctly carinate down the centre; the apex is broadly rounded, almost truncate. Base of mandibles densely covered with short silvery pubescence; the apex is broadly red, thorax opaque, alutaceous, covered with a sericeous short pubescence; pronotum ending in a rounded part in the centre; mesonotum truncated at base; metathorax nearly longer than the mesothorax; not very distinctly striolated, except at the sides and apex; the latter semi-oblique, furrowed in the middle, the sides densely covered with silvery pile. Abdomen pruinose, hardly longer than the thorax, the apex acute; the pygidial area very shining and bearing a few punctures. Radial cellule not reaching to the apex of the third cubital, wide, and very sharply oblique at the apex; the second cubital cellule shorter than the third, and a very little longer than the space bounded by the recurrent nervures. Legs densely silvery sericeous; the spines and spurs black.

Hab. Barrackpore, Tirhoot; Allahabad, N.W. Provinces (*Rothney*), Poona (*Wroughton*). Not uncommon.

NOTOGONIA.

Notogonia, Costa, *Ann. Mus. Zool. Univ. Napoli* IV., 80 and 82; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 249.

Larrada, Smith = *Tachytes*, Dahlbom, St. Fargeau, Saussure, Taschenberg.

This genus apparently contains more species than either *Larra* or *Liris*.

1. Notogonia pulchripennis, *sp. nov.*

Nigra, sericea; mandibulis, tegulis, pedibus (coxis trochanteribusque nigris) abdominisque basi late, rufis, alis flavo-hyalinis, apice fumatis. Long. 12 mm.

Antennæ short, moderately thick; the second joint half the length of the third, the third and fourth subequal. Head almost shining, the face densely covered with silvery pubescence; the vertex with a sparser and shorter pubescence, which does not hide the surface; alutaceous. There is a somewhat triangular depression behind the hinder ocelli; a wide and deep furrow runs down from the anterior, and the depressions on either side of it are deep, curved, and broad. Clypeus not much convex, the apex slightly depressed, and broadly rounded. Eyes at the top separated by the length of the second and third joints united. Thorax densely sericeous, alutaceous, the metathorax transversely striolated, coarsely so at the apex; there is a shallow furrow in the centre of the mesonotum, and there is a narrower and deeper furrow on the apex of the metanotum. The pile on the mesonotum inclines to golden; the metathorax bears a longish white pubescence. Abdomen longer and narrower than the thorax, sericeous; the pygidial area rufous; longitudinally punctured; covered with a silvery pubescence; the sides keeled, the apex rounded, and bearing stiff bristles. Legs moderately sericeous; the bristles and calcaria blackish to fuscous; metatarsal brush silvery. The second cubital cellule is one-third the length of the third at the top, and somewhat less than the space bounded by the recurrent nervures.

Hab. Jeypore (*Rothney*).

2. Notogonia jaculator.

Smith, *Cat. Hym. Ins.* IV. p. 279.

In this species the eyes at the top are separated by the length of the fourth antennal joint; there is a longish shallow ∧-shaped depression above the posterior ocelli; the front depressed where the front ocellus is; and from the apex of the depression a short wide furrow runs; there are three wide depressions on the front above the antennæ, the central being furrowed down the middle. The clypeus is almost transverse. The basal joint of the antennæ is longer than the second and third united; the second is about one-third the length of the third, the latter not being much longer than the fourth. The second cubital cellule is about one-fourth shorter than the third, and wider than the space enclosed by the two recurrent nervures. The pygidial area bears a fulvous to cinereous pile; the apex is broadly rounded. The ♂ has the wings and the nervures darker than in the ♀; the pygidial area has a soft, short, pale pubescence.

Hab. Barrackpore, Mussoorie hills (*Rothney*), Poona (*Wroughton*).

3. NOTOGONIA DEPLANATA, Kohl, *Verh. z.-b. Ges. Wien*, 1883, 358.

Hab. Ceylon.

4. NOTOGONIA SUBTESSELATA, Smith. *Cat. Hym. Ins.* IV., 277, 11.

Hab. Barrackpore. Common (*Rothney*), Poona (*Wroughton*), Sumatra, Java.

A common species.

LIRIS.

Liris, Fabricius, *Syst. Piez.* 227; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 254.

This genus contains, so far as is known, but few species. It is readily known from *Notogonia* by the absence of a notch on the lower side of the mandibles. The pygidial area is clothed with short hair and at the end with stiff bristles; the abdominal segments are usually clothed with a sericeous pile, and the fore tibiæ are spined on the outer side.

1. LIRIS HÆMORRHOIDALIS.

Pompilius hæmorrhoidalis, Fab., *Syst. Piez.* 198.

Liris Savignyi, Spinola, *Ann. Soc. Ent. Fr.* VII., p. 476.

Lyrops aureiventris, Guérin, *Icon. regn. anim.* t. III., 440, *pl.* LXX. f. 9. ♂.

Liris orichalcea, Dahlbom, *Hym. Ent.* I., 135.

Tachytes illudens, St. Fargeau, *Nat. Hist. Ins. Hym.* III., 249, 12.

Larrada hæmorrhoidalis, Smith, *Cat. Hym. Ins.* IV., 280.

Larrada hæmorrhoidalis, Kohl, *Verh. z.-b. Ges. Wien*, 1884, 256.

A widely distributed species, being found in the Mediterranean region, Syria, Egypt, Senegal, Gambia, Sierra Leone; Punjaub, Poona (*Wroughton*). Smith (*l.c.*) records the species from the Punjaub, but he omits it from his general Catalogue of Indian species (*Trans. Linn. Soc.* 1869).

2. LIRIS AURATUS.

Sphex aurata, Fab., *Ent. Syst.* II., 213, 64.

Liris aurata, Fab., *Syst. Piez.*, p. 228, 3. Kohl, *Verh. z.-b. Ges. Wien*, 1884, 241.

Larrada aurulenta, Smith, *Cat. Hym. Ins.* IV., 276, 6, pl. VII. fig. 5.

Tachytes opulenta, St. Fargeau, *Nat. Hist. Ins. Hym.* III., 246, 7.

Widely distributed. India (common in Calcutta district); Borneo, Sumatra, Java, Bachian, Celebes, China, Japan, Cape of Good Hope, and Gambia.

3. LIRIS NIGRIPENNIS, *sp. nov.*

Nigra, nitida, punctata; facie clypeoque argenteo pilosis; area pygidialis aurea hirsuta; alis fusco-violaceis. Long. ♀ 18; ♂ 15 mm.

Antennæ stout, as long as the thorax. The basal joint keeled on lower side ; as long as the second and third joints united ; the second joint one-third the length of the third, which is longer than the fourth. Head as wide as the thorax ; almost opaque, closely punctured ; eyes at the top separated by the length of the fourth antennal joint. A triangular depression above the ocelli, the vertex above this being indistinctly furrowed ; there is a wide depression on either side of the ocelli close to the eye ; and the space between the upper and lower ocelli is widely furrowed in the middle, the furrow being continued beyond the lower ocellus. The front above the antennæ is widely furrowed along the sides of the eyes, and down the centre. Clypeus distinctly margined at the apex, slightly waved towards the centre. Mandibles black ; somewhat hollowed and finely rugose at the base; the apex piceous. Thorax finely punctured ; the mesonotum shining, the pleuræ opaque ; metanotum also opaque, finely rugose. The pronotum is brought to a point in the middle, and its edge bears a covering of white pubescence; the mesonotum is a little depressed in the centre towards the base ; the mesopleural furrow is almost complete ; the meta- is shorter than the mesothorax ; its apex is semi-perpendicular and transversely striolated. Abdomen shorter than the thorax ; shining ; the segments edged with a pale short silky pile ; the pygidial area densely covered with a stiff depressed—golden at the apex, fuscous at the base—pile ; and its apex bears stiff golden spines ; its surface also bearing stiff blackish bristles. At the top the second cubital cellule is one fourth of the length of the third ; the recurrent nervures are almost united, and are received a little before the middle of the cellule. The wings are pale across the cubital cellules. The spines, etc., on the legs are black ; the metatarsal brush and the brush on the inner spur dull fulvous.

The ♂ has the hair on the face and clypeus with a more golden hue; the second cubital cellule is longer in comparison with the third; the recurrent nervures are more widely separated ; the pygidial area is less strongly pilose, and wants the bristles on the surface and apex, being also shorter, broader, and with the apex incised.

Hab. Bangalore (*Mus. Cal.*), Poona (*Wroughton*).

PIAGETIA.

PIAGETIA, Ritzema, *Ent. M. Mag.*, IX, 120; Kohl, *Verh. z.-b. Ges. Wien*, 1884, p.

1. *Piagetia Ritsemæ*, Ritzema, *Ent. M. Mag.* IX., p. 120. *Hab.* Sourubuya, Java.

2. PIAGETI RUFICORNIS, *sp. nov.*

Nigra, antennis, ore, clypeo, prothorace, metathorace (medio metanoti nigro) petiolo pedibusque, rufis; alis hyalinis, fascia substigmatali fusca; nervis testaceis. ♀. Long. 9 mm.

Antennæ rather slender, almost bare. The second joint half the length of the fourth, which is shorter than the third. Head wider than the thorax, opaque, finely granular; a furrow runs down from the ocellus to the base of the antennæ, and there is a wider curved furrow on either side of the front; clypeus broadly keeled (the keel narrowed at base), densely covered with a silvery pubescence, the apex with an incision in the middle. Eyes at the top separated by the length of the third antennal joint. Mandibles black at the apical half. Thorax finely aciculated, covered with a close silvery pile; the metanotum finely rugose, with a shallow depression in the centre having a fine keel in the middle. The mesopleuræ and sternum are entirely black; the mesopleural suture rather indistinct; the mesonotum is broadly rufous on either side at the base. Pygidial area almost bare, and marked all over with large punctures. The second cubital cellule at the top is longer than the third; the recurrent nervures are received not far from the base of the cellule, and are almost united. There is a short black line on the top of the middle femora; the posterior femora are entirely lined with black above; the hinder tibiæ are infuscated behind; the coxæ black at the base; the femoral spine is a mere thickening as in *P. ritsemæ*.

May be known from *P. ritsemæ* by there being only a fascia in the wings below the stigma, the entire apex not being infuscated; by the antennal being entirely red; the mesothorax black, &c.; from *P. fasciatiipennis* it differs in being larger; in having the antennæ entirely red; in having the mesonotum broadly red in front; in the mesopleuræ not being entirely black, it being red at base and apex and under the wings; in the metanotum being only black in the middle, the apex too being red; in the second abdominal segment being red at the base; the pygidial area is entirely red and much more strongly punctured; the metathorax can hardly be said to be transversely striated; the wings are not so clearly hyaline, having a fuscous tinge, especially behind the stigma, and the cloud is much more distinct and wider. There is of course, also, the difference in the form of the clypeus and of the femoral spine, but these are doubtless sexual differences which cannot be compared in the absence of the ♂ of *ruficornis* and the ♀ of *fasciatiipennis*.

Hab. Poona (*Wroughton*).

3. *P. fasciatiipennis*. Cameron, *Mem. Lit. and Phil. Soc., Man.* II. (4) 16.

Hab. Ceylon.

TACHYTES.

Tachytes, Panzer, *Krit. Revis.* II., 129; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 327.

Like *Larra* this has been split up into three genera, and the same difficulty is experienced in elucidating Smith's species.

The following are the species which cannot be referred to their proper genus.

1. TACHYTES AURIFEX, Smith, *Jour. Linn. Soc.* II., 101.
   Hab. Borneo.
2. T. FERVIDUS, Smith, *Cat. Hym. Ins.* IV., 298, 11.
   Hab. " India."
3. T. NOVARÆ, Saussure, *Novara Reise, Hym.*, 69.
   Hab. Nicobar Island.

1. TACHYTES ERYTHROPODA, *sp. nov.*

Niger, nitidus, argenteo pubescens; mandibulis, pedibus (coxis nigris) abdominisque segmentis 1—3, *rufo-testaceis; alis hyalinis, apice fere fumatis.* ♀. Long. 8 mm.

Hab. Mussoorie hills (*Rothney*).

Head broader than the thorax, shining, sparsely punctured; the vertex sparsely, the cheeks and clypeus densely covered with long silvery hair. Antennæ short, thick, microscopically pilose; the second joint nearly half the length of the third, which is a little longer than the fourth. Eyes but slightly converging at the top; separated there by the length of the first, second, and third joints united. Ocellar area longer than broad, surrounded by a furrow, and furrowed down the middle; and a furrow winds down from the front ocellus. Lateral prominences indistinct; the clypeus slightly projecting in the middle; the apex in the middle gaping, roundly incised. Thorax shining, impunctate; the pronotum punctured; the metanotum irregularly transversely striolated and covered with long, silvery white hairs. Abdomen longer than the thorax and narrower than it, shining, covered with silverywhite pubescence, except on the basal segments in the centre; pygidial area covered closely with stiff fulvous, mixed with white, bristles; the sides keeled; the apex rounded; beneath it is punctured. Femora slightly, tibiæ and tarsi densely covered with white pubescence; tibial and tarsal spines whitish; calcaria rufous; claws for the greater part black. Second cubital cellule about one-fourth longer than the third at the top, and one-half longer than the space bounded by the recurrent nervures.

2. TACHYTES MONETARIUS.

Tachytes monetarius, Smith, *Cat. Hym. Inst.* IV., 298.

The largest and handsomest of the Indian species, and readily known by the abdomen being covered all over with silky golden pubescence. The antennæ have the third joint longer than the fourth, and four times the length of the second. Front and vertex opaque, closely and finely rugosely punctured; eyes at top separated by a little more than the length of the third antennal joint. Clypeus rounded at the apex. Thorax opaque, closely roughly punctured; the medial segment much more strongly than the mesonotum and finely and closely transversely striated at the apex. Second cubital cellule at the top nearly one-fourth shorter than the third; the first recurrent nervure is received about the length of the second cubital cellule from the transverse cubital nervure; the second is received a little beyond the middle of the cellule.

The ♂ has the antennæ stouter; the third joint is distinctly longer than the fourth.

Common, Barrackpore; Mussoorie hills (*Rothney*), Poona (*Wroughton*).

3. TACHYTES MODESTUS.

Tachytes modestus, Smith, *Cat. Hym. Ins.* IV., 299.
Saussure, *Hym. Novara Reise*, 72.

This is a larger and stouter insect than *T. ornatipes*; the legs are red, except the coxæ, trochanters and base of femora, the abdomen is shorter, thicker, and more ovate, that of *T. ornatipes* being elongate and narrow; the wings have a more decided yellow tint, and the nervures are more decidedly yellow or rather of a ferruginous colour, but in this respect the wings vary.

Common. Mussoorie hills (*Rothney*). Shanghai (*Saussure*).

4. TACHYTES ORNATIPES, *sp. nov.*

Niger, geniculis, tibiis tarsisque anterioribus, rufo-testaceis; alis fere flavo-hyalinis, nervis testaceis; clypeo, facie thoraceque longe fulvo-hirtis. Long. 12 mm.

Antennæ stout; the third joint hardly longer than the fourth, and three times the length of the second. The hair on the face and clypeus is long and dense, the front and vertex sparsely haired, opaque and sparsely punctured on the vertex, which is depressed and furrowed in the centre. Eyes at top separated by the length of the third antennal oint. Mandibles reddish at the basal half; punctured and covered with silvery-golden hair; palpi reddish testaceous. Thorax opaque. Clypeus punctured; the margin depressed, incised in the middle, the scutellum distinctly punctured; the hair moderately long and thick; the pronotum above with a fringe of silvery pubescence. Abdomen shining; the segments bordered (except in the centre) with silvery pubescence. Pygidial area densely covered with stiff golden hair; sharply narrowed towards the apex, which is rounded. Ventral surface (especially towards the apex) thickly covered with dark brown pubescence and with some scattered longish hairs. Legs cinereous pilose; the femora with scattered hairs; the anterior tibiæ are entirely testaceous; the middle pair are broadly blackish in the centre; the posterior are black, testaceous at base and apex; the hind tarsi black, more or less testaceous at the apex and at the apex of the two basal joints; the spines pale testaceous; the spurs and claws for the greater part rufo-testaceous. The second and third cubital cellules are subequal at the top; the first recurrent nervure is received at a little more than half the length of the top of the second cubital cellule from the transverse cubital nervure; the second a very little beyond the middle of the cellule.

Hab. Barrackpore (*Rothney*).

5. TACHYTES VIRCHU, *sp. nov.*

Niger, femoribus postecis rufis; capite thoraceque dense fulvo-hirtis; pedibus dense argenteo pilosis; *alis fere hyalinis, nervis fuscis.* ♂. Long. 8 mm.

Hab. Mussoorie hills (*Rothney*).

Antennæ with the third joint a little shorter than the fourth, and twice the length of the second. Pubescence on clypeus, and face dense, silvery to fulvous; front and vertex bearing long pale fuscous hair; opaque, alutaceous; the vertex rather deeply depressed in the centre. Clypeus with the apex depressed, rounded and shining; thorax with the hair dense and long, opaque; the scutellum finely punctured; the apex of median segment irregularly transversely striated and deeply furrowed in the middle. Abdomen ovate, shorter than the thorax, shining; the segments at the apex with a dense broad silvery fringe slightly interrupted in the middle, except on the apical segment. Pygidial area not much longer than broad, densely covered with depressed silvery hair; the apex broad, truncated. Ventral surface punctured, rather densely covered with dark brown pubescence. Femora behind densely covered with silvery hair; tibiæ and tarsi still more densely with a silvery pile. Spines pale; calcaria fuscous, testaceous at base and apex; claws reddish. Second cubital cellule fully longer than the third at the top; the first recurrent nervure received at the length of the top of the second cubital cellule from the transverse cubital nervure; the second a little beyond the middle of the cellule.

Hab. Mussoorie hills (*Rothney*).

6. Tachytes Rothneyi, *sp. nov.*

Niger, dense fulvo-hirtus ; abdominis segmentis argenteo fasciatis ; tibiis tarsisque dense fulvo-pilosis ; alis flavo-hyalinis, apice fere fumatis ; tegulis rufis. Long. 16—18 mm.

Head and thorax opaque, finely and closely punctured ; the scutellum distinctly and strongly punctured ; the metanotum at apex irregularly striated and deeply furrowed in the middle. Face and clypeus densely covered with a longish fulvous pile ; the vertex sparsely with longish fuscous hair ; the occiput with a silvery pile ; the mandibles at base with golden pubescence. Eyes at top separated by the length of the fourth antennal joint. Scape of antennæ densely covered with a silvery pile and with some long fuscous hair ; the third joint about one fourth longer than the fourth, and three times the length of the second ; the fourth—sixth joints are slightly contracted at base and apex, bulging out broadly in the middle. Clypeus broadly carinate in the middle ; the apex rounded, entire, and depressed. Mandibles inclining to red towards the apex. Abdomen longer than the thorax ; becoming gradually narrowed towards the apex ; the basal segment covered with fulvous pubescence ; the other segments broadly fringed with silvery pubescence (but the fringe does not extend quite to the middle) at the apex. Pygidial area densely covered with silvery—inclining to golden—depressed stiff pile ; its apex truncated. Ventral segments punctured and covered with blackish hair. Tibiæ and tarsi densely covered with fulvous hair, the femora much more thinly ; calcaria and spines rufous. The second cubital cellule at the top is nearly one-fourth shorter than the third but at the bottom is longer than it ; the first recurrent nervure is received at one-half the length of the second cubital cellule at the top, the second a little beyond the middle, the distance between the two being a little more than the length of the third cubital cellule at the top.

Tirhoot, Bengal (*Rothney*) ; Calcutta (*Mus. Cal.*).

7. TACHYTES VICINUS, *sp. nov.*

Niger, dense cinereo hirtus, abdominis segmentis apice pedibusque argenteo pilosis; facie et clypeo longe dense argenteo pilosis; alis fere flavo-hyalinis; tegulis piceis. ♂. Long. 13 mm.

Scape sparsely covered with long pale hair; flagellum opaque, microscopically pubescent: the third joint is, if anything, shorter than the fourth, and not much more than twice the length of the second. Eyes at the top separated by nearly the length of the second and third antennal joints united. Clypeus equally projecting throughout; the apex rounded, hardly depressed. Vertex opaque, alutaceous; sparsely covered with longish fuscous hair; the front bears also long fuscous hair, and laterally a dense silvery pubescence. The silvery pubescence on the clypeus is long and dense. Clypeus distinctly punctured; mandibles still more distinctly and strongly punctured at the base, and bearing a short silvery pile; at the apex they are piceous. Thorax closely punctured all over; at the apex transversely striated. The hair is long and is especially thick on the metathorax. On the sides of the pronotum, and on the mesonotum in front of the tegulæ is a patch of silvery pubescence. The furrow on the apex of the metanotum is narrow and shallow. Abdomen aciculate; the base with sparse fuscous hair; the segments at the apex banded with silvery pubescence, interrupted on the second and third in the middle. Pygidial area with the silvery pile, dense and very bright; the apex roundly incised. Ventral segments at the apices bearing a dense tuft of longish brownish hair, and strongly punctured. Tibiæ and tarsi densely covered with silvery pile; the femora sparsely haired; the calcaria rufous; the tibial and tarsal spines whitish.

Hab. Tirhoot (*Rothney*).

8. TACHYTES NITIDULUS.

Crabro nitidulus, Fabricius, *Ent. Syst.* II., 294, 6; *Syst. Piez.* 309, 7.

Tachytes nitidulus, Smith, *Cat. Hym. Ins.* IV., 298; Dahlbom, *Hym. Ent.* I., 470.

Tachytes trigonalis, Saussure, *Hym. Novara Reise*, 72.

Common, Barrackpore (*Rothney*), Java.

9. TACHYTES TARSATUS.

Tachytes tarsatus, Smith, *Cat. Hym. Ins.* 296.

A specimen from Barrackpore, and another from Tirhoot, are probably referrable to this species. The antennæ are covered with a pale microscopic down; the third joint is a little longer than the fourth, and three times the length of the second. Eyes at the top separated by the length of the third antennal joint. Vertex and front almost shining, finely rugosely punctured. Clypeus punctured, the apex depressed, broadly rounded, entire. Thorax closely punctured all over; the median segment transversely punctured, the apex transversely striated, deeply furrowed down the centre. Abdomen aciculated, punctured closely and finely towards the apex. Pygidial area elongated, sharply pointed at the apex. Ventral surface shining, sparsely haired, aciculated, the apical segments punctured laterally. Wings yellowish hyaline, the nervures yellowish testaceous; the second cubital cellule one-fourth longer than the second; the first recurrent nervure is received about the length of the top of the second cubital cellule from the recurrent nervure; the second about the same distance beyond it, and before the middle of the cellule. The tarsi are only red at the apex.

T. fervidus, Sm., is the only other known Indian species with red abdomen, but it has the legs reddish.

Hab. Tirhoot (*Rothney*).

10. TACHYTES BASALIS, *sp. nov.*

Niger, dense argenteo pilosus; mandibulis, tegulis, scapo antennarum, abdomine dimidio basali apiceque tarsorum, rufis; *alis hyalinis, nervis rufo-testaceis.* ♀. Long. 10 mm.

Antennæ stout, densely covered with a whitish pile; the third and fourth joints subequal, and about three times longer than the second. Head almost shining; the cheeks, face, and clypeus densely covered with long silvery hair. A narrow but distinct furrow runs down the vertex to the front ocellus, going through the raised ocellar region, which is shining and impunctate at the sides and behind. Clypeus, broadly projecting, becoming sharply turned inwardly before the extreme apex, which thus does not stand on the same plane as the rest of the clypeus; the apex broadly rounded; eyes at the top, separated by about the length of the second and third joints united. Mandibles black at base and apex; the base densely covered with silvery pubescence; the sides bear some long white hairs. Thorax finely and closely punctured; the metathorax finely rugose; its sides and apex densely covered with long silvery hair; the apical furrow rather narrow. Sides of mesonotum bearing close to the tegulæ a broad band of silvery pubescence. The two portions of prothorax subequal laterally; the sternum projecting in front of the fore coxæ. Pleuræ and head densely covered with longish silvery hair. Abdomen shorter than the thorax, shining, aciculate; the segments edged with a fringe of silvery hair. Venter bearing some long fuscous hair. Pygidial area elongate, sharply rounded at the apex; covered with golden, interspersed with silvery bristles; the sides with a not very distinctly raised margin. The coxæ, trochanters and femora in the lower side densely covered with silvery hair; the tibiæ and tarsi densely covered with silvery pile; tibial and tarsal spines pale white; calcaria rufous; outer row of tibial spines rufous; metatarsal brush pale rufous.

Hab. Mussoorie hills (*Rothney*).

TACHYSPHEX.

Tachysphex, Kohl, *Ber. Ent. Zeit.* XXVII., 166; *Verh. z.-b. Ges. Wien*, 1884, 347. = *Tachytes* Auct.

1. TACHYSPHEX ERYTHROGASTER, *sp. nov.*

Niger; capite et thorace dense argenteo pilosis, basi antennarum, clypeo, pedibus abdomineque, rufis, alis clare hyalinis, tegulis pallide rufis, nervis fuscis. ♀. Long. 13 mm.

Antennæ short, stout; the third joint somewhat shorter than the fourth. Head finely rugose, but the rugosity hid, except in the centre of vertex, by the dense pubescence; ocellar region raised, broadly, but not deeply, furrowed in the centre; eyes at the top separated by the length of the third and fourth antennal joints united. Clypeus with an oblique slope at the apex, which is truncated; labrum with an incision in the middle; mandibles red, black at the apex; the base covered with silvery pubescence. Mesonotum and scutellum punctured; the sculpture of the rest of thorax hid by the dense covering of hair. The apex of metanotum furrowed, perpendicular; abdomen longer than the head and thorax united, very finely aciculated; the segments at the apices bearing a band of silky pile; pygidial area impunctate, narrowing to a point from the middle to the apex; the sides not very distinctly margined. The second cubital cellule less than one-fourth shorter than the third, and of the length of the space bounded by the recurrent nervures. Legs sparsely pilose, the spines white, the spurs red, the claws blackish.

Hab. Poona (*Wroughton*).

2. TACHYSPHEX ARGYREA.

Larrada Argyrea, Smith, *Cat. Hym. Ins.* IV.

The eyes at the top are separated by fully half the length of the third antennal joint. The part in which are the ocelli is raised; there is a broad transverse depression behind it; a thin furrow is on the top of the vertex, and a wider one runs down from the ocelli. Clypeus bare, shining, impunctate, pale rufous; the apex margined, projecting in the middle. Antennæ filiform rather than stout, densely covered with a pale pile; the second joint is one-third the length of the third. Pronotum rather depressed, having an oblique slope from the top. Pygidial area shining, impunctate, bare, the sides margined, but not stoutly; the apex rather sharply pointed and truncate. The abdominal segments bear laterally a dense silvery pubescence forming broad bands, which do not reach across.

The quantity of black on the abdomen varies, some specimens having the middle segments only slightly infuscated, while others have broad bands on the third—fifth segments. Smith, it may be added, does not state that the clypeus of *Argyrea* is rufous.

Hab. Mussoorie hills (*Rothney*).

3. TACHYSPHEX BENGALENSIS, *sp. nov.*

Niger, nitidus, punctatus, metathorace rugoso-reticulato, breviore quam mesothorace; alis clare hyalinis, nervis fere nigris. ♀. Long. 10 mm.

Head as broad as the thorax, the vertex sparsely, the cheeks, face and clypeus thickly covered with silvery hair; rather strongly punctured; the eyes at the top separated by the length of the second and third antennal joints united; ocellar region raised; a ∧-shaped depression behind them, with a short longitudinal furrow leading from it, this furrow being continued through the ocellar region itself. Clypeus punctured; margined, and almost truncated at the apex. Mandibles covered with long silvery hair at the basal half. Antennæ nearly as long as the head and thorax united, covered with a dense greyish pile, the third and fourth joints subequal. Thorax shining, bearing a fuscous to silvery pubescence ; the metathorax much more thickly than the mesothorax ; strongly (especially the pleuræ) punctured; the scutellum not so strongly as the mesonotum. Metathorax shorter than the mesothorax, broader than long, almost rounded at the apex, coarsely rugose, running into reticulations ; the apex strongly, nearly transversely striolated. Abdomen as long as the head and thorax united ; shining, obscurely shagreened ; the segments edged with silvery bands of pubescence, interrupted in the middle; the apex rather acuminate; pygidial area very shining, margined along the side, sparsely punctured. Femora sparsely, tibiæ and tarsi densely covered with white silvery hair ; the spines and claws pale ferruginous ; the calcaria blackish, reddish on the lower side. The second cubital cellule is about one-fourth longer than the third, the latter at the top being somewhat longer than the space bounded by the recurrent nervures. The apex of the radial cellule is narrow, not sharply angled on the lower part, but rather rounded, and reaches near to the apex of the third cubital. The appendicular cellule is narrow, but distinct.

Hab. Tirhoot (*Rothney*).

4. TACHYSPHEX AURICEPS, *sp. nov.*

Niger, aureo-hirtus; pedibus, abdominisque segmentis 1 et 2 rufis, coxis, trochanteribus basique femorum, nigris, alis flavo-hyalinis. ♀ *et* ♂. Long. 12 mm. ♀, 9 mm. ♂.

Antennæ stout, covered with a short white pile ; the third and fourth joints subequal. Head as wide as the thorax ; the front, cheeks, face, and clypeus covered with a golden pubescence, the vertex with a much shorter and thinner fulvous to golden pile ; finely punctured ; the eyes at the top separated by the length of nearly the second and third antennal joints united ; the vertex furrowed in the centre, the furrow ending in a short Λ-shaped furrow ; ocellar region raised, a wide and shallow furrow in the centre, continued down the front as a narrower and more distinct furrow; clypeus at the apex with a distinct, moderately wide margin, rounded and with some small irregular indentations. Mandibles with a red band towards the apex. Thorax covered with a short golden fulvous pile, much longer and thicker on the sides and metathorax; finely and closely punctured; metanotum irregularly transversely rugose, the apex tranversely striolated. Abdomen longer than the thorax; the segments with a broad interrupted band of white pubescence; aciculate; pygidial area with a raised margin along the sides; the apex sharply rounded, bare. Legs shortly pilose; the tibial spines and spurs red; the claws fuscous towards the apex. Second cubital cellule at top half the length of the third, and less than the length of the space bounded by the recurrent nervures, which are received a little in front, and a little beyond the middle respectively.

The ♂ agrees in coloration with the ♀, but the golden pubescence on the head is closer and thicker, the eyes at the top are separated by slightly more than the length of the fourth antennal joint; the third joint is shorter than the fourth; the metanotum is rugose; the two basal joints of the abdomen are banded with black; the wings want the yellowish hue; the second cubital cellule is longer than the third; the nervures are fuscous; and the first transverse cubital nervure is more sharply angled below the middle.

Hab. Poona (*Wroughton*).

GASTROSERICUS.

Gastrosericus, Spinola, *Ann. Soc. Ent. Fr.* VII., 480; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 408.

A genus of small extent, only three species having been hitherto described.

1. GASTROSERICUS WROUGHTONI, *sp. nov.*

Niger, albo pilosus; tegulis, abdominis segmentis 1—2 *apiceque tarsorum, rufis; alis hyalinis.* Long. 11 mm.

