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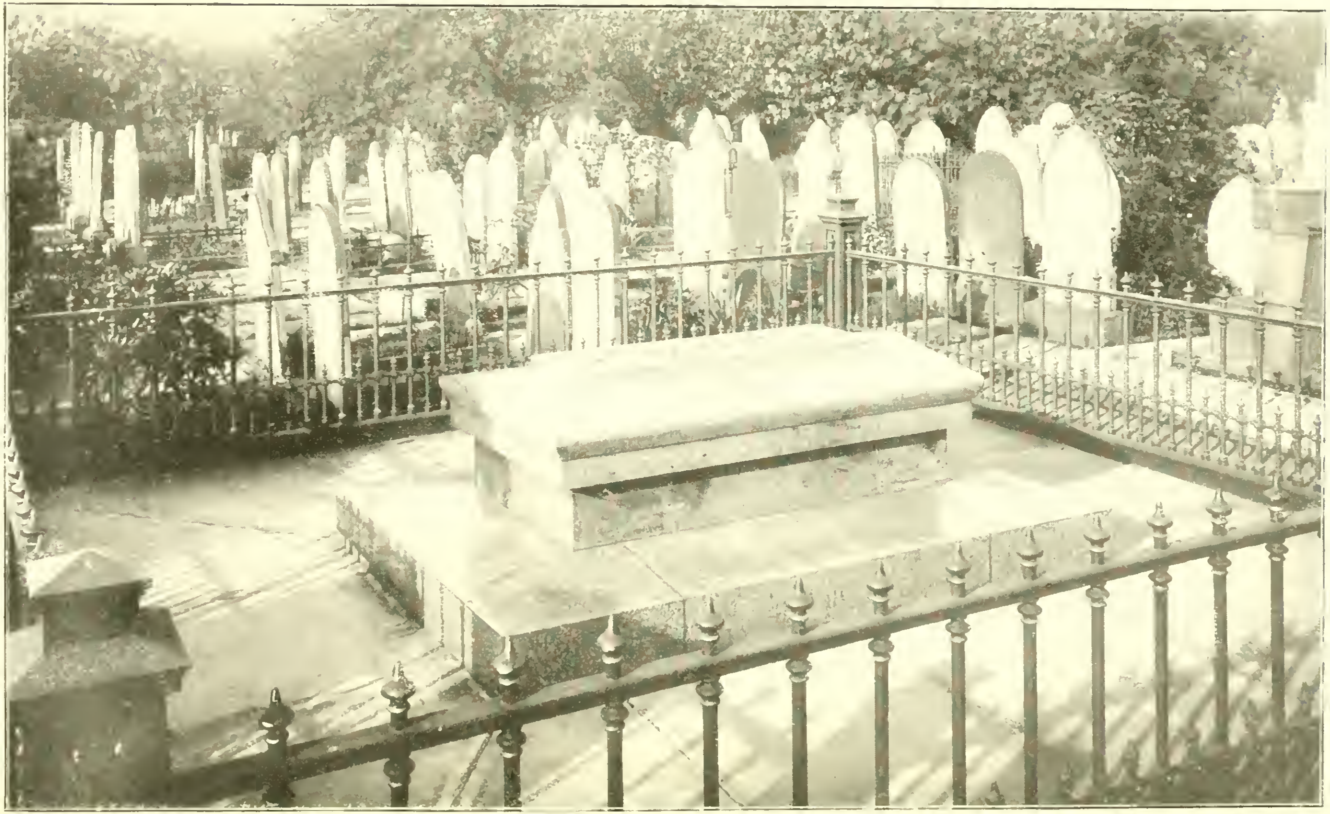

DALTON'S TOMB IN ARDWICK CEMETERY, MANCHESTER.

MEMOIRS AND PROCEEDINGS

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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.

Manchester Memoirs, Vol. xliv. (1899), *No.* **1.**

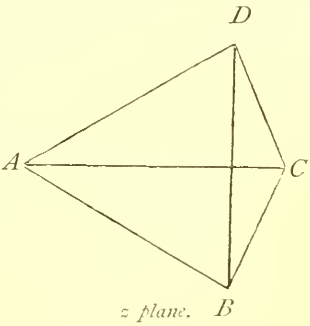
I. On the Electrical Resistance between opposite sides of a Quadrilateral one Diagonal of which bisects the other at right angles.

BY CHARLES H. LEES, D.Sc.

Received and read October 14th, 1899.

If by means of the equation $z'=f(z)$ where z' and z are the vector coordinates of two points in two planes, the z plane is conformally represented on the z' plane, any two conjugate systems of curves in the z plane transform into two systems which are conjugate in the z' plane.* If the curves in the z plane are the stream and equipotential lines respectively for some flux having a potential, the corresponding curves in the z' plane are also stream and equipotential lines, and if the points A, B in the z plane transform into A' B' in the z' plane, the difference of potential between A' and B', and the flux a cross line joining them, are equal respectively to the difference of potential between A and B and the flux across a line joining them.

Let $ABCD$ be a quadrilateral in the z plane, the diagonal AC bisecting the other diagonal BD at right angles, so that the triangles ABC and ADC are equal. Let AD and BC be two equipotential lines and AB, DC stream lines. The resistance of the quadrilateral may be found if the figure can be transformed by an equation of the above form, into another in the z' plane for which the resistance is known,



z plane.

Fig. 1.

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* Maxwell, *Electricity and Magnetism* I., p. 265.

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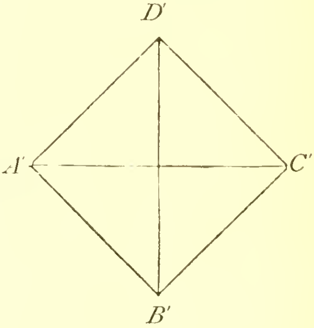
e.g., a square $A'B'C'D'$ the angular points A', B', C', D', of which correspond to the points A, B, C, D of the quadrilateral.

That this is possible may be seen from the fact that the contour $ACDA$ of the triangle ADC in the z plane, may be transformed into the axis of real quantities in a third plane, the w plane, the three points A, C, D, becoming any three assigned points on that axis, and the area within the triangle the upper half of the w plane.* Similarly the contour $A'C'D'A'$ of the triangle in the z' plane may be transformed into the same axis, the points $A'C'D'$ becoming the same three points, and the interior the upper half of the w plane.



z *plane.*

Fig. 2.

Hence the triangle ACD of the z plane may be transformed into the triangle $A'C'D'$ of the z' plane.† By

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* Christoffel, *Ann. di Mat.* I., p. 95 (1867). Schwarz, *Ges. Werke*, II., p. 65. Forsyth, *Theory of functions*, p. 541. Love, *American Journal of Mathematics*, XI., p. 164 (1889).

† If the internal angles of the triangle ADC are $\alpha\pi$, $\delta\pi$, $\gamma\pi$ respectively, and those of $A'D'C'$ $\frac{\pi}{4}$, $\frac{\pi}{2}$, $\frac{\pi}{4}$, the transforming equation is obtained by eliminating w from

$$z = \mathrm{D}\int\frac{dw}{(w-a)^{1-\alpha}(w-b)^{1-\delta}(w-c)^{1-\gamma}}$$

and

$$z = \mathrm{D}'\int\frac{dw}{(w-a)^{\frac{3}{4}}(w-b)^{\frac{1}{2}}(w-c)^{\frac{3}{4}}}.$$

Love, *l.c.*, has worked out the integrals for :—

$$\alpha=\frac{1}{3},\quad \delta=\frac{1}{3},\quad \gamma=\frac{1}{3};$$

$$\alpha=\frac{1}{2},\quad \delta=\frac{1}{4},\quad \gamma=\frac{1}{4};$$

$$\alpha=\frac{1}{2},\quad \delta=\frac{1}{3},\quad \gamma=\frac{1}{6};$$

they can be expressed by elliptic functions. In the general case they can be expressed, with certain limitation as to paths of integration, by Abelian functions. Forsyth, *Theory of Functions*, p. 543.

symmetry it is also evident that the triangle ACB may be transformed into the triangle $A'C'B'$, and two contiguous points on opposite sides of AC transform into two contiguous points on opposite side of $A'C'$, *i.e.* the quadrilateral $ABCD$ in the z plane transforms into the square $A'B'C'D'$ in the z' plane.

If t is the thickness of the square and ρ the resistivity of the medium, the quotient of the difference of potential between $A'D'$ and $B'C'$ by the current from one to the other $= \rho/t$.

Hence the resistance of the quadrilateral $ABCD$ from the side AD to the side BC is equal to ρ/t, where t is the thickness and ρ the resistivity of the material of the quadrilateral.

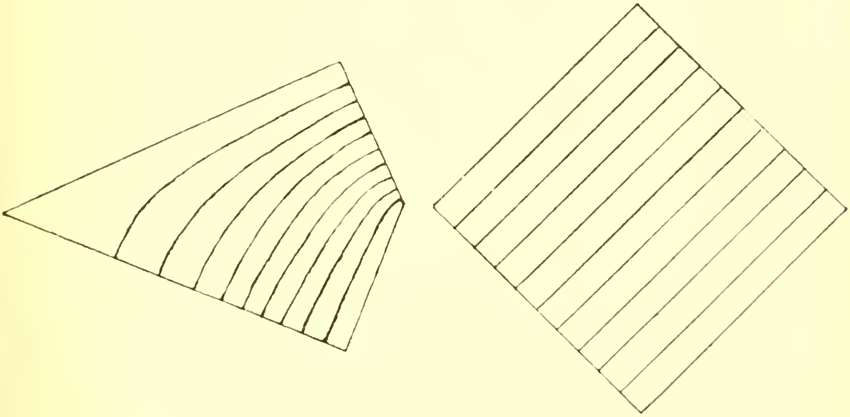

Fig. 3.

Fig. 3 shows approximately the equipotential lines when the angles at B and D are right angles, and that at $A=45.^{\circ}$ They have been drawn by making use of the fact that in the neighbourhood of each angular point the transforming equation may be written $z'=Az^{n}$. The closeness of the approximation will therefore be least near the centre of the quadrilateral.

Manchester Memoirs, Vol. xliv. (1899), *No.* **2.**

II. On the question of Irish Influence on Early Icelandic Literature, illustrated from the Irish MSS. in the Bodleian Library.

By Winifred Faraday, B.A.,
Late Scholar and Fellow of the Victoria University.

Communicated by F. J. Faraday, F.L.S.

Received and read October 31st, 1899.

The theory of an Irish influence on early Icelandic literature forms such a convenient and obvious explanation of the early maturity of that branch of the Scandinavian race, that there is a general tendency to take it for granted. It would explain not only why the Icelanders alone so early developed the Germanic myths into literary form, but also how their classical literature came to flourish at a time when the work produced by other Germanic races was scanty or experimental. It is argued with some reason that the union of the German, slow to begin and slow to reach maturity, but having the classical qualities which make work enduring, with the Celt, possessing the inventive impulse and every talent except these essential qualities of stability and sense of form, may well have produced the same results in Icelandic as in English literature. There is interest also in the possibility that the Celt, who, however fruitful his legends have proved in other hands, has produced no classical work, should have directly inspired the most magnificent work of the youth of the Germanic race, which has despised its more unstable rival.

The later champions of Irish influence do not take the line of attributing the whole of classical Norse literature,

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or the impulse which started it, to Celtic admixture of race; nor do they seek in any way to account for the literary supremacy of Iceland. Devoting themselves solely to the poems of the Edda, they dwell on the difference in spirit between these and the prose literature, and account for it by claiming for the majority of the poems an origin not in Iceland, but directly under Celtic and other influences in the British Isles; thus by inference excluding both the Sagas, the greater work of Iceland, and the Skaldic poetry, from these influences. As this theory has lately been brought into special prominence by Professor Bugge, whose work has to a great extent been seriously accepted in England, and has found supporters even in cautious and scientific Germany (Dr. Mogk, of Leipzig, accepts Professor Bugge's arguments wholesale), I will consider it before discussing the broader question.

In view of Professor Bugge's hypotheses, and of the stress laid by Professor York Powell[1] on the "prosaic" or unimaginative character of the Icelander (an argument based on the hypothesis it claims to prove), attention has been directed rather to possibilities and to fanciful analogies than to the actual facts which go to prove Celtic influence or its absence. From a philological point of view at least, it may be contended that such evidence as does exist, in borrowed words or proper names, is in favour of Norse influence on Irish life and thought, rather than of Celtic influence on Iceland.

Professor Bugge has advanced his theory in his *Studier over de nordiske Gude- og Heltesagns Oprindelse.*[2] As time goes on, he tends more and more to emphasize

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[1] *Folklore*, V. p. 98.

[2] *Studien über die Entstehung der nordische Götter- und Heldensagen*, transl. Brenner (München, 1889); *Helgedigtene* (Köbenhavn, 1896); English version of the latter by Dr. Schofield, *Home of the Eddic Poems*, with new introduction (London, Nutt, 1899).

Anglo-Saxon influence on the Edda, and to slur over Irish, without however abandoning the latter. Thus in his latest utterance, the Introduction to the *Home of the Eddic Poems*, his theory is stated as follows: that the Norse myths were "shaped by Scandinavian mythological poets who associated with Christians in the British Isles, especially with English and Irish'; further, that "The great majority of both mythological and heroic poems were composed by Norwegians in the British Isles, the greater number probably in Northern England, but some, it may be, in Ireland, in Scotland and in the Scottish Isles. Very few Eddic lays seem to have arisen outside of the British Isles."[1]

Dr. Vigfusson's theory (with which presumably Prof. York Powell agrees, as it is stated also in the introduction to the *Corpus Poeticum Boreale*, their joint edition of the Northern poetry) is much the same: "That these poems (with one or two exceptions) owe their origin to Norse poets in the 'Western Islands'—that the Lays are, in fact, to these Islands, what the Saga was to Iceland."[2]

I. *Gaelic Loan-Words in the Eddic Poems.*

The most weighty argument for this theory would naturally be the production of loan-words; a few are advanced, most of which have been left unchallenged. Professor Bugge gives the following:

1. *Krás*,[3] a dainty, "wahrscheinlich aus *ir.* crois, cráes,"[4] *i.e.*, excess, gluttony; but he saw himself the impossibility of this derivation, and withdrew it in an appendix.[5]

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[1] *Home of the Eddic Poems*, pp. xiv., xviii.

[2] *Sturlunga Saga* (Oxford, 1878), Prolegomena, p. clxxxvi.

[3] *þrymskviþa*, 24. (Wimmer and Jónsson, Facs. of Cod. Reg., p. 34, l. 22, *krasir allar*). *Rígsmál* l. 69 (omitted in Bugge's edition). *Helgi Hundingsbani*, I. 36.

[4] *Nordische Götter- und Heldensagen*, pp. 6, 7.

[5] ib. p. 574.

2. *Linnar* or *lindar*,[1] "gen. sing. fem. von linn, sonst lind, *Quelle*, scheint aus dem *ir.* lind oder linn, *Wasser*, *Weiher*, *kleiner See*, entlehnt."[2] The derivation is very doubtful, as the phrase in which the word occurs, *lindar loga*, a kenning for gold, translated according to this reading "flame of the pool," is a *ἅπαξ λεγομένον*; and if this spelling is correct, it could as well be read "flame of the shield," which would be an equally appropriate kenning, and one which might easily occur to a poet who had seen the gold-adorned shield of a northern warrior flashing in the sun.

3. *bjoðum*,[3] earth. "Das Wort stammt möglicherweise von *ir.* bioth, bith, *Welt.*"[4] This is quite impossible. The Irish word means age, or world, and could no more be used in the material sense in which the Norse word occurs in *Völuspá*, in Egil's *Höfuðlausn*,[5] and elsewhere, than *mundus* or *saeculum* could be used as a synonym for *terra*. Further, the form *bioth* with infected vowel is middle Irish, and does not occur in Irish MSS. of the date of the Edda. Professor Bugge adds elsewhere,[6] "In later Icelandic poems *bjöð* was adopted from *Völuspá* and used in the meaning of 'earth,' *e.g.*, by the Skald Kormak." But Kormak's verses[7] were written in the reign of King Harald Gráfeld, within a year or two of whose death in 965 (if not indeed during his lifetime), the poet died[8]; while another famous skald who uses the word, Egill Skallagrímsson, died in Earl Hákon's time,[9] therefore before 995. It is very improbable, for metrical reasons, that *Völuspá* was composed before the 11th century; therefore the word is found in Skaldic poetry before it occurs in the Edda.

[1] *Reginsmál*, Facs. p. 57, l. 13, *linar loga.*

[2] *Götter- und Heldensagen*, p. 7. *Corpus Poeticum Boreale*, p. lx.

[3] *Völuspá*, 4 (Facs. bioðō).

[4] *Götter- und Heldensagen*, p. 7, note. *Corpus Poeticum*, p. lx.

[5] *Höfuðlausn*, 2, "á Engla bjoð."

[6] *Home of the Eddic Poems*, p. xxxiv.

[7] *Kormáks Saga*, ch. 19, Strophe 61, "enn *bjöð* sekkvisk." (*Corpus Poeticum* II., 65, Improvisations 9.)

[8] See *Kormáks Saga*, ch. 25-27.

Egils Saga Skallagrímssonar, ch. 85.

4. *Kartr*,[1] cart, "ist wohl jedenfalls von den britischen Inseln nach dem Norden gekommen, wenn auch nicht mit Sicherheit gesagt werden kann, aus welcher Sprache."[2] Vigfusson has no doubt on the subject, but quotes it confidently as Gaelic.[3] It has been shown elsewhere[4] that it is not a Gaelic loan, since the Irish *cart* is late, borrowed from the English; and the Old Irish *cret* is too far away in form.

Dr. Vigfusson, in addition to the above, gives the following words[5]:

5. *æti*,[6] which he translates "oats." It is however a pure Germanic word, from the "eat" root, as the context shows. In answer to the question, "Segþu mér hvé þat sáþ heitir" (tell me what seed is called), the dwarf replies:

Bygg heitir með mönnum	(It is called "bygg" among men,
enn barr með Goðom;	but "bearing" among Gods;
kalla vaxt Vanir;	the Vanir call it "growth,"
eti iötnar; &c.	the giants "food," &c.)

each name being descriptive. If we assume that *eti* is the real name of a special kind of corn seen in foreign countries, we should logically assume the same for *vaxt*.

6. *niol*.[7] Dr. Vigfusson[8] does not equate this word, which is given among the descriptive names for night. He may have been thinking of the Irish *nél* (cloud, mist). *Njól* is a Germanic word, corresponding to the A. S. *neowol*, deep.

7. *tir*, "*earth*, if we read rightly in the Western Volsung Lay, l. 85."[9] But the *tír* which occurs there,[10] in the compound *megin-tíri*, does not mean "earth," but is an old Germanic word

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[1] *Rígsmál*, 19.

[2] *Götter- und Heldensagen*, p. 7.

[3] *Sturlunga Saga*, p. clxxxvi.

[4] *Zeitschrift für Keltische Philologie* I.

[5] *Corpus Poeticum Boreale.* Introd., pp. lix., lx., lxix.

[6] *Alvíssmál*, 32. (Facs. p. 39, 14—15).

[7] *Alvíssmal* 30 (Facs. p. 39, l. 12).

[8] *Corpus Poeticum Boreale*, pp. lx., lxix.

[9] *Corpus Poeticum Boreale*, p. lx.

[10] *Sigrdrífumál*, 5 (Facs. p. 63, l. 19).

for glory, common in Anglo-Saxon poetry and in Old Saxon; and is so translated correctly by Dr. Vigfusson himself, both in the Dictionary and in the *Corpus Poeticum.*

8. *Righ*,[1] used as a proper name in *Rígsmál*, seems to be a genuine Gaelic word, the only one in the Eddic poems. (Irish *rí*, *ríg*, a king).

Professor Bugge states further[2], but without giving specific references, that there are Irish words in *Reginsmál* and in *Fafnismál.* The only word in *Reginsmál* which lays any claim to Celtic descent, is the doubtful *lindar*, discussed above ; there are no Celtic words in *Fafnismál.*

This forms the whole of the linguistic evidence in favour of the theory that the Eddic Poems were composed under Celtic influences.

II. *Vocabulary of the Eddic Poems.*

Dr. Vigfusson supplements the scanty list of so-called Celtic loan-words by a number of words found in the Edda but not used in Icelandic prose.[3] These however are all Germanic words and cannot be used to prove Celtic influence as he attempts to use them. In all old Germanic literatures the poetic vocabulary contains many words not used in prose, and *salr*[4] (hall), which occurs besides in local and personal names, *búr*[5] (in the sense of "a chamber"), *mjötuðr*[6] (guardian, or fate, bane), may well be such ; *sal* and *bur* occur in Anglo-Saxon and Old High German, *metod* in Anglo-Saxon and Old Saxon. Other

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[1] *Corpus Poeticum Boreale*, p. lxx.

[2] *Helgeaigtene*, p. 22.

[3] *Corpus Poeticum Boreale*, p. lviii., lix., lxi.

[4] e.g. *Völuspá*, 20. The word is so common, both in Eddic and Skaldic poetry, and also in local and personal names, that we may safely reject the suggestion of borrowing from England.

[5] *Oddrúnagrátr*, 17. *Guðrúnarkviða*, II., l.

[6] *Völuspá*, 2, 46.

words in the list occur in Norwegian (*e.g.*, *jafnendr*,[1] umpire, a Norse legal term); others may be borrowed from Anglo-Saxon (*e.g.*, *óðaltorfa*,[2] inherited land; the compound is a ἅπαξ λεγομένον in Icelandic; Anglo-Saxon *êðeltyrf*); some are apparently borrowed from the Continental Saxons (*e.g.*, *plógr*,[3] a plough, is neither Norse nor Anglo-Saxon). The editors of the *Corpus Poeticum* must have been at a loss for arguments before they accepted these good Germanic words as proofs of Celtic influence. Their idea is that the poets of the Edda were writing in the midst of a Celtic civilisation, and used rare words to describe an unfamiliar life. But this argument would apply equally to Anglo-Saxon and Old High German poetry; and both the things quoted and their names were common in Germanic countries. This remark applies also to the next section.

III. *Local Colour in the Eddic Poems.*

In considering local colour as evidence of the birthplace of the Edda, it is necessary to remember that the Icelanders were a far-travelled race whose wanderings extended from Greenland to Constantinople, and who regarded a stay-at-home as a man of no mark.[4] We should therefore expect their poetry to show some knowledge of other countries. Local colour is nevertheless the argument in which both scholars seem to place most confidence. They quote as characteristic of the British Isles:

1. *Peat-digging*,[5] Rigsmál, 12. It is true that peat-digging

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[1] *Hárbarðsljóð*, 42.

[2] *Sigurðarkviða*, III., 62.

[3] *Rígsmál*, 22.

[4] *Laxdæla Saga*, ch. 72. "þykkir mér maðr við þat fáviss verða, ef hann kannar ekki víðara enn hér Island" ("A man seems to me little wise, if he knows nothing beyond Iceland here.")

[5] *Corpus Poeticum Boreale*, p. lix.; *Sturlunga Saga*, p. clxxxvi.

was unknown in Norway, where there were large forests; it was different in Iceland, where wood was scarcer. Turf was there, as in Ireland and the Scottish Isles, the ordinary fuel.

2. *The Stag*[1] (*hjörtr*), *Helgi Hundingsbani*, I. 49[2]. *Guðrúnarkviþa*, 68.[3] The stag was known outside the British Isles, *e.g.*, in Norway; and *Hjörtr* is found as a proper name in Landnamabók.

3. *Red-deer* (*rauð-dýri*), which is never mentioned by name in the poems, though Bugge[4] agrees with Dr. Björn Magnússon Ólsen[5] in adopting Dr. Finnur Jónsson's emendation *hösum dýrum* (grey deer) for the MS. *hvossom dýrom*[6] (keen deer) in *Helgi Hundingsbani* II., and in taking this as an allusion to the red deer. He omits the line, however, from his own edition of the poem.

4. *Goatherding*,[7] *Helgi Hundingsbani*,[8] I., 34; *Rígsmál*, 12. Goats, too, were kept outside the British Isles; Professor Bugge acknowledges that they were herded in Norway.

5. *Swineherding*,[9] *Helgi Hundingsbani*, I., 34, *Rígsmál*, 12, is also not peculiar to the British Isles, as Professor Bugge agrees. His argument that these two occupations were held in especial contempt in Ireland is unconvincing: in any country they would have been unworthy of such warriors as Sinfiotli or Guðmundr. There are articles in *Grágás*, concerning swineherding[10]; and *svín*, like *geitr*, is common as an element in place names in Landnama.

Of the other examples shortly given by Professor

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[1] *Helgedigtene*, p. 114; *Home of the Eddic Poems*, p. 118. *Corpus Poeticum*, p. lx.

[2] *Rakka hirtir* (the ring-harts), a kenning for ships.

[3] *Corpus Poeticum* I., 326. Facs. p. 73, l. 9. Omitted in Bugge's edition.

[4] *Helgedigtene*, p. 113. *Home of the Eddic Poems*, p. 118.

[5] *Tímarit hins Islenzka Bókmentafjelags*, 1894, p. 59.

[6] Facs. p. 73, l. 9, omitted in Bugge's edition.

[7] *Helgedigtene*, p. 117, f., *Home of the Eddic Poems*, p. 118, f.

[8] Passage omitted in Bugge's edition.

[9] *Helgedigtene*, p. 117; cf. *Corpus Poeticum*, p. lix.

[10] *Grágás*, Cod. Reg. (ed. Vilhjálmur Finsen, Köbenhavn), art. 207.

Bugge[1] from *Helgi*, none are peculiarly British (*e.g.*, the eagles on the ash tree, the bear-hunt, the ash tree and the thorns, etc.). The Icelanders visited many countries where these could have been seen; most of them could be seen in Norway; and none are called by Celtic or English names.

An instance of so-called local colour given with great confidence by Dr. Vigfusson and his co-editor, is *vígnisting*,[2] which he translates "a wicker shield" (presumably deriving it from the Irish *fígim*, I weave); he quotes this word as a striking and characteristic Irish touch. It does not however occur in Codex Regius,[3] which has *vef-nistingō* (woven texture, the sails), as also have all the editions, including Dr. Vigfusson's own.[4] This is an example of the same curious literary morality as that which permits Professor Bugge to quote in support of a theory lines which he omits in his own edition of the texts in question.

IV. *Geographical Allusions.*

British place-names are rare in the Edda. Dr. Vigfusson points out two. One, *Suðr a Fivi* (South in Fife), *Guðrunar-kviða in forna*, 16, is genuine. The other *Pettlandfjörðr* (Pentland Firth), is given as from the prose introduction to *Grotta-söngr*; this prose introduction does not belong to the poetic Edda, and is not taken from the MS. (Codex Regius), but from Snorra Edda; it is inserted by Munch in his edition of Sæmundar Edda as an introduction to the poem.

Even if the above instances were perfectly sound, the utmost that they prove is that Icelanders had visited and observed Gaelic countries; this we knew already from the

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[1] *Helgedigtene*, p. 118.

[2] *Corpus Poeticum*, p. lxi.

[3] Facs., p. 41, l. 5.

[4] *Corpus Poeticum*, I., p. 134.

Sagas and other historical sources. Professor Bugge and the *Corpus Poeticum* editors have not proved that Icelanders learnt to understand the speech of the Irish or Scottish Gaels; they have not adduced a single instance of the re-appearance of Gaelic legend in Norse literature; while the theory that the poems were composed by settlers in the Isles, and there heard by Icelanders who carried them home when they returned, is mere hypothesis. No trace of them has been found outside Iceland; and while we know that the Icelanders were a literary race, furnishing most of the skalds to Norway, we have no grounds for attributing literary skill to the island settlers.

Professor Bugge tries to show[1] that one native Irish story influenced the Helgi poems; this story, the *Cath Ruis na Ríg*,[2] is a late composition of the 11th century, itself influenced by the events of the Norse and Danish occupation. Further, none of the peculiar and distinctive elements in the story reappear in *Helgi*, such as the resounding of the Three Waves of Ireland and the shields of the Ultonian host, in answer to the moan of Conchobur's shield,[3] nor the marching of the army under oak branches[4]; the so-called influence is shown in expressions which may indeed be parallel, but which in a large number of cases are simple statements of facts that might have occurred a dozen times in the actual experience of either Irish or Norsemen. Such are: "Sendi áru allvaldr þaðan[5]" (the king sent messengers thence), by the Irish "faitte dano fessa ocus techta uad"[6] (then were heralds and messengers sent out from him); or "þaðan beið þengill unz þinig

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[1] *Helgedigtene*, pp. 37—55.

[2] *Cath Ruis na Ríg*, ed. Hogan (Dublin, 1892).

[3] *Cath Ruis na Ríg*, ch. 35.

[4] Ib., ch. 37.

[5] *Helgi Hundingsbani*, I. 21.

[6] *Cath Ruis na Ríg*, ch. 8.

kómu"[1] (there the prince waited until they came thither), by the Irish "Et tancatar co hairm i mbái Conall" (and they came to the place where Conall was); or the description of a storm at sea.[2])

The theory[3] that the Valkyriur of Old Norse myth are due to the working of Celtic suggestion on a Germanic basis of fact, is again unsupported hypothesis. In the absence of any evidence of actual intercourse, no scholar can do more than point out that supernatural battle-maids, of very different character, appear in both literatures, as also in the literature of other races; there is no proof that either borrowed from the mythology of the other, except such as may be drawn from a few isolated and obscure references in Irish stories, which look like suggestions from Norse mythology; and these might be otherwise explained with greater knowledge.[4]

We now return to the older and broader theory that a Celtic admixture in race first gave the impulse for literary composition in Iceland.[5] That such an admixture was large enough either to ensure a knowledge of the Irish speech among Icelanders or to make the spread of Irish ideas probable, is not supported by such evidence as we

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[1] *Helgi Hundingsbani*, I. 22.

[2] *Helgi Hundingsbani*, I., 27-31; *Cath Ruis na Ríg*, ch. 10.

[3] *Helgedigtene*, p. 177.

[4] Such is the sentence "Fanócrat in dá fiach drundechta (? druidechta) dogensat in tslúaig" (*Serglige Conculaind*, Lebor na hUidhre, fol. 48a, R. I. A. Dublin), which may be translated "The two ravens announced the enchantments which the host performed"; no ravens have been mentioned before, and their isolated appearance here as messengers from the battlefield seems like a reminiscence of Odin's two ravens.

[5] See Matthew Arnold, *Study of Celtic Literature* (London, 1867), p. 141, f., "There is a fire, a sense of style, a distinction, in Icelandic poetry, which German poetry has not. Icelandic poetry too shows a powerful and developed technic; and I wish to throw out . . . . the suggestion that this power of style and development of technic in the Norse poetry seems to point towards an early Celtic influence or intermixture." See also *Sturlunga Saga*, Prolegomena, p. xx.

can gather from historical sources. Personal names should be to some extent a criterion of the intermixture of races, as local names are of their geographical distribution. Investigation on this point seems to show a very considerable Scandinavian element among the Irish of the East and South, for centuries after the raids had ceased; but an insignificant and rapidly vanishing Gaelic element in Iceland.

Of the 85 possibly Irish[1] names which occur in Norse sources, not much more than a third were ever actually used on Icelandic soil; only eight[2] were ever borne by native Icelanders; and only three obtained any hold, or lasted for more than a generation or two. Of these, two, Njáll and Kormakr, must have been heard at an earlier time than the others, possibly from Irish monks on the continent, and not in the west; since both are found in Norway in Harald Harfagr's time: *i.e.*, Njáll,[3] the brother of Eyvind Skaldaspillir, and son of Finn Skjálg, and Kormakr,[4] the grandfather of Kormak the skald. His parentage is not given, but he is described in the Saga as "víkverskr að ætt, ríkr ok kynstórr" (a Vík man by descent, powerful, and of a great family).

The possibly Norse names in the Irish annals are about equal in number. Dr. Whitley Stokes gave an incomplete list in Bezzenberger's Beiträge XVIII., 121-3. The following names which he omits may be noted (I include foreign names which came through the Norse):

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[1] See Mr. Craigie's list in *Zeitschrift für Keltische Philologie*, I. pp. 444-450.

[2] These are *Dufnall* (Ldn. 2. 17). *Kaðall* (Ldn. 2. 18, Njála, 148). *Kiallakr* (Ldn. 2. 11, 19). *Kjartan* (Ldn., Laxdæla), *Konall* (Sturlunga, vii. 26), *Kormakr*, *Kýlan* (Ldn. 2. 1), *Njáll.*

[3] *Fornmanna Sögur*, I. 2.

[4] *Kormaks Saga*, 1.

1. *Arnaill* Scott, Cogadh Gaidhil[1], ch. 106; *Ernail*, ib. 117. Probably Old Norse *Arnljótr*[2].

2. *Colla* mac Bairid, Chronicon Scotorum[3], 923; *Colla* mac Barit, Annals of the Four Masters[4], 922. There appears to have been an Irish name *Colla*, found in the legendary Three Collas, and in some Irish families which claimed descent from them; but occurring at such an early date as the name of a Norseman's son, it is probably here the Old Norse *Kolr*.

3. *In Ingen Ruadh*, Cogadh Gaidhil, ch. 36, *Inghine Ruaidhe*, ib. ch. 117, da mhac *na hIngene Ruaidhe* (the two sons of In Ingen Ruadh). The words are Irish, and mean "the red-haired maiden." As In Ingen Ruadh and her sons were Norse leaders, it is possible that this is an attempt to reproduce one of the Norse female names beginning with *Ingi-*, *e.g.* Ingigerð or Ingerið.

4. *Pol* mac Amaind, Annals of Ulster[5], 1103. *Pol* Adhmann, Annals of Loch Cé[6], 1103. *Pól* mac Amaind, Annals of the Four Masters, 1103. Raghnall mac *Póil*, Four Masters and Loch Cé, 1133. Old Norse *Pál.*

5. *Birnd*, Cogadh Gaidhil, ch. 46. Old Norse *Björn.*

There are some points to be noticed in connection with some of the names in Dr. Stokes' list:

1. *Asgall*, Old Norse *Áskell.* A form more like the original occurs in the Annals of Tigernach,[7] fol. 25^b, 1. which has *Ascall*, *Aschall*, at the date 1171. Loch Cé gives *Axoll* at the same date.

2. *Aufer*, Chronicon Scotorum, 925; Four Masters, 924. Dr. Stokes says: *Afvirðr*, Icelandic *Auvirðr*, Anglo-Saxon

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[1] *Wars of the Gaedhil and the Gall*, ed. Todd, Rolls Series.

[2] Ib. Introduction, p. clxxxi., Steenstrup, *Normannerne*, III., p. 166 (Köbenhavn, 1876-82).

[3] *Chronicon Scotorum*, ed. Hennessy, Rolls Series.

[4] *Annals of the Four Masters*, ed. O'Donovan.

[5] Bodleian MS., Rawl. B. 489, fol. 46^b 1, l. 34. (*Annals of Ulster*, ed. Hennessy and MacCarthy, Rolls Series.)

[6] *Annals of Loch Cé*, ed. Hennessy, Rolls Series.

[7] *Annals of Tigernach*, Rawl. B. 488.

æfwyrd. It might equally well represent Old Norse *Ölver* or *Álfr*, both much commoner names.

3. *Auisle*, Annals of Ulster 862, &c. Dr. Stokes equates this with Anglo-Saxon *Eowils.* It may, however represent Old Norse *Auðgisl* (compare the form *Aðísl* of Islendinga Bók, 12). He takes the form *Ossill, Osil*, of Cogadh Gaidhil, ch. 29, for a different name, "perhaps *Ásvaldr*"; but the Annals of Ulster (Rawl. B. 489), fol. 25^a, 2, l. 6, and the Three Fragments[1] have respectively *Auisle, Oisle*, for the same entry, in 866; and the older M.S. (Book of Leinster) of Cogadh Gaidhil, has *Oisli.*

4. *Birndin*, Cogadh Gaidhil, ch. 36. Dr. Stokes suggests that perhaps *Birn-*=*Bjarni* or *Björn*, and *-din* some Irish termination. But the *-d-* evidently belongs to the stem, from the form *Birnd*, mentioned above (a form unnoticed by Dr. Stokes). Then *-in* might be an error for the *m.* (abbreviation of *mac*) of a patronymic; or it might be the Irish diminutive suffix *-in.*

5. *Brodor* iarla, Cogadh Gaidhil, ch. 87; Annals of Ulster, 1014. "*Bruadar* taoisioch na nDanar," (*i.e.*, leader of the Danes) Chronicon Scotorum, 1012, &c. It seems doubtful whether this is a Norse name, though the man here mentioned in the entries referring to the battle of Clontarf is certainly the *Bróðir* of Njáls Saga, 155-7. But it occurs nowhere else in Norse sources as a proper name, while it does come much earlier in the Irish annals, as an Irish name; *e.g. Bruadar* Mac Aedha, (Four Masters, 851, Chronicon Scotorum, 853); *Bruadar* Mac Dunlaing (Four Masters, 860); *Bruadar* Mac Eachthighern (Annals of Tigernach 982, fol. 15^a, 2, l. 12).

6. *Colphin*, Cogadh Gaidhil, ch. 24. Old Norse *Kolbeinn.* Dr. Stokes does not notice that the name occurs elsewhere in the annals in a form much more like the Norse: *Colbain*, Four Masters 988, Chronicon Scotorum 987, Annals of Tigernach 989 (fol. 15^a, 2, l. 42, out of place).

7. *Dolfinn* is given by Dr. Stokes as Anglo-Saxon, but is more probably Scandinavian; the father *Finntuir* (Annals of

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[1] *Three Fragments of Irish History*, ed. O'Donovan.

Ulster, 1054), or *Finntair* (Loch Cé, 1054), bears a name which is undoubtedly Norse, *i.e.*, **Finnþor* for *Þorfinn*.[1]

8. *Elgi*, *Ailche*. Old Norse *Helgi*. Other forms which occur are *Ailgi* (Four Masters 920, 922), *Elgim* (Cogadh Gaidhil, ch. 46).

9. *Griffin* is probably not Norse (Cogadh Gaidhil, 36); the only name resembling it is *Griffinus*, the form which the Welsh *Gruffudd* takes in Latin chronicles.

10. *Laghmuind*, Cogadh Gaidhil, ch. 26. Old Norse **Lagmann* (*Lögmaðr*). Other forms are *Ladhmann* (Loch Cé, 1116); and as the name of a Hebridean family, *na Ladgmann*, Four Masters, 960.

11. *Oduind*, Cogadh Gaidhil, ch. 36. Old Norse *Auðunn*. The form *Eodond* occurs in ch. 46.

12. *Roalt* (Four Masters, 924), *Roilt* (Chronicon Scotorum, 925). Old Norse *Hróaldr*. This is not certain, for the Innisfallen Annals[2] have in the same entry *Arolt* (= *Haraldr*), fol. 17^a, 1, l. 27.

13. *Roduilbh* (Three Fragments, 860). Old Norse **Hróðúlfr*, *Hrólfr*. The shorter form also occurs; *e.g.*, *Roailbh* (Loch Cé, 1344), Aedh mac *Rouilb* (Annals of Ulster, 1342, fol. 76^a, 1, l. 18). Piliḃ mac *Rouilbh* (Annals of Ulster, 1362, fol. 78^a, 1, l. 1). *Roolbh* mac Mhathgamna (Annals of Ulster, 1310).[3]

14. *Rodlaibh* (Three Fragments, 863), *Rothlaibh*, (Four Masters, 860), Old Norse *Hrolleifr* (= *Hroðleifr). It should however be noticed that the Three Fragments in the 860 entry have *Roduibh̄* (= *Hróðúlfr*).

15. *Snuatgaire* (Cogadh Gaidhil, ch. 36), *Snadgair* (ib. ch. 94). Dr. Stokes takes this for *Nadd* + *geirr*, treating it as a different name from *Suartgair*, though it is possibly only an error

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[1] Symeonis Hist. Dunelm. Ecclesiae, p. 127, "Dolfini filii Torfini." (ed. Arnold, Rolls Series 75, vol. I.).

[2] Rawl. B. 503.

[3] In MacCarthy's edition; the leaf is lost from the Bodleian MS.

for that form, since corresponding to *Snadgair* in ch. 94 of Cogadh Gaidhil, the Annals of Ulster, 1014 (fol. 36^b 2, l. 19), has *Snartgair* and Loch Cé, 1014, *Suairtghair*. This would be *Svartgeirr* in Norse.

16. *Suainin*, genitive, (Cogadh Gaidhil, ch. 36, 117), *Suanin* nominative, (ch. 94), may be for *Sveinn*. The nominative form is not in accordance with the usual sound-changes from Norse to Irish; but the name occurs in a form resembling it in a Latin chronicle,[1] which has "*Suani* regis Danorum filii Haroldus, Canutus," &c., where other annals (*e.g.*, Ann. Cambr.) have *Sveyn* or *Svein*.

17. *Suimin*, genitive, (Cogadh Gaidhil, ch. 117), *Suimin*, (ch. 36), *Sunin* nominative, (ch. 94). Dr. Stokes only quotes the first two forms, and equates with Norse *Svín-inn*, the swine. He does not notice that in both these cases the word is in the genitive, and that the only nominative form given could not possibly represent *Svin-inn*.

18. *Toirbeardaigh*, (Cogadh Gaidhil, ch. 36), is given by Dr. Stokes as perhaps for Norse *Þórvarðr* with a Gaelic suffix. The simple form *Þórvarðr*, which he does not give, occurs in Loch Ce, 1210, 1211, *Toirberd* mac Gall Ghoeidil.

19. *Tomrair* Erell (Annals of Ulster, 847, etc.). Dr. Stokes derives from *Þórir*, *Þóreirr*, *Þórgeirr*; the first is probably right. He also gives *Tamar*, *Tomar* = *Þórr*, from * *Þonar*, a view which is shared by Steenstrup.[2] There is no need to differentiate here, as the shorter form is probably a scribal error. *Þorr* never occurs in Norse as a man's name; and in almost all cases where the shorter form occurs in Irish, other sources give the longer. So for *Tomar* (Dublin MS. of the Innisfallen Annals, 848), Annals of Ulster, 847 (fol. 23^b, 1, l. 28) and Chronicon Scotorum, 848, have *Tomair*: for *Tamrar* mac Elgi (Cogadh Gaidhil, ch. 33), the Bodleian Innisfallen Annals (fol. 10^b 1, l. 32) have *Tomrair* mac Elgi; in Cogadh Gaidhil, ch. 23, where the Dublin MS. has *Tomar*, the Book of Leinster has

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[1] Sym. Dunelm. Historia Regum, 1000.

[2] *Normannerne* (Kobenhavn, 1870-82) II. 301.

Tomrair; and corresponding to *Tomur* in Cogadh Gaidhil, ch. 24, the Three Fragments, 869, have *Tomrar*, *Tomrair*, *Tomrur*.

20. *Torbend* (Cogadh Gaidhil, ch. 94), Torfind (Annals of Ulster, 1124), Old Norse *þorfinnr*. Another form, *Toirfhinn*, occurs in Loch Cé, 1124. The forms *Finntuir*, *Finntair*, of the Annals of Ulster and Loch Cé, 1054, also belong here.

21. *Torchar*. Old Norse *þorgeirr*. The name is found in a form more like the original in the Bodleian MS. of the Innisfallen Annals, 1172, Mac *Torgair* (fol. 38^{b}, 1, l. 14).

22. *Torstan* mac Eric (Annals of Ulster and Four Masters, 1103). Old Norse *þorsteinn* (Eiríksson). Loch Cé, 1103, gives another form, *Trosdán* mac Erec.

The other Norse names[1] which occur in the Irish annals are: *Accolbh* (Four Masters, 928) and *Scolph* (Cogadh Gaidhil, ch 23). (=Áskólfr); *Agond*. *Hacond* (=Hákon); *Albdan*, *Alpthann*, *Albdean*, *Albann*, *Alband* (=Hálfdanr); *Amhlaim*, in very many forms (=Óláfr); *Amond* (=Hámundr); *Aralt* (=Haraldr); *Baethbarr*, *Badbarr* (=Böðvarr); *Barith*, *Baraid*[2] (=Bárðr or Bárði); *Blacair*, *Blacaire* (=Blakári); *Cnutt* (=Knútr); *Elair* (perhaps=Haldórr); *Eoan*,[3] Eoin, Eon (=Jón); *Eric*, *Erec*, *Ericc* (=Eiríkr); *Eruilbh*, *Erolbh* (=Herjólfr); *Ettla* (perhaps=Atli); *Fulf*. *Ulf*, *Ulbh*, *Hulb*, *Olbh* (=Úlfr); *Goffraidh*, *Gothbraith*, *Gothfrith*, *Gobhfraigh*,[4] etc. (=*Guðfriðr, Guðröðr); *Graggabai* (=Krakabeinn); *Heimar* (=Einarr); *Herling*[5] (=Erlingr); *Hingamund* (=Ingimundr); *Hona* (perhaps = Án, Áni); *Horm* (=Ormr); *Iargna* (perhaps=Járnkné?); *Illulb* (perhaps=*Íllúlfr); *Imar*, *Iomar*, *Imhar*, etc. (=Ívarr); *Loduir*, *Lotair*, *Luadar*, etc. (=Hlöðver); *Magnus*, *Manus*, *Maghnus*, etc., (=Mag-

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[1] For details see Bezzenberger's Beiträge, xviii., 121-3.

[2] Rawl B. 489, fol. 26^{b}, 1, l. 7.

[3] Rawl. B. 488, fol. 25^{b}, 1, ll. 40, 41.

[4] Rawl. B. 488, fol. 19^{b}, 2, l. 10.

[5] Book of Leinster, fol. 172^{a}, 18.

núss); *Odolbh* (= Auðólfr); *Oistin* (= Eysteinn); *Oitir,*[1] *Oittir*, *Ottir*, *Otir*, etc. (= Óttarr); *Ragnall*, *Raghnall*, *Radnaill*[2] (= *Ragnvaldr, Rögnvaldr); *Raghnailt* (= female name, Ragnhild); *Ruamand*, *Ruadhmand* (= Hrómundr, *Hróðmundr); *Saxulb*, *Saxolbh* (= *Saxúlfr, Söxólfr); *Sicfrith*, *Sichfrit*, *Sichfraidh*, *Siugrad*, *Sighrud*, etc. (= *Sigfriðr, Sigurðr); *Sigmall* (= *Sigvaldr); *Simond* (= Sigmundr); *Sitriuc*, *Sitriug*, *Sitricc*, etc. (= Sigtryggr); *Somarlid*, *Somhairlidh*, *Somairligh*, *Somhairle*, etc. (= Sumarliði); *Stain*, *Zain*, *Sdain*,[3] (= Steinn); *Tomralt* (= þorvaldr); *Torgeis*, *Turges* (perhaps = þorgils); *Torolb*, *Torolbh* (= þórólfr); *Turcaill*,[4] *Torcaill*, *Turgaill* (= þorkell).

Other names given as Norse which cannot be satisfactorily equated are: *Anrath; Goistilin; Grisin* or *Grisine*; *Infuit; Laraic; Muraill* or *Smurall*; *Milid Bun* (perhaps = Búi?); *Lummin; Oiberd* (Dr. Stokes thinks = Óbjarto, "beardless," or Hróbjarðr; it might represent Eyvindr); *Onphile; Ota; Plait; Staball; Sortadbud.*

More significant than the actual number of Norse names in Irish sources is the persistence and increasing frequency with which they recur among Irish families in the later annals; for that reason, I have gone more fully into them than into the Irish names in the Sagas. A Celtic name in Iceland rarely survived more than a generation or two; the exceptions, Njáll and Kormakr, are peculiar, as having been adopted very early (see above). In Ireland, the case is quite different. At first rarely, but with increasing frequency, Norse names occur in Irish families. The first case, if the usual reading of the passage is taken, is not till 1031

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[1] Rawl. B. 488, fol. 23^a, 1, l. 31.

[2] Ib., fol. 16^b, 2.

[3] Ib., 16^b, 2, l. 53.

[4] Ib., fol. 24^a, 2, l. 21; 23^a, 1, ll. 12 13, 31.