Antennæ as long as the thorax, densely covered with a silvery pile; the third and fourth joints subequal, dilated at the apex; the second one-third of the length of the third. Head fully wider than the thorax; the cheeks, face, and clypeus densely covered with a silvery pubescence; the front and vertex much more sparsely. Eyes at the top separated by fully the length of the second and third joints united; there is a shallow indistinct furrow in the centre of the vertex; ocelli surrounded by a deep furrow; hinder ocelli shining, curved, elongated; vertex and front coarsely aciculated. Apex of clypeus truncated; mandibles reddish, black at the apex. Thorax punctured, densely covered with cinereous pubescence; metanotum finely rugose; its apex perpendicular, almost truncated, but with the sides rounded. Abdomen longer than the thorax, shining, aciculated, the segments broadly banded with a silvery pubescence; pygidial area bare, except at the apex, which bears long depressed fulvous hair; the basal portion with scattered punctures. Legs densely covered with silvery pubescence, especially thick on the tibiæ and tarsi; the anterior tibiæ and tarsi are for the greater part reddish, as are all the knees and spurs; the spines are whitish. At the top the cubital cellule is somewhat longer than the space bounded by the recurrent nervures, which are received in the basal fourth of the cellule; the second transverse cubital cellule is curved to near the top, when it becomes angled and straight.

2. GASTROSERICUS ROTHNEYI, *sp. nov.*

Niger, argenteo pilosus, punctatus; geniculis lineaque tarsorum, albis; alis hyalinis, apice fere fumatis; nervis fuscis; tegulis albis. Long. 7 mm.

Antennæ with a silvery pile; the third and fourth joints subequal. Head closely punctured; the face, cheeks, and clypeus densely covered with long silvery pubescence; eyes almost parallel, at the top separated by the length of the second, third and fourth joints united. Ocellar region raised, roundish, surrounded by a furrow; hinder ocelli as in *G. Wroughtoni*; a narrow indistinct furrow runs down from the front ocellus. Clypeus with a broad truncated projection in the middle at the apex; the middle keeled. Mandibles reddish, black at the base. Thorax finely and closely punctured; the metanotum finely transversely striated, its apex with an oblique slope and furrowed in the middle. The pleuræ and the edge of the pronotum are densely covered with silvery pubescence; the pubescence being especially long on metapleuræ; the tubercles are white. Abdomen aciculate, the segments broadly edged with cinereous pile; pygidial area densely covered with fulvo-golden stiff pubescence. The legs are pilose: the knees, a broad line on the tibiæ behind, the apex of the tarsi and the greater part of the claws are white. The second recurrent nervure is joined to the first before the latter is united to the cubital; the second transverse cubital nervure is not so sharply elbowed as in the preceding species.

Hab. Barrackpore (*Rothney*).

PALARUS.

Palarus, Latreille, *Hist. Nat. Crust. et Ins.* VII., 336; Kohl, *Verh. z.-b. Ges. Wien*, 1884, 416.

1. *Palarus orientalis*, Kohl, *l. c.*, 422.
(?) *Palarus interruptus*, Dahlbom, *Hym. Ent.* I., 468.
Hab. Ceylon.

2. *Palarus interruptus*, Dahlbom, *Hym. Ent.* I., 468.
Hab. " Ind. Or."

ASTATA.

Astatus, Latr., *Precis. des caract. gén. des. Ins.*, p. 114, 14.

Astata, Latr., *Hist. Nat. Gén. et part. des Crust. et Inst.* t. III., p. 336.

Over thirty species of this genus are known from various parts of the world, but more particularly from America. Only two have hitherto been recorded from our region.

1. ASTATA MACULIFRONS, *sp. nov.*

Niger, fronte proparte tegulisque flavis; abdominis segmentis 2—5 *rufis; alis fusco-hyalinis.* ♂. Long. 9 mm.

Antennæ thickened towards the apex, the scape and second and third joints covered with longish hair; the second joint a little longer than the third, and both are perceptibly thinner than the succeeding joints. Front and vertex strongly punctured, almost rugose; the clypeus almost impunctate; the apex broadly rounded; mandibles rugosely punctured at the base; the apex piceous-red. The yellow mark on the front is broader than long, and is rounded at the sides, and is incised in the middle. Pro- and mesothorax shining, sparsely but distinctly punctured; the pleuræ more strongly punctured than the mesonotum; metathorax opaque, coracious, striolated at extreme base; the central part separated from the sides by a curved deep furrow; there is an indistinct keel down the centre, and the apex is rugosely punctured. Abdomen red, the base and the apical two segments black. The second cubital cellule is about two-thirds of the length of the third, and half the length bounded by the recurrent nervures; the first recurrent nervure is received not far from the base; the second a little before the middle of the cellule. The stigma and the nervures beyond its base are testaceous; the apex of the wing is almost hyaline. The legs are covered with long black hair; the anterior knees, tibiæ, and tarsi in front are sordid testaceous, the posterior tarsi have the apices of the joints testaceous.

Hab. Mussoorie hills (*Rothney*).

2. Astata agilis.

Smith, *Trans. Ent. Soc.*, 1875. 39.

Nigra, facie pleurisque longe argenteo pilosis; *abdominis segmentis* 1—3 *rufis; metathorace reticulato; alis hyalinis, apice fumatis; tegulis piceis.* ♀. Long. 9 mm.

Antennæ with a close glistening pile; the third joint a little longer than the fourth. Head shining, the front closely but not strongly punctured; the occiput, cheeks, face, and clypeus covered with long silvery hair; there is a short furrow below the front ocellus; the clypeus is rounded at the apex; the mandibles black, reddish in the middle and on the lower side. Thorax shining; the pro- and base of mesonotum closely punctured, the rest of the latter and the scutellum with scattered punctures; the pleuræ coarsely punctured; metanotum longitudinally reticulated; the metapleuræ strongly obliquely striolated; the apex coarsely rugose. Abdomen aciculate; the pygidial area finely rugose; margined at the sides, sharply pointed at the apex. Second cubital cellule half the length of the third and of the space bounded by the recurrent nervures; the first recurrent nervure is received a little before the middle, the second at a somewhat greater distance beyond the middle of the cellule. Tibiæ thickly spined, the apices of the tarsi fuscous.

Hab. Tirhoot, Nischindepore (*Rothney*), Poona (*Wroughton*).

3. Astata orientalis. Smith, *Cat. Hym. Ins.* IV. p. 310, 14.

"India."

This species appears to be closely allied to the preceding, but it differs in having four carinæ on the mesothorax, the wings are flavo-hyaline, clear at the apex, and with ferruginous nervures.

Hab. Nischindipore (*Rothney*).

4. ASTATA ARGENTEOFAÇIALIS, *sp. nov.*

Nigra, argenteo hirsuta, subtilisme punctata; *metanato rugoso; abdomine fusco*; *alis hyalinis.* ♀. Long. 8 mm.

Antennæ covered with a white microscopic pile; the third joint perceptibly longer than the fourth. Head opaque, coarsely alutaceous; the occiput, lower part of front, face, and clypeus densely covered with a silvery pubescence; clypeus incurved in the middle at the apex; mandibles piceous-red, black in the middle. Thorax opaque, coarsely aciculated; the metanotum finely rugose, furrowed down the centre, near to the apex above; the apex oblique, coarsely rugose; the pleuræ, the pronotum (except in the centre), the sides of the mesonotum; the hollow at the side of the scutellum, and the sides of the metanotum densely covered with silvery pubescence. Abdomen shining, very finely aciculate; the segments lined at their junction with a silvery pile; the basal and apical segments are more or less blackish. Legs covered with a silvery pile; the spurs and spines white. The second cubital cellule at the top is half the length of the third, and half the length of the space bounded by the recurrent nervures; at the bottom it is not much shorter than the third; the first and second transverse cubital nervures are straight; the first recurrent nervure is received not far from the base of the cellule, the second at nearly double the distance from the apex.

What is apparently the same species has the first and second abdomial segments clear red, and the others quite black.

Hab. Barrackpore (*Rothney*).

ASTATA NIGRICANS, *sp. nov.*

Nigra, nitida, punctata, longe argenteo hirta; *metanoto striolato; alis hyalinis, nervis, fuscis.* ♂. Long. fere 8 mm.

Antennæ as long as the thorax, microscopically pilose, the joints dilated slightly at the apex; the third joint slightly longer than the fourth. Head (except the ocellar region) densely covered with long silvery hair, moderately punctured ; the apex of clypeus rounded ; mandibles piceous beyond the middle; the palpi fuscous. Mesonoto and pleuræ punctured, the latter strongly; the metanotum strongly longitudinally striolated, and irregularly reticulated ; the hair on the upper part moderately dense, on the sides long and thick; abdomen of the length of the pro- and mesothorax ; shining, aciculated ; the sides and ventral surface densely covered with long cinereous hair ; the segments broadly dull piceous, red at the apices. Legs densely covered with long cinereous hair ; the tarsi piceous-red. Second cubital cellule at the top one fourth of the length of the third, and half the length of the space bounded by the recurrent nervures, which are received on either side of the middle of the cellule. The appendicular cellule is incomplete, the nervure ending not far from the radial cellule ; the third transverse cubital nervure is angled and issues a short nervure below the middle ; the first is sharply angled below the middle.

Hab. Poona (*Wroughton*).

NOTE.—The reference to *Pelopœus violaceus* (p. 102) should be deleted. I now believe, contrary to the opinion of André, that the European *P. violaceus* is not found in India, and is quite distinct from *P. bengalensis.*—P.C., April 15th, 1889.

Ordinary Meeting, February 5th, 1889.

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

Mr. F. J. FARADAY read a letter from M. C. Tondini de Quarenghi, stating that the French Minister of Public Instruction had informed him that he proposed to invite a conference in Paris this year to resume the consideration of the question of the unification of time and the adoption internationally of a common meridian for scientific purposes, or, in other words, to take up the work of the unsuccessful congress held at Washington.

Dr. BOTTOMLEY read a paper entitled, "On the equation to the instantaneous surface generated by the dissolution of an isotropic solid."

On the equation to the Instantaneous Surface generated by the dissolution of an Isotropic Solid. By James Bottomley, D.Sc.

(*Received February 5th, 1889.*)

I. *The Subject considered geometrically.*

Although the phenomenon of dissolution of a solid is one of the most striking in chemistry, it does not, as a general problem, seem to have been the subject of exact enquiry; nor do the text books of chemistry supply an answer to the following question:—Given the form of an isotropic solid placed in a menstruum capable of dissolving it, what will be the surface at any subsequent time bounding the undissolved portion. Considering the infinite variety of forms which the primitive solid may have, whether bounded by continuous or discontinuous surfaces, the subject might seem to be impracticable. After some reflection on the matter, two propositions occurred to me which seem to be of sufficient generality to include every case which may present itself. The first of these propositions is as follows: *If lines normal to a curve be cut by a second curve at a constant distance from the first, then these lines will be normal to the second curve.* The proof is not difficult; let X, Y be co-ordinates of a point P on the first curve, and

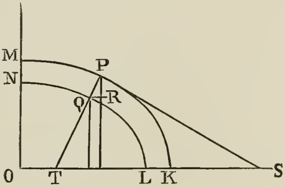


Fig. 1.

x, y co-ordinates of a point Q on the second curve, let PT and PS be the normal and tangent at P, also let $PQ = c$ be a constant, then we have

$$(X - x)^2 + (Y - y)^2 = c^2 \qquad (1)$$

c being constant, and all the other variables being regarded as functions of X, we get by differentiation

$$(X - x)\left(1 - \frac{dx}{dX}\right) + (Y - y)\left(\frac{dY}{dX} - \frac{dy}{dX}\right) = 0 \qquad (2)$$

but $\frac{Y - y}{X - x} = \tan PQR = \tan PTS = \cot PST = \frac{1}{\tan PST} = -\frac{1}{\frac{dY}{dX}}$

by substitution in (2) we get

$$1 - \frac{dx}{dX} - \frac{1}{\frac{dY}{dX}}\left(\frac{dY}{dX} - \frac{dy}{dX}\right) = 0$$

$$\therefore \frac{dY}{dX} = \frac{\frac{dy}{dX}}{\frac{dx}{dX}} = \frac{dy}{dx} \qquad (3)$$

Hence the tangent at Q is parallel to the tangent at P, and PT is normal to the second curve at the point Q. This proposition will be of service in treating of the dissolution of cylindrical solids, and surfaces of revolution. The co-ordinates of the curves will be connected by the following relationship :

$$x = X - c\cos\phi \qquad (4)$$
$$y = Y - c\sin\phi$$

ϕ denoting the angle PTS. If for the angular functions we substitute their values in terms of the co-ordinates X, Y, we shall obtain equations which we may write

$$x = f_1(X, Y, c) \qquad (5)$$
$$y = f_2(X, Y, c)$$

and from these we may obtain equations of the form

$$Y = F_1(x, y, c) \qquad (6)$$
$$X = F_2(x, y, c)$$

if the primitive equation be $\psi(X, Y) = 0$, to obtain the derived equations we must substitute for X and Y from (6).

In these equations c is a variable parameter, and by giving it successive values from 0 until we exhaust the normals to the first surface, we may obtain the equations to the successive derived curves from the commencement of dissolution until its completion.

If s and S denote the lengths of the derived and primitive curves measured from two fixed points up to the common normal, we may deduce from (3)

$$\frac{ds}{dx}=\frac{dS}{dX}, \qquad (7)$$

and by integration

$$s=\int\frac{dS}{dX}\frac{dx}{dX}dX, \qquad (8)$$

from (4) by differentiation we obtain

$$\frac{dx}{dX}=1+c\sin\phi\frac{d\phi}{dX}$$

also $\frac{dS}{dX}=\frac{1}{\sin\phi}$; substituting in (8) and completing the integration we obtain the equation

$$s=S+c\phi+n,$$

n denoting a constant; to find its value suppose that in Fig. 1 MP=S and NQ=s, then we shall have simultaneously $s=0$, $S=0$, $\phi=\frac{\pi}{2}$; hence $n=-c\frac{\pi}{2}$, and the last equation may be written

$$s=S-c\left(\frac{\pi}{2}-\phi\right) \qquad (9)$$

There is also another equation which may be deduced from this, which will be found useful. Suppose that c is not greater than the radius of curvature at any point of the curve MK, and that OM, OK are normals, then the area MNLK may be written $\int^{c} sdc$, if then we multiply (9) by dc, and integrate we get

$$\text{MNLK}=Sc-\frac{c^2}{2}\left(\frac{\pi}{2}-\phi\right) \qquad (10)$$

In the figure the angle at O is a right angle, so that in this case $\phi = 0$. From the last equation we may obtain an expression for the undissolved area, for we shall have

$$\text{ONL} = \text{OMK} - \text{S}c + \frac{c^2}{2}\left(\frac{\pi}{2} - \phi\right) \qquad (11)$$

when for ϕ, 0 must be written, if as in the figure the angle between the extreme normals be a right angle. As a particular example of the foregoing investigation, suppose that we have a cylinder of which a section normal to its length is the parabola

$$\text{Y}^2 = 4a\text{X}$$

From the two following equations

$$(\text{Y} - y)^2 + (x - \text{X})^2 = c^2,$$

$$\frac{\text{Y} - y}{x - \text{X}} = \frac{\frac{1}{2a}}{\text{Y}},$$

along with the equation to the parabola, we obtain

$$(x - \text{X})^2(\text{X} + a) = ac^2$$

$$\text{X}(2a + \text{X} - x)^2 = ay^2 \qquad (12)$$

From these equations we may deduce

$$\text{X} = \frac{x - 2a}{3} + \sqrt{\frac{y^2 + x^2 - c^2}{3} + \frac{(x - 2a)^2}{9}}.$$

substituting this value of X in (12), we obtain the following as the equation to the curve cutting the normals to a parabola at a constant distance.

$$ay^2 = \left\{\frac{x - 2a}{3} + \sqrt{\frac{y^2 + x^2 - c^2}{3} + \frac{(x - 2a)^2}{9}}\right\} \left\{\sqrt{\frac{y^2 + x^2 - c^2}{3} + \frac{(x - 2a)^2}{9}} - \frac{x - 2a}{3}\right\}^2 \qquad (13)$$

This equation when expanded so as to get rid of radical forms, is of the sixth degree ; it will also include an external branch, cutting the normals produced externally at a distance c. If in (13), 0 be written for c, it will be found to include the parabola itself; for we then may write the equation in the form

$$(y^2 - 4ax)^2\left(y^2 + (x - a)^2\right) = 0.$$

In the present enquiry it will only be necessary to consider the internal portion of the curve. The radius of curvature at the vertex of the parabola is $2a$; provided c be not greater than this quantity, the internal curve will cut all the normals to the parabola in the first quadrant in the same quadrant, but if greater, it will cut some of these normals in the lower quadrant, as in Fig. 2, where EB cuts

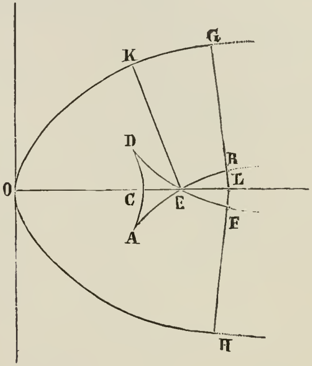


Fig. 2.

all the normals in the first quadrant, but the remaining portion of this branch of the curve cuts them in the second quadrant; having descended some distance below the axis of the parabola, this branch will cease to cut the normals, but at the point A there is a cusp, and the portion AC cuts the remaining normals drawn to the parabola in the first quadrant; hence OC the intercept on the axis is equal to c. From symmetry, we may infer that the branch AC will be continued above the axis of x to a point D where there will be another cusp, and that there will be a branch DF corresponding to AB, and passing through E, which will therefore be a double point. The position of the cusps is given by the equations

$$x = a\left(3\left(\frac{c}{2a}\right)^{\frac{2}{3}} - 1\right), \quad y = \pm 2a\left\{\left(\frac{c}{2a}\right)^{\frac{2}{3}} - 1\right\}$$

if in (13) $y=0$ the corresponding values of x are $\pm c$ and $a+\frac{c^2}{4a}$, this latter quantity will be the distance OE of the double point from the origin. In order to assign some definite volume to the cylinder, we may suppose it to be bounded by two planes, of which the sections by a plane normal to the length of the cylinder are the lines GL, LH; furthermore let these lines be normals to the parabola at G and H, let also the planes just mentioned, and the extremities of the cylinder be covered with some insoluble compound so that dissolution is confined to the curved surface. The first stage of dissolution will be to remove a thin shell in the element of time dt, this shell having everywhere the same normal thickness dc; to the new surface the same lines will be normal, and in another element of time dt a second shell will be removed, having everywhere the same infinitesimal thickness, and so the process will continue until the solid be exhausted. Of the curve in Fig. 2 the portion EAD has no physical existence; the portion bounding the undissolved area will be BEF; as dissolution proceeds there will be a progression of the point E on the axis of x, at the same time the area BEF diminishes, and the length of c increases, hence the object of the enquiry will be to represent this area as a function of c, and if c be some ascertainable function of the time, we may determine, either exactly or with any required degree of approximation, the area of BEF, and consequently the dimensions of the undissolved cylinder at any time. At this point then we may see that the doctrine of solution consists of two enquiries, the determination of the volume of the undissolved solid as a function of c, and the determination of c as a function of the time, the first is a geometrical question, the second a chemical one, to be decided by experiments in the laboratory; the first enquiry may be pursued in perfect independence of the latter. In the present case the area BEF in terms of c may be obtained as follows:

$$\text{BEF} = 2\text{BEL} = 2(\text{OGL} - \text{EBGK} - \text{OKE})$$

Let ϕ be the angle OEK, Ω the angle OLG, then

$$\text{EBGK} = \text{arcKG}.c - \frac{c^2}{2}(\Omega - \phi),\ \text{KG} = \text{OG} - \text{OK}$$

$$\text{OK} = a\frac{\sin\phi}{\cos^2\phi} + a\log\{\tan\phi + \sqrt{1 + \tan^2\phi}\}$$

$$\text{OKE} = \frac{4}{3}a^2\tan^3\phi + c^2\frac{\sin\phi\cos\phi}{2}$$

also, we have the following equation connecting ϕ and c

$$2a = c\cos\phi,$$

from these equations by elimination of ϕ we obtain

$$\text{area BEF} = \text{A} + \frac{(c^2 - 4a^2)^{\frac{3}{2}}}{6a} - \text{P}c + 2ac\log\frac{c + \sqrt{c^2 - 4a^2}}{2a}$$
$$+ c^2\left(\Omega - \cos^{-1}\frac{2a}{c}\right)$$

wherein A stands for the area, and P for the perimeter of the curve GOH; if l be the length of the normal LG, then the values of c in the last equation will extend from $2a$ to l; in the latter case the area BEF vanishes, and this corresponds with complete dissolution of the cylinder. If c be less than $2a$ for the area BEF we should have the value $\text{A} - \text{P}c + c^2\Omega$.

In what precedes the figure has been supposed to represent a section of a cylinder, if we suppose the figure to revolve round OL, the values of x and y deduced from equations (4), and the equation to the parabola, introduced into the expressions $\text{V} = \pi\int y^2dx$, would serve to find the volume undissolved at any time of a surface of revolution generated by the solution of a paraboloid, the action being restricted to the curved surface.

Next consider a right cylinder of which the section is the ellipse

$$b^2X^2 + a^2Y^2 = a^2b^2.$$

Also let us suppose that the action of the solvent is confined to the curved surface, then x, y being co-ordinates of a point on the instantaneous curve situated on the same normal as the point X, Y we have the following relationship

$$\frac{Y-y}{X-x} \cdot \frac{b^2X}{a^2Y} = 1$$

whence

$$Y = \frac{b^2yX}{a^2(x-X)+b^2X}$$

substituting this value of Y in the equation to the ellipse and the equation

$$(Y-y)^2 + (X-x)^2 = c^2,$$

we obtain

$$X^2\{a^2x - X(a^2-b^2)\}^2 + a^2y^2b^2X^2 - a^2\{a^2x - X(a^2-b^2)\}^2 = 0$$

$$(X-x)^2[a^4y^2 + \{a^2x - X(a^2-b^2)\}^2] - c^2\{a^2x - X(a^2-b^2)\}^2 = 0$$

expanding these equations in powers of X, we may for brevity write the results as follows

$$PX^4 - QX^3 + RX^2 + SX - T = 0 \qquad (14)$$

$$UX^4 - VX^3 + WX^2 - YX + Z = 0 \qquad (15)$$

the coefficients of the different powers of X having the following values:

$$\left.\begin{aligned}
P &= U = (a^2-b^2)^2 \\
Q &= 2a^2x(a^2-b^2) \\
R &= a^2y^2b^2 + a^4x^2 - a^2(a^2-b^2)^2 \\
S &= 2xa^4(a^2-b^2) \\
T &= a^6x^2 \\
V &= 2x(a^2-b^2)(2a^2-b^2) \\
W &= a^4(x^2+y^2) + 4a^2x^2(a^2-b^2) + (a^2-b^2)^2(x^2-c^2) \\
Y &= 2\{a^4x(x^2+y^2) + a^2x(a^2-b^2)(x^2-c^2)\} \\
Z &= x^2a^4(x^2+y^2) - x^2a^4c^2
\end{aligned}\right\} \qquad (16)$$

Since P = U, if we subtract (14) from (15), we obtain

$$X^3(Q-V) + X^2(W-R) - X(Y+S) + Z + T = 0 \qquad (17)$$

If we multiply this last equation by PX, and subtract from (14), multiplied by Q − V, we obtain

$$-X^3\{Q(Q-V)+P(W-R)\}+X^2\{R(Q-V)+P(Y+S)\}$$
$$+X\{S(Q-V)-P(Z+T)\}-T(Q-V)=0$$

eliminating X^3 between this equation and (17), we obtain the following quadratic equation for determining X :

$$\left.\begin{array}{r} X^2\{(R(Q-V)+P(Y+S))(Q-V)+(Q(Q-V)+P(W-R)) \\ (W-R)\}+X\{(S(Q-V)-P(Z+T))(Q-V)-(Q(Q-V) \\ +P(W-R))(Y+S)\}-T(Q-V)^2+(Q(Q-V) \\ +P(W-R))(Z+T) \end{array}\right\}=0$$

If we write the solution of this equation in the form

$$X=-\frac{B}{2A}+\frac{1}{2A}\sqrt{B^2-4AC}$$

the following will be the values of the letters A, B, C deduced from (16):

$$A=(a^2-b^2)^4\{x^4(a^2-b^2)^2+2x^2(a^2y^2(a^2+b^2)-(a^2-b^2)^2(a^2+c^2))$$
$$+(a^2y^2+(a^2-b^2)(a^2-c^2))^2\}$$
$$B=2(a^2-b^2)^3a^2x\{x^4(a^2-b^2)^2+x^2(a^2y^2(2a^2-b^2)-2(a^2-b^2)^2(a^2+c^2))$$
$$+(a^2y^2+(a^2-b^2)(a^2-c^2))^2\}$$
$$C=(a^2-b^2)^3a^4x^2\{x^4(a^2-b^2)+x^2((2a^2-b^2)y^2-2(a^2-b^2)(a^2+c^2))$$
$$+(y^2+a^2-c^2)(a^2y^2+(a^2-b^2)(a^2-c^2))\}$$

From the value of X thus obtained, we may deduce the value of Y by writing in the formulæ b, y, x for a, x, y respectively ; these values of X and Y substituted in the equation to the ellipse or in the equation

$$(X-x)^2+(Y-y)^2=c^2$$

will give the equation to the instantaneous curve generated by the dissolution of an elliptic cylinder. It will also give an external curve cutting the normals at a distance c from the ellipse. The radius of curvature at the extremity of the major axis of the ellipse has the value $\frac{b^2}{a}$, while c is less than this value, the internal curve cuts the normals drawn in any quadrant in the same quadrant, when c is greater, the curve becomes more complicated and assumes the form represented in the figure. The branch CD cuts a portion of the

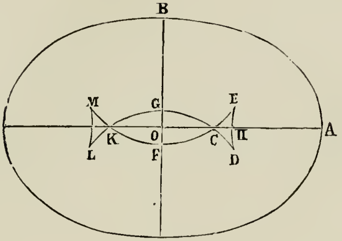


Fig. 3.

normals to AB; at D is a cusp and the remaining normals in the first quadrant are cut by HD; the normals to the lower quadrant are cut by the branch FCEH, there being a second cusp at E, and C being a double point; to the left of the axis of y there is another portion of the curve symmetrical with that to the right. Of the curve thus found the portions ECD, LMK, have no physical existence, the undissolved area at any time will be represented by CGKF. The position of the cusps is given by the equations,

$$y = \pm \frac{c}{a^2 \sqrt{a^2 - b^2}} \left\{ a^2 - \left(\frac{b^2 a^2}{c} \right) \right\}^{\frac{3}{2}}$$

and

$$x = \pm \frac{1}{\sqrt{a^2 - b^2}} \left(a^{\frac{4}{3}} - b^{\frac{2}{3}} c^{\frac{2}{3}} \right)^{\frac{3}{2}};$$

the final positions of the cusps corresponding with total dissolution of the cylinder will be obtained by writing b for c, they will be

$$y = \pm \frac{b}{\sqrt{a^2 - b^2}} \left(a^{\frac{2}{3}} - b^{\frac{2}{3}} \right)^{\frac{3}{2}} \text{ and } x = \pm \frac{\left(a^{\frac{4}{3}} - b^{\frac{4}{3}} \right)^{\frac{3}{2}}}{\sqrt{a^2 - b^2}}.$$

The position of the double points is given by the equations

$$y = 0, \quad x = \pm \frac{\sqrt{(b^2 - c^2)(a^2 - b^2)}}{b}.$$

In order to trace the progress of the dissolution of the cylinder it will be necessary to express the area as a function of c; by reference to Fig. 4, it will be seen that

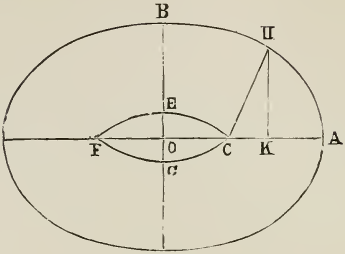


Fig. 4.

$$\text{CEFG} = 4.\text{OEC} = 4(\text{OBHK} - \text{EBHC} - \text{CHK}).$$

X being the abscissa of the point H, we have the following relations (ϕ denoting the angle HCA).

$$\text{EBCH} = c.\text{BH} - \frac{c^2}{2}(\pi - \phi);$$

$$\text{BH} = \int \frac{d\text{X}}{\sin\phi};$$

$$\text{OBHK} = \frac{b}{a}\left\{\frac{\text{X}\sqrt{a^2 - \text{X}^2}}{2} + \frac{a^2}{2}\sin^{-1}\frac{\text{X}}{a}\right\};$$

$$\text{X} = \frac{a^2}{\sqrt{a^2 + b^2\tan^2\phi}};$$

$$\text{Cos}\phi = \frac{b}{c}\,\frac{\sqrt{b^2 - c^2}}{\sqrt{a^2 - b^2}};$$

$$\text{CHK} = \frac{c^2}{2}\cos\phi\sin\phi.$$

From these equations we obtain by elimination

$$\text{CEFG} = \frac{2\sqrt{(b^2 - c^2)(a^2c^2 - b^4)}}{b} + 2ab\sin^{-1}\frac{a}{b}\sqrt{\frac{b^2 - c^2}{a^2 - b^2}}$$

$$- 4\frac{a^2c}{b}\int \frac{c^2dc}{\sqrt{(a^2c^2 - b^4)(b^2 - c^2)}} + 2c^2\left(\frac{\pi}{2} - \sin^{-1}\frac{1}{c}\sqrt{\frac{a^2c^2 - b^4}{a^2 - b^2}}\right).$$

This formula applies from

$$c = \frac{b^2}{a} \text{ to } c = b.$$

If we suppose the last figure to revolve round the axis of x, then the instantaneous curve will trace out the surface bounding the undissolved portion at any instant, when a prolate spheroid is acted upon by a solvent; the values of x and y substituted in the formula $\pi\int y^2dx$ will give the volume of this undissolved solid; in like manner, if the figure revolve round the axis of y, from the foregoing investigation we may deduce the value of the integral $\pi\int x^2dy$, being the volume at any instant of the solid generated by the solution of an oblate spheroid.

The second proposition, before referred to, which enables us to investigate geometrically the dissolution of all solids is as follows. *If a surface be drawn cutting the lines normal to a given surface at a constant distance from the surface, then these lines will be normal to the surface so drawn.* Let X, Y, Z, be co-ordinates of a point on the given surface $\phi(X, Y, Z,)=0$ and x, y, z co-ordinates of a point on the instantaneous surface $\psi(x, y, z)=0$, then c denoting a constant we have the equation

$$(X-x)^2+(Y-y)^2+(Z-z^2)=c^2. \qquad (18)$$

At a contiguous point we shall have

$$(X+dX-x-dx)^2+(Y+dY-y-dy)^2+(Z+dZ-z-dz)^2=c^2;$$

expanding and eliminating the constant, we get

$$(X-x)(dX-dx)+(Y-y)(dY-dy)+(Z-z)(dZ-dz) \\ +(dX-dx)^2+(dY-dy)^2+(dZ-dz)^2=0;$$

if the second point be taken indefinitely near to the first point, then neglecting small quantities of the second order, the last equation may be written in the form

$$(X-x)dX+(Y-y)dY+(Z-z)dZ=(X-x)dx \\ +(Y-y)dy+(Z-z)dz.$$

since the line is normal to the surface $\phi(X,Y,Z)$ the expression on the left vanishes. Hence we have

$$(X-x)dx+(Y-y)dy+(Z-z)dz=0,$$

and this is the condition to be fulfilled, that the line may be a normal to the instantaneous surface $\phi(x,y,z)$.