(Annals of Tigernach,[1] = Loch Cé, 1036), where the son, Flaithbertach, of a *Trostan* (= Þorsteinn) mac Murcertaigh of the Ui Neill is mentioned. In 1034 and 1037 of the same annals, we find a *Sitriuc* (= Sigtryggr) hUi Flandacan of the Ui Mane; in 1049 (Annals of Ulster), Imhar (= Ívarr) hUa Beice; in 1087 (Annals of Tigernach), Sitric (= Sigtryggr) mac Consleibe hUi Fergail; in 1101 (Annals of Ulster), Sitriuc hUa Maelfabhaill king of Carraic Brachaide, and (Innisfallen Annals) Amlaib mac Echach; 1103 (Annals of Ulster), Raghnaill Ua Ocain, lawgiver of Telach-óg. From this time, the beginning of the 12th century, Norse names become more and more frequent, Ragnall, Amlaib, Goffraidh, Magnus and Imar, occurring on nearly every page of the annals. From 1180 to the end of the Annals of Ulster (200 years), the Ui Conchobuir (= O'Conor) were never without a Magnus or Mac Magnusa. During the same period, the chief of Muintir Eolais was always a Raghnall or Mac Raghnaill, and Mac Raghnaill became the surname of the family. Among the Ui Raghaillaigh (= O'Reilly), Goffraidh and Maghnus are frequent; the female name Raghnailt also occurs. Of the Ui Ruairc (= O'Rourke), we find as chieftains Amlaib in 1184, 1228, 1248, 1259 (Four Masters), and 1271 (Annals of Ulster); Sitriuc in 1165 (Annals of Ulster); Maghnus, 1380 (Four Masters). Among the Ui Cathain (O'Kane), Goffraidh, Maghnus and Raghnall are frequent, the two latter as late as the 16th century. These and one or two other Norse names are also common among the Ui Domnaill (= O'Donnell), Ui Gailmredaigh, Ui Fergail, Ui hEochadha, and other families. Somhairlidh is found especially among the Mac Domhnaill (M'Donnell). Colla and Eoan or Eoin might of course be either Scandinavian or Gaelic; in some cases at least, as when they occur

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[1] Rawl. B. 488, fol. 16^b, 2, l. 22.

among the Mac Domhnaill of the Isles, they are probably Scandinavian. The very name by which the Irish called the invaders, Lochlann, was taken by the Irish themselves as a personal name, and Ua Lochlainn (O'Loughlin) became the name of a great family.

We find, therefore, no instance of a Norse name in an Irish family until 17 years after the Battle of Clontarf had settled once for all the relations between the Irish and the settlers; and they do not become common until 80 or 90 years after that event. We find the sons of Norse fathers bearing Gaelic names 40 or 50 years before Clontarf, but these names are of the character of nicknames, such as Gluniaraind (Iron-knee), Cuallaid (Wild Dog), Dubcend (Black-head), and would be given to them by their Irish opponents. They are, of course, only found in Irish sources. The only exception is Niall hua hEruilb (Annals of Ulster, 957, Four Masters, 956); and as we have seen, the name Njáll was at this time already naturalised in Norway. We are surely justified in concluding from this that real mixture between the two races in Ireland did not become general until the beginning of the 12th century, 200 years after the settlement of Iceland was completed. This tells against the theory that the early raiders who spent a short time in the islands and then passed on to settle further west, obtained even a fair knowledge of the Gaelic speech. Both probability and evidence are against the idea. It is not likely that those Norsemen who only stopped at the islands to plunder, on their way to found new homes in Iceland, found either time or opportunity to study the speech of the natives; as a rule they did not even trouble to learn the names of the thralls they took, but renamed them; these thralls, too, quickly died off in Iceland, or rebelled and were killed. When it was necessary that the two races should understand each other, that which for the time was the weaker had probably to give way, and learn to understand the speech of the stronger. Those who settled permanently in the isles did, of course, speak Gaelic, but this very fact makes it all the less probable that a knowledge of Gaelic would reach Iceland, for Icelanders who visited Ireland in their journeys east mixed chiefly with those who spoke their own tongue[1], and if they had any intercourse with Gaels, would hardly trouble to learn a new language when they had interpreters in plenty. The sagas give us two instances only of Icelanders or Norwegians who spoke Irish when they visited Ireland; one of these, an Icelander, Óláfr Pá,[2] had been taught the language in secret by his Irish mother; the other,[3] a Norseman, acted as interpreter for the hostages left by Magnus Berfættr with Myrkjartan, King of Connaught, but his knowledge of the language can hardly have been extensive, since when he tried to make a complimentary speech to the king, the result was, to the indignation of the court, a curse (written down phonetically by the saga-writer).

The relative number of loan words in the two languages confirms these suppositions. Some 200 words[4] of probable Norse origin occur in Gaelic. A few of these appear sporadically in references to the Norsemen, nicknames, or quotations; by far the greater number are still living words in Gaelic, many having derivatives with Gaelic suffixes. About twenty might phonetically as well come from Anglo-Saxon forms, but in most of these the

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[1] Cf. *Njáls Saga*, ch. 85, f., 152, f., *Eyrbyggja*. ch. 29, 64. *Gunnlaugs Saga Ormstungu*, ch. 8.

[2] *Laxdæla Saga.*

[3] *Biskupa Sögur* I., 227.

[4] *Arkiv för nordisk Filologi*, vol. X., 149-166.

phonetic reasons for a Norse or English origin are equal, and history is in favour of Norse.

In Icelandic prose, omitting the two corrupt phrases quoted in *Biskupa Sögur*, there are six words which are almost certainly Gaelic: *bjanak* (Ir. bendacht, blessing); *erg*, a shieling (Irish airghe); *gelt*, men mad with fear (Irish *geilt*); *ingian* (Irish ingen, ingean, girl); *kvaran*, in the name of a King of Dublin, Óláf Kvaran (Irish cuarán); and *minnþak*,[1] a mixture of flour and butter made by Hjörleif's Irish thralls (Irish mín, flour). With one exception, these occur only once or twice, generally in connection with Gaels. The exception is *gelt*[2], first identified by Dr. Meyer[3] with Irish *geilt*, men who go mad with fear in a fight. It is apparently the same word as *gjalti*, in the phrase "verða at gjalti," which occurs several times, and seems to be a familiar expression. This form used to be regarded as connected with *göltr*, a hog, and is so given as "an old dative" in the Oxford Dictionary; but this it could not be, since the root vowel of *göltr* is *a*, and the *ja* of *gjalti* could only come from an original *e*. A few other words are sometimes claimed as Gaelic loans, but *brók*, *brækr*, (old Irish *bróc*, shoe); *kesja* (Irish *ceis*, a spear); *des* (Irish *dais*, heap), may have been borrowed by the Irish from Norse.

It will be seen that all the evidence is negative. We expect to find Gaelic names in Iceland; we do not find them. We expect to find Gaelic loan-words in Iceland; we do not find them. On the other hand, Norse words are fairly plentiful in Gaelic; while Norse personal names survive even to the present day in Irish and Scottish surnames. The Norsemen have left traces in Ireland; there is no trace in Iceland of a strong Irish influence.

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[1] *Zeitschrift für Keltische Philologie*, I., p. 442. *Papar* seems to be Latin, and *kúði* has never been equated.

[2] *Speculum Regale*, ed. Brenner, 1881.

[3] *Folklore*, V. p. 312.

Manchester Memoirs, Vol. xliv. (1899), *No.* **3**.

III. Correction in the Wilde Lecture of 1897, "On the Nature of the Röntgen Rays."

Sir George Stokes writes :—

> "I must apologise to the Society for having overlooked an error of pure inadvertence which unfortunately is of such a nature as to puzzle the reader, as there is nothing to suggest that it is a mere slip. In p. 18, l. 17,* the word 'cathode' should have been 'target.'"

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* *Manchester Memoirs*, Vol. xli. (1897), No. 15.

February 23rd, 1900.

Manchester Memoirs, Vol. xliv. (1899), *No.* **4.**

IV. Report on the Mollusca of the "Jackson-Harmsworth" Expedition to Franz-Josef Land (1896-97), and of the "Andrew Coats" Cruise (1898) to Kolguev, etc.

By JAMES COSMO MELVILL, M.A., F.L.S.,

AND

ROBERT STANDEN,

Assistant Keeper, Manchester Museum.

Received and read November 28th, 1899.

We are indebted to Mr. W. S. Bruce, the naturalist attached to these two important Arctic expeditions, so successful in their scientific results, for the opportunity of examining and reporting on the large mass of molluscan material obtained, mostly by dredging, and in case of the first, at all events, rendered especially interesting by having been found at a more northerly latitude than any previously reported. These Mollusca were exceedingly carefully collected, and are now catalogued by us under the respective heads of

(1) From Franz-Josef Land (Lat. 80°—82° N.).

(2) „ Kolguev. (Lat. 69°—78° N.).

As might be expected, there is hardly anything of actual novelty. So much attention has, during the last half of this nineteenth century, been paid to the natural productions of the polar circle, that it is hardly likely further researches will add much to the list, for, of course, the nearer the actual pole is attained, the less will life flourish.

With such works of reference before us as those especially, of G. O. Sars, A. Th. von. Middendorf, Hermann Friele, and the more recently published 'Conspectus' of

H. J. Posselt*—the arrangement of whose nomenclature we are now following—malacologists are well supplied with literature of Arctic mollusca, and we feel there is but little to be said with regard to Mr. Bruce's specimens besides giving a mere catalogue, with exact localities.

Mr. Walter Wellman has lately returned home (in August, 1899), having completed the survey of the more northerly parts of Franz-Josef Land, and giving the finishing touches to the work of the Jackson-Harmsworth Expedition, but we have yet to learn if any mollusca were collected.

A large proportion of the specimens are preserved in formalin, a medium of which we are sorry to be obliged to speak unfavourably as regards the calcareous covering, —however valuable for the preservation of anatomical parts—the shells being so frequently rendered fragile, and much deterioration occurring owing to its corrosive action on the carbonate of lime.

Our best thanks are due to Dr. Hermann Friele, of Bergen, and to Mr. Edgar Smith, of the British Museum (Natural History), who have both aided us with advice and examination of specimens.

We may add that a few *Nudibranchiata* were in the collection, and also two or three *Pteropoda* and *Heteropoda*, but these are not dealt with in the present paper.

CATALOGUE OF SPECIES.

I. FRANZ-JOSEF LAND.

BRACHIOPODA.

Rhynchonella psittacea (Gmel.).

Hab. Off Cape Mary Harmsworth, 53—93 fathoms.

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* Conspectus Faunae Grœnlandicae (Grönlands Brachiopoder og Bloddyr af Henr. J. Posselt, 1898, Kjobenhavn, 1898).

PELECYPODA.

Pecten grœnlandicus (Sow.).

Hab. Cape Flora, 8 fathoms. Off Cape Gertrude, 30 fathoms. Near Wilczek Land, 127 fathoms. Off glacier between Cape Flora and Cape Gertrude, 30 fathoms.

Limatula subauriculata (Mont.).

Hab. Dredged, Lat. 77°55′ N., Long. 53°20′ E., 130 fathoms.

Crenella decussata (Mont.).

Hab. Off Flora Cottage, one mile out, 15 fathoms.

Crenella discors (L.).

Hab. Off West glacier, 1 to 3 fathoms.

Modiolaria lævigata (Gray).

Hab. Cape Flora, on shore, and dredged 8 fathoms. Günther Sound, 10 fathoms. Beach at North end of Windy Gully, Günther Sound. Off Flora Cottage, about one mile out, 15 fathoms. Off West Bay, Cape Flora, 8 fathoms. Off Cape Gertrude, 30 fathoms. Off East glacier, Cape Flora, 1—30 fathoms. South-west of Elmwood, 18 fathoms. Off Cape Mary Harmsworth, 53—93 fathoms. Off West Point, Cape Flora, 2—5 fathoms. The examples obtained were unusually fine, and in some localities abundant.

Modiolaria nigra (Gray).

Hab. Off Cape Gertrude, three-quarters of a mile from east end, 12—30 fathoms. Off glacier between Capes Flora and Gertrude, 30 fathoms. From walrus' stomachs, Miers Channel. Cape Flora, 8 fathoms. Günther Sound, 10 fathoms.

Portlandia frigida (Torell).

Hab Lat. 77°55′ N., Long 53°20′ E.

Portlandia lucida (Lov.).

Hab. Lat. 77°55′ N., Long. 53°20′ E., 130 fathoms.

Leda pernula (Müll.).

Walrus' stomachs, Miers Channel.

Cardium (Serripes) grœnlandicum (Chem.).

Hab. North end of Windy Gully, Günther Sound.

Cardium (Cerastoderma) islandicum (L.).

Trawled, 75 fathoms.

Astarte banksi (Leach).

Hab. Günther Sound, 10 fathoms. Off West glacier, Cape Flora, 1—3 fathoms.

Astarte borealis (Chem.).

Hab. Beach, north end of Windy Gully, Günther Sound. Shore of west end of Cape Günther. Near Wilczek Land, 127 fathoms.

Astarte compressa (Mont.).

Hab. Off Elmwood, two-thirds of a mile to the south-west, 18 fathoms. Lat. 77°55′ N., Long. 55°25′ E., 115 fathoms.

Astarte crenata (Gray).

Hab. Lat. 77°55′ N., Long. 53°20′ E., 130 fathoms. From walrus' stomachs, Miers Channel.

var. *subaequilatera* (Sow).

Dredged, 140 fathoms.

Astarte elliptica (Brown).

Dredged, 60 fathoms.

Astarte fabula (Roe.) var. *Warhami* Hancock.

Hab. Günther Sound, 10 fathoms. Dredged, 60—140 fathoms.

Astarte semisulcata (Leach).

Hab. Shore of Shell Gully, west end of Cape Gertrude. Günther Sound, 10 fathoms.

var. *Withami* Wood.

Off Cape Gertrude, east end, 12 fathoms.

Astarte sulcata (Da Costa).

Beach, north end of Windy Gully, Günther Sound.

Cryptodon sericatus (Carp.).

Hab. Off East glacier, Cape Flora, 4 fathoms, one living specimen. Günther Sound, 10 fathoms, dead.

Venus fluctuosa (Gould).

Hab. Günther Sound, 10 fathoms. Off West glacier, Cape Flora, 1—3 fathoms. Abundant.

Macoma calcaria (Chem.).

Dredged, 60 fathoms.

Thracia papyracea (Poli.) var. *villosiuscula* (Macg.).

Hab. One and a half mile south-west of Elmwood, 26 fathoms.

Thracia, sp.

Hab. Wilczek Land, 127 fathoms.

A right and left valve of a *Thracia* which does not seem exactly analogous to any known species and which is probably new to science, but the very imperfect condition of the valves decided us to defer description for a possible future opportunity.

Pandora glacialis (Leach).

Hab. Off Cape Gertrude, 12 fathoms. Off West glacier, Cape Flora, 1—3 fathoms. Günther Sound, 10 fathoms.

Saxicava arctica (L.).

Hab. Off Elmwood, 18 fathoms. From isolated beach of most westerly rocks south of Mabel Island. From beach at north end of Windy Gully, Günther Sound. Off Flora Cottage, about one mile out, 15 fathoms. From walrus' stomach, Miers Channel. Off Cape Mary Harmsworth, 53—93 fathoms. Off West Point, Cape Flora, 2—6 fathoms. Cape Gertrude, 30 fathoms. Günther Sound, 10 fathoms. Off East glacier, Cape Flora, 30 fathoms.

Some specimens are unusually large, and the species is generally abundant.

Mya truncata (L.).

Hab. Near East glacier, Cape Flora, 4—30 fathoms, also from floe in West Bay. From isolated beach of most westerly rocks South of Mabel Island. Off Cape Gertrude, 12 fathoms. Günther Sound, 10 fathoms, and from beach at north end of Windy Gully. From walrus' stomachs, Miers Channel (siphons only).

Very abundant. All the examples obtained are small sized, and the majority are excessively truncate, agreeing exactly with var. *uddevalensis* Forbes.

SCAPHOPODA.

Siphonodentalium vitreum (M. Sars.).

Trawled, 100 fathoms.

PLACOPHORA.

Chiton (*Lepidopleurus*) sp.

Dredged, 140 fathoms.

We have not been able to identify this, but it seems near to *C. alveolus* (Sars.). The sculpture, however, in our shell forms lines which do not occur in *alveolus*. It also recalls *C. fuliginatus* (Ad. and Roe.).

Chiton (*Boreochiton*) *marmoreus* (Fab.).

Hab. Off Cape Cortin, three miles,

Chiton (*Lophyrus*) *albus* (L.).

Dredged, 60 fathoms.

GASTROPODA.

Lepeta cæca (Müll.).

Trawled, 75 fathoms.

Puncturella noachina (L.).

Hab. Off Cape Mary Harmsworth, 53—93 fathoms.

Mölleria costulata (Möller.).

Hab. Cape Gertrude, 30 fathoms.

Margarita cinerea (Couth.).

Hab. Off West Glacier, Cape Flora, 1—6 fathoms. Günther Sound, 10 fathoms. Off Flora Cottage, about one mile out, 15 fathoms.

Margarita elegantissima (Bean.).

Trawled, 75 fathoms.

Margarita grœnlandica (Chem.).

Hab. Günther Sound. 10 fathoms. Off West Bay, Cape Flora, 8 fathoms.

Margarita helicina (Phipps).

Hab. Off Elmwood, near West Point, 2—3 fathoms. Off Flora Cottage, about one mile out, 15 fathoms. Off East glacier, Cape Flora, 1—4 fathoms. In dredgings from Flagstaff Point to one mile west, 2—10 fathoms. Günther Sound, 10 fathoms. Near Wilczek Land, 127 fathoms.

Margarita umbilicalis (Brod. and Sow).

Hab. Cape Flora, from floe in West Bay, and dredged in 8 fathoms. Beach at north end of Windy Gully Günther Sound. Off Elmwood, 2—3 fathoms. Off East glacier, Cape Flora, 30 fathoms. Dredged, West Bay, 2—10 fathoms. Günther Sound, 10 fathoms. Near West Point, 2—3 fathoms. Occurred in great profusion. Posselt considers this species a mere variety of *M. grœnlandica* Chem., but we are inclined to keep them distinct, both being well marked forms.

Velutina lanigera (Möller).

Hab. Günther Sound, 10 fathoms. Cape Gertrude, 30 fathoms.

Velutina lævigata (Pennant).

Hab. Off East glacier, Cape Flora, 30 fathoms.

Natica affinis (Gmel.).

Hab. Off Cape Gertrude, 12 fathoms.

var. *septentrionalis* (Beck.),

Some very large examples of this variety occurred with the type.

Bela schantarica (Midd.).

Hab. Off West glacier, Cape Flora, 1—3 fathoms.

Bela turricula (Mont.).

Trophon clathratus (L.).

Hab. Top of Cape Flora rocks, about 1,100 fathoms (D. W. Wilton). Off East glacier, Cape Flora, about 30 fathoms.

Trophon lamellosus (Gray).

Hab. Off East glacier, Cape Flora, 30 fathoms.

Sipho (*Siphonorbis*) *lachesis* (Mörch).

Trawled, 100 fathoms.

Sipho gracilis (Cost.).

Trawled, 100 fathoms.

Sipho togatus (Mörch).

Trawled, 100 fathoms. A number of living specimens were obtained, all of which were covered with *Actiniæ*, which had preserved the epidermis from the usual wear. We have submitted a specimen to Dr. Hermann Friele, who says, " It is a fine specimen of my *Sipho curta* (Norw. N. Atl. Exped., 1876-78, p. 17, pl. ii., figs. 1—6). It is the *Fusus togatus* of Mörch, and *F. Sabini* (Jeffreys). It may be that I err in judging this form to be the North American *Fusus curtus* (Jeff.), but I am not at all convinced that I have made a mistake. I have seen a great number of specimens, and there is no doubt that both forms run into each other."—*H. Friele in litt.*

Sipho islandicus (Chem.).

Trawled, 75 fathoms.

Neptunea despecta (L.).

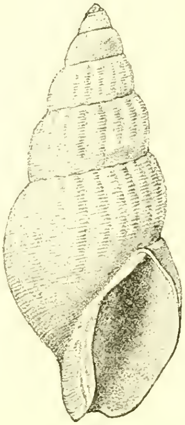
Hab. North end of Windy Gully, Günther Sound. Trawled, 75 fathoms.

var. *carinata* (Lam.).

Many examples, mostly dead, and covered with *Balani*, exhibiting every gradation between typical *despecta*, and the forms *fornicata* (Fab.) and *carinata* (Lam.).

Buccinum glaciale L.

Hab. North end of Windy Gully, Günther Sound, 10 fathoms. Off Flagstaff, Cape Flora, 5 fathoms. From walrus' stomachs, Miers Channel, foot soles and opercula only. Trawled, off Cape Mary Harmsworth, 75 fathoms.



Buccinum brucei, sp. nov.

B. testa attenuata, oblongo-fusiformi, tenui, cinereo-albescente, epidermide olivacea, contecta, apice in typo corroso, anfractibus verisimiliter octo, quorum quinque inferis apud suturas impressis, ventricosulis, longitudinaliter undato-

plicatis, plicis irregularibus et infra evanidis ad basim anfractus penultimi et ultimi, undique spiraliter arctissime et pulcherrime striatis, ultimo producto, cæteros longitudinine magnopere exæquante, apertura parva, ovata, intus albocarnea, labro extus paullum expanso, columella recta, nitida albocarnea, canali brevi.

Long. 41 mm., lat. 18 mm.

Hab. North end of Windy Gully, Günther Sound, Franz-Josef Land.

This interesting shell, which we have much pleasure in dedicating to its discoverer, may be known by its narrow form, close-set whorls, and small aperture. It occupies the same position in its genus that *Sipho lachesis* (Mörch) bears in Sipho, and does not appear to be nearly allied to any other of the genus, arctic or otherwise.

Buccinum grœnlandicum (Chem.).

Hab. North end of Windy Gully, Günther Sound. Dredged between Elmwood and East glacier, 5 fathoms.

var. *tenebrosa* (Hancock).

Off Elmwood, near West Point, 2—3 fathoms.
Off Flagstaff, Cape Flora, about 5 fathoms.

Buccinum hydrophanum (Hancock).

Hab. East of Elmwood, on floe, and dredged off West Point, 2—3 fathoms. Trawled, 76 fathoms, alive.

Buccinum tenue (Gray) = *B. scalariforme* (Beck).

Trawled, 75 fathoms.

Buccinum Totteni (Stimp) = *B. ciliatum* (Gld.).

Hab. North end of Windy Gully, Günther Sound, dead.

Buccinum undatum (L.).

Hab. North end of Windy Gully, Günther Sound, dead.

Homalogyra atomus (Phil.).

Hab. Cape Gertrude, 30 fathoms.

Rissoa (*Cingula*) *castanea* (Möller).

Hab. Günther Sound, 10 fathoms.

Parthenia eximia (Jeff.).

Hab. Günther Island, 10 fathoms.

Lacuna vincta (Mont.), var.

Hab. Off Elmwood, West Point, 2—3 fathoms. Günther Sound, 10 fathoms.

Amphisphyra hyalina (Turton).

Hab. Off West Point, 2—3 fathoms, alive and dead. Off West glacier, 1—3 fathoms, and West Bay, Cape Flora, 8 fathoms, alive.

Cylichna alba (Brown) = *Bulla nucleola* (Rve.) var. *corticata* (G.O. Sars.).

Hab. Off East glacier, 4 fathoms. Off West glacier, Cape Flora, 1—3 fathoms. Bay west of Flagstaff, Cape Flora, 5 fathoms. Off Elmwood.

Bulla semilævis (Seguin).

Hab. Bay west of Flagstaff, Cape Flora, 5 fathoms.

Philene lima (Brown).

Hab. Cape Gertrude, 30 fathoms. Trawled, 75 fathoms.

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2. KOLGUEV.

Through the kindness of Mr. Andrew Coats, of Paisley—to whom science is indebted for much enthusiastic support—Mr. Bruce was enabled to accompany him on his yacht the "Blencathra" in an expedition to the Barents Sea, south of Alout, visiting Novaya Zemblia, the Wiche Islands, and Kolguev, and obtained from the latter place only the mollusca we now enumerate.

BRACHIOPODA.

Rhynchonella psittacea (Gmel.).

Dredged, 60 fathoms, alive.

PELECYPODA.

Pecten grœnlandicus (Sow.).

Trawled, 10 fathoms.

Pecten islandicus (Müll.).

Trawled, dead, off North Kolguev, and from 75 fathoms, alive. Dredged, alive, both adult and juvenile, from 60 fathoms.

Mytilus edulis (L.).

Trawled, alive, 75 fathoms. Shore of east coast, dead. Three miles off east coast, 5 fathoms, valves.

Modiolaria corrugata (Stimps).

Dredged, 60 fathoms, dead.

Modiolaria lævigata (Gray).

Trawled, 20 fathoms, alive.

Portlandia intermedia (M. Sars.).

Trawled, 76 fathoms, alive

Leda minuta (Müll.).

Dredged, 60 fathoms, alive.

Cardium (*Serripes*) *grœnlandicum* (Chem.).

Dredged, 60 fathoms, dead. Shore of east coast, and three miles further out in 5 fathoms. Trawled, alive, in 75 fathoms.

Astarte banksii (Leach).

Dredged, 60 fathoms.

Astarte borealis (Chem.).

Dredged, 60 fathoms, and 5 miles out, 17 fathoms, off west of Hope Island, alive.

Astarte crenata (Gray).

Trawled, 30—76 fathoms, and dredged, 60—140 fathoms, alive.

Tellina (*Macoma*) *calcaria* (Chem.).

Dredged, dead.

Pandora glacialis (Leach).

Three miles east of Kolguev, 5 fathoms.

Saxicava arctica (L.).

Dredged, 27—60 fathoms, alive and dead.

Mya truncata (L.).

On shore of east coast, and dredged, 60 fathoms.

GASTROPODA.

Acmæa testudinalis (Müll.).

Trawled, 20 fathoms, one specimen, dead.

Lepeta cæca (Müll.).

Dredged, 60 fathoms, one, alive.

Puncturella noachina (L.).

Dredged, 60 fathoms, one, alive.

Margarita grœnlandica (Chem.).

Dredged, 60 fathoms, alive.

Margarita (*Machæroplax*) *albula* (Gould).

Trawled, about 20 fathoms.

Natica (*Lunatia*) *nana* (Möller).

Dredged, 60 fathoms, one, alive.

Natica affinis (Gmel.).

Trawled. 12—30 fathoms. Shore of Kolguev, east coast. Off west coast, dead; and trawled, 75 fathoms, alive. Dredged, two miles off Kolguev, 7—8 fathoms, alive. Var. *septentrionalis* occurred with the type.

Bela pleurotomaria (Couth.).

Shore of Kolguev.

Bela turricula (Mont.).

Dredged, 60 fathoms.

Admete viridula (Fab.).

Dredged, 60 fathoms, alive.

Trophon clathratus (L.).

Dredged, 60 fathoms, one, dead.

Trophon fabricii (Beck.).

Sipho islandicus (Chem.).

Trawled, off north coast, 8—12 fathoms, dead; from 100—110 fathoms, alive.

Sipho (*Tritonofusus*) *kroyeri* (Möller).

Dredged, 60 fathoms.

Volutopsis norvegica (Chem.).

Dredged, off north coast, dead.

Neptunea despecta (L.).

Trawled, off north coast, dead. Shore of east coast.

Buccinum glaciale (L.). var.

Dredged, off east coast, 12 fathoms. (Three fine examples of this form, tenanted by *Pagurus*, were also dredged off the coast of Novaya Zemblia, in 20 fathoms).

Buccinum grœnlandicum (Chem.).

Trawled, 76 fathoms, alive. Off north coast, 30 fathoms, dead,

Buccinum tenue (Chem.).

Off east coast, 12 fathoms.

Buccinum undatum (L.).

Trawled, and on shore, east coast, dead.

Manchester Memoirs, Vol. xliv. (1899), *No.* **5.**

THE WILDE LECTURE.

V. The Mechanical Principles of Flight.

By the Rt. Hon. LORD RAYLEIGH, F.R.S.

Delivered February 13th, 1900.

The subject under discussion includes both natural and artificial flight. Although we are familiar with the flight of birds, there are many interesting questions which arise in connection with natural flight, and some of them are yet very obscure.

In still air a bird, being heavier than the fluid displaced, cannot maintain his level for more than a short time without working his wings. In this matter the vicarious principle holds good. If the bird is not to fall, something must fall instead of him, and this can only be air. The maintenance of the bird thus implies the perpetual formation of a downward current of air, and involves therefore performance of work. Later we shall consider more particularly how this work is applied ; but a preliminary difficulty remains to be discussed. It is well known that large birds, such as vultures and pelicans, are often observed to maintain their level for considerable periods of time, without flapping or visibly working their wings. On a smaller scale, and in more special situations, sea-gulls in these latitudes perform similar feats. This question of the soaring or sailing flight of birds has given rise to much difference of opinion. Few of the naturalists, to whom we owe the

April 26th, 1900.

observations, are familiar with mechanical principles, and thus statements are often put forward which amount to mechanical impossibilities. The arm-chair theorist at home, on the other hand, may be too willing to discredit reports of actual observations, especially when they are made in other parts of the world. On both sides it seems to be admitted that there is no sailing flight in the absence of wind; but observers, untrained in dynamics and misled by the analogy of the kite, are apt to suppose that the existence of wind at once removes the difficulty. The doctrine of relative motion shows however that, so long as there is no connection with the ground, a uniform horizontal wind is for this purpose the same thing as absolutely still air.

In a short paper upon this subject (*Nature*, vol. xxvii., p. 534, 1883) I pointed out that, "Whenever a bird pursues his course for some time without working his wings, we must conclude either (1) that the course is not horizontal, (2) that the wind is not horizontal, or (3) that the wind is not uniform. It is probable that the truth is usually represented by (1) or (2), but the question I wish to raise is whether the cause suggested by (3) may not sometimes come into operation." Case (1) is that of a rook gliding downwards from a tree in still air with motionless wings. We shall presently consider upon what conditions depend the time and distance of travel possible with a given descent. Case (2) is closely related to case (1). If the air have an upward velocity equal to that at which the rook falls through it in a vertical direction, the vertical motion is compensated, and the course of the rook relatively to the ground becomes horizontal. It is not necessary, of course, that the *whole* motion of the air be upwards; a horizontal motion of the air is simply superposed. A bird gliding into a wind having a small upward component may thus maintain relatively to the ground an absolutely fixed position, or he may advance over the ground to windward at a fixed level.

There can be no doubt that the vertical component of wind plays a large part, not merely in the flight of birds, but in general atmospheric phenomena. Living at the bottom of the atmospheric ocean, where the wind is necessarily parallel to the ground, we are liable to overlook the importance of vertical motions. This is the more remarkable when we consider that wind is due to atmospheric expansion and condensation, so that the primary movements are vertical and not horizontal. Thus the inhabitants of an oceanic island are specially interested in the so called land and sea breezes, but the primary phenomenon is the rise and fall of air over the island as it is heated by the sun during the day and cooled by radiation at night.

A recent American observer (Huffaker, *Smithsonian Report* for 1897) has recorded many examples of vultures soaring under circumstances which suggested that they take advantage of the upward currents which rise locally from the ground when it is strongly heated by the sun. On dull days and in light winds the vultures were not seen to soar. There is no doubt that under the influence of a strong sun the layers of air near the ground approach an unstable condition, and that comparatively slight causes may determine local upward currents. Mr. Huffaker suggests that in some cases the birds themselves, by flying round, may determine the upward current. Some of his observations certainly point in this direction ; but it must be remembered that the immediate effect of flight will be a downward and not an upward current.

The more obvious examples of upward motion occur when an otherwise horizontal wind meets an obstruction.

Some years ago I visited the north side of Madeira, where cliffs, nearly 2,000 feet high, rise perpendicularly from the sea. Being on the top of the cliff, we had difficulty in finding a sheltered spot until we noticed that *close to the edge* there was almost complete calm. Lying upon the ground and moving only one's arms, it was possible to hold a handkerchief by the corner so that a little behind the plane of the cliff it hung downwards as in still air, and a little in front of the cliff was carried upwards in the vertically rising stream. A ball of crumpled paper thrown outwards was carried up high over our heads. Of course gulls and other birds found no difficulty in rising up the face of the cliff without working their wings. During a recent visit to India, I frequently watched the effect of similar upward currents deflected by rocky fortresses which rise from the plains. Kites could be seen to maintain themselves for minutes together without a single flap of the wings. When this occurred, the birds were sailing to and fro over the *windward* side of the rock.

We now turn to the consideration of case (3).

"In a uniform wind the available energy at the disposal of the bird depends upon his velocity *relatively* to the air about him. With only a moderate waste this energy can at any moment be applied to gain elevation, the gain of elevation being proportional to the loss of relative velocity squared. It will be convenient for the moment to ignore the waste referred to, and to suppose that the whole energy available remains constant, so that however the bird may ascend or descend, the relative velocity is that due to a fall from a certain level to the actual position, the certain level being of course that to which the bird might just rise by the complete sacrifice of relative velocity."

In illustration of case (3) I instanced a wind blowing everywhere horizontally but with a velocity increasing upwards, taking for the sake of simplicity the imaginary case of a wind uniform above and below a certain plane where the velocity changes. Since a uniform motion has no effect, we may suppose without further loss of generality, that the velocities of the wind above and below the plane are $+u$ and $-u$. Let us consider how a bird, sailing somewhat above the plane of separation and endowed with an initial relative velocity v, might take advantage of the position in which he finds himself.

The first step is, if necessary, to turn round until the relative motion is down wind (in the upper stratum) and then to drop through the plane of separation. In falling down to the level of the plane there is a gain of relative velocity, but this of no significance for the present purpose, as it is purchased by the loss of elevation; but in passing through the plane there is a really effective gain. In entering the lower stratum the actual velocity is indeed unaltered, but the velocity relatively to the surrounding air (moving in the opposite direction) is *increased.*

If h denote the height above the plane of separation to which the initial relative velocity v is due, we have $v^2 = 2gh$. Here v is the velocity, relatively to the air in the upper stratum, with which the bird crosses the plane. After crossing, the velocity, now reckoned relatively to the air in the lower stratum, becomes $v + 2u$, and the new value of h is given by

$$2gh' = (v + 2u)^2,$$

so that

$$2g(h' - h) = 4uv + 4u^2 = 4u(u + v).$$

Here $(h' - h)$ is the gain of potential elevation and, if u is given, it increases as v increases.

At this stage the bird is moving against the direction of the wind in the lower stratum. He next turns round—

it is supposed without loss of relative velocity—until his direction is reversed so as to be with the wind of the lower stratum and contrary to the wind of the upper stratum. A passage upwards through the plane now secures another gain of relative velocity, or of potential elevation, of nearly the same value as before. The process may be repeated. At every passage through the plane (whether in the upwards or in the downwards direction) there is a gain of potential elevation, and if this gain outweighs the losses all the while in progress, the bird may maintain or improve his position without doing a stroke of work.

It may be of interest to consider a numerical example. Suppose that

$$v = 30 \text{ miles per hour} = 1{\cdot}34 \times 10^3 \text{ cm. per second,}$$

and that

$$h' - h = 10 \text{ feet} = 305 \text{ cm.};$$

then in C.G.S. measure

$$(v + 2u)^2 = v^2 + 2g\,(h' - h)$$

$$= 1{\cdot}80 \times 10^6 + {\cdot}60 \times 10^6 = 2{\cdot}40 \times 10^6,$$

and

$$v + 2u = 1{\cdot}55 \times 10^3;$$

so that

$$2u = {\cdot}21 \times 10^3 \text{ cm./sec.} = 4{\cdot}7 \text{ miles/hour.}$$

In this case a freshening of the wind amounting to 4·7 miles per hour is equivalent to a gain of 10 feet of potential elevation.

In order to take advantage of the gradual increase of wind with elevation usually to be met with, a bird may describe circles in an inclined plane, always descending when moving to leeward and ascending when moving to windward. Whether the differences of velocity available at considerable elevations in the atmosphere are sufficient to allow a bird to maintain his position without working his wings appears to be doubtful. Near the level of the ground or sea these differences are greater, and probably suffice to explain much of the sailing flight of albatrosses and other sea-birds.

Another way in which a bird may draw upon the internal energy of the wind has been specially discussed by Dr. Langley (*Smithsonian Contributions*, 1893), who calls attention to the fact that the well known *gustiness* of the wind, at any rate near the earth's surface, is underestimated in the usual meteorological records. The differences of horizontal velocity involved in what are commonly called gusts of wind imply in general vertical motions also, but near the ground these latter may, perhaps, be left out of account. The advantage which a bird may take of the variations in the speed of the wind is explicable upon the principles already applied, the *inertia* of the bird playing in some sort the part of the string of a kite.

If u denote the speed of the wind at any moment, and v the speed of the bird in the opposite direction, both *e.g.*, reckoned relatively to the ground, the available energy is measured by $\frac{1}{2}(v+u)^2$. Suppose now that the wind freshens, u becoming $u+du$, while v remains constant. The *increment* of available energy is

$$\tfrac{1}{2}(v+u+du)^2 - \tfrac{1}{2}(v+u)^2 = (v+u)\,du\ ;$$

or in time t,

$$\int_0^t (v+u)\,du \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1).$$

The speed of the wind being supposed to be periodic, and the integration being taken over a sufficiently long period of time, we have

$$\int_0^t u\,du = 0\ ;$$

and thus the mechanical advantage may be reckoned as

$$\int_0^t v\,du \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

In order that this may have a finite value, v must vary; the principle being that to get the most advantage v must be great when du is positive, that is when the wind is freshening, and smaller when the wind is failing. The higher velocity required to meet the freshening wind is to be obtained by a previous fall to a lower level.

As an example, let us suppose that u and v are periodic, so that

$$u = u_0 + u_1 \sin pt, \quad v = v_0 + v_1 \cos(pt + e);$$

then

$$\int v\,du = pu_1v_1 \int \cos pt \,.\, \cos(pt + e)\,dt,$$

and, when t is great,

$$\int v\,du = \tfrac{1}{2} pt\,u_1v_1 \cos e \quad . \quad . \quad . \quad . \quad . \quad (3).$$

The mechanical advantage obtained in time t is greatest when e vanishes, *i.e.*, when du and v are in the same phase. This mechanical advantage is to be set against the frictional and other losses neglected in our original supposition. Were there no such losses, the value of v, or of the elevation, might continually increase.

This example shows that it is quite possible for a bird moving in a very natural manner against a strong and variable wind to maintain himself and to advance over the ground without working his wings. Observations of this kind are recorded by Mr Huffaker. It will be understood, of course, that a bird, not being interested in simplifying the calculation, will take any advantage that offers itself of the internal energy of the wind and of upward currents in order to attain his objects.

In the preceding discussions we have assumed, for the sake of simplicity, that a bird or a flying machine is able to *glide* in still air without loss of energy. It is needless to say that the truth of such an assumption can, at best, be only approximate. Apart from frictional losses, the maintenance of a given level implies the continual formation of a downward aerial current, and consequent expenditure of energy. We have next to consider the magnitude of these losses, taking the case of a plane moving at a uniform speed. And, in the first instance, we shall neglect the frictional forces, assuming that the reaction of the air upon the plane is truly normal.

Before we can advance a step in the desired direction we must know how the normal pressure upon an aeroplane is related to the size and shape of the plane, to the velocity of the motion, and above all to the angle between the plane and the direction of motion. According to an erroneous theory, to some extent sanctioned by Newton, the mean pressure would depend only upon the area of the plane and the *resolved part* of the velocity in a direction perpendicular to the plane. If V be the velocity, a the angle between V and the plane, ρ the density of the air (or other fluid concerned), the pressure p would be given by

$$p = \tfrac{1}{2}\rho V^2 \sin^2 a. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

That this formula is quite erroneous, especially when a is small, has long been known.[*] At small angles the pressure is more nearly proportional to $\sin a$ than to $\sin^2 a$ and, as was strongly emphasized by Wenham in an early and important paper on aerial locomotion,[†] the question of shape and presentation is by no means indifferent. In the case of an elongated shape moving with given velocity V, and at a given small inclination a, the pressure is much greater when the long dimension of the plane is perpendicular than when it is (nearly) parallel to V.

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[*] A further discussion will be found in *Phil. Mag.*, vol. ii., p. 430, 1876, *Scientific Papers*, vol. i., p. 287, and in *Nature*, vol. xlv., p. 108, 1892.

[†] *Report of Aeronautical Society*, 1866, p. 10.

According to a theoretical formula developed on the basis of Kirchhoff's analysis (*Phil. Mag., loc. cit.*), we should have for the mean pressure, instead of (4),

$$p=\frac{\pi \sin \alpha}{4+\pi \sin \alpha}\rho V^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad (5).$$

This applies strictly to motion in two dimensions, or practically to the case of a very elongated blade, whose length is perpendicular to V.

At perpendicular incidence ($\alpha=90°$) the difference between (4) and (5) is not important; but when α is small, the value of p in (5) may be enormously greater than the corresponding value from (4).

As regards numerical values, if we use C.G.S. measure, so that V is measured in centimetres per second, we have in the case of air under standard conditions $\rho=\cdot 00128$, and p, at perpendicular incidence, measured in dynes per square centimetre, is according to (4),

$$p=\cdot 00064\, V^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6).$$

This does not differ greatly from the data given in engineering tables. To compare with Langley's more recent experiments, we may express V in metres per second and p in grams weight per square centimetre. Thus

$$p'=0065\, V'^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7):$$

while the mean of Langley's numbers gives

$$p'=\cdot 0087\, V'^2 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (8),$$

about 30 per cent. greater. The difference is accounted for, at any rate partly, by the *suction* which experiment shews to exist at the back of the plate.

As regards the law of obliquity, the early experiments of Vince (1798) sufficed to shew that the effect was more nearly as $\sin\alpha$ than as $\sin^2\alpha$. In recent times this subject has been very thoroughly investigated by Langley, who has examined not only the influence of obliquity, but also of the shape and presentation of the plane. His results for the case to which (5) relates indicate an even greater relative effect at small angles, probably referable to the back suction. A laboratory experiment to demonstrate the reality of this suction was described in one of the papers already referred to (*Nature, loc. cit.*).

Experiments upon the law of obliquity, as executed for the case of air, by Dines* and Langley,† involve cumbrous and costly whirling machines, and if made in the open are greatly embarrassed by wind. An apparatus capable of working in the laboratory, or as a lecture illustration, has long been a desideratum. With the aid of Mr. Gordon I have recently constructed one which, while very simple and inexpensive, performs sufficiently well. It may be regarded as a kind of adjustable windmill. An axis of hard steel, finely pointed at the ends, is carried by agate cups. From a central boss six spokes of round steel project symmetrically, carrying at their ends six similar vanes of tin-plate. The vanes are provided with projecting sockets of brass tubing, which fit the spokes somewhat tightly, but yet allow the vanes to be rotated when desired. The vanes are 4 inches long and 1½ inches wide, the distance of their inner ends from the axis being about 3·7 inches. The whole apparatus is as light as may be (about 120 gm.) consistently with the necessary rigidity.

If the vanes are all inclined at the same angle, the apparatus works like an ordinary windmill, and may be set into rapid rotation by a motion through the air parallel to the axis. This motion may take place either in a horizontal or in a vertical direction. If means were

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* *Proc. Roy. Soc.*, June, 1890.

† *Smithsonian Contributions to Knowledge*, 1891.

provided for estimating the couple needed to prevent rotation, we should obtain the efficiency of the vanes at the given obliquity and speed. Observations at the same speed and at other obliquities would then give the means of determining the law of obliquity.

Such a proceedure would be analogous to that adopted in former experiments with whirling machines. The essential feature of the present method consists in setting some of the vanes to compensate others inclined at different angle. The balance of effects is independent of the speed of the wind, so long as it is uniform over the whole section in operation. To guard against errors that might arise from a deficient fulfilment of this condition, I have preferred so to arrange that *opposite* vanes were inclined always at the same angle. For example, two pairs of opposite vanes might be set so that their planes make an angle of 6° with the axis. The remaining pair of opposite vanes would then be set at a greater angle, and this would be varied until no tendency remained to turn in either direction. The exact point of balance could be inferred either from the absence of observable effect, or by interpolation from equal slight effects in opposite directions.

As has been suggested, the motion itself may be either horizontal or vertical. Fair results may be obtained indoors at a walking speed, and my first idea was to determine balances by holding the wheel overhead while travelling in a dog-cart at 10 or 12 miles per hour. But when the axis is horizontal, much time is lost owing to the necessity of readjusting the centre of gravity after almost every shifting of the vanes. With a nearly vertical motion the position of the centre of gravity is of less consequence, and it was found that very good results could be arrived at by somewhat rapidly lowering the apparatus while held in the hands with axis vertical. It is possible that part of the delicacy obtained in this way is due to a partial annulment of gravity during the downward acceleration and consequent diminution of frictional effect at the bearings.

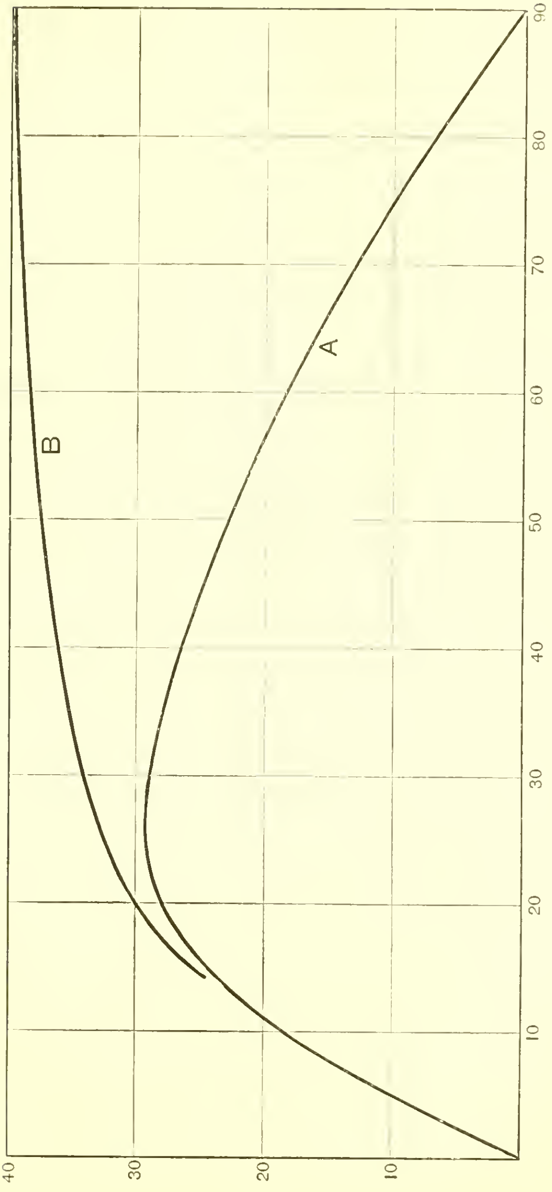
Some of the observations presently to be discussed were made in this way, but in most of them the arrangement was rather different. The wheel was removed from its bearings and suspended by a fine wire, whose torsion was insufficient to check the rotation seriously. The wire was pulled up vertically by a cord running over a pulley overhead. Although this arrangement offered some advantages, they were largely neutralised by disturbances due to draughts ; and it is probable that equally good balances might be obtained by the simpler method.

According to an old and long discredited law, the normal pressure upon a vane moving through the air at given speed would be proportional to the square of the sine of the angle (a) between the plane of the vane and the direction of motion. The resolved part of this in the direction of rotation would be $\sin^2 a \cos a$, which expression would represent the efficiency of the vanes of our mill as dependent upon the angle of setting. When a is small, the second factor is of little importance. A very simple experiment will now decide whether the law of $\sin^2 a$ is, or is not, an approximation to the truth. We find, in fact, that four vanes set at 6° markedly overpower two vanes set at 9°, whereas according to the law of $\sin^2 a$ the reverse should happen. In order to balance the four vanes at 6°, the two vanes need to be be at about $14\frac{1}{2}$°.

By observations of this kind materials are collected for a complete plotting out of the curve of efficiency. The efficiency necessarily vanishes when $a = 0$, and also on account of the resolving factor, when $a = 90°$. In order to balance four vanes set at 5°, we may set the remaining two vanes either at $10\frac{1}{2}$° or at about 58°. The efficiency reaches a maximum in the neighbourhood of 27°. The results are shown in A (*Fig. 1*), or in the second column of the accompanying table. The scale of the ordinates is, of course, arbitrary. The efficiency for 5° is assumed to be 10.

α	Rotatory Efficiency.	Normal Pressure.
0	0·0	0
5	10·0	25
10	19·0	48
15	24·8	64
20	28·0	75
25	29·2	80
30	29·0	84
40	27·0	88
50	23·5	91
60	19·0	94
70	13·2	96
80	6·9	99
90	0·0	100

In order to deduce the normal pressure, the results for the rotatory efficiency must be divided by cos α, and accuracy is necessarily lost in the case of the larger angles. The numbers thus arrived at are plotted in curve B, and are given in the third column of the table, reduced so as to make the maximum (at 90°) equal to 100. As regards


40
30
20
10
10
20
30
40
50
60
70
80
90
A
B

the relative pressures at the smaller angles, the results appear to be at least as accurate as those obtained on a larger scale with the whirling machine; but the reference to the pressure operative at 90° is probably less accurate. The principal conclusion that at small angles the pressure is proportional to $\sin\alpha$, and by no means to $\sin^2\alpha$, is abundantly established.

In applying these results, the first problem which suggests itself for solution is that of the gliding motion of an aeroplane. It was first successfully treated by Pénaud,* and it may be taken under slightly different forms. We may begin by supposing the motion to be strictly horizontal, the velocity being V and the inclination of the plane to the horizon being α. Under these circumstances a propelling force F is required, which we suppose to act horizontally. The mean pressure upon the plane we will denote by $\kappa V^2 \sin\alpha$, the assumption of proportionality to $\sin\alpha$ being amply sufficient for the case of *small* angles, with which alone we are practically concerned. If S be the area of the plane, the whole normal force is $\kappa S V^2 \sin\alpha$. In view of the smallness of α, we may equate this to the weight (W) supported. Thus

$$W = \kappa S V^2 \sin\alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9),$$

also

$$F = \kappa S V^2 \sin^2\alpha \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10).$$

If F be independent of V, as approximately in the method of rocket propulsion, these equations show at once that there is no limit to the weight that may be supported by a given F. It is only necessary to make α small enough, and to take V large enough to satisfy (9).

In other methods of propulsion we should have to

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* *Société Philomathique de Paris*, 1876; *Report of Aeronautical Society*, 1876. See also W. Froude, *Glasgow Proceedings*, vol. xviii., p. 65, 1891.

do rather with the rate (H) at which energy is expended than with the force F itself. The relation is

$$H = FV \quad . \quad . \quad . \quad . \quad . \quad . \quad (11),$$

so that in place of (10)

$$H = \kappa S V^3 \sin^2 \alpha. \quad . \quad . \quad . \quad . \quad . \quad . \quad (12).$$

Or, again, since in many cases the power that might be expended is proportional to the weight lifted, we may conveniently write

$$H = WU \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13).$$

From these equations we derive

$$V = \frac{W^2}{\kappa S H} = \frac{W}{\kappa S U} \quad . \quad . \quad . \quad . \quad . \quad . \quad (14),$$

$$\sin \alpha = \frac{\kappa S H^2}{W^3} = \frac{\kappa S U^2}{W} \quad . \quad . \quad . \quad . \quad (15);$$

and it is possible so to determine V and α that, with a given U and a given S, any weight W can be supported. As W increases, V must be greater and α smaller. The same is true, in an enhanced degree, if it be H that is given in place of U.

According to what has been shown (6), (7), (8), *Fig.* (1), we have in C.G.S. measure

$$\kappa \sin 5^\circ = \cdot 25 \times \cdot 00085,$$

so that

$$\kappa = \cdot 0024 \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (16).$$

In the case of a very elongated plane the value of κ would be a little higher. We must remember that V is reckoned in centimetres per second, S in square centimetres, and the normal force in dynes.

The conclusion that a weight, however great, may be supported with a given S and a given U, or even a given H, is unpractical for more than one reason. There must be a limit below which α cannot be reduced, if only because of the high degree of instability that such an adjustment must have to contend with. Another important matter is the tangential force upon the plane, although some distinguished experimenters have expressed the opinion that it is negligible. In order to take account of it, we may add to the right-hand member of (10) a term proportional to V^2, but independent of α. Thus (12) becomes

$$H = WU = (\kappa S \sin^2\alpha + \mu) V^3 \quad . \quad . \quad . \quad (17)$$

(9) remaining unchanged. Eliminating V, we find

$$\frac{U^2}{W} = \frac{(\kappa S \sin^2\alpha + \mu)^2}{\kappa^3 S^3 \sin^3\alpha} \quad . \quad . \quad . \quad . \quad . \quad . \quad (18).$$

We may apply (18) to find for what value of $\sin\alpha$ the quantity U^2 attains a minimum. By the ordinary rules,

$$\sin^2\alpha = \frac{3\mu}{\kappa S} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (19),$$

and, of course, this value of $\sin^2\alpha$ must be *small*, if the investigation is to be applicable. If μ vanish, $\sin\alpha$ diminishes without limit. In general the minimum value of U^2 is given by

$$U^2 = \frac{16W}{\kappa S}\left(\frac{\mu}{27\kappa S}\right)^{\frac{1}{2}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20),$$

and the corresponding value of V^2 by

$$V^2 = \frac{W}{3^{\frac{1}{2}}\kappa^{\frac{1}{2}}\mu^{\frac{1}{2}}S^{\frac{1}{2}}} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (21).$$

These equations shew that the necessary work depends entirely upon μ, and that without a knowledge of this element no numerical conclusions can be arrived at.

It might be supposed that μ, so far as it depends upon the aeroplane, would be proportional to S, but this relation is more than doubtful. In any case of a practical machine there must at any rate be a part of μ not proportional to S.

It may be well to recall that U represents the velocity at which a weight equal to W would have to be raised in order to do work equal to that done by the propelling force F. By (20), *caeteris paribus*, U varies as $S^{-\frac{1}{4}}$.

We may now pass to the case of an aeroplane gliding in still air, the path being slightly inclined downwards. If θ be the small angle between the path and the horizontal, we may regard the component of gravity in this direction, viz., $W \sin \theta$, as the propelling force F. Thus

$$H = WU = FV = WV \sin \theta \quad . \quad . \quad . \quad (22),$$

so that

$$U = V \sin \theta \quad . \quad . \quad . \quad . \quad . \quad . \quad (23).$$

The same equations apply as before, with the understanding that α, being the inclination of the plane to the direction of motion through the air, is no longer identical with the inclination of the plane to the horizon. The latter angle, reckoned positive when the leading edge is downwards, will now be denoted by $(\theta - \alpha)$.

Introducing (23) into (14), (15), we get

$$V^2 = \frac{W}{\kappa S \sin \theta}, \qquad \sin \alpha = \frac{\kappa S V^2 \sin^2 \theta}{W}. \quad . \quad . \quad . \quad (24),$$

from which it appears that whatever may be the values of W and S, θ may still be as small as we please. Thus, if frictional forces can be neglected, a high speed is all that is required in order to glide without loss of energy. This is the supposition upon which we discussed the manner in which a bird may take advantage of the internal work of the wind ; and we see that the motion of the bird must be of such a character that he always retains a high velocity relatively to the surrounding air. The advantage that we showed to be obtainable must be set against losses due to friction and to imperfect fulfilment of the condition just specified.

When frictional forces are included we may use equation (18), merely substituting $V\sin\theta$ for U. The problem already considered of making U a minimum is still pertinent, since U denotes the rate of vertical descent. By (19), (20), (21)

$$\sin^2\alpha = \frac{3\mu}{\kappa S}, \quad \sin^2\theta = \frac{U^2}{V^2} = \frac{16\mu}{3\kappa S} \quad . \quad . \quad . \quad (25),$$

so that, θ and α being small,

$$\alpha = \tfrac{3}{4}\theta, \qquad \theta - \alpha = \tfrac{1}{3}\alpha = \tfrac{1}{4}\theta \quad . \quad . \quad . \quad (26).$$

This result, due to Pénaud, shews that when the rate of vertical descent is slowest, or when the time of falling a given height is greatest, the slope of the plane to the horizon is downwards in front, and equal to one-quarter of the slope of the line of motion. The actual minimum rate of vertical descent is given by (20). This rate is relative to still air. If there be a wind having a vertical component of the same amount, the course of the plane may be horizontal.

Another slightly different minimum problem is also treated by Pénaud, in which it is required to determine how *far* it is possible to glide while falling through a given vertical height. From (9), (17), (23), we have in general

$$\sin\theta = \frac{\sin^2\alpha + \mu/\kappa S}{\sin\alpha}. \quad . \quad . \quad . \quad . \quad (27).$$

When θ is a minimum by variation of α,

$$\sin\alpha = \tfrac{1}{2}\sin\theta = \sqrt{(\mu/\kappa S)}. \quad . \quad . \quad . \quad . \quad (28).$$

In this case the plane bisects the angle between the horizontal and the direction of motion.

In the flying machines of Pénaud, Langley, and Maxim, the propelling force is obtained by a screw, acting like the screw-propeller of a ship. A rough theory of this action is easily given and is of interest, not only in the application to the horizontal propulsion of an aeroplane, but also because a screw rotating about a vertical axis may be used for direct maintenance. The latter question may conveniently be considered first.

The screw is supposed to maintain a weight W at a fixed position in still air. This it does by creating a downward current of velocity v. If S' be the area of section of the current, equal to that swept through by the screw, the volume of air acted upon per second is $S'v$, and the momentum generated per second is $S'v \, . \, \rho v$, or $S'\rho v^2$. Hence

$$W = S'\rho v^2. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29).$$

Again, the kinetic energy generated per second is $\frac{1}{2}S'\rho v^3$; so that if U be the velocity at which W would have to be lifted to do a corresponding amount of work, we may, neglecting frictional losses, equate the above to UW. Thus

$$UW = \tfrac{1}{2}S'\rho v^3. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30).$$

From (29), (30), $\frac{1}{2}v = U$,

and
$$S' = \frac{W}{4\rho U^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (31).$$

So far as these equations are concerned, any weight can be maintained by a limited expenditure of work, but the smaller the power available the larger must be the section of the stream of air, and consequently of the screw, or other machinery, by which the air is set in motion. Again from (31)

$$WU = \frac{W^{\frac{3}{2}}}{(4\rho S')^{\frac{1}{2}}} \cdot \quad . \quad . \quad . \quad . \quad . \quad . \quad (32),$$

so that if S' be given, the whole power required varies as $W^{\frac{3}{2}}$.

To obtain numbers applicable to the case of a man supporting himself in this way by his own muscular power, we take in C.G.S. measure

$$W = 68000 \times 981, \qquad U = 15, \qquad \rho = \tfrac{1}{800},$$

thus finding

$$S' = 6{\cdot}0 \times 10^7 \text{ sq. cm.}$$

This represents the cross-section of the descending column of air. If we equate S' to $\frac{1}{4}\pi d^2$, d will be the diameter of the screw required, and we get $d = 90$ metres. It is to be observed that this assumed value of U corresponds to the power which a man may exercise when working for eight hours a day. But even if he could do ten times as much for a few minutes, d would still amount to 9 metres; and in this estimate nothing has been allowed for the weight of the mechanism, or for frictional losses. It seems safe to conclude that a man will never support himself in this manner by his own muscular power.

A screw works to better advantage when it has a forward motion through the fluid, for then a larger mass comes under its influence. Let us suppose that a screw, now rotating about a horizontal axis, is advancing through still air with horizontal velocity V. Also let v be the actual velocity with which the column of air leaves it. The volume acted on per second is $S'(V+v)$. If F be the propulsive force

$$F = S'\rho\,(V+v)\,v. \quad . \quad . \quad . \quad . \quad . \quad (33).$$

Again, the work per second required to generate the kinetic energy of the column is

$$\tfrac{1}{2}S'\rho\,(V+v)\,v^2. \quad . \quad . \quad . \quad . \quad . \quad (34).$$

The whole work expended per second (H') is accordingly

$$H' = FV + \tfrac{1}{2}S'\rho\,(V+v)\,v^2 = F(V + \tfrac{1}{2}v) \quad . \quad . \quad (35).$$

When V is great compared with v, the right hand member of (35) reduces to its first term. We conclude that when a screw advances at a sufficiently rapid rate, the energy left behind in the fluid is negligible, so that the whole work done is available for propulsion. The distinction between W' and W, as formerly employed, then disappears.

If U denote the rate at which W would have to be lifted in order to do the work actually performed by the machine, we may now take from (15), as applicable to the *rapid* flight of an aeroplane,

$$U = \sqrt{\left(\frac{W \sin \alpha}{\kappa S}\right)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (36).$$

In the case of direct maintenance by a screw rotating about a vertical axis, (31) gives

$$U = \sqrt{\left(\frac{W}{4\rho S'}\right)} \quad . \quad . \quad . \quad . \quad . \quad . \quad (37).$$

It may be interesting to compare the powers required in the two methods, especially as some high authorities have favoured direct maintenance, without the use of an aeroplane, as the more economical. The ratio of the values of U in (36), (37) is

$$2\sqrt{\left(\frac{\rho \sin \alpha}{\kappa} \frac{S'}{S}\right)} \quad . \quad . \quad . \quad . \quad (38)$$

or, in the case of air, since $\kappa = \cdot 0024$, $\rho = \cdot 0012$,

$$\sqrt{(2 \sin \alpha \,.\, S'/S)} \quad . \quad . \quad . \quad . \quad . \quad (39).$$

Since α may be made small, and S the area of the plane may be a large multiple of S' the area swept over by the screw, it would appear that the advantage must lie with the aeroplane, even if the object be mere maintenance, and not a rapid transit from place to place.

But although the flying machine of the future will, as it appears to me, be on the principle of the aeroplane, it cannot be denied that the method of direct maintenance by a vertically rotating screw offers certain present advantages. Among the most important of these are a much better ensured stability, and less danger in alighting owing to the absence of rapid horizontal motion. The first experiments might well be made with screws driven by electric motors, the power being supplied from the ground by means of vertical wires 30 or 40 feet long. In this way the necessary experience would be easily gained, and most of the doubtful points settled, before a completely self-contained machine was attempted.

In natural flight revolving mechanism is not, and apparently could not have been, used. As we all know, a bird flying horizontally through still air performs the necessary work by flapping his wings. The effect of a reciprocating motion in modifying the action of an aeroplane was, I believe, first considered in detail by Professor M. Fitzgerald.* It may be convenient to give, as naturally connected with the foregoing, an outline of this theory in a modified form, following Professor Fitzgerald in assimilating the wing to a simple aeroplane, upon which is imposed (without rotation) a vertical reciprocating motion.

We denote by u the horizontal velocity of the plane supposed uniform, by v the vertical velocity at time t, by θ the inclination of the plane to the horizon at time t, while S and W denote the area and weight as before. If we assume the same formula for the pressure as before, although the application is now to an *unsteady* motion, and further suppose that v/u and θ are always small, we get as in (9) for the whole normal pressure upon the plane at time t

$$\kappa S\,(u^2+v^2)\,(\theta+v/u) \quad . \quad . \quad . \quad . \quad . \quad (40),$$

in which however v^2 in (u^2+v^2) may be omitted.

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* *Proc. Roy. Soc.*, vol. lxiv., p. 420, 1899.

We now assume that θ and v are periodic, for example that

$$\theta = \theta_0 + \theta_1 \cos pt \quad . \quad . \quad . \quad . \quad . \quad . \quad (41),$$

$$v/u = \beta \cos (pt + \epsilon) \quad . \quad . \quad . \quad . \quad . \quad . \quad (42),$$

where the periodic time τ is related to p according to

$$\tau = 2\pi/p.$$

At this stage the criticism may present itself that the assumed motion involves a reaction for which we have made no provision. In practice the reaction is supplied by the inertia of the body of the bird to which the wings are attached. The difficulty would be got over by supposing that there are several planes executing similar movements, but in different phases regularly disposed. It seems hardly worth while to complicate the present investigation by introducing a vertical movement of the weight.

By (40) the whole pressure at time t, perpendicular to the plane is

$$\kappa S u^2 \{\theta_0 + \theta_1 \cos pt + \beta \cos (pt + \epsilon)\} \quad . \quad . \quad . \quad (43)$$

Of this the mean value is to be equated to the weight W supported, so that

$$W = \kappa S u^2 \theta_0 \quad . \quad . \quad . \quad . \quad . \quad . \quad (44).$$

The horizontal component of the whole pressure at time t is

$$S \, . \, \kappa u^2 . \{\theta + v/u\} \, \theta \quad . \quad . \quad . \quad . \quad . \quad (45),$$

and of this the mean value is to be supposed to be zero, in order that the plane may move with uniform horizontal velocity. Thus

$$\theta_0{}^2 + \tfrac{1}{2} \theta_1{}^2 + \tfrac{1}{2} \beta \, \theta_1 \cos \epsilon = 0 \quad . \quad . \quad . \quad . \quad (46).$$

Again, if WU be the (mean) rate of expenditure of work,

$$WU = S \, \kappa u^2 . \int_0^\tau (\theta + v/u) v \, d(t/\tau) = S . \tfrac{1}{2} \kappa u^3 (\beta \, \theta_1 \cos \epsilon + \beta^2) \quad . \quad (47).$$

If we eliminate β between (46), (47), we get

$$WU = S \cdot \tfrac{1}{2}\kappa u^3 \frac{(2\theta_0^2 + \theta_1^2)(2\theta_0^2 + \theta_1^2 \sin^2\epsilon)}{\theta_1^2 \cos^2\epsilon} \quad . \quad (48),$$

from which we see that if θ_1 be given (as well as S, W, u), U is least when $\epsilon = 0$, viz., when the phase of maximum vertical velocity coincides with the phase of greatest inclination. In this case by use of (44) we have

$$U = \frac{W}{\kappa S u}\left(1 + \frac{2\theta_0^2}{\theta_1^2}\right) \quad . \quad . \quad . \quad . \quad . \quad (49).$$

If we regard W, S, u as given, the smallest value of U corresponds to θ_1 being large in comparison with θ_0 which is given by (44).*

The smallest value is

$$U = \frac{W}{\kappa S u} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (50).$$

The work required to be done is here the same function of S, W, and the horizontal velocity as was found in (14), where V has the meaning here assigned to u.

We see from (46) that, under the circumstances supposed, $\theta_1 + \beta$ is numerically small in comparison with θ_0, and *a fortiori* in comparison with θ_1. Accordingly the forward edge of the plane is inclined downwards when the motion of the plane is downwards.

As regards the pressure, it is by (43) proportional to

$$\theta_0 + (\theta_1 + \beta)\cos pt,$$

in which the second term is relatively small. The pressure acts always upon the under side of the plane, and the weight is approximately supported in all phases.

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* It must not be forgotten that θ_1 itself has been assumed to be small.

Manchester Memoirs, Vol. xliv. (1900), *No.* 6.

VI. Geometrical Representation of the Relation between Wave-Velocity and Group-Velocity.

By Prof. HORACE LAMB, M.A., LL.D., F.R.S.

Received December 12th, 1899, read January 9th, 1900.

The fact that in a group of progressive waves on water the velocity of advance of the group as a whole is much less than that of the individual waves composing it seems to have been first distinctly recognised by Scott Russell.* The theoretical explanation has been given,

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* *Brit. Ass. Rep.*, 1844, p. 369. As Russell's share in the matter appears to have been somewhat overlooked, the following quotations may be of interest:

"One observation which I have made is curious. It is, that in the case of oscillating waves of the second order, I have found that the motion of propagation of the whole group is different from the apparent motion of wave-transmission along the surface; that in the group whose velocity of oscillation is as observed 3·57 feet per second, each wave having a seeming velocity of 3·57, the whole group moves forward in the direction of transmission with a much slower velocity. The consequence of this is a difficulty in observing these waves (especially such as are raised by the wind at sea), namely, that as the eye follows the crest of the wave, this crest appears to run out of sight, and is lost in the small waves in which the group terminates. . . . . There is to be observed, therefore, this distinction in a group of waves of the second order, between the velocity of individual wave-transmission and the velocity of aggregate wave-propagation.

"I have not found it possible to measure this velocity of aggregate propagation of a group of waves, from want of a point to observe. If I fix my eye upon a single wave, I follow it along the group, and it gradually diminishes and then disappears; I take another and follow it, and it also disappears. My eye, in following a wave-crest, follows the visible velocity of transmission merely. After one or two such observations, I find that the whole group of oscillations has been transferred along in the direction of transmission with a velocity comparatively slower; but I have not been able to measure this velocity of propagation of the wave-motion from one place to another. . . . .

"*On Observations of the Waves of the Sea.* . . . . Besides the coexistence of different series of waves, we have the difficulty arising from the fact already

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from different points of view, by Sir G. Stokes and Prof. Osborne Reynolds[†]; and the problem has been further generalised by Lord Rayleigh[‡], who has shewn that in any medium where the wave-velocity V (Russell's 'velocity of wave-transmission') is a function of the wave-length λ,

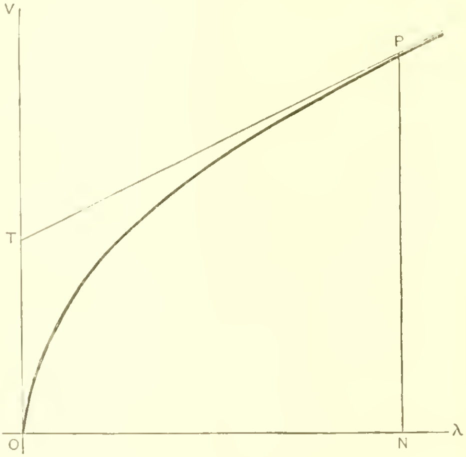

Fig. 1.

the group-velocity U (Russell's 'velocity of wave-propagation') is given by the formula

$$U = V - \lambda\frac{dV}{d\lambda}.$$

This result admits of a simple geometrical representation. If a curve be constructed with λ as abscissa and

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mentioned, that a difference exists between the velocity of transmission and the velocity of propagation. From this it results, that after the eye has followed the apparent ridge of a wave, moving with a given velocity of transmission, it will outrun the velocity of propagation, and the wave will appear to cease. This I have continually observed at sea. The eye follows a large wave, and suddenly it ceases to pass on, but on looking back we find it making once more an appearance on the same ground along which we formerly traced its ridge; this arises from the cause just mentioned."

[†] *Nature*, vol. xvi., p. 343 (1877).

[‡] *Theory of Sound*, § 191.

V as ordinate, the group-velocity will be represented by the intercept made by the tangent on the axis of V. Thus in *Fig.* 1, PN represents the wave-velocity for the wave-length ON, and OT represents the group-velocity. The frequency of vibration, it may be noted, is represented by the tangent of the angle PON.

Some particular cases may be noticed.

(1) In the case of gravity-waves on deep water, $V \propto \lambda^{\frac{1}{2}}$; the curve has the form of the parabola $y^2 = 4ax$, and $OT = \frac{1}{2} PN$, *i.e.*, the group-velocity is one-half the wave-velocity.

(2) For capillary waves, without gravity, $V \propto \lambda^{-\frac{1}{2}}$, and the curve has the form $xy^2 = a^3$. In this case $OT = \frac{3}{2} PN$.

(3) When both gravity and capillarity are operative,

$$V \propto \sqrt{\left(\frac{\lambda}{a} + \frac{a}{\lambda}\right)},$$

where a is a certain constant, and the curve has the form

$$\frac{y^2}{b^2} = \frac{x}{a} + \frac{a}{x}.$$

This is shewn in *Fig.* 2. The curve indicates at once the existence of a minimum wave-velocity corresponding to $\lambda = a$; also that for any prescribed wave-velocity greater than the minimum there are *two* possible wave-lengths, of which one rapidly increases, whilst the other diminishes, as the wave-velocity increases. It appears, moreover, that the group-velocity is less than, equal to, or greater than the wave-velocity according as the wave-length is greater than, equal to, or less than the critical wave-length a. The frequency on the other hand, steadily increases as the wave-length diminishes. All these are of course known results. It may also be noted that since two tangents can be drawn to the curve from any point on the axis OV

(beyond a certain distance from O), there are two values of the wave-length corresponding to any prescribed value of the *group*-velocity U. These two values of λ coincide when U has a certain (minimum) value, indicated by the point where the tangent to the curve at the point of inflexion cuts OV; and it may be easily shewn that we then have

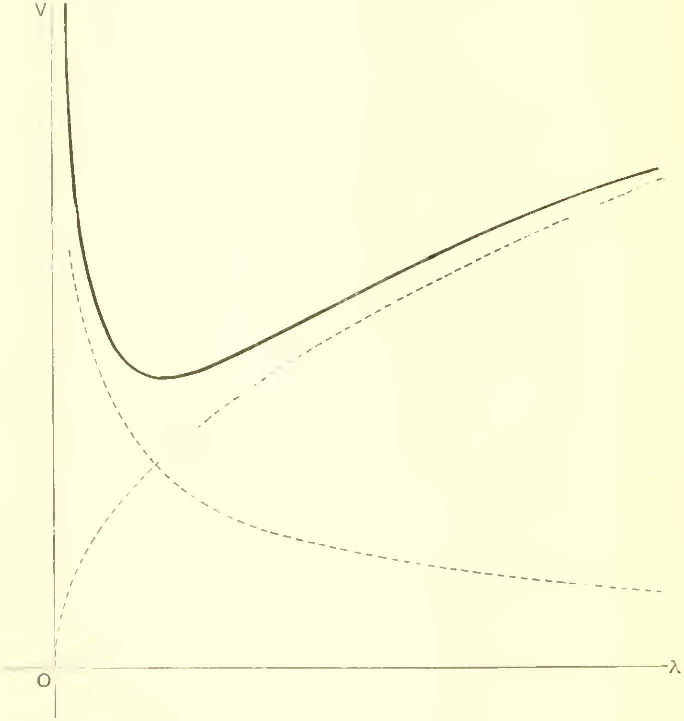

Fig. 2.

$$\frac{\lambda}{a} = \sqrt{(3 + 2\sqrt{3})} = 2\cdot542,$$

$$U = \cdot767\, V_o,$$

where V_o is the minimum *wave*-velocity. These points are of some interest in relation to Poisson's and Cauchy's investigations of the effect of an isolated impulse on the surface of water, as interpreted by Lord Kelvin.*

(4) For waves of flexure travelling along an elastic rod, $V \propto \lambda^{-1}$; the curve is then a hyperbola $xy = a^2$, and $OT = 2PN$.

(5) For waves on a tense string every point of which is urged towards its equilibrium-position by a force varying as the displacement,

$$V \propto \surd(a^2 + \lambda^2)$$

where a is a constant. The curve has then the form of a hyperbola

$$\frac{y^2}{b^2} = 1 + \frac{x^2}{a^2},$$

and OT varies inversely as PN; *i.e.*, the group-velocity varies inversely as the wave-velocity.

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* *Proc. Roy. Soc.* Feb. 3, 1887.

Manchester Memoirs, Vol. xliv. (1900), *No.* 7.

VII. The Formation of Minerals in Granite.

By C. E. Stromeyer, M.Inst. C.E.

Received and read January 23rd, 1900.

It is needless to recapitulate here the various suggestions which have been put forward to account for the curious fact that in granite we have an assemblage of crystals so arranged as to leave no doubt that quartz, the least fusible of the constituents, must often have been the last to solidify. The differences between the melting temperatures of quartz and felspars, micas and hornblendes (as will be seen from *Table I.*), are as great as the difference between the melting temperatures of ice and tin, lead or zinc ; granite therefore presents to us a problem as difficult to solve as if we were required to explain how water could be made to freeze when in contact with, say, molten tin.

Before trying to point out how this problem can be solved, it will be as well to deal with two attempted explanations. It has been urged that, given a molten mass of granite which, if cooled under ordinary conditions, would result in a solid resembling pitchstone, there would be no tendency for the felspars, micas, &c., to separate from the quartz. There are, however, numerous well-authenticated facts to prove that this separation is possible under certain circumstances. On heating to the right temperature an alloy of lead with a little silver, pure lead crystals can be separated from the fluid lead-silver liquor. If salt water is cooled to the right temperature below 0°C., pure ice is formed, while a more concentrated salt liquor remains fluid. It is interesting to note that, although this

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freezing takes place below 0°C., the ice formed would not melt again until 0°C. is reached. The process is therefore not a reversible one. Another point urged is the difficulty of accounting for water in the quartz of granites, and, more particularly, why it should be found in the quartz and not in the other minerals, or only slightly so. This is, to my

TABLE I.

MELTING TEMPERATURE OF MINERALS.*

Mineral.	Melting Temperature.	Mineral.	Melting Temperature.
Quartz softens ..	1406°C.	Hornblendes:—	
,, melts ...	1425 ,,	Actinolite...	1272-1288°C.
,, fluid ...	1440 ,,	Augite	1187-1199 ,,
Felspars :—		Diallage ...	1264-1300 ,,
Albite	1172-1175 ,,	Diopside ...	1187-1195 ,,
Labradorite	1223-1235 ,,	Enstatite ...	1295 ,,
,,	1230 ,,	Hornblende	1187-1200 ,,
Oligoclase ..	1220 ,,	Spodumene.	1173 ,,
		Tremolite	1219-1223 ,,
Orthoclase Adularia ..	1164-1175 ,,	Wollastonite	1203-1208 ,,
Microcline..	1169-1175 ,,		
Sanidine ..	1140 ,,		

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* Extracts from J. Joly, "Melting Points of Minerals," *Proc. R.I.A.*, Ser. 3, Vol. 2 (1891), p. 39; and R. Cusack, *ibid*, Ser. 3, Vol. 4. (1897), p. 411.

mind, a case of occluded gases. It is assumed that, because air, carbonic acid, and other gases occluded by water, are driven out by heat, steam would be driven out of quartz or granite while fluid, rather than that it should separate out when they are in a plastic, or perhaps even in a solid state; but we have the well-known cases of silver and copper absorbing oxygen while in a molten condition and violently ejecting this gas when solidifying. Gases are also given off by steel when cooling, forming blow-holes in the castings. It is therefore possible that molten silica has a natural inclination to occlude steam and that, if the pressure is sufficiently great, the weight of steam occluded is proportionately great. The large percentage of water contained in some quartzes seems to indicate that silica when fluid can, under pressure, absorb a large volume of steam. Possibly the expulsion of steam takes place at some definite temperature, and not necessarily at that of freezing. It may be well to point out here that the measurements made on the sizes of the cavities in the quartz, and the amount of water they contain, do not necessarily indicate a definite temperature as suggested by Mr. Sorby. At least, it is very near that of the critical temperature of steam, and as at high temperatures, the product of volume and pressure of steam is proportional to the temperature, and the temperature of the earth's crust to the depth below the surface, it follows that the relative volumes of the cavities and the steam they contain will be constant for every temperature of formation. We are, therefore, not limited to any definite temperature as being the only one at which granite has been formed, which would have to be the case if the above view were strictly true.

Turning now to the previously mentioned differences of melting temperatures of the minerals in granite, it seems to have been vaguely felt that, as has been explained above, quartz may possess a greater affinity for steam than the other minerals, and that the effect of this occluded steam may have been to lower the melting temperature of quartz. Such a lowering is possible, but only after the separation of minerals has taken place; it does not account for the separation, and it does not account for the formation of those granites in which the quartz contains little or no water. It also fails to account for the diversity of mineralogical composition of such granites as are nearly alike in chemical composition.

The whole difficulty, to my mind, may be explained if such experiments on the changes of volumes while melting as have already been carried out by Mr. J. Joly* on basalt, augite and orthoclase, and Mr. Barus† on diabase, could be extended to the individual minerals which go to make up granite; provided, however, that such experiments should show that, on fusing, quartz expands less than the other minerals, or, better still, that it contracts like ice, bismuth, arsenic, and antimony.

These few words will no doubt at once suggest the explanation which it is intended to give.

In 1849 Mr. J. Thomson,‡ and in 1850 Herr R. Clausius,** showed theoretically that the melting temperature of a solid could be altered by pressure; that it would rise under pressure if the volume of the substance increased on fusion, as in the case of sulphur, phosphorus, etc.; and that it would fall under pressure if the volume decreased on fusion, as in the case of ice, bismuth, etc. This theoretical deduction was speedily verified by Lord

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* *Trans. Roy. Dublin Soc.*, Ser. 2, Vol. 6 (1897), p. 283.

† *Amer. Journ. Sci.*, Vol. 42 (1891), p. 498.

‡ *Trans. Roy. Soc. Edinb.*, Vol. 16 (1849), p. 575.

** *Pogg. Ann.*, Bd. 81 (1850), p. 168.

Kelvin[†] as regards ice and water for pressures up to 16 atmospheres, and M. A. Mousson[††] verified the hypothesis down to a temperature of 18°C., but the latter's estimate of a pressure of 87 tons per square inch is clearly much too high, for his experimental tube could not have stood it. Bunsen,[§] Hopkins,[§§] and others of more recent date, extended the enquiry to other substances. Amongst recent experiments which fitly illustrate the matter, may be mentioned those by M. E. Mack[‖] on naphthylamine and paratoluidine for which the experimental results are given in *Table II.* and in *Fig. 1.*, from which it will be seen that whereas there is a differ-

TABLE II.

MELTING TEMPERATURES AT VARIOUS PRESSURES.

Pressures in atmospheres.	Napthylamine °C.	Paratoluidine °C.
1	48·5	39
280	—	50·8
430	—	55·0
515	60·5	—
579	—	59·7
730	—	64·0
900	68·3	—

[†] W. Thomson, *Phil. Mag.*, Vol. 37 (1850), p. 123.

[††] *Pogg. Ann.*, Bd. 105 (1858), p. 161.

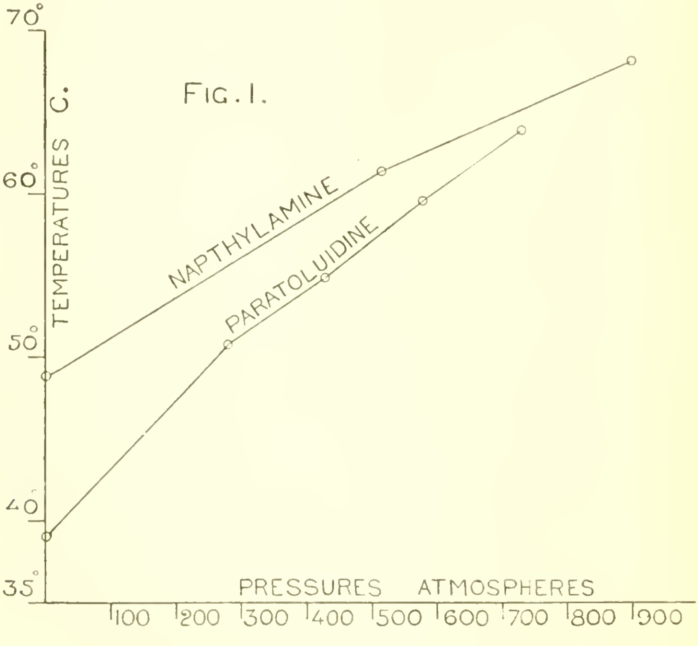
[§] *Ibid*, Bd. 81 (1850), p. 562.

[§§] *Athenæum*, 1854, p. 1207.

[‖] *Comptes Rendus*, Tome 127 (1898), p. 361.

ence of 9½° between the melting temperature of the two substances at a pressure of one atmosphere, there is no difference at about 750 atmospheres, and the difference would evidently have been reversed to about 10°C., if the experiments could have been extended to a pressure of 1,800 atmospheres.

FIG. I.



Now, taking the mean density of the earth's crust at 3, a depth of 10 feet is equal to a pressure of about one atmosphere, so that at a depth of 18,000 feet, if one could keep the temperature below about 90°C., one would find that napthylamine melts first by about 10°C, while on the surface it melts last by 9½°C. With the one substance the rate of increase of melting temperature is about 1°C.

per 450 feet of depth, with the other substance it is about 1 C. per 300 feet of depth. Assuming now, for instance, that these rates also applied to felspar and quartz respectively, and starting with the melting temperatures as given in *Table I.*, remembering also that the mean temperature gradient in the earth's crust is about 1°C. per 110 feet, we can construct *Table III.* which gives hypothetical melting points for quartz and felspar at varying depths down to 200,000 feet.

TABLE III.

Depth.	Earth Temperature.	Hypothetical Melting Point.	
		Quartz.	Felspar.
Feet.	°C.	°C.	°C.
0	30	1406 (actual)	1220 (actual)
50,000	480	1517	1387
100,000	940	1628	1583
150,000	1390	1739	1720
200,000	1850	1850	1887

Although these values are purely imaginary, except for the depth 0, they are not at all impossible ones; Maxwell* even assumes rates of increase of melting temperatures exceeding the earth's temperature gradient. Besides, both napthylamine and paratoluidine raise their melting point under pressure, and it is only the difference in their two rises which has in this example been taken into account; if, however, the melting point of quartz were to sink under pressure, while that of

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* *Theory of Heat*, 1888, p. 21.

the felspars were to rise, it would be evident that at a depth of 200,000 feet we might expect quartz to melt at about 1,000°C., and felspar to melt as above at 1,900°C. If this could be demonstrated, the origin of almost any granite could easily be explained. That such values are not impossible will be seen from *Table IV.*, which contains the elements for calculating the changes of melting temperatures of various substances, when the pressure is increased. The estimated rates are given in the seventh column and two experimental results are given at the foot. For some materials no estimates could be made, owing to want of complete information. Antimony and arsenic are well-known cases of contraction on fusion, but its amount and other necessary elements are not known. The table contains such information as could be collected on this subject, except as regards organic compounds, and, although it throws no direct light on the important question of the melting temperatures of minerals when under great pressure, it shows at least that amongst eleven substances, of which only two are compounds, the rate of change may vary from $-0{\cdot}0073$ for ice to $+0{\cdot}0066$ for sulphur, and it is not unreasonable to suppose that similar, if not greater, differences of rates will be met with amongst minerals.

The formula for calculating $\frac{dt}{dp}$ the rise of melting temperature with the pressure is

$$\frac{dt}{dp} = t\,\frac{V_f - V_s}{J\lambda},$$

where t = (absolute) melting temperature,

J = Joule's mechanical equivalent of heat = 42,658 g.c.,

λ = latent heat of melting,

V_f and V_s = volume in cub. cm. of 1 gram of substance in the fluid and solid states respectively at the melting temperature, and

TABLE IV.

Material.	Volume of 1 gram at melting temperature.			Latent heat of melting.	Absolute melting temp.	Estimated rise of melting temp. per atmo. = 1,000 grm. per sq. cm.
	Solid.	Fluid.	Diff.			
Elements.	c.cm.	c.cm.	c.cm.	Cals.	Deg.	Deg.
Phosphorus	0·552	0·572	+ 0·020	5·00	317	+ 0·0029
Sulphur ...	0·483	0·552	+ 0·069	9·368	387	+ 0·0066†
Bismuth ...	0·1135	0·1000	− 0·0035	12·64	544	− 0·00033
Tin	0·139	0·143	+ 0·004	13·30	499	+ 0·00035
Zinc	0·143*	0·154	+ 0·011	28·10	685	+ 0·00062
Cadmium ..	0·119	0·125	+ 0·006	13·67	591	+ 0·00060
Potassium .	1·175	1·205	+ 0·030	?	335	+ ?
Sodium ...	1·051	1·077	+ 0·026	?	371	+ ?
Silver	0·095*	0·105	+ 0·010	21·00	1223	+ 0·00136
Lead	0·091	0·095	+ 0·004	5·86	598	+ 0·00095
Mercury ...	0·0705	0·0730	+ 0·0025	2·80	234	+ 0·0046
Compounds.						
Ice	1·09082	1·00012	− 0·09070	79·0	273	− 0·0073‡
SO_3	0·521	0·515	− 0·006	31·7	288	− 0·00013
P_2O_3 .. .	0·469	0·518	+ 0·049	?	295	+ ?
CO_2	0·833	0·769*	− 0·064	?	193	− ?

* Estimated volumes at melting temperature.

† Experiment gives the rise at the rate of 0·00525° between the pressures of 1 and 519 atmospheres. Between 519 and 729 the rate is only 0·00188°. This change is probably due to differences in the elasticity of the solid and fluid, and indicates that for very high pressures the rate may be reversed.

‡ Experimental determination—0·0078. Water is about twice as compressible as ice; the rate of rise should therefore increase with increasing pressure, particularly as the latent heat decreases with falling temperature.

dp the increased pressure is expressed in grams per sq. cm. One atmosphere is 1,033·4 grams per sq. cm.; in the table the value 1,000 grams has been adopted. As λ is in the denominator, and as it is believed to be very low for most minerals of the earth's crust, the value of $\frac{dt}{dp}$ will be large. Its sign is determined by the change of volume when melting. Its value will also vary with the pressure, unless the elasticity of the solid and the liquid are equal; it may even be reversed under high pressures.

The determination of these various values for quartz and other minerals is attended with great difficulty. Professor Joly, as already mentioned, measured the changing volume of basalt, augite and orthoclase. The apparatus consisted of a sheet of platinum, bent into a cylindrical shape and heated to definite temperatures by an electric current; a small bead of mineral about $\frac{1}{20}$ inch in diameter was suspended in the hollow, and its changing diameter with rising temperature was measured with a long-focus microscope. His results and those obtained by Mr. Barus on cooling diabase are plotted as curves in *Fig.* 2.

The upward bends in the temperature-volume curves is very marked; apparently they do not coincide with the melting points, which are stated to be 1,090 for the basalt specimen, and 1,190 (sticky) for the diabase. If only similar experiments could be made on quartz, the question whether the formation of granite can be explained by the influence of pressure on the melting point would speedily be settled. Unfortunately, quartz does not melt until 1,400°C has been reached, at which temperature the platinum electric furnace would collapse; besides, silica seems to act on platinum at high temperatures. Possibly Mr. Barus' method might lead to results. Should quartz possess the property, like ice, of contracting on fusion, then it would float on its fluid, or, like ice, would be slippery* when near its melting temperature, if rubbed by an even less fusible substance.

It has been known for many years that water enclosed in capillary tubes must be cooled considerably below 0°C. before it freezes, also that in polar regions rain or mist can

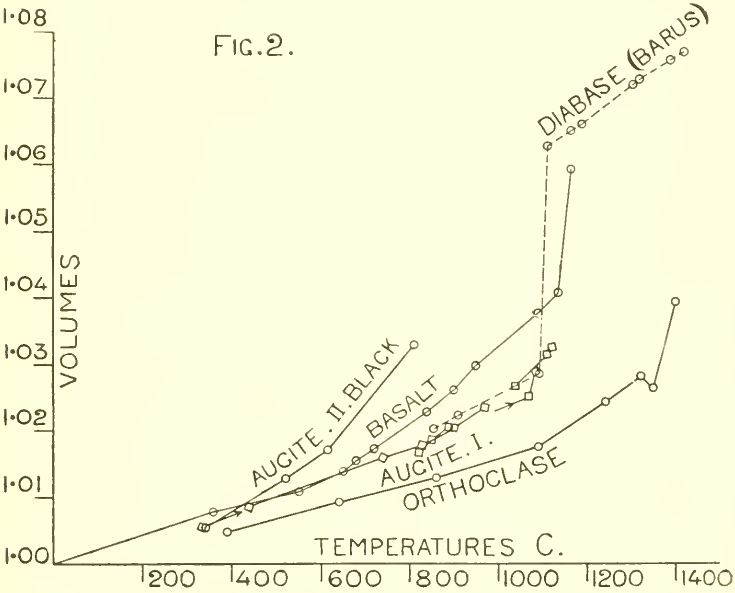
FIG. 2.

often exist in an atmosphere much colder than 0°C. without being converted into ice or snow, provided that the globules of rain or mist are sufficiently small. Clerk Maxwell also mentions seeing a rainbow in winter on a sheet of ice, due evidently to water globules lying on the ice. To my mind this phenomenon is due to the compressive action of the

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* Professor Osborne Reynolds on "The Slipperiness of Ice."—*Manchester Memoirs*, Vol. xliii., 1899. No. 5.

surface tension, and, although an estimate as to the internal pressure in one of these water globules, if only one hundred thousandth of an inch in diameter, could not account for a material lowering of freezing temperature, it must be remembered that surface tension is a misnomer when applied to very small bodies, and that in a small globule of the above size the molecular forces tending to compress it do not act only on its surface but also across its diameter.* In any case it is evident that when water is reduced to drops of very small diameter it behaves as if it were subjected to an enormous pressure, and lowers its freezing point considerably. We thus have a means of obtaining some information as to the influence of pressure on the melting temperature of minerals; all that is necessary is to measure the differences of the melting temperatures of small but different sized beads of minerals, and then ascertaining their diameters and shapes when cold. Possibly, too, the difference of density of the original specimens of minerals and of the resultant beads will show itself by affecting the melting temperature. All this could be done in Prof. Joly's Meldometer.

The determination of the latent heat of melting, another necessary element, should not be a very difficult matter, but it is unnecessary unless there is a good prospect of finding the changes of volume. The following concluding considerations as to the bearing of this suggestion will show its importance to geologists and mineralogists.

There exist amongst the porphyretic granites, quartz-porphyry in which the quartz crystals are large and the

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* Clerk Maxwell, in his article on "Capillary Action," in the *Ency. Brit.*, mentions that the molecular pressure for water is 5,000 atmospheres. If correct, then infinitely small water globules would not freeze until 40°C. has been reached.

matrix granular, and there are felspar porphyry in which the felspar crystals are large, indicating that in the one case the quartz crystallised first, in the other case the felspar ; this, again, implies that in the one case solidification took place nearer the earth's surface and under less pressure than in the other, and presents no difficulty if we bear in mind the great diversity amongst the earth's crust temperature gradients. Granite veins, as is well known, are in extreme cases either almost pure quartz, indicating that it was fluid and could force its way into cracks, while the already crystallised felspar remained behind, or these veins are fairly pure felspars—pegmatite veins—showing that the quartz to a great extent had crystallised first, and this again implies that in the one case the pressure was higher than in the other.

The chemical composition of granite seems to affect its mineralogical composition only partially. The felspars being silicates of alumina and potash, soda or lime ; the micas being silicates of alumina and potash, lithia or magnesia and iron ; the hornblendes being silicates of nearly all the above with or without iron protoxide and alumina, each of these minerals could be formed from one and the same molten rock if it contains all these ingredients. We find, however, that it is generally only one or two of these classes of minerals which occur together, and rarely (if ever) are the sub-classes mixed. It is, therefore, but natural to assume that it is not so much the chemical composition as the conditions of solidification, viz., pressure, temperature, and rate of cooling, which determine the mineralogical composition, except as regards quantities. See *British Petrology*, by J. J. H. Teall, 1888.

Two extreme conditions are conceivable.

I. The solid rock resting on molten granite is of a low specific gravity and would be a fairly bad conductor of heat ; the temperature gradient would in this case be a steep one, say 1°C. per 40 feet, the depth at which granite would commence to solidify would not be great, the pressure would not be great, and most probably the quartz would crystallise first, and then the felspars, etc., forming, say "quartz porphyry," provided, of course, that there is an excess of silica.

II. The rock resting on the molten granite is heavy, containing, say, much iron oxide, and would probaby be a good conductor of heat ; the temperature gradient would not be steep, say 1°C. per 200 feet. The depth at which the granite would commence to solidify would be much greater than in the above case and the pressure much greater, most probably the quartz would remain fluid long after the felspars had crystallised, forming, say, "felspar porphyry."

Every intermediate condition is now conceivable, and rocks in which quartz is missing, although the chemical analysis shows plenty of silica, have probably been formed under conditions where the melting points of quartz and the other minerals are almost equal.

Although we have as yet no experiments which throw light on this subject, and although it may perhaps be impossible to carry out really reliable ones, it is hoped that the possible influence which pressure exerts on the melting temperature of rocks, and therefore on the formation of their minerals, will permit of a rough classification on a somewhat more systematic plan than is now the case. In this respect, probably more would be learnt by a careful study of variations in a single large mass of granite than by comparing samples from different parts of the world ; and although our range, as regards depth of formation, is limited to at most 10 per cent. of the actual depth at which solidification may have taken place, there is at least a reasonable probability that marked differences of temperature existed on the same levels and in the same mass, the centres of the granite bosses remaining hotter, and therefore longer fluid, than the sides.

In any case the above suggestion removes two formidable barriers to further inquiries. If it is correct, there is no necessity to limit the temperature of granite formation, as suggested by Mr. Sorby, nor to assume that the earth's interior is solid.

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VIII. Notes on some Jurassic Plants in the Manchester Museum.

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(*Communicated by Professor F. E. Weiss, B.Sc., F.L.S.*)

Received and read January 23rd, 1900.

The late Professor Williamson's career as a student of Fossil Botany dates from the days of his boyhood when, in company with his father, John Williamson, he collected fossils from the Inferior Oolite rocks exposed in the cliff sections north and south of Scarborough. Several of the specimens which they discovered were forwarded to Prof. Lindley, accompanied by descriptive notes and drawings supplied by the younger Williamson, and afterwards reproduced in the classic "*Fossil Flora*," of Lindley and Hutton. Professor Williamson in his autobiography recalls how he prepared many of the drawings of the Yorkshire coast fossil plants "at one end of Mr. Weddell's kitchen-table, whilst the housekeeper was occupied at the other end with the several processes of providing the day's dinner."[1]

During recent visits to the Manchester Museum I have had an opportunity, through the courtesy of Mr. Hoyle, of examining the rich collection of Jurassic plants, among which were found several of the originals of Williamson's

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[1] Williamson (96) p. 36. The numbers in parentheses after an author's name refer to the year of publication of the work quoted, *e.g.* (96) = 1896; *vide* the Bibliography at the end of these notes.

May 4th, 1900.

drawings in the "*Fossil Flora.*" These figured specimens form part of the Williamson Collection, and are usually referred to by Lindley and Hutton as being "in the collection of Mr. Williamson."