From the two last equations we may deduce

$$dz = -\frac{(Y-y)}{Z-z}dY - \frac{(X-x)}{Z-z}dX$$

$$dz = -\left(\frac{Y-y}{Z-z}\right)dy - \left(\frac{X-x}{Z-z}\right)dx\,;$$

hence we have

$$\frac{dZ}{dY} = -\frac{Y-y}{Z-z}$$

$$\frac{dZ}{dX} = -\frac{X-x}{Z-z}$$

$$\frac{dz}{dx} = -\frac{X-x}{Z-z}$$

$$\frac{dz}{dy} = -\frac{Y-y}{Z-z}$$

hence

$$\frac{dZ}{dX} = \frac{dz}{dx} \text{ and } \frac{dZ}{dY} = \frac{dz}{dy}$$

and from these equations we may obtain,

$$\sqrt{1 + \left(\frac{dZ}{dX}\right)^2 + \left(\frac{aZ}{dY}\right)^2} = \sqrt{1 + \left(\frac{dz}{dx}\right)^2 + \frac{dz}{dy}\Big)^2} \qquad (19)$$

the expression on the left measures the inclination of the tangent plane at the point X, Y, Z, to the plane of xy, and the expression on the right measures the inclination of the tangent plane at x, y, z, to the same plane, hence these tangent planes are parallel, therefore the line

$$\frac{X-x}{c} = \frac{Y-y}{c} = \frac{Z-z}{c}$$

is normal to both surfaces. If a, β, γ be the direction angles of the normal to the primitive surface ϕ(X, Y, Z,) we have the equations

$$\begin{aligned} x &= X - c\cos a \\ y &= Y - c\cos\beta \\ z &= Z - c\cos\gamma \end{aligned} \qquad (20$$

which may be written in the form

$$x = \frac{X - \dfrac{d\phi}{c dX}}{\sqrt{\left(\dfrac{d\phi}{aX}\right)^2 + \left(\dfrac{d\phi}{dY}\right)^2 + \left(\dfrac{d\phi}{dZ}\right)^2}}$$

$$y = \frac{Y - c\dfrac{d\phi}{dY}}{\sqrt{\left(\dfrac{d\phi}{dX}\right)^1 + \left(\dfrac{d\phi}{aY}\right)^2 + \left(\dfrac{d\phi}{dZ}\right)^2}}$$

$$z = \frac{Z - c\dfrac{d\phi}{dZ}}{\sqrt{\left(\dfrac{d\phi}{aX}\right)^2 + \left(\dfrac{d\phi}{aY}\right)^2 + \left(\dfrac{d\phi}{dZ}\right)^2}}$$

if in these equations we substitute for the differential coefficients their values in terms of the co-ordinates, we may write

$$\begin{aligned} x &= f_1(X,Y,Z,c) \qquad (21) \\ y &= f_2(X,Y,Z,c) \\ z &= f_3(X,Y,Z,c) \end{aligned}$$

from these equations we may deduce

$$\begin{aligned} X &= F_1(x,y,z,c) \qquad (22) \\ Y &= F_2(x,y,z,c) \\ Z &= F_3(x,y,z,c) \end{aligned}$$

These values of X, Y, Z substituted in the equation $\phi(X,Y,Z) = 0$, or in (18) will give the instantaneous surface generated by the solution of the given surface. By the variation of c, we shall obtain the successive surfaces from the commencement until the completion of dissolution; the equation will also include the primitive surface if we write 0 for c.

In order to test the accuracy of the above reasoning, suppose the primitive surface to be the sphere

$$X^2 + Y^2 + Z^2 = r^2$$

then, since

$$\frac{dz}{dx} = -\frac{X}{Z}, \quad \frac{dZ}{dY} = -\frac{Y}{Z}$$

we shall have the additional equations

$$X - x + (Z - z)\frac{X}{Z} = 0$$

$$Y - y + (Z - z)\frac{Y}{Z} = 0$$

$$(X - x) + (Y - y)^2 + (Z - z)^2 = r^2;$$

from these we may deduce

$$Z = \frac{zr}{r \pm c}, \quad X = \frac{xr}{r \pm c}, \quad Y = \frac{yr}{r \pm c},$$

and these values substituted in the primitive equation give the equation

$$x^2 + y^2 + z^2 = (r \pm c)^2$$

representing two spheres, one cutting the normals to the primitive surface internally, and the other externally, a result which might have been expected. In the case of solution we must take the radius $r - c$. It might be asked, what is the interpretation of the equation with the expression $r + c$ for the radius? The physical interpretation is this; chemical solutions can not only *dissolve* but also *deposit* and the external surface corresponds to the case of deposition; this remark will also apply to the external surface included in the general equation to the instantaneous surface; hence, dissolution and deposition are included in the same mathematical investigation. In the present enquiry, dissolution alone is considered. In the case of any isotropic solid dissolution will proceed as follows: in the element of time dt there will be removed a shell having everywhere the same infinitesimal normal thickness; lines normal to the original surface will be normal to the new surface; along these lines again measure off the elementary length dc, the locus of the extremities will be the new surface bounding the undissolved portion; this process, continued until we exhaust all the normals, will exhibit the process of solution from its commencement until its completion.

The relation between the area of the primitive and of the instantaneous surface may be obtained as follows:

from (19) we have

$$\frac{d^2a}{dydx}=\frac{d^2\mathrm{A}}{d\mathrm{Y}d\mathrm{X}}$$

integrating we obtain

$$a=\int\int\frac{d^2\mathrm{A}}{d\mathrm{Y}d\mathrm{X}}dydx$$

changing the variables from x, y to X, Y by means of (20) the last equation becomes

$$a=\mathrm{A}-c\int\int\sec y\left(\frac{d\cos a}{d\mathrm{X}}+\frac{d\cos\beta}{d\mathrm{Y}}\right)d\mathrm{Y}d\mathrm{X}+c^2\int\int\sec y\left(\frac{d\cos a}{d\mathrm{X}}\frac{d\cos\beta}{d\mathrm{Y}}-\frac{d\cos a}{d\mathrm{Y}}\frac{d\cos\beta}{d\mathrm{X}}\right)d\mathrm{Y}d\mathrm{X}.$$

It will be possible to assign to c such values that the coefficients of c and c^2 in this equation do not contain c. If we denote these coefficients by P and Q, multiply both sides by dc and integrate, and denote by V the volume of the shell, bounded by the primitive and the instantaneous surfaces we shall get the following equation

$$\mathrm{V}=\mathrm{A}c-\frac{c^2}{2}\mathrm{P}+\frac{c^3}{3}\mathrm{Q} \qquad (23)$$

a result which will be frequently useful in the theory of solution.

II. *The subject considered chemically.*

In the foregoing investigation, dissolution has been considered as a geometrical question, there yet remains to consider the matter as a chemical problem.

The rate of diminution of a solid depends on a variety of circumstances. If the acid be very dilute, the action is slow, and if concentrated, in some cases the action may be slow also, as in the case of strong sulphuric acid and zinc. Solution requires not only the presence of an agent capable of forming a soluble compound with the solid, but also the presence of some menstruum which continually removes the product so formed. If the solution be heated, there is usually an acceleration of action ; hence, if there be an evolution of heat during the solution, this will have some effect on the rate of solution. Also, if there be an evolution of gas, the adhesion of bubbles of gas may interfere with the contact of the solid and solvent. Also the solid may be partially soluble and like cast iron, contain carbon or silicon in forms not soluble, so that a crust of insoluble matter may accumulate and impede the rate of dissolution.

In what follows, the following conditions are supposed to hold: 1st, that the mass of the solvent is kept in such a state of agitation, that at any time it may be considered homogeneous; in such a case the strength of the acid in contact with the solid will be proportional to the total quantity of anhydrous acid remaining uncombined. 2nd, that the temperature remains unaltered during solution; if it be desired to keep the temperature from rising we may suppose ice or some appropriate refrigerating agent applied to the exterior of the vessel in which the operation takes place, so that the flux of heat outwards shall neutralize the rise of temperature due to chemical action, or by regulating the external application of heat any constant temperature compatible with the circumstances of the experiment may be maintained within the vessel. 3rd, that the successive surfaces exposed to the action of the solvent are homogeneous, in which case the action of the solvent along every normal to the surface is the same, so that the thin shell removed in an element of time has everywhere the same normal thickness. With these suppositions, it seems evident that the rate of dissolution will be proportional to the extent of surface exposed to the solvent, it will also be some function of the unsaturated acid. Let v denote volume of solid at time t, let a denote the mass of unsaturated acid (anhydride), s surface of the solid at time t; then we have the relation

$$dv = -ns\phi(a)dt \qquad (24)$$

where n denotes a constant depending on the temperature at which the action takes place, and the quantity of water holding the anhydride in solution, also on the chemical nature of the solid to be dissolved. The number of variables in (24) may be diminished as follows. Suppose that during the solution the same chemical compound is formed, let a_0 be the mass of the anhydride at the beginning, m_0 the initial mass of the solid, m the mass at time t. Then $m_0 - m$ will be the mass of the solid dissolved, and $a_0 - a$ will be the mass of the anhydride which has entered into combination with it, but by Dalton's law of combination the first of these quantities will bear to the second a constant ratio depending on the combining weights of the anhydride and the substance to be dissolved, hence we have

$$m_0 - m = h(a_0 - a)$$

when h denotes a constant. Hence

$$a = \frac{m + ha_0 - m_0}{h}$$

Also if e denote the density of the solid $m = ev$, and the equation of chemical action becomes

$$dv = -ns\phi\left(\frac{ev + ha_0 - ev_0}{h}\right)dt.$$

The form of the function ϕ has, I think, not yet been determined experimentally in a satisfactory manner; subject to previously mentioned conditions, I think it not unlikely that the rate of dissolution will be found proportional to the quantity of the anhydride remaining uncombined at any instant. With this hypothesis the last equation may be written in the form

$$\frac{dv}{v + r} = -lsdt \qquad (25)$$

where r has been written for $\frac{ha_0}{e} - v_0$ and l for $\frac{ne}{h}$. We have now three cases to consider depending upon the values of r. (1) Suppose that the quantity of acid is just sufficient to combine with the solid then $r = 0$; (2) suppose that the mass of the solid, is greater than that required to saturate the acid, then r is negative; (3) suppose that the mass of the solid is less than that required to saturate the acid, then r is positive. The expressions obtained by integrating (25) will be different in each case. If we suppose r negative and integrate (25) in its present form we obtain the equation

$$v = r + (v_o - r)\epsilon^{-l\int sdt},$$

which may also be expressed in the form

$$a = a_o \epsilon^{-l\int sdt},$$

when a denotes the mass of the unneutralised anhydride at any time; this would make the time required to saturate the acid infinite, if the mass of the solid be just sufficient to combine with the acid, or if it be greater than the mass required to saturate the acid; this would seem contrary to experience, but practically the acid might be considered to be neutralised in a finite time, for the quantity remaining unneutralised might be too small to be detected. For example, suppose the area of the surface exposed to the acid to be constant so that we may write

$$a = a_o e^{-lst};$$

if the quantity of acid neutralised in one hour be nine-tenths of the initial quantity, after the lapse of ten hours the quantity of free acid would be only $\dfrac{1}{10000000000}^{\text{th}}$ of the initial quantity.

In a former part of the paper it was pointed out that from an isotropic solid there would be removed in the small element of time dt, a shell having everywhere the same normal thickness dc, also that the volume remaining undissolved at time t would be some function of c; hence for dv we may write $-sdc$, and (25) may be written in the form

$$\frac{dc}{f(c) + r} = ldt.$$

I shall now consider the application of the foregoing investigation to the solution of some of the more familiar geometric forms. As a particular case consider the parallelopiped, of which the lengths of the edges at any instant are x, y, z; then the volume will be xyz, and after the lapse of time dt the volume will become $(x - 2\,dx)\,(y - 2dy)\,(z - 2dz)$, if every face of the solid be equally acted upon by the solvent; also the area of the surface will be $2\,(xy + zy + xz)$. Neglecting products of small quantities we get the equation

$$dv = 2(xydz + xzdy + zydx)$$

and as the rate of action is everywhere the same

$$dx = dy = dz$$

Integrating these equations, and denoting by z_0, y_0, z_0 initial values we get the equations

$$y = y_0 - y_0 + x, \qquad z = z_0 - x_0 + x.$$

Writing h_1 for $y_0 + z_0 - 2x_0$, and h_2 for $(y_0 - x_0)\,(z_0 - x_0)$ the differential equations of solution becomes

$$\frac{dx}{x^3 + x^2h_1 + xh_2 + r} = -ldt$$

an expression which may be readily integrated, and its value determined at any time when the arithmetical values of the constants are assigned. If either $y_0 = x_0$, or $z_0 = x_0$, h_2 vanishes; if both the equations are true h_1 vanishes also. In this case the solid becomes a cube, and the integral becomes

$$c - r^{\frac{2}{3}}lt = \frac{1}{6}\log\frac{(x + r^{\frac{1}{3}})^3}{x^3 + r} + \frac{1}{\sqrt{3}}\tan^{-1}\frac{2x - r^{\frac{1}{3}}}{r^{\frac{1}{3}}\sqrt{3}};$$

the constant to be determined by the condition that when $t=0$ $x=x^o$; the time required for dissolution of the cube may be obtained by writing o for x, and will be

$$\frac{1}{r^{\frac{2}{3}}l}\left\{\frac{1}{6}\log\frac{(x_0 + r^{\frac{1}{3}})^3}{x_0^3 + r} + \frac{1}{\sqrt{3}}\left(\tan^{-1}\frac{2x_0 - r^{\frac{1}{3}}}{r^{\frac{1}{3}}\sqrt{3}} - \tan^{-1}\left(-\frac{1}{\sqrt{3}}\right)\right)\right\}$$

If r be negative, the relation between the length of the edges of the cube and the time which has elapsed will be given by the formula

$$r^{\frac{2}{3}}lt = \frac{1}{6}\log\left(\frac{(x_0 - r^{\frac{1}{3}})^3}{x_0^3 - r}\cdot\frac{x^3 - r}{(x - r^{\frac{1}{3}})^3}\right) + \frac{1}{\sqrt{3}}\left\{\tan^{-1}\frac{2x + r^{\frac{1}{3}}}{r^{\frac{1}{3}}\sqrt{3}} - \tan^{-1}\frac{2x_0 + r^{\frac{1}{3}}}{r^{\frac{1}{3}}\sqrt{3}}\right\}$$

If the quantity of acid be just sufficient to dissolve the cube, the equation of dissolution becomes

$$\frac{dx}{x^3} = -ldt,$$

the complete integral will be

$$x = \frac{x_0}{\sqrt{1 + 2ltx_0^2}}.$$

If the solid to be dissolved have the form of a sphere, x being its radius at time t, the differential equations are

$$\frac{dx}{\frac{4}{3}\pi x^3 + r} = -ldt$$

$$\frac{dx}{\frac{4}{3}\pi x^3 - r} = -ldt$$

$$\frac{dx}{\frac{4}{3}\pi x^3} = -ldt$$

the integral of the first expression is

$$c - r^{\frac{2}{3}}l\left(\frac{4\pi}{3}\right)^{\frac{1}{3}}t = \frac{1}{6}\log\frac{\{(4\pi)^{\frac{1}{3}}x + (3r)^{\frac{1}{3}}\}^3}{4\pi x^3 + 3r} + \frac{1}{\sqrt{3}}\tan^{-1}\frac{2(4\pi)^{\frac{1}{3}}x - (3r)^{\frac{1}{3}}}{(3r)^{\frac{1}{3}}\sqrt{3}};$$

the constant to be determined by the condition $x = x_0$ when $t = 0$; the time required to dissolve the sphere may then be found by making $x = 0$. If the quantity of acid be insufficient to dissolve the sphere, from the second equation we obtain the following relation between the radius of the sphere at any time, and the time which has elapsed.

$$r^{\frac{2}{3}}l\left(\frac{4\pi}{3}\right)^{\frac{1}{3}}t = \frac{1}{6}\log\left\{\frac{4\pi x^3 - 3r}{4\pi x_0^3 - 3r}\cdot\left(\frac{(4\pi)^{\frac{1}{3}}x_0 - (3r)^{\frac{1}{3}}}{(4\pi)^{\frac{1}{3}}x - (3r)^{\frac{1}{3}}}\right)^3\right\}$$
$$+\left(\tan^{-1}\frac{2(4\pi)^{\frac{1}{3}}x + (3r)^{\frac{1}{3}}}{(3r)^{\frac{1}{3}}\sqrt{3}} - \tan^{-1}\frac{2(4\pi)^{\frac{1}{3}}x_0 + (3r)^{\frac{1}{3}}}{(3r)^{\frac{1}{3}}\sqrt{3}}\right)\frac{1}{\sqrt{3}}.$$

If the quantity of acid be just sufficient to dissolve the sphere, the integral becomes

$$\frac{4}{3}\pi lt = \frac{1}{2}\left(\frac{1}{x^2} - \frac{1}{x_0^2}\right),$$

which we may also write in the form

$$x = \frac{x_o}{\left(1 + \frac{8}{3}\pi l x_o^2 t\right)^{\frac{1}{2}}}.$$

Next suppose the solid to have the form of a right cylinder with a circular section, and first suppose that the ends of cylinder are covered with sealing wax or some other material not acted upon by the acid, so that dissolution is confined to the curved surface; the three differential equations assume the form

$$\frac{dx}{n\pi x^2 + r} = -ldt;$$

$$\frac{dx}{n\pi x^2 - r} = -ldt;$$

$$\frac{dx}{n\pi x^2} = -ldt;$$

n denoting the length of the cylinder, and x the radius of the base at any time. The complete integral of the first expressions will be

$$t = \left\{\tan^{-1}\left(\frac{n\pi}{r}\right)^{\frac{1}{2}} x_o - \tan^{-1}\left(\frac{n\pi}{r}\right)^{\frac{1}{2}} x\right\}\frac{1}{l(n\pi r)^{\frac{1}{2}}}.$$

The time required for complete dissolution of the cylinder will be

$$\left(\tan^{-1}\left(\frac{n\pi}{r}\right)^{\frac{1}{2}} x_o\right)\frac{1}{l(n\pi r)^{\frac{1}{2}}}.$$

The complete integral of the second expression is

$$(n\pi r)^{\frac{1}{2}} t = \frac{1}{2}\log\left\{\frac{x_o\sqrt{n\pi} - r^{\frac{1}{2}}}{x_o\sqrt{n\pi} + r^{\frac{1}{2}}} \cdot \frac{x\sqrt{n\pi} + r^{\frac{1}{2}}}{x\sqrt{n\pi} - r^{\frac{1}{2}}}\right\}$$

If the quantity of acid be just sufficient to dissolve the cylinder, the complete integral is

$$\frac{1}{x} - \frac{1}{x_o} = n\pi lt.$$

As a variation of the problem, suppose the whole surface of the cylinder to be exposed to the action of the solvent.

The whole surface will be $2\pi x^2+2\pi xy$, x denoting the radius of the cylinder and y its length, also the volume will be $\pi x^2 y$. If the cylinder be isotropic, and dx the decrement of the radius, dy the decrement of each extremity, we shall have the relation $dx=dy$; whence $y=x+y_0-x_0$, and the expression to be integrated become

$$\frac{dx}{\pi x^3+\pi x^2(y_0-x_0)+r}=-ldt,$$

$$\frac{dx}{\pi x^3+\pi x^2(y_0-x_0)-r}=-ldt,$$

$$\frac{xd}{\pi x^3+\pi x^2(y_0-x_0)}=-ldt.$$

Hence in each case the velocity of the action is expressible as an algebraic function of the variable x; in each case the determination of the complete integral will offer no difficulties when the arithmetical values of the constants entering into the equation are given. If the length of the cylinder be equal to the radius, the differential equations differ from the corresponding equations for the sphere in having π as the coefficient of x^3 instead of $\frac{4\pi}{3}$, and the integrals may be obtained by making this substitution in the corresponding integrals relating to the sphere.

As another example, suppose the solid to be one of the regular solids; then x denoting the length of the edge of one of the plane faces bounding the solid, for the volume of the solid we may write mx^3, and for the surface nx^2; the parameters m and n having different values for each of the five regular polyhedra. Differentiating the expression for the volume with regard to x, and substituting in the general equations of solution we obtain

$$\frac{3mdx}{mx^3+r}=-lndt$$

$$\frac{3mdx}{mx^3-r}=-lndt$$

$$\frac{3dx}{x^3}=-lndt,$$

the velocity of dissolution is therefore in each case a simple algebraic function of the variable, and the determination of the integral will present no difficulties when the kind of regular polyhedron is specified. In the previous examples the mass of the solvent has been supposed to be finite; but we may suppose that we have a solvent consisting of an infinite amount of anhydrous acid mixed with an infinite amount of water. If in such a mixture a solid of finite dimensions be dissolved, and the medium be kept in a constant state of disturbance, the diminution in strength of the acid due to neutralisation by the solid will be so small as to be negligible, and the acid may be considered to be always of its initial strength; this will be approximately the case when a small mass is dissolved in a large mass of the solvent. If the solvent be an acid solution the strength of the acid will depend on the ratio of the mass of the anhydride to the mass of the water; if this ratio be denoted by q, and this letter be substituted for $\phi(a)$ in (24), the differential equation of solution becomes

$$dv = -nqsdt,$$

from which by substituting $-sdc$ for dv, we obtain the equation

$$dc = nqdt,$$

and by integration

$$c = nqt.$$

Under these circumstances the time required for the complete dissolution of some of the familiar forms of solids becomes a simple function of some linear dimension of the solid; for instance the times required to dissolve spheres are as their radii, the times required to dissolve cubes are as their edges; this last remark also applies to the remaining regular polyhedra. By substituting for c in the instantaneous equation, we may also determine its form and dimensions at any time, and by substituting in (23) we may determine the mass of the shell removed from a solid in time t.

The most complete series of experiments which I have found in connection with the subject of this paper are contained in a memoir by Spring and Van Aubel in the *Annales de Chimie et de Physique* [6], 11. They there give the details of experiments to determine the velocity of dissolution of spheres of zinc containing a minute amount of lead in Hydrochloric, Hydrobromic, and Hydriodic acids of different degrees of concentration, and at different temperatures. They found that the maximum velocity, measured by the volume of Hydrogen evolved, did not occur at the commencement of the reaction; they first noted an increase and then a decrease. The period during which the velocity is increasing they term the period of induction; this is most noticeable when the acids are dilute; with concentrated acids, the maximum velocity is almost simultaneous with the commencement of solution. Unfortunately their results are not strictly comparable with the results of the theory announced in this paper; I have supposed that the mass of the solvent is kept in such a state of disturbance that at any instant the whole mass may be considered homogeneous. This condition does not seem to have been fulfilled in their experiments; the evolution of Hydrogen when brisk would no doubt tend to mix the different parts of the solution, but when the evolution was slow this agency might not be sufficient to secure the supposed condition. Hence we might expect, on comparing results of experiments with calculations founded on the above theory, that the times found by experiment would depart further and further from the calculated times as the solution approached completion. The calculation applies of course only to that portion of the observations which commences at the completion of the period of induction.

The numbers in the following table are taken from the memoir above cited; they show the results of the action of a 10 per cent solution of hydrochloric acid at the temperature 15° C. on a sphere of zinc. Complete solution would furnish 1145 cc. of hydrogen at 750 mm. pressure and 15° C. The sphere was acted upon by sufficient acid to produce this quantity of gas.

A.		B.	A.		B.
0	...	0	600	...	1573
50	...	301	650	..	1788
100	...	455	700	...	2044
150	...	561	750	...	2356
200	...	649	800	...	2746
250	...	731	850	...	3283
300	...	813	900	..	4018
350	...	899	950	...	5082
400	...	995	1000	...	6748
450	...	1106	1050	...	—
500	...	1239	1100	...	—
550	...	1392	1145	...	—

The numbers in columns A are the cubic centimeters of gas given off, the numbers in columns B the times in seconds required for the evolution of the corresponding volume of gas. If we subtract 561 from 649, the difference is 88, this number of seconds has elapsed while 50 cc. of gas were given off; if we subtract 649 from 731 the difference is 82; therefore, in this interval, the velocity has been greater than in the former one; if we examine the successive intervals we shall not find a greater velocity than this. Suppose then that we commence our observations after the lapse of 649 seconds, we then derive the numbers given in columns A and B of the following table.

A.		B.		C.		D.
0	...	0	...	0	...	0
50	...	82	...	82	...	82
100	...	164	...	172	...	167
150	...	250	...	271	...	256
200	...	346	...	381	...	348
250	...	457	...	505	...	445
300	...	590	...	644	...	546
350	...	743	...	803	...	653

400	929	985	766
450	1139	1175	886
500	1395	1449	1014
550	1707	1749	1153
600	2097	2128	1304
650	2634	2607	1470
700	3369	3243	1695
750	4433	4140	1872
800	6099	5531	2124
850	——	8055	2446
900	——	14693	2914
945	——	∞	4572

Column A contains the quantities of gas given off; column B has been formed by subtracting 649 from all the succeeding numbers in the corresponding column in the first table; it shows the time which has elapsed. The total volume of hydrogen which the sphere could furnish by dissolution, at the commencement of the observations recorded in the second table, will be 1145 − 200 cc.; that is, 945 cc. In a former part of the paper the following expression was obtained for the radius (x) of a dissolving sphere at time t:

$$x = \frac{x_0}{\left(1 + \frac{8}{3}\pi l x_0^2 t\right)^{\frac{1}{2}}}. \qquad (26)$$

This formula may be adapted to the present case as follows. Let H be the equivalent in hydrogen of the mass of the sphere at any time, H_0 the equivalent of the initial mass; then we may derive the equations

$$m = \frac{4}{3}\pi d x^3 = n\mathrm{H}, \qquad m_0 = \frac{4}{3}\pi d x_0^3 = n\mathrm{H}_0,$$

d denoting density and n a constant. Substituting in (26) we may write the equation in the form

$$\mathrm{H} = \frac{\mathrm{H}_0}{(1 + kt)^{\frac{3}{2}}},$$

k denoting a constant. If h denote the hydrogen already given off, the last equation may be changed into

$$t = \frac{1}{k}\left\{\left(\frac{\mathrm{H}_0}{\mathrm{H}_0 - h}\right)^{\frac{2}{3}} - 1\right\};$$

from this equation the calculated numbers in column C of the last table have been derived; the value of the constant employed is 0·00045, and has been obtained from the observation that 50 cc. of gas were evolved in 82 seconds. In several cases there is a fair agreement between the observed and the calculated time; in the latter stages of the dissolution, the observed intervals increase more rapidly than the calculated intervals; the reason may probably be the one previously suggested, that there was not sufficient disturbance of the solvent to render it homogeneous. The observed rapid diminution of evolution of the gas towards the end of the operation would also harmonise well with the theory which I have advanced, which would require for perfect solution an infinite time. In none of their experiments have the authors given the observed time of the complete dissolution of the sphere; they only carried their observations as far as the evolution of 1,000 cc. of gas.

The authors in their paper give the following equation to denote the velocity of solution,

$$V = KS_o(A - C)^{\frac{2}{3}}A^{\frac{1}{3}}.$$

In this equation V denotes the velocity of the solution, S_o the initial surface of the sphere, A the initial concentration of the acid employed, and C the portion of the acid consumed in the operation, K denotes a constant.

This formula does not appear to me to be adapted to their own results. They have estimated the velocity as follows: they collected the gas in a graduated vessel, and the time required for the evolution of each successive 50 cc. of gas was noted; this number divided by the interval of time they take as the velocity; but this will not be a correct expression for the velocity at any given instant, it will be the mean velocity during the interval, and will only be suitable when the velocity varies slowly. If h be the volume of hydrogen evolved at time t, the proper expression for the velocity will be $\frac{dh}{dt}$. Let H denote the volume of hydrogen corresponding to the initial strength of the acid, h the volume of hydrogen corresponding to the acid consumed; then n denoting some constant quantity, we have

$$H = nA, \qquad h = nC,$$

substituting these values in their equation, writing p for $KS_0A^{\frac{1}{3}}n^{\frac{1}{3}}$, we obtain the following differential equation:

$$\frac{dh}{dt} = p(H - h)^{\frac{2}{3}}.$$

Integrating and determining the constant by the condition $h=0$, $t=0$, we get the following equation:

$$t = p\{H^{\frac{1}{3}} - (H - h)^{\frac{1}{3}}\} \qquad (27)$$

The value of p determined by the condition $t=82$ $h=50$ is 465·9. By means of equation (27) the numbers in column D in the last table have been derived. The divergence of the observed and calculated times in the latter part of the operation is very marked. Also solution ought to have been completed in 4572 seconds, but according to the experiment it was not completed in 6099 seconds, and even then there remained 145 cc. of hydrogen to be evolved with a rapidly diminishing velocity.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, February 11th, 1889.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section in the Chair.

There were exhibited :—

By Mr. P. CAMERON : A collection of European *Chrysididæ*, containing nearly 60 species.

By the PRESIDENT : *Zizyphinus haliarchus*, a new and unique species of *Trochus*, described by him in the current number of the Journal of Conchology, January, 1889. The specimen belongs to the Museum Collection at Owens College, having been formerly in the possession of Mr. Reginald Cholmondeley, of Condover Hall, Salop. It is the fourth or fifth in size in the genus, most of the larger species being natives of Australia or New Zealand, From the former country the *Z. haliarchus* in all probability comes, but there has been some little misplacement in the original labelling. It differs from all the existing species in its truly conical and pyramidal contour, with straight sides, light structure,smoothish whorls, being very minutely beaded in close grained lines, the graining slightly larger and coarser at the sutures, colour pale fawn, with darker brown flames surrounding the periphery. Specimens of the nearest allies to this new species were exhibited also for comparison. The President also exhibited a form of *Plantago maritima* new to this country, and a collection of other species of *Plantago* for comparison, both British and European.

Mr. H. C. CHADWICK read a paper on two nematode worms, *Ascaris mystax*, and *Ascaris lumbricoides*, and showed specimens of both species.

Ordinary Meeting, February 19, 1889.

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

Dr. A. HODGKINSON and Mr. R. HOLMES, B.A., were appointed auditors of the Society's accounts.

A coloured representation of the Roman pavement at Leicester, part of which was uncovered in 1832 and the remainder in 1885, sent by the Leicester Literary and Philosophical Society, was exhibited.

The President referred to the recent earthquake in Manchester, the occurrence of which at Fallowfield he timed at 10.36 p.m.

Dr. G. H. BAILEY read a paper "On Vitrified Cement from an Ancient Fort."

Mr. J. COSMO MELVILL read a paper "On a form of *Plantago maritima*, new to this country."

On the Vitrified Cement from an ancient fort. By G. H. Bailey, D.Sc., Ph.D.

(*Received March 5th, 1889.*)

In October, 1882, Dr. Angus Smith described before this Society a vitrified mass of stone from Glen Nevis, and gave an analysis of the stone.

In the Manchester Museum at the Owens College is also a mass composed of fragments of gneiss cemented together by vitrefaction and said to be derived from the forts of the Picts.

Having recently visited some of these forts in the Highlands, I was interested in this specimen, and having, by the permission of Professor Boyd Dawkins, obtained a sample of the stone, I asked one of my students, Mr. W. B. Hopkins, to make an analysis of the vitrified part. The points of interest seemed to me to be :—

(*a*) Whether the materials which had been converted into the molten mass had been selected by trial in order that a body of low fusing point might be obtained or had been taken indiscriminately ;

(*b*) whence they were derived ;

(*c*) what temperature would be required in order to bring about the fusion ?

The vitrified part showed locally a glazing, and had been distinctly fluid, but now presented somewhat the appearance of lava, being honeycombed with air spaces from which gases had apparently escaped during the fusion. Samples were taken from different parts and mixed together, and partial examination was made of the different samples with a view to detecting variations in the composition of the mass. No considerable differences were found, except that in some parts the iron was entirely oxidised, whereas in others it still remained, for the most part, in the ferrous condition, and in addition to this there seemed to be rather more alkalies in the denser parts of the mass. The typical sample gave on analysis the following results, the sample analysed by Dr. Angus Smith being placed alongside for the sake of comparison, though I have no evidence that they are identical specimens, and indeed the analyses themselves would certainly indicate that they were not.