In addition to these specimens, the Manchester Museum possesses numerous examples of Jurassic plants which throw fresh light on certain species included in the rich Flora from the Oolite rocks of the Yorkshire Coast. The following notes deal with the plants figured by Lindley and Hutton, and include descriptions of some other specimens worthy of mention as affording important data towards a more complete knowledge of Jurassic vegetation. A list is added of Inferior Oolite plants included in the Museum collections; many of the specimens are also referred to in a forthcoming British Museum Catalogue of Jurassic plants. The present communication deals only with Inferior Oolite species from the Gristhorpe plant-bed and other localities on the Yorkshire coast; it is proposed to give an account of other Jurassic plants in the Museum in a second paper.

1. *Specimens figured in the "Fossil Flora."*

Type specimen of pl. 168. *Sphenopteris arguta* L. & H.
= *Coniopteris hymenophylloides* (Brongniart[1]),
(No. 49 in the Manchester collection).

Type specimen of pl. 169. *Pecopteris dentate* L. & H.
= *Todites Williamsoni* (Brongn.), (Nos. 44 and 45).

Type specimen of pl. 155. *Otopteris cuneata* L. & H.
= *Sagenopteris Phillipsi* (Brongn.), var. *cuneata*
(No. 57).

Type specimen of pl. 92. *Tæniopteris major* L. & H.
= *Tæniopteris major* L. & H. (No. 13).

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[1] An author's name is enclosed in parentheses when the generic designation has been altered since the species was first described; *e.g.* Brongniart first described this species as *Sphenopteris hymenophylloides.*

Type specimen of pl. 194. *Zamites lanceolatus* L. & H. = *Podozamites lanceolatus* (L. & H.), (No. 321).

Original specimen of pl. 93. *Lycopodites Williamsonis* Brongn. = *Pagiophyllum Williamsoni* (Brongn.), (Nos. 16 and 48).

Original specimen of pl. 167. *Thuites expansus* Sternb = *Brachyphyllum mamillare* Brongn., (No. 52).

II. *Other specimens described in these notes.*

Ctenis sp. Pl. ii., figs. 3 and 4 (No. 53 in the Manchester collection).

Ginkgo digitata (Brongn.). Pl. ii., fig. 5 (No. 3).

Cladophlebis denticulata (Brongn.). Pl. iv., fig. 9 (No. 313).

Williamsonia pecten (Phill.). Pl. iii., fig. 6 (No. 33).

III. *Species of Inferior Oolite Plants from the Yorkshire coast represented in the Manchester Museum.*

PTERIDOPHYTA.

EQUISETALES.

Equisetites columnaris Brongn.

E. Beani (Bunb.). [This species is represented by the type-specimen (No. 88) of Bunbury,[1] which has since been figured by Gardner[2] as a possible example of a monocotyledonous stem—a suggestion made by Williamson—; and by myself under the name *Equisetites Beani*.[3]]

LYCOPODIALES.

Lycopodites falcatus L. & H.

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[1] Bunbury (51).

[2] Gardner (86).

[3] Williamson (83); Seward (98).

FILICALES.

Laccopteris polypodioides (Brongn.).
L. Woodwardi (Leck).
Todites Williamsoni (Brongn.).
Klukia exilis (Phill.).
Coniopteris hymenophylloides (Brongn.).
C. quinqueloba (Phill.).
C. arguta (L. & H.).
Dictyophyllum rugosum L. & H. [Specimen No. 27 shows the form of branching of this frond unusually well.]
Cladophlebis denticulata (Brongn.).
C. lobifolia (Phill.).
Tæniopteris vittata (Brongn.).
T. major L. & H.
Sagenopteris Phillipsi (Brongn.).
S. Phillipsi var. *major.*
S. Phillipsi var. *cuneata.*

GYMNOSPERMÆ.

CYCADALES.

Williamsonia gigas (L. & H.).
W. pecten (Phill.).
Otozamites Beani (L. & H.).
O. Bunburyanus Zigno.
O. graphicus (Leck.).
Ctenis falcata L. & H.
Podozamites lanceolatus (L. & H.).
Anomozamites Nilssoni (Phill.).
Nilssonia tenuinervis Nath.
N. compta (Phill.)
N. mediana (Leck.)

CONIFERÆ.

Brachyphyllum mamillare Brongn.
Pachyphyllum Williamsoni (Brongn.).

Cryptomerites divaricatus Bunb.
Taxites zamioides (Leck).
Cheirolepis setosus (Phill.).
Araucarites Phillipsi Carr.
Czekanowskia Murrayana (L. & H.).

GINKGOACEÆ.

Ginkgo digitata (Brongn.).
Baiera gracilis Bunb.
B. Phillipsi Nath.
B. Lindleyana (Schimp.).
Beania gracilis Carr.

I. *Specimens figured in the "Fossil Flora" of Lindley and Hutton.*

A. FILICALES.

Coniopteris hymenophylloides (Brongniart).

Text-figure 1. (Specimen No. 49.) Type-specimen. Original of pl. clxviii., *Fossil Flora*, 1835.

1828. *Sphenopteris hymenophylloides*, Brongniart. *Hist. Vég. Foss.*, p. 189, pl. lvi., fig. 4.
Pecopteris Murrayana, ibid., p. 358, pl. cxxvi., fig. 5.
1829. *Sphenopteris stipata*, Phillips, *Geol. Yorks.*, p. 47, pl. x., fig. 8.
S. muscoides, ibid., p. 153, pl. x., fig. 10.
1835. *Sphenopteris arguta*, Lindley and Hutton, *Foss. Flora*, pl. clxviii.
Tympanophora simplex, ibid., pl. clxx. A.
T. racemosa, ibid., pl. clxx. B.
1836. *Hymenophyllites Phillipsi*, Göppert, *Foss. Farrn.*, p. 256.
1848. *Hymenophyllites Phillipsi*, Bronn, *Index Pal.*, p. 602.
1849. *Coniopteris Murrayana* (pars), Brongniart, *Tableau*, p. 105.

1851. *Sphenopteris nephrocarpa*, Bunbury, *Quart. Journ. Geol. Soc.*, vol. vii., p. 179, pl. xii., figs. 1*a* and 1*b*.

1873. *Sphenopteris Pellati*, Saporta, *Pal. Franç.*, vol. i., pl. xxxi., fig. 1, p. 278.

1875. *Sphenopteris affinis*, Phillips, *Geol. Yorks.*, p. 213, lign. 30,

S. dissocialis, *ibid.* p. 214, lign. 32.

1876. *Thyrsopteris Murrayana*, Heer, *Flora Foss. Arct.*, vol. iv. (ii.), p. 30, pl. i., fig. 4; pl. ii., figs. 1-4; pl. viii., fig. 11*b*.

T. maakiana, *ibid.*, p. 31, pl. i., figs. 1-3, and figs. 5 and 6.

1878. *Dicksonites clavipes*, *ibid.*, vol. vii., p. 33, pl. ii., fig. 7.

1892. *Dicksonia Heerii*, Raciborski, *Flora Krakow.*, p. 174, pl. x., figs. 5-14.

D. zareczny (pars), *ibid.*, p. 175, pl. xii., figs. 8, 9, 11, and 12.

Fig. 1. *Coniopteris hymenophylloides* (Brongn.). (nat. size).

It is extremely difficult to decide how best to deal with the numerous examples of Sphenopteroid fronds afforded by the Yorkshire plant-bearing strata; they are abundantly represented in the Inferior Oolite Flora, and exhibit considerable variations as regards both the sterile and fertile segments. The wide range of variation suggests the presence of several species of closely allied ferns, but, on the other hand, the more extreme forms are connected by numerous intermediate examples, and it seems practically hopeless to separate the various types into species distinguished by well-defined characteristics.

The type-specimen of *Sphenopteris arguta* L. & H., was found at Gristhorpe and sent to the authors of the *Fossil Flora* "by Mr. Williamson, junior," who added a description of the specimen, and expressed his opinion that the fern was distinct from *Sphenopteris hymenophylloides* Brongn. and *S. stipata* Phill. As shown in fig. 1, the specimen, which is on the whole accurately represented in Williamson's drawing (*Fossil Flora*, pl. clxviii.), consists of a portion of a pinna 5·5 cm. long; the axis is slightly winged, and bears cuneate pinnules, with a deeply dissected lamina; the ultimate segments are acuminate and entire or more or less deeply lobed. The venation, which is indistinctly shown, is of the *Sphenopteris* type.

I have adopted the name *Coniopteris* in place of *Sphenopteris*, on the ground that the fertile specimens of this Jurassic species, in which *S. arguta* L. and H. is included, enable us to assign the plant to a definite family of ferns—the Cyatheaceæ. Brongniart[1] proposed the generic term *Coniopteris* for ferns possessing characters intermediate between *Pecopteris* and *Sphenopteris*, and which agree in the form of the sori with the recent Dicksoniæ. The specimen figured by Lindley and Hutton is of the *Sphenopteris* type, but the sori point to a close affinity with Cyatheaceous ferns. Solms-Laubach[2] has also advocated the application of Brongniart's genus

[1] Brongniart (49), p. 26.

[2] Solms-Laubach (91), p. 157.

Coniopteris to some of the Jurassic species of ferns in preference to the use of recent generic names such as *Dicksonia* or *Thyrsopteris.* An examination of a large number of specimens of Lower Oolite Sphenopteroid fronds has led me to include *Sphenopteris arguta* of Lindley and Hutton, and several other 'species,' as synonyms of *Coniopteris hymenophylloides* (Brongn.). To discuss fully the reasons for using Brongniart's specific designation in the comprehensive sense in which I have employed it would extend these notes beyond reasonable limits, the main object of this paper being to draw attention to certain important specimens in the Manchester Museum, and to express opinions as to their systematic position.

Todites Williamsoni (Brongniart).

Pl. i., figs. 1 and 2.[1]

Type-specimens of pl. clxix., figs. 1 and 2 (Nos. 44 and 45).

1828. *Pecopteris Williamsonis*, Brongniart, *Hist. Vég. Foss.*, p. 324, pl. cx., figs. 1, 2.
    P. Whitbiensis, *ibid.*, pl. cix., figs. 2-4.
    P. tenuis, *ibid.*, p. 322, pl. cx. figs. 3, 4.

1829. *Pecopteris recentior*, Phillips, *Geol. Yorks.*, p. 148, pl. viii. fig. 15.
    ? *P. hastata*, *ibid.*, pl. viii., fig. 17.
    P. curtata, *ibid.*, p. 148, pl. viii., fig. 12.

1833. *Neuropteris recentior*, Lindley and Hutton, *Foss. Flora*, pl. lxviii.
    Pecopteris Williamsonis, *ibid.*, pl. cxxvi.

1835. *Pecopteris dentata*, *ibid.*, pl. clxix.

1836. *Acrostichites Williamsonis*, Göppert, *Foss. Farrn.*, p. 285.
    Alethopteris dentata, *ibid.*, p. 306.

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[1] The upper figure in Pl. i. is referred to as fig. 1.

1849. *Clodophlebis dentata*, Brongniart, *Tableau*, p. 105.
C. Williamsonis, *ibid.*, p. 105.
C. recentior, *ibid.*, p. 105.
C. tenuis, *ibid.*, p. 105.
C. Whitbiensis, *ibid.*, p. 105.
1854. *Pecopteris Huttoniana*, Morris, *Cat. Brit. Foss.*, p. 15.
1856. ? *Dichopteris microphylla*, Zigno, *Flora Foss. Oolit.*, vol. i., p. 122, pl. xv., fig. 5.
1869. *Pecopteris* (*Acrostichites*) *Williamsoni*, Schimper, *Traité Pal. Vég.*, vol. i., p. 528.
1884. *Todea Williamsonis*, Schenk, *Palæontographica*, vol. xxxi., p. 168, pl. iii., fig. 3.
1889. *Cladophlebis Virginiensis*, Fontaine, *Potomac Flora*, p. 70, pl. iii., figs. 3-8 ; pl. iv., figs. 1 and 4.
C. parva, *ibid.*, p. 73, pl. vi., figs. 1-3.
C. distans, *ibid.*, p. 77, pl. xiii., fig. 4.
1889. *Asplenium Whitbiense*, Yokoyama, *Journ. Coll. Sci. Japan*, vol. iii., p. 32, pl. iii., fig. 3.

The identification of the numerous examples of bipinnate fern fronds of the *Cladophlebis* type afforded by the Yorkshire coast plant-beds is a difficult task, owing to the considerable variation in the size and form of the pinnules and the confused state of the nomenclature. It is evident that the earlier authors multiplied unnecessarily the number of specific names, and the confusion is rendered worse by the fact that the same specific name has occasionally been employed by different writers for species which are no doubt distinct. As an example of the application of the same name to distinct species, it may be noted that the fern which Brongniart named *Pecopteris Whitbiensis* is in all probability distinct from that which Lindley and Hutton referred to that species. *Pecopteris Whitbiensis*[1], as figured in the "*Fossil Flora*," is, I believe,

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[1] The type-specimen of Lindley and Hutton has not been found in the Manchester collection.

identical with *P. denticulata* of Brongniart. The specimens referred by Phillips and by Lindley and Hutton to *Pecopteris recentior* differ from Brongniart's *P. Williamsonis* in their larger and longer pinnules, but an examination of several large fronds in various collections has convinced me of the identity of the two forms.

The specimen shown in pl. i., fig. 1 [=pl. clxix. (upper figure) of Lindley and Hutton] has a length of 7 cm., and represents the apical portion of a frond bearing linear pinnæ with crowded deltoid and slightly falcate pinnules, having a serrated margin. In the larger pinnules there is a fairly well marked midrib, from which are given off forked and spreading lateral veins. Williamson's drawing gives a fairly accurate idea of the specimen, but the pinnules are broader and less sharply pointed than as shown in the figure given by Lindley and Hutton. The type-specimens were obtained by Williamson from Gristhorpe Bay, and forwarded to Lindley with a descriptive note, in which they are compared with *Pecopteris Whitbiensis*, *P. hastata*, *P. ligata*, and *P. denticulata*.

In the specimen represented in pl. i., fig. 2, the rachis measures 9·5 cm. in length, and 2 mm. in breadth. The pinnæ, of which portions only are preserved, have the same uniform breadth as in the example shown in fig. 1; the pinnules are closely set and approximately at right angles to the pinna axis, and are linear and slightly falcate with a serrate apex, which points towards the tip of the pinna. In Williamson's drawing the pinnules are somewhat inaccurately represented; they are characterised by a more deeply concave outer margin, and a more convex inner margin than the drawing in the *Fossil Flora* indicates. The lateral veins are given off from the midrib at a more acute angle than as shown in the drawing.

The most striking features in the two specimens (pl. i., figs. 1 and 2) are the long linear pinnæ and the erect falcate and comparatively broad pinnules.

Both specimens are undoubtedly portions of the same species, which I believe to be identical with *Pecopteris Williamsonis* of Lindley and Hutton. Fertile specimens of this species are fairly common, but it is rare to find examples in which the nature of the sporangia can be accurately determined. It has been clearly shown, however, by Schenk and Raciborski, that the sporangia agree, both in their manner of occurrence and structure, with those of the Osmundaceæ. An excellent specimen of this species in the Leckenby collection, Cambridge (Woodwardian Museum), enables me to confirm the conclusions of these authors. The generic name, *Todites*, is adopted as a more suitable designation than the recent genus *Todea*, which some authors have used. In the form of the frond, and in the shape of the pinnules, the fossil fern agrees with *Cibotium Barometz* Link, but the character of the sporangia demonstrates that *Todites Williamsoni* must be included in the family Osmundaceæ. It is to Schenk[1] and Raciborski[2] that we are indebted for accounts of the sporangia; the former author published a figure of a fertile pinnule in his paper on the plants collected by Szeckenyi in China, and Raciborski afterwards published additional figures confirmatory of Schenk's account. Raciborski's figures should be consulted as the best evidence so far adduced in proof of the affinity of this Jurassic fern.

Sagenopteris Phillipsi (Brongniart).

Pl. iii., figs. 7 and 8.

Fig. 7 = Type-specimen of *Otopteris cuneata* L. & H., pl. clv. (No. 57).

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[1] Schenk (85).

[2] Raciborski (91) and (94).

1828. *Glossopteris Phillipsi*, Brongniart, *Hist. Vég. Foss.*, p. 225, pl. lxi*bis.*, fig. 5 ; pl. lxiii., fig. 2.

1829. *Pecopteris paucifolia*, Phillips, *Geol. Yorks.*, p. 148, pl. viii., fig. 8.

1833. *Glossopteris Phillipsi*, Lindley & Hutton, *Foss. Flora*, pl. lxiii.

1835. *Otopteris cuneata*, *ibid.*, pl. clv.

1836. *Acrostichites Phillipsi*, Göppert, *Foss. Farrn.*, p 286.
Adiantites irregularis, *ibid.*, p. 385.

1838. *Tæniopteris Phillipsii*, Sternberg, *Flora d. Vorwelt*, fasc. vii , p. 140.
Sagenopteris Phillipsii, *ibid.*, p. 165.
Cyclopteris cuneata, *ibid.*, p. 135.

1849. *Phyllopteris Phillipsii*, Brongniart, *Tableau*, p. 105.

1851. *Sagenopteris cuneata*, Bunbury, *Quart. Journ. Geol. Soc.*, vol. vii., p. 184.

1894. *Sagenopteris Goeppertiana*, Raciborski, *Flora Krakow.*, p. 214, pl. xx., figs. 14-18.

There is abundant evidence that *Sagenopteris Phillipsi* (L. & H.) is a species characterised by a considerable variation in the form and number of the leaflets. The specimen represented in pl. iii. fig. 7, to which Lindley and Hutton gave the name *Otopteris cuneata*, differs considerably from the examples figured by these authors as *Glossopteris Phillipsi*, but the difference is hardly sufficient to warrant the specific separation of the two forms of leaf. In 1851 Bunbury discussed at some length the affinities of *Otopteris cuneata* L. & H., and expressed the view that this type "is merely an imperfect or abnormal state—probably a seedling—of *Sagenopteris Phillipsi*." In the third edition of Phillips' *Geology of the Yorkshire Coast*, it is also suggested the small cuneate form may be specifically identical with *Sagenopteris Phillipsi*.

The specimens from Gristhorpe Bay figured by Lindley and Hutton in their pl. clv. were drawn and described by Williamson, who considered them to be examples of the genus *Glossopteris* ; but the authors of the *Fossil Flora* considered the absence of a midrib indicative of an affinity with their species *Otopteris Beanii.*

Fig. 2, pl. clv. of the *Fossil Flora* (refigured in pl. iii., fig. 7) represents a specimen consisting of a stalk 1 cm. in length, bearing two terminal leaflets 1·4 cm. long. The stalk is comparatively broad and winged, and the lamina of the obcuneate leaflets is traversed by numerous branched and anastomosing veins, which are rather fewer in number than in Williamson's drawing.

Although it is practically impossible to decide the question of identity of *Sagenopteris Phillipsi* L. and H. and *Otopteris cuneata* L. and H., I am inclined to agree with Bunbury that it is at least reasonable to suppose that both forms of leaf were borne by the same species. Evidence of the variation of leaf-form displayed by this genus is furnished by the numerous specimens in the British and other museums ; the leaflets vary in size, in the proportion of length to breadth, and in the distinction or prominence of a midrib. Again, in the series of figures of the Rhaetic species *Sagenopteris rhoifolia* (Presl),[1] and in the drawings published by Zigno[2] and Nathorst[3] of species of this genus, we have abundant proof of the variability displayed by the leaflet. It may be a convenience to refer to such specimens as that shown in fig. 5, pl. i., as *Sagenopteris Phillipsi* var. *cuneata.*

Pl. iii., fig. 8 (No. 310). This specimen represents an imperfect leaf, 10 cm. in length, terminating distally in a

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[1] Schenk (67).

[2] Zigno (56).

[3] Nathorst (78-86).

bluntly rounded apex, and gradually tapering towards the base. There is a fairly distinct midrib, which gradually breaks up in the apical portion of the lamina into oblique anastomosing veins. The lateral veins are of the *Glossopteris* type, and frequently anastomose with one another as they pass upwards and outwards towards the margin of the lamina. In the later edition of Phillips' *Geology of the Yorkshire Coast*, and in the more recent notes by Nathorst on Jurassic plants from English localities, there is a reference[1] to a large form of *Sagenopteris* represented in the Leckenby collection and elsewhere, which agrees closely with the plant described by Zigno as *Sagenopteris Goeppertiana*. The example shown in fig. 8 is one of the best specimens I have seen of this large type of leaf; it is considerably larger than the type-specimens of *S. Phillipsi* of Lindley and Hutton, but examples are not wanting which enable us to construct a series illustrating the gradual passage from smaller and narrower to larger and broader leaves. It is, I believe, the better plan to regard such specimens as that shown in fig. 8 as specifically identical with the more typical examples of *Sagenopteris Phillipsi*, and to refer to them as *S. Phillipsi* var. *major*.

Tæniopteris major Lindley & Hutton.

Type-specimen of pl. xcii., Lindley & Hutton (No. 13).

1833. *Tæniopteris major*, Lindley & Hutton, *Foss. Flora*, pl. xcii.

1836. *Aspidites Williamsonis*, Göppert, *Foss. Farrn.*, p. 353.

1856. *Tæniopteris Williamsonis*, Zigno, *Flora Foss. Oolit.*, vol. i, p. 205.

1869. *Macrotaeniopteris major*, Schimper, *Traité Pal. Vég.*, vol, i., p. 610.

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[1] Nathorst (80).

The specimen on which Lindley & Hutton instituted their species was found by Williamson in the Gristhorpe plant-bed, and sent by him with a drawing and descriptive notes to the authors of the "*Fossil Flora*"; it has a length of 11 cm. and is 5·5 broad at the widest end. The lateral veins, which are very clearly shown, are almost at right angles to the midrib, and dichotomise as they pass to the edge of the lamina. Williamson's drawing is fairly accurate, but the specimen is less perfect than the figure representing it. On the same piece of rock there is a specimen of *Pagiophyllum Williamsoni* (Brongn.) and a piece of *Nilssonia compta* (Phill.).

The distinction between *Tæniopteris vittata* and *T. major* is not very well defined, but it is perhaps better to confine the specific designation *vittata* to the longer and narrower fronds, and to distinguish the broader form as *T. major*.

Nathorst has suggested that *Tæniopteris major* may represent an entire leaf of *Anomozamites Nilssoni* (Phill.), a species characterised by the possession of a lamina divided into segments of unequal size, but this is, I think, improbable; the latter species seems to be distinct and characterised both by the divided lamina and by the venation.

B. GYMNOSPERMÆ.

Podozamites lanceolatus (Lindley and Hutton).

Type-specimen of pl. cxciv., Lindley and Hutton.

(No. 321.)

1836. *Zamites lanceolatus*, Lindley and Hutton, *Foss. Flora*, pl. cxciv.

1870. *Podozamites lanceolatus*, Schimper, *Traité Pal. Vég.*, p. 160.

1896. *Podozamites Schenki*, Hartz, *Med. Grönl.*, vol. xix., pl. xiii., figs. 2 and 7.

This type-specimen was obtained by Williamson from Haiburn Wyke, and presented with a drawing and brief description to Lindley; it is described by the former as "no doubt produced by some one of the Cycadeoideous stems of the Oolitic rocks." The rachis is 13 cm. in length, bearing irregularly disposed linear pinnæ, about 7 mm. broad, attached by a narrow base. The longest pinna measures 7 cm. in length, and tapers gradually to an acuminate apex, but becomes suddenly narrow towards the basal end; a few of the pinnæ appear to be laterally attached to the rachis, with a slightly decurrent lower margin, but in one or two of the pinnæ the attachment appears to be rather on the upper face of the rachis. The veins are numerous and parallel, as in the Cycadean genus *Zamites*. The specimen is not sufficiently well preserved to enable us to determine the exact manner of attachment of the pinnæ, and it is very doubtful if all of them are shown in their original position. It is probable that the pinnæ of this species were deciduous and separated from the rachis by a definite separation surface, and this circumstance adds to the danger of assuming that the leaflets are all in their original positions.

Zamites lanceolatus, or, as it is more usually designated by recent writers, *Podozamites lanceolatus*, is probably the frond of a Cycadean plant, but it is by no means impossible that it may be a twig of a Conifer similar to *Agathis australis* Salisb. of New Zealand.

Pagiophyllum Williamsoni (Brongniart).

Original specimens of pl. xciii., figs. 1 and 2. (Nos. 16 and 48).

1828. *Lycopodites Williamsonis*, Brongniart, *Prodrome*, p. 83.

1829. *Lycopodites uncifolius*, Phillips, *Geol. Yorks.*, p. 147, pl. viii., fig. 3.

1833. *Lycopodites Williamsonis*, Lindley and Hutton, pl. xciii.

1848. *Walchia Williamsonis*, Bronn, *Index Pal.*, p. 1374.

1849. *Palissya? Williamsonis*, Brongniart, *Tableau*, p. 106.

1870. *Pachyphyllum Williamsoni*, Schimper, *Traité Pal. Vég.*, vol. ii., p. 251.

1890. *Araucaria Williamsoni*, Schenk, in Zittel's *Handb. Pal.*, p. 280.

The original of pl. cxiii., fig. 1, of Lindley and Hutton, is much less perfect than Williamson's drawing represents it, but the general features are faithfully shown. The specimen has a length of 13·5 cm., the main axis bears several lateral branches given off at an acute angle, clothed with numerous spirally-disposed, angular and strongly-incurved leaves. The form of the leaves is very similar to that of the leaves of the Norfolk Island pine (*Araucaria excelsa* R. Br.)

The original of pl. cxiii., fig. 2, consists of a branch 4·8 cm. in length, terminating in an imperfectly preserved cone, which is much less perfect than as represented in the drawing. The cone consists of a central axis, bearing crowded imbricated scales with broadly acuminate distal ends. The leaves borne on the branch agree with those on the larger specimen (pl. xciii., fig. 1), and resemble the thick and curved leaves of *Araucaria excelsa.*

Brachyphyllum mamillare.

Original of pl. clxvii., Lindley & Hutton (No. 52).

1828. *Brachyphyllum mamillare*, Brogniart, *Prodrome*, p. 109.

1829. *Thuites expansus*, Phillips, *Geol. Yorks.*, pp. 147, 153, pl. x., fig. 11.

1835. *Thuites expansus*, Lindley & Hutton, *Foss. Flora*, pl. clxvii.

1876. ? *Echinostrobus (Thuites) expansus*, Feistmantel, *Jur. Flora Kach*, pl. ix., figs. 6-9.

The specimen from the Gristhorpe plant-bed, which is figured by Lindley and Hutton as *Thuites expansus*, is, I have no doubt, specifically identical with the plant which these authors represent in plates clxxxviii. and ccxix. as *Brachyphyllum mamillare.* The specimen has a length of 9·5 cm., and represents an imperfectly preserved twig, bearing short lateral branches clothed with spirally disposed and fleshy broadly triangular scale-leaves, closely adpressed to the axis. Each leaf terminates in a sharp point, and is traversed on the ab-axial surface by a fairly prominent median ridge.

II. *Other specimens in the Manchester Museum.*

A. FILICALES.

Cladophlebis denticulata, Brongniart.
Pl. iv., fig. 9. (No. 313.)

1828. *Pecopteris denticulata*, Brongniart, *Hist. Vég. Foss.*, p. 301, pl. xcviii., figs. 1 and 2.
P. Phillipsii, *ibid.*, p. 304, pl. cix., fig. 1.
Phlebopteris undans, *ibid.*, p. 375, pl. cxxxiii., fig. 3.

1829. *Pecopteris ligata*, Phillips, *Geol. Yorks.*, p. 148, pl. viii., fig. 14.

1833. *Neuropteris ligata*, Lindley and Hutton, *Foss. Flora*, pl. lxix.

1834. *Pecopteris insignis*, *ibid.*, pl. cvi.
P. Whitbiensis, *ibid.*, pl. cxxxiv.
P. undans, *ibid.*, pl. cxx.

1836. *Polypodites undans*, Göppert, *Foss. Farrn.*, p. 345.
Alethopteris insignis, *ibid.*, p. 307.
Neuropteris ligata, *ibid.*, p. 205.
Alethopteris Phillipsii, *ibid.*, p. 304.
1849. *Cladophlebis ligata*, Brongniart, *Tableau*, p. 105.
1882. *Pteris frigida*, Heer, *Flora Foss. Arct.*, vol. vi., p. 27, pl. x., pp. 1-4; pl. xi.; pl. xii., fig. 2; pl. xiii., fig. 2; pl. xvi., figs. 1 and 2.
P. longipennis, *ibid.*, pl. x., figs. 11 and 12; pl. xiii., fig. 1.
P. ligata, *ibid.*, pl. xvi., fig. 3.
1889. *Cladophlebis denticulata*, Fontaine, *Potomac Flora*, p. 71, pl. vii., fig. 7.
1896. *Cladophlebis Stewartiana*, Hartz, *Med. Grönl.*, vol. xix., p. 231, pls. xi. and xii.

The specimen shown in pl. iv., fig. 9, is an unusually perfect and well-preserved pinna, 12 cm. in length, bearing linear falcate pinnules, of which the longest has a length of 2·7 cm.; each pinnule has a well-marked midrib, from which are given off numerous forked lateral veins; the apex of the lamina is finely serrate.

The example in the Manchester collection agrees exactly with the larger specimen figured by Lindley and Hutton as *Pecopteris insignis*, and this I regard as identical with the English fern which Brongniart named *Pecopteris denticulata*; Nathorst has suggested that the fragment figured by Lindley and Hutton as *Pecopteris undans*, and referred to by other authors as *Phlebopteris undans*, may be a fertile pinna of *P. denticulata*. An examination of several examples of *P. undans* enables me to confirm Nathorst's opinion, but any discussion of the complex synonymy of the present species must be reserved for the more detailed description of the Jurassic plants, which will be published in a forthcoming British Museum Catalogue.

B. CYCADALES.

Williamsonia pecten (Phillips).

Pl. iii., fig. 6 (No. 33).

1829. *Cycadites pecten*, Phillips, *Geol. Yorks.*, p. 148, pl. vii., fig. 22.

C. pectinoides, *ibid.*, p. 125, pl. x., fig. 4.

1834. *Pterophyllum pecten*, Lindley and Hutton, *Foss. Flora*, pl. cii.

1849. *Zamites pecten*, Brongniart, *Tableau*, p. 106.

Otozamites Goldiaei, *ibid.*, p. 106.

1854. *Palaeozamia pecten*, Morris, *Brit. Foss.*, p. 15.

1864. *Palaeozamia hastula*, Leckenby, *Quart. Journ. Geol. Soc.*, vol. xx., p. 77.

Otopteris lanceolata, *ibid.*, p. 78, pl. viii., fig. 4.

1870. *Ctenophyllum pecten*, Schimper, *Traité Pal. Vég.*, vol. ii., p. 144.

Williamsonia pecten, Carruthers, *Trans. Linn. Soc.*, vol. xxvi., p. 694.

1875. *Otozamites gracilis*, Phillips, *Geol. Yorks.*, p. 224. lign. 52.

The specimen shown in fig. 6, pl. iii., has been chosen for illustration as it represents a good example of this common type of Lower Oolite Cycadean plant, which differs in some respects from the better-known form of the species. The portion of frond seen in the photograph has a length of 14·5 cm., and is 4 cm. broad in the widest part. The rachis bears crowded linear pinnæ attached to its upper surface; each pinna tapers to an asymmetrically pointed distal end, the upper margin is practically straight up to the tip, but the lower margin bends suddenly upwards at the apex. The upper edge of the base of the pinnæ is slightly lobed or auriculate. The veins are spreading from the base, but preserve an approximately parallel course slightly oblique to the upper margin throughout the great part of each pinna.

The abundance of specimens of this form of Cycadean frond in the museums of London, Manchester, Scarborough, and elsewhere, enables us to recognise a considerable range in the size and shape of the pinnæ. There is another specimen (No. 326) in the Manchester collection which represents a somewhat different form of frond, also, I believe, to be referred to Phillips' species. In some of the specimens of *Williamsonia pecten* the base of the pinnæ shows no indication of any broadening or auriculation; but in the specimen shown in fig. 6 the upper margin of base is slightly auriculate, and this character is still more pronounced in the larger frond, No. 326.

The Indian fronds, usually referred to a distinct genus, *Ptilophyllum*, are, in many cases, I believe, generally if not specifically identical with the English specimens. I have arrived at this conclusion as the result of an examination of some specimens figured by Morris in a memoir by Grant, "to illustrate a geological map of Cutch," and now in the museum of the Geological Society, and by comparing several other Indian specimens in the British Museum with the Yorkshire coast fronds. Evidence in support of this opinion will be more fully set forth in the forthcoming British Museum Catalogue.

Ctenis, sp.

Pl. ii., figs. 3 and 4 (No. 53).

1880. *Anthrophyopsis*, nov. sp., Nathorst, *Berätt. Resa Engl.*, pp. 43, 62, and 83.

In his valuable notes on specimens of Jurassic plants in English Museums Nathorst refers to a fossil in the Manchester Museum, which reminded him of *Anthrophyopsis Nilssoni*, a species described by him from Scania. The specimen mentioned by the Swedish palaeobotanist is no doubt that shown in fig. 4, which was found at Claughton Wyke; it represents an imperfect leaflet or pinna, 9 cm. long and 2·6 cm. wide, with prominent irregularly parallel and anastomosing veins. The substance of the leaflet must have been fairly stout; it is represented in the fossil by a brittle brown lamina which readily separates from the shale, and under a low magnifying power presents a finely punctate appearance. On the back of the specimen Prof. Williamson has written, "Probably an *Anthrophyopsis* of Nathorst." In a later memoir on the Flora of Bjuf, Nathorst[1] refers the plants previously included by him in the genus *Anthrophyopsis* to the older genus *Ctenis* of Lindley and Hutton, and there is little doubt that this designation is more correct. In a recent paper on fossil *Ctenis* species, Staub[2] adopts the generic term *Ctenis* for Nathorst's Scanian specimens, originally placed under *Anthrophyopsis*.

In fig. 3 a portion of the epidermis (lower?) of the pinna is represented to show the form of the epidermal cells; the straight or slightly curved walls agree with those of the epidermal cells of most recent cycads, and differ from the undulating walls which are usually met with in the leaves of ferns. Each epidermal cell in the fossil pinna is characterised by the presence of a central papilla in the outer wall, which in surface-view presents the appearance of a spherical nucleus. A few of these papillæ are shown in surface view in fig. 3A, P. A side-view of the cells at once reveals the true nature of these nucleus-like bodies, and shows that each cell possesses a fairly prominent central papilla (fig. 3B). It is these papillæ which give to the specimen its finely punctate form, as seen under a low magnifying power. A surface view of

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[1] Nathorst (78-86).

[2] Staub. (96).

the epidermis demonstrates also the occurrence of stomata (S, fig. 3), which appear to have been situated below the level of the epidermis. The longer cells represented in the lowest part of fig. 3A, illustrate the form of the epidermal elements situated immediately above the veins.

The specimen in the Manchester Museum is clearly distinct from the well-known Lower Oolite species, *Ctenis falcata* L. and H., but it hardly affords sufficient data for the institution of a new specific name; we may refer to it as *Ctenis* sp., cf. *Ctenis fallax* Nath.

C. GINKGOACEÆ.

Ginkgo digitata (Brongniart).

Pl. ii., fig. 5 (No. 3).

1828. *Cyclopteris digitata*, Brongniart, *Hist. Vég. Foss.*, p. 219, pl lxi*bis.*, figs. 2 and 3.

1829. *Sphenopteris latifolia*, Phillips, *Geol. Yorks.*, p. 148, pl. vii., fig. 18.

1833. *Cyclopteris digitata*, Lindley and Hutton, *Foss. Flora*, pl. lxiv.

1836. *Adiantites digitatus*, Göppert, *Foss. Farrn.*, p. 217.
A. Huttoni, *ibid.*, p. 217.

1843. *Baiera digitata*, Braun, in Münster's *Beitr. Petrefact.*, p. 21.
B. Huttoni, *ibid.*, p. 21.

1868. *Cyclopteris incisa*, Eichwald, *Leth. Ross.*, pl. iv., fig. 6.

1877. *Ginkgo digitata*, Heer, *Flora Foss. Arct.*, vol. iv. (i.), p. 40, pl. viii., fig. 1A; pl. x., figs. 1-6.
G. Huttoni, *ibid.*, p. 43, pl. x., fig. 10, *etc.*

1878. *G. integriuscula*, *ibid.*, vol. v., ii., p. 25, pl. vi. figs. 5 and 6.

1884. *Salisburia digitata*, Saporta, *Pal. Franç.*, vol. iv., p. 294, pl. clx., figs. 1-5.
S. Huttoni, *ibid.*, p. 299, pl. clix., figs. 4 and 5; pl. clx., fig. 8.

I have been led to include *Cyclopteris Huttoni* Sternb. and some other 'species' under *Ginkgo digitata* as the result of an examination of the leaves of the solitary recent species *Ginkgo biloba* L., which show considerable variation in the form and dissection of the lamina; a careful comparison of numerous Jurassic specimens has convinced me that it is impossible to found satisfactory specific distinctions on the depth or number of the segments into which the lamina is divided.[1]

The specimen represented in pl. ii., fig. 5, affords an interesting example of this species of *Ginkgo*, which had a wide geographical range in the Jurassic period. This leaf is larger than the majority of the English specimens, and agrees fairly closely with a specimen described by Eichwald, from Russia, as *Cyclopteris incisa;* it measures 8 cm. across, and the lamina is divided into several short and comparatively broad lobes.

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[1] An account of the structure and geological history of *Ginkgo biloba* L. is published in the *Annals of Botany*, March, 1900.

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EXPLANATION OF PLATES.

PLATE I. *Todites Williamsoni* (Brongn.) (nat. size).

Fig. 1. (upper figure) Specimen No. 45 (Williamson Collection, Manchester Museum).

,, 2. (lower figure) Specimen No. 44 (Williamson Collection, Manchester Museum).

PLATE II.

Fig. 3. *Ctenis.* A surface-view of a piece of the epidermis; S = stomata; P = papillæ. B. Epidermal cells in side-view (× 120) No. 53.

Fig. 4. *Ctenis* (nat. size) No. 53.

,, 5. *Ginkgo digitata* (Brongn.) (nat. size) No. 3.

PLATE III.

Fig. 6. *Williamsonia pecten* (Phill.) (nat. size) No. 33.

,, 7. *Sagenopteris Phillipsi* (Brongn.) (nat. size) No. 57.

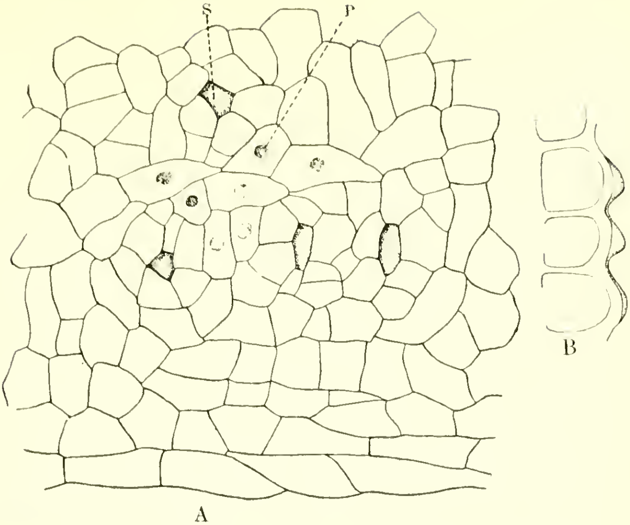
,, 8. ,, ,, ,, ,, No. 310.

PLATE IV.

Fig. 9. *Cladophlebis denticulata* (Brongn.) (nat. size) No. 313.

TODITES WILLIAMSONI.

3.



4.

CTENIS.

5.

GINKGO.

6.

WILLIAMSONIA.

7.

8.

SAGENOPTERIS.

9.

CLADOPHLEBIS DENTICULATA

Manchester Memoirs, Vol. xliv. (1900), *No.* 9.

IX. On the Conditions for the Propagation of a Solitary Wave.

By R. F. GWYTHER, M.A.

Received and read February 6th, 1900.

The characteristics of the solitary wave as experimentally obtained by Scott Russell, and of which a full mathematical investigation is still wanting, are:—it consists of a single elevation, which is not necessarily small in comparison with the undisturbed depth of the water, and it has not been found possible to form a corresponding wave of depression; there is a limit to the extent of the elevation in water of given depth, but the precise relation between the greatest elevation and the depth has not been determined: and, when the limit at which the conditions requisite for the propagation of the wave are succeeded, the wave breaks near the crest.

The form of the wave has been examined by Boussinesq and Lord Rayleigh, and Mr. McCowan has investigated the conditions of the wave-propagation in a manner more allied to that which I here propose, and the expression found by him for the velocity of propagation is identical with that which I obtain. The references to these investigations are given in Art. 234 of Lamb's *Hydrodynamics.*

The difficulty of satisfying the surface-conditions over the wide extent of the solitary wave makes the complete solution of the question difficult. As it is improbable that any expression can be obtained from which these conditions can be completely satisfied everywhere, and the plan of seeking an approximate expression for which the conditions are satisfied at a suitably chosen series of points along the surface is hardly practicable, we are obliged to base a solution on the fulfilment of the surface conditions, with close approximation in some parts of the wave, and examine the degree of approximation obtained over the rest of the wave. Since the conditions appear from experiment to be more readily satisfied over the outskirts of the wave than in the neighbourhood of the crest, it is natural to base the approximate solution upon the enforcement of the surface-condition upon the outskirts, and to examine the results in the neighbourhood of the crest. It must, however, be admitted that this condition is not very well fitted for comparison with results of experiment performed in a tank.

For this purpose it is necessary to take the form of the approximate solution such as will represent something, roughly at any rate, of the form of the wave in question.

Consider the motion, by the usual artifice, reduced to the state of steady motion, and write, with the usual notation,

$$\begin{aligned} x + iy &= f(\phi + i\psi) \\ &= \frac{\phi + i\psi}{c} + \lambda \tanh m \frac{\phi + i\psi}{c} \quad . \quad . \quad . \quad (1) \end{aligned}$$

Let β denote the depth of the fluid, and $\psi = c\beta$ the free surface, the maximum elevation h will be found when $\psi = c\beta, \phi = 0$; thus $h = \lambda \tan m\beta$.

Hence

$$x = \frac{\phi}{c} + h \sinh \frac{2m\phi}{c} \Big/ \left(\cosh \frac{2m\phi}{c} + \cos 2m\beta\right) \tan m\beta,$$

$$y = \beta + h(1 + \cos 2m\beta) / \left(\cosh \frac{2m\phi}{c} + \cos 2m\beta\right),$$

at the free surface.

These equations indicate a form of free surface having the general character of that of the solitary wave, and, in the case of either small or large values of ϕ, the equation connecting x and y can be formed and is found to give relations in the form found by Boussinesq and Lord Rayleigh.

To show this relation we may conveniently write the expressions

$$x = \frac{\phi}{c} + 2h \tanh \frac{m\phi}{c} \Big/ \left(1 + \tanh^2 \frac{m\phi}{c} \tan^2 m\beta\right) \sin 2m\beta,$$

$$y = \beta + h \operatorname{sech}^2 \frac{m\phi}{c} \Big/ \left(1 + \tanh^2 \frac{m\phi}{c} \tan^2 m\beta\right),$$

whence we obtain, when ϕ is small,

$$y = \beta + h \operatorname{sech}^2 mx \Big/ \left(1 + \frac{2mh}{\sin 2m\beta}\right);$$

and, when ϕ is large,

$$y = \beta + h \cos^2 m\beta \operatorname{sech}^2 mx\,.$$

This function would then appear to give a wave surface having something of the character of that of the solitary wave. It will be seen later to what extent this will be found insufficient to satisfy the conditions which it is proposed to apply.

In working out the analytical conditions, I take another term in the suggested series, and attempt to find whether the expressions

$$x + iy = f(\phi + i\psi)$$

$$= \frac{\phi + i\psi}{c} + \lambda_1 \tanh m \frac{\phi + i\psi}{c} + \lambda_3 \tanh^3 m \frac{\phi + i\psi}{c} \quad . \quad . \quad (4),$$

(where the free surface is given by $\psi = c\beta$, and

$$h_1 = \lambda_1 \tan m\beta, \quad h_3 = -\lambda_3 \tan^3 m\beta,$$

and $h = h_1 + h_3$ is the greatest elevation of the wave), can be made to give a good approximation to the known characteristics of the wave, subject to the condition that $h_3 : h_1$ is a small quantity so that the general shape of the free surface indicated by the first term is not gravely altered. It seems more than probable that if a series of these terms were included we could obtain a good representation of the wave by ensuring that the surface conditions are satisfied for a series of values of ϕ, say $\phi = kc\beta$, when k represents a series of suitably selected numbers. This method of treatment being too laborious, we take only two of the terms and in order to ensure the fulfilment of the conditions over a wide stretch of the wave, we apply conditions to cover all cases when ϕ is considerable, and also when $\phi = 0$ at the crest of the wave.

The general expression for the pressure at any point in the fluid is

$$\frac{p}{\rho} = g(C-y) - \frac{1}{2f'(\phi+i\psi)f'(\phi-i\psi)} \quad . \quad . \quad . \quad (5),$$

when C is an absolute constant. Hence the defect of pressure at any point of the free surface below that at an infinite distance along that surface is

$$g(y-\beta) - \frac{1}{2}\left\{c^2 - \frac{1}{f'(\phi+i\psi)f'(\phi-i\psi)}\right\} \quad . \quad . \quad (6).$$

This defect of pressure we are unable to make rigidly null at all points; we first make it very small for considerable values of ϕ. For this purpose we write it as a fraction having the terms arranged in powers of

$$1\Big/\left(\cosh\frac{2m\phi}{c} + \cos 2m\beta\right), \text{ or } 1/D,$$

and by making the coefficients of the lower powers of $1/D$ in this fraction null, the defect of pressure over the outskirts of the wave will be made negligible, and we thus learn the circumstances under which the wave must travel if, as in the solitary wave, the conditions seem most completely satisfied at a distance from the crest.

We thus obtain

$$y - \beta = \frac{\lambda_1 + 3\lambda_3}{D} \sin 2m\beta - \frac{6\lambda_3}{D^2} \sin 2m\beta \cos 2m\beta$$
$$- \frac{4\lambda_3}{D^3} \sin^3 2m\beta \quad . \quad . \quad (7),$$

and

$$c^2 f'(\phi + i\psi) f'(\phi - i\psi) = 1 + \frac{4m(\lambda_1 + 3\lambda_3)}{D} \cos 2m\beta$$
$$+ \frac{4m^2(\lambda_1 + 3\lambda_3)^2 + 4m\lambda_1 \sin^2 2m\beta + 12m\lambda_3(3 - 5\cos^2 2m\beta)}{D^2}$$
$$- 48 \frac{m^2\lambda_3(\lambda_1 + 3\lambda_3)\cos 2m\beta + 2m\lambda_3 \sin^2 2m\beta \cos 2m\beta}{D^3}$$
$$+ 48 \frac{m^2\lambda_3(\lambda_1 \sin^2 2m\beta + \lambda_3 \cos^2 2m\beta) - m\lambda_3 \sin^4 2m\beta}{D^4} \quad (8).$$

Taking, in the first place, only the first term in the series we find that putting

$$c^2 = g\beta \tan 2m\beta \,/\, 2m\beta \,,$$
$$\frac{mh_1}{\sin 2m\beta} = \frac{1 - \cos 2m\beta}{4\cos^2 2m\beta - 1} \,,$$

the defect of pressure over the service at the crest is

$$16g\rho h_1 \sin^4 2m\beta \cos^2 2m\beta / (4\cos^2 2m\beta - 2\cos 2m\beta + 1)^2,$$

and this defect decreases rapidly along the slope of the wave.

If $m\beta$ is small, $h_1 : \beta$ is small and the defect may be negligible, but here I propose to examine the magnitude of the next term in the approximation necessary to satisfy the conditions without stipulating for a small value of the ratio $h_1 : \beta$.

Another problem suggests itself to the mind, which appears to be quite consistent with the results of Scott Russell's experiments, namely that the motion is not one capable of being reduced to steady motion, but that the gradual reduction of the altitude of the wave is a necessary part of the phenomenon. This view has had the support of Sir George Stokes, but the method now adopted is not suitable to the investigation of it.

Proceeding with the investigation before us, we obtain from the equations (7) and (8), by applying the conditions proposed,

$$c^2 = g\beta \tan 2m\beta/2m\beta \quad . \quad . \quad . \quad . \quad . \quad . \quad (9),$$

and

$$\frac{mh_1}{\sin 2m\beta} = \frac{1 + 9\frac{\lambda_3}{\lambda_1}}{\left(1 + 3\frac{\lambda_3}{\lambda_1}\right)^2} \quad \frac{1 - \cos 2m\beta}{4 \cos^2 2m\beta - 1} \quad . \quad . \quad . \quad (10).$$

Of these relations the first is identical with that found by McCowan, the second we shall consider later. With these we combine the expression of the fact that we also suppose that the defect of pressure is null at the crest of the wave.