	Mass in Manchester Museum.	Mass from Glen Nevis.
Silica	69·59	68·88
Alumina	11·12	16·17
Ferric oxide	13·01	5·33
Lime	0·53	3·73
Magnesia	0·32	3·39
Potash	1·86	1·83
Soda	1·49	0·26
Loss on ignition	1·12	0·92

There may have been originally more alkalies present ; the stone is of such a porous nature that these would be partially dissolved away by exposure to atmospheric conditions.

There is then a very low proportion of alumina, practically no lime or magnesia, and little alkali. No common mineral or rock substance, as far as I am aware, shows such a composition.

It has been suggested by previous writers on this subject that basalt was added to clay, or some such substance, to form a mass which could be fused at such temperatures as were likely to be at the command of the builders of these forts. Wood, it has been suggested, was the fuel used, and indeed in one case wood has been actually found *in situ* between the layers of stone constituting the wall.

In the case of the specimen examined, however, no basalt can have been added, for though the large proportion of iron might have lent some colour to such a suggestion, it is absolutely negatived by the absence of calcium and magnesia, which are always present in basaltic rocks.

For the same reason, and because of the low percentage of alkalies, it cannot have been a gneissose or granitic base that was used, nor (considering the low percentage of alumina,) can kaolin or clay have constituted any considerable portion of the material. In some parts of Scotland where such forts occur there are beds of red sandstone (of the old red sandstone age and of formations older than this), and the essential difference in composition between these lies only in a rather lower percentage of iron and of alumina and a little higher percentage of silica. These rocks, however, approach nearer to the vitrified stone than any other accessible material, and with the addition of a little iron ore, or slag, might at any rate be brought in almost exact agreement. The question of the source of the material, in this particular case, is rendered more difficult because the actual locality from which the mass was obtained is not known, and in any case it would be necessary, in order to solve such a question satisfactorily, to analyse samples of vitrified forts from different districts, and to take the results in connection with the rocks found in the district. With regard to the temperature that would be required to bring about the fusion of such a mass, I may call to notice a series of investigations which have, during recent years, been undertaken by Seger (*Thonindustrie-Zeitung*, 1886, p. 135,) with a view to determine the relation of fusibility of a mixture to the proportions in which the constituent parts occur. Seger made up mixtures of silica, kaolin, and marble in different proportions, until he, by means of trials in a pottery furnace, arrived at a proximate idea of the best proportions for obtaining low fusibility. Having found this, he then made a large number of mixtures, varying the several constituents, whilst keeping others in the proportions established by the preliminary trials. It is already known that the presence of alkalies, especially soda, increases the fusibility of a mixture, and that oxide of iron acts also in the same direction. He found, however, that the keystone to fusibility rested with the relative proportion of alumina and its relation to the other bases. It is singular that in this particular the vitrified stone agrees very nearly with the proportions discovered by Seger.

If, therefore, we take this in conjunction with the peculiar composition of the vitrified stone, it would certainly seem to show that, in this case at any rate, the materials used were an artificial mixture of natural products, the proper constituents of which were arrived at by a process of trial, and that the builders of the fort had some acquaintance with the behaviour of different substances under the action of heat, nor indeed can it be thought very remarkable if they did possess some such knowledge. It has been thought that in some cases the actual stones themselves were melted together by heat, and, however this may be, there can be no suspicion of this in the example before us. The schist, of which the fort has been built, shows no marked alteration, and certainly nothing approaching fusion. The temperature of fusion of such a mixture as is indicated by the results of the analysis, would be about 1,200° C. to 1,300° C., and this could be readily attained by means of wood, in the manner already suggested by different writers on this subject.

Notes on a form of Plantago maritima [L.] new to Great Britain: f. Pumila (Kjellman). By James Cosmo Melvill, F.L.S.

(*Received February 21st, 1889.*)

On 20th July, 1888, the ascent of Ben Hope, a high and imposing mountain in north-west Sutherlandshire, was made by Mr. Frederick Hanbury, F.L.S., and myself. Most of the mountains in this district, *e.g.*, Ben Hee, Ben Clibreck, Ben Leoghal (Loyal), with Ben Hope, stand alone, and these four form, roughly speaking, a quadrilateral, situated some ten miles apart from each other, Ben Hope being in the north-west corner of the quadrilateral and nearer to Ben Leoghal than to the others.

The botanical riches of this mountain are notorious; but it is not very often ascended, owing to its forming part of a deer forest, and, consequently, being strictly preserved and closed to the public.

The primary object in view was to study the *Hieracia*, and in this we were more successful than our most sanguine expectations, obtaining one or two probably new and undescribed forms. I forbear more detail on this subject at present as the plants are being cultivated by Mr. Hanbury, and will flower this summer, and till then, it is premature to discuss their distinctness or otherwise, suffice it to say that new county records for *Hieracium lingulatum* (Backhouse) and *H. holosericeum* (Backhouse) were established.

We ascended by the west face, to the left of the Altnacaillich Waterfall, and passing through a tract of boggy ground, rich in Carices, *e.g.*, *C. pauciflora*, *C. vaginata*, etc., rounded a great spur of the mountain, and soon came to plenty of *Arctostaphylos alpina, Juniperus nana, Betula nana*, etc. Soon some Alpine *Hieracia*, and *Cherleria sedoïdes* were displayed, and the ground became very barren and stony, with spaces of pulverised sand, caused by the small disintegration of the boulders strewn everywhere in inextricable confusion. Turning towards the large corrie on the south-east, at about 2,900 feet, we came upon patches of *Juncus trifidus, Luzula spicata*, a stunted form of *Armeria maritima*, with very woody roots, and large heads of flowers, and a *Plantago*, which did not resemble the mass of *P. maritima* we had gathered at lower elevations. At the time I took it to be more allied to *P. alpina* (L.) so frequent in the mountains of the Valais in Switzerland.

This plant, which I now exhibit, has been submitted by me to Mr. J. G. Baker, F.R.S., of Kew, to Prof. C. C. Babington, F.R.S., of Cambridge, and Mr. Arthur Bennett, F.L.S., of Croydon, and the following notes shew what opinions these gentlemen have, at present, as to this curious form :—

Mr. Baker wrote on 2nd January :—

"We have a *Plantago* here (in the Kew Herbarium) that exactly matches your Ben Hope specimen, among the plants of the Nordenskiold Expedition of 1875. It is labelled *P. maritima* (L.), *var. pumila* (Kjellman), and was collected at Cap Grebenig, Insula Wajgatsch, Scandinavia, in July, 1875, by Kjellman and Lundström, the botanists of the expedition. A very similar form grows in Teesdale on the sugar limestone of Widdy Bank Fell."

Prof. Babington favoured me with three letters on the subject, of which the first is as follows :—

"Your *Plantago* is undoubtedly difficult. I have the dwarf form gathered by Mr. Tate, Bressa Sound, in Shetland, and which appears quite distinct from yours. I believe the Bressa plant is the *P. maritima-hirsuta* (Syme) = *setacea-lanata (Edmundstone)*. I do not look towards the

Alps for your plant, but to the north, and if Baker clearly identifies the plant (as one collected during the Nordenskiold Expedition) that must be enough."

And again, in his next letter:—

"Without seeing specimens, I find it difficult to determine Lange's *P. borealis.* His description in Fl. Dan. (here follows description) is not your plant. It has very short scapes, not rising above the leaves. This was gathered by Sir W. J. Hooker in Iceland, at Thingwellen, and it is the alpina (?) of my Flora of Iceland [*Journal Linn. Soc. Botany* 1870, p. 323] and is very near the *maritima-hirsuta* (Syme) [*Eng. Bot.* t. 1167]. My final conclusion is that I fear your plant must stand as a mountain form of *P. maritima* at present."

Mr. Arthur Bennett writes February 8th, 1889:—

"Many thanks for the little *Plantago.* I write at once to say that Kjellman did not call it a var.—(but a form)—*P. maritima* (L.) *f. pumila* (Kjelln.).—'Vega' Exped. 'Vekuskaplajn Arbeten,' p. 324. Found near Cap Grebeni, Svenska Exped. 1875."

This form of an abundant plant throughout our country, especially near the sea coast, mainly differs from the type in the shortness of the leaves, and also their not being at all fleshy, the isolated growth of individuals, the leaves forming a rosette round the central rootstock. In the round flower spikes, it resembles *P. alpina* (L.). Upon examining the various forms of *P. maritima* with the continental forms of *P. Crassifolia* (Forster) *subulata* (L.), *serpentina* (Vill.), *recurvata* (L.), *carinata* (Schrad), *alpina* (L.), etc., one cannot help being confused with the mass of synonymy and entanglement that has arisen: and though none of them, except perhaps *P. alpina*—and there is some doubt about this—is Scandinavian, very likely upon our southern shores some of the afore-mentioned may impinge, and, therefore, I would keenly advocate large gatherings being made of all the forms of our species, and what is more important, they should, if possible, be placed under cultivation, before any decision be attempted as to their specific or sub-specific merits.

Ordinary Meeting, March 5th, 1889.

Professor OSBORNE REYNOLDS, M.A., L.L.D., F.R.S., President, in the Chair.

The PRESIDENT referred to the loss sustained by the Society through the death of Mr. RICHARD PEACOCK, M.P., M.Inst.C.E.

The first of a series of papers entitled, "Colour and its relation to the Structure of Coloured Bodies, being an investigation into the Physical Cause of Colour in natural and artificial bodies, and the Nature of the Structure producing it," by ALEXANDER HODGKINSON, M.B., B.Sc., was read by the author.

Colour and its relation to the Structure of Coloured Bodies; being an investigation into the Physical Cause of Colour in natural and artificial bodies, and the Nature of the Structure producing it. By Alexander Hodgkinson, M.B., B. Sc.

(*Received April 8th, 1889.*)

Introduction.

Colour has always been to me a subject of special interest, and as far back as I can remember I began to collect objects characterised by striking colour effects or possessing some peculiarity of appearance produced under varying conditions of illumination. In the course of years my collection became extensive, and a voyage round the world some twelve years ago enabled me not only to add to my collection, but also gave me the opportunity of personally observing many natural objects of great beauty not to be seen under the same favourable conditions away from their native habitats.

With the object of ascertaining the cause of the colour of these various bodies—animal, vegetable, and mineral—they have been submitted to different methods of examination. Miscroscopic investigation is, of course, essential for discriminating the different parts of such structures; but alone, and as a mere amplifying appliance, the microscope is inadequate for revealing the structural cause of colour in most of the objects under consideration. Nor is this to be wondered at, since the colours of all objects, whether natural or artificial, are due to the suppression of certain of the rays of light received from the source of illumination, and such suppression is due either to so-called absorption or to interference. Both these phenomena are known to be dependent on structural arrangements of a magnitude commensurate with the wave-length of light, and light tends to break down, so far as its image-forming capabilities go, when acted on by structures of such small dimensions. Now the microscope is essentially dependent for its effect on image formation, and hence the possibility of its inadequacy under the above conditions. Failing other methods, the microscope has been employed, and that by most careful and reliable observers, for the purpose of determining the cause of colour in many of the most striking colour-producing structures, *e.g.*, iridescent feathers, innumerable species of gaudy insects, opal, mother of pearl, and the like. In the varying results of these observations we have one of the most convincing proofs of the inadequacy of the microscope alone to reveal this cause. A few instances of these varying results may be cited out of innumerable examples. The changing colours of the opal are by one observer attributed to a structure of fine lines, by another to thin plates, whilst a third holds them due to both these causes. Again the iridescent hues of the feathers of humming-birds, sun-birds, and various other tropical birds, as also the brilliant and changing tints of innumerable insects are, by almost all observers, considered due to a structure of fine lines. In some of these instances, as for example in the case of scales from the wings of Lepidoptera, and from the elytra of some beetles, and various parts of other insects, the fact that lines and markings do exist, as we shall presently see, would seem at first sight to confirm this assumption. Whilst fully recognising the existence of lines and markings in these and numerous other instances, and whilst admitting that the most brilliant diffraction colours are produced by them, facts will be adduced to show that the colours produced by these lines and markings are either imperceptible in the natural condition of these objects, or, if apparent, so inconspicuous as to play no part in the characteristic colours of these bodies. Such characteristic colours are, as will be shown, due to the same cause as the colours of thin plates in all these structures almost without exception. The colours of these bodies, all, therefore, obey the laws which regulate the change of tint in thin plates with varying obliquity of illumination. Thus, as the angle of incidence of the illuminating light increases, or the direction becomes more oblique, all such iridescent objects as feathers, butterflies, beetles, flies, opal, mother of pearl, &c., &c., change in colour from red towards violet in the order of the colours of the spectrum. Thus, if any of this extensive group of iridescent bodies, whether bird, insect, or mineral appears red when the light by which it is illuminated falls on it and is reflected from it at a certain angle, such body will appear yellow when the angles of incidence and reflection become greater, that is to say when the light is made to fall on the object at a greater obliquity, and if these angles are still further increased the body will appear green. Examples of this are seen in the case of the crimson body of the common British fly, the Ruby-tail, *Chrysis ignita*, and many other members of the same genus, the curious little beetle *Poropleura bacca*, feathers from the crest of the humming-bird *Chrysolampis mosquitus* or Ruby-crest, and innumerable other natural objects. Again, if any of such class of bodies appears yellow when the light falls on it at a small incident angle, it will change to green, and then perhaps to blue as the incidence becomes successively greater. I say 'perhaps' because it is not always possible, though commonly it is so, to observe *three* changes in the same object. Examples of yellow objects changing to green are met with in the cases of all iridescent feathers, the colour of which is yellow at normal incidence. Thus the orange throat, or gorget as it is termed, of the same humming-bird *Chrysolampis* is seen to change to green on increasing the obliquity of the illumination, and the same is well seen in the case of the outermost ring surrounding the eye of the peacock's feathers. Various golden beetles and iridescent flies are examples, as also various iridescent minerals, fire marble *lumichella*, opal, &c. Examples of iridescent objects, both natural and artificial, presenting at a normal or small angle of incidence some shades of green, are innumerable; feathers of humming-birds, sun-birds, hosts of tropical beetles and flies, and butterflies. In the mineral kingdom may be mentioned opal, *lumichella* labradorite, &c., and of artificially prepared bodies thin films of mica and certain crystals of chlorate of potash. On inclining any of these bodies, so that the illumination is more and more oblique, the colour is seen to change from green, through the various intermediate shades of greenish blue, to blue, and then possibly to purple. Such change is well seen in the outer ring of the eye of the peacock's feather. Though not so common as the above, both natural and artificial iridescent objects exist, which, at perpendicular or normal incidence, are blue, and this, as the incident angle is increased, changes to purple, and by further increase in the obliquity of the illumination such objects cease to appear coloured, reflecting white or colourless lights. Various insects, more especially *Lepidoptera* of the genus *Morpho*, the so-called Glory-of-Brazil butterflies, belong to this group, also flies and beetles, feathers of numerous birds, mother of pearl, and various mineral bodies as labradorite, specimens of various ores covered with films of tarnish, thin films of mica, certain iridescent crystals of chlorate of potash, &c. Lastly, iridescent objects are met with which, even at normal incidence, appear either violet or purple, and then, as the light is made to fall on them more obliquely, simply change to a higher degree of the same tint and then become white or colourless as the incidence becomes still more oblique. Examples of this are met with in the case of the feathers of many humming-birds, *e.g.*, tail feathers of the blue-tailed sylph, *Cyanthus forficatus*, the glossy blue black plumage of many tropical and British birds, the purplish blue patch (speculum) in the wing of the mallard, innumerable flies, dragon flies, beetles, and butterflies, and many minerals, as labradorite, opal, &c., mother of pearl, and also bodies artificially prepared, as thin films of mica, certain crystals (twin crystals) of chlorate of potash. It is needless here to individually specify these various objects, because in their appropriate sections I purpose mentioning striking and typical examples from the various groups of coloured bodies for the purpose of drawing attention to the nature and properties of their colours and the structures producing them. The above sequence of colour phenomena is what is commonly observed in almost all iridescent *natural* bodies in which the colours are due to thin plates. How constant this change of colour is maybe inferred from the fact that, keeping in mind the simple principle which governs the production of colour by thin plates, I was able to predict, without a single mistake, the sequence of changing tints that arose by regarding from different points of view the numerous specimens constituting that magnificent collection of humming-birds known as the Gould Collection at the South Kensington Museum.

It was this constancy in the colour phenomena presented by thin plates that naturally suggested the inference that *if such colour phenomena were really constant and peculiar to thin plates, such appearances might be accepted as proof of the existence of a structure of thin plates, even though such structure might not be apparent by ordinary microscopic investigation alone.* But the fact that the same colours and sequence of colours are observed on viewing a structure composed of a series of fine lines, at once proves that such colours, so far as regards their composition or tint, and also as regards their sequence, are identical :

though the cause varies, the effect, *so far as regards tint and sequence*, under varying incidence of light is the same. Hence the reason why some observers have inferred thin plates as the cause, others fine lines, in the same object. Though identical in tint and sequence of colours, it occurred to me to ascertain whether there were not some features in the colour phenomena of fine lines which differed from the colour phenomena of thin plates, because, if such could be found, the two phenomena could be distinguished and the correct structural cause inferred. To answer this question—and I go into detail on this point to serve as an example of methods I have adopted, with the necessary modifications, in other instances—I took examples of both these structures, thin plates and fine lines, prepared *artificially*, so that there could be no doubt of their structural nature. For a thin plate I took an iridescent film of mica, for fine lines a small diffraction plate consisting of a series of fine lines engraved on silvered glass by Zeiss. These I examined in the following manner :—First by transmitted light ; placing the diffraction grating, the lines of which were of course sufficiently near to one another to produce diffraction colours, on the stage of the microscope, I illuminated it from below in the usual manner, except that I used a diaphragm with an aperture made by a fine needle point. Employing a low power (1 in.), I focussed, not for the grating but for this aperture, so arranging the grating that the light passed through it before entering the objective. On observing the result, as seen through the eyepiece, a central *colourless* image of the aperture of the diaphragm is seen, and on either side of this central image, and in a plane at right angles to the direction of the markings, is a series (in this instance two) of spectra of this opening in the diaphragm having the violet end of each spectrum towards the central opening. If the grating be rotated in altitude on an axis in the direction of the lines, the colourless image still retains its central position, but the lateral spectral images become individually broader and more distantly separated from each other. If the grating be rotated in azimuth the plane of the spectral images also rotates so as always to maintain a direction at right angles to the direction of the lines. Apart from the distinctive appearance of this phenomenon we learn from it that light transmitted by a structure composed of fine lines gives rise to colour—diffraction colours, *but the light in the axis of the illuminating beam is colourless.*

If now, adopting precisely the same arrangement of the microscope as in the previous instance, I replace the series of lines by a film of some material sufficiently thin to give rise to the so-called colour of thin plates—say a film of mica—and, using the same objective (1in.), I focus for the small hole in the diaphragm with the film in such a position that the light from this opening on its way to the objective passes through such film, on viewing such opening in the ordinary way through the eye-piece it is seen as a single central *faintly-coloured* image. On rotating the film in altitude, it is seen to change in colour. Rotating in azimuth no alteration in appearance is perceptible. From this we learn that the light transmitted by an iridescent thin plate *is only in the axis, or parallel to the axis, of the illuminating beam and is coloured. The colour is confined to the direction of the illuminating beam.*

From these two results we learn that in the case of colour-producing structures composed of fine lines, thus examined by transmitted light, the resulting colour is absent in the axis of the illuminating beam, whilst in the case of a colour-producing structure of thin plates, the colour is confined to the direction of the illuminating beam.

Such is the result of examination by transmitted light, available therefore in the case of transparent structures only. Most of the objects under consideration, however, are opaque bodies, and therefore only admit of examination by reflected light. To make our investigation complete, therefore, it behoves us to examine the manifestations of these two colour-producing structures, fine lines and thin plates, by *reflected light*.

Using the same objects, a series of engraved lines, and a film of mica, I will first consider the fine lines.

Placing this object on the stage of a binocular microscope and employing a 1-inch objective, the following method of illumination is employed :—Removing one of the eye-pieces, I substitute a mirror so arranged that a beam of light may be reflected down the tube and through the objective on to the object beneath. If now the plane of reflection of the object is normal to the direction of this beam, the light is reflected up the other tube, forming an image of the object which is obscured in the usual way. *Such image in the present instance is seen to be colourless.* Rotated in altitude at any azimuth, the image disappears. From this we learn that *a colour-producing structure of fine lines reflects colourless light at an angle equal to that of incidence.* The above arrangement ensures incidence and reflection being equal, since they are identical, being both normal to the reflecting plane.

Replacing the fine lines by an iridescent film of mica, mounted on black velvet so as to avoid the reflection of adventitious light, and subjecting it to precisely the same method of examination as in the last instance, a striking difference is noticed in the result. Instead of the colourless image of the object as observed in the previous instance, the image of the film appears as an intensely brilliant object tinged with hues which, though they may be equalled, are certainly unsurpassed, even by the interference colours of polarised light. If by tilting the stage the film is made to rotate in altitude at any azimuth, the colours immediately disappear. From this we learn that *a colour-producing structure of thin plates reflects a coloured light only at an* *angle equal to that of incidence*, a feature which distinguishes it at once from a structure of fine lines.

We see from these experiments that, however closely the colour manifestations of these two colour-producing structures may resemble each other to ordinary observation, when in the above typical form, and submitted to some such method of examination as the above, the resemblance breaks down, and we have presented phenomena so markedly distinct as scarcely to admit of confusion. Could we, therefore, ensure these conditions being always complied with, our investigation would be a comparatively simple matter. Such is, of course, not the case. Whilst our *method of examination*, being adapted for opaque as well as transparent objects, is constantly applicable, infinite variations from the typical condition of the structures examined exist. In the case of thin-plate structures we shall find them wonderfully constant in their manifestations, but even here I shall draw attention to natural and artificial bodies in which colour phenomena of singular interest and beauty are produced by the superposition of numerous iridescent plates, seen in the case of most iridescent beetles and flies, silvery-scaled fish, and certain twin crystals of chlorate of potash, &c. When other methods of colour production co-exist with that of thin plates, as we find of constant occurrence, the appearances, though more complex, still admit of analysis if properly examined, and, each phenomenon having its own structural significance, the results of examination in such instances are of more than ordinary interest. Thus, in the case of mother of pearl *when ground*, we have an example of a structure composed of thin plates and fine lines, and, accordingly, this substance yields colour phenomena bearing the characteristics of both these structures. As shown by Brewster, the *diffracting* structure of this substance is communicable to wax. I shall show that in the case of mother of pearl, however, the diffracting structure is probably caused by the grinding, thus leaving the natural colours of mother of pearl due to thin plates alone. Again, another common mode of colour-production, absorption, may co-exist with that of thin plates, constituting a method of colour-production not, so far as I am aware, before described. From the mode of formation of this class of colours I shall refer to them as the *Colours of Thin Absorption Plates*, and under this title I have devoted a section to their consideration. This mode of colour-production is interesting, as affording an explanation of the reflected and transmitted colours of metals, aniline colours and iridescent crystals of permanganate of potash, and some other almost opaque bodies.

Finding, as a result of experiment, that these two colour-producing structures—fine lines and thin plates—when in their typically perfect condition, and when examined in a suitable way, produced optical effects peculiar to, and therefore characteristic of, such structures, and noting that even when the structures were not typically perfect, proportionately characteristic results were obtained, I was led to see that there are other indications of structure than mere image formation; that there are, in fact, two ways in which minute structure may reveal itself by the agency of light; one in which the illuminating light is so refracted or reflected as to admit of the formation by means of one or more lenses of an appreciable image on the retina. This, which may be termed the direct method, is what occurs in ordinary microscopic observation when the instrument is used as a mere magnifying appliance, and in this instance we have to do with an image of the object identical in appearance and differing from such object only in size. In the second or indirect method the structure so materially modifies the light as to reveal itself, not in the form of an image or replica of itself, but by the production of some other optical effect, such as reflection, refraction, absorption, dispersion, interference, diffraction, and double infraction, or polarisation. What is the structural significance of these various phenomena, and to what extent we are justified in relying on them as indications of structure, I have considered in detail in a paper on "Ultra-microscopic Structure, and Methods of its Investigation," which I hope to have the opportunity of laying before the Society.

In the present communication, dealing as it does with coloured bodies, I purpose selecting from the various divisions of the animal, vegetable, and mineral kingdoms, typical examples of objects characterised by striking or peculiar colour-production. Having drawn attention to the peculiar features of such appearances, and the modification these undergo by varying conditions of illumination, I shall, so far as I am able, describe the structural or physical cause of these colours. This, the main object of the communication, was in the first instance my sole intention, and this more especially as I have, in the previously mentioned paper, considered in detail the methods for investigating ultra-microscopic structures. It occurred to me, however, that without some explanation of the methods by which I had arrived at the results in the present instance, these might not be so interesting or acceptable as if a sufficient reason were given for them. Accordingly I have devoted preliminary sections to the consideration of the nature and properties of colour, and having described the different modes of colour-production, and shown the relationship, so far as known, to the structures producing them—in other words, their structural significance. I have considered separately each of these different modes of colour-production in order to ascertain their characteristic features, so that they might, by examination, be easily recognised.

The main object in such methodical examination has been so to vary the relationship of the various natural and artificial bodies, or their parts, to the source of illumination as to produce characteristic appearances, or colour changes. When such colour effect has been found to agree in its nature and properties with one of the known modes of colour-production, it has itself been referred to such group, and the same structural cause has been inferred to exist in it as characterises the group *even though microscopic and other methods of examination fail to reveal such structure.* Such method, which is only a part of a more extensive, but similar, method framed to allow of the investigation of *all* bodies, whether coloured or not, *vide* "Ultra-microscopic Structure and Methods of its Investigation," I shall speak of under the title of "Chromatic Analysis," and to facilitate such method, I have constructed a systematic table, by following which, the different colour phenomena may be the more readily grouped. I have felt justified in thus taking colour-production as a manifestation of structure, because I find that of all optical phenomena, excepting of course image formation, those attended by the production of colour are the most significant of structural conformation.

Examination of bodies, according to the plan advocated, naturally necessitated some modification in existing instrumental appliances. These I shall, as occasion arises, bring before your notice. On the present occasion I will only call your attention to a microscope, constructed for me by Messrs. Smith and Beck, and so arranged as to allow of great variety in the relationship of bodies, or their parts, to the source of illumination. The moveable parts are all graduated so that this relationship may be known and recorded. Without some such appliance as this, I should have been quite unable to have done even what little I have accomplished.

In the preceding cursory sketch I have attempted to convey some notion of the nature of the enquiry I have entered upon, and have alluded to the necessity of employing some method other than mere microscopic examination for carrying on such enquiry. According to their action on light all structures may be divided into three distinct classes :—

(*a*) Structures, the physical nature of which is such as to allow of a visible *image* being formed of them by reflection or refraction of light, and these, since they are amenable to ordinary microscopic examination, I have characterised as *microscopic* structures. As examples of microscopic structures may be cited all such as are sufficiently large or coarse, and of suitable optical density, or colour, in relation to their environment, to allow of the formation of a perceptible image. Their name is legion.

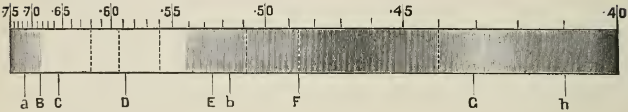
(*b*) Structures which, from their physical nature, are incapable of so acting on light as to admit of the formation by reflection or refraction of a visible image (or replica) of themselves, yet can so modify light as to produce some optical phenomenon which is characteristic of the structure producing it. To this group belong all bodies which appear structureless by ordinary microscopic examination, and yet give rise to some optical effects, as reflection, refraction, absorption, polarisation, and various interference phenomena. This is the class to which I have applied the term *ultra-microscopic*, since the microscope is either not applicable for their investigation, or, if employed, is merely used as an aid to some other method of observation, or to observe some other feature of the object than its ordinary image.

Since most colour-producing structures belong to this group, it is that with which we are the most concerned in the present inquiry.

(*c*) Finally we have abundance of evidence of the existence of structures, the physical nature of which is such as to render them invisible, and incapable of producing any of the above optical phenomena, and therefore to belong to neither microscopic nor ultra-microscopic group as defined above. Films of mica may be separated so thin as to be incapable of reflecting light of any colour at any incidence, and therefore to appear black under any conditions of illumination. The same condition is met with in the case of the thin film constituting the central spot of Newton's rings. True it is, that in these instances, the invisibility is ascribed to interference, arising, as pointed out by Young, from the loss of half an undulation which occurs when light is reflected at the surface of the denser of two media. Still, even though this loss of half an undulation were an undoubted truth, the fact remains that transparent films, the thickness of which is less than a quarter of a wave-length of violet light, neither reflect light nor give any other positive optical evidence of their existence. In the case of interference from thicker films, on the other hand, we have reflected and refracted colours of the most varied description. Again, a complex arrangement of portions of such invisible films would still remain invisible, and the same is true of structures generally when composed of elements too thin to produce optical effect. Thus, in the case of mica, certain crystals of chlorate of potash, and other minerals which exhibit cleavage, we notice no internal evidence of arrangement in lamellæ, and yet no one can doubt that such structural arrangement does exist, but the lamellæ being in optical contact, that is separated by intervals of less than a quarter of a wave-length, and themselves of similar dimensions, fail to give optical evidence of their existence, and thus the mass appears homogeneous. Just as transparent films when of a certain thinness are invisible, so must transparent particles when of the same diameter be invisible, and a body composed of such small particles would appear homogeneous; and just as a thin invisible film which gradually increases in thickness when illuminated by white light, first reflects those rays of shortest wave-length, namely, violet or blue, so do small particles always first reflect light of the same colours, thus producing the phenomenon of opalescence. The blue of the sky, of smoke, and of steam is of this nature. That such transparent particles before attaining a certain size *are* invisible, is well exemplified in the case of a jet of steam, in which, in immediate proximity to the nozzle before the particles have run together by condensation and thus augmented in size, they are invisible, but assume a blue colour so soon as the diameter of the particles is equal to a quarter wave-length of this colour. Again, in the case of a structure composed of fine lines, Abbé has conclusively demonstrated that the microscopic image of such structure is constituted by the superposition of the ordinary or dioptric image and the interference images formed by diffraction, and that when the diffraction images are obstructed by diminishing the aperture of the objective, or otherwise, the appearance of such object may be modified so as to present the most varied appearances, or to *present an absolute blank*, according as the diffraction images are partially, or wholly, excluded from taking part in the image formation. Of the truth of these facts any one can easily satisfy himself, since Messrs. Zeiss and Son, the opticians of Jena, supply apparatus of the most simple kind, by means of which the part played by diffraction in image formation is rendered apparent. This variation in the appearance of such objects where examined by the microscope has called forth the opinion expressed in a recent publication, "The Microscope in theory and pratice," Naegeli and Schwenderer, p. 235, that "under these circumstances every attempt to discover the structure of finely organised objects, as, for instance, diatom valves, by the mere observation of their microscopic images, must be characterised, is wholly mistaken."

Seeing now that the microscopic resolution of structures, *e.g.*, a series of fine lines, of less than a certain degree of fineness, is essentially dependent on their diffractive action, and seeing it admits of easy proof that, when the distances between the centres of the lines constituting such structures is less than half a wave-length of light, no diffraction *can* occur *even with light of any obliquity*, it is evident that such structure must be invisible under any microscopic power. Since, moreover, such structure, so far as I am aware, fails to produce any optical manifestation whatever, it cannot be classed in the group we have termed ultra-microscopic. To take one more example :—Structures of the same optical density and colour as their environment yield no optical evidence of their existence, and belong, therefore, neither to microscopic nor ultra-microscopic structure. A slip of crown glass, for example, is invisible in cedar-wood oil, and the same is true of other structures of the same refractive index and colour. So far as ordinary light is concerned such structures are non-existent. On this fact, indeed, is founded the homogeneous immersion system of lenses.