This gives us

$$1 = \frac{\tan 2m\beta}{4m(h_1 + h_3)} \left\{ 1 - \frac{1}{\left(1 + \frac{2m(h_1 + 3h_3)}{\sin 2m\beta}\right)^2} \right\} \quad . \quad . \quad (11).$$

It will be noted that the relations obtained from the extreme part of the wave depend on the ratio $\lambda_3 : \lambda_1$; while those at the crest depend upon $h_3 : h_1$ or $\lambda_3 \tan^2 m\beta : \lambda_1$, which for values of $m\beta$ less than $\pi/4$ will be the smaller ratio.

Assuming $h_3 : h_1$ to be small, and writing z to stand for $mh/\sin 2m\beta$, we get

$$1 = \frac{1 + z}{\cos 2m\beta(1 + 2z)^2}\left(1 - \frac{1 - z}{1 + z} \quad \frac{h_3}{h_1}\right),$$

or, neglecting the small term

$$\cos 2m\beta(1 + 2z)^2 = 1 + z \quad . \quad . \quad . \quad . \quad . \quad (12).$$

To test the agreement of results drawn from these expressions with the results of experiments on the solitary wave is the only method which we can now adopt. We notice that all the expressions recur with the period π for $m\beta$; also that c^2 has a negative value between the values $\pi/4$ and $\pi/2$, $3\pi/4$ and π, of $m\beta$.

Calculating from these equations for values of $m\beta$

starting from $\pi/18$ at equal intervals of $\pi/72$, we may obtain the following schedule.

$m\beta$	$\frac{\pi}{18}$	$\frac{5\pi}{72}$	$\frac{\pi}{12}$	$\frac{7\pi}{72}$	$\frac{\pi}{9}$	$\frac{\pi}{8}$	$\frac{5\pi}{36}$	$\frac{11\pi}{72}$	$\frac{\pi}{6}$	$\frac{13\pi}{72}$	$\frac{7\pi}{39}$	$\frac{5\pi}{24}$
$mh/\sin 2m\beta$	·021	·034	·051	072	·099	·133	·176	·233	·309	·421	·571	·829
$\frac{1+9\frac{\lambda_3}{\lambda_1}}{\left(1+3\frac{\lambda_3}{\lambda_1}\right)^2}$	·893	·831	·758	·669	·576	·443	·323	·175	0	—·208	—·464	—·810
$\frac{h_1}{\beta}$	·041	·055	·097	·136	·185	·242	·310	·398	·511	·673	·878	1·222
$\frac{\tan 2m\beta}{2m\beta}$	1·043	1·069	1·103	1·145	1·203	1·274	1·365	1·487	1·653	1·89	2·25	3·30
$h_3 : h_1$									·037	·05	·07	·09

The values of $h_3 : h_1$ are given to show the rate of increase for the larger values of $m\beta$, and the values of the other quantities for values of $m\beta$ less than $\pi/18$ have been omitted because $h_3 : h_1$ being exceedingly small, and $h_1 : \beta$ being also small, there is little interest attaching to them.

It will be noticed that about the value $13\pi/72$ of $m\beta_1$ the ratio $h_3 : h_1$ being about one-twentieth, the values of $h_1 : \beta$ and $\tan 2m\beta/2m\beta$ shew signs of inordinate increase, and it is about this point that I should place the limit by which the validity of this investigation is bounded. It also appears to be somewhere about the limit of the height of the wave in experimental investigations.

For the purpose of comparison with the investigations of Scott Russell on the velocity of the wave, on writing

$$u^2 \text{ for } g\beta\left(1+\frac{h}{\beta}\right), \quad v^2 \text{ for } g\beta \tan 2m\beta/2m\beta,$$

and V for Scott Russell's experimental value, we see from these numbers that u and v become about equal when $h : \beta$ is about ·04 and that for higher values of this ratio v is slightly in excess of u, so that when $h : \beta$ is about ·4, $v : u$ is about 1·03, and the ratio for higher values increases more rapidly.

In discussing a formula proposed by Airy, Scott Russell* in his Report gives two tables of small and large waves respectively, from which we can very conveniently compare the values of V and u for values of $h : \beta$. It is then seen that V is smaller than u for the smaller values of $h : \beta$ and greater than u for the greater values of $h : \beta$. The values calculated from these tables (retaining the order in the tables) run as follows:—

SMALL WAVES.

$h : \beta$	·075	·13	·07	·09	·066	05	·05	·07
$V : u$	.98	·96	·98	·97	·99	·99	·98	·98

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* Brit. Assoc. Report, Vol. lxiii. (1844) pp. 335—337.

LARGE WAVES.

·2	·26	·15	·14	·18	·27	·16	·34	·13	·21	·14	·13
·98	·99	·95	1·00	1·00	1·01	1 00	1·02	1·01	1·02	1·00	·98

From these tables it would seem that, for such waves as Scott Russell experimented upon, if v gives the true velocity, u is empirically a good representative of the velocity, and that, on comparison, the experimental value for the velocity seems to agree better with v than with u, although the comparison is not decisive.

Finally, Scott Russell's experiments show that although a wave of depression could be propagated, it had a different character from the wave of elevation, and especially failed in those points which I have selected as typical of the solitary wave. It is, therefore, essential to show that these hypotheses would not allow of the propagation of a similar wave of depression.

For this purpose putting $\beta = \frac{\pi}{2m} + \gamma$, the three equations which we have to consider become

$$c^2 = g \tan 2m\gamma / 2m\,,$$

$$w = -\frac{1 + 9\frac{\lambda_3}{\lambda_1}}{\left(1 + 3\frac{\lambda_3}{\lambda_1}\right)^2} \cdot \frac{1 + \cos 2m\gamma}{4\cos^2 2m\gamma - 1}\,.$$

and

$$\cos 2m\gamma(1 - 2w)^2 + (1 - w) = 0$$

where w stands for $mh_1/ \sin 2m\gamma$.

Writing this last equation in the form

$$\cos 2m\gamma(1 - 2w)^2 + \tfrac{1}{2}(1 - 2w) + \tfrac{1}{2} = 0.$$

we find that $\cos 2\,m\gamma < \frac{1}{8}$, or (say) $m\gamma > \frac{11\pi}{48}$, while the greatest value of $m\gamma$ we have to consider is $\frac{12\pi}{48}$. Moreover, within this interval, the equation would give positive values for w and therefore for h_1, and the wave represented is not a wave of depression.

Although I have found no explicit equation to the free surface, it is more easy to draw the forms of series of such surfaces from the equations

$$x = \frac{\phi}{c} + h_1 \sinh 2m\frac{\phi}{c} / \tan m\beta \left(\cosh \frac{2m\phi}{c} + \cos 2m\beta \right),$$

$$y = \beta + h_1 (1 + \cos 2m\beta) / \left(\cosh \frac{2m\phi}{c} + \cos 2m\beta \right),$$

than it would be to work from the explicit equation.

Leaving the discussion of the mathematical expressions, the physical ideas which they are intended to express are there. In the experiments of Scott Russell, the wave, by whatever method it was formed, in a short distance cleared itself at its base from extraneous disturbances and masses of water, and then travelled in its definite form, breaking, if it did break, near the crest. It has therefore been made an essential point in the mathematical discussion that the surface-conditions are satisfied with great nicety in the outskirts of the wave, and so the slopes of the wave serve as buttresses to it, allowing of any defect of pressure near the crest to be rectified by a slight local readjustment of the fluid particles. This could only be the case so long as the graph of mh in relation to $m\beta$ (Fig. 1) has a slight gradient. When the gradient becomes steep, the rearrangement would no longer be small and local, but a change in the circumstances of the wave would demand an inordinate change in the elevation. The point at which this would happen cannot be fixed, and is perhaps not very definite, but there is evidently a very definite difference of the circumstances represented at the two extremities of the graph.

The elevation of the waves experimented upon

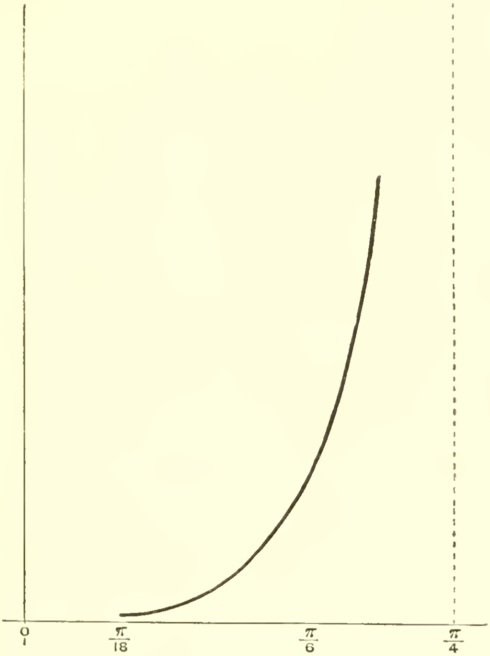

Fig. 1.

by Scott Russell are often quoted as much in excess of those with regard to which he gives any details in his reports, (perhaps owing to an obvious misprint in a table* referring to wave xxvii., where 1·10 for the height of the wave should be ·10). The highest waves referred to† are found in connection with some figures in the plates, for which no numerical measurements of speed are given.

For the purpose of such measurements, the waves were reflected at the ends of a trough, and, as the question of the reflection without change is identical with that of meeting and passing a similar and equal wave without

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* Brit. Assoc. Reports, vol. lvi. (1837) p. 440.

† Ibid., vol. lxiii. (1844) pp. 386 7. Plates 50, 51.

change, and as the effect of the meeting of two waves is figured in Plate 50, just referred to, no doubt the elevation of the waves for which measurements are given is limited to those which could suffer reflection without obvious change. Neither the measurements nor this investigation apply to a wave of height about equal to the depth of the fluid, which Scott Russell describes as becoming "acuminate, finally cusped." *

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* Ibid, p. 340.

Manchester Memoirs, Vol. xliv. (1900), *No.* **10.**

X. On the Motion of the Fluid Particles in a Class of Cases of Steady Motion.

By R. F. Gwyther, M.A.

Received and read February 6th, 1900.

Although the most interesting cases of fluid motion depend upon the general motion of the fluid and not upon the motion of individual particles, it is desirable to obtain, if possible, a few cases in which the motion of a particle is determined without approximation and satisfying absolutely the surface conditions. Such a case can be found for standing waves in a channel, but no case of steady motion has been obtained. This paper shows how far we can proceed in what would seem the most simple class of cases, and shows what are the difficulties still remaining.

I deal with that class of cases of steady motion where

$$x+iy=f(\phi+i\psi)$$

can be found to represent explicitly the Eulerian relation.

When this can be done it is probably the most useful form possible, as it allows the lines of motion to be readily drawn on a diagram. It is also very convenient when surface-tension has to be taken into account, since the measure of curvature of any line of motion is given by

$$i\{f''(\phi+i\psi)f'(\phi-i\psi)-f''(\phi-i\psi)f'(\phi+i\psi)\}$$
$$/2\{f'(\phi+i\psi)f'(\phi-i\psi)\}^{\frac{3}{2}};$$

and even if the surface-tension has not been accounted

May 4th, 1900.

for in the problem, this gives a convenient measure of the quantity which we are neglecting.

The point to which I wish to call attention is that in these cases, the solution of the Lagrangian equations and also the expression for the pressure take the same form as the corresponding quantities derived from the Eulerian equations, and that, in form, only a quadrature is necessary to complete the solution for the motion of the particles.

The first part of this statement will be accepted as obvious on a little consideration, but I will give a formal proof based on the Lagrangian equations. The functional solution of these equations, in irrotational motion, is that

$$\frac{d}{dt}(x+iy)$$

shall be a function of $x-iy$ and of t, and in our case of steady motion a function of $x-iy$ only.

Writing

$$\frac{d}{dt}(x+iy)=\phi'(x-iy)$$

we get

$$\phi'(x+iy)\frac{d}{dt}(x+iy)=\phi'(x+iy)\phi'(x-iy)$$
$$= \text{a real quantity,}$$

and therefore

$$\phi(x+iy)=u+ib,$$

where u is real and b is independent of t.

Supposing now that this can be conveniently reversed, we write

$$x+iy=f(u+ib)\quad.\quad.\quad.\quad.\quad.\quad.\quad(1),$$

and again

$$\frac{d}{dt}(x+iy)=f'(u+ib)\frac{du}{dt}.$$

This expression is to be a function of $x-iy$ and therefore of $u-ib$, and can only take the form

$$\frac{c}{f'(u-ib)},$$

when c is an absolute constant.

We therefore have

$$f'(u+ib)f'(u-ib)\frac{du}{dt}=c\,,$$

$$\int f'(u+ib)f'(u-ib)\,du=ct+a \quad . \quad . \quad . \quad (2).$$

Here a and b of the Lagrangian equations are introduced as constants of integration. The analogy with the other method is evident, b corresponding with ψ.

Turning to the equations to find the pressure, we have

$$\frac{d}{da}\left\{\frac{p}{\rho}+gy-\tfrac{1}{2}(\dot{x}^2+\dot{y}^2)\right\}+\frac{d}{dt}\left(\dot{x}\frac{dx}{da}+\dot{y}\frac{dy}{da}\right)=0$$

etc.

In our case

$$\dot{x}^2+\dot{y}^2=c\dot{u}\,,$$

$$x\frac{dx}{da}+y\frac{dy}{da}=c\frac{du}{da}\,,$$

$$x\frac{dx}{db}+\dot{y}\frac{dy}{db}=c\frac{du}{db}\,, \quad \text{so that}$$

$$\frac{d}{da}\left\{\frac{p}{\rho}+gy-\tfrac{1}{2}c\dot{u}\right\}+\frac{d}{dt}\left(c\frac{du}{da}\right)=0\,,$$

with a precisely similar equation.

The condition that the motion shall be irrotational requires that c shall be independent of a and b, which is satisfied in the case of steady motion when c is an absolute constant. The pressure is then given by

$$\frac{p}{\rho}+gy+\tfrac{1}{2}cu=\text{constant},$$

$$\text{or}\quad \frac{p}{\rho}+gy+\frac{c^2}{2}/f'(u+ib)f'(u-ib)=\text{constant} \quad . \quad . \quad (3).$$

Comparing this with

$$\frac{p}{\rho}=g(C-y)-\frac{1}{2f'(\phi+i\psi)f'(\phi-i\psi)}\,,$$

used in the Eulerian notation, we see that the two forms are alike, and that when we form the necessary surface conditions in either case, the results are, *mutatis mutandis*, applicable to the other.

If then $x+iy=f(\phi+i\psi)$, is a solution of the Eulerian equations which can be made to satisfy the surface conditions, then

$$x+iy=f(u+ib),$$

where

$$\int f'(u+ib)f'(u-ib)du=ct+a,$$

is under the same circumstances the solution of the Lagrangian equations.

The character of the difficulties, supposing those connected with the surface conditions to have been overcome, are now obvious. To obtain the case of a simple, compact solution, it is requisite that the integral must be of such a character that u can be obtained from it as a manageable function of a and b.

Manchester Memoirs, Vol. xliv. (1900), *No.* **11.**

XI. On Aerial Locomotion.

By Henry Wilde, F.R.S.

Received and read April 3rd, 1900.

"A general speculation, without particular experiment, may conjecture at many things, but can certainly effect nothing." "Amongst other impediments of any strange invention or attempt, it is none of the meanest discouragements, that they are so generally derided by common opinion."—Bishop Wilkins, F.R.S., *Mathematical Magick*, Lib. 2, Cap. 6, 1680.

1. The Bakerian Lecture, delivered before the Royal Society by Faraday in the year 1850, "On the possible relation of Gravity to Electricity,"* is remarkable from the entirely negative character of the experimental results obtained. Nevertheless, the conviction that such relation subsisted between these forces was in no degree shaken in the mind of the illustrious experimentalist. He commended the subject to other investigators, for if true, he adds, "no terms could exaggerate the value of the relation they would establish."

2. It is not easy to realise the nature of the manifestation that Faraday expected to find as the result of his experiments, beyond the transformation of the mechanical force generated by a falling body into heat or electricity, but, as gravity (notwithstanding its universality) is not, like extension, a necessary property of matter, the range of the enquiry might have included the property of levitation, either real or apparent, just as we have the mutually repellent action of similarly electrified or magnetised bodies.

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* *Phil. Trans.*, 1851, p. 1.

May 4th, 1900.

3. The notion that relations subsist between gravity, electricity, and magnetism to cause the levitation of bodies, has been seriously as well as humorously suggested by several imaginative writers. One of these, M. de la Folie, in his book entitled, *Le philosophe sans prétention* (1775), has described a levitating machine which derived its ascensional power from frictional electricity generated by means of two large globes of glass. A well designed plate at the head of the work represents the machine at the moment of elevation surrounded by an electrical glory, with the seated figure of a man turning the glass globes and ascending with the machine in the presence of a wondering crowd of spectators.

4. Dean Swift in his *Gulliver* had previously (1726) represented Laputa as a levitating island containing a huge loadstone, mounted on a strong axle in such a manner that, when an attractive pole was presented towards the earth the island descended, but when the repellent pole was downwards the island mounted directly upwards. The extravagant humour of this description is sobered in the same chapter by the prediction of the two satellites of Mars (discovered by Hall in 1877), with their orbits and times of revolution roughly calculated from Kepler's third law.

5. In the course of a subsequent lecture on Mental Education, delivered before the Prince Consort and the members of the Royal Institution, Faraday had occasion to remark upon the number of abortive theories that must necessarily pass through the minds of the most successful scientific investigators, and be destined to be crushed in silence and secrecy after being put to the test of experiment.* This observation accords so closely with my own

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* *Observations on Mental Education*, 1855.

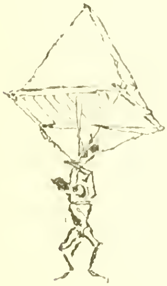
experience that I am free to confess that, during a somewhat lengthy career as an experimentalist, I have accumulated a considerable stock of negative knowledge, both in pure and applied science.

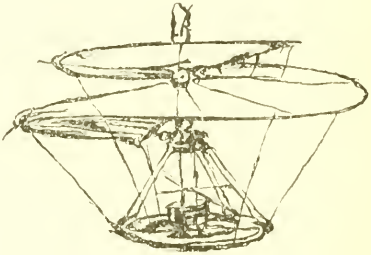
6. One of the branches of unsuccessful experiment in which I was engaged at intervals for many years was an investigation into the possibility of aerial locomotion. The interesting lecture on "The Mechanical Principles of Flight," recently delivered before the Society by Lord Rayleigh, emboldens me to bring forward a brief summary of the results of my investigations, with the intention that they may be utilised to lighten the path of those adventurous experimenters who may attempt the solution of the fascinating problem of navigating the aerial main.

7. The literature of aeronautics is now very extensive, and the subject has of late years been investigated, both theoretically and experimentally, by men of the highest scientific attainments. It will be sufficient to mention the names of Dr. Pettigrew, F.R.S., of Edinburgh, MM. Marey and Tissandier, in France, and Prof. Langley and Mr. O. Chanute, in America. The last named is an eminent civil engineer, whose recent work on *Progress in Flying Machines* is the most complete epitome of the history and principles of aviation that has yet been presented to the world.

8. Omitting from the purview of this paper the legends of antiquity like those of Dædalus and Apollonius Tyanæus, in which men were reputed to have aviated and been levitated above the earth's surface, either with or without the aid of mechanical appliances, the first serious attempt to study the problem of aerial locomotion was made about 1500 by Leonardo da Vinci, who not only proposed to provide man with wings, but also experimented with paper

screws which, when rotated, mounted into the air. He also proposed an aerial-screw machine of large size to be built of iron and bamboo framework, covered with linen cloth. The great Italian artist has also the singular merit of inventing the parachute. Several sketches of his mechanism of flight have been found in his note-books, two of which are reproduced in the *Comptes rendus de l'Académie des Sciences*, tome xciii., 1881. The sketch of the parachute, fully inflated, shows the figure of a man in the act of descending with it. Copies of these interesting designs are shown below.





9. The next important contribution to Aeronautics which deserves notice was made by the learned Dr. Wilkins, Bishop of Chester, whose name appears in the first Charter of the Royal Society as one of the original Fellows. His work entitled, *Mathematical Magick, or, the Wonders that may be performed by Mechanical Geometry* (1680), a quotation from which appears at the head of this paper, is remarkable in that it is strongly pervaded with the Baconian method of interrogating nature by observation and experiment. The general principles on which experiments on mechanical flight are to be conducted are stated with great clearness and precision, and his general method has been followed by all subsequent workers in the field of aeronautics.

10. Chapter VI. of this remarkable book treats upon flying automata, whereby they are carried aloft in the open air like the flight of birds. To those objecting to the heaviness of the materials in such an invention it is answered that it is easy to contrive such springs and other instruments whose strength shall much exceed their heaviness. Scaliger and Gellius are quoted to show that "such automata may be actuated by some lamp or fire within them which might produce such a forcible rarefaction as should give a motion to the whole frame."

11. Respecting the utility of these experiments it is urged "that, though the composing of such motions may be a sufficient reward to any one's industry in searching after them, yet, there are some other inventions depending upon them of more general benefit and importance; for if there be any such artificial contrivances that can fly in the air, then it will clearly follow that it is possible for a man to fly himself; it being easy from the same ground to frame an instrument wherein anyone may sit and give such a motion unto it as shall convey him aloft through the air."

12. Chapters VII. and VIII. treat on the several ways whereby the art of flying may be attempted, either by wings fastened to the body, or by a flying chariot so contrived as to carry several persons within it.

13. Although some of the means proposed by Dr. Wilkins to accomplish mechanical flight are, in the light of modern knowledge, impracticable in the extreme, yet, his general method of attacking the problem still retains its value. In the divergency of his method from its practical realisation the learned prelate was paralleled by his illustrious prototype Bacon, who, notwithstanding the depth of his philosophy, strongly opposed Gilbert's

work on terrestrial magnetism, and denounced the idea of the diurnal rotation of the earth as extravagant, declaring that it could be demonstrated to be most false.

14. My own investigations on the possibility of aerial locomotion were commenced as early as the year 1860, when strongly imbued with the kinetic theory of gases, I sought, by various means, to disturb the equilibrium of pressure in a metal cylinder containing air by the rapid heating and cooling of its opposite ends simultaneously. The cylinder was suspended from a balance during the operation of heating and cooling, but no difference of pressure between the two ends was manifested.

15. The next attempt to produce a change of equilibrium in a vessel was by the reaction caused by the discharge of steam of high pressure from a number of orifices of various sizes and forms. Good results were anticipated from this investigation, as Mr. W. Froude, F.R.S., in a paper read before the Institution of Civil Engineers (1847),* "On the discharge of elastic fluids under different pressures," had challenged the correctness of the commonly accepted formula for the velocity of discharge. This distinguished engineer stated that the correction required by the formula for non-elastic fluids when applied to those which are elastic, was to divide its results by the square root of its corresponding expansion ; thus "a fluid which in issuing expands to four times its volume will be discharged at only half the rate assigned to it by the ordinary theory, and if expanding 100 times, only at one-tenth of that rate." Hence, from this formula, by increasing the pressure indefinitely, a point would be arrived at when the discharge would be indefinitely small or cease absolutely. Now had the proposed formula been

* *Proc. Inst. Civil Engineers*, Vol. 6, 1847.

only approximately correct, the problem of aerial locomotion could have been solved in an ideal manner, as the ascensional power would be derived from stationary apparatus without the use of machinery. By discharging steam downwards, the generator with a car attached would rise in the air, and lateral discharges of small amount would propel the whole apparatus in any direction required.

16. Numerous experiments made on the discharge of steam and of air at pressures from 10 lbs. to 120 lbs. per sq. in. directly into the atmosphere, and from orifices of various forms, proved conclusively that, while the rate of discharge was much less than that deduced from established theory, the amount was far too great for the reactive force to be utilised as a motor in aerial or any other kind of locomotion.

17. Experiments were next made to ascertain if the rate of efflux would be diminished materially by causing steam of 60 lbs. pressure to be discharged through a succession of deep gratings arranged in a cylinder, and also through similar gratings in a long rectangular chamber with a space of several inches between each grating. The results of these experiments showed that, while the rate of discharge was greatly reduced by the number of gratings through which the steam was discharged for the same area of orifice, the reactive force was always less than twice the effective steam pressure, just as when the discharge was made through a simple orifice.

18. The same results were obtained when air of a constant pressure of 120 lbs. was discharged through a series of short thermometer tubes and expanded into a succession of cavities between the tubes.

19. With a constant number of short tubes and alternating cavities, as in the preceding experiment, and

pressures varying from 20 lbs. to 120 lbs. per sq. in., the rate of discharge was approximately in accordance with the proposed formula of Mr. Froude, for the discharge from a simple orifice.

20. Experiments were next made to ascertain if the rate of discharge of steam was influenced by a powerful current of electricity transmitted through a helix surrounding a vulcanite discharging tube. It was found that electricity had no influence on the rate of discharge under these conditions. The same result was obtained when an iron tube forming a powerful electro-magnet was substituted for the one of vulcanite.

21. The like negative result was also obtained when air at 120 lbs. pressure was discharged through a thermometer tube 24 inches long and coiled with a helix of the same length through which a powerful electric current was transmitted.

22. An experiment was made to ascertain if the rapid molecular extensions and contractions of a tubular U-formed electro-magnet, in which air of eight atmospheres was compressed, would manifest any reaction when a powerful electric current alternating 7,000 times per minute was transmitted through the coils. The limbs of the electro-magnet were nine inches long and were suspended horizontally by means of a fine cord. When the electro-magnet was excited, no deviation from the perpendicular occurred to indicate any reactive force of the enclosed air from the free ends of the magnet.

23. Experiments were also made on the reactive force produced by the explosion of a mixture of coal gas and air, contained in a specially constructed cylinder of steel. The cylinder was five feet high and three feet in diameter. One end of the cylinder was pierced with a

number of inch holes fitted with screw plugs, for the purpose of varying the aggregate area of the discharging orifices. The gases were mixed in various proportions and ignited by an electric spark. The amount of reactive force generated by the explosion of the gases directly into the atmosphere was not, however, considered satisfactory, and the experiments were soon discontinued.

24. The results of all these experiments on the discharge of elastic fluids, made with a view to the possibilities of aerial locomotion, were purely negative, and proved decisively that the solution of the problem was not to be found in that direction.

25. Science, however, has profited by these enquiries, since with the apparatus and appliances at command I was enabled to undertake a series of experiments on the velocity with which air rushes into a vacuum, and to investigate some phenomena attending the discharge of atmospheres of higher into those of lower density.* These experiments were described in two papers read before the Society, and showed: (1) that air of the mean atmospheric pressure of 15 lbs. per sq. in. rushes into a vacuum at the rate of 667 feet per second, or approximately one-half the velocity due to the height of a homogeneous atmosphere,—the velocity due to the whole height having been previously assumed to be correct; (2) that the times of discharge from an orifice of equal volumes of air after expansion are inversely as the pressures; and (3) as a corollary to the preceding, that the velocity of discharge of an elastic fluid through a simple orifice, at a constant temperature, was the same for all pressures; (4) that the hydraulic co-efficient, ·62, for

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* *Manchester Memoirs*, Vol. xxx., 1887. *Phil. Mag.*, December, 1885; June, 1886.

the discharge through an orifice in a thin plate, is not applicable to the discharge of elastic fluids, the co-efficient for the latter being ·937; (5) that in the discharge of atmospheres of higher into those of lower density, the latter act as a vacuum when the recipient atmosphere is not greater than one-half the density of the higher atmosphere, in confirmation of the results previously obtained by different methods.

26. The phenomenal rate of discharge of atmospheres of higher into those of lower density was also shown to be directly correlated with the phenomena observed in the experiments of Richard Roberts and of Peter Ewart, members of this Society.* Lord Rayleigh in his lecture on "Flight," recently delivered at the Royal Institution, described a similar experiment with a light piece of brass plate, evenly pivoted in and nearly filling up an aperture through which air was issuing under pressure, that tended to set itself square to the aperture so as to block it as much as possible, but, if started, continued to rotate in either direction, emitting a roaring sound. This experiment finds a full elucidation in the rarefaction of the air near the discharging orifice, as shown in the experiments of Roberts and of Ewart referred to.

27. Having satisfied myself that the problem of aerial locomotion was not to be solved by the reactive force of elastic fluids, either with or without the aid of electricity and magnetism, I repeated and extended some of my earlier experiments on the reactive force of aerial screws. The experiments were made with vanes from one to four feet in diameter, adjustable to any angle, and driven at different velocities up to 2,000 revolutions per minute. The results obtained were not sufficiently promising to induce

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* *Manchester Memoirs*, Ser. 2, Vol. V., p. 208. *Phil. Mag.*, 1829.

me to proceed far in this direction, as, in addition to the large amount of power absorbed and the high velocities required to produce a workable amount of thrust, an actual aviating machine would of necessity require two sustaining screws revolving in opposite directions to prevent the machine from acquiring a rapid rotatory motion in the direction of a single screw. Moreover, in addition to the complicated mechanism involved in this arrangement, the amount of friction created by the concentration of the entire weight of the machine upon two sustaining points would be very considerable and greatly diminish the efficiency of the motor used for driving the screws.

28. Although my experimental investigations on the possibility of aerial locomotion have so far been of a negative character, the confidence I have in the ultimate solution of the problem still remains unshaken. The fact that man has been able to transport himself through the air across the Irish Sea, to and from the Continent, and has reached a height of nearly seven miles above the surface of the earth, is sufficient encouragement to inspire inventors in the field of aeronautics to further efforts till the object of their ambition is attained.

29. Notwithstanding the large amount of attention that has been given to the subject of aviation since the time of Leonardo da Vinci, the world is yet waiting the advent of a flying machine sufficiently energetic to transport a man from one place to another, as in ordinary balloon practice. It is also to be observed that, not only are most of the proposals for navigating the air mere repetitions of those already known, but they manifest a strange disregard of the fundamental conditions that must be fulfilled before aviation can rank with man's achievements in locomotion on land and on water.

30. These conditions or criteria may be summarised as follows :—

(i.) An aviating machine should have power to rise from any point of the earth under ordinary conditions of wind and weather ;

(ii.) The aviators should be able to descend with the machine at any time and at any place ;

(iii.) The machine should have power to move in any direction, vertically, horizontally, or to remain stationary at any height, within practicable limits, above the earth.

(iv.) The machine should contain within itself an automatic principle of safety by which, in the event of any accident to a vital part of the mechanism, the descent would be made without danger to the aviators, or damage to objects upon which the machine might happen to alight.

31. It is now all but universally admitted that *man, by his own strength alone, can never attain the power of flight by the aid of any mechanical appliance through which his muscular force is or may be transmitted.*

32. Although the balloon is a most brilliant invention from the great impulse which it has given to the study of aeronautics, from the service it has rendered to meteorological science, and from its application to the conduct of military operations, yet, as a means of locomotion, it fails to comply with three out of the four criteria specified above. The numerous attempts that have been made to give direction to the course of a balloon have only succeeded in a comparatively still atmosphere, and clearly demonstrate the physical impossibility of overcoming this difficulty even in a moderate current of air. The power

of the aeronaut to descend upon any point of the earth can only be exercised within wide areas, while the conditions of safety are wholly absent in general practice, as the numerous fatalities recorded unhappily testify.

33. I have already indicated (27) some of the difficulties to be encountered in the construction and working of aviating machines the sustaining power of which is derived from aerial screws. Even if these difficulties were ultimately overcome, there would still remain the element of danger arising from the accidental failure of the rotating mechanism. The magnitude of this danger, with its consequences, as I have said, is hardly realised or is altogether ignored by aeronautical projectors. Those who have had much experience with moving mechanism, with its liability to derangement from various causes, will feel that the penalty involved for human error and want of foresight is too severe to warrant the belief that the sublime consummation of successful aerial locomotion will be brought about by a machine deriving its support from aerial screws.

34. The like observation in regard to the absence of a principle of safety also applies to the various flying machines projected, which derive their support in the air from flapping wings actuated by a steam-engine or other motor.

35. Much attention has been given by aviators during recent years to the means by which the soaring of birds is accomplished, with a view to adapting the principle to the production of a soaring aerial machine. In the experiments which have hitherto been made with this object, stationary aeroplanes inclined upwards in the direction of motion derive their ascensional power from their rapid motion horizontally through the air, the driving power

being furnished by the reaction of aerial screws actuated by a motor of some kind.

36. Excepting the remarkable experiment made by Mr. Hiram S. Maxim, and excluding those which, like the unfortunate Lilienthal's, depend on the action of the wind for their support, no aeroplanes have been constructed on a scale sufficient to raise the weight of a man.

37. The soaring or stationary aeroplane fails conspicuously in all the criteria above laid down, as, first, a suitable track, either natural or artificial, is required to enable the machine to acquire the necessary horizontal velocity to raise itself from the ground; secondly, the machine cannot descend upon the place from which it started, or upon any other except within wide areas; thirdly, as the sustaining power of the aeroplane is dependent on its horizontal velocity, it cannot remain poised in the air or descend vertically when required; fourthly, it contains no automatic principle of safety in the event of the failure of the sustaining mechanism. With these disadvantages, soaring aeroplanes can hardly be entitled to rank as machines for navigating the air, but partake more of the character of projectiles or aerial torpedoes. Mr. Maxim is, I believe, disposed to view the result of his recent magnificent experiment in this light, and has even proposed that his machine should be used as a military projectile.

38. As none of the means that have so far been devised is competent to solve the problem of aerial locomotion, and, with one exception, the category of possible solutions is now exhausted, it only remains for me (in the absence of the discovery of some new property of matter) to indicate the remaining method by which the problem of avia-

tion may in the future be attacked with any prospect of success.

39. The plan, in brief, is to reverse the action of a parachute by a vibratory motion, causing it to ascend against the action of gravity, instead of using the apparatus solely for the purpose of descending towards the earth as heretofore.

40. Let a parachute be constructed with a light framework of steel, firmly stayed to a tubular central shaft, the lower end of which forms the piston-rod of a gas or steam motor. The sudden downward stroke of the piston will cause the cylinder, with the car attached thereto, to rise against the action of gravity, and a rapid succession of such impulses will increase the height gained by each preceding impulse until the desired elevation is attained.

41. The alternating upward strokes of the piston may be assisted by a valvular arrangement in the covering of the parachute, and also by the rarefaction of the air on its upper surface during the sudden downward stroke. I have proved by experiments made some years ago that such a rarefaction on the posterior surface of a plane moved rapidly through the air does actually occur, and I am pleased to notice that Lord Rayleigh, in his recent lecture at the Royal Institution, performed an experiment to show the reality of this suction in the case of a bird's wing, about which he said there had been much scepticism.

42. When the power of ascension is once attained, the horizontal movement, or travelling through the air, is a comparatively minor problem, on account of the small amount of power required for the purpose. This movement may be brought about by inclining the vibrating parachute from the perpendicular for the direction of

motion required, by mounting the engine cylinder on trunnions, and regulating the angle of inclination by well-known mechanical means.

43. Instead of causing the parachute to vibrate by the direct action of a piston fixed on the sustaining shaft, the motive power may be transmitted through the cranks of two or more engine cylinders arranged horizontally, or from cranks driven by an electro-motor. In either of these alternatives the lower end of the sustaining shaft would require to be jointed to receive the crank rod of the motor.

44. The inclination of the parachute for obtaining horizontal locomotion in this case may be effected by means of a rectangular or inverted ∩-shaped frame, the lower ends of which would be trunnioned on the same centre as the crank shaft, and the sustaining shaft would reciprocate through a suitable bearing in the upper end of the rectangular frame.

45. The steering of the vibrating parachute, when moving rapidly in a horizontal direction, would be affected by means of an aerial rudder attached to the car, or, when moving slowly, by slightly altering the distribution of weight in the car and causing it to gyrate in the required direction.

46. The sustaining surface of the vibratory parachute would be sufficiently large to enable the aviators to descend with safety in the event of a sudden failure of any part of the mechanism.

Manchester Memoirs, Vol. xliv. (1900), *No.* **12.**

XII. Grating Films and their Application to Colour Photography.

By Thomas Thorp.

Received and read October 17th, 1899. Received in the present form, May 16th, 1900.

Some two years ago it occurred to me to try the experiment of taking a cast from a Rowland's metal grating of 14,438 lines to the inch, which I possessed, and after many attempts, I found this to be possible without causing the least injury to the delicate surface of the grating, by using a solution of ordinary commercial celluloid in amyl acetate. Many experiments were, however, necessary before perfect and uniform replicas suitable for optical work were successfully obtained.

When a grating bright in the first order is used, the replica gives a very faint spectrum in the whole of the orders, but if bright in the second or third order on one side, the first order film spectrum is very bright on one side at least.

In order to obtain a direct vision spectrum from mounted films, a crown glass prism of about 30° is used, the film being mounted on one of the faces, with the lines or grooves of the film parallel to the thin end of the prism.

When first using such a prism-grating, the film being the replica of a grating bright in the second and third order on one side, it was at once noticed that not only was the spectrum of the first order lengthened, but it was actually *brighter* than when mounted on a parallel plate of glass, and that the brightness increased as the prism was slightly tilted, with a consequent lengthening of the spectrum also. This effect was not produced from a replica of another grating bright in the first order. The form of the groove had evidently, therefore, given rise to the increase in brightness, and since the original paper was read I have succeeded in making a grating of small size, the film replica of which causes nearly all the transmitted light to be concentrated in the first order on one side. Further experiments on the production of a more perfect grating of this kind are in progress.

For solar prominence observation a prism-grating forms a very efficient battery of itself, and by tilting it to an angle somewhat greater than is necessary to give minimum deviation, its dispersion is quite equal to six flint glass prisms of 60° in the red portion of the spectrum, whilst still retaining all its sharpness of definition.

As might be expected there is a certain shrinkage of the film upon drying, and this fact is made use of to determine both the number of lines to the inch and the quality of the replica. On placing the mounted film face downward upon the original grating with the lines parallel to each other, interference bands are seen. When these appear parrallel and equidistant it is confidently assumed that the replica is suitable for work of a high class and the number of bands per unit distance added to that of the original grating, gives the actual number of lines on the film. With a good grating prism as described several lines are very distinctly seen between the two D lines in the solar spectrum, with a low sun. The B group is particularly well seen and the individual lines distinguishable.

It has been found possible to silver the grooved side of the mounted films by the ordinary glass silvering process, but occasionally much difficulty in doing so is experienced and reliable results are even now not always obtainable.

Mounted on concave spherical surfaces and silvered, the films give brilliant spectra suitable for photographic work, but owing to the nature of the ruling, as is well known, the aberration is too great to admit of their being used for other work.

Whilst engaged in making and mounting these films it had often occured to me that they might in some way be utilised for exhibiting photographs in colours, but not until Professor Wood, of Wisconsin, U.S.A., had published his ingenious plan, did any practical method of doing so suggest itself. Briefly, Professor Wood's process consists in using gelatine plates rendered sensitive to light by means of bichromate of potash, placing a transparent grating of some 2,000 to 3,000 lines to the inch in contact with the film, and printing through a transparency made from a negative taken through a coloured screen (as a matter of fact Professor Wood used slides prepared for the Kromscop; they were also adopted by me in my experiments as being taken through the proper screens and ready to hand).

When a plate so exposed to light is washed in warm water the parts affected are insoluble, and a slight ridginess due to the action of the grating is produced, whilst those parts unaffected by the light are washed away to some extent and no effect is produced upon them.

By superposing three such plates acted upon through transparencies, properly illuminating and viewing them, one picture in natural colours, or very nearly approaching them, is seen, the effect being produced by diffraction from the grooves or ridges of the gelatine films.

To obtain this effect Professor Wood uses gratings of 2,000, 2,400, and 2,750 lines to the inch, as the red, green, and blue-violet in the spectrum of each, respectively, coincide, and thus all colour combinations are rendered possible, as is well known.

The spectra produced by the rulings just mentioned are, however, unfortunately very short, and the slightest movement in observing the pictures brings other colour combinations into view, and as the pictures could not be produced in much closer lines by the contact method with any degree of uniformity, I resorted to the following means for lengthening the spectra, and so obtaining lines of any degree of closeness.

To the bichromated gelatine solution was added a small percentage of glycerine, which had the effect of rendering the surface "tacky" when the gelatine had set. One of the celluloid films was then impressed, grating side down, into the surface of the gelatine, which thus took the form of the grooves. To do this without enclosing air bubbles was no easy matter, and the plan adopted eventually was to mount the film on a slightly convex yielding surface, and perform the operation in vacuo.

A transparency now being placed over the film side of the plate, the whole was exposed to a strong light (the length of time necessary varying from 1½ minutes with a bright summer sun to a quarter of an hour when covered with fleecy clouds), and the celluloid film dissolved off by acetone, the whole plate was found to have a grating surface, but more particularly decided in the portions acted upon by the light. The plate was then washed in warm water, when all parts but those affected were rendered clear, the affected parts varying in their power to produce colour effects in proportion to the degree of opacity of the transparency through which they were printed, whilst the sharpness of the diffracted picture was, with the most successful experiment, all that could be desired.

As I had only a single grating, however, with which to make my experiments, it was necessary therefore to adopt some other means, both of illumination and of superposition, than those adopted by Professor Wood.

Three sources of light became manifestly necessary, and, to show the pictures stereoscopically, six.

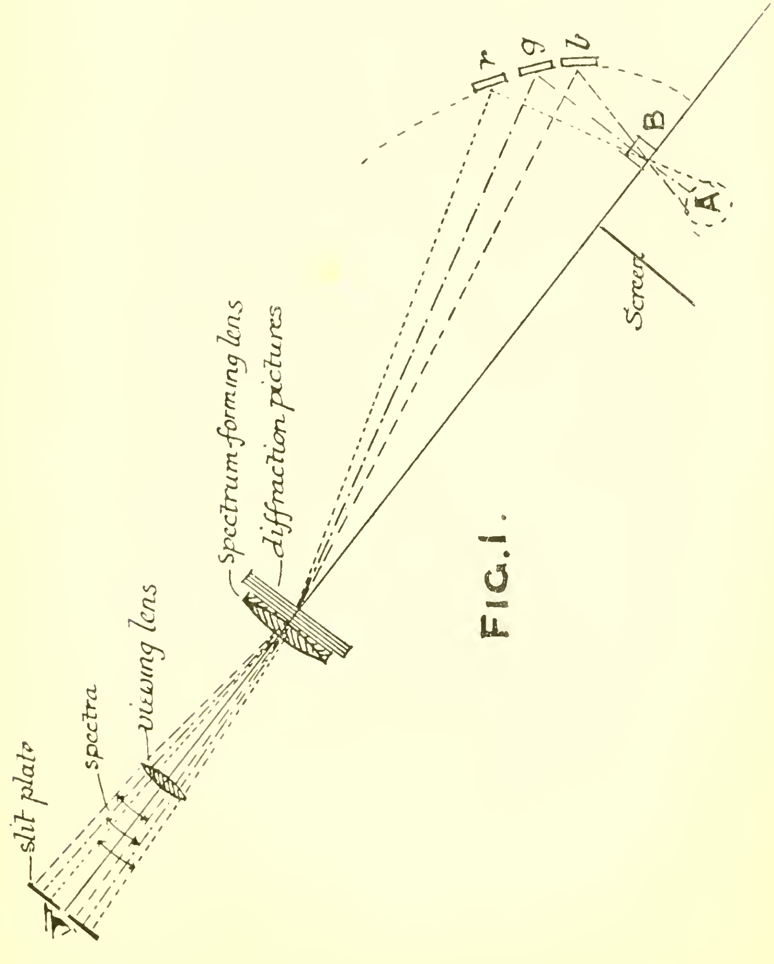


FIG. 1.

By the device shown diagramatically on *Fig.* 1, one source of light alone fulfils all purposes.

A set of three small mirrors *b*, *g*, and *r*, is arranged on each of the inner surfaces of two ellipsoids; a slit, through which the light passes from a source at *A* (a Welsbach burner being found very suitable) being in one of the foci of each ellipsoid and the stereoscopic pictures in the other.

Total reflecting prisms, *B*, are placed over each slit to deflect the rays proceeding from the source arranged between the two slits, on to the mirrors, the effect being as though there were six sources of light at a uniform distance from the pictures. These mirrors being adjustable, light from any desired angle can thus be directed on the picture. A central ray from each is shown in dotted lines, showing the overlapping of the spectra formed at the eye end, a slit being necessary to confine the view to the axial rays. It will thus be seen that the blue of the spectrum formed by the picture illuminated by light from the mirror *b*, coincides at the eye slit with that of the green from the mirror *g*, and that of the red from the mirror *r*, when they are set at the proper angle, and white light is produced. Pictures taken through colour screens, superposed and viewed in such an apparatus appear simply as ordinary photographs and without colour. To produce colour effects, the pictures must therefore act independently, and transmit to the eye only those colours corresponding to the screen through which the original photographs were taken. To enable this to be done, the lines of the grating composing the pictures are arranged at a slight inclination to each other—about 10° being found suitable—and the mirrors moved laterally to the corresponding angles on the ellipsoid. Separate spectra are now produced at the eye slit and the pictures are seen, as exemplified in the apparatus shown at the meeting, in their natural colours, the spectra being such that a slight movement has practically no deleterious effect upon the colours of the pictures.

With gratings of say 30,000 to the inch, purer colours still would result, for as is well known, the length of the spectrum increases as the distance between the lines dimininishes, and there is practically no limit to the closeness of lines which this method of reproducing them is capable of.

It is quite evident, of course, that any colour combination besides the natural ones can be made by merely altering the positions of the mirrors. The apparatus is therefore particularly applicable to designs in colour, such as stained glass, &c., for which purpose photography, except as applied to the bichromated gelatine film, is not necessary.

The requisite designs can be produced by hand, and printed through the grating films, when colour combinations of an almost infinite variety can be made up, by altering the position of the mirrors.

For producing merely natural colour effects by means of diffraction-gratings, Professor Wood's method of using three differently ruled gratings cannot well be improved upon, or, at least, that would appear to be the case. There is, however, the difficulty that parallel superposed gratings give interference bands, but whether these would be sufficiently obtrusive as to produce a visible effect can only be determined by direct experiment. That there are such bands on Professor Wood's own pictures is plainly seen, but they are possibly due to the unequal spacing of the lines.

Up to the present time I have not succeeded in impressing more than one grating film on to one gelatine plate, but am in hopes that a metal matrix may yet be made into which the three gelatine pictures can be impressed. Reproductions might then be made in transparent celluloid after the manner of the grating films, and mounted, when the effect produced would be precisely similar to that by the original superposed pictures.

Even if this is not found practicable, reproductions of the pictures in celluloid can be made, thus obviating the necessity of using films, printing, and washing.

In case it is found practicable to take the three pictures on one film, then by silvering the film, mounting it on a concave surface, and viewing by reflected light, the spectrum-forming lens at least can be dispensed with, as well as the viewing lenses, unless stereoscopic effects are desired.

The same effect would be produced from a flat surface if the rulings were circular and variably spaced, and in such a case our best ornithological, botanical, zoological, &c., books, at least, might be illustrated in a manner, failing some simpler new method, which would yield pictures more nearly corresponding to those of the objects themselves than is possible to obtain by any printing process.

In the case of designs no printing at all is actually necessary. All that is required is to obliterate the parts of an ordinary celluloid film which are not required to be coloured, by some transparent medium, and surperpose in the ordinary way. This will probably be found the method most applicable to new designs, but where an existing design is required to be reproduced, photography and printing as described would be necessary.

XIII. On the Production of Nitric Acid from Air by means of the Electric Flame.

By Arthur McDougall, B.Sc.,
and
Fred Howles, B.Sc.

Received and read March 6th, 1900.

Nitric acid has been known and used from very early times. We find the Arabian alchemist, Geber, teaching the method of obtaining it by distilling a mixture of saltpetre, copper vitriol, and alum in certain proportions. Raymund Lullius, in the 13th century, gave directions for preparing it by distilling saltpetre with iron vitriol. Glauber, in the 17th century, obtained it by distilling saltpetre with oil of vitriol, the process by which it is prepared at the present day.

It is not, however, until we come to the beginning of the 19th century, that any mention is made of preparing nitric acid by other means than that of distilling saltpetre with oil of vitriol.

It was Cavendish who, at this time, succeeded in demonstrating that atmospheric air is a mixture of oxygen (dephlogisticated air) and nitrogen (phlogisticated air) in constant proportions, and that nitric acid can be produced by the passage of electric sparks through these gases confined over water.