It is thus evident that a class of structures exists which are wholly unsuited, from their physical nature and that of light, for investigation by any known optical method. Such structures might be aptly termed *Hyperphotic*, since it seems unlikely they will ever be revealed by the agency of light. With such a group, therefore, the method of investigation we are at present considering is in no way concerned, since an essential feature of ultra-microscopic structures is that they so modify light as to produce characteristic optical effects. It remains now to briefly refer to the relationship of such method of ultra-microscopic examination to ordinary or unaided microscopic investigation. In other words, can we attain results by its employment not to be attained by means of the microscope alone? And, if so, are such results of sufficient importance to justify the expenditure of the time and trouble required? The answer to this may best be given in the form of an example. For this purpose any of the various bodies we have been treating of might be selected. I have taken an iridescent feather from the breast of the humming-bird *Chrysolampis mosquitus*. Placed on the stage of the microscope, and examined in the ordinary way, it is seen to consist of a central shaft or rachis, from the sides of which spring the so-called barbs, and arranged along the edge of these are seen numbers of elongated flat bodies, termed 'barbules,' which, towards the extremity of the feather, overlap. These latter, with the barbs, constitute the web, and the two webs with the intermediate shaft, the vane of the feather. These barbules are seen to be brilliantly coloured, they constitute the colour producing structure of this iridescent feather. Here, so far as the structure of these barbules goes, microscopic examination ends, and here ultra-microscopic investigation steps in. Retaining the structure on the stage of the microscope, modified so as to permit of the necessary adjustment, the object is, by suitable movements of stage and illumination, examined by light falling on it, and reflected from it at varying angles. It is seen to change colour from a higher towards a lower order of tint as the incident light becomes more and more oblique; in other words, it belongs to the class of iridescent bodies. Such colours might be due to dispersion, polarisation, diffraction, or interference of thin plates. Polarisation we may at once exclude, since the object is a natural body, and colour by polarisation, so far as I am aware, is unknown in nature. Examined according to the method already alluded to for the distinguishing of diffraction colours from those of thin plates, it is seen to belong to this latter group, to consist of thin plates. But the theory of colour-production by thin plates is well understood, and it can easily be shown that, neglecting the effect produced by variation in the optical density of the substance composing the plate, a given colour is produced by a given thickness of plate. That is to say, if the colour is known, the thickness of the plate can be calculated. To ascertain the nature of the colour we employ the only reliable test of colour composition, the prism. Adapted to the microscope in the form of the so-called microspectroscope, this shows the orange light reflected from the feathers at normal incidence to have a composition



Spectrum of feather from breast of the "Ruby and Topaz" Humming-bird
(Chrysolampis mosquitus).

indicated by the above spectrum. Such spectra are readily mapped out on blank charts prepared for the purpose. Since now, as remarked above, disregarding optical density, a given spectrum is peculiar to a given thickness of plate, it only becomes necessary to compare the obtained spectrum with the spectra of thin plates of known thickness to learn the thickness of plate-structure producing the spectrum in question.

To facilitate such comparisons I have constructed the accompanying "Spectral Chart." (See coloured plate.) This, as seen, allows of the immediate determination of all interference colours whether due to polarisation or produced by thin plates, from the 1st to the 7th order inclusive. We shall subsequently refer to the construction of this chart. To use it, it is merely necessary to slide the map of the spectrum of the body under observation up the spectral chart, beginning at the bottom, until on a level with a tranverse section of the chart which shows the same colour composition as the map. Opposite such points in the right hand column of figures we have the approximate thickness of the plate in micromillimetres, and still further to the right the corresponding undecomposed colour. On applying the map of the spectrum of the breast feather of our humming-bird, it is seen to correspond in colour composition with a line crossing the spectral chart at a point indicated in the right hand column by the number ·485. This number, therefore, represents the thickness of the plate in question in micromillimetres. This point, moreover, is opposite the orange of the 2nd order, and we thus also ascertain the position of the colour examined on the Newtonian colour-scale.

From the foregoing example it is obvious that something more has been ascertained regarding the structure of the objects under observation than can be determined by the microscope alone. The barbules, which to ordinary microscopic investigation appear devoid of structure, are seen to possess the property of colour-production. Examining such colour phenomenon, under varying conditions and with suitable appliances, it is seen to correspond in all respects with the interference colours produced by thin plates. We are, therefore, justified in assuming the same structure as the cause of the colour in the barbules, and, therefore, of attributing to the colour-producing portion of the feathers a structural arrangement composed of thin plates. It has been pointed out how an approximate measurement of the thickness of such plates is indicated by the position of the spectrum on the chart.

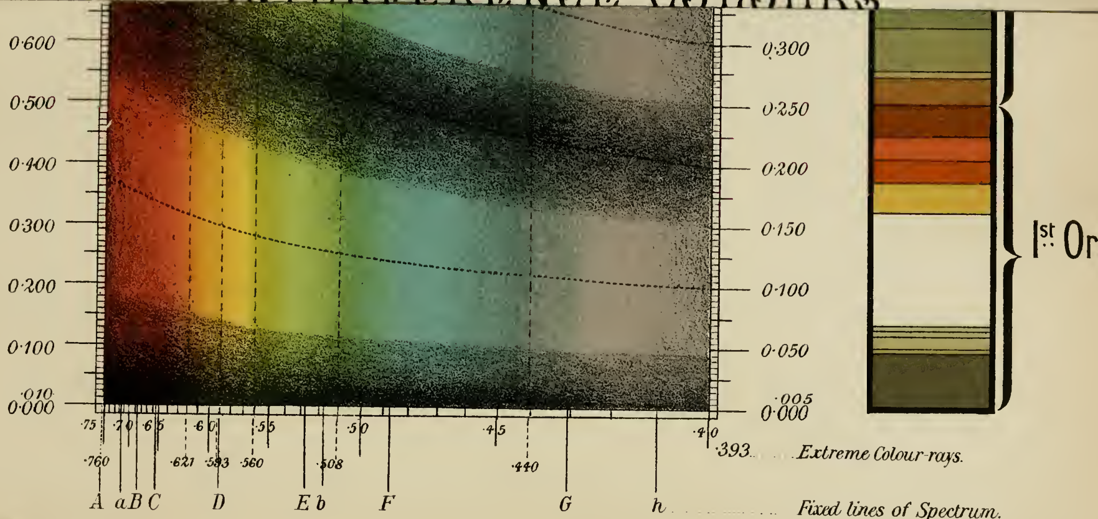
In the above example we have an instance of a structure exhibiting a marked optical effect, namely, the production of colour. From the nature and properties of such colour we have inferred the nature of the structure producing such effect. If all ultra-microscopical structures possessed the property of colour-production, and if the structural cause of all colour-production were known, the determination of the nature of ultra-microscopic structures generally would be a simple matter. Such is, however, not the case. Though, as we shall see, structure does commonly manifest colour phenomena, in numbers of instances no such effect is apparent. In other instances colour is produced giving rise to appearances of the most distinctive kind, but which, owing to our ignorance of the cause of such colour-phenomena, have for us no structural significance. So-called absorption colours are of this nature, since, though many attempts have been made to explain their production on a physical basis, they have, so far as I am aware, as yet had no satisfactory explanation.

Colour alone, therefore, not being a universal manifestation of ultra-microscopic structure, we must in such instances rely on other optical phenomena as indications of structure. Such are polarisation, reflection, opalescence, &c. These I shall subsequently consider and endeavour to show to what extent they are indicative of structure.

SPECTRAL CHART

FOR DETERMINATION OF

INTERFERENCE COLOURS



ALEX HODGKINSON, PIX

LITHOGRAPHED BY KLEINERTZ, MANCHESTER

* I, exclusive of loss or gain of ½ λ by variation in optical density of media, = 2 μ t cos á; and at normal incidence 2 μ t.

† Scale readings are for light <u>normally</u> incident on plate.

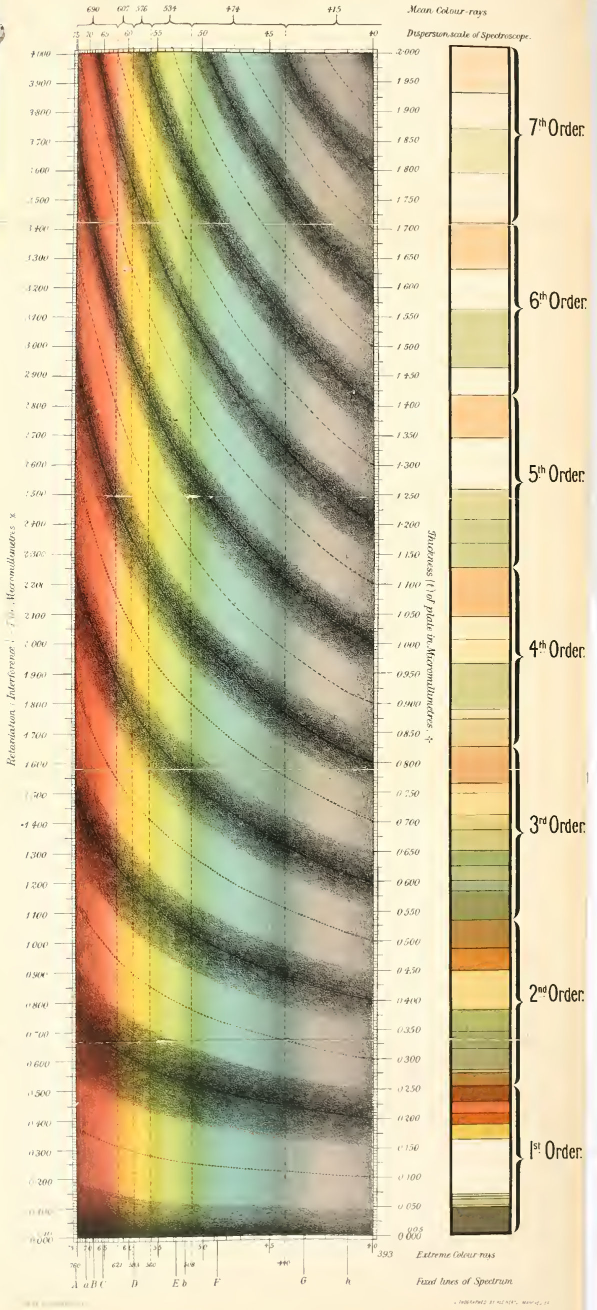
SPECTRAL CHART

FOR DETERMINATION OF

INTERFERENCE COLOURS

FROM THE

1ST TO THE 7TH ORDER.



I, exclusive of loss or gain of ½ λ by variation in optical density of media = 2 μ t cos i, and at normal incidence 2 μ t

Scale readings are for light normally incident on plate.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, March 11th, 1889.

Mr. J. COSMO MELVILL, M.A., F.L.S., President of the Section, in the Chair.

There were exhibited :—

By Mr. H. HYDE, shells of various species of *Zizyphinus.*

By Mr. P. CAMERON, an apparently undescribed species of *Athalia* from Japan, and a new species of Saw-fly from Gibraltar, allied to *Athalia*, but with the antennæ 20-jointed and forming probably the type of a new genus.

By Mr. H. C. CHADWICK, a piece of rock of a remarkable hexagonal honeycomb structure.

By Mr. THEODORE SINGTON, a number of specimens of resin from the East Coast of Africa, containing insects, spiders, &c.

By Dr. HODGKINSON, a humming bird, *Chrysolampis mosquitus.* Dr. Hodgkinson drew attention to the fact that in this and most other humming-birds the brilliant colouring is situated on the crest and gorget. The colour is best seen when the position of the bird is such that the light is reflected from those parts directly to the front. The intensity of the coloured light thus reflected is very great, and can be shown to be sufficient to illuminate very perceptibly objects on which it falls. It would thus seem that such light would serve to light up the dark tubes of flowers which the bird might be visiting in search of insects or honey.

[*Physical and Mathematical Section.*]

Annual Meeting, March 13th, 1889.

WM. THOMSON, F.R.S. Ed., F.C.S., F.I.C., Vice-President of the Section, in the Chair.

The Treasurer's accounts for the year 1888-9 were presented, and showed :—Balance from last year £5. 2s. 4d., cash received during the current year, £4. 1s. 8d., making a total of £9. 4s. 0d., against which were payments during the current year £4. 3s. 10d., leaving a balance in favour of the Section of £5. 0s. 2d.

On the motion of Mr. J. A. Bennion, seconded by Mr. Wm. Thomson, it was resolved :—"That the Treasurer's accounts be received and passed."

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

President.—JAMES BOTTOMLEY, B.A., F.C.S., D.Sc.

Vice-Presidents.—JAMES P. JOULE, D.C.L., LL.D., F.C.S., F.R.S.; WILLIAM THOMSON, F.R.S. Ed., F.C.S., F.I.C.

Secretary.—J. A. BENNION, M.A., F.R.A.S.

Treasurer.—JOHN ANGELL, F.C.S., F.I.C.

The following is a list of the members and associates of the section :—

Members.—JOHN ANGELL, F.C.S., F.I.C.; JAMES BOTTOMLEY, B.A., D.Sc., F.C.S.; F. J. FARADAY, F.L.S., F.S.S.; J. P. JOULE, LL.D., D.C.L., F.R.S., F.C.S.; WILLIAM MATHER, M.P.; S. OKELL, F.R.A.S.; WM. THOMSON, F.R.S. Ed., F.C.S., F.I.C.

Associate.—J. A. BENNION, M.A., F.R.A.S.

Ordinary Meeting, March 19th, 1889.

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

Dr. CHARLES CLAY read a paper "On the results of some calculations with a certain class of figures" embodying some arithmetical calculations bearing on the problem of the squaring of the circle.

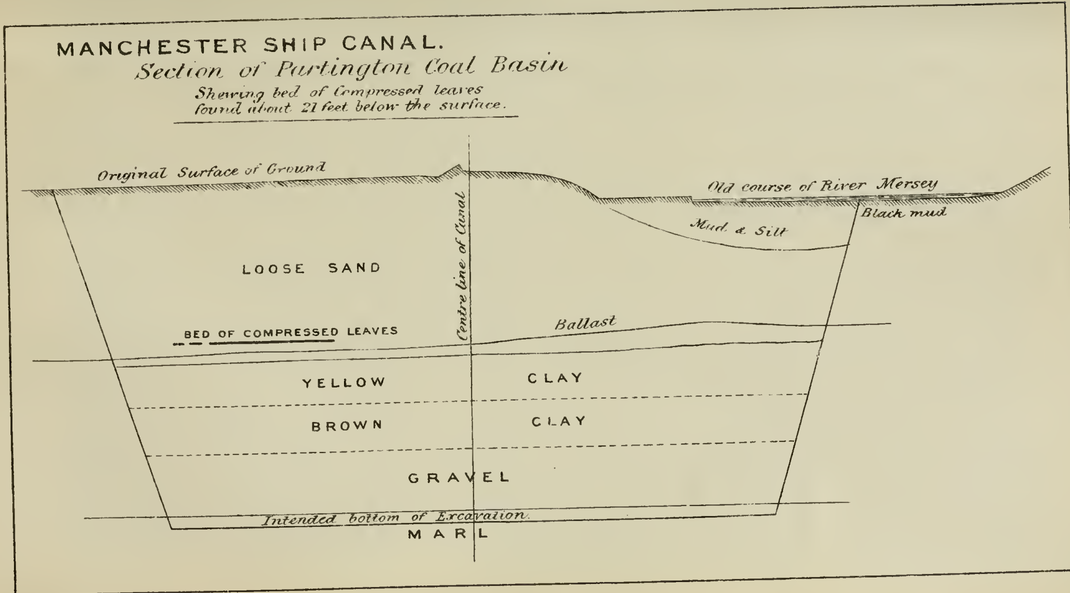
Mr. WM. THOMSON, F.R.S.ED., read a paper "On the presence of green colouring matter in leaves found about 21 feet under the surface in an excavation connected with the Ship Canal Works," and exhibited specimens of the deposit.

Dr. HODGKINSON read the second of a series of papers "On Colour and its relation to the Structure of Coloured Bodies; being an Investigation into the Physical cause of Colour in natural and artificial bodies and the Nature of the Structure producing it," treating of some of the physiological phenomena of colour sensation.

On Leaves found in the cutting for the Manchester Ship Canal, 21 feet under the surface, and on Green Colouring Matter contained therein. By William Thomson, F.R.S. Ed., etc.

(*Received May 15th, 1889.*)

My attention was drawn by Mr. Alderman Bailey to these leaves which had been found in the cutting for the Ship Canal. On further enquiry I learned that they had been brought to notice by Mr. Walter Taylor, one of the Company's Engineers, to whom I am indebted for the following notes respecting the position in which they were found. I went to look at the deposit on the 19th of March last, and by the kindness of Mr. W. O. E. Mead King and Mr. Taylor, I was enabled to obtain a considerable supply of the leaves. They were embedded in the sand in two or three different layers of one to two inches in thickness, the one above the other; at some places, with a layer of sand of about an inch or two in thickness between the layers of leaves. There was, however, chiefly one layer of leaves, about two inches in thickness, which lay in a bed curved in the direction of the width, which was about 40 feet by about 14 feet long. This bed of leaves was found in the Partington Coal basin, near Irlam, 21 feet under the surface: it was about 650 feet from the present river, and 50 feet from the old Mersey river course, which had been filled up near to the surface with mud and silt and black mud. It occurred in the space between the two arms in the bend of the old river known as Sandy Wharps, the whole of the space between the two arms of this bend or knuckle being filled up with loose sand, such as is found at


MANCHESTER SHIP CANAL.
Section of Partington Coal Basin
Shewing bed of Compressed leaves
found about 21 feet below the surface.
Original Surface of Ground
Old course of River Mersey
Black mud
Mud & Silt
Centre line of Canal
LOOSE SAND
Ballast
BED OF COMPRESSED LEAVES
YELLOW
CLAY
BROWN
CLAY
GRAVEL
Intended bottom of Excavation.
MARL

the sea side. This loose sand continued on either side of the two arms of the river, and ended in a layer of clay extending from the surface and sloping downwards on either side towards the river arms, not many yards from the opposite banks of the ancient river course. A few inches below where these leaves were found occurred a layer of ballast, and in order under that boulder clay, 6 feet thick, coarse gravel, 3 feet, then the new red sandstone.

On further opening out the cutting towards Manchester, at about the same depth from the surface (24 feet exactly) this bed of leaves occurs more or less continuously for more than 800ft. It is in several layers divided by thin beds of sandy clay; in one place the four or five layers, with the clay between, reached a thickness of 15 inches. These leaves differ slightly from the others, in that they contain a good percentage of moss mixed with them, but are evidently about the same date, being at the bottom of the deep layer of sand under the top soil and clay. The deposit is about 800 feet (nearer Liverpool) from the old junction of the Mersey and Irwell. The accompanying diagram of this section was kindly provided for me by Mr. Hunter, another of the Manchester Ship Canal Engineers.

When the leaves were removed from the sand they were very damp, and possessed a dirty olive-green colour. They lay very evenly on each other, so that they could easily be separated into layers, each layer showing some perfectly formed leaves, many of them differing from the surrounding ones in colour, some being more or less touched with yellow or other delicate shade, and it was remarkable how free they were from sand, twigs, or débris: there was mixed with them, however, the fruit of certain trees and plants. It is evident from the remarkable state of preservation of these leaves and fruit, that they must have been suddenly immersed and imbedded, and it might be assumed that this took place somewhere about the Autumn, as was suggested by Mr. Charles Bailey, F.L.S., because of the fruit found.

When allowed to dry the leaves became more brittle, and they could then be separated from each other only with much difficulty. These leaves and fruit have been examined by different botanists, and the following identified by Mr. W. Carruthers, F.R.S., of the British Museum; Mr. Scott, M.A., F.L.S., of the Science and Art Department, South Kensington; Mr. Cosmo Melvill, F.L.S., Mr. Charles Bailey, F.L.S., Mr. John Boyd, and Mr. Leo H. Grindon, of Manchester:—

Aspen (*Populus tremula, L.*).
Oak (*Quercus Robur, L.*).
Shoreweed (*Litorella lacustris*).
Grey Willow (*Salix cinerea*).
Hawthorn (*Cratægus Oxyacantha*).
Osier (*Salix viminalis*).
Fruit of the Rose (probably *Rosa arvensis*).
Black poplar (*Populus nigra*).
Sedges.
Bramble seeds.
Buttercup fruit.
Potamogeton fruit.
Dock leaves.
Acer fruit.

As to the age of this vegetation, so far as one can judge, it must be at least some centuries and probably one or more thousands of years. In some thin layers in the sand, about the same depth from the surface, but at some distance from this bed, I observed a number of bits of wood, rounded pebbles, a few rounded bits of coal, &c. Mr. Percy F. Kendal, of the Owens College, informed me that horns of the red deer had been found in the Ship Canal cutting, about the same depth underground, and that fact led him to put the *minimum* age of this deposit at from 300 to 400 years. Not far from this deposit was subsequently found a rude boat (since described before this Society by Mr. Alderman Bailey) about 25 feet underground. This boat lay on a bed of leaves, similar to the one above-mentioned, but much more decayed.

The dark olive green colour of the leaves first-mentioned, led me to examine them for chlorophyll, by the method employed by Berzelius, Verdeil, Schulze, and Mulder, in which acid is employed in the separation. By thus treating these leaves in comparison with ordinary grass, I obtained by spectroscopic examination absorption bands which were identical. Dr. Edward Schunck, F.R.S., however, who must be regarded as our greatest authority on chlorophyll, subsequently examined the colouring matter of these buried leaves, and in his most interesting paper, given before this Society, he shows that it is not really chlorophyll which exists in these leaves, but modified chlorophyll, which is a very much more permanent colour, produced by the action of acid on chlorophyll. This colour, however, permanent as Dr. Schunck has proved it to be, is entirely destroyed when leaves are exposed to the air and rain and sunshine for a few months, at all events within a year, and it, therefore, seems an interesting fact that this modified chlorophyll should have remained intact, buried in this wet sand for *at least* some hundreds of years, and probably for one or more thousands of years. I examined the leaves which were supplied to me by Mr. Taylor, which were found under the boat above-mentioned, and I could only detect in them a comparatively very small quantity of the green colouring matter (modified chlorophyll) found in the others.

Ordinary Meeting, April 2nd, 1889.

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

Professor SCHUSTER described Lord Rayleigh's colour-mixer, for testing colour sensations. There are many small peculiarities in colour sensation different from colour blindness, but certain more distinct peculiarities are rare and seem to run in families. Persons affected by these greater diversities agree quite well among themselves in their judgment of a colour, and there is no intermediate class between them and those having normal sight.

Mr. RALPH HOLMES, B.A., read a "Note on the Propagation of Sound through an Atmosphere of Varying Density."

Dr. HODGKINSON read a third communication "On Colour and its relation to the Structure of Coloured Bodies; being an Investigation into the Physical Cause of Colour in natural and artificial bodies and the Nature of the Structure producing it," describing the structures which cause the silvery sheen of the herring and other fish, and those which produce the distinctive colours of fish. The author explained how, on drying, these scaly structures give rise to the changing colours of the dying dolphin.

On Sound propagated through an atmosphere, in which the surfaces of constant density are parallel planes, in a direction perpendicular to these planes. By Ralph Holmes, B.A.

(*Received May 8th, 1889.*)

We will endeavour to obtain a solution of this question when the law of change of density is any whatsoever, provided this change is very small.

With the usual notation let p, ρ be equilibrium density and pressure at any point x, $p+p'$; $\rho+\rho'$ what these become when there is wave motion.

Then

$$\frac{1}{\rho}\,\frac{dp}{dx}=X$$

$$\frac{1}{\rho+\rho'}\,\frac{d.(p+p')}{dt}=X-\frac{du}{dt}-u\frac{du}{dx}.$$

Hence to first order of p', ρ', u, we have

$$\frac{1}{\rho}\,\frac{dp'}{dx}-\frac{\rho'}{\rho^2}\,\frac{dp}{dx}=-\frac{du}{dt}\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(i.)}$$

Also from the equation of continuity,

$$\frac{d\rho'}{dt}+\frac{d.\rho u}{dx}=0\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\text{(ii.)}$$

Now, whenever we have compression or rarefaction of air due to a wave of sound, on the supposition that there is no ingress or egress of heat, we have the relation that the change of pressure is γ times as great as it would have been had there been no change of temperature. Thus

$$\frac{1}{p+p'}\,\frac{\delta.\overline{p+p'}}{\delta.t}=\frac{\gamma}{\rho+\rho'}\,\frac{\delta.\overline{\rho+\rho'}}{\delta.t}.$$

But

$$\frac{\delta}{\delta t}=\frac{d}{dt}+u\frac{d}{dx}.$$

Hence

$$\frac{1}{p}\left\{\frac{dp'}{dt}+u\frac{dp}{dx}\right\}=\frac{\gamma}{\rho}\left\{\frac{d\rho'}{dt}+u\frac{d\rho}{dx}\right\}\ldots\ldots\ldots\ldots\ldots\text{(iii.)}$$

Hence, eliminating p', ρ' from (i.), (ii.), (iii.), we obtain

$$\frac{d^2u}{dt^2}=\frac{\gamma p}{\rho}\left(\frac{d^2u}{dx^2}+\frac{1}{p}\frac{dp}{dx}\frac{du}{dx}\right)+\frac{1}{\rho}\left(\frac{d^2p}{dx^2}-\frac{1}{\rho}\frac{dp}{dx}\frac{d\rho}{dx}\right)u\ldots\ldots\text{(iv.)}$$

Supposing that the changes in the pressure and density are so small that we may neglect their second differentials and products and powers of differentials above the first, the equation (iv.) to determine u becomes

$$\frac{p\gamma}{\rho}\frac{d^2u}{dx^2}+\frac{\gamma}{\rho}\frac{dp}{dx}\frac{du}{dx}=\frac{d^2u}{dt^2}\quad\ldots\ldots\ldots\ldots\ldots\ldots\text{(v.)}$$

If p and ρ were constant, a solution of this equation may be written

$$u=\mathrm{A}f\left(t-\frac{x}{\sqrt{\frac{\gamma p}{\rho}}}\right)+\mathrm{BF}\left(t+\frac{x}{\sqrt{\frac{\gamma p}{\rho}}}\right)$$

where A and B are constants.

Let us therefore assume, as a solution of equation (v.)

$$u=\mathrm{A}f\left(t-\int\frac{dx}{\sqrt{\frac{\gamma p}{\rho}}}\right)+\mathrm{BF}\left(t+\int\frac{dx}{\sqrt{\frac{\gamma p}{\rho}}}\right)$$

where A and B are now slowly varying functions of x, such that their second differentials and products of their first differentials with the first differentials of p and ρ may be neglected. We have, putting $q^2=\frac{\rho}{p\gamma}$,

$$\frac{du}{dx}=\frac{d\mathrm{A}}{dx}f-\mathrm{A}qf'+\frac{d\mathrm{B}}{dx}\mathrm{F}+\mathrm{B}q\mathrm{F}'$$

$$\frac{d^2u}{dx^2}=-2q\frac{d\mathrm{A}}{dx}f'+\mathrm{A}q^2f''+2q\frac{d\mathrm{B}}{dx}\mathrm{F}'+\mathrm{B}q^2\mathrm{F}''-(\mathrm{A}f'-\mathrm{EF}')\frac{dq}{dx}$$

$$\frac{d^2u}{dt^2}=\mathrm{A}f''+\mathrm{BF}''$$

Substituting these values in equation (v.), we have

$$\left(-\frac{2}{q}\frac{d\mathrm{A}}{dx}-\mathrm{A}\frac{1}{q^2}\frac{dq}{dx}-\mathrm{A}\frac{1}{pq}\frac{dp}{dx}\right)f'+\left(\frac{2}{q}\frac{d\mathrm{B}}{dx}+\mathrm{B}\frac{1}{q^2}\frac{dq}{dx}-\mathrm{B}\frac{1}{pq}\frac{dp}{dx}\right)\mathrm{F}'=0.$$

So that to determine A and B we have the equations

$$\frac{2}{q}\frac{dA}{dx} + A\frac{1}{q^2}\frac{dq}{dx} + A\frac{1}{pq}\frac{dp}{dx} = 0.$$

$$\frac{2}{q}\frac{dB}{dx} + B\frac{1}{q^2}\frac{dq}{dx} + B\frac{1}{pq}\frac{dt}{dx} = 0.$$

$$\therefore\ A^2 p^{\frac{1}{2}} \rho^{\frac{1}{2}} = \text{constant}.$$

$$\&\ B^2 p^{\frac{1}{2}} \rho^{\frac{1}{2}} = \text{constant}.$$

Thus we obtain

$$u = Ap^{-\frac{1}{4}}\rho^{-\frac{1}{4}} f\left(t - \int \frac{dx}{\sqrt{\frac{\gamma p}{\rho}}}\right) + Bp^{-\frac{1}{4}}\rho^{-\frac{1}{4}} F\left(t + \int \frac{dx}{\sqrt{\frac{\gamma p}{\rho}}}\right)$$

where A and B must now be regarded as constants. This result holds, whatever be the law of variation of pressure and density, provided that their variation is slow.

If $p \propto \rho^\gamma$, which is the case for convective equilibrium of the atmosphere, we see that the amplitude of vibration varies inversely as the $\frac{\gamma + 1}{4}$th power of the density.

If $p \propto \rho$, we see in the same way that the amplitude of vibration varies inversely as the square root of the density.

In the case of a constant temperature, where the variation of density is caused by a constant gravitational force g, the terms which we have neglected in equation (iv.), viz.,

$$\left(\frac{d^2 p}{ax^2} - \frac{1}{\rho}\frac{dp}{dx}\frac{d\rho}{dx}\right)u$$

are actually zero.

[*Microscopical and Natural History Section.*]

Annual Meeting, April 8th, 1889.

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

The Secretary read the Thirty-first Annual Report of the Council of the Section, and the Treasurer submitted the annual balance sheet and statement of accounts. (See p. 267).

On the motion of Mr. CHARLES BAILEY, F.L.S., seconded by Mr. R. E. CUNLIFFE, the annual report and Treasurer's accounts were approved.

The following gentlemen were elected officers and members of the Council of the Section for the ensuing session :—

President :—J. COSMO MELVILL, M.A., F.L.S.

Vice-Presidents :—CHARLES BAILEY, F.L.S., ALEX. HODGKINSON, M.B., B.Sc., W. C. WILLIAMSON, LL.D., F.R.S.

Treasurer :—MARK STIRRUP, F.G.S.

Secretary :—JOHN BOYD.

Other Members of the Council :—WILLIAM BLACKBURN, F.R.M.S., P. CAMERON, H. C. CHADWICK, ROBT. E. CUNLIFFE, R. D. DARBISHIRE, B.A., F.G.S., F. NICHOLSON, F.Z.S., THOS. ROGERS, THEODORE SINGTON.

Mr. A. A. MUMFORD, M.B. (Lond.), M.R.C.S., L.R.C.P., was elected an associate of the section.

Dr. ALEX. HODGKINSON exhibited specimens of dissections of eyes, showing that the cause of luminosity in the dusk is due to the existence of a triangular patch of flat colourless cells situated between the retina and the pigmentary layer of the choroid. In the centre of the reflecting patch the cells are arranged in many layers, the number of such layers decreasing toward the periphery. At the extreme edge the cells constitute a discontinuous layer, consisting in fact of isolated cells on a dark ground. The cells are sufficiently thin to produce interference of the reflected light. The rays reflected from the isolated cells and portion of the patch consisting of a single layer are bluish, nearer the centre greenish, whilst still more centrally the reflected light appears yellowish white. Such appearances may be observed in the living eyes of many nocturnal animals as the cat, fox, &c.

General Meeting, April 16th, 1889.

Mr. CHARLES BAILEY, F.L.S., in the Chair.