By the substitution of potash solution for water a mixture of nitrite and nitrate of potash is produced, which, on evaporation, yields saltpetre ; and, as we already know, nitric acid can be obtained from this salt by distillation with oil of vitriol. In this way Cavendish succeeded in preparing, under favourable conditions, saltpetre, at the rate of 0·003607 grm. per hour.

August 16th, 1900.

This pioneer work, however, opened out a new field, and we find several chemists endeavouring to prepare nitric acid by the aid of the electric spark. Among these may be mentioned Newton (1859), whose apparatus consisted of a number of platinum wire terminals, between which electric sparks passed, the terminals being contained in a large chamber, the floor of which was covered with water for the absorption of the oxides of nitrogen, with the subsequent production of nitric acid. Arrangements were also made for supplying air, and for drawing off the nitric acid produced.

Prim (1882) makes use of the combined effect of the spark and the silent discharge. The quantity of nitric acid produced by these processes was almost indefinitely small. It was only with the invention of the modern dynamo, by means of which electrical energy can be produced in any desired quantity, that the idea of preparing nitric acid by its aid could be entertained.

In 1892, Sir William Crookes exhibited an electric flame produced by a high-tension alternating-current discharge between platinum terminals, and depending for its maintenance upon the combustion of atmospheric nitrogen and oxygen. A flame of this nature was utilised by Lord Rayleigh and Professor Ramsay, for the isolation of argon from the atmosphere (*Phil. Trans.* vol. 186, pp. 187—241) and also in a later research by Lord Rayleigh (*Chem. Soc. Journ.* 1897) on "The Oxidation of Nitrogen Gas."

The electrical arrangements are described in detail in this paper. To generate the high-tension current, a transformer, insulated in oil, was used. It was found to be necessary to use nearly 8,000 volts on the open secondary circuit to maintain a steady flame. When the discharge passed, the voltage fell to 2,000 or less.

A choking coil with an adjustable core was also included in the primary circuit of the transformer, so that out of 100 volts available at the mains, only 30 volts were taken. The current amounted to 40 amperes.

With the flame thus produced, working in a spherical glass vessel of 50 litres capacity containing an alkali fountain and having a continuous supply of a mixture of 11 parts of oxygen and 9 parts of air, or in the theoretical proportion for the formation of NO_2, Lord Rayleigh obtained an absorption of 21 litres per hour. This is equivalent to the production of 39·3 grms. of nitric acid. The power expended amounted to 800 watts, or rather more than a horse-power, per hour.

To make a further study of the oxidation of nitrogen by means of electricity, and more particularly of the rate of oxidation when atmospheric air, unmixed with oxygen is used, the following experiments were carried out.

The electrical apparatus consisted of a Siemen's alternator, frequency 60, with two armature circuits, one capable of generating 12 amperes at 400 volts, and the other 24 amperes at 200 volts. The current from this machine was used to feed the primary circuit of a transformer, transforming upwards in the ratio of 1 : 40. It was therefore possible to obtain a potential of 16,000 volts or 8,000 volts —according to the alternator circuit used—at the terminals of the secondary of the transformer. By varying the strength of the current feeding the primary circuit, any voltage between 8,000 and 16,000, or lower than 8,000, could be obtained as desired.

The primary current was directly measured by means of an amperemeter. A voltmeter gave the voltage at the alternator terminals, and, in addition, a wattmeter was included in the circuit, by means of which a correct reading of the power consumed by the flame could be obtained.

Readings of the Power Consumed in Producing the Flame.

Time.	Readings in watts.	Stoppages.
6.30 a.m.	185	
7.0 ,,	180	
7.30 ,,	175	
8.0 ,,	168	
8.30 ,,	165	
9.0 ,,	162	
9.30 ,,	160	15 minutes
10.0 ,,	165	
10.30 ,,	170	
11.0 ,,	170	
11.30 ,,	170	
12.0 ,,	180	
12.30 p.m.	185	15 minutes.
1.0 ,,	175	
1.30 ,,	170	
2.0 ,,	172	
2.30 ,,	175	
3.0 ,,	173	
3.30 ,,	170	20 minutes.
4.0 ,,	170	
4.30 ,,	170	
5.0 ,,	173	

Duration of experiment, 9 hours 30 minutes.
Average watts used in flame, 172.
Yield of nitric acid, 35 grms.

The high-tension current was led to a pair of platinum-iridium electrodes situated in a stoneware vessel, which will be called the "combustion chamber." Air was continuously drawn into this vessel, and, when the flame was burning, a portion of the nitrogen became oxidised. The oxides thus produced were drawn through a condensing apparatus, consisting of a series of Woulff's bottles containing water, and towers filled with broken glass, down which a stream of water or alkali flowed. In this way a complete absorption of the oxides of nitrogen was effected, and nitric acid or nitrates were respectively formed.

During the experiment, readings of the power consumed in the flame were taken every half hour. After the expiration of a definite period—usually about 12 hours—the average reading in watts was calculated.

The Woulff's bottles and towers were then emptied, well washed with water, and the quantity of nitric acid produced estimated by tituration with standard alkali.

The combustion-chamber underwent several modifications before a final form was decided upon. The first (*Fig.* 1) consisted of a large glazed-earthenware pipe 76 cm. in length and 20 cm. in diameter, supported horizontally. Both ends were closed by slabs of slate. A perfectly

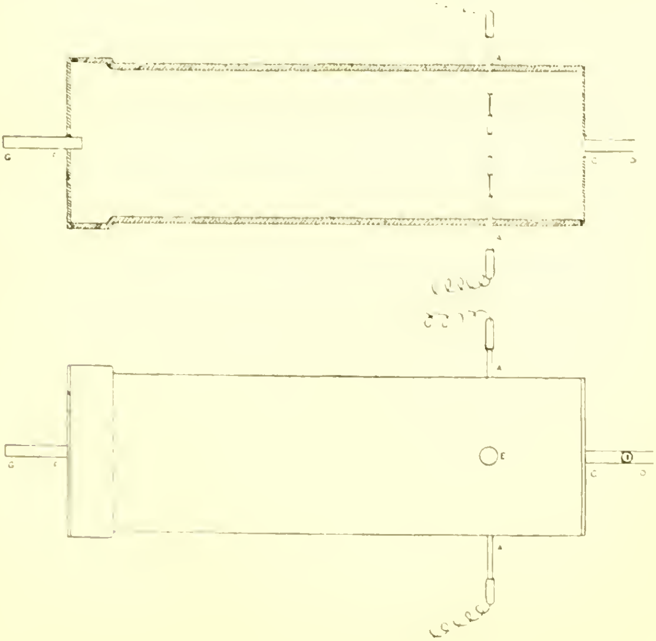


Fig 1.

gas-tight joint was secured in this, and all succeeding experiments, by the use of a cement composed of a mixture of clay, sand, and sodium silicate. This cement sets as hard as stone, and is not easily cracked by sudden variation in temperature, which is important in experiments of this nature.

The electrodes were introduced at A, A′, and were capable of adjustment. A glass tube, C D, conveyed air to the flame. A small plate of glass, E, through which the behaviour of the flame can be observed covers a hole in the slate. At the other end of the vessel, the tube F G conveys the oxides of nitrogen to the condensing apparatus. The gases were drawn through the whole system by means of a powerful pump.

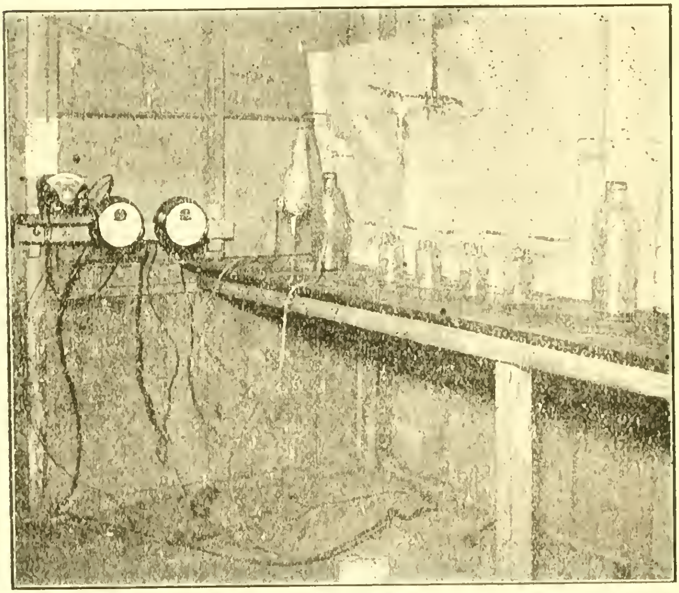


Fig. 2.

The two large bottles (*Fig.* 2) were not used during the preliminary experiments, but eventually it was found that their interposition had a great effect upon the yield of acid. The oxides of nitrogen appeared to dissolve more readily after their addition, and, when water alone was used for absorption, less than 1 per cent of the oxides formed was found in the gases leaving the last tower. On the other hand, when the bottles were not included in the condensing arrangement, it was usual to find 2 to 3 per cent of the oxides actually produced escaping with the exit gases. This appears to confirm Lord Rayleigh's view, that the gases on immediately leaving the flame are not in a condition ready for absorption. Hence the greater efficiency obtained by him on using large vessels in which to produce and absorb the oxides of nitrogen.

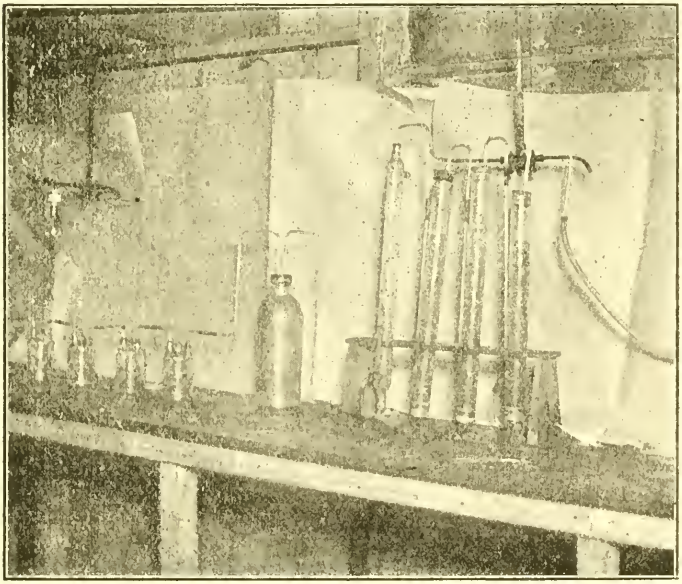


Fig. 3.

With this apparatus it was found that an expenditure of 220 watts, operating for 20 hours, produced 38·44 grms. of nitric acid. This is equivalent to 98 grms. of nitric acid per horse-power per 12 hours.

A second experiment gave almost identical results. The voltage on the open secondary circuit during these experiments was 7,000, which fell to 1,100 when the discharge was passing. The current taken was only 0·2 ampere.

It was now decided to substitute a combustion-chamber of form and capacity different from the one already in use. A stoneware bottle (*Fig.* 4) 30 cm. in height, and 10 cm. in diameter, was procured. The electrodes entered the vessel diametrically at A, A'. E represents a small glass plate through which the behaviour of the flame and the adjustment of the terminals may be observed. Air was supplied to the flame through the tube CD, which was let into the bottom of the vessel directly under the flame. The interior end of the tube CD was covered with very fine wire-gauze. In this way

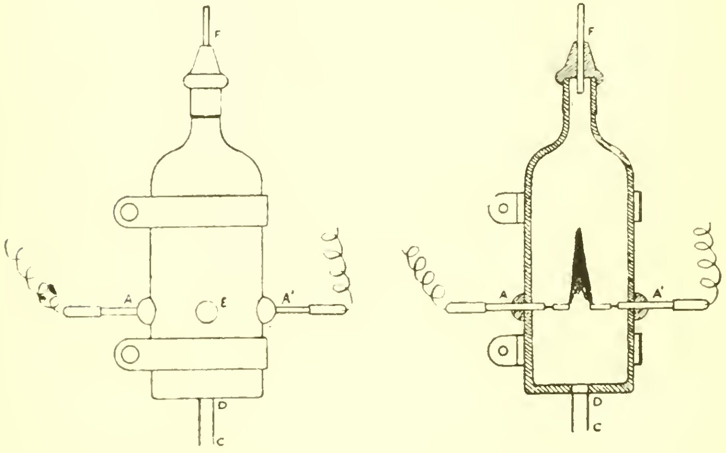


Fig. 4.

any powerful draught was prevented from impinging upon the flame, and rendering it unsteady.

The rate of oxidation of the nitrogen, in this apparatus, far exceeded that in the previous one. In an experiment extending over 11 hours, 48·76 grms. of nitric acid were produced for a continuous expenditure of 227 watts. This is equivalent to 180 grms. of nitric acid per horse-power per 12 hours, or almost twice the quantity produced in the first apparatus.

A second experiment of the same duration, but in which only 200 watts were consumed in the flame gave 51·9 grms. of nitric acid. This is equivalent to 210 grms. per horse-power per 12 hours.

A third experiment extending over 30½ hours, and in which 227 watts were used in producing the flame gave 138·16 grms. of nitric acid.

This is equivalent to 180 grms. per horse-power per 12 hours.

The relative efficiency of the three forms of "combustion-chamber" is more easily seen by comparing the results tabulated below.

Succeeding experiments with this apparatus gave results closely agreeing with the preceding, and from these figures it would seem that the form of "combustion-chamber" to be arrived at is one in which the oxides of nitrogen should be removed from the influence of the flame as quickly as possible, and in which convection currents should be avoided. If these conditions are not observed, the gaseous products of oxidation will be again partly resolved into oxygen and nitrogen by the intense heat of the flame, the temperature of which is about 2,000° C. The decomposition of both nitric oxide and of the peroxide begins to take place at a red heat.

The vessel finally assumed the form represented by

Fig. 5. The lettering employed is the same as in the preceding drawings.

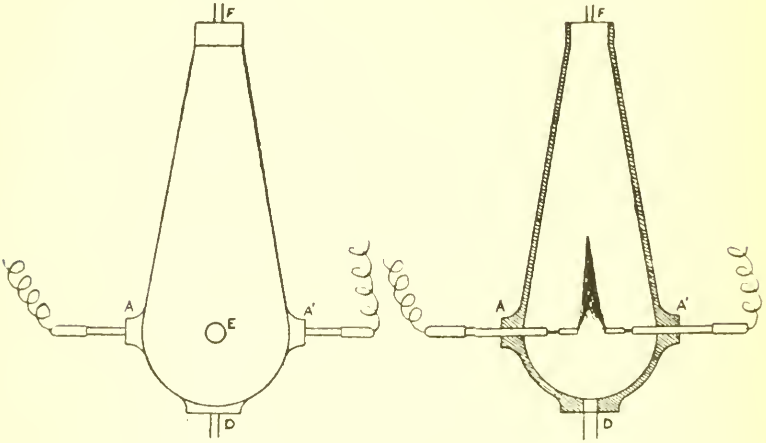


Fig. 5.

The first experiment conducted in this apparatus extended over a period of 22½ hours. The power continuously used was 225 watts. On analysis, it was found that there was an increase in the products from the condensing apparatus. The production of nitric acid had proceeded

	Watts.	Yield of nitric acid per horse-power per 12 hours.
Horizontal combustion-chamber	220	98 grms.
Vertical combustion-chamber	227	180 ,,
	200	210 ,,
	227	180 ,,
Second vertical combustion-chamber	225	270 ,,
	172	300 ,,

at the rate of 270 grms. per horse-power per 12 hours, thus showing an increase of 60 grms. over and above the quantities obtained in the former experiments. Confirmatory experiments, in which the above conditions were observed as closely as possible, gave, within the limits of experimental error, results agreeing with the first one.

It was important to try the effect of increasing or decreasing the current of air through the apparatus. So far the air had been supplied to the flame at the rate of about 20 litres per hour.

Too great an increase in the air supply caused the flame to become unsteady, and appeared to diminish the oxidation taking place in the flame, and the oxides of nitrogen, being also in a state of greater dilution, were more difficult to absorb. On the other hand, if the air supply was deficient, the oxides remained for too long a period under the influence of the flame, and probably suffered partial dissociation and a diminished yield of nitric acid therefore resulted.

In the light of the preceding experiments, it was deemed interesting to try the effect of varying the current in the secondary circuit, and thus to increase or decrease the temperature of the flame or combustion-chamber as a whole.

The current used to feed the primary of the transformer in the former experiments varied between 8 and 10 amperes. The high-tension discharge would therefore convey a current of about 0·2 to 0·25 ampere. This was now raised to from 0·3 to 0·38 ampere. After the flame had been in operation for 12 hours, only 71 grms. of acid were found to have been produced. This is equivalent to 180 grams per horse-power per 12 hours, or $\frac{2}{3}$ the quantity when only 0·2 ampere is used in the flame. This result was confirmed by subsequent experiments. Increasing the air supply just to within the point of causing the flame to become unsteady had no appreciable effect. The temperature of the combustion-chamber was raised considerably, so much so that it made the eyes smart badly if brought and kept for any length of time within 6 inches of the peep-hole for the purpose of observing the flame.

By decreasing the high-tension current, so that only 0·15 ampere was used to feed the flame, 55 grms. of nitric acid were produced in an experiment extending over 9½ hours.

This is equivalent to 300 grms. per horse-power per 12 hours, showing an increase over the quantities produced in all former experiments. A result which was anticipated.

In the last three sets of experiments, whilst varying the current, the voltage was kept as constant as possible. The results are more easily compared in the following table :

Watts used in flame.	Current used in flame.	Yield of acid per h.-p. per 12 hours.
302	0·3—0·38 ampere	180 grms.
225	0·2—0·25 ,,	270 ,,
172	0·15—0·2 ,,	300 ,,

Too great a decrease in the current caused the flame to become unsteady, and liable to extinction. Of course theoretically as the current is decreased, the discharge should resemble more and more that obtained from a Ruhmkorff's coil or electrical machine, only less in intensity, until finally only a streak or spark is obtained.

The production of nitric acid in this apparatus, at the rate of 300 grms. per horse-power per 12 hours, represents

51·5 per cent of the amount theoretically obtainable from the amount of air passed in.

This result favourably compares with that obtained by Lord Rayleigh, who, working with a mixture of oxygen and nitrogen in the proportion of two volumes of the former to one of the latter, produced 440 grms of nitric acid in the same time with the same amount of power.

When air alone is used to supply the flame, the theoretical proportions of nitrogen and oxygen are diluted with 2⅓ times their volume of nitrogen. This, of course, will exert a retarding effect upon the rate of oxidation of the nitrogen.

An experiment was conducted with a mixture of oxygen and nitrogen in the proportion of two to one. The gaseous mixture was passed through the apparatus at the usual rate. A quantity of acid, almost double that previously obtained, amounting to 590 grms., was produced.

To still further study the effect of temperature upon the process of oxidation, the air before passing into the burner was raised to a considerable temperature. For this purpose, a porcelain tube, 13 mm. in diameter and 305 mm. in length, was packed with asbestos, around which, and interlacing with it, was a thick platinum wire. On passing a sufficiently powerful current of electricity through the wire, the whole tube was raised to incandescence, and the air, after circulation through the heated asbestos, was raised to a considerable temperature. The tube was cemented into the air-inlet of the combustion-chamber. With the flame operating in this apparatus, an experiment extending over eight hours, in which 182 watts were used, showed a decrease in the yield of nitric acid. Only 35·12 grms. were produced. This is equivalent to 217 grms. per horse-power per 12 hours.

Two more experiments were made, under similar conditions, the yield of acid in each case was almost identical, and is readily compared in the following table.

Watts.	Yield of nitric acid per H.P. per 12 hours.
182	217 grms. with hot air
188	211 ,, ,,
186	225 ,, ,,
172	300 ,, with air at ordinary temperatures
225	270 ,, ,, ,, ,,

Watts.	Current.	Yield of nitric acid per H.P. per 12 hours.
302	0·3	180 grms.
225	0·2	270 ,,
172	0·15	300 ,,

The current during the first three experiments was kept practically constant, and was intermediate between the currents used in the two experiments with cold air.

Thus the effect of temperature on the yield of acid is very evident, and, if some means could be devised to remove the products of oxidation still more quickly from the flame, an increased yield of acid might result. That the increased amperage in the flame exerts no direct effect upon the rate of oxidation is shown by the above experiments where the current is kept as constant as possible.

At this juncture it was thought that it would be interesting to determine the amount of nitric acid produced in a given time by the low-tension electric discharge taking place between carbon poles in the presence of a large excess of air.

In this case the conditions of high temperature obtain in an excessive degree. Whether nitrogen oxides would be produced by the combustion of the cyanogen, or by direct oxidation of the nitrogen itself under these conditions, formed an interesting question. To study this, the apparatus used in the former experiments was employed. Carbon electrodes, about 20 mm. in diameter, were substituted for the platinum-iridium terminals. A current of 15 amperes at about 100 volts was used to generate the arc. The air was drawn through the apparatus in the usual way. After operating for six hours, it was found that only 0·424 grm. of nitric acid had been formed.

The loss suffered by the platinum-iridium electrodes due to the passage of the electric discharge is very slight. A pair was weighed, and, after being in operation for 80 hours, lost only 0·01 grm. in weight. The platinum-iridium settled in the exit-tube from the combustion-chamber, and formed a kind of mirror.

A curious phenomenon is observed when the electrodes are made red hot. They may be drawn out to the maximum distance apart, when sometimes a bluish glow is seen, somewhat resembling the brush discharge from an electrical machine. Then, all at once there is a click, and the flame is established. The initial striking distance in this case may have been only about 2 mm., and the maximum from 25 to 40 mm.

J. J. Thomson has proved that gases become electrified in the neighbourhood of glowing metals, the ions so produced being able to discharge insulated condensers. In this case we may look upon the electrodes as condensers, and the breaking down of the air-insulation as being due to the discharge taking place through the electrified gas.

Several attempts were made to substitute some other material in place of platinum-iridium for the electrodes, but no very great success was achieved. In one case rods of calcium oxide 6 mm. in diameter were prepared, and it was possible to get the high-tension current to pass through these on warming. The appearance of the electric flame was, however, altered, being much thinner and straighter than when platinum-iridium was used. It was also very unsteady, with a tendency to constantly creep back from the point of the electrode to the metal connection.

In continuing these experiments it was thought desirable to observe the behaviour of the electric flame when produced directly, by means of a high-tension alternator, and, also to try under what conditions the flame could be maintained and worked in parallel. Messrs. Johnson and Phillips were kind enough to grant permission for the experiments to be carried out in their testing-house.

An alternator, frequency 50, capable of generating 7,500 volts, was placed at our disposal, and the general arrangement of the apparatus is shown by *Fig.* 6.

A number of electrodes arranged in parallel circuit were supported in a framework of wood, each electrode being capable of adjustment. The voltage at the terminals of the alternator was registered by means of an electrostatic voltmeter. A similar instrument gave the voltage at the electrodes when the discharge was passing. An ampere-meter inserted in the circuit also enabled the current taken to be read.

The experiments were begun with a tension of 3,000 volts. All attempts to establish a flame when no choking was included in the circuit resulted in failure. The electrodes were immediately fused, the current meanwhile

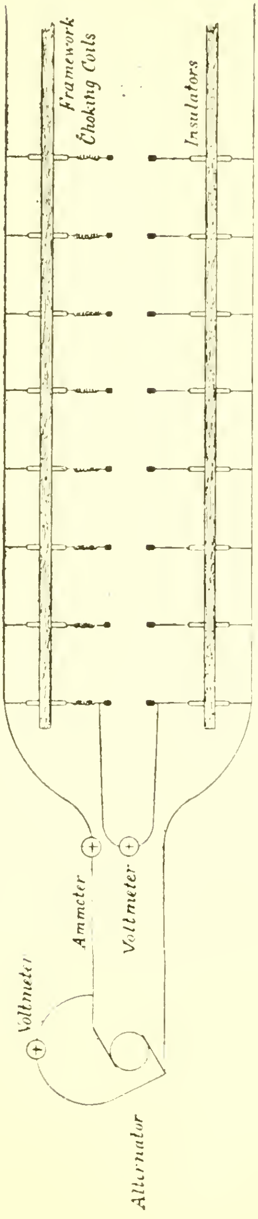

Framework
Choking Coils
Insulators
Ammeter
Voltmeter
Voltmeter
Alternator

Fig. 6.

rising to 20 amperes. This behaviour is what one would have expected. By introducing a choking coil into the circuit, however, a flame was readily obtained. Simultaneously, the voltage at the electrodes fell to 600 when the latter were about 9 mm. apart. The voltage was now gradually run up. More flames were got into operation, until finally eight were working quite steadily. This result was obtained by including in the circuit of each flame two choking coils, each with 600 turns of wire. Even with this adjustment the electrodes got hotter than when the transformer was used.

The following table shows the drop in volts at the electrodes when the flames were working.

The gap or distance between the electrodes is the maximum consistent with the steady working of the flame.

Volts at alternator.	Volts at electrode.	Gap (maximum).
3000	600	9·5 mm.
3200	1000	19·0 ,,
3400	1200	21·0 ,,
4200	1300	25·4 ,,
4500	1300	28·4 ,,
4800	1400	34·0 ,,
5000	1500	38·0 ,,
5300	1500	40·0 ,,
5500	—	—
6000	—	—
6500	—	—
7000	—	—
7500	—	—

When the tension reached 5,500 volts, the voltmeter connected with the electrodes broke down, arcing taking place between the needle of the instrument and the quadrants.

At 5,000 volts a very fine and steady flame was obtained, the electrodes being separated by a distance of about 38 mm.

At 7,500 volts the electrodes were nearly 50 mm. apart, a steady flame still burning.

The voltage registered at the electrodes in all cases depends upon the distance between the latter when the discharge is passing. As the electrodes were drawn apart, the drop in volts became less. The current also became less. Thus, in one case, 4,700 volts were registered at the alternator terminals. When the discharge was running, the electrodes were 6 mm. apart. Only 100 volts were indicated on the voltmeter connected to the electrodes. As the latter, however, were separated, the voltage gradually rose, until, when at a distance of 30 mm., 1,100 volts were registered, the current at the same time decreasing from 0·3 to 0·15 ampere.

This result is probably explained by the greater choking-action exerted by the coils when the electrodes are near together and the current passing is greater.

Manchester Memoirs, Vol. xliv. (1900), *No.* **14**.

XIV.—Selections from the Correspondence of Lieutenant-Colonel John Leigh Philips, of Mayfield, Manchester. Part II.

By W. Barnard Faraday, LL.B.,

Barrister-at-Law.

Received and read April 24th, 1900.

Just ten years ago the Manchester Literary and Philosophical Society published the first series of these "Selections," edited by Mr. F. J. Faraday. This first part presented, on the whole, a complete outline of the life of Mr. John Leigh Philips, and, to a certain extent, brought the Manchester of 100 years ago home to us, and enabled us to judge for ourselves of the Manchester celebrities of that day, and of the class of men who founded this Society. The series of letters which it is now proposed to make public deals to a very large extent with the sister town of Liverpool, and enables us to gauge the literary, artistic and social capacities of the two towns during the last quarter of the eighteenth century.

The greater number of the letters mentioned in the following pages are from the pen of Mr. Thomas Taylor, the intimate companion of Leigh Philips. The friendship between these two was a very remarkable one in many respects. Each was, or became in later life, a leading citizen of his native town, each was happily placed in life, each was blessed with cultivated tastes and a very earnest

August 16th, 1900.

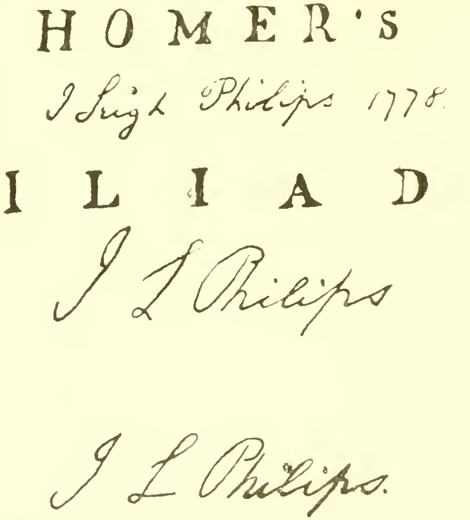
patriotism. The two towns in which they lived are closely linked together, not only by the shortness of the space which separates them geographically, but also by that strongest of ties, mutual interest. It is to be questioned indeed, whether anywhere else on the surface of the globe can be found an example like that of the two great Lancashire municipalities; they were practically born together, they have grown and developed together, and at the present day they practically still observe the same relative positions.

Living as they did just at the critical point in the history of Manchester and Liverpool, and being what they were, it may be supposed that Philips and Taylor exercised a great influence upon the local destinies, and we may justly claim that much of what is best in Manchester and Liverpool life at the present day is due in some degree to the influence of their friendship. It is obvious to the reader of these letters that we are dealing with two very fine characters, of a type best calculated to appeal to English people. They were both of them eminently steadfast in their mutual affection, but in no wise demonstrative. They were both blessed with an almost excessive sense of humour, coupled with refined and cultivated tastes. They were both "manly" men. Taylor, artist, poet and book-lover as he was, was a man with a good deal of quiet, determined courage, while one might even go so far as to call Philips "fire-eater" in this respect, at any rate when he is presented to us in certain phases. To conclude this comparison, Philips was more actively engaged in business than Taylor, who was a confirmed *dilettante* in art matters and let his enthusiasm in this direction run to even greater lengths than did Philips. Both must have been from youth upwards extremely loveable men, Taylor the milder mannered, with a constant touch of good-humoured irony, Philips charitable at heart, but blunter spoken, and at times irascible.

The intercourse between Manchester and Liverpool at the time of which we write seems to have been constant and stimulating, and as a young man Philips was a frequent visitor to Liverpool, and had his literary, artistic, and natural history tastes strengthened by the cultivated Liverpool circle, of which William Roscoe, the "elegant historian of the Medici," to quote Washington Irving's description of him, was the acknowledged head. The letters teem with references to Roscoe, and also, among others, to Dr. James Currie, the biographer of Burns; Mr. Daniel Daulby (who married Roscoe's sister), the author of the "Descriptive Catalogue of the Works of Rembrandt and of his Scholars—Bol, Livens, and Van Vliet," published in Liverpool in 1796, and an amateur artist of repute; and William Paulet Carey, who brought Chantrey, the sculptor, and James Montgomery, the poet, to public notice. It was in Liverpool that Leigh Philips found his wife, Caroline Penny; and it was to Liverpool that his sons and widow retired after his death. Of the pleasant social relations existing between the two towns the following letters give us some idea; they also show us the healthiness of the general spirit at that time, of which the natural result was the golden age of English science and philosophy.

The present selections may be suitably introduced by the following tracing, which was sent to my predecessor by the late venerable Mr. James Radford, of Newcastle-on-Tyne, and formerly of Manchester.

It is taken from the title page of a duodecimo copy of Pope's translation of the Iliad. The first signature with the date is that of Philips when he was about 17 years of age; the others agree with specimens of his handwriting at a much later period of life. The following letter, the earliest in the collection, was written to him four years before the earliest of the signatures, when he was a boy of



HOMER'S

J Leigh Philips 1778

ILIAD

J L Philips

J L Philips.

thirteen, the writer of the letter being at the time a youth of sixteen. We of course retain the original spelling and punctuation :

Liverpool, 10th. May, 1774

Dear Friend

I recev'd your kind Favour by the Servant, and also one some time Before with a very pretty Landscape of your Drawing, which I am very much oblig'd to you For, & will soon send you one of my Best, For I have began to Learn of Mr Chabbard a very famous hand here, to Draw in Chalk and Crayons which I am very Fond of and think it is by far the Best way. I have waited some time in hopes of having some opportunity of writing to you by a Private hand, but as none has Offerd I was detirmined to stay no Longer, wherefore I hope you will excuse my Delay. My Cousin Martineau* & Sister whom we have expected so long from Norwich are at last come, & are now Performing Quarantine at Warrington, for I'm sure its very like it after coming from so farr of, to lie so near us and Can't see them for above a Month. Jack is quite in the Dumps about it, however he is very well and desires to be rememberd to you. Mr & Mrs Earle are both at Allerton he

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* See page 25.

comes home to Day, and she sets off the 16th. Inst. for Litchfield to bring home the Young Ladies so that with them, my Cous. & Sister, & Miss Leighs we shall have a Pretty full house. Please to give my Compts to your Papa & Mama & not forgetting Little Harry I remain

Your sincere Friend
THOS TAYLOR.

The writer is, of course, the Thomas Taylor to whom we have alluded, and from their schooldays, until the marriage of Philips in 1786 ended their joint bachelor life, the two men were, as I have said, constant and intimate companions. Taylor was an offshoot of a family which has been truly said to have been conspicuous for virtues and talents for many generations and in many branches. The Taylor family, indeed, has produced so many notable worthies that the task of tracing out its many claims to distinction is anything but an easy one. Though conspicuously associated with the town of Norwich, where the periodical gatherings of the various branches of the family were held, at which a hundred or more of its members would assemble, it is of Lancashire origin. The other literary family, the Taylors of Ongar, of whom an account is given by Isaac Taylor in that curious book, "The Family Pen," were not related to the Norwich Taylors. Jane and Ann Taylor, known to childhood in the "Original Poems," belonged to the Ongar family.

Dr. John Taylor, the author of the "Hebrew Concordance," from whom the Norwich Taylors were descended, was born at Lancaster—where the family was known in the 15th century—in 1694, and settled in Norwich in 1733. In 1757 he became the tutor in Divinity at the Warrington Academy, opened in that year, the first student at which was Thomas Percival, who, as Dr. Percival, was subsequently one of the founders of the Manchester Literary and Philosophical Society, to whose memory there is a mural tablet above the Presidential chair in the Society's house in George

Street. Dr. John Taylor's son, Richard, married the granddaughter of John Meadows, one of the ejected ministers, and carried on the business of a printer and publisher at Norwich. One of Richard's sons, John Taylor, was a spinner at Norwich, and his home became the centre of the literary *coterie* of that town. His wife, whose maiden name was Susannah Cook, was the subject of an enthusiastic eulogium by Sir James Mackintosh, who was a regular visitor of the Taylors when on the Norfolk circuit. In one of his letters, Mackintosh speaks of her as the "Madame Roland" of that town. Basil Montague, in an account of his experiences with Sir James Mackintosh on the Norfolk circuit, writes of her as follows:—"Norwich was always a haven of rest to us, from the literary society with which that city abounded. . . . . But our chief delight was in the society of Mrs. John Taylor, ... mild and unassuming, gentle and meek, sitting amidst her large family, occupied with her needle and domestic duties, but always assisting by her great knowledge the advancement of kind and dignified sentiment and conduct. Manly wisdom and feminine gentleness were in her united with such attractive manners that she was universally loved and respected . . . . In her society we passed every moment we could reserve from the court." Some occasionial hymns, songs, and other verses written by Mr. John Taylor, and set to music by him, remain as memorials of this amiable couple.

One of their daughters, Sarah, married, in 1820, the celebrated John Austin, justly called the founder of modern scientific jurisprudence. Mrs. Austin is described by Dr. Robert Campbell in the following terms:—"To the attractions of great personal beauty in early life, she added the enduring qualities of a clear and energetic intellect, high principles of action, and a large heart." It was she who nursed her delicate husband during his life, and, afterwards, aided by the notes of the original lectures taken by John Stuart Mill, edited and placed before the public the remarkable "Lectures on Jurisprudence, or the Philosophy of Positive Law." Mrs. Austin, as may be imagined, took a distinguished place in London literary society. Her daughter, Lucie Austin, became Lady Duff Gordon, and sustained the literary reputation of her mother's family in the celebrated "Letters from Egypt." Another daughter of Mrs. John Taylor married Dr. Reeve, and their son was the translator of De Tocqueville's "Democracy in America." The sons of Mr. and Mrs. John Taylor all achieved considerable distinction. The eldest was John, a mining engineer and a chemical manufacturer. He was elected a Fellow of the Geological Society in 1807, and became a Fellow of the Royal Society in 1825. He was one of the founders of University College, London, and was for many years its treasurer. He also helped to found the British Association, and was its treasurer until 1861. Richard Taylor, the second son, was the founder of the printing and publishing firm of Taylor and Francis, and was in 1810 secretary of the Linnean Society; he was a philosophical and scientific writer of some note. The third son, Edward, was the Gresham Professor of Music. The fourth son, Philip, was a civil and mechanical engineer with a world-wide reputation. He had a large and interesting circle of friends, among whom were Brunel, James Nasmyth, Michael Faraday, Wheatstone, Gay-Lussac, Arago, and many others almost equally eminent.* The other son, Arthur, was an antiquary and a printer.

Another member of the family was Edgar Taylor, F.S.A., the translator of Grimm's "Fairy Tales" and "Lays of the Minnesingers"; the author of the "Chronicle of the

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* "Dictionary of National Biography"

Norman Conquest," the "Book of Rights"; and a contributor to the "Westminster Review." The eldest brother of Mr. John Taylor of Norwich, already referred to as being, with his wife, the literary centre of that town in Macintosh's day, was the Reverend Philip Taylor, who was born at Norwich in 1747, and subsequently settled at Old Court, Harold's Court, county Dublin. A son of his was Philip Meadows Taylor, who became a Liverpool merchant at the beginning of this century. He married the youngest daughter of Bertram Mitford, Esq., of Mitford Castle, Northumberland, one of the most ancient Saxon families in the country. Philip Meadows Taylor was educated in Germany, where he learnt the value of the rifle as a military weapon. He subsequently became executive captain of a volunteer rifle corps in Liverpool. He was the first, indeed, to introduce the use of the rifle into this country. Later, meeting with serious financial reverses, he honourably settled his liabilities in full, and giving up his luxurious home in Rodney Street, accepted an appointment as manager of a brewery in Dublin. This change of fortune made it necessary for his son to make his own way in a mercantile house in Bombay, to which place he sailed at the age of fifteen. The length of the voyage in those days allowed him time to begin the study of the native languages of India. Like Robert Clive, a boy of Lancashire training, he soon abandoned business, and obtained a commission in the Nizam's military contingent. Taylor taught himself land-surveying and engineering, and obtained an exceptional influence over the natives through his knowledge of the languages of Southern India. As Colonel Meadows Taylor, he crossed over into Berar without troops, and, aided by the extraordinary confidence which the natives had in him, saved Southern India from joining in the Mutiny. The hereditary literary abilities of the family found expression in his case in a number of works: "Confessions of a Thug," "Manual of Indian History," "Tara," "Ralph Darnell," "Tippoo Sultaun," and "Seeta." His autobiography, "The Story of My Life," was edited by his daughter, Miss A. M. Taylor.

Returning to Dr. John Taylor, of the Warrington Academy, it will be seen that he had several grandsons, the children of his only surviving son Richard. The eldest of these was the Rev. Philip Taylor, who was the grandfather of Colonel Meadows Taylor; another was Samuel, the father of Edgar Taylor, F.S.A.; another was Mr. John Taylor, the grandfather of Lady Duff Gordon; another was the Thomas Taylor, whom, as a youth of sixteen, we find writing from Liverpool, where he had apparently begun a business career in the house of Mr. Thomas Earle, a merchant dealing with Leghorn and Genoa, who was the second surviving son of John Earle, one of the founders of the mercantile greatness of Liverpool at the beginning of the last century.

From William, a younger brother of Thomas Earle, is descended the titled family resident at Allerton Tower, of which General Earle, who commanded the Nile expedition for the relief of Gordon, and who was killed in the Soudan, was a member. Thomas Earle, who was born in 1719, became established as a merchant at Leghorn, where he resided for many years, and where his two daughters, Maria and Elizabeth Jane (to whom there are constant references in these letters) were born in 1761 and 1764 respectively. In 1754 he married Mary, the only daughter and heiress of Adam Mort, of Wharton Hall. She was born in 1726, her mother being a daughter of George Leigh, of Oughtrington Hall, Cheshire, by the latter's first wife. Another daughter, Sarah, was the mother of John Leigh Philips. In 1766 Thomas Earle and his family returned to Liverpool, and in the following year were residing in a house in Hanover Street, then a fashionable quarter of Liverpool. This house is now the Hanover Hotel. Mr. Thomas Earle died on April 18th, 1781, and his wife died on January 29th, 1785, the two daughters, Maria and Elizabeth Jane, inheriting their father's fortune and the estates of Adam Mort, their grandfather on the mother's side. Maria married her cousin, Thomas Earle of Spekelands, the son of William Earle, and Elizabeth Jane married Richard Gwillym* of Bewsey Hall, Warrington.

Thomas Taylor, the youthful friend of Leigh Philips, appears to have remained unmarried. He seems to have been one of those men whose lot it is to do zealous and hard public work, under the shadow of more prominent and older men, and to find his reward in self satisfaction at the success of the enterprises undertaken, rather than in public recognition of his labours. To him Liverpool is largely indebted for its municipal progress, its Academy of Art, and its Athenæum, though his name is practically forgotten—and only those who read the letters he sent to his friends know how ungrudgingly he gave his services. He died in 1803, and in a letter written to William Roscoe from Norwich, in that year, Sir James E. Smith, the botanist and first President of the Linnean Society, gives the following sketch of the man: "My good and kind host, my oldest friend out of my own family, is no more! In all our childish amusements he was always my instructor and example (Taylor was a year older than Smith), when he went to boarding-school it was the first real trial of my fortitude. He was my first correspondent. I used to dream night after night that he was home for the holidays. He then went to Liver-

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* High Sheriff of Lancashire, 1796.

pool; time, new connections and pursuits made us less interested in each other. We met occasionally in London with mutual pleasure, though with not so many ideas in common as heretofore. At length my fortunate visit to Liverpool, in the planning of which I found all the original friendship and benevolence of his heart exerting themselves as warmly for me as ever, promised the revival of our old attachment through our lives. We parted for the last time at your door. You had witnessed his eagerness and anxiety to serve me; nor can I ever forget his benevolent, unobtrusive, and unostentatious hospitality, his hearty welcome, the freedom with which he told me all his concerns, and the pleasure he took in recalling the events of our youth . . . . His heart was in no degree worse for living in the world, but in some points I have thought it improved; this might be owing to a slight cloud of ill-success, which had but too often accompanied his path. He was always more successful in serving others than himself."

Continuing our selections from the correspondence, we find the next letter from Taylor to Philips written upwards of five years later—it is dated Sept. 29, 1779—when Taylor was about 21 and Philips about 18. It is in verse, in compliance with the "severe command" of his Manchester friend expressed by Taylor as follows:—

I must not come in my Old stile
And trudge on Foot from mile to mile,
But must on Pegasus be mounted
And boldly gallop on my own Tit.

The lines go on to give an account of a visit to "a sage" in Liverpool, who had apparently undertaken to cure Philips of deafness. This doctor was—

famous for expelling
Diseases from his fellow mortals,
Displayed in Letters on his Portal.

The following passage from the same letter bears on the early musical history of Manchester and Liverpool. It refers to a concert given at Liverpool 121 years ago, which evidently, in more respects than one, resembled some concerts of to-day :—

I must before I send my story
  Touch on our late grand Korotory,
Fiddles there were whose notes would charm ye,
  And Syren strains would quite disarm ye.
Fine folks there were as thick as bees,
  Old, Young, High, Low, of all degrees
Some part there were who went to hear
  And not a few to Gape and Stare,
Coxcombs who go to prate and gabble
  More music find in senseless babble,
Than in the notes of Bach & Abel,
  Each found, however what he wanted
So every one went home contented.
  Our Doctor's so well pleas'd, I hear
He'll try the same another year.

The "Doctor" here referred to appears to have been Dr. Currie, whose name appears as one of the earliest honorary members of the Manchester Literary and Philosophical Society. From a letter from Taylor, dated January 13th, 1781, from Norwich, where Taylor seems to have regularly spent the Christmas holidays for some years, we learn that Philips had been staying at Wavertree with a Mr. Okell,* and that he had already, at the age of 20, become a collector of engravings. In it is a reference to a Miss Braddock, as an "irresistable attraction" to Wavertree, and to a purchase on Philips' account in Norwich, for the total sum of 40s., of "five beautiful things of Bartolozzi's, four small Rembrandts, two large etchings, a beautiful French landscape in aquafortis, and three small things by Albert Durer," Norwich having been

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* This was Mr. John Okell, of Wavertree, who married Miss Jane Leigh, second daughter of George Leigh, of Oughtrington. He was therefore J. L. Philips' uncle by marriage.

recommended as a cheaper market than London for things of this kind. Taylor adds:—"I have had a most joyous time here. There is an excellent Catch Club at this place. I have endeavoured to pick up some new things in that way, and am promised some more in London." The Bartolozzi referred to is of course Francesco Bartolozzi, who was appointed engraver to George III., and was the inventor of the so-called "red chalk" method.

The next letter is written from Liverpool on March 3rd of the same year. Taylor explains how, on his return from London, he was detained by the coach at Birmingham. He alludes to Philips' forthcoming visit to Allerton at Whitsuntide, and continues:—

> I was in hopes to have given you a verbal account of my proceedings in London, the Compas of my paper is not sufficient to give you the heads of what I intended to say, but if you'll come here while I stay you'll have enough of it. I was at the houses of almost every artist of eminence in London, saw several capital private eollections of paintings, also those at the public buildings. I was at the Ediphusicon & the Holo-phusicon, at the Plays—Opera—heard Allegranti & Ansani sing, & Paccharotti & Tenducci squeak. I was at the Pantheon Concert & at the Oratorio at Drury Lane, In short I was from Pillar to Post & saw everything that I thought worthy my attention, to conclude, I think I now know a little of what's what & there's no saying what advantage & improvement it may be to you to be with me a week or two.

The next letter is dated July 19th:—

> I have received both your letters and should have wrote to you sooner but I have been so busy since you left us that I have not had time, I am dispatching a ship to Leghorn & can only just inform you that I shall if possible slip over to Crosby to-morrow and deliver your Cards to the Ladies. I was there on Sunday and told Carolina* she might expect them soon, she say'd she was afraid you would not find a Card large enough for her name.
>
> As to the Book print, I find I cannot have time to make a design for one if I was able to do it, so I must leave it to yourself, only begging it may not be quite so ferocious as the other—the Taylors are without question a valiant race, but three Lyons is rather too much for one of them.

On the 25th of the same month, Taylor tells of the visit to Crosby, where he gave the young ladies of the party

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* This may be Caroline Penny, but there is no trace of her having been acquainted with the Earles.

the cards designed by Philips. These two young ladies were Maria and Elizabeth Jane Earle, aged 20 and 17 respectively; they were the daughters of Thomas Earle, of Leghorn, whom I mentioned above. Mrs. Earle, their mother, was living with them. The mourning (alluded to in the letter) was worn for Mr. Thomas Earle, who died on April 18th, 1781. The house at Crosby was in the occupation of Mr. Ralph Earle, and Mrs. Hardman and Mrs. Stanley frequently stayed there. Mrs. Stanley was Sarah, the sister of Thomas Earle and the widow of the Hon. and Rev. John Stanley, who was Rector of Liverpool from 1726 to 1740. He was subsequently Rector of Bury. He died on May 16th, 1781. Mrs. Hardman was Jane, the daughter of George Leigh, sen., of Oughtrington. She died in 1795, aged 93. She was thus the great-aunt of Colonel John Leigh Philips, being his mother's* aunt, and the great-aunt of the two young ladies we have mentioned, being half-sister to their grandmother, Mrs. Martha Mort of Wharton Hall. Mrs. Hardman herself lived chiefly at Allerton, in which she had a life interest.

In this letter Taylor addresses his friend, for some unapparent reason, as "Happy Dog," and continues :—

> I went to Crosby on Sunday & deliver'd your cards to their serene highnesses & it is with the sincerest satisfaction that I communicate to you the result of my Embassy. They were Graciously pleas'd in the Plenitude of their Princely Benignity, to receive your Humble Offering with an affability & condescension astonishing in personages of a rank so elevated & a station so exalted. And not content with bestowing on your performance the mere empty acknowledgement of praise they have resolv'd the ingenious Artist shall receive more solid advantages. A Patent was instantly ordered to be made out constituting you their Highnesses sole Engraver and it only remains that you come and kiss their Imperial hands and you are at once in possession of all the emoluments annex'd to that most Lucrative Office.—
>
> To descend a little—the cards have given the ladies the greatest pleasure

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* Sarah Leigh, the tenth child of George Leigh, became Mrs. John Philips, of Bank, Heaton Norris. She was born in 1742 and died in 1809.

& so they have to everybody else who have seen them. I gave Matthew Gregson a couple & have shown them to many other ingenious people. There is only one thing amiss, which is that they can use none of them this year to come as they are in mourning I mentioned this to Morland* and he told me you cou'd very easily do off some in Black for present use, if it can be done with(out) much trouble to you they would be glad to have a few but not otherwise . . . . .