The following gentlemen were elected ordinary members of the Society:—Mr. GEORGE W. MOULTRIE, Bank of England, King Street, Manchester; Mr. GEORGE NORBURY, Hillside, Prestwich Park, Prestwich; Mr. HERBERT S. BROOKS, Slade House, Levenshulme; Mr. T. B. WILSON, C.E., 37, Arcade Chambers, St. Mary's Gate, Manchester; Mr. W. J. ROBERTSON, Hollins Mount, Heaton Moor, Stockport.

Ordinary Meeting, April 16th, 1889.

Mr. CHARLES BAILEY, F.L.S., in the Chair.

Mr. WM. BROCKBANK, F.L.S., F.G.S., read a paper entitled "Notes on Seedling Saxifrages grown at Brockhurst from a single scape of *Saxifraga Macnabiana*," and exhibited the plants referred to.

Dr. EDWARD SCHUNCK, F.R.S., F.C.S., read a paper entitled "On the green colouring matter from leaves found in one of the cuttings for the Manchester Ship Canal," and exhibited specimens of chlorophyll and its derivatives, and their spectra.

Notes on Seedling Saxifrages grown at Brockhurst from a single scape of Saxifraga Macnabiana. By William Brockbank, F.L.S., F.G.S.

(*Received April 16th, 1889.*)

Saxifraga Macnabiana is considered to be the most showy of all the cultivated saxifrages, having the scape of *S. Cotyledon*, but with the petals dotted over with deep carmine spots. It was raised at the Royal Botanical Gardens, Edinburgh, in 1876, when Mr. MacNab was the curator, and was named after him. Mr. Lindsay, the present curator, who was the real raiser of the plant, informs me that nothing whatever was known of its parentage, but that *S. nepalensis* produced the seeds. This is merely a garden variety of *S. Cotyledon*, which occurs in the wild state throughout Europe from the Pyrenees to Lapland. In Lapland it is called the Fjeld frier, and it is the sweetheart's gift to his lady-love in that country, where it produces lovely panicles of white flowers two feet high. Mr. Lindsay when in Norway, in 1877, gathered many specimens of *S. Cotyledon* differing considerably from the type in flowers and foliage. It will be seen that this susceptibility to variation is characteristic of the plant under cultivation.

When *S. Macnabiana* was raised, the only plant near *S. Cotyledon* was *S. lingulata*, a species of dwarfer growth, the petals spotted with pink, and the foliage edged with encrusted pores. Mr. Lindsay therefore believes that *S. lingulata* was the pollen parent, and this is probably the case, as many of the seedlings are like this species, and the dwarfer habit of the plant may also have been brought about by this cross. *S. Macnabiana* seldom exceeds half the height of *S. Cotyledon.* Its leaves are also much smaller. A fine flower scape will number over a hundred flowers. One fine plant of *S. nepalensis*, in flower at Brockhurst in 1883, carried 44 branches from the centre stalk, each having from 12 to 22 flowers, so that there were about 750 flowers, each the size of a fourpenny-piece, in one panicle of bloom. Now as these flowers occur in succession, it will be clear that there may be considerable variety in the time of ripening of the flowers, and thus there is room for great divergence.

In 1886 a fine scape of *S. Macnabiana* ripened its seed in my garden, and a quantity was saved from it. This was sown, and produced a large crop of plants. It was soon noticed that there were great differences amongst the seedlings, and these increased as the plants grew. The most notable were therefore separated, and were grown on in small pots, and of these 110 varieties are now exhibited; every one resulting from the seed of this one single scape. In the garden where the plant grew there were nearly all the known species and varieties of saxifrage, at least 150; and, therefore, it is possible enough that pollen from a great variety of saxifrages might be carried by insects to the mother plant. Likenesses are evident, amongst the 110 seedlings, to the following species and varieties of *Saxifraga*:—*lingulata*, *Hostii*, *crustata*, *pectinata*, *elatior*, *carinthiaca*, *Cotyledon*, *Aizoon*, and *Guthreana*.

Here then we have a remarkable illustration of the multiplication of varieties from a single scape of bloom; and it affords an excellent example of the truth of Darwin's investigations on the fertilization of plants by insects.

Sprengel was, I believe, the first to point out that many flowers were fertilized by insects; and Andrew Knight showed that in no plant does self-fertilization occur for an unlimited number of generations. Our own Dean Herbert nearly made the same discovery, as he found that advantage was derived from the seed obtained by pollen from another individual of the same variety, rather than its own. Darwin, however, finally showed by careful investigation that plants were improved by crossing with another stock ; that the application of pollen to the pistil of the same flower is less efficient than pollen from another individual. He also showed how frequently self-fertilization is prevented by the relative position of the reproductive organs, or by their ripening at different times. This subject has been carried much further by Müller, whose book contains minute descriptions of the reproductive parts of every class of flower, and long lists of the insects which are found to frequent each flower in search of food. Müller, however, does not appear to have observed the saxifrages, and he gives no list of insects frequenting them. He merely states that Dr. A. Engler investigated 38 species of saxifrages, and found them all to be proterandrous ; the pollen-tipped stamens moving singly, in succession, towards the centre of the flower. In this way the pistil became fertilized. This, I find, may readily be observed in many of the saxifrages, and particularly in *S. oppositifolia*, and there is but little variety in this class of self-fertilized saxifrages. Müller then remarks that in some Alpine species there is the peculiarity that the anthers are withered before the stigma has ripened. He does not name *S. Cotyledon*, or any species having these habits, but herein we have the key to the question before us.

Julius von Sachs, in his "Physiology of Plants," just translated by Professor Marshall Ward, describes this peculiar arrangement under the term "Dichogamy," *i.e.*, the non-simultaneous development of the two sexual organs. When this occurs, as it does in *S. Cotyledon* and *S. Macnabiana*, insects are the means by which the pollen is carried to the ripe pistil, and thus a great variety of pollen may be carried to the individual flowers of a single scape, and the progeny will be varied accordingly.

The 110 varieties of Saxifrages now exhibited are illustrations of this curious subject.

On the Green Colouring Matter from Leaves found in one of the Cuttings for the Manchester Ship Canal. By Edward Schunck, Ph.D., F.R.S.

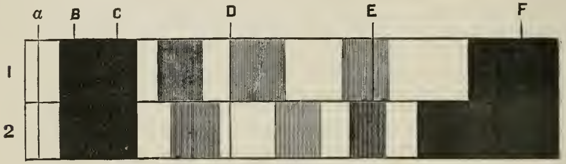
(*Received April 27th, 1889.*)

At the Meeting of the Society held on March 19th, Mr. William Thomson read a paper on a deposit of leaves found at a depth of about 21 feet in one of the cuttings for the Ship Canal, near Irlam. Mr. Thomson stated that he had been able to extract from these leaves a green colouring matter, the solutions of which showed the absorption bands of chlorophyll.

Having myself paid some attention to the subject of chlorophyll, I feel an interest in any new fact relating to it. Some confirmation of Mr. Thomson's statement seemed desirable, since chlorophyll, as everyone knows, is one of the most fugitive and easily decomposed of natural colouring matters, and it seemed improbable, therefore, that it should have been preserved unchanged within the vegetable tissue during the long period that these leaves are said to have lain underground.

Having expressed a wish to make a few experiments myself, Mr. Thomson very kindly placed at my disposal some of the material employed by him, and an additional quantity was supplied to me by Mr. Mead King, engineer over that section of the canal where the deposit was found.

My examination is not to be considered exhaustive. I merely wished to ascertain whether the colouring matter referred to was chlorophyll, and, if not, whether it was in any way related to the latter. The material was treated at once with boiling alcohol, which extracted the whole of the colouring matter, leaving behind the cellular tissue of the leaves mixed with sand and débris. The extract was filtered boiling hot, and, being left to stand some time so as to allow fatty matters and other impurities to deposit, was filtered again. The extract thus obtained did not show the bright green colour characteristic of solutions of pure unchanged chlorophyll from fresh leaves, but had a yellowish-green tint. Its absorption spectrum also differed in more than one respect from that of chlorophyll.



The absorption spectrum of chlorophyll shows four bands, the first of which in the red is very dark, whilst the fourth, near the line E, is faint. The alcoholic extract of the leaves from the Ship Canal deposit, on the other hand, showed a tolerably dark band near E, while the third band between D and E appeared very faint and further away from the red end; its absorption spectrum coincided in fact with that of so-called "modified chlorophyll." There can be no doubt that modified chlorophyll is a product of the action of acids on chlorophyll. When a solution of pure chlorophyll is mixed with a little hydrochloric acid it loses its bright green colour, and soon becomes yellowish-green ; it then exhibits the spectrum of modified chlorophyll. Weak acids produce the same effect, but more slowly. Hence it appears probable that in the case of the leaf deposit, the chlorophyll had come into contact with some acid conveyed possibly by infiltration from above, or formed, perhaps, in consequence of the oxidation of some leaf constituent or other, and thus become modified. Modified chlorophyll, like all derivatives of the colouring matter, is much more stable than the parent substance. Its solutions may be exposed to air and light for a considerable time without undergoing much change, whereas solutions of normal chlorophyll, on exposure to the same combined agency, are rapidly bleached, with entire destruction of the colouring matter. The circumstance of the chlorophyll having undergone modification in the leaves of the deposit may serve to explain its continued presence after the long period during which it is said these leaves have lain buried. Still the fact of its remaining unchanged for so long a time, even in the modified state, is sufficiently remarkable, and can only be explained by supposing that the leaves were suddenly and completely buried under a mass of material which to a great extent preserved them from the action of light and air. It is worthy of remark that the leaves of the deposit are comparatively poor in colouring matter, yielding far less than the same quantity of fresh leaves would do.

Annual General Meeting, April 30th, 1889.

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

Mr. HARRY THORNBER, of Rookfield Avenue, Sale, Cheshire, was elected an ordinary member.

The following gentlemen, nominated by the Council as honorary members, were elected :—Professors G. HALPHEN, and H. RÉSAL, Membres de l'Institut, Paris ; W. HERTZ, Bonn ; D. MENDELEEFF, St. Petersburg ; LOTHAR MEYER, Tübingen ; FERDINAND COHN, Breslau ; W. G. FARLOW, Cambridge, U.S.A. ; WILHELM ROSCHER, Leipsic ; GEORGE SALMON, Dublin ; MICHAEL FOSTER, Sec. R.S., Cambridge ; Messrs. EDWARD JOHN ROUTH, F.R.S., Cambridge; ERNST WERNER SIEMENS, Berlin ; A. W. WILLIAMSON, For. Sec. R.S., London ; Sir JOHN LUBBOCK, M.P., London ; W. H. FLOWER, F.R.S., British Museum ; and W. CARRUTHERS, F.R.S., British Museum.

The annual report of the Council was presented (see page 252), and it was moved by Dr. SCHUNCK, F.R.S., seconded by Mr. WM. THOMSON, F.R.S.Ed., and resolved, "That the Annual Report be adopted and printed in the Society's *Memoirs and Proceedings*."

It was moved by Mr. Alderman W. H. BAILEY, seconded by Mr. SAMUEL CLEMENT TRAPP, and resolved, "That the system of electing Sectional Associates be continued during the ensuing session."

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

President :—OSBORNE REYNOLDS, M.A., LL.D., F.R.S.

Vice-Presidents :—WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S., Foreign Member of the Royal Swedish Acad. Sc.; EDWARD SCHUNCK, PH.D., F.R.S., F.C.S.; JAMES PRESCOTT JOULE, D.C.L., LL.D., F.R.S., F.C.S., Corr. Mem. Inst. Fr. (Acad. Sc.) Paris, and Roy. Acad. Sc. Turin; ARTHUR SCHUSTER, PH.D., F.R.S., F.R.A.S.

Secretaries:—FREDERICK JAMES FARADAY, F.L.S., F.S.S.; REGINALD F. GWYTHER, M.A.

Treasurer:—CHARLES BAILEY, F.L.S.

Librarian:—FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council:—JAS. BOTTOMLEY, B.A., D.SC., F.C.S.; JOHN BOYD; WILLIAM HENRY JOHNSON, B.SC.; JAMES COSMO MELVILL, M.A., F.L.S.; HAROLD B. DIXON, M.A., F.R.S.; ALEXANDER HODGKINSON, M.B., B.SC.

Ordinary Meeting, April 30th, 1889.

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

Mr. Alderman W. H. BAILEY read a paper "On the Ancient Canoe recently found near Barton, in one of the cuttings for the Manchester Ship Canal," and exhibited sections and diagrams.

A paper on "The Fermentation Theories," by ALFRED SPRINGER, PH.D., of Cincinnati, U.S.A., was communicated by Mr. WILLIAM GRIMSHAW. The author called attention to the following points: (1) The exciters of fermentation are minute organisms reduced to a single cell; (2) Ferments, like all other living things, are subject to physiological, or, more specially, pathological functions of life; (3) They are so sensitive that any abnormal influence either changes their whole mode of existence, or destroys it altogether; (4) A medium suitable to the life of one special kind is changed by it into products which cease to sustain it, but can nourish a lower class of organisms, thereby making analyses, made at different times, vary in their results. We cannot class such reactions with those chemical ones taking place according to the laws of equivalents. The author summed up Pasteur's "oxygen-abstracting theory" of fermentation as "life without free oxygen." In organic cells there resides a special force capable of producing chemical reactions. This force reveals its activity by decompositions effected upon complex molecules. It is motion communicated by vital force, and dependent upon it. Naegeli's theory that "Fermentation is the transmission of the molecular motion of the different compounds of the plasma or cell-contents to the fermentable material, without itself being affected," has caused Liebig's chemico-physiological theory, that the cause of fermentation is the communication of internal molecular motion of matter in the course of decomposition to other matter, the elements of which have a feeble affinity, to regain some significance. Schützenberger repeated Pasteur's experiments, but has given a different explanation. He argues that if the decomposition of sugar were the result of a respiration of the cells of yeast at the expense of combined oxygen recruiting the free oxygen, it seems evident that fermentation ought not to take place, or at least ought to be sensibly lessened, in the presence of free oxygen ; but the reverse of this is the case. The respiratory power of yeast is independent of the quantity of oxygen contained in the medium in which it lives ; it only varies with the temperature, and the more or less favourable conditions of nutrition, as well as with the more or less perfect state of health of the cell. The respiratory power and the fermenting power are two qualities inherent in the cell of the *Saccharomyces* which are not the two variable terms of a constant sum, of which the one vanishes when the other attains its maximum value; on the contrary, all facts tend to prove that these two values grow weak, are destroyed, or attain their maxima at the same time, under the influence of the same causes. Pasteur and other zymologists have set down the following laws :—(1) The spores of the *Ascomycetes*, when submerged in a fermentable liquid, require a certain amount of free oxygen in order to bud or develop into yeast; when once thus developed, they can abstract the requisite oxygen from the compounds contained in the fluid, thereby fermenting the same. Actual fermentation begins the moment the ascospores have developed into yeast cells. (2) On the total absence of free oxygen, the fermentative action of budding yeast may continue for a number of generations, but after this the action becomes weakened and the ferments cease to live if not again brought in contact with free oxygen. (3) The number of generations in which the ferment-organisms can exist without free oxygen has not yet been definitely determined ; but it seems to be greatest with *Saccharomyces cerevisiæ.* Yeast follows the general laws of digestion, for it not only assimilates bodies from the surrounding liquid, which it uses for its nourishment, but it also excretes substances into it which are of no further use. After a cell has reproduced several times, its time of life expires, but the cell does not immediately become inactive, for the membrane allows fluids to pass in and out of it until equilibrium is established between it and the outer liquid. These statements explain the manner of nourishing and multiplication of yeast, but do not explain the cause thereof. It has been argued :—(1) The yeast cell consumes the nutritive parts of the fermentable liquid, and excretes alcohol, carbonic acid, and other products. This theory assumes fermentation to be a purely physiological act ; a small portion of sugar is used for the construction of new cells, but the greater portion is thrown off in a form useless to the ferment-organisms. According to this idea the production of new yeast must be proportionate to the amount of fermentation products. (2) The yeast consumes only as much of the nutritive parts of the fermentation liquids as it needs for its nourishment and reproduction; in its excretiaments one or more combinations are formed which have the power of converting sugar into fermentation products. This theory is purely a chemical one. The organisms, and the reproductions thereof, have nothing to do with the fermentation. The function of the yeast is to produce that body or bodies which act as ferments. If these real ferments could be artificially produced without the intervention of organisms the theory would be fully established. (3) The yeast cell nourishes itself on the existing substances, and, after vegetating for some time, dies off, and thereby creates a fermentation of sugar. This theory is a pathological one, according to which it is not the normal productive yeast which acts, but the dying one: that is, when it approaches its dissolution. Its partisans claim that if sugar is consumed by the yeast and alcohol ejected, then this action would be greatest when it reproduces the most; but this is not the case, for the most alcohol is produced when the maximum reproduction is passed. The author alluded as follows to the question whether a ferment organism can change its physiological action when placed under abnormal influence:—"I have made some careful examinations in this direction, but cannot conscientiously affirm that the ferments sown in the liquids were pure. For instance, if a quantity of starch or sugar, and cheese or meat is sown with lactic ferment, butyric acid is formed at the end of the reaction. If now we take a trace of the butyric ferment out of the liquid, examine it carefully under the microscope and perceive no other ferment present, place it in a medium like the above, but which has previously been heated so as to destroy the existing germs, then add the butyric ferment to the same, and close the bottle with a cotton stopper, lactic acid is again the first formed. Has then in this experiment the butyric ferment changed into a lactic, or are the germs of the lactic so small that, although present in the drop containing the butyric ferment sown in the liquid, they escaped microscopical detection? It seems to me that this question can only be satisfactorily answered when an antiseptic is discovered which has fatal effects on one and none on the other. Pasteur's assertion that oxygen kills the butyric ferment must still be taken with a grain of salt." As regards the bearing of fermentation on technology, the principal questions to be studied are, how to make the mediums most suitable for the nutrition and multiplication of the desired ferments by keeping a sufficient supply of the necessary ingredients ; and secondly, of no minor importance, how either to get rid of the excremental matter by separating it out, or combining it in such a manner as to make it uninjurious to the other ferments. Could the alcohol formed during alcoholic fermentation be removed, the yield would be much greater. The temperature has great influence on the formation of certain products during fermentation. When a mash is kept below 65° C. starch is converted into maltose and dextrin according to the following equation : $4C_6H_{10}O_5 + 2H_2O = C_{18}H_{34}O_{17} + C_6H_{10}O_5$. Maltose is fermentable, dextrin only slightly so. Should the mash be kept close to 75° C., maltose and dextrin are formed according to the following equation : $6C_6H_{10}O_5 + 2H_2O = C_{18}H_{34}O_{17} + C_6H_{10}O_5$. Schlösing and Müntz have shown that nitrification is due to the action of ferments. Etard and Olivier assert that the sulphates of arable earth are dissociated by bacteria. The author had the pleasure of showing that the nitrates of dead plants are dissociated by ferments and the nitrogen returned to the atmosphere. It has been claimed that the growing of plants and the ripening of fruits are nothing but consecutive fermentations where special cells play the part of ferments. Pasteur claims that the power of resolving glucose into alcohol and carbonic acid, or changing it into lactic acid, and that again into a mixture of hydrogen, carbonic, and butyric acids does not belong for each special fermentation to a single organism, to a single ferment, or to a species very nearly allied, as for instance the *Saccharomyces*, but that these reactions are the result of cell life in general, when the organic cells are placed under special conditions. Lechartier and Bellamy have been led to the important conclusion that the elementary organs of plants in general are endowed, though in a less degree than the cells of yeast, with the property of exciting alcoholic fermentation.

The *Schyzomycetes* differ from other ferments in being able to accommodate themselves to any reaction of the fluid and almost any organic nutriment. Their very simple organisation permits them to assimilate substances upon which higher organisms cannot live. They can live without free oxygen, and if carbonic acid is passed through a putrefying liquid, it does not check the process. They can withstand high temperatures. Fluids must be heated to 130°C. to be certain that they are all killed. All antiseptics have less effect upon them than on other ferments. They can withstand comparatively large amounts of carbolic acid; but bi-sulphide of carbon and sulpho-carbolic acid are effective in destroying them. When a fermentable liquid is left exposed to the air consecutive fermentations take place. Thus, when fluids are attacked by ferments, the highest organized first make their appearance, as the mildews; these are followed by the *Saccharomyces*, and these again by the lowest organisms, the split fungi. With reference to antiseptics, the author pointed out that they do not act with equal power on all organisms. The alcoholic ferment thrives when oxygen is passed through the fluid in which it is submerged. The butyric, on the other hand (according to Pasteur) dies under the same condition. An acid medium is injurious to the lactic and butyric ferments, but does not interfere with some of the split fungi. Gustave Le Bon arrived at the conclusion that the effect of a disinfectant diminishes with the progress of putrefaction. Further, between disinfectant power and antiseptic effects on the putrescent agents there is no parallelism; the potassium permanganate, which is the most powerful disinfectant, does not in the least affect the ferments. Alcohol, on the contrary, which stuns them, is but a weak disinfectant. Neither is there any parallelism between the power of preventing putrefaction and that of checking it when once begun. Alcohol and carbolic acid, which are powerful preservatives, do not have much effect when putrefaction has once set in. Le Bon's experiments also seem to show that there is no parallelism between the poisonous effects of a putrefying body and that of the volatile products arising from it. They seem inversely proportional. The very small amount of advanced putrefaction products mixed with air breathed by an animal, which is sufficient to kill it, shows the terribly poisonous character of the volatile alkaloids. In conclusion, the author suggested the desirableness of a revision of the nomenclature of micro-organisms.

CROSS SECTION OF SHIP CANAL.

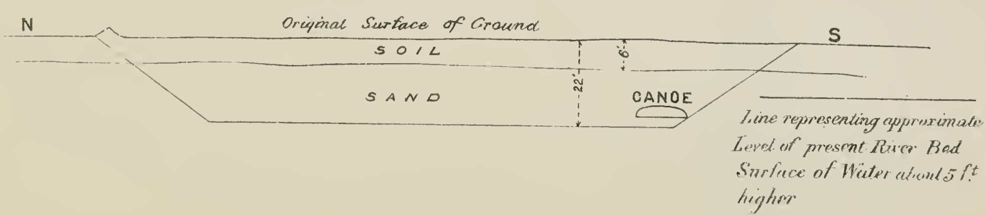


Fig. 1.

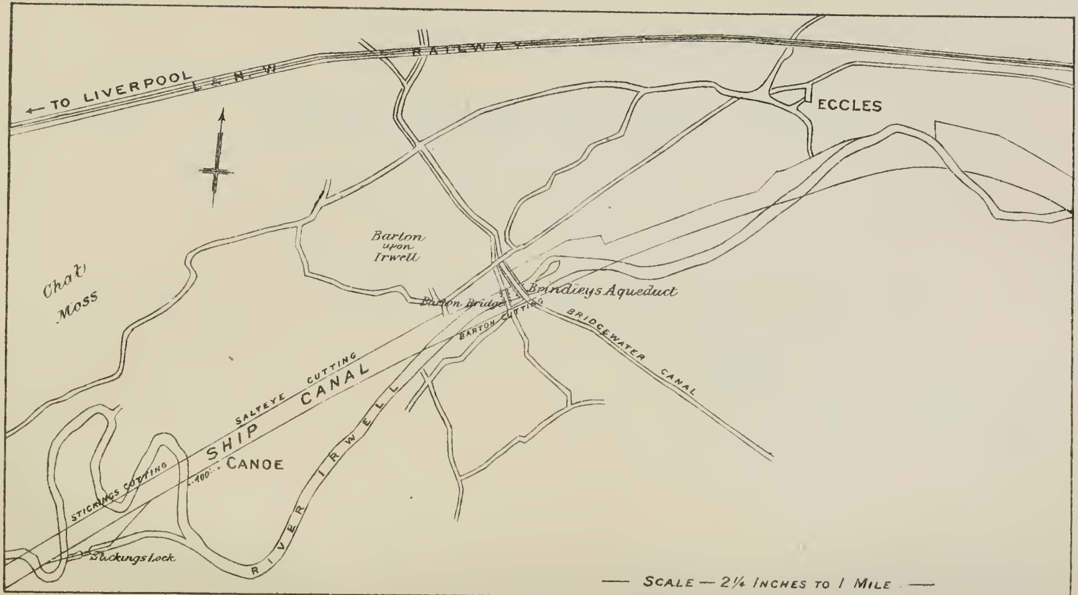

← TO LIVERPOOL
L & N. W RAILWAY
ECCLES
Barton upon Irwell
Chat Moss
Barton Bridge
Brindleys Aqueduct
BARTON CUTTING
BRIDGEWATER CANAL
SALTEYE CUTTING
SHIP CANAL
CANOE
STICKINGS CUTTING
Stickings Lock
RIVER IRWELL
SCALE — 2¼ INCHES TO 1 MILE

Fig. 2.

On an old Canoe recently found in the Irwell Valley, near Barton, with observations on Pre-historic Chat Moss. By Mr. Alderman W. H. Bailey.

(*Received May 14th, 1889.*)

Where Found.

The old Canoe, which I will endeavour to describe, was found a few days ago in the Irwell Valley in the sand at the cuttings of the Manchester Ship Canal, exactly one mile west of Brindley's Aqueduct at Barton. It is somewhat interesting to note that the discoverer was Lady Egerton, who happened to be passing at the time with a party of friends who were inspecting the works. Her ladyship called attention to the black-looking object in the sand which a steam navvy had partially uncovered, and said that in her opinion it was an old canoe. This surmise proved to be correct, and it is only proper to place this fact on record.

The river Irwell is 400 feet distant from the site of the old boat; the river bed is about 15 feet above the level where it was found; the boat had over it 6 feet of surface soil, and about 20 to 22 feet of sand. (See section, Fig. 1.)

It will be seen from the map (Fig. 2) that in the vicinity the river has a very tortuous course, and, many years ago, in order to improve the navigation, the two feet of a figure like the letter "M" were coupled together, and the distance was thus shortened by what is called "Stickings Cut."

It will also be seen from the map that the position of the canoe was about halfway between Chat Moss and Carrington Moss from North to South.

Description and Dimensions of the Canoe.

Mr. Ward, the photographer, of Oxford Street, Manchester, has taken a very good photograph of the boat, but in order that we may have an exact record of its dimensions I have caused four mechanical drawings to be prepared, from which it will be seen that the boat in section is nearly an exact semi-circle slightly flattened at the sides. (See

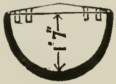


Fig. 3.

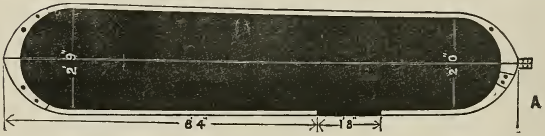


Fig. 4.

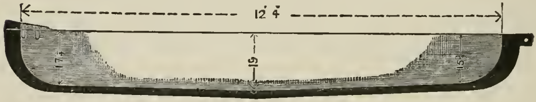


Fig. 5.

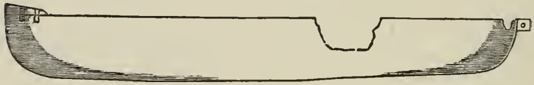


Fig. 6.

Fig. 3.) It bears internal evidence of some attempt at design. An imaginary line drawn right through the centre from one end to the other becomes the true centre, that is to say, there is as much boat on one side as there is on the other. (See Fig. 4.) I would infer from this that before the boat was made it was designed, and that it was not made by what is called "rule of thumb." The inside

measurements are as follow:—At one end 17¼ inches deep, becoming deeper to the centre to 19 inches, and then gradually decreasing to the other end to 15¼ inches. The width where it is deepest is 2 feet 9 inches, gradually decreasing to 2 feet wide. The thickness at the sides is 1½ inches, gradually thickening to the bottom to 2¼ inches. The thickness of the stem and stern is 6 inches. It is 12 feet 4 inches inside measurement. (See Figs. 5 and 6.)

It is a matter of opinion as to which is the bow and which is the stern, because both ends are so much alike, except that one is shallower than the other, and that may have been by design or by reason of the shape of the timber. It seems to be the general opinion that the material is oak. There is a peculiar strengthening piece fastened on with four wooden pegs at one end of the boat, and the projecting wooden nose or staple at the other end is cut out of the solid timber, and has a hole 1¼ inches in diameter. This is supposed to have been for the passage of a rope, no doubt for mooring purposes.

There is an interesting bit of patchwork at one end (see Fig. 4 at A), showing a place which might have been for a rudder, or it is possible it might have been a repair, for two holes exist into which wooden pegs have been driven to secure a small bit of timber, in the same manner as the strengthening piece is fastened at the top of the boat at the deep end. There is no metal of any sort on the boat. There are tool marks distinctly visible all over the boat inside, but whether these marks were made by iron, steel, or bronze tools it is impossible to say.

Mr. Knott, a relative of Mr. Walker, the contractor for the Manchester Ship Canal, who has charge of the Salford docks' section of the canal, informs me that many similar boats have been dug out by Mr. Walker's men in the excavations for improving the Ribble at Preston.

The old canoe, as I have stated, was found in the Irwell valley, near to the Chat Moss basin, which I will now describe, adding some observations on the causes which led to the formation of the Moss.

Pre-historic Chat Moss.

Chat Moss is in the Irwell valley, bounded on the north and east by the highlands of Patricroft, Worsley, and Astley, on the west by the river Glazebrook, and on the south by the river Irwell, which immediately changes its name to the Mersey. On the opposite side of the valley, near Partington, is Carrington Moss, and similar moss lands or lagoons exist extending along the south side of the valley to the tidal estuary of the Mersey. St. Chad, of Chester, was Bishop of Mercia in the year 669, and had dominion over an extensive tract of country, from Manchester to Chester and all lands between the Mersey and the Dee; and it has been said that this is the origin of the name Chat or Chatley Moss.

Most writers assert, with but little evidence, that the Moss was formerly an extensive forest. It is five miles long from east to west, and about three miles broad from north to south.

According to Baines, the forest of Chatley must have disappeared before the Norman conquest, as the Doomsday Book only gives in the Hundred of Salford very much less forest land than the entire of Chat Moss, as the forests of Horwich and Blackley alone were equal to nine miles long and five and a quarter miles in width, which is about the area of forest lands of the district recorded in that survey.

Underneath the Moss the soil is of a sandy nature, and below this is found boulder clay; and although I am not in possession of sufficient information to lead to a definite conclusion, I believe that a forest did not exist on Chat Moss in the ancient days. We have sufficient evidence to show that it was formerly a great lake, probably with forest trees on the margin, and that it was fed by the Irwell and subjected to occasional inundations of tidal water from the Mersey, and that the outlet of this inland lake in course of time became impeded by wind-blown sand driven from the Mersey estuary by the western gales.

This wind-blown sand not only impeded the drainage of this inland lake, but, from time to time, changed the course of the Irwell as well as that of the Mersey. The enormous amount of clean sand, absolutely free from pebbles or boulders, laid bare by the excavations of the Manchester Ship Canal in the vicinity and immediately below Chat Moss, is, I think, convincing testimony of this. This sand would effectually impound the drainage of the small rivulets and water-courses from the upper lands of Patricroft, Worsley, and Astley, the water from which before went into the river through the lake, which would probably extend right across to the Carrington side of the river to the high lands of Lymm, and would be in shape similar to the great Mersey Bay lower down the stream, into which the Ship Canal enters, and which I will call Eastham Bay.

The accumulation of rank vegetation would increase the impediment, and in course of years the whole district would become a moss, instead of a great lake. That the river bed was formerly much deeper we have evidence in the discovery of the old boat I have described, and in the great quantity of old forest trees found even at much lower depths in the Ship Canal cuttings. I have not been able to get the exact levels all over the Moss, as it is difficult to obtain the information. I, however, find that in some places it is 150 feet to the sand, and the depth varies to 50, 30, and 25 feet. The greatest depth at present known is at a point not far from Astley station, on the London and North Western Railway; indeed at one point in that locality it is 180 feet deep. This places the level at the bottom far below tidal water, as even a depth of 50 feet places it much below the tidal water now coming up to Warrington.