I see you have advertized the Fiddling Bout, which I dare say will be very Capital. I don't go over to Dublin as I intended Mr. Wm. Earle I find wishes I wou'd give it up which I certainly shall witht much hesitation rather than it shou'd be any inconvenience to these good ladies. As this is the case I may perhaps find time to steal over to Manchester at your Joyous Week. there is a party of Musical Chaps forming amongst whom are Daulby, Eyes, Wyatt etc—perhaps I may be able to join in & take a few lessons in Catch singing, but more of this hereafter.

Mrs Earle & the Young Ladies left Crosby yesterday, they are now at Darby, but get to Allerton by Sunday when I hope to see them. Mrs Hardman was well to-day.

Daniel Daulby was very fond of agricultural pursuits, and was a great fruit grower—breeding a special kind of gooseberry known as the "Manchester Red;" and he appears to have trained this plant up a brick wall, as it produced better fruit when treated in that way. The Eyes alluded to was Mr. Chas. Eyes, of Liverpool, the son of the engineer who surveyed the "Sankey" canal from Prescot to Liverpool in 1755. An allusion is made in Taylor's letter to Philips on February 25th, 1785, to a journey by Eyes to London on the matter of some plans to be submitted to Parliament. He was an architect and surveyor. A Mr. Edward Eyes, a member of the same profession, is mentioned in Smithers' "History of Liverpool" as living in 1825, while it might be mentioned that William Roscoe was in 1769 articled to Mr. John Eyes, Solicitor, of Liverpool.

In a letter, dated December 9th, Taylor tells of his projected journey to Norwich to spend Christmas

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* Patrick McMorland, the miniature painter, who was born at Manchester 1741, and died at Liverpool just one hundred years later. There are several of his letters to Col. Leigh Philips in this collection.

at the head quarters of his family; he adds that he will go on to London. The letter continues :—

> Miss Earle's go to Lymm the same day that I set off [to London], and I suppose will stay nearly the same time, I dare say you will find opportunities of seeing them. I was told you had an intention of coming to Allerton this Xmas, this intelligence will undoubtedly fix you in your design, it will be so kind & charitable to visit the two Old Ladies when the Young people are away, and as the amiable Miss Braddock will be there you'll be just four of you to sit down to a Pool as snug as anything—Oh! how I envy you.

The above is plainly a mild sarcasm, the insinuation being that Taylor hardly expects that his friend, a volatile young fellow of twenty, will be content to sit down to play cards with two old ladies of seventy-nine and sixty-four.

During the summer Taylor apparently came to Manchester and spent some time with Philips, the two friends amusing themselves with their usual congenial occupations. Writing on September 27th Taylor refers to the late "happy time" at Manchester. He adds :—"We had to-day a certain account from Cork of the safe arrival there of the West India Fleet, which has brightened the faces of many of our old dons." As in the previous year Taylor goes to spend Christmas at Norwich, and the next letter (March 13th, 1782) tells of his adventures in London.

> I thought of you frequently in London & how I should have enjoy'd your company to the various exhibitions. I had a friend with me but he is one who had no relish for the Arts so that it was rather a toil to him to go with me to many places, and several times I was forc'd to relinquish the sight of what I wished in order to accompany him to entertainments more to his mind than Painters' Galleries, yet I contriv'd to see all the best of them. I was delighted beyond measure with West* and was so fortunate to visit his rooms when they were uncommonly well fill'd, by a lucky accident my friend blunderd into an inner room where strangers are not admitted. West himself happened to be there at work and on our making apologies for our mistake he desir'd us to walk in & look about us which we did, much to our satisfaction, there are several Capital matters in an unfinished state two of which he said wou'd be compleat'd for the exhibition. S^r Joshua has a

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* Benjamin West, P.R.A., *vide* first series of these "Selections."

vast Number of Pictures by him, but to you I will venture to say what I cou'd not there have declared with safety that I think Romney as a portrait painter much his superior, and I must tell my opinion in another respect tho' perhaps it may not agree with your own, you must know then that I have conciev'd a contemptible opinion of those old prints and etchings so much sought after by you Vertuosos, they are infinitely eclips'd by the productions of the present day; have you seen the etchings of Blight from Mortimer's designs? answer me candidly can you produce from among your antique hoards such works as his? or from the works of Rembrandt can you equal Worledge's etching of the raising of Lazarus? The man at Norwich from whom I had your prints has two excellent impressions of this last for which he asks £1—11—6. I bought two or three etchings of him for you of Rembrandt's, but if I had stayed till I got to London, I shoud have bought no old prints I am so thoroughly convinc'd how misapplied money is that is given for them to the neglect of more modern productions. The Prints I bought for you will be sent off to-night by Matthew Gregson with Watt's numbers. I have marked the price in pencil on each and in the whole they Amo^t to £2—16—6. I wish they may meet your approbation. Bartolozzi's Tickets are allowed by the Learn'd here to be very cheap and the Etching by Hollar charged (**) I was told in London is worth three times the money, the other etchings you may depend are originals.

This Mathew Gregson was a very celebrated Liverpool worthy. Of obscure parentage, he was apprenticed to a paperhanger and stationer in Liverpool, where his great taste in the decorating of houses made him very popular. He was a strong supporter of all the literary and scientific institutions of his native town, a Fellow of the Society of Antiquaries, and a collector of prints and books. In 1817 he issued some proposals for publishing a "Portfolio of Fragments of the History and Antiquities of Lancaster." * This was illustrated by many plates and armorial bearings at some expense to himself. It is a most beautiful and elaborate production. In 1813 Mr. Gregson was Treasurer of the Liverpool Blue Coat School, and President of the Lyceum Library. His favourite toast was "The Pen, the Pencil, and the Lyre." He died in 1824 from an accident in his library.

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* Printed at Liverpool, June 4, 1817, and dedicated to the Prince of Wales, "Son of the Duke of Lancaster."

Taylor goes on to say that Mrs. Earle wishes Philips to spend Easter with them at Allerton, and indulges in some badinage about his friend's supposed attachment to one of the two young ladies. In this letter Taylor also reports the arrival of a bale of yarn from Drogheda in the "Earl of Dublin," apparently on Philips' account, and asks him to tell his "Uncle Rigby" that the "tune books I sent him are to go to my brother's at Norwich." A daughter of Dr. Taylor, of the Warrington Academy, married a Mr. John Rigby, of Chowbent. She had two children, Edward Rigby, a celebrated obstetrician, and Sarah, who married Dr. Caleb Parry, and was the mother of Sir W. E. Parry, the famous Arctic Explorer. Taylor also asks Philips to send him the "music of 'Care thou Canker' which we have not got in Liverpool and I wish much to introduce it."

On May 22nd, Taylor writes that he is glad to hear of the safe arrival of Mrs. Earle and her family at Bank (the residence of Philips' father at Heaton Norris), and speaks of a box of oranges sent to that place from Liverpool. The succeeding letter deals with the volunteer movement in England, which followed the outbreak of war with France. It shows admirably Taylor's usual humorously straightforward manner of expressing himself. Lord Shelburne's plan for the defence of the country was practically to enrol the civil population of each town, under the direction of the local authorities, that is to form "Town Guards" in all the principal places.* That it was by no means universally popular we see from the following letter :—

Liverpool, 30 May, 1782

Dear Sr

I beg you will deliver the enclosed letter to Mrs. Earle, and inform her that the Business which I intended writing to her about is postponed till her return, not on account of her absence, but of Mr. Roscoe's who is in London

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* *Vide* "Annual Register" for 1782, p. 300.

& will not be back this fortnight. Let her know likewise that the work-people are going on as fast as possible with the house, the rooms above stairs are paper'd and painted, and the Ceiling of the back parlour is done in a proper manner, and looks as well as possible, the front Parlour is not finish'd, for Matthew Gregson was disap^{d} of the paper but he expects it from London to-morrow.

I shall be much obliged to you to inform me what steps have been taken in Manchester in consequence of Lord Shelburn's plan of Association, at the first meeting held about the business here the measure was universally approved of, and (*erasure*) chose to forward the putting of it in execution, whose first step was to appoint themselves Officers which gave great disgust and no person would enter into the Ranks tho' proposals were offered for that purpose two days, at the end of this time a few young men call'd a meeting of their acquaintances at the Hotel, where near 100 attended their first step was to make Mr. Gill Slater Chairman, and afterward nominated him Captain of a Company which they agreed to form agreeable to a plan which I had the honour to lay before them which differed very much from Lord Shelburn's as it reserved to ourselves the right of electing our own officers, keeping the arms in our own custody and of offering our services to march from the town if we saw the necessity for it, and then only, to be under military discipline, we engaged also to find ourselves, Arms, Cloaths & Accoutrements and at no time to receive any pay from Government—but our Mayor was highly displeas'd at our proceedings and he said that our scheme would entirely spoil that which he wished to take place, the Secretary's—and as we did not wish to make a division in the town it was agreed by all Mr. Slater's Company to learn the exercise in private partys, and not interrupt the Mayor, but after he should have raised as many as he wished on Lord Shelburn's plan, then to offer ours to Government. the Mayor then offer'd proposals again, but cou'd prevail on nobody to sign, and in a day or two he gave it entirely up till he shou'd hear again from his Lordship ; we have been learning the exercises ever since, in partys of about 20, and have learn'd everything that so small a number can, and this evening Mr. Slater has called the whole Company to meet him to fix on a proper place to meet all together, and in a little time, if the Mayor hears nothing from Government, we mean to offer our proposals—this affair has been carried on in a very spirited manner tho' not at all to the satisfaction of the Corporation, who are vex'd at being thwart'd by the young men and at their choosing for their leader Mr. Slater, who has always been a very obnoxious man to them, tho' without exception the most popular character in Liverpool—.

I shoud imagine the Gentlemen in Manchester would be of the same opinion with us, and prefer the inconvenience of forming themselves to the use of Arms, than to put them in the hands of the Lower Class of people, and especially as you would be enabled effectively to keep under that propensity to rioting which your weavers &^{c} seem so much adicted to—I shall be glad to hear from you in answer to this as soon as you conveniently can spare time.

I beg my respects to the ladies, and to all the family at Bank. I hope Mrs Earle has had no return of her complaint. I remain

Your sincere friend, Hbl Sir
THOS. TAYLOR

I hope the oranges arrived safe.
Pray tell Mrs Earle that I have just received a letter from Fa * * * that the young woman she wrote to was engaged before the letter reached her.

The Mr. Gill Slater mentioned was a prominent merchant of Liverpool, and took some part in founding the Sunday School in that town. He lived in Castle Street.* The lieutenant of the Military Association was Mr. Joseph Brooks. The next letter continues the subject of the volunteers :—

Liverpool 14 June 1782

I thank you for your letter of yesterday with the Plan of your Volunteer Association which in general I approve of much but not entirely the 7th article I do not like. I would have no fine for anything but dirty Arms, if you have any man among you who requires to be quickened in his attendance by the fear of a trifling fine, depend upon it you had better got rid of him, and all others of that stamp, make a point of honour to attend strictly and the disgrace of being absent at the calling of the Roll will be a sufficient spur. I had introduced your 9th article into my proposal, but I found it did not meet with general satisfaction, I mean that part of it which proposed the officers to be chang'd, it can answer no good end, Officers that are frequently to be renewed will never properly understand their business, for by the time they have attained they must resign, they won't be able to carry that authority which is absolutely necessary if you mean to put yourselves on a respectable footing, and as you are to elect your own officers it is your own fault if they are not respectable and proper persons, and should it happen any of them prove disagreeable, there can be no doubt but the representation of it by the Company would effect their removal—we had several different opinions what the facing of our Cloaths should be, but that the Coat should be scarlet was determined without a dissenting voice. We shall have the appearance of soldiers if ever we have the occasion to turn out, which we never should have in a fantastic livery—we still continue to exercise, but intend to proceed no further till we hear the event of the motion which the Secretary-at-War has given notice of in the house of Commons, my opinion is that Lord Shelburn's plan will be defeated, and indeed I wish it may for my sentiments about it have always been that it is a very weak measure, for it is an acknowledgement that Government is inadequate to the defence of the nation, a period at which we are not I hope arrived, and till that day I think the unbounded supplys which are granted by the nation ought to

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* Died at Bath, Sept. 24, 1802.

> furnish troops sufficient for its service. observe I am speaking of the scheme of putting arms into the hands of the Commonality and requiring their time and trouble without any pay except when called from home for though Administration should adopt the more eligible plan of raising more Soldiers or augmenting the Militia, I think it would still be highly beneficial to encourage Associations of Gentlemen and Tradesmen who by defending their own town and neighbourhood might release the Soldiers or Militia stationed there, and they might whenever there was occasion—a little time will clear this matter up, at any rate we may continue together and practice the exercise for our own entertainment.

In the next letter, on August 3rd, Taylor addresses his friend as "most valiant Captain," so we may presume that it was about this time that Philips first gained command of his company. After communicating the congratulations of the ladies, Taylor goes on to refer to the performances of the Italian Opera, then proceeding in in Liverpool :—

> I regretted your absence on Monday evening, I never saw our Boxes so Brilliant, nor were they ever so crowded. Henderson receiv'd £163 which has pleas'd him much & I hope we shall have him again, I went to the Opera on Thursday and was I confess prejudiced against the Performers but I assure you I return'd in a very different humour, it was very well done & met general applause the Music is most excellent. I thought of you many times, however I am glad to inform you you will have an opportunity of seeing them for they intend to perform in Manchester next Week and I don't doubt they will meet encouragement. they had a very genteel audience and have been solicited to exhibit again but our Manager will not permit them, and that you may be able to recommend them I can assure you the opinion of Wiatt Zinck and other Gentlemen, whom you know to be Judges, is that they are worthy of encouragement. for my own part I thought 'em quite equal to what I saw in London. the Men have all fine strong voices particularly Ferrari. Sgra Castine is the best Woman & much superior to Mme Martryr.

The Wiatt mentioned is apparently the Liverpool architect referred to in Bellinge's *Liverpool Advertiser*, of March 23, 1795, as the designer of a model for the new Liverpool Exchange, the old building having been burnt down in that year.

The following letter, while intrinsically interesting in so far as it refers to the Liverpool Volunteer Association, has a very strong personal interest. It shows, as do all his letters, that Taylor had that habit of "foying" at his undertakings (to use the local term), which was peculiar to his family in particular and Lancashire men in general. Whatever work he took up absorbed his whole attention, to the exclusion of everything else. In this case it is the formation of the Volunteer Corps and the working out of the details :—

Liverpool 14 October 1782

I have intended writing to you for some time past but have been so much engaged in my new occupation I have not had time to do it, Mr. Wallace is gone to Buxton to spend a few weeks, previous to which he had me upon close drill that I might be enabled to take the Command in his absence, I have no leisure to look round me and examine the state of my correspondence, and you are the first I shall set myself straight with, I thank you for your reply to my request about the regulations of your Association which I am sensible it was impracticable for you to furnish me with, I need not have troubled you about it for I found little difficulty in the business, I wish I cou'd say we were in more flourishing situation, we are only 60, nor do I expect any increase this winter, we keep together very well, the light we are held in by our Grandees is indeed unfavourable, but if we can but hold together till the spring I have not doubt of our doing very well. I have had a world of Trouble about it but I do not begrudge it for I have the future of the corps very much at heart, our belts are just come and our new Arms from Robin which give great Satisfaction and shall go to no further Expense this winter as we have resolved that the present Jacketts are sufficient uniforms till the Spring when we intend having a very smart one, so that I give up thought of appearing en militaire at the Assembly, it is necessary for us to be economical, we have no fund to recur to to furnish the extraordinaries but I do not think us the less respectable on this account it gives us a nearer resemblance to our Brethren in Ireland, whose Conduct I wish us to imitate in all respects. I have been sorry to hear some reflections lately thrown out by some Townsmen of yours and those friends to the Association, that the Officers in your Companies have gone to expence in their dress, and have made a shew and parade by no means consistent with the true spirit of the institution, and I heard the names of several Gentlemen mentioned who had left the Corps on that account, I wish these insinuations may have been wrong or exaggerated, for I shall always wish to hear you shall proceed on right principles.

I find it is your intention to honour us with a visit very shortly, pray inform me the time. I have not entirely deserted the house in King St tho' no longer an inhabitant in it so that you may stand a chance of seeing me now and then. the Assemblies have been uncommonly brilliant, and as several changes will soon take place it is not likely they will decrease in splendor, wou'd you have me drop you a line when I hear of one certain to a good one, for these things are pretty generally known some days beforehand. It is said D^{r} Currie and Miss Wallace are to form a Junction next month (but I beg you will not mention my name as your Author for family reasons), on which occasion we doubt not all that is polite will be collected together, and wou'd be a glorious opportunity foi the purpose. Certain Evolutions have occurred since you were here.

The Miss Wallace referred to here was the daughter of Mr. William Wallace, an Irish gentleman established as a merchant in Liverpool, and lineally descended (as well as his wife, who was his cousin-german and the daughter of Mr. Hans Wallace, of Waterford) from the Scottish hero of that name. The son of this marriage, William Wallace Currie, says, in his "Life of Doctor Currie": "Satisfied after an intimate knowledge of some years that he might safely intrust his child's happiness to Dr. Currie's care, Mr. Wallace with generous and open heart bestowed her upon one whose personal character and rising reputation constituted nearly all he had to offer in return." The fact that Mr. Wallace was an Irishman calls to mind a remark made by Derrick, Master of the Ceremonies at Bath, respecting Liverpool in 1760, that "The great increase of their commerce is owing to the spirit and indefatigable industry of their inhabitants, the majority of whom are either native Irish, or of Irish descent, a fresh proof that the Hibernians thrive best when transplanted." There are, of course, frequent references to Dublin in these letters.

Dr. Currie himself, who was M.D. of Glasgow, devoted much attention to the study of fevers. It was he who insisted, in spite of much opposition, that fever patients should not be treated in the Liverpool Infirmary, but should be isolated in a separate building. In 1797 he published a pamphlet, "Medical Reports on the Effects of Cold and Warm Water in Febrile Diseases." In 1793, under the *nom de plume* of "Jasper Wilson," he issued a

"Letter, Commercial and Political, to Mr. Pitt." This aroused much attention, and ran through several editions. Another publication of his was an essay on "Tetanus and Convulsive Disorders."

The Liverpool Athenæum was founded by the joint efforts of Thomas Taylor, Dr. Currie, William Roscoe, Wm. Clarke and Joshua Lace, at a meeting held at the Theatre Tavern, Williamson Square, November 22nd, 1797.

In the next letter, Taylor asks for information on a point of military etiquette :—

Liverpool 18 October 1782

I am glad you intend writing me again soon, when you do, pray mention what Rules are observed by the Privates of your Corps as to the Etiquette of their Dress at an assembly or any publick place. is it necessary to wear a sword, one or two Epaulets, or do they wear a Cross Belt with a Bayonet. I shall be glad to know what is the thing on these Occasions, which no doubt you can inform me of.

The next letter deals with Philip's intended trip to London :—

Liverpool 26th Novemr. 1782.

Dear Leigh

I had not time to write to you before you wou'd be set off to London, where this will find you and where I wish with all my soul I was with you. I can easily conceive how you relish the variety of interesting objects that divide your attention, (from what I experienc'd last winter) I wish I had posponed my Journey till this time for I was much at a loss for a Companion, in my researches after the same objects you will be on the hunt for, I enclose a few lines to Mr. Phillips, the father of the enchanting Miss Phillips of Drury Lane, this Old fellow is an oddity, but endeavour to humour him, for you will find yr advantage in it, you will by means of it get acquainted with his Daughter, whose sweet pipe will delight you, and the Old Man has it in his power to procure you much entertainment in the manner I have mentioned in his letter, If you have an opportunity, give my particular regard to Miss Phillips, and tell her how much we wish to see her in Liverpool.

Jack Martineau will I am sure be very happy to see you. I would not on any account you should leave London without calling on him. I fancy he is not sufficiently known in his neighbourhood to risque his name only, you will therefore enquire for him at his brewery which was lately occupied by Samuel Warings Esq Kings Arms Stairs Lambeth—I beg you will tell Jack to write to me soon.

Mrs Earle and her daughters went to Allerton yesterday and will stay till the first week in January. It is lucky you postponed your Visit. I advise you to come at Miss Wallace's Wedding, which will be an affair of some moment—if you have time to write to me from London I shall esteem it a singular favor – but at any rate I hope you will let me hear from you as soon as you get back

believe me yours sincerely

THOS. TAYLOR

Jack Martineau was Taylor's cousin, his mother being Sarah Meadows, sister to Margaret Meadows, who was Taylor's mother, both being the daughters of Philip Meadows, Mayor of Norwich in 1734. A brother of Jack Martineau's was Thomas Martineau, who married Elizabeth Rankin and had eight children, among whom were the celebrated Miss Harriet Martineau and the late Dr. James Martineau.

The Miss Phillips referred to was Anna Maria Phillips, better known to the theatrical and musical world as the beautiful Mrs. Crouch. She was born April 20, 1763, and first appeared on the stage at Drury Lane as Mandane in Arne's "Artaxerxes," in 1780, being then not 17, and at once captivated the audience. Her first appearance on the Liverpool stage was on June 11, 1781, as Polly in "The Beggar's Opera," and she and her father seem to have had good introductions to Liverpool society. John Kemble was then playing at Liverpool, immediately preceding his engagement in London, and their association there gave rise to an unfounded rumour of marriage. Her father was Peregrine Phillips, who was descended from an ancient family in Wales, the elder branch of which included a long line of baronets, one of whom was made a peer of Ireland in 1776. His mother was a near relative of Charlotte Corday, the assassin of Marat. Peregrine Phillips had a very chequered life. In the early part of his career he resided in North America, and was acquainted with Dr. Benjamin Franklin, being at that time a merchant. On returning to England he obtained a lucrative post in the Wine License Office, from which he was dismissed in consequence of his activity as a supporter of John Wilkes. His wife was a Miss Gascoyne, daughter of a Worcestershire farmer. He published letters on the contest with the North American Colonies with the signature of "An Old English Merchant," which were attributed to Franklin; a poem, "Covent Garden: a Satire"; a prose work, entitled "The Diary"; and numerous selections from the English and Latin works of Richard Crashaw, Canon of the Chapel of Loretto in 1650. Miss Phillips appeared on the Liverpool stage again in the summer of 1782, the year in which Taylor appears to have made her acquaintance, she being then about nineteen. Her marriage with Lieutenant Crouch took place at the beginning of 1785. Peregrine Phillips was an old friend of John Taylor, editor of the *Sun* newspaper, who was the grandson of Chevalier Taylor, oculist to George II. and Frederick the Great. He belonged to a branch of the Norwich Taylors. It is in one of John Taylor's poems, called "The Stage," that the lines occur—

> See Kelly next, and beauteous Crouch appear,
> With mutual aim to grace the vocal sphere,
> And hence their powers in happy union move,
> To aid the scenes of harmony and love.

Peregrine Phillips and his daughter, at the time of this letter, lived in Gray's Inn Lane.

In the succeeding letters we have references made to the appearance of Dr. Currie and his bride at the Liverpool Assemblies, the ladies in attendance being Miss Earle and Miss Kent, and the groomsmen Mr. Thomas Earle and Mr. John Lightbody, the latter officiating for Dr. Bell, "who comes however (from Manchester) to the Assembly; could you not contrive to come with him?" The reference is to Charles Bell, M.D., who was elected a member of the Manchester Literary and Philosophical Society on December 12, 1781. The following letter relates to this event. One wonders what the "Manchester turbulence of spirit" was about, but may guess it had something to do with the military rivalries :—

Liverpool 21 January 1783

Dear Leigh

I do assure you I was much mortified at the receipt of the letter in which you told you were not to come to the Assembly last Thursday, and more so when the time came, it was the most brilliant meeting I ever saw at our Exchange and ev'rything wou'd have gone off very well but for a little of your Manchester turbulence of spirit—which it seems even your Doctors are not free from—I had some notions of going over to stay at Manchester for a few days soon, but I am not sure whether it will be perfectly safe till this furor is a little abated—I shall however be obliged to you to let me know what your plan is respecting coming here. Mrs Earle and her Daughters go to Bath the middle of next Month, to stay a considerable time consequently without you can come very soon you must defer your visit till their return, shou'd this be the Case pray inform me, & also when your next publick Concert is, and on what day your Association exercise, Wiatt and two or three of our Corps have it in agitation to take a trip over but we should like to fix a time when it is probable we should have most entertainment.

We got amazing Credit on the Queen's Birthday I wish you had seen us, we made a capital appearance, & fired admirably, the afternoon was one of the most Joyous I ever spent. But it seems probable an end will soon be put to our Military occupations by the Peace, which appears now almost certain, we wish to hit on some plan to continue it at any rate, pray has anything of this kind been mentiond with you?

I shall be glad to hear from you by return of Post

I am Yrs sincerely
THOS. TAYLOR.

In February, 1783, Mrs. Earle goes to Bath, and Taylor (on the 8th) gives to Mr. James Williamson, his "right hand man in the right division of the Liverpool Military Association." a letter of introduction to Philips. On the 24th of the same month he writes :—

We had a grand field day on Thursday on receiving our Colours The place of exercise was a field opposite our Captain's house at Everton, the weather being fine a great deal of company was present. after all was over we marched into the house and were very genteely entertained, an accident happened which discomposed us a little, one of Probin's guns burst with two charges in, but luckily it only hurt the Arm of the Person next him that fired it and that not materially. I believe it to be entirely owing to the manner in which it was charg'd, for I saw the barrel prov'd with two Balls about a fortnight since. the Gentleman who fired it is a new Soldier and he only ramm'd the second Cartridge about halfway down, a method which would burst any barrel in the world.

I shall be glad to know whether you have concluded anything positive about continuing your Association, I believe ours will continue some time longer but it is not finally resolved on, we had a very animating speech from our Captain on receiving the Colours, and on Sunday we are to have a sermon from our Chaplain on the subject.

The pair of colours alluded to here were presented to the Liverpool Volunteers on February 20, 1783; one being presented by the King (George III.), and the other by Mrs. Rawlinson, wife of Mr. Henry Rawlinson, one of the members of Parliament for the Borough. The next letter is one of the most amusing in the series :—

Liverpool 7th April 1783

Dear Sir,

I received your letter advising of the Box of fruit which I despatched this day to Allerton, with a letter to your Mother. The box had taken no hurt in the Carriage.

In this period when the spirit of Liberty seems to burst forth around us, I am happy to tell you it has not quite deserted this Island some genuine sparks of it have been kindled this day in Liverpool which I do not doubt will be the foundation of a permanent generous flame, in a word the Burgesses who for near a Century past have been subject to the tyrranous rule of the unconstitutional & arbitrary Corporation, have this day gained a triumph over them which they have anxiously wished for these 40 years back ; the affair stands thus. Our Council have usurped a power of choosing themselves, which is the right of the freemen at large, they refuse to make any disclosure of their accounts and proceedings & spend the public money just as they please—they have always taken special care to associate with them as vacancies happen none but such persons as they are certain will proceed upon this system, it happened last October, which was the time of electing the Mayor that Mr Brown was fixed upon in Council to be proposed to the Burgesses at the annual Common Hall, he told them he wd. not serve, but however he was chosen, and they applied to the King's Bench to compel him, but finding that Mr Brown wou'd petition the Court to inspect the Council Books to make his defence, and by that means a disclosure of all their dark transactions would be brought to light, the Council without consulting the Burgesses dropt the Action, and told the Court they wou'd elect somebody else, accordingly a Summons was given out for us to meet this Morning for that purpose—but previous to it a number of spirited leading people had been concerting a plan to defeat their purpose, a meeting was held at Forshaw's and at 8 o'clock this morning, when a Numerous Company of Freemen met & heard the scheme explained, they were exhorted to abide by their choice of Mr Brown, who wou'd still refuse, *and to serve them* stand a tryal, in the event of which they would be put in possession of facts which wou'd entirely overturn this cursed Combination—at about a quarter before ten, we march'd forth in a body with Colours flying, and took possession of the Hustings, and the places round it, and when the Council arrived and proposed another person (Mr Boats), to be Mayor, every voice was exerted against him, they however proceeded to a poll, being advised by Lawyer Davenport whom they had engaged for 100 guineas to be present on the occasion. At two o'clock the books were closed, when there appeared for Mr Boats 35 and for Mr Brown 342. they were therefore constrained once more to declare him duly elected and we retired in Triumph—I never enjoyed anything more in my life. Williamson was of infinite service in the Affair, and your friend Wakefield a most active Man, he soon collected 100 or two of freemen but the head man was our worthy Captain who is the Idol of the Common people.

I am so full of this Victory that I could not help making you acquainted with the particulars, and though you are not interested in it I am sure you will rejoice whenever Liberty is triumphant and I hope long to tell you we have compleated the affair entirely

I am your sincere friend and Serv$^{t.}$
THOS. TAYLOR.

The letter tells its own story plainly enough. At the time it was written all municipal corporations were in a very corrupt state. Liverpool received its first charter in the reign of John, and for several hundred years its administration was by no means pure; up to the year 1780 the Corporation were in the habit of selling the freedom of the borough at prices varying from three to fifty guineas, according to the circumstances of the purchaser. Mr. John Brown was elected Mayor of Liverpool at the end of 1782, but refused to serve. Accordingly, on the 7th of April, 1783, the Burgesses were summoned to elect another Mayor by the Bailiffs. On the 12th of September, 1783, Mr. Brown took the oath as Mayor; thus the town was without Mayor for nearly a year. Taylor's letter is interesting, inasmuch as it throws light on a situation for which the various Liverpool histories are only partly able to account. On December 3rd, 1783 (Corporation Book of Records)—

> Mr Brown made an apology in Council for the trouble & expence to which this Corporation was put, on account of his refusing to take upon himself the office of Mayor.—ordered that his apology be accepted of.

Mr. William Boats, who played such a laughable part in this comedy, was one of the principal merchants of the town, and lived in Drury Lane (Liverpool). In 1791 over 1,000 of the Burgesses requisitioned the Mayor for an inspection of the Corporation Books. They obtained judgment against the Corporation in the King's Bench, and the case was ordered to be re-tried at Lancaster. Here, though the Burgesses again won, the Corporation succeeded in getting an order for a third hearing from the King's Bench. The matter was then dropped. The Liverpool Corporation was reformed in 1836, the first Mayor under the new Charter being William Wallace Currie, son of Dr. Currie.

The next letter, written October 7th, 1783, tells of Taylor's experiences during a musical festival at Chester. There seems to have been some arrangement between the three towns of Manchester, Liverpool, and Chester, then all three much of a size, for the engagement of accomplished musicians. Each town had a musical festival. The second part of the letter tells of the foundation of the Liverpool Academy:—

> I promised you to send an account of the proceedings at Chester after my return but I have been so busy ever since (Mr Wallace being confined with the gout), that I could not fulfill my promise, You have however had a better account of the music from Burchall and Boden than it would have been in my power to give you, I can only say how much I was pleased with the whole together, but from scientific people much more may be gleaned, their business is to point out what is wrong. Boden seemed to pity my ignorance when I told him I liked Mrs Kennedy's Scotch Ballad which gain'd so much applause, the Oratorio had a great disadvantage in the place

of performance, the Cathedral is too large. the wide recesses on each side the Isle carry away the sound, but the Concerts were very well heard. there was much good Company, but not more than at yours. Peter Martineau and I went to the masked ball. I sported (I don't say supported) the Character of an old Woman. he went in a Domino. 'Twas but insipid work, yet on the whole I was satisfied with it. 'Twas worth while to go had it only been to see the number of fine women and the elegance and splendour of the fancy dresses. but the publick breakfast with the Catches and Glees pleas'd me as much as any part of the week's entertainment this was a new idea and the Chester people must have Credit for pointing out a most excellent addition to a week's amusement of this kind ; it now remains to be seen what can be done at Liverpool. I dare say as much will be made of it as possible. the new Rooms will be finished in time though the plans and estimates were only compleated last week. Zinck is the projector and Wiatt is his privy counsellor.

We have a plan of another kind just going to be put into execution here, which I think I mentioned when I was over with you, the revival of the Academy for drawing which was instituted in Burdett's time and dropt when he left Liverpool. the number of painters now in town first gave rise to the present purpose, they muster eleven strong, Morland, Tate, Pack, Chubbard, Caddick etc. Lectures are to be given as before on Anatomy and Chemistry so far as it relates to colours, by Dr Turner who is a chief supporter of it. Lectures are also to be prepared by the professors and delivered in rotation and by other gentlemen on perspective architecture etc. I have entered myself as a pupil & expect much satisfaction in it. Wakefield, Roscoe, Chas Eyes, Daulby, Mr Gregson, and others you are acquainted with will also attend, & I expect before the winter is over we shall have drawings enough to furnish an exhibition. pray when do you intend to come to see us, you might take a spell with us if you make any tolerable stay : but we don't mean to call it an Academy or make any noise about it, we intend to let its own merit bring it into repute or else let it remain in obscurity—Pack desires his compliments to you, he goes on bravely, we are going to be fellow lodgers at a very convenient house in Duke Street. I hope we shall have the pleasure of your company there.

Mrs Earle and her daughters have not found their way from the North yet, they have been to the Lakes.

There were two Wakefields in Liverpool at this time, with both of whom Taylor was probably acquainted. One was Gilbert Wakefield, M.A., of Jesus College, Cambridge, and a most interesting character. He was an eminent classical scholar, and was Curate of St. Peter's, Liverpool, in 1778. In the following year he was made Classical tutor at the Warrington Academy. He afterwards became a prominent dissenter—Unitarian. In 1803 he was imprisoned for two years in Dorchester Gaol, as a consequence of a letter he wrote to the Bishop of Llandaff. As is well known the prisons at that time were very insanitary, and Wakefield was ruined in health He was liberated, but died immediately after from fever. The other Wakefield was a wealthy sugar refiner of Liverpool, who devoted much attention to agriculture and cattle breeding on his experimental farm, a mile out of Liverpool. He successfully raised cattle on the succory plant, or wild endive, which he cropped three times a year. He was associated with Mr. William Roscoe in the latter's undertaking to drain Trafford Moss and Chat Moss. This is probably the man referred to in the letter. Thomas Chubbard was a landscape and portrait painter of some eminence. He invented a mode of engraving on glass. William Tate was a portait painter, a pupil of the celebrated Mr. Wright, of Derby, a memoir of whom was published by Col. Leigh Philips in 1797. Christopher Pack was born at Norwich in 1750, and afterwards resided in Liverpool and London. He was a fashionable portrait painter and exhibited several times in the Royal Academy.

The first attempt to found an Academy in Liverpool was made in 1769, when a Society met in a room in John Street, under the Presidency of Mr. P. P. Burdett, other members being Thomas Chubbard, Richard Tate, Richard Caddick, Peter Romney, Mathew Turner, M.D., Joshua Eyes, and Chas. Eyes. It was revived in 1773, W. Caddick being President, and lectures were delivered and an Exhibition held in August, 1774. This attempt, too, had only a short life, the Academy being dissolved in 1775. In 1783 the Academy mentioned here was founded. Mr. Henry Blundell of Ince was the President, William Roscoe the

Vice-President, and Thos. Taylor, Secretary. This Society, of which Taylor speaks so hopefully, survived until 1794. Other attempts were made, but were doomed to fail. The efforts finally culminated in 1814, when the Liverpool Institution was founded. This received a Royal Charter in 1822, and has ever since been highly successful.

The next letter was written on October 30th. Taylor expresses his regret that he was not able to attend the Review of the Military Association at Manchester—"Mr. Wallace being at Buxton (evidently for the gout before alluded to) I was tied fast." Taylor, we know, was employed with Mr. Thomas Earle before the latter's death in 1781, and this seems to convey the idea that he had now entered the house of Mr. Wallace. The letter continues:—

> I am glad you approve of our intended Academy. we have not launch'd forth in a pompous manner yet the promoters of it shew great zeal for its establishment, and it has met with great encouragement from the inhabitants of Liverpool, not only such as have a taste for the Art of painting, but from many who have never shewn any disposition that way; I shall enclose you a sketch of the plans which are thought proper to have printed, that the design of the institution might be rightly understood. I have no doubt it will be a very useful one, and setting London aside, I don't suppose there is any place in the kingdom where better instruction may be had on these subjects. Roscoe is to open this day week and I venture to say his lecture will be a high treat, it is his favourite pursuit and it was his Ode on a similar institution here some years since which established his title to poetic fame. he has much at heart the reestablishing the Academy and has endeavoured in forming the plan to avoid the Rock on which the former split. which was that it was made to rest entirely on the Artists, who being transient inhabitants the matter dropt when they left town. but now the artists are secondary instruments only, the principal parts are in the hands of residents. We had like to have had a disagreement among the painters but it has blown over. Tate (who by the by is the most silly ignorant fellow I ever met with) gave himself very great airs, he wanted to have the direction and be at the head of everything and treated Pack very contemptuously. but finding that it would not be submitted to, he declined any part in the Lectures, and is going soon to leave the town. The truth is he is cursedly chagrined at the manner in which he has been received here, he has only done one or two pictures though he has been here these three months, while on the contrary Pack has been

very successful, but Morland is the man we look to as the principal in the line of visitors.

When I saw you at Manchester you said your first excursion would be to Liverpool. if it was convenient for you to come next week I think you could not choose a better time. Mrs Earle and her fair Daughters are at present at home and Miss Leigh with them, to a man of your attachment to the fair part of creation what need I say more. but I have others to add. I mentioned to you our great improvement in Catch singing, We have gone on rapidly since, and next Wednesday Evening we are to have a grand catch at my new Lodgings, where I have a capital room for the purpose and a harpsichord ready. I shall muster 10 or 12 good singers, and you shall confess we can do something in *stile*. On Thursday Evening is the lecture by Roscoe, here I attack you as a man of taste—if that is not sufficient the same evening is the Dancing Assembly which you may resort to afterwards for the lecture will be over by eight. On Friday is the Concert for Miss Casson at the Theatre, it will be a very good one I believe, and the company I am sure will be numerous and brilliant as the greatest part of the seats are taken. if there is not music enough already to induce you I believe I can say there will be a private concert on the following evening—put the things altogether and if they have sufficient weight let me know as soon as you can. I have further to beg the favour of you to see Mr Burchall and present my Compliments to him and if he comes here on the Wednesday evening I shall be glad he would favour me with his Company.

The next letter (dated November 25th) continues the subject of the Academy, into the organization of which Taylor seems to have entered with his usual enthusiasm :—

I hope you still intend coming to Liverpool, we wish you to see our Academy which goes on Charmingly, we meet every evening to draw for about a couple of hours, and some excellent things have been produced, and we have now compleatly fitted up the Room & a very comfortable place it is. The Lectures have been clever, Roscoe's was one of the most elegant compositions I ever heard ; the succeeding ones have been on Anatomy by Turner,* and very clever indeed. next Thursday we have a Chymical one, and on the Thursday following Morland mounts. I have attempted to draw with them but find it very difficult at first, but I mean to persevere. Wakefield will draw in a masterly Manner, I never saw anybody so fond of it, but Morland will carry the palm away from them all and does in my opinion now, tho' it is a kind of work he is not used to. Pack has had the direction of everything and we are much indebted to him, he goes on very successfully in his painting. he has done a very capital picture of Charles Eyes which he means to exhibit and is making preparations for a large historical piece for the same purpose, his application is such that I think he cannot avoid making great improvement. We have an Idea of coming over to Manchester for two or three days during the winter, but not

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* Matthew Turner, Surgeon, of John St., Liverpool.

at present. Chas. Eyes will make a third with us when we do, & give you a touch of his double base, on which he now plays famously. I shall be obliged to you to inform me the next time you write what time your publick concert is and also when the Association exercise, two things we should like to be present at, but I hope to see you here before that time. Mrs Earle goes to Allerton Saturday month. you will contrive badly if you don't come before then.

Mr Hadfield* spent the evening with Pack and I on Sunday, If he is not gone I shall send this by him.

The next letter, written on the 18th December, alludes to Philips' interest in ballooning experiments which were then being made in Manchester:—

I take the opportunity of sending by my friend Miller £2—8— the balance of the bill you remitted me on Devonport and Co. which is paid. Miller I fancy won't appear this time at Manchester in his Cap and Jackett nevertheless he is entitled to the notice of Brother Volunteers, for his attachment to the Cause as long as it lasted with us.

We were attentively on the Watch for you the whole of last night expecting every moment your descent from the Clouds. as we were given to understand you intended to embark in your aerial caravan, and alight among us grovelling mortals who are contented to confine our speculations to this dirty earth & never soar above its surface, we were at the Academy from 6 o'clock till 9, and apprehending it to be as likely a place as any for you to land in, we kept a South East window open to receive you, but all to no purpose.

In the next letter Taylor speaks of the musical raid on Manchester proposed by himself and his friends. The Miss Leigh so frequently alluded to in these letters, appears to have been one of the grand-daughters of George Leigh, of Oughtrington, and Philips' cousin:—

Liverpool 19 February 1784

Dear Sir

I have applied, in consequence of your letter to the Captain of the Dublin and find he has delivered your Claret safe into the hands of Mr Green who I doubt not will forward it to you.

I propose to be in Manchester on Sunday Evening in Company with Pack and Chas. Eyes and shall stay till Wednesday. I am glad we are fortunate in coming at the Publick concert, ours was last Tuesday and a very good one, after the concert was over a pretty large party stay'd and were entertain'd with catches & glees by the gentlemen of the Cecilian Club, a celebrated Society for the practice of vocal Harmony established in this place, of which some of your friends are members. I propose putting my

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* Probably Joseph Hadfield, who was elected a member of this Society in 1782.

Catch book in my pocket and hope to meet with Boden and one or two others who excell in this line that we may do something, you know Chas. Eyes is famous, and it is not unlikely that Wiatt & Mr Drinkwater may be in Manchester on Tuesday, they have business there next week and will contrive to meet if possible.

Your excuse for not coming at Xmas leaves us nothing to say. Allerton is now very dull, Miss Leigh is returned to Oughtrington, and Miss Earles are at Chester. Pack has had great Success. He did not go on with his historical piece, he had prepared a whole length Canvas for it but a Lady engaged it for a family picture of herself and two children, which he is very forward with & for which he is to have 30 gs. he has done a fancy piece in oil at the Academy by lamplight, which is very clever. the subject is St John in the Wilderness—I have not seen Miller's picture but doubt not it is good from the character I hear of the artist. but it is astonishing to me that a man possessed of such abilities should paint for such low prices, or that his friends should suffer him to so degrade himself—Pack desires his compts. and I remain, Yr sincere friend

THOS. TAYLOR.

In a letter, probably written at the beginning of 1784, but to which no date is attached, Taylor mentions that Dr. Currie is lying dangerously ill from inflammation of the lungs, the result of a cold caught at the funeral of his friend Dr. Bell, of Manchester. He then says:—

I got the volume of plays I was to get changed for you, if you send it to me at any time it shall be done. I will troubl you to get copied the rest of the glees etc, all but "Hark the Lark" & "Return Blest Day," and also the words of the two other verses of adieu to the Villiage Delights, which I have not.

The succeeding letter alludes to an enigma, which was sent to one of the young ladies in Liverpool by Philips, and the reception of which induces Taylor to encourage his friend to hope that he may win the lady's hand. One letter written on May 4th, tells of the favourable reception of the enigma; another, written on May 13th, goes more into details. Taylor adds, "It is unnecessary for me to say I am most heartily interested in the accomplishment of your wishes, and that it has given me much pleasure to find a favourable aspect appear. I think I can with certainty say you have no prior inclination to contend against." But this romance of upwards of a century ago does not appear to have been fortunate. Either the lover's courage failed or the watchful friend was mistaken. Anyway, Philips was not married until three years later, and then not to the lady alluded to.*

In his next communication, on July 14th, Taylor speaks of another visit to Norwich. Mrs. Earle had had a severe fall in the spring which caused her some trouble:—

> I am at length got back again and a little settled after my long absence, I was obliged to stay away longer than w^s intended as I found it a difficult matter to collect all together the scattered branches of our family. we did however at length accomplish it & muster'd about as strong as the Manchester Association on their ordinary field days. You may imagine the voice of gladness was heard in the tents of Israel on so great an occasion, it was a second Jubilee without doubt though it did not make quite so much noise as Handell's ; I left them about 10 days since and stay'd a few days in London on my return. Mrs Earle and the fair damsels had left it about a week before & were gone to Matlock, they stay'd there a fortnight and got home all safe & well last Friday. Mrs Earle is most wonderfully recover'd & in her usual good spirits. the young ladies are going the latter end of next month to Knutsford races in complement to the Lady Patroness, but they don't mean to stay long at Oughtrington—we no doubt shall see you here at the Festival if not before, it is to be the 14th of September, and from the spirited proceedings of the Committee I think it is very likely to be a capital meeting. I suppose you have seen the performers names in the papers, the songs will be better sung than they were in London, and the Trombones and Double Drums will greatly assist the Chorusses : I found everybody greatly charm'd with Miss Phillips, I have been several times to see her since I returned & have had the pleasure to sing glees with her, she is a delightful Girl, and I think astonishingly improved in her voice her shake is the best I ever heard & she has as much taste as any singer.

On the 19th of the same month Taylor speaks of a "Turtle," which Philips has asked him to send to Manchester. He adds, "I find our players are to visit you in turns three succesive Tuesdays, 'tis a scheme of the Managers, who have persuaded the players to come into it, and to give their performance gratis, Miss Phillips goes to-morrow." The succeeding letter deals with the Liver-

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* See page 13 and note. From the letter written March 13, 1782, it appears the above construction is the right one.

pool Musical Festival, and with the Academy Exhibition at the same town :—

Liverpool 4 August 1784.

Dear Leigh

I thank you for your information respecting the Oratorios which agrees with the account our Committee were possessed of, the Gentlemen who have the management of ours are entirely ignorant of music in every shape, and have engag'd themselves in a monstrous expense, it being already £1,100 so that the prospect of gain is not much, it will beyond comparison be the best Band ever got together in this part of the kingdom, and the performances will fairly deserve the advanced price, though this measure causes great murmuring at present, yet I think people will all go when the time comes—the Committee in the present situation of the business are not likely to increase their terms with performers. I don't know what they offer'd your fiddlers, but I hear it is more than Crathorn had for going over to your festival, and I apprehend setting Burchall aside you have none who deserve more than Crathorn.

Mr Roscoe has received a letter from Miss Gartside with four paintings which I will take care shall be properly placed, we are now busy preparing for the Exhibition, pictures are coming in daily, Dan Stringer* has sent us seven. We shall have 9 or 10 of Wrights', as many Sandby's, and are likely to have the best picture that Zoffany ever painted, Garrick in Tancred, in short I believe seriously it will be as good an Exhibition as the Royal Academy was. I wrote to Stodardt but have yet had no answer. We are more in want of Drawings than anything, I remember you promis'd us two and I hope you will have them ready, it will do if they are here three weeks from this day and I hope Mr Kershaw† will send us something. I am preparing two tinted drawings. If you have anything of Sandby's framed we shall be obliged to you for 'em as we have his liberty to put up all his works that we can find.

If you don't come over to the festival you will certainly come over to the exhibition, it will open a fortnight before then continue open for all that week and the week following. I shall be obliged to you to let me know what drawings we may expect from Manchester, pray has Mr Astley nothing he could let us have, have you any acquaintance with him? Pack desires his compliments to you. He is going to Dublin very soon.

Believe me yr. sincere friend and Servt.

THOS. TAYLOR.

On August 9th Taylor speaks of a farce in which Miss Phillips is to play at Manchester. The subject of the Exhibition is continued in the next letter :—

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* Daniel Stringer, of Knutsford.

† Apparently Thomas Kershaw, who joined this Society in 1781.

Liverpool 30th Aug. 1784.

Dear Sir,

I received your letter of the 26th & am satisfied with the reason you give for not having wrote sooner. the day after Mr Martineau left us the pictures arrived from Manchester, but I am sorry no drawings of yours came with them, it was a heavy stroke upon us, but I hope we shall yet be able to hold up our heads. We are now in midst of the Hurry. I am just returned from the house where are arrived a great number of pictures, I believe above a hundred, and among them many very capital. we have arrang'd the Catalogue and with Roscoe's assistance have made it a very respectable one. to-morrow we meet to hang the pictures and I am afraid we shall find it difficult to please all parties. Tarlton is come and proves as hot as fire, yet they don't all shrink from it. Pack has exceeded my hopes in Miss Phillips, he has got a striking likeness, and has made it an elegant picture, 'tis his masterpiece. Tate has painted Mrs Richard Heywood* the same size (half length) these are to be pitted against each other on each side Sr Joshua. I am pleased to find this business has caused such an emulation—you can't be serious in talking of not coming to the exhibition, that wou'd be too bad indeed, you can certainly spare a couple of days during the three weeks we shall keep it open, which will be from the 6th to the 27th of next month, this includes the festival week, your plan will therefore be, to come over some day during the music, and hear one or two of the concerts if you can do nothing else. Now I am on the subject of music I have something to say to you respecting the concert you mention which Old Prospero hinted when last at Manchester. He told me about it the other day, and I endeavoured to dissuade him from it by assuring him that I never knew anything of that kind answer, he has not come to a determination to try it, but I find some Manchester people who were lately here have assured him it would be successful from the favourable light she stands in. he says moreover he can have any assistance necessary, without expence, and he doubts not one of the principal singers will also lend him a hand. the Theatre he can have for nothing—under the circumstances, and with the certainty of making a successful concert perhaps you may think more favonrable of it. I should be glad to have your opinion, but I perceive you are not desirous of having anything to do with the Old Fellow, and I suppose you don't wish to encourage them to come. I don't wonder at this at all, but I own I am a dood deal surprised you did not see Miss Phillips either of the times she was over. I would not have been bored by the old man so long without being repaid by a little of his daughter's company, but I daresay you had sufficient reason for declining it.