The trees found in the Moss may have grown on the banks of the lake, or more probably may have been washed down from the upper reaches of the Irwell, for many similar trees are continually discovered in the excavations of the Ship Canal along the whole course of the valley. These trees are trunks only, having no small timber about them, no branches, or evidence of decayed wood near them. We may infer that if these had grown *in situ*, branches and roots would be in the vicinity. There can be little doubt that these bare trunks have drifted from the forests of the upper lands after storms.

It may be of some interest to state that the Moss is subsiding gradually ; the farmsteads built on piles driven through the Moss into the earth beneath are in some cases now 10 feet above the level of the surrounding land, and those built upon the Moss without the support of the piles are from 5 to 15 feet below the surrounding level.

The geological formation of the strata at Chat Moss has been described by Mr. W. Brockbank, in a paper read before this Society in 1866, (*Proceedings, Lit. and Phil. Soc. of Man.*, Vol. V. p. 91.) In one place Mr. Brockbank found 17 feet of peat moss, 18 inches of sandy clay or loam, and then a depth of 26 feet 6 inches of boulder clay, and below that, soft red rock. Generally the bed of the moss is sandy.

In consequence of the imperfect drainage, after long continuous rains the Moss became so full of water many years ago as to cause its upper surface to move.

Leland describes an accident of this sort, which occurred in the reign of Henry the Eighth, as follows :—

"Chatelay More, in Darbyshire, is three or four miles in "bredthe, and six miles yn length sum way brast up within "a mile of Morley Hall, and destroied much ground with "mosse thereabout, and destroied much fresch water fische "therabowt, first corrupting with stinking water Glasebrook "and so Glasebrook carried stinking water and moss into "the Mersey water, and Mersey corruptid carried the "roulling mosse part to the shores of Wales, part to the Isle "of Man, and sum into Ireland. In the very toppe of "Chateley More where the mosse was hyest and brake, is "now a fair plaine valley, as was in tymes paste, and a rille "runnith in it, and peaces of small trees be found in the "botom. Syr John Holcrofte's house within a mile or "more of Morle stoode in jeopardi with fleeting of the "mosse."

Also in the reign of Elizabeth, Camden describes Chat Moss as a swampy tract of great extent, a considerable part of which was carried off in the last age by swollen rivers with great danger.

In the 15th year of Edward II., the Moss is placed in the manor of Manchester ; this would be in the year of our Lord, 1322, and in a description of the time Chat Moss is of the soil of the Lords of Barton, Worsley, Astley, Workedby, and Bedford. "The tenants of these Lords had here Common Turbary but no profit can be computed, because of the unfair quality of it."

Modern Chat Moss.

The success of the works of the Bedford Level Drainage on the East Coast caused much attention to be paid to similar lands in other parts of the country. It will be remembered that this great work was begun in the reign of Charles I. Many thousands of acres of land have been reclaimed and made profitable to agriculture. In an old book I bought the other day, a poet encourages such undertakings in verses of which the following are a sample. The book was printed by Moses Pitt, at the Angel in St. Paul's Churchyard, in the year 1665 :—

After long Tillage, it doth then abound
With Grass so plentiful, so sweet, so sound,
Scarce any tract but this can Pastures shew
So large, so rich, And, if you wisely Sow
The fine *Dutch* Clover, with such Beauty spreads,
As if it meant t' affront our *English* Meads.

Ye busie Gentlemen, that plant the Hop,
And dream vast gains from that deceitful Crop,
Or by manuring what you ought to Let
Thrive backwards, and too dearly purchase Wit,
Leave off these Lotteries, and here take your Lot ;
The Profit's certain, and with ease, 'tis got.

Courageous Merchants, who, confronting fates,
Trust Seas and Pyrates with your whole Estates,
Part in this Bank, methinks were far more sure ;
And ye, whom hopes of sudden Wealth allure,
Or wants into *Virginia*, force to fly,
Ev'n spare your pains ; here's *Florida* hard by.

If therefore Gain, or Honour, or Delight,
Or care of Publick Good, will Men invite
Into this fortunate Isle, now let them enter
With confidence ; since here they all concenter ;
But if all these be choakt, and drown'd with flegm,
Let them enjoy their Sloth, sit still, and dream.

The success of the Bedford Level undertaking, and in later times the utilisation of other moss lands for agriculture in the fen country, caused many experiments to be made in this district.

Scroope Egerton, the first Duke of Bridgewater, and Francis, the third Duke, commenced operations in the neighbourhood of Worsley, and were to some extent successful.

At the commencement of this century, William Roscoe the poet, philosopher, and banker, the grandfather of Sir Henry Roscoe, M.P., and, to use the words of Baines, "the elegant historian of Leo X.," was a very busy man. His genius was many-sided, for in the midst of active commercial pursuits he found time to lecture on the fine arts as well as on the national importance of introducing new food seeds, and on improved methods of agriculture. He composed odes, psalms, and sweet sonnets, wrote histories which are classical to the student of Italian literature, and as an orator and essayist he influenced the public conscience in favour of the righteous work of his friends, Wilberforce and Clarkson, the liberators of the African slave.

We also find him, with the sanction of Parliament, engaged in improving Chat Moss, dividing it into farms, draining it, and making it increase the food supply of this country. For more than a quarter of a century this energetic lover of utility and beauty devoted himself and his fortune to the cultivation of this morass.

In 1811 a poet pays homage to his achievements :

> Roscoe to whose patriot breast belong
> The Roman virtue and the Tuscan song,
> Led Ceres to the bleak and barren moor,
> Where Ceres never gained a wreath before.

It is interesting to note that it was through the work of William Roscoe's steward, Mr. Stannard, that the difficulty of crossing Chat Moss by the Manchester and Liverpool Railway was overcome, as Mr. Stannard took the contract to make the railway across the Moss, and it is possible that, had it not been for his great experience in moss treatment, Stevenson would have taken the railway a mile and a half further north at a considerable expense to the Company.

Mr. Edward Baines continued the cultivation of Chat Moss, commenced by Mr. Roscoe, and there are now hundreds of acres under cultivation.

Permit me in conclusion to call the attention of the members of the Society to the opportunities, which should not be neglected, now presented to the geologist, the antiquary, and to all students of the knowledge of causes, for the Ship Canal steam navvies have opened more than 20 miles of the Irwell valley, and those who study the story of the rocks have in the book before them, the records of centuries on each page.

Annual Report of the Council, April, 1889.

The Treasurer reports that the improvement in the Society's finances, which was referred to in the Annual Report of the Council for 1888, has been fully maintained throughout the current year, and for the first time for many years, balances remain at the credit of all the accounts. The general balance in favour of the Society on the 31st March, 1889, as represented by cash on deposit at the Society's bankers, is £335. 8s. 2d. In addition to this amount, the Society holds £1,225 preference stock in the Great Western Railway Co., the interest upon which is devoted to Natural History purposes in accordance with the terms of the trust.

The accompanying balance sheets will explain the sources of income, and the expenditure, of the Society during the session now ended, and, as usual, the corresponding information for the previous session is appended for purposes of comparison.

The Societies which are accommodated on the premises are the same as last year, viz.: the Manchester Geological Society, the Manchester Medical Society, the Manchester Photographic Society, and the Manchester Scientific Students' Association, who have paid the amounts stated in the balance sheet.

A special item appears in the accounts this session, viz., a grant of £51. 0s. 7d. from the Local General Committee, and Guarantors, of the British Association Meeting held in Manchester in 1887, which was paid over to the Society in accordance with the terms of the following resolution, passed at the Town Hall, Manchester, 6th March, 1888, proposed by Mr. Edward Donner, seconded by Mr. Mark Stirrup, and carried unanimously :—

> "That, after payment of all expenses, any balance remaining over from the final call upon the Guarantee Fund be divided between the Library of the Owens College and the Literary and Philosophical Society, in recognition of the valuable assistance rendered by them in granting the use of their buildings and rooms ; but that, previous to such division, a copy of this resolution be sent to each guarantor, and his proportionate share be returned to any one desiring it."

Your Council's predecessors acknowledged this kindness in last year's report.

There are few items in the Society's expenditure which need any special reference. The index to the whole of the Society's *Proceedings*, and *Memoirs* 1st, 2nd and 3rd Series, has been completed by Mr. Richard Hargreaves, and will be printed in the course of next session. The Binding Fund has still a balance of £34. 18s. 2d., but works from the Society's library have already been bound, which, with what are still in the binder's hands, will exhaust this fund.

The Editor reports that the publications of the Society, which, as will be observed, include a more numerous list of papers than last year, are complete up to March 5th, and that the next number, which will complete the second volume, will be issued in the course of the next fortnight.

The Council are very sensible of the honorary services of the Editor in preparing the Society's *Memoirs and Proceedings*. The new form of publication has proved successful in respect both as to cost and as to promptitude of issue.

The Librarian reports that the number of volumes received in exchange from other Societies during the last year has increased. The Library now includes an almost unique collection of the printed issues of foreign Societies, and, amongst other works recently added, contains 43 volumes of "Reports on the Scientific Results of the Exploring Voyage of H.M.S. Challenger." Authors' presentation copies have been received from Professor Cayley, "Collected Mathematical Papers"; Professor Prestwich, "Geology, Chemical, Physical, and Stratigraphical"; Professor G. G. Stokes, "Mathematical and Physical Papers"; The Council of the Royal Society, "The Eruption of Krakatoa and subsequent phenomena," and also the following:—"Verdeeling Der Warmte over de Aarde," by C. H. D. Buys Ballot; "Notes, &c., Sur L'Histoire Générale des Pays-Bas," by C. Paillard; "Tripolitania Cirenaica E. Fezzan," by F. Borsari; "Memoir on The Winds and Monsoons of the Arabian Sea and North Indian Ocean," by W. L. Dallas; "Report on the Royal Observatory, Edinburgh," and "The Edinburgh Equatorial in 1887," papers by C. P. Smyth; "The Cause of Electricity, with remarks on Chemical Equivalents," "The Cause of Light," "The Planets upon Cœrdioides," by G. T. Carruthers, M.A.; "Eskimo of Hudson's Strait," by F. F. Payne; "Treatise on Chemistry," Vol. III., Part 5, by Sir H. E. Roscoe and C. Schorlemmer. These have been duly acknowledged.

Influenced by the example of the Royal, Linnean, and other learned Societies, the Council decided during the past session to arrange for a conversazione in the Society's house, in order to exhibit some of the more interesting memorials in the Society's possession, and to illustrate the work of past and present members. A doubt having been expressed as to whether the Council would be justified in utilising the funds of the Society for this purpose without a special resolution from the members, and it being considered undesirable, taking into account the experimental character of the project, to submit it for discussion at a General Meeting, the President offered to defray the whole cost of the gathering; whereupon, at a meeting of the Council, it was resolved unanimously "that the Council thank the President for his generous offer to defray the entire cost of the conversazione, and gratefully accept it, with the condition that he will permit all members of the Council who may desire to do so, to be associated with him in bearing the expense, and that the invitations be sent out in the name of the President and Council." The conversazione, therefore, has involved no charge on the funds of the Society. It was held on the evening of April 4th, 1889, and about two hundred ladies and gentlemen responded to the invitations issued. A copy of the programme, suitable for binding with the *Memoirs and Proceedings*, has been sent to each member. To the list of exhibits described therein should be added a special collection of living plants, for which the Council were indebted to Mr. William Brockbank, F.L.S., F.G.S., including *Synthiris reniformis*, a North American plant introduced by the exhibitor to Kew in 1885, and described in the *Bot. Mag.*, Tab. 6860, 1886; examples of the *Ajax* section of daffodils and various narcissi collected wild in Portugal; and examples of dwarf Japanese maples with many varieties of foliage grafted into each plant.

The Secretaries, on behalf of the Council, have duly acknowledged the important assistance received from various members and friends of the Society on the occasion.

The Council consider it desirable to continue the system of electing Associates of the Sections, and the usual resolution for the approval of the members will be submitted at the Annual General Meeting. The Natural History Section, in consideration of the large number of Associates connected with it, has resolved to increase its annual contribution from £2. 2s. to £5. 5s.

The number of ordinary members on the roll on March

31st, 1889, was one less than at the corresponding date last year. Eight new members had been elected, eight had resigned, and one, Mr. Richard Peacock, M.P., M.I.C.E., had died. The Society has also lost by death one honorary member, Professor Rudolf Clausius.

RICHARD PEACOCK was one of that numerous class of "self-made" engineers who have been connected with the Society. He was the seventh child of a working lead miner, and was born in Swaledale, in the North Riding, in 1820. His father, Ralph Peacock, appears to have been a man of much natural ability and especially ingenious in mechanical construction, who worked his way, we are told, to the position of foreman or superintendent of several mines in the dale in which the subject of this notice was born. Richard inherited his father's taste for mechanics, and his future career seems to have been practically determined by the bent given to his mind in consequence of being taken by his father, at the age of five, to see George Stephenson's "No. 1" locomotive running on the Stockton and Darlington Railway, opened on September 27th, 1825. In 1830, the elder Peacock removed to Leeds to fill the position of assistant superintendent in the construction of the Leeds tunnel on the Leeds and Selby Railway, on which line he continued to be employed for the remainder of his working life. Richard's education was obtained at a Sunday School and partly at the Leeds Grammar School, and at the age of fourteen he was apprenticed to Messrs. Fenton, Murray and Jackson, a firm employed in the construction of locomotives for the Leeds, and the Liverpool and Manchester Railways. His progress in mechanical knowledge is indicated by the fact that at the age of eighteen he was offered the position of locomotive superintendent on the railway on which his father was employed. Like young Nasmyth, ten years earlier, however, he was inspired with a desire to proceed to London, and, again like Nasmyth, he went thither armed only with useful introductions and a readiness to engage in any kind of work in connection with his special proclivities. An interview with Mr. (afterwards Sir) Daniel Gooch, chief engineer under Mr. Brunel on the Great Western Railway, resulted in an engagement on that line. "Young Peacock's duties," says the writer of the obituary notice in the *Manchester Guardian*, "were as varied as they were laborious. Sometimes he superintended a gang of navvies; occasionally he took charge of an engine used by the great engineer for running up and down the line, and in this way established with him a friendly relation which was interrupted only by Mr. Brunel's death." At the age of 21 (in 1841) Peacock obtained the appointment of locomotive superintendent on the Manchester and Sheffield Railway. His connection with Manchester dates from this event. He witnessed the arrival of the first engine for the line, and continued in the company's service for a period of fourteen years. "He chose Gorton," adds the writer already quoted, "for the site of the locomotive depôt, which was afterwards erected from his designs. This led to the rapid development of Gorton and of the adjoining township of Openshaw, and of the great engineering establishment with which his name will always be identified. It was at his suggestion that Mr. Ashbury built his extensive carriage and waggon works at Openshaw, of which Mr. Peacock laid the foundation stone. He also recommended the late Sir Joseph Whitworth to transfer to the same neighbourhood his manufactory of guns and mechanical tools, and he purchased the land for the Midland Railway on which that company placed its locomotive sheds. Not inappropriately has he been designated as the founder of the trade and prosperity of these two townships." In 1854 Mr. Peacock entered into partnership with Mr. Charles Beyer, previously manager of the extensive works of Messrs. Sharp Bros. (and who, it may be mentioned, was elected a member of this Society in January of the same year), in order to establish the well-known works at Gorton, with which Mr. Peacock continued to be associated until his death, officiating as manager and chairman of the Board of Directors after the conversion of the firm into a limited liability company in 1883. In these works from 2,000 to 3,000 people are employed, and about 200 engines are annually constructed. Mr. Peacock was elected a member of the Society in its centenary year, 1881. He took an active interest in the educational, economic, and political life of the district in which his business was established and in which he lived, promoting the formation of savings banks, the erection of new schools, and presenting to it a church of considerable beauty, built from designs by another member of the Society, Mr. Thomas Worthington, F.R.I.B.A. The Brookfield church, Gorton, was built in 1870, to take the place of the ancient non-conformist chapel, which stood in the old burial ground on the low land below the church, through which the Gore Brook flows. The site was previously a most uninviting and desolate mass of clay pits, and was raised considerably, with the adjoining high road, so as to form a suitable position for the new church; in the erection of which Mr. Peacock took the liveliest interest. The church is a structure of considerable size, and with its lofty detached tower and spire forms a land-mark in the district. It is in the early Geometric style of the 13th century, and the tower contains a peal of eight musical bells. Over the chancel arch a choir of angels singing the *Te Deum* form a striking feature on entering the building, and the general scheme of decoration, with the polished granite columns and stained glass windows, gives much richness of effect to the interior. In 1885 Mr. Peacock was returned as the first representative in Parliament of the Gorton division, and was re-elected in 1886. He died at his residence, Gorton Hall, on the evening of March 3, 1889.

RUDOLF CLAUSIUS, who died on August 24th, 1888, was connected with us even more by the close relation of his distinctive work with that of Dr. Joule, than by the fact of his election as one of our honorary members. He was born on the 2nd of January, 1822, one of the youngest of a family of eighteen. For the sake of his younger brothers, he felt himself bound to discontinue his studies in Berlin and gain his own livelihood, first as a tutor, later as a schoolmaster; ultimately graduating at Halle in 1848. In 1855 he was made Professor in the Polytechnicum at Zurich, and in 1857 in the University of that town. In 1867 he was called to Würzburg, and in 1869 to Bonn, where he spent the rest of his life (declining invitations to Strassburg and Göttingen) in the discharge of his duties and the ceaseless pursuit of his studies. The establishment of the equivalence of heat and work by Joule and his fellow-workers was the great scientific advance in Clausius' student days, and it decided the direction of his life work. The material theory of heat had led to no scientific result comparable with Carnot's theory, and the destruction of the material theory by the mechanical had left this important and apparently correct result without support. Recognising the inherent merits of Carnot's work, Clausius undertook the examination of it from the point of view of the new mechanical theory of heat, and in his first investigation on the subject, presented to the Berlin Academy in 1850, he showed that a new and independent principle in thermo-dynamics was necessary, from which by an indirect method he deduced Carnot's Theory. Considering Joule's Principle of the equivalence of heat and work as the First Law, Clausius' Principle of the equivalence of transformations, in one of its various forms, is accepted as the Second Law of thermo-dynamics. Clausius has himself stated it in different ways; we give it thus:—It is inconceivable that heat, unaided by any external agency, should of itself pass from a colder to a hotter body. This essential idea he further developed in his memoirs of 1854, 1862, and 1865, basing on it a great mechanical principle, as Thomson had on Joule's Law, and enunciating them together at the end of the last named paper ;—The energy of the universe is constant, the entropy of the universe tends to a maximum : principles now usually called the Conservation and Dissipation of Energy. During this stage of his activity, two Englishmen, Thomson and Rankine, were working in the same direction ; it is no part of our purpose to raise small questions of priority, the work of each was original and distinctive, and the new science of thermo-dynamics had need of all. The fundamental ideas of the mechanical theory of heat called not only Joule and Krönig, but also Clausius back to Daniel Bernoulli's kinetic theory of gases. In a paper on the Form of Motion which we call heat (1857) he deduced Boyle's law with less special assumption than Joule had employed, arrived at the conditions under which Charles' law holds good, and established the law of Avogadro. In a paper (1858) on the mean free path of a gas molecule, he developed the statistical method of investigation which the character of the problem makes necessary, and opened the way to his successors. From this point Maxwell and Boltzmann have carried the method to its fullest extent. In this short notice we can only allude to Clausius' service to Abstract Dynamics by his introduction of the Virial, to his modification and development of W. Weber's electrodynamic theory, and to the papers on the theory of dynamo-electric machines, which occupied the last years of his life. Clausius' papers form a very long list, and are characterised by an originality, thoroughness, and breadth of view which are excelled by few. He was active in the discharge of his duties as a professor, and that he performed his duties to the State may be inferred from the fact that during the war of 1870 he acted as bearer in the ambulance corps of Bonn students. By his death we have lost one of those who have made the century remarkable for the progress of science.

The following papers and communications have been read, or will be read before the close of the session, at the ordinary meetings of the Society :—

OCTOBER 2nd, 1888.

"An account of Hertz's experiments showing the propagation of electrical vibrations in direct accordance with Maxwell's theory of light as an electro-magnetic phenomenon." By R. F. Gwyther, M.A.

"Incompleteness of Combustion in Gaseous Explosions. By Prof. Harold B. Dixon, F.R.S., and H. W. Smith, B.Sc.

OCTOBER 16th, 1888.

"On the excessive abundance of *Aphis dianthi*, Schr., round Manchester in September, 1888." By P. Cameron. Communicated by John Boyd, Esq.

"A decade of new *Hymenoptera*." By P. Cameron. Communicated by John Boyd, Esq.

OCTOBER 30th, 1888.

"A New System of Logical Notation," by Joseph John Murphy. Communicated by the Rev. Robert Harley, M.A., F.R.S., Corresponding Member.

"Electrolysis under Pressure." By W. W. Haldane Gee, B.Sc., and Henry Holden, M.Sc.

NOVEMBER 13th, 1888.

"The Permanence of Oceanic Basins." By Professor W. C. Williamson, LL.D., F.R.S., and Professor W. Boyd Dawkins, M.A., F.R.S., &c.

NOVEMBER 27th, 1888.

"An historical account of the spectroscopic evidence in support of the hypothesis that oxygen exists in the sun, with special reference to M. Janssen's recent researches on telluric oxygen and aqueous vapour lines and bands." By F. J. Faraday, F.L.S.

DECEMBER 11th, 1888.

"Note on the behaviour of Iodine in the presence of Borax." By James Bottomley, D.Sc.

"Notes on some of the peculiar properties of Glass." By William Thomson, F.R.S.Ed., F.I.C., F.C.S.

"On the British Species of *Allotrinæ*, with descriptions of other new species of Parasitic *Cynipidæ*." By P. Cameron. Communicated by John Boyd, Esq.

December 27th, 1888.

"Letter on an accompanying photograph of his original drawing of the solar surface." By James Nasmyth, F.R.A.S., &c.

January 8th, 1889.

"On the unification in the measure of time, with special reference to the contest on the initial meridian." By C. Tondini de Quarenghi. Communicated by F. J. Faraday, F.L.S.

January 22nd, 1889.

"*Hymenoptera Orientalis*; or Contributions to a knowledge of the *Hymenoptera* of the Oriental Zoological Region." By P. Cameron. Communicated by John Boyd, Esq.

February 5th, 1889.

"On the equation to the Instantaneous Surface generated by the dissolution of an Isotropic Solid." By James Bottomley, D.Sc.

February 19th, 1889.

"On the vitrified cement from an ancient fort." By G. H. Bailey. D.Sc., Ph.D.

"Notes on a form of *Plantago maritima* [L.] new to this country, viz. f. *pumila* (Kjellman)." By James Cosmo Melvill, F.L.S.

March 5th, 1889.

"Colour and its relation to the Structure of Coloured Bodies, being an investigation into the Physical Cause of Colour in natural and artificial bodies, and the Nature of the Structure producing it." Part I. By Alexander Hodgkinson, M.B., B.Sc.

March 19th, 1889.

"On the results of some calculations with a certain class of figures." By Charles Clay, M.D.

"On the presence of green colouring matter in leaves found about 21 feet under the surface in an excavation connected with the Ship Canal Works." By William Thomson, F.R.S. Ed.

"On Colour and its relation to the Structure of Coloured Bodies; being an Investigation into the Physical Cause of Colour in natural and artificial bodies and the Nature of the Structure producing it." Part II. By Alexander Hodgkinson, M.B., B.Sc.

April 2nd, 1889.

"Note on the Propagation of Sound through an Atmosphere of Varying Density." By Ralph Holmes, B.A.

"On Colour and its relation to the Structure of Coloured Bodies; being an Investigation into the Physical Cause of Colour in natural and artificial bodies and the Nature of the Structure producing it." Part II., continued. By Alexander Hodgkinson, M.B., B.Sc.

April 16th, 1889.

"Notes on Seedling Saxifrages grown at Brockhurst from a single scape of *Saxifraga Macnabiana.*" By Wm. Brockbank, F.L.S., F.G.S.

"Some remarks on the Chlorophyll obtained by Mr. Wm. Thomson from leaves found in cutting the Ship Canal." By Edward Schunck, Ph.D., F.R.S., F.C.S.

April 30th, 1889.

"On the position of the ancient canoe found in cutting the Ship Canal." By Alderman W. H. Bailey.

"On the Fermentation Theories." By Alfred Springer, Ph.D., of Cincinnati. Communicated by William Grimshaw, Esq.

Charles Bailey, Treasurer, in Account with the Society,

Dr. *Statement of the Accounts*

	£ s. d.	1888–9. £ s. d.	1887-8. £ s. d.
1889– March 31st :—			
To Cash in hand, 1st April, 1888		218 5 7	1 6 7
To Members' Contributions :—			
Old Members, 1886-7, 3 Subscriptions at 42s.	6 6 0		
,, 1887-8, 18 ,, ,, ...	37 16 0		
,, 1888-9, 101 ,, ,, ...	212 2 0		
,, 1889-90, 1 ,, ,, ...	2 2 0		
New Members, 1888-9, 4 ,, ,, ...	8 8 0		
,, ,, 4 Half ,, 21s.	4 4 0		
,, ,, 8 Admission Fees at 42s.	16 16 0		
	———	287 14 0	302 8 0
To Library Subscriptions :—			
One Natural History Associate at 10s.		0 10 0	0 10 0
To Contributions from Sections :—			
Microscopical and Natural History Section, 1887-8	2 2 0		
,, ,, ,, ,, 1888-9	5 5 0		
Physical Mathematical Section 1888-9	2 2 0		
	———	9 9 0	2 2 0
To Use of the Society's Rooms :			
Manchester Geological Society to 31st March, 1888	30 0 0		
,, ,, ,, 31st March, 1889	30 0 0		
Manchester Medical Society to 30th Sept., 1888	25 0 0		
Manchester Photographical Society to 30th Sept., 1888..	25 0 0		
Manchester Scientific Students' Association to 30th Sept., 1888 ..	9 0 0		
	———	119 0 0	105 0 0
To Sales of the Society's Publications, 1888-9		4 13 3	0 18 9
To Natural History Fund, 1888-9 :—			
Dividends on £1225, Great Western Railway Co Stock..		59 13 1	59 8 0
To Bank Interest, less Bank Postages, 1888-9		2 15 6	0 7 7
To Donation from Local Committee, British Association		51 0 7	
To Binding Fund Subscriptions			31 5 0
		£753 1 0	£503 5 11

1889.—April 1. To Cash in Manchester and Salford Bank, Limited .. .. £335 8 2 *from 1st April, 1888, to 31st March 1889, with a Comparative or the Session 1887-1888.* **Cr.**

1889—March 31st:—	1888-9. £ s. d.	£ s. d.	1887-8. £ s. d.	£ s. d.
By Charges on Property:—				
Chief Rent (Income Tax deducted)	12 11 5		12 10 7	
Income Tax on Chief Rent	0 6 3		0 7 4	
Insurance against Fire	13 17 6		13 17 6	
Repairs, &c.	5 3 6		2 13 10	
Tablets to Portraits	.. .. ..		3 5 0	
By House Expenditure:—		31 18 8		32 14 3
Coal, Gas, Candles, Water, &c.	31 9 9		28 9 9	
Tea, Coffee, &c., at Meetings	10 14 3		16 15 4	
Cleaning, Brushes, &c.	5 13 10		5 2 9	
Expenses in connection with British Association	.. .. ..		4 14 3	
Step ladder for Library	.. .. ..		1 10 0	
By Administrative Charges:—		47 17 10		56 12 1
Curator and Assistant Secretary	.. .. ..		17 10 0	
Clerk and Housekeeper	62 8 0		60 10 0	
Postages and Carriage of Parcels	21 16 10		19 6 11	
Stationery, Printing Circulars, Receipts, and Engrossing	15 0 4		12 2 1	
Distributing 'Memoirs'	5 19 9		1 19 0	
Legal Charges	.. .. ..		1 1 0	
Advertising, &c., for Clerk and Housekeeper	.. .. ..		1 19 9	
By Publishing:—		105 4 11		114 8 9
Printing and Binding 'Memoirs,' old series	31 10 0		.. .. ..	
Printing and Binding 'Proceedings'	.. .. ..		33 14 9	
Printing and Binding 'Memoirs and Proceedings,' new series	97 18 0		3 16 9	
Wood Engraving and Lithography	.. .. ..		6 0 6	
Preparing Index to 'Memoirs and Proceedings,' all the series	5 0 0		.. .. ..	
By Library:—		134 8 0		43 12 0
Books and Periodicals	14 18 3		16 2 7	
Assistant in Library	9 10 0		5 0 0	
Palæontographical Society for the year 1889	1 1 0		1 1 0	
Ray Society for the year 1889	1 1 0		1 1 0	
Geological Record for the year 1879	.. .. ..		0 10 11	
Zoological Record, Vol. 24.	1 0 0		.. .. ..	
By Natural History Fund..		27 10 3		23 15 6
Works on Natural History	16 13 2		13 17 9	
Grant to Microscopical and Natural History Section ..	40 0 0		.. .. ..	
Plates for Natural History Papers in 'Memoirs'	14 0 0		.. .. ..	
		70 13 2		13 17 9
By Balance 31st March, 1889		335 8 2		218 5 7
		£753 1 0		£503 5 11

Audited and found correct, April, 1889,

ALEX. HODGKINSON.
R. HOLMES

	£	s.	d.	£	s.	d.
General Account :—						
Balance against this Account, 1st April, 1888	21	5	4			
Expenditure during the Session 1888-9	346	19	8			
	368	5	0			
Receipts during the Session 1888-9	475	2	4			
Balance in favour of this Account 31st, March, 1889				106	17	4
Compounders Fund :—						
Balance in favour of this Account, 1st April, 1888	151	5	0			
Balance in favour of this Account, 31st March, 1889				151	5	0
Natural History Fund :—						
Balance in favour of this Account, 1st April, 1888	53	7	9			
Dividends received during the Session 1888-9	59	13	1			
	113	0	10			
Expenditure during the Session 1888-9	70	13	2			
Balance in favour of this Account, 31st March, 1889				42	7	8
Binding Fund :—						
Balance in favour of this Account, 1st April, 1888	34	18	2			
Balance in favour of this Account, 31st March, 1889				34	18	2
Cash in Manchester and Salford Bank, Limited, 31st March, 1889				£335	8	2

Annual Report of the Council of the Microscopical and Natural History Section.

The usual meetings have been held each month during the session, and at most of them interesting papers have been read, and at all, numerous specimens and objects of interest have been shown; and advantage has been taken of the fine set of microscopes the Society possesses, to exhibit more minute preparations. Some very valuable original papers have been contributed by Mr. P. Cameron, and these are in course of being printed in full in the Society's *Memoirs and Proceedings*. The interest in the meetings and the attendance at them has been fully maintained.

The Council have felt it desirable to increase the annual contribution to the funds of the parent Society to five guineas.

The following is a list of members and associates of the Section:—

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

Associates:—William Blackburn, F.R.M.S., E. S. Bles, H. S. Brooke, B.A., M.B, Peter Cameron, Herbert C. Chadwick, E. Pyemont Collett, Peter Cunliffe, F. R. Curtis, G. J. Crosbie Dawson, H. L. Earl, B.A., James Fleming, F.R.M.S., John Ray Hardy, Frank Huet, L.D.S., R.C.S., Henry Hyde, Leslie Jones, M.D., H. L. Knoop, W. Leach, A. A. Mumford, M.B., M.R.C.S., L.R.C.P., John Noton, F.R.M.S., J. B. Pettigrew, J. B. Robinson, F.R.M.S., Thomas Rogers, George Nash Skipp, John Smith, M.R.C.S., Mark Stirrup, F.G.S., Theodore Sington, J. Tatham, B.A., M.D., W. Ladd Torrance, Edward Ward, F.R.M.S, Sidney Young, D.Sc.

Total 29 members and 30 associates, against 28 members and 29 associates at the corresponding period of last year.

The Microscopical and Natural History Section of the Manchester Literary and Philosophical Society in account with the Parent Society for Grant from Natural History Fund.

Dr. *From 14th April, 1888, to 2nd April, 1889.* **Cr.**

1888.		£	s.	d.
Apl. 16.	To Grant by Parent Society per Treasurer	40	0	0
	„ Balance owing to the Section	3	2	4
		£43	2	4

1888.			£	s.	d.
April 4.	By	Balance from 1887-8..	20	10	1
July 6.	„	Challenger Publications, Zoology, Vols. 23–25..	7	3	4
Aug. 30	„	Do. „ 26, 27..	3	6	8
Nov. 30	„	Do. Vol. 28	1	6	3
1889.					
Jan. 25.	„	Do. „ 29 (3 vols.)	3	15	0
April 1.	„	Do. „ 30 (2 vols.)	3	15	0
Jan. 17.	„	Dulau & Co., Durand, Index	0	16	0
	„	Fowler's Coleoptera, Parts 16–27 (12 parts)	2	10	0
			£43	2	4

Mark Stirrup, Treasurer, in account with the Microscopical and Natural History Section of the Manchester Literary and Philosophical Society.

Dr. **Cr.**

1888.			£	s.	d.
Apl. 14.	To	Balance in Manchester and Salford Bank (St. Ann's Street)	17	8	1
„ 16.	„	Grant for Books, by Parent Society from Natural History Fund..........	40	0	0
Dec. 20.	„	Interest allowed by Bank..	0	12	3
1889.					
Apl. 2.	„	Subscriptions and Arrears received during the Session 1888-9.............	26	10	0
			£84	10	4

1888.			£	s.	d.
Apl. 16.	By	Parent Society—Sectional Subscription, 1887-8......	2	2	0
May 14.	„	Jas. Collins & Co., Note Paper	0	6	6
„	„	J. E. Cornish, Microscopical Journal and Naturalist ..	0	18	2
July 6.	„	West, Newman, & Co., Journal of Botany, 1888..	0	12	0
„	„	J. E. Cornish, "Challenger Reports," Zool. Vol. 23-25	7	3	4
„	„	J. E. Cornish, Fowler's Coleoptera, Parts 16-17........	0	8	4
Aug. 10.	„	Do. do. Parts 18-20	0	12	6
„	„	Do. Naturalist, April to June	0	1	6
17.	„	C. Simms & Co., Circulars	0	5	6
31.	„	J. E. Cornish, "Challenger Reports," Zool., Vol. 26 ..	2	1	8
„	„	Do. do. Vol. 27			
Nov. 30.	„	Do. Fowler's Coleoptera, Parts 22-23	2	12	6
„	„	Do. Microscopical Jour. and Naturalist			
„	„	Do. "Challenger Reports," Zool., Vol. 28...	1	6	3
Dec. 14.	„	Do. American Naturalist for 1889	0	18	0
1889.					
Jan. 24.	„	Gurney & Jackson, "Ibis," 1889	1	1	0
25.	„	J. E. Cornish, "Challenger Reports," Zool., Vol. 29, 3 Vols.	3	15	0
„	„	Do. Fowler's Coleoptera, Parts 24-25	0	8	4
„	„	C. Simms & Co., Circulars, Sep. to Dec.	1	5	6
17.	„	Dulau & Co., per C. B. Durand, Index	0	16	0
Mar. 22.	„	Parent Society—Sectional Subscription, 1888-9	5	5	0
Apl. 1.	„	J. E. Cornish, Fowler's Coleoptera, Parts 21, 26, 27....	0	12	6
„	„	Do. "Challenger Reports," Zool., Vol. 30, 2 vols.	3	15	0
Apl. 1.	„	Charles Hargreaves, Tea, Coffee. &c., 62/8, Postages. &c., 30/-	4	12	8
2.	„	C. Simms & Co., Circulars	0	16	6
	„	Balance in Manchester and Salford Bank (St. Ann's Street)	42	14	7
			£84	10	4

Examined and found correct,
(Signed) J. B. PETTIGREW.
HENRY HYDE.
6th April 1889.

1889.—April 2. To Balance to Credit of Section £42 14 7

THE COUNCIL
AND MEMBERS
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

April 30, 1889.

President.

OSBORNE REYNOLDS, M.A., LL.D., F.R.S.

Vice-Presidents.

WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.,
Foreign Member of the Royal Swedish Acad. Sc.
EDWARD SCHUNCK, Ph.D., F.R.S., F.C.S.
JAMES PRESCOTT JOULE, D.C.L., LL.D., F.R.S., F.C.S.,
Corr. Mem. Inst. Fr. (Acad. Sc.) Paris, and Roy. Acad. Sc. Turin.
ARTHUR SCHUSTER, Ph.D., F.R.S., F.R.A.S.

Secretaries.

FREDERICK JAMES FARADAY, F.L.S., F.S.S.
REGINALD F. GWYTHER, M.A.

Treasurer.

CHARLES BAILEY, F.L.S.

Librarian.

FRANCIS NICHOLSON, F.Z.S.

Other Members of the Council.

JAMES BOTTOMLEY, B.A., D.Sc., F.C.S.
JOHN BOYD.
WILLIAM HENRY JOHNSON, B.Sc.
JAMES COSMO MELVILL, M.A., F.L.S.
HAROLD B. DIXON, M.A., F.R.S.
ALEXANDER HODGKINSON, M.B., B.Sc.

HONORARY MEMBERS.

Date of Election.	
1847, April 20.	Adams, John Couch, LL.D., F.R.S., V.P.R.A.S., F.C.P.S., Director of the Observatory, and Lowndsean Prof. of Astron. and Geom. in the Univ. of Cambridge. Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *The Observatory, Cambridge.*
1843, April 18.	Airy, Sir George Biddell, K.C.B., M.A., D.C.L., LL.D., Hon. Mem. R.S.E., R.I.A., F.C.P.S., For. Mem. Inst. Fr. (Acad. Sci.), &c. *The White House, Croom's Hill, Greenwich Park, S.E.*
1887, April 19.	Armstrong, Sir Wm. Ceorge, C.B., D.C.L., LL.D. *Newcastle-on-Tyne.*
1886, Feb. 9.	Baker, Benjamin. 2, *Queen's Square Place, Westminster, S.W.*
1886, Feb. 9.	Baker, John Gilbert, F.R.S. *Kew.*
1886, Feb. 9.	Berthelot, Prof. Marcellin, For. Mem. R.S. *Paris.*
1886, Feb. 9.	Buchan, Alexander, F.R.S.E. 72, *Northumberland Street, Edinburgh.*
1860, April 17.	Bunsen, Robert Wilhelm, Ph.D., For. Mem. R.S., Prof. of Chemistry at the Univ. of Heidelberg. *Heidelberg.*
1887, April 19.	Buys Ballot, Dr. H. D., Supt. of the Royal Meteor. Institution. *Utrecht.*
1888, April 17.	Cannizzaro, S. Professor of Chemistry. *University of Rome.*
1889, April 30.	Carruthers, William, Pres. L.S., F.R.S. Keeper of Botanical Dept., British Museum.
1859, Jan. 25.	Cayley, Arthur, M.A., LL.D., D.C.L., V.P.R.A.S., F.C.P.S., Sadlerian Prof. of Pure Maths. in the Univ. of Cambridge, Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Garden House Cambridge.*
1886, Oct. 30.	Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Professor of Natural Philosophy, Oxford. *New Museum, Oxford.*
1889, April 30.	Cohn, Ferdinand, Professor of Botany. 26, *Schweidnitzer Stadtgraben, Breslau.*
1887, April 19.	Cornu, Professor Alfred, For. Mem. R.S. *Ecole Polytechnique, Paris.*
1886, Feb. 9.	Dawson, Sir John William, C.M.G., M.A., F.R.S., LL.D., F.G.S. *McGill College, Montreal.*
1888, April 17.	Dewalque, Gustave, Professor of Geology. *University of Liège.*
1889, April 30.	Farlow, W. G., Professor of Botany. *Harvard College, Cambridge, Mass., U.S.A.*

Date of Election.

1889, April 30. Flower, William Henry, C.B., LL.D., F.R.S. Director of Nat. Hist. Dept., British Museum.

1889, April 30. Foster, Michael, M.A., M.D., LL.D., Sec. R.S., Professor of Physiology. *Trinity College, Cambridge.*

1860, Mar. 9. Frankland, Edward, Ph.D., M.D., LLD., D.C.L., V.P.C.S. F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *The Yews, Reigate Hill, Reigate.*

1843, Feb. 7. Frisiani, nobile Paola, Pros., late Astron. at the Observ. of Brera. Milan, Mem. Imper. Roy. Instit. of Lombardy, Milan, and Ital. Soc. Sc. *Milan.*

1889, April 30. Halphen, Professor G. H., Membre de l'Institut. *17, Rue Ste.-Sophie, Versailles.*

1889, April 30. Hertz, H., Professor of Physics. *Bonn.*

1848, Jan. 25. Hind, John Russell, LL.D., F.R.S., F.R.A.S., Superintendent of the Nautical Almanac. Cor. Mem. Inst. Fr. (Acad. Sci.). 3, *Cambridge Park Gardens, Twickenham.*

1888, Feb. 9. Hirn, Gustav Adolph. *Colmar.*

1881, April 17. Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*

1886, Feb. 9. Helmholtz, Geheimrath Hermann von, LL.D., For. Mem. R.S. Präsident der Physikalisch-technischen Reichsanstalt. *Berlin.*

1866, Jan. 23. Hofman, A. W., Ph.D., M.D., LL.D., F.R.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c, 10, *Dorotheenstrasse, Berlin.*

1869, Jan. 12. Huggins, William, LL.D., D.C.L., F.R.S., F.R.A.S., Cor. Mem. Inst. Fr. (Acad. Sci.). 90, *Upper Tulse Hill, Brixton, London, S.W.*

1872, April 30. Huxley, Thomas Henry, M.D., Ph.D., LL.D., D.C.L., P.P.R.S., Hon. Prof. of Biology in Royal School of Mines. Cor. Mem. Inst. Fr. (Acad. Sci.), &c. 4, *Marlborough Place, Abbey Road, N.W.*

1852, Oct. 16. Kirkman, Rev. Thomas Penyngton, M.A., F.R.S., *Croft Rectory, near Warrington.*

1886, Feb. 9. Kopp, Prof. Hermann. *Heidelberg.*

1887, April 19. Langley, Prof. S. P., *Alleghany Observatory, Pittsburg, U.S.*

1887, April 19. Laveleye, Emile de, *Liège University.*

1887, April 19. Lockyer, Norman, F.R.S., Cor. Mem. Inst. Fr., (Acad. Sci.). *Science School, Kensington.*

1889, April 30. Lubbock, Sir John, Bart., M.P., D.C.L., LL.D., F.R.S. *15, Lombard Street, E.C.*

1889, April 30. Mendeléeff, D., Professor of Chemistry. *St. Petersburg.*

1889, April 30. Meyer, Lothar, Professor of Chemistry. *Tübingen.*

Date of Election.

1887, April 19. Newcomb, Prof. Simon, For. Mem. R.S. *Johns Hopkins University, Baltimore, U.S.*

1844, April 30. Owen, Sir Richard, K.C.B., M.D., LL.D., F.R.S., F.L.S., F.G.S., V.P.Z.S., F.R.C.S. Ireland, Hon. M.R.S.E., For. Assoc. Inst. Fr. (Acad. Sci.), &c. *Sheen Lodge, Richmond.*

1886, Feb. 9. Pasteur, Louis, For. Mem. R.S. *Paris.*

1851, April 29. Playfair, Rt. Hon. Sir Lyon, K.C.B., LL.D., Ph.D., F.R.S., F.G.S., M.P., V.P.C.S., &c. 68, *Onslow Gardens, London, S. W.*

1866, Jan. 23. Prestwich, Joseph, F.R.S., F.G.S., Cor. Mem. Inst. Fr. (Acad. Sci.). *Shoreham, near Sevenoaks.*

1866, Jan. 23. Ramsay, Sir Andrew Crombie LL.D., F.R.S., F.G.S., 15, *Cromwell Crescent, South Kensington, London.*

1849, Jan. 23. Rawson, Robert, F.R.A.S. *Havant, Hants.*

1886, Feb. 9. Rayleigh, John William Strutt, Lord, M.A., D.C.L., (Oxon.), LL.D. (Univ. McGill), Sec. R.S., F.R.A.S., *Terling Place, Witham, Essex.*

1887, April 19. Römer, Dr. Fred. *Breslau.*

1889, April 30. Résal, Professor Henri, Membre de l'Institut. *Ecole Polytechnique, Paris.*

1889, April 30. Roscher, Dr. Wilhelm, K. Geheimer Rath, and Professor of Political Economy. *Leipsic.*

1889, April 30. Routh, Edward John, Sc.D., F.R.S. *Newnham Cottage, Cambridge.*

1872, April 30. Sachs, Julius von, Ph.D. *Würzburg.*

1889, April 30. Salmon, Revd. George, D.D., D.C.L., LL.D., F.R.S., Regius Professor of Divinity. *Trinity College, Dublin.*

1889, April 30. Siemens, Dr. Ernst Werner von, Geheimer Rath. *Provost's House, 94, Markgrafenstrasse, Berlin.*

1869, Dec. 14. Sorby, Henry Clifton, LL.D., F.R.S., F.G.S, &c. *Broomfield, Sheffield.*

1851, April 29. Stokes, Sir George Gabriel, Bart., M.A., M.P., LL.D., D.C.L., Pres. R.S., Lucasian Professor of Mathem. Univ. Cambridge, F.C.P.S., Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *Lensfield Cottage, Cambridge.*

1886, Feb. 9. Strasburger, Professor. *Bonn.*

1861, Jan. 22. Sylvester, James Joseph, M.A., D.C.L., LL.D., F.R.S. Savilian Prof. of Geom. in the Univ. of Oxford, Cor. Mem. Inst. Fr. (Acad. Sci.), &c. *New College, Oxford.*

1868, April 28. Tait, Peter Guthrie, M.A., F.R.S.E., &c., Professor of Natural Philosophy, Edinburgh. 38, *George Square, Edinburgh.*

Date of Election.

1851, April 22. Thomson, Sir William, M.A., D.C.L., LL.D., F.R.S.S. L. and E. Prof. of Nat. Phil. in Univ. of Glasgow. For. Assoc. Inst. Fr. (Acad. Sci.), 2, *College, Glasgow.*

1872, April 30. Trécul, A., Member of the Institute of France. *Paris.*

1886, Feb. 9. Tylor, Edward Burnett, F.R.S., D.C.L. (Oxon.), LL.D. (St. And. and McGill Colls.), Keeper of University Museum. *Oxford.*

1868, April 28. Tyndall, John, LL.D., M.D., D.C.L., Ph.D., F.R.S., F.C.S. *Royal Institution, London, W.*

1889, April 30. Williamson, Alexander William, Ph.D., LL.D., For. Sec. R.S., Corr. Mem. Inst. Fr. (Acad. Sci.). *High Pitfold, Shottermill, Haslemere.*

1886, Feb. 9. Young, Prof. C. A. *Princeton College, N.J., U.S.*

1888, April 17. Zirkel, Ferdinand, Professor of Mineralogy. *University of Leipsic.*

CORRESPONDING MEMBERS.

Date of Election.

1860, April 17. Ainsworth, Thomas. *Cleator Mills, near Egremont, Whitehaven.*

1861, Jan. 22. Buckland, George, Professor, University College, Toronto. *Toronto.*

1870, March 8. Cockle. The Hon. Sir James, M.A., F.R.S., F.R.A.S., F.C.P.S. 12, *St. Stephen's Road, Bayswater, London.*

1866, Jan. 23. De Caligny, Anatole, Marquis, Corresp. Mem. Acadd. Sc. Turin and Caen, Socc. Agr. Lyons, Sci. Cherbourg, Liège, &c.

1861, April 2. Durand-Fardel, Max, M.D., Chev. of the Legion of Honour, &c. 36, *Rue de Lille, Paris.*

1849, April 17. Girardin, J., Off. Legion of Honour, Corr. Mem. Instit. France, &c. *Lille.*

1850, April 30. Harley, Rev. Robert, F.R.S., F.R.A.S. 17, *Wellington Square, Oxford.*

1882, Nov. 14. Herford, Rev. Brooke. *Arlington Street, Boston, U.S.*

1862, Jan. 7. Lancia di Brolo, Frederico, Duc, Inspector of Studies, &c. *Palermo.*

1859, Jan. 25. Le Jolis, Auguste-François, Ph.D. Archiviste perpétuel and late President of the Soc. Nat. Sc. Cherbourg, &c. *Cherbourg.*

1857, Jan. 27. Lowe, Edward Joseph, F.R.S., F.R.A.S., F.G.S., Mem. Brit. Met. Soc., &c. *Shirenewton Hall, near Chepstow.*

1862, Jan. 7. Nasmyth, James, C.E., F.R.A.S., &c. *Penshurst, Tunbridge.*

1867, Feb. 5. Schönfeld, Edward, Ph.D., Director of the Mannheim Observatory.

ORDINARY MEMBERS.

Date of Election.

1888, Nov. 13. Adams, C. N., B.A., *The Hulme Grammar School, Alexandra Road.*

1881, Jan. 11. Adamson, Daniel, M. Inst. C.E., F.G.S., *The Towers, Didsbury.*

1861, Jan. 22. Alcock, Thomas, M.D., Extr. L.R.C.P. Lond., M.R.C.S. Engl., L.S.A. *Oakfield, Ashton-on-Mersey.*

1873, Jan. 7. Allmann, Julius. 70, *Deansgate.*

1870, Dec. 13. Angell, John, F.C.S., F.I.C. 81, *Ducie Grove, Oxford Road.*

1861, Jan. 22. Anson, Ven. Archd. George Henry Greville, M.A. *Birch Rectory, Rusholme.*

1885, Nov. 17. Armstrong, Thomas, F.R.M.S. *Brookfield, Urmston; Deansgate.*

1837, Aug. 11. Ashton, Thomas. 36, *Charlotte Street.*

1881, Nov. 1. Ashton, Thomas Gair, M.P., M.A. 36, *Charlotte Street.*

1887, Nov. 16. Ashworth, J. Jackson. 35, *Mosley Street, City.*

1865, Nov. 15. Bailey, Charles, F.L.S. *Ashfield, College Road, Whalley Range, Manchester.*

1888, Nov. 13. Bailey, G. H., D.Sc. Ph.D., *The Owens College.*

1888, Feb. 7. Bailey, Alderman W. H. *Summerfield, Eccles New Road.*

1876, Nov. 28. Barratt, Walter Edward. *Kersal, Higher Broughton.*

1867, Nov. 12. Barrow, John. *Beechfield, Folly Lane, Swinton.*

1889, Jan. 8. Beard, J. R., *Richmond Grove, Longsight.*

1868, Dec. 15. Bickham, Spencer H. *Oakwood, Alderley Edge.*

1861, Jan. 22. Bottomley, James, D.Sc.. B.A., F.C.S. 210, *Lower Broughton Road.*

1889, Jan. 22. Bowman, George, M.D. *Monifieth, Stretford Road, Old Trafford.*

1875, Nov. 16. Boyd, John. *Sandiway House, Palatine Road, Didsbury.*

1855, April 17. Brockbank, William, F.G.S., F.L.S. *Prince's Chambers,* 26, *Pall Mall.*

1861, April 2. Brogden, Henry, F.G.S. *Hale Lodge, Altrincham.*

1844, Jan. 22. Brooks, Sir William Cunliffe, Bart., M.A., M.P. *Bank,* 92, *King Street.*

1889, April 16. Brooks, Herbert S. *Slade House, Levenshulme.*

1860, Jan. 23. Brothers Alfred, F.R.A.S. 12, *Swinton Avenue, Manchester.*

1886, April 6. Brown, Alfred, M.A., M.B. *Claremont, Higher Broughton.*

1846, Jan. 27. Browne, Henry, M.A. (Glas.), M.R.C.S. (Lond.), M.D. (Lond.). *Heaton Mersey.*

1889, Jan. 8. Brownell, T. M. *School Board Offices, St. James' Square, Manchester.*

1872, Nov. 12. Burghardt, Charles Anthony, Ph.D. 35, *Fountain Street,*

1854, April 18. Christie, Richard Copley, M.A., Chancellor of the Diocese, *The Elms, Roehampton, S.W.*

1841, April 30. Clay, Charles, M.D., Extr. L.R.C.P. (Lond.). M.R.C.S. (Edin.). *Tower Lodge, Poulton-le-Fylde, Lanc.*

1886, Dec. 14. Cohen, J. B., Ph.D. *The Owens College.*

1884, Nov. 4. Corbett, Joseph. 9, *Albert Square.*

1853, Jan. 25. Cottam, Samuel, F.R.A.S., F.R. Hist. S., F.C.A. 49, *Spring Gardens.*

1859, Jan. 25. Coward, Edward. *Heaton Mersey, near Manchester.*

1861, Nov. 12. Coward, Thomas. , *Higher Downs, Altrincham.*

1849, Jan. 25. Crowther, Joseph Stretch. *Endsleigh, Alderley Edge.*

1876, April 18. Cunliffe, Robert Ellis. *The Poplars, Eccles Old Road, Eccles.*

1854. Feb. 7. Dale, John, F.C.S. 1, *Chester Terrace, Chester Road.*

1871, Nov. 8. Dale, Richard Samuel, B.A. 1, *Chester Terrace, Chester Road.*

1853, April 19. Darbishire, Robert Dukinfield, B.A., F.S.A., F.G.S., 26, *George Street.*

1878, Nov. 26. Davis, Joseph. *Engineer's Offices, Lancashire and Yorkshire Railway. Hunt's Bank.*

1869. Nov. 2. Dawkins, William Boyd, M.A., F.R.S., F.G.S., F.R.S., Assoc. Inst. C.E., Hon. Fellow Jesus College, Oxford; Professor of Geology in Owens College. *The Owens College.*

1861, Dec. 10. Deane, William King. *Almondbury Place, Chester Road.*

1879, Mar. 18. Dent, Hastings Charles. F.L.S., F.R.G.S. 20, *Thurloe Square, London, S.W.*

1887, Feb. 8. Dixon, Harold B., M.A,, F.R.S., Professor of Chemistry. *The Owens College.*

1886, Mar. 9. Dodgshon, John. *Kingston Road, Didsbury.*

1883. Oct. 2. Faraday, Frederick James, F.L.S., F.S.S. *Ramsay Lodge, Slade Lane, Levenshulme.*

1886, Feb. 9. Gee, W. W. Haldane, B.Sc. *The Owens College.*

1881, Nov. 1. Greg, Arthur. *Eagley, near Bolton.*

Date of Election.

1874, Nov. 3. Grimshaw, Harry, F.C.S. *Thornton View, Clayton.*
1888, Feb. 7. Grimshaw, William. *Stoneleigh, Sale.*
1875, Feb. 9. Gwyther, R. F., M.A., Fielden Lecturer in Mathematics, Owens College. *The Owens College.*

1862. Nov. 4. Hart, Peter. *Messrs. Tennants & Co., Mill Street, Clayton, N., Manchester.*
1873, Dec. 16. Heelis, James. 71, *Princess Street.*
1828. Oct. 31. Henry, William Charles, M.D., F.R.S. *Haffield, near Ledbury, Herefordshire.*
1889, Jan. 8. Heywood Chas. J., *Chaseley, Pendleton.*
1833, April 26. Heywood, James, F.R.S., F.G.S., F.S.A. 26, *Kensington Palace Gardens, London, W.*
1864, Mar. 22. Heywood, Oliver. *Bank, St. Ann's Street.*
1884, Jan. 8. Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street, Manchester.*
1846, Jan. 27. Holden, James Platt, 3, *Temple Bank, Smedley Lane, Cheetham.*
1887, April 19. Holmes, Ralph, B.A. *Hulme Grammar School, Alexandra Park.*
1882, Oct. 17. Holt, Henry. *The Cedars, Didsbury.*
1873, Dec. 2. Howorth, Henry H., F.S.A., M.P. *Bentcliffe House, Eccles.*
1884, Jan. 8. Hurst, Charles Herbert. *The Owens College.*
1888, April 17. Hutton, James Arthur. *29, Dale Street.*

1870, Nov. 1. Johnson, William H., B.Sc. 26, *Lever Street.*
1878, Nov. 26. Jones, Francis, F.R.S.E., F.C.S. *Grammar School.*
1885, Dec. 1. Jones, Henry, B.A. *Norman Road, Rusholme.*
1842, Jan. 25. Joule, James Prescott, D.C.L., LL.D., F.R.S., F.C.S., Hon. Mem. C.P.S., and Inst. Eng. Scot., Corr. Mem. Inst. Fr. (Acad. Sc.) Paris, and Roy. Acad. Sc. Turin. 12, *Wardle Road, Sale.*

1886, Jan. 12. Kay, Thomas, J.P. *Moorfield, Stockport.*
1852, Jan. 27. Kennedy, John Lawson. 47, *Mosley Street.*
1862, April 29. Knowles, Andrew. *Swinton Old Hall, Swinton.*

1886, Mar. 9. Lamb, Horace, M.A., F.R.S., Professor of Mathematics at the Owens College. 106, *Palatine Road, Didsbury.*
1863, Dec. 15. Leake, Robert, M.P. *The Dales, Whitefield.*
1884, April 15. Leech, Daniel John, Professor, M.D. *The Owens College.*
1850, April 30. Leese Joseph. *Messrs. S. & E. Leese, Fylde Road Mill, Preston.*
1884, Jan. 22. London, Rev. Herbert, M.A. *Pocklington, Yorkshire.*

Date of Election.

1857, Jan. 27. Longridge, Robert Bewick. *Yew-Tree House, Tabley, Knutsford.*

1870, April 19. Lowe, Charles, F.C.S. *Summerfield House, Reddish, Stockport.*

1866, Nov. 13. McDougall, Arthur B.Sc. *Clifton Lodge, Gore Street, Greenheys.*

1859, Jan. 25. Maclure, John William, M.P., F.R.G.S., *Whalley Range.*

1875, Jan. 26. Mann, John Dixon, M.D., M.R.C.P., Lond. 16, *St. John Street.*

1879, Dec. 2. Marshall, Arthur Milnes, M.A., M.D., D.Sc., F.R.S., Professor of Zoology, Owens College. *The Owens College.*

1864, Nov. 1. Mather, William. *Iron Works, Salford.*

1873, Mar. 18. Melvill, James Cosmo, M.A., F.L.S. *Kersal Cottage, Prestwich.*

1879, Dec. 30. Millar, John Bell, M.E., Assistant Lecturer in Engineering, Owens College. *The Owens College.*

1881, Oct. 18. Mond, Ludwig, F.C.S. *Winnington Hall, Northwich.*

1861, Oct. 29. Morgan, John Edward, M.D., M.A., F.R.C.P. Lond., F.R. Med. and Chir. S., Professor of Medicine in the Victoria University. 1, *St. Peter's Square.*

1889, April 16. Moultrie, George W. *Bank of England, King Street, Manchester.*

1873, Mar. 4. Nicholson, Francis, F.Z.S. 62, *Fountain Street.*

1889, April 16. Norbury, George. *Hillside, Prestwich Park, Prestwich.*

1862, Dec. 30. Ogden, Samuel. 10, *Mosley Street West.*

1884, April 15. Okell, Samuel, F.R.A.S. *Overley, Langham Road, Bowdon.*

1861, Jan. 22. O'Neill, Charles, F.C.S., Corr. Mem. Ind. Soc. Mulhouse. *Glen Allan, Manley Road, Whalley Range.*

1844, April 30. Ormerod, Henry Mere, F.G.S. 5, *Clarence Street.*

1861, April 30. Parlane, James. *Rusholme.*

1876, Nov. 28. Parry, Thomas, F.S.S. *Grafton House, Ashton-under-Lyne.*

1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. 18, *Exchange Street.*

1854, Jan. 24. Pochin, Henry Davis, F.C.S. *Bodnant Hall, Conway.*

1854, Feb. 7. Ramsbottom, John, M. Inst. C.E. *Fernhill, Alderley Edge.*

1859, April 19. Ransome, Arthur, M.A., M.D., Cantab., F.R.S., M.R.C.S. 1, *St. Peter's Square.*

Date of Election.

1888. Feb. 21. Rée, Alfred, Ph.D., F.C.S. 121, *Manchester Road, Middleton.*

1869, Nov. 16. Reynolds, Osborne, LL.D., M.A., F.R.S., M. Inst. C.E., Professor of Engineering, the Owens College. *Ladybarn Road, Fallowfield.*

1884, April 3. Rhodes, James, M.R.C.S. *Glossop.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S. Ed., F.R.C.P. (London). *Ravenswood, Broughton Park.*

1889, April 6. Robertson, W. J., *Hollins Mount, Heaton Moor, Stockport.*

1864, Dec. 27. Robinson, John, M. Inst. C.E. *Westwood Hall, Leek.*

1858, Jan. 26. Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., F.C.S., M.P. 10, *Bramham Gardens, Wetherby Road, London, S.W.*

1851, April 29. Sandeman, Archibald, M.A. *Garry Cottage, near Perth.*

1870, Dec. 13. Schorlemmer, Carl, LL.D., F.R.S., F.C.S. *The Owens College.*

1842, Jan. 25. Schunck, Edward, Ph.D., F.R.S., F.C.S. *Kersal, Manchester.*

1873, Nov. 18. Schuster, Arthur, Ph.D., F.R.S., F.R.A.S. *The Owens College.*

1881, Nov. 29. Schwabe, Edmund Salis, B.A. 41, *George Street.*

1886, April 6. Simon, Henry, C.E. *Darwin House, Didsbury.*

1859, Jan. 26. Sowler, Thomas. 24, *Cannon Street.*

1884, Mar. 18. Thompson Alderman Joseph. *Riversdale, Wilmslow.*

1873, April 15. Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution.*

1889, April 30. Thornber, Harry. *Rookfield Avenue, Sale.*

1860, April 17. Trapp, Samuel Clement. 88, *Mosley Street.*

1879, Dec. 30. Ward, Thomas. *Brookfield House, Northwich.*

1873, Nov. 18. Waters, Arthur William, F.G.S. *Care of Mr. J. West, Microscopical Society, King's College, London.*

1859, Jan. 25. Wilde, Henry, F.R.S. *The Hurst, Alderley Edge.*

1859, April 19. Wilkinson, Thomas Read. *Manchester and Salford Bank, Mosley Street.*

1874, Nov. 3. Williams, William Carleton, B.Sc., Professor of Chemistry. *Firth College, Sheffield.*

1888, April 17. Williams, E. Leader, M.I.C.E. *Bowdon, Cheshire.*

1887, April 19. Williamson, J. H. R. 14, *St. Ann's Square.*

1851, April 29. Williamson, William Crawford, LL.D., F.R.S., Professor of Botany, The Owens College, M.R.C.S. Engl., L.S.A., For. Mem. Swed. Acad. *Egerton Road, Fallowfield.*

1889, April 16. Wilson, Thomas B. 37, *Arcade Chambers, St. Mary's Gate, Manchester.*

Date of Election.

1860, April 17. Woolley, George Stephen. 69, *Market Street.*

1863, Nov. 17. Worthington, Samuel Barton, M. Inst. C.E. 12, *York Place, Oxford Street.*

1865, Feb. 21. Worthington, Thomas, F.R.I.B.A. 40, *Brown Street.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore Life Members :

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Johnson, William H., B.Sc.
Sandeman, Archibald, M.A.
Lowe, Charles, F.C.S.

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