We expect a deal of company at the Festival. The Prince of Wales will be at Lord Derby's, together with the Duke & Duchess of Devonshire, Duke & Duchess of Portland, and a long string of Nobility, so there is no doubt but that the scheme will answer very well at the advanced subscription. I remain as usual, yours,

THOS. TAYLOR

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* Mary, daughter of William Earle.

Writing on September 8th Taylor remarks on the capital appearance made by the Exhibition, and of the "beautiful performances" of Miss Gartside. Philips, we gather from a letter written on September 30th, did not attend the Exhibition. On November 19th, 1784, Taylor writes :—

I must confess my negligence of late has deserved reprehension though I assure you I have several times sat down with intention to write but have been prevented by the many weighty avocations which take up my attention. I have been again compell'd into the arduous office of secretary of the Academy, for nobody else would take the trouble of it, & I was loth to desert an institution which I have more & more every day occasion to think well of, and I think its pemanentcy is now established beyond doubt, the number of members and students is double what they were last year and the places are commonly all fill'd every night. We have a handsome sum in hand from the Exhibition and last year's subscriptions.

On February 24th, 1785, Taylor writes that his friend Charles Eyes is going to London on behalf of the Corporation with reference to the Parliamentary approval of new docks of which Eyes, it seems, drew up the plans. Probably the reference is to the King's and Queen's Docks, powers for which were obtained in that year. On March 28th, after referring to Miss Phillips'* marriage, Taylor goes on to say :—

You mention'd when you were here that you believ'd Wainwright wou'd not be engaged at your festival, some days since we were talking about it, and he spoke as if he had no doubt of being employ'd but had no expectation of playing the Organ or harpsichord. I ask'd what he would play if he had an offer, and he said the Violincello—surely there can be no objection to this but on the contrary I shou'd think you would be glad to have him, for I know that at our meeting they found it difficult to procure any good Basses—I shou'd be sorry if he had the mortification to find himself neglected, and in my opinion it should be laid down as an invariable rule if these meetings are to be triennial that the musicians of each shou'd be employ'd in preference to others, but I am sure it is unnecessary for me to say anything to you to serve Wainwright, as I know you esteem him and I make no doubt you will use your influence in the Concert to get him an engagement.

Philips was married in 1787, and henceforth was to remain much more at home than formerly ; indeed his

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* Mrs. Crouch.

marriage had the effect, usual in such cases, of breaking up the bachelor society. As soon as he was settled, however, he seems to have asked Taylor over to stay with him, and accordingly on Sept. 24th, 1787, we find Taylor writing to Philips as follows :—

> I expected before this to have the pleasure of seeing you in Manchester, but Wakefield being from home Mr Okell could not conveniently be absent also. We have however taken places in the Coach for the Boat on Friday next & hope to pay you & Mrs Phillips our respects that evening ; we propose to stay with you till Monday, when we shall depend on your returning to Liverpool with us ; the Exhibition closes on Saturday Evening, but I have managed so that none of the pictures shall be taken from their places till you have seen them which you will do with more satisfaction when other persons are not admitted ; your Sister will also be in Town frem Allerton on Tuesday as she goes to the Concert that evening, so that on the whole I think we have made a very good arrangement—Moreover Charles Eyes is gone on an excursion to Buxton Doncaster York etc in Company with Cizos, & proposes to meet us at your house on Saturday evening on their way home, you will perhaps wonder to find Charles with a companion of so opposite a disposition as Monsieur Melancholy, but he was resolved on the jaunt & could get nobody else to join him ; so they sallied forth in a Buggy on Saturday noon, and have taken the Catch Books with them, not wishing to be without an expedient for raising supplies should they happen to fall short on the Road, so that it is not improbable the relation of their proceedings and adventures may cause us some entertainment.

The Cizos mentioned here seems to have been an *emigré* French gentleman, resident in Liverpool. He appears to have maintained himself by means of his musical abilities, and by teaching the French language. There is only one letter from Cizos in the Leigh Philips collection, enclosing a curious circular headed :—

PROPOSALS
for delivering a course of
READING IN THE FRENCH
Language
Intermixed with Singing

It seems to have been an ingenious and refined entertainment and met with some success in Liverpool. In

1800 he wrote Philips, with reference to a scheme to begin a similar course in Manchester :—" I am urged to this venturous scheme by the necessity of either removing to America (this *inter nos*) or of vegetating here upon the very precarious and circumbscribed emolument of a profession which is hardly sufficient for a bare maintenance since the prodigious influx of emigrants who derive their subsistence all from the same means." The supporters of the Bourbons in France, who had been driven out of their country by the Revolution, sought an asylum in this country in great numbers. Their lot was a sad one, as sensitive and refined people, many of them belonging to the highest ranks of society, compelled to work for a pittance in order to exist. Even the almost universal hospitality which these *emigrés* received in this country could of course only temper their fortunes in a very slight degree.

The letters between the friends now begin to come at much longer intervals, and the next letter is not until April 30th, 1797, when Taylor, who does not seem to have prospered as well as might be wished, writes to Philips in the following terms :—

> Though it has happened that for some time past we have not occasion to keep up a correspondence, I still flatter myself the Friendship which was so early formed between us is not extinguish'd although we have had so little opportunity of intercourse. Under this persuasion I trust it will not be altogether uninteresting to you to be inform'd that I have embraced an offer of entering into business and I hope with a fair prospect of placing myself in that state of independence which the employment I have held under the Corporation (however agreeable in many respects) was not likely to lead to—I believe you know that for a considerable time past I have lived with Mr Busch who was formerly in partnership with Mr Wagner—during the last three years we have kept house together, and have been upon such terms of unreserved communication as to give me opportunity of becoming acquainted with the nature of his business ; and having observed that his connections have continued to increase and that he was likely to have more to do than he could properly attend to himself (altho' a man of great activity & attention) I determined to make him a proposal of partnership on equal terms, which he

accepted—I was enabled to make him such proposal by means of the powerful assistance of my worthy friend Mr Clarke, indeed it is entirely through him that the connection has been brought about & in consequence of his assurance of essential support from his Bank—a principal branch of our business is the executing of foreign orders for the purchase of West India produce, and in doing this to advantage it is absolutely necessary to have the confidence of a Bank as large advances are required—Mr Busch has a very extensive correspondence all over Germany, and his Commissions have been from 12 to £1500 per annum for several years past—there is a great field for such business here, and we trust with the attention & application that we are determined to give to it that we may do something considerable—I hope it will be in my power by means of my friends in different quarters to add something to our connection and among others I flatter myself I may hope for your good offices should it be in your power to throw anything in our way; I know you have an agent here very capable of attending to your business, and therefore I say nothing on that head, but it may possibly happen that you may be able to recommend us to your friends—We are confined to general Commission business entirely, doing nothing on our own account. Mr Busch has had great experience in the corn trade, and we hope to get a good many commissions in that line: a great deal of business is done here for Commission for account of London Houses in the Foreign trade & any introductions in that way would be very acceptable to us—

I have some thoughts of writing to your brother Henry on this matter and will thank you to furnish me with his direction.

On January 17th, 1803, Taylor writes to Philips as follows:—

Dear Sir,

I believe it is three or four years since any correspondence has taken place between us, and I am glad of an occasion to break through this long silence, my Nephew and Partner Meadows Taylor has desired me to give the bearer Mr W. Clemens of Baltimore a letter of introduction to your house, his brother William Clemens being a very particular friend of his, and a man of whom he has the highest opinion. Mr Clemens (who was with my nephew at the time he was in Bremen) was for several years the Agent in Germany for Smith Buchanan & Co, of Baltimore, and had the entire confidence of that House. His father is a man of property & from what Meadows knows of the elder Brother he is of opinion they will form a house of much respectability—this is all we can say about them, you can easily by your connections with America learn more if you are disposed to do anything with 'em and I shall be glad they may prove worth your attention.

After a severe turn of fortune I find myself very comfortably settled in a regular business with my nephew, who is everything I could wish, smart & active and uncommonly attentive, we intended to have made the foreign trade our principle object, but our connections in Ireland have done so much for us that our principal attention will be directed to that quarter, and our German partner will leave us at the end of this year—it is probable my nephew will have to attend your corn market soon when he shall call upon you, you know I believe, that he is the Son of my Brother the Parson I hope Mrs Philips & your family are well, pray give my best respects to her—you seem to have deserted Liverpool entirely to the concern of many besides myself who I am sure would be happy to see you.

believe me dear Sir
Yrs very Sincerely
T. TAYLOR.

Our friend Young has certainly very much improved of late, particularly in Comedy which I incline now to think is his forte. he wants sadly to get to London but in my opinion he is better where he is for a while; he made £450 last year and has every reason to expect £100 more this.

This was probably the last letter Philips received from his friend, as Taylor died a little later in the same year. His "brother the Parson," was the Rev. Philip Taylor, and it is from his son, Philip Meadows Taylor, that we find the next letters to Col. Leigh Philips.

My Dear Sir,

Its a very long time since I have had the pleasure of hearing from you, but I trust you and Mrs. P. and Miss Philips are quite well. I have now to request that you will if possible do me the favour to ascertain the value of a small sample of extract of Dyewood, which is no less than an extract of the Real Brazil Wood—hitherto sold by exclusive privelege of the Queen of Portugal. As its contraband (not here but in the Brazils) I wd. not wish you to mention where the sample came from, but merely know what in the estimation of your Dyers it is worth p. lb.

I have about 20 or 30 lbs. weight of it. which I wd. send provided we cd. agree as to price—but what I now hold has merely been sent as a sample of a larger quantity and the great object is to know the real value—this sample stands us in nearly 10/- per. lb. but our friends abroad expect it will prove very nearly as valuable as cochineal. Will you do me the favour to consult with one of your eminent Dyers or Dry Salters on the subject & I expect a keg of the Yellow extract very soon a sample of which I will send you likewise. Should you here a good account of this Dye I request you will not mention the matter to *anyone*, as we might be immediately interfered with.

The enemies of corruption are going to have a grand feast to-day at Forshaws—they will certainly prove themselves friends of corruption *in one sense*—whatever I may think. However sincerely I may rejoice at seeing Villainy unkennelled, or the Mask torn from the face of a Commander in Chief, yet I disapprove these meetings devoted to the acrimony of party feelings, I think they are more calculated to raise a ferment in the Country than to render any essential service to the community, under this Idea I have refused to be present, and shall console myself with a glass of Champagne at Lowndes's—a Gentleman whose name you have no doubt heard as one of our great brokers—and allow me to add, as one of the best feeders in Liverpool.

Pray give my kindest respects to your brother & all at Mayfield, & believe me dear Sir

Yours most sincerely
P. MEADOWS TAYLOR.

Liverpool Friday ½ past one. [*April 21, 1809*]

Died—on its Parade Ground at eight o'clock yesterday morning the Liverpool Independent Rifle Corps—long the admiration of all beholders, its decease was gradual, but its fate certain as in most consumptive cases—only 4 Heroes and one Inspecting field Officer in at the death—In the language of our litterary captain, it may truly be said that from a *Corps* it is now certainly reduced to a Corpse.

Colonel Leigh Philips was greatly interested in madder and its possible substitutes. From Dickson's Agricultural Survey of Lancashire, we learn that he succeeded in growing the plant on the waste moss land round Manchester, and that the dye thus produced was successfully applied in the manufacture of Turkey reds. On April 7, 1801, Charles Taylor* writes to him from the Society of Arts: "By the Coach this day I have forwarded you a small Box containing some Madder Roots proper for planting. Le Clef de Zoroaster and Urn accompanying it and La Vie de Jerome Sharpe, also two copies of the account of Mr. Wakefield's Steam House. I have also sent you some foreign seeds in the state I received them without any explanations, therefore I know not whether they are valuable or not. I hope they will arrive and wish you may approve of them. If I can get you some madder seeds from Turkey I will not fail to do it." Mr. Wakefield's "Steam House," it may be said here, was some information he published for the Society of Arts relative to the heating of glass-houses by means of steam.

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* Elected a member of the Manch. Lit. and Phil. Soc. in 1781. One of the "Committee on Papers."

My Dear Sir

I have just received your line by my Cousin Henry Taylor, and your kind letter of the 7th. I am truly obliged to you & Mrs P. for your invitation, & Mrs Taylor wd be most happy to accept it but our nursery is rather too young *at present* and our last boy just inoculated with the Cow Pock. In about 10 days, if possible, I shall be looking out for a third seat in a Chaise, and anticipate a quiet day with you & Mrs Philips at Mayfield, with much pleasure. I am very anxious previous to Hardman's reappearance to see how the land lies with his opponents. I foresee a weak resistance, or rather a faint attack on the part of the enemy, but if they bring up the Artillery of the Law, and particularly that huge gun of Lord Ellenborough's our works may be carried & Pill Garlick overwhelmed —Statutes are awkward things to contend against, and an Act of Parliament an unaccommodating Visitor—My hopes centre in the Grand Jury, & their proceedings will be guided very much by Evidence brought forward or *kept out of the way*—Pray how is the Man Shot? I hope he does not resemble the House of Commons as represented by Sir Francis Burdett but that he has two legs to stand upon & not in want of further reform.

I assure you I never was so much hurt in my life as upon the occasion on which I sent Henry Taylor to Stockport. I was thunderstruck on receiving a note from Rogers telling me that M & P's Drft was refused acceptce. but still more, that in sending it up he had made the payment of this debt on as due yesterday dependant on their own Bill being honoured—He must therefore from some quarter (I think I can guess which), have had his suspicions roused—else why give such Instructions to Sir James Esdaile? I immediately went to Mr Moss & requested whether he wd. order the acceptce to be paid for Martin & Phillip's honour—this he declined, and not being able to scrape up enough at so short a notice, I thought it best to send off at once. I fear the transaction will diminish the little remains of cordiality & confidence between Messrs M. P. & R. and myself—& I must say I feel hurt that Martin should have drawn—under circumstances of the smallest doubt—as everyone wd suppose he had strained an uncertain point to accommodate *me*, whereas I consented to some undue acceptance to oblige his house. He writes to draw another £500—but as the matter now stands I see no good the Draft could possibly do him, & on the contrary believe it would prove of mutual disadvantage—I the more regret this matter as I am confident if they had a man of business to manage and arrange their affairs they never could experience a want of Capital—on the contrary it ought to bring in as fine a profit as a little gold-mine—I wish I had such a certain business to look to. I wd never desire a better—I have not had a line from Martin since poor fellow I sincerely sympathise with him—illness preys upon his energies & saps the scanty remnant of his activity & spirit.

There has been an awful accident in Liverpool to day in ringing for Church, two of the bells of the *Old* Church gave way & came down, and about five minutes after the whole of the spire & part of the tower fell down with a tremendous crash—The rector was entering at the East End and as the ringing had just ceased most providentially many people had not taken their seats. the Charity children were seated in the aisle, & about 20 of these & 4 or 5 grown people have been taken out dreadfully mangled and all killed —it is impossible to say how many are still under the ruins, but had the accident occurred one quarter of an hour later, a hundred people at least must have perished—the spire was old & fell in upon the roof & into the Church—Often as we read of the Carnage on board a Man of War, or the losses in the field of Battle, yet a domestic calamity of this kind is truly distressing.

Mrs Taylor unites with me in best remembrance & believe me my dear Sir

Yours always

P. MEADOWS TAYLOR.

Sunday Evening
[*Feb. 12. 1810*]

The "Old Church" is the Church of St Nicholas. In 1774 it was thoroughly repaired under the direction of Mr. Joshua Brooks, the interior of the roof being painted to represent the heavens, with the "blue ceiling, black and white clouds, golden sun moon and stars painted and gilt upon the roof." At the falling of the spire, which dated from 1360, 23 people were killed, 17 of them being children. The antique font was destroyed in the accident.

Meadows Taylor failed in 1810, and Philips made many offers of assistance and friendship. The following letter is from the Rev. Philip Taylor, father of the unfortunate merchant :—

Harolds Court 10th July 1810.

My dear Sir,

Your truly kind and welcome letter of the 24th last demanded a more speedy acknowledgment than I had the ability to give it. It found me labouring under a severe fit of Gout which commenced on Midsummer day & has continued to harass me with violent and almost incessant pain until the end of last week. I am now restored to a state of comparative ease. I am again able to sit up in my chair ; and the first act I do, however imperfectly it shall be performed shall be to return you my most sincere thanks for the high and & well timed consolation which you have afforded me under an affliction that has touched me to the quick, for the friendly interest you take in my dear son's welfare, and for those sentiments of personal attachment to him which you express with so much warmth of affection. Your letter was in truth, one of the happiest cordials which I could have received from the hand of friendship : be assured that I feel the efficacy of the consolation you have administered though I cannot express my gratitude for it as I could wish. Had my son been neglectful of his business or wasteful of his properry, but especially had he in any instance stooped to mean and fraudulent practices I had then most assuredly been a wretched parent. But while I receive such honourable testimonies to the propriety of his conduct which have been given me by you and other respected characters, who, for several past years have observed him with attention, I must be unreasonable indeed, not to find myself essentially relieved. The generous manner in which my son's creditors behave towards him under his present embarrassments is the strongest testimony they can give of their approbation of his past behaviour, and creates hopes of his future better success which cannot be resisted. The kind intention which for yourself and brother you have expressed of rendering him service when he shall enter in business again demands my most grateful acknowledgments. I know what lasting impression your friendship will make on Meadows' heart. Poor fellow! he is neither deficient in the milk of human nature, nor in those virtues which it requires an habitual energy of mind to practice; intelligence, & activity in business he is generally allowed to possess, and never was he addicted to any species of extravagant expense. I will therefore cheerfully embrace that hope, which you so kindly offer me, that with these properties, under the guidance of his own dear bought experience, and the good counsel of yourself and other sincere & intelligent friends, that he may still be so far established in the world as to support himself & family in respectability and comfort, though he should never arrive at a state of affluence. I expect him and his family here very shortly to pass a few weeks with us. What a comfort it is to me that the Dublin merchants speak most respectfully of his conduct & that he owes little, if anything to his correspondents here.

I am much concerned to hear of the declining health of my old & much respected friend Dr. Barnes.* Dr Edd. Percival gives me frequent reports of his situation, which with respect to this world appears hopeless indeed. He will however leave a good name behind him whenever he goes. I suppose his uncommon abstinence from wine arose much from the singular bodily infirmity he carried with him from childhood, and which increased with years.

Accept, my dear Sir, my best regards and good wishes and present them to your good lady & your brother. Mrs Taylor, who sensibly feels with me the kindness of your last letter desires to unite her respects to you & all your family with mine.

Believe me your affectionate & much grateful friend
PH. TAYLOR.

The next letter was, to judge from the handwriting, written with the left hand; Meadows Taylor had apparently broken his right arm. The postscript refers to Napoleon's disastrous retreat from Moscow, the "Cormorant" being, of course, the Emperor Napoleon, who occupied

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* This is probably the Rev. Thomas Barnes, D.D., one of the founders of this Society.

a very undesirable place in the popular affections. The reference to "Jonathan" is an allusion to the commercial alliance existing in this year between the United States and France, both of which were at war with Great Britain.

Bangor Ferry Saturday Night
[*Dec. 1812*]

My Dear Friend

I have been lying flat on my back since Tuesday Evg. the fracture is so close to the shoulder that the splints and bandages cannot be applied so effectually as if lower down. I have a Navy Surgeon attending me a very clever young man, who has cut off & spliced legs & Arms without number, but I shall be content with the splicing merely. I am tolerably easy, but want to get up sadly as my back aches. I had a four days beard taken off to-day by a Joiner, the Bangor Barber being lame & unable to shave except in his own shop I thought that Chin & all were gone—such a rasping I never yet endured. You would smile should you see me writing on my back—a pretty little Welsh Girl holding my paper before me & a Candle on my Bed. I am getting on famously I think. The Doctor seems most disappointed that I will not go into a fever. he says that fever ought by custom to go with broken bones.

Many thanks for the Aparatus which I will return as soon as I reach Livl. I regret that my arms and shoulder are not stout.

I had heard, before your letter came by the ** Mail of your Caroline's death—a happy release but a sad life—she was one of a very few & I most sincerely lament her departure, though poor soul ! not on her account, for she is happy ! Pray present my kindest regards to Mrs. Philips & beg her to accept my heartfelt condolence in this melancholy event.
Remember me to your brother Henry & believe me

Ever yours most truly
P. M. TAYLOR.

The French have just got what they have so long deserved, and I hope the Cormorant himself will not escape. Jonathan's spirit's will be low Malison must take a Glass of Grog extraordinary to wash down an Extraordinary Gazette—can you tell me whether the Duke of Devonshire is at Chatsworth ?

Colonel Leigh Philips was in the habit of going with his family to spend the summer at Southport, then just rising out of the sand at North Meols. He had a cottage there, and many friends. The next letter is a reply to an invitation he gave to Meadows Taylor.

Liverpool Sept. 28. 1813.

My dear Friend

I am greatly mortified to think that I must give up all thought of seeing you at Southport for the present. I had prepared everything for going on Saturday, when a number of my Correspondents arrived from Cork & Dublin, & instead of *bouting* it I was obliged to give a dinner *chez moi*—not to mention wine & whiskey.

I have now a Captain Sheen addressed to me from India, a clever well-informed man, he has come home with a moderate Fortune, & is much struck with Liverpool. In a day or two more I have a Bed to prepare for my cousin Mr William Johnston of Bordeaux, & the moment he leaves me I must join for a few days a happy party at Street Court in Herefordshire, where my wife & boys are staying at present and Captain Mitford daily expected Henry has made me some capital flies for the Lugg, which I am in hopes the noble grayling of that river will form a more intimate acquaint$_{ce}$ with. Thus you see my movements towards the North are interrupted at all points, nor can I even steal a forced March.

We have had a glorious musical festival, and as you may suppose, an everlasting stir in *Catgut*, we have had Airs as well as Graces, and it is admitted that Handel's music was incomparably *Handled*. I treated myself with the Creation and a Concert. the o^{r} matters I left to my Neighbours —The last Concert was so full that there was universal screaming & fainting & I am told that Mrs Leyland at full length, fainting, would have afforded a fine subject for a picture—when order was restored Hats Shawles Gloves Bracelets & shoes were held up on white wands & exposed to be claimed by those whose property was viewed, and a worthy friend of mine, not so fortunate as his Neighbours, & who had lost his shoes, sat all night with his feet in his Hat—at the Assembly there were 2500 people—and 257 Coaches drove up to the Ball Room *before* 11—being acquainted with a sapient Gentleman who stood till that hour & counted them, thereby adding to the discoveries of the Age & proclaiming himself an A.S.S. at the same time.

Pray write me a few lines, & tell me how your health is, I trust better and that Mrs. Philips is quite well—give my kind regards to her, & believe me most truly

your sincere & affectionate friend

P. MEADOWS TAYLOR.

I wish you would bring Mrs Philips over for a night or two *this week*—I shall have an excellent Bed for you, & Catalani will sing at the theatre every night but *Friday* as well as Naldi—Zaniewitch Harvey Wiesbach Corri. &c. &c, all in the Orchestra. Do pray come. I will make you as welcome *as any Prince and Princess in Christendom.*

Here these memorials of a friendship of the 18th century must close. It is the lot of some men to be gifted with supreme genius, and to have the reward of their life's work in the immortality of their names. But the greatness of a nation is not exclusively due to the world-wide reputation of its greatest sons, any more than the grandeur of a mountain mass is due exclusively to its loftiest peaks. Much must be recognised as the fruits of the efforts of inconspicuous labourers, without whom the work of the greatest would be impossible; the honorary officials who seek no fame, but devote their energies to the details of intellectual and progressive movements from simple love of the work, and find their happiness in the mere satisfaction of their refined impulses and tastes, are entitled to some gratitude from posterity. And such men were Thomas Taylor of Liverpool, and his friend Leigh Philips of Manchester.

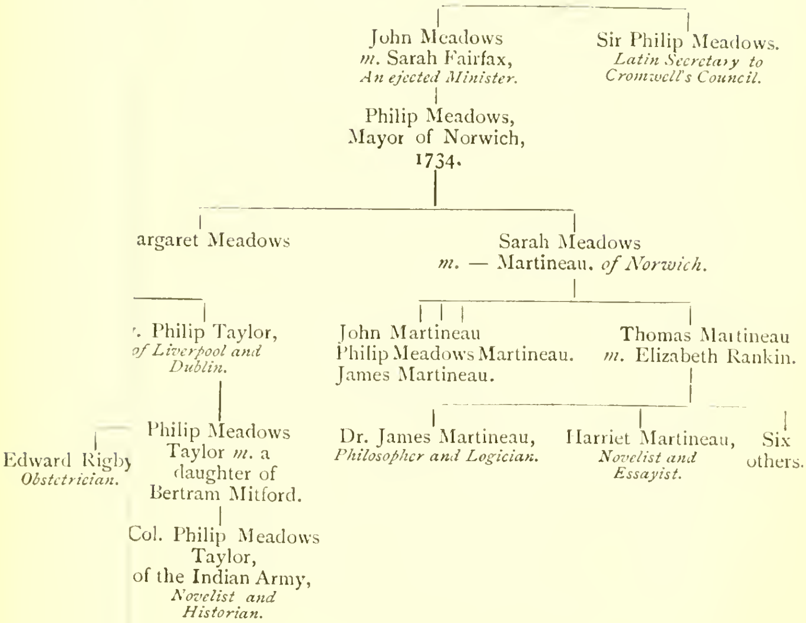
[Since writing the above, I discovered, in *Gore's Liverpool Advertiser* of Oct. 6th, 1803, the following obituary notice: "Died, on Wednesday the 28th ult., in the 43rd year of his age, Mr. Thomas Taylor, Merchant, of this town. He had gone to Buxton with a view to meet some of his nearest relations, and there fell an untimely victim to that cruel malady, the Typhus Fever. Severely as his loss will be felt by his own immediate relations and intimate friends, who were most accustomed to the endearments of his manners, the accomplishments of his mind, and the rectitude of his heart, the inhabitants of Liverpool, in general, have much cause to deplore the too early decease of a man, who, for many years, successfully employed his excellent abilities to promote both the substantial benefit of the public, and those scientific and refined pleasures which were so congenial to his own elegant taste. It may truly be said, that of the many useful and ornamental public institutions which our town can boast, there is scarcely one which is not considerably indebted to his solid judgement, and persevering exertions."]

NOTE: For facts relating to the Earle family I am indebted to Mr. T. A. Earle, of Hartford, Cheshire, who kindly sent me his "Earle of Allerton Tower" (privately printed in 1889), and placed other sources of information at my disposal.—W. B. F.

le,

IE

EAU FAMILIES.



John Meadows
m. Sarah Fairfax,
An ejected Minister.

Sir Philip Meadows.
Latin Secretary to Cromwell's Council.

Philip Meadows,
Mayor of Norwich,
1734.

argaret Meadows

Sarah Meadows
m. — Martineau. *of Norwich.*

. Philip Taylor,
of Liverpool and Dublin.

John Martineau
Philip Meadows Martineau.
James Martineau.

Thomas Martineau
m. Elizabeth Rankin.

Edward Rigby
Obstetrician.

Philip Meadows Taylor *m.* a daughter of Bertram Mitford.

Dr. James Martineau,
Philosopher and Logician.

Harriet Martineau,
Novelist and Essayist.

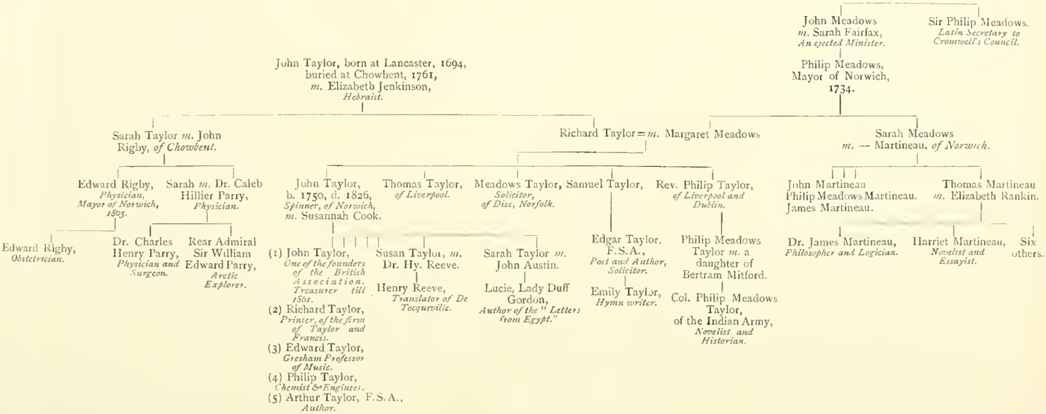
Six others.

Col. Philip Meadows Taylor,
of the Indian Army,
Novelist and Historian.

Genealogical Table,

SHOWING THE RELATIONSHIP OF THE

TAYLOR, MEADOWS, AND MARTINEAU FAMILIES.



Manchester Memoirs, Vol. xliv. (1900), *No.* **15.**

XV. Hymenoptera Orientalia, or Contributions to the knowledge of the Hymenoptera of the Oriental Zoological Region. Part IX.

The Hymenoptera of the Khasia Hills. Part II. Section 1.

By P. CAMERON.

[*Communicated by J. Cosmo Melvill, M.A., F.L.S.*]

Received October 10th, read October 31st, 1899.

MUTILLIDÆ.

The Khasia *Mutillidæ* in the collection are all males, the native collectors apparently gathering only winged insects.

A. THE GROUP OF M. SEXMACULATA. Large species, black, with ferruginous abdomen, and with the scutellum gibbous; the abdominal segments fringed with rufous hair.

MUTILLA EMPIRICA, *sp. nov.*

Nigra; dense albo-pilosa, vertice mesonotoque longe nigro-pilosis; abdomine ferrugineo, basi apiceque nigris; alis violaceis ♂

Long. 18 mm.

Scape of antennæ thickly covered with long white hair, grooved beneath; the flagellum opaque, covered with a microscopic pile. The front and vertex covered

October 9th, 1900.

closely with large deep punctures and thickly with long dark fuscous hair; between and below the antennæ is a tuft of long pale hair. The face and clypeus smooth and shining; the sides and the lower orbits with a dense band of silvery pubescence. Mandibles black; their basal half thickly covered with long pale hair. On the upper half of the face in the centre is a stout keel. Pronotum coarsely punctured; the propleuræ bearing stout oblique keels; the apex smooth. Mesonotum shining, bearing large deep punctures all over and sparsely covered with long black hairs; the two furrows are wide and deep. Scutellum large, pyramidal, and covered with large deep punctures, the top rounded, blunt, smooth and shining; post-scutellum smooth in the middle, the sides punctured; both are covered with long black hair. Metanotum reticulated, thickly covered with silvery pubescence, the basal third of the area wide; the apex rounded; the middle obliquely narrowed. The raised central part of the mesopleuræ coarsely punctured and thickly covered with long white hair. Metapleuræ reticulated; the middle smooth. Legs thickly covered with long white hair; the spurs pale. Wings deep violaceous; the basal two cubital cellules streaked with hyaline in the middle; the second and third cubital cellules are almost equal in length on the top; the first recurrent nervure is received shortly, but distinctly, beyond the middle; the second near the base of the apical fourth. Abdomen ferruginous; the petiole and apical segment black; the petiole is strongly and deeply punctured and covered with long white hairs; the second segment is sparsely punctured, almost impunctate in the middle; the apices of the second to sixth segments fringed with bright golden, the last with long black hair, except in the middle, which is smooth and shining. The base of the under side of the petiole has a large, elongate depression in the middle ; the keel is straight throughout. The sides of the hypopygium are raised on the apical half, the raised part depressed at the base ; in the centre at the apex are two shorter keels, also dilated at the apex.

Comes near to *M. perdita* and *M. cressida* ; the former may be known from it by having the keel on the petiole dilated at the apex and by having the four apical abdominal segments black ; the latter is more stoutly built and may be known by the second cubital cellule being clearly longer above than the third and by the median segment bulging out in the middle.

MUTILLA ANTERA, *sp. nov.*

Nigra, abdomine ferrugineo, basi apiceque nigris, basi scutelli medio canaliculato ; alis violaceis. ♂.

Long. 20 mm.

Belongs to the group of *M. dimidiata* Lep., having the scutellum raised and the abdomen for the greater part ferruginous ; but may be easily known by the base of the scutellum having a wide and deep depression in the middle.

Scape of the antennæ covered with long white hair ; the flagellum with a pale pile ; the third and fourth joints almost equal in length, but, if either, the third is the shorter. Head coarsely rugosely punctured, a large smooth space on either side behind the ocelli. Clypeus broadly projecting in the middle, its apex slightly waved. Mandibles thickly covered with long, pale fulvous hair at the base ; the lower tooth is much shorter and more rounded than the upper ; the palpi black. Pronotum rugosely punctured, thickly covered with long fuscous hair ; the propleuræ at the base rugosely punctured ; the middle depression bearing seven stout, distinctly separated keels ; the apex is smooth.

Mesonotum shining, thickly covered with black hairs, and bearing all over large deep punctures; the two central furrows are deep. Scutellum rugosely punctured, thickly covered with long black hairs; the upper portion of the middle basal part smooth, impunctate, shining; its lower three-fourths widely and deeply furrowed, the furrow narrowed and rounded above. Post-scutellum finely punctured in the middle, the sides rugose. Mesopleuræ coarsely punctured, thickly covered with long grey hair. Metapleuræ, except at the base, strongly reticulated. Legs thickly covered with white hair; the calcaria white, the tibial spines rufous. Wings deep violaceous; the second cubital cellule shorter at the top, longer at the bottom, than the third; the first recurrent nervure is received shortly beyond the middle; the second near the base of the apical fourth of the cellule. Median segment thickly covered with long white hair; reticulated, the reticulations on the apex smaller than on the base; the central area broad at the base, much narrowed towards the apex; the sides at the base parallel, before the middle curved; the apex is rounded; in the middle at the base is a longitudinal keel. Abdomen dark ferruginous, the basal and apical segments black; the petiole bearing large deep punctures, except in the middle; the apex is rufous and more finely punctured; the ventral keel is straight, not dilated at base or apex. The pygidium is covered with long black hairs, except in the middle, which is smooth.

MUTILLA PERDITA, *sp. nov.*

Nigra, dense albo-pilosa, mesonoto nigro-hirto; abdominis segmentis 2-is et 3-is rufis; alis violaceis, basi fere hyalinis. ♂.

Long. 22—23 mm.

Scape of antennæ covered with long, pale fulvous hair; the third and fourth joints equal in length. Front and vertex coarsely and deeply punctured, except at the sides of the ocelli; the vertex sparsely covered with long fuscous hair; the front, inner orbits, and sides of the clypeus densely with silvery pubescence. Clypeus broadly carinate, the sides of the keel oblique; the apex transverse. Mandibles black, the base thickly covered with depressed pubescence; on the under side near the base is a stout, projecting tooth. Pronotum with a band of white pubescence; the pleuræ sparsely pilose, mixed with fuscous hair; coarsely punctured above; the middle, except at top and bottom, with stout, widely separated keels; the apex is smooth. Mesonotum deeply and strongly punctured, and covered with longish black hairs; the furrows are deep; in the middle at the base is a smooth, shining, longitudinal keel. Scutellum rugosely punctured; the punctures large and deep; the apical half in the middle flat, smooth, and shining, rounded at the apex; the basal hollowed, the depression narrowed at the top; the depression at the base is smooth and shining. Post-scutellum finely rugose, slightly depressed in the middle. The basal half of the median segment is thickly covered with depressed silvery pubescence, which hides the surface; the middle area extends to the end, and is widened at the base; the apex has an oblique slope and is thickly covered with long pale hair. Mesopleuræ coarsely punctured, covered with long white hair; the base and apex smooth. The basal half of the metapleuræ smooth, except for some large, deep punctures on the lower part in the middle; the apex is closely and strongly reticulated. Legs thickly covered with long white hair; the calcaria pale. Wings deep violaceous, almost hyaline at the base; the first recurrent nervure is received at the base of the apical third; the second shortly beyond the middle. Abdomen black, thickly covered with white pubescence; the extreme apex of the first, and the whole of the second and third segments ferruginous; the petiole coarsely punctured, except at the apex; the keel is short and stout; beneath, it is slightly and roundly curved upwards; the second segment is rather strongly, but not closely, punctured, except for a somewhat triangular smooth space at the side near the apex; the pygidium coarsely punctured, thickly covered with long black hair.

B. THE GROUP OF M. PANDARA. Species with the thorax black; the abdomen more or less rufous at the base, and with the segments thickly fringed with whitish hair; the scutellum not gibbous.

MUTILLA PANDARA, *sp. nov.*

Nigra, petiolo segmentoque 2-o basi late rufis; alis fusco-violaceis, stigmate nervisque fuscis. ♂.

Long. 15 mm.

In Bingham's arrangement comes into "*A. a.* b^1. Wings dark fuscous, with a purple effulgence. a^2. Basal two abdominal segments red," which includes only *M. unifasciata* Sm. It comes near to *M. aglaia* here described; but may be known from it by the petiole being entirely red; by the base of the second segment having a distinct oblique slope; by the base of the pronotum having two rows of irregular broken keels, instead of an area enclosed by stout keels; by the first recurrent nervure being received in the middle, and the second distinctly beyond the middle; and by the mesopleuræ being much more distinctly punctured and reticulated.

Scape of the antennæ punctured, thickly covered with long pale hair; the lower side sharply keeled; the flagellum covered with a pale down; the apical joints more or less brownish beneath; the third and fourth joints are almost equal in length; the front and vertex sparsely covered with long black, the antennal region and the clypeus with long white hair. The front and vertex are coarsely rugosely punctured. The upper part of the clypeus is roundly convex, slightly and gradually widened towards the apex; the apex is depressed, distinctly margined laterally, and marked before the apex with a distinct transverse keel, which projects roundly backwards in the middle, there being also a raised part at the apex of this projection. Mandibles black, piceous before the apex; the hairs are long and pale fulvous. Prothorax rugosely punctured, except at the base and apex of the pleuræ; the mesopleuræ rugosely punctured, except in the middle at the base; behind, the punctures run into reticulations; the metapleuræ coarsely reticulated on the apical half; the middle and the upper part of the basal portion smooth; the lower part of the base with long, shallow, irregular punctures. Legs thickly covered with long white hair; the calcaria and spines white; the claws rufous; the base of the incision on the anterior tarsi is also rufous. Wings uniformly brownish, with a slight, but distinct, violaceous tinge; the nervures are testaceous; the second and third cellules at the top are equal in length; below, the second is about one-third longer than the third; the second cellule receives the recurrent nervure in the middle; the second recurrent is received shortly beyond the middle. The petiole and the second abdominal segment, except at the apex, are ferruginous, closely punctured and sparsely covered with long white hair; the petiole is short, scarcely one-half the length of the second segment, broad, narrowed at the base; the second segment is obliquely raised towards the middle; at the base the slope is longer and more oblique than it is at the apex; the third, fourth, and fifth segments are thickly covered on the apical half with pale fulvous hair; the hair on the apex of the second segment and on the apical ones is black; the pygidium has a broad, smooth space on the middle of the apical half, this part being keeled down the middle.

MUTILLA ISORA, *sp. nov.*

Nigra, abdominis dimidio basali rufo, alis fusco-violaceis, nervis testaceis; tegulis testaceis. ♂.

Long. 14 mm.

Comes nearest to *M. schletterei* from Burma and Sikhim, with which it agrees in coloration and in having the front and vertex striated, but may be known from it by having the median segment coarsely, not delicately, reticulated; by the punctures on the scutellum not being "fine and delicate"; and by the tegulæ being entirely testaceous, not testaceous along their outer margin only.

The antennæ distinctly tapering towards the apex; the scape covered with long white hair; the flagellum densely with short stiff pubescence. The front and vertex sharply and distinctly striated; in front of the anterior ocellus is a deep, somewhat triangular, depression; the outer orbits are strongly striated; the striæ intermixed with punctures; clypeus smooth, shining; indistinctly keeled in the middle. The front is covered with long fulvous, the clypeus with long silvery, hair; the vertex more sparsely with longer, pale fuscous hair. Mandibles rufous in the middle. Thorax black; the pro- and mesothorax thickly covered with fuscous hair; the hinder edge of the pronotum bears a thick belt of fulvous pubescence. Mesonotum strongly and deeply punctured; the parapsidal furrows deep, distinct, narrowed at the base. Scutellum distinctly punctured, but not so strongly as the mesonotum; its hair longer and paler. Metanotum strongly and regularly reticulated all over; its base covered with fulvous pubescence; its basal half is rounded; its apex has an oblique slope. Propleuræ impunctate, but marked with four stout keels on the lower part and a narrower one in the middle; the mesopleuræ strongly but not deeply punctured, and thickly covered with long, pale fulvous hair; the metapleuræ strongly reticulated, except for a smooth oblique band in the middle. Legs thickly covered with white hair; the spines and calcaria white. Wings fusco-violaceous; the stigma and nervures dark testaceous; the second cubital cellule at the top is distinctly shorter than the third, at the bottom about equal to it in length; it receives the recurrent nervure shortly, but distinctly, beyond the middle; the second is received at the base of the basal third. Abdomen black; the basal three segments entirely ferruginous; the second to fifth segments fringed at the apex with long, pale fulvous hair; the apical thickly with black hair. Petiole stout, becoming gradually wider towards the apex; in length about half that of the second; both are rather strongly, but not closely, punctured; the pygidial area is strongly punctured, except in the middle. The petiole beneath is strongly punctured; in the middle the keel is straight throughout; rounded at the base, oblique at the apex; the third segment is black, rufous at the base and apex.

MUTILLA RESPONSARIA, *sp. nov.*

Nigra, abdominis segmentis primis tribus late rufo-ferrugineis; alis fumatis, basi fere hyalinis; tegulis testaceis. ♂.

Long. 11 mm.

Head coarsely rugosely punctured; sparsely covered with longish pale hair; the labrum and clypeus smooth and shining; mandibles entirely black; at their base on the lower side is a stout tooth, rounded at the apex. The scape of the antennæ punctured, sparsely covered with longish white hair; the flagellum is densely covered with short stiff pubescence. Thorax thickly covered with white hair; the pronotum has a broad band of pale pubescence; above it is stoutly punctured; the pleuræ smooth, except for a few obscure striæ. Mesonotum strongly and deeply punctured; thickly covered with fuscous hair, and with two deep furrows in the middle; the scutellum is more strongly and irregularly punctured; the post-scutellum is strongly aciculated. Median segment strongly reticulated; the central basal area is longer than it is broad; widest at the base, its apex rounded and slightly dilated at the apex. Propleuræ at the apex with some indistinct striæ; the middle of the metapleuræ punctured; the apex of the metapleuræ strongly reticulated; the base on the lower side obscurely punctured. Wings fuscous, with a faint violaceous tinge; the base more hyaline; the nervures are dark fuscous; the second cubital cellule is slightly shorter at the top, longer at the bottom than the third; the first recurrent nervure is received in the middle; the second at the base of the apical third. Legs thickly covered with white hair; the calcaria pale; the tarsal spines rufous. The basal three segments are ferruginous; the petiole is closely punctured, covered with long white hair; the apical halves of the third, fourth, and fifth segments thickly covered with pale fulvous hair; the apical segments covered with long black hairs; strongly punctured, except on the middle of the apical half. The petiole, on the under side in the middle, is strongly and deeply punctured; there is no distinct keel in the centre, which is straight.

MUTILLA ONARA, *sp. nov.*

Long. 16—17 mm. ♂.

Agrees in coloration with *M. honorata*—black, with the basal three segments of the abdomen red, and the third segment thickly covered with pale fulvous pubescence—but may be known from it by being larger, by the central area on the median segment being much broader and not nearly so much narrowed at the apex, and by the basal half of the metapleuræ being impunctate.

Scape of antennæ shining, sparsely covered with long white hair; the flagellum with a dense microscopic pile; the third joint is slightly shorter than the fourth. Front and vertex deeply rugosely reticulated; the front broadly, in the middle thickly, covered with long white hair. Clypeus very smooth and shining; its sides and apex raised. Mandibles at the base thickly covered with long, pale fulvous hair; palpi black, covered with short hair. The upper edge of the pronotum has a broad band of silvery pubescence, and is strongly rugosely reticulated; the pleuræ, except above, have in the middle stout, somewhat irregular, longitudinal striæ. Mesonotum coarsely, irregularly, rugosely punctured and reticulated, more finely and closely at the base than at the apex; the hair is long, black and sparse; there are four longitudinal furrows, the inner being the shorter. Scutellum roundly convex, not much raised; rugosely punctured, sparsely covered with long black hairs; the post-scutellum rugose. Median segment thickly covered with long white hair; largely reticulated; the central area wide, in length scarcely twice the width at the base; the apex slightly narrowed; the apex itself with the sides oblique. Mesopleuræ closely rugosely punctured, covered with white hair; the basal half of the metapleuræ smooth; the apical largely reticulated. The sides of the mesosternum irregularly stoutly striated; the middle more closely, indistinctly, transversely striated. Legs thickly covered with white hair; the calcaria pale fulvous. Wings deep violaceous, slightly paler at the base; the first and second cubital cellules are equal in length above; the recurrent nervures are received shortly beyond the middle. The basal two segments of the abdomen and the basal half of the third are rufous; the petiole is rugosely punctured; the basal keels are stout; the ventral keel is slightly curved upwards beneath, its apex is slightly more produced than the base; it is smooth and shining. The petiole is covered thickly with long, the second segment more sparsely with shorter, white pubescence; the apical half of the third segment is covered thickly with pale fulvous, depressed pubescence; the hair on the apical segments is black; the pygidium is closely punctured; in the middle on the apical half is a smooth line.

MUTILLA HONORATA, *sp. nov.*

Nigra, abdominis basi late rufo; capite thoraceque reticulatis; alis violaceis; tegulis nigris. ♂.

Long. 15 mm.

Antennæ black; the scape covered with long fuscous hair; the flagellum thickly with a short stiff pile, which is black on the basal joints, paler on the apical; the third joint is a little longer than the fourth. Head thickly covered with long fuscous, the oral region with shorter silvery hair; the front coarsely reticulated; the vertex behind the ocelli coarsely punctured. Clypeus smooth and shining; its apex obliquely depressed, glabrous. Mandibles at the base covered with long white hair. The pronotum covered with depressed, dark silvery pubescence; its upper part coarsely rugosely punctured;

the propleuræ depressed and marked with six stout longitudinal keels. Mesonotum strongly reticulated all over, and thickly covered with longish black hair; the parapsidal furrows deep, smooth and shining; they originate shortly before the middle and do not reach to the apex. Scutellum roundly raised, coarsely and deeply punctured all over and covered at the base with blackish, at the apex with longer fuscous hair. Post-scutellum opaque and granular in the middle; the sides irregularly rugosely punctured; like the apex of the scutellum it is covered with long pale hair. Median segments stoutly reticulated all over; the base covered thickly with depressed grey pubescence, the rest of it more sparsely with long pale hairs: the basal median area large, about three times as long as broad; the apical two-thirds gradually narrowed and with the apex lanceolate. Mesopleuræ coarsely and deeply punctured, except on the lower part of the base, which is glabrous; the rest and the sternum thickly covered with longish grey hair. Metapleuræ above coarsely reticulated; there is a smooth space below the middle; the part under this is punctured. Mesosternum irregularly punctured; in the centre at the base is a smooth, somewhat triangular, depression. Legs thickly covered with long white hairs; the spines and calcaria pale. Wings fusco-violaceous; the nervures dark fuscous; the second and third cellules at the top are equal in length; below, the second is longer than the third; the first recurrent nervure is received a short distance beyond the middle, the second at the base of the apical third of the cellule. The basal three segments of the abdomen are ferruginous; the petiole becomes gradually wider towards the apex, and is not half the length of the second segment; it is strongly, but not closely, punctured; at the base on either side is a stout, somewhat triangular, oblique tooth ; the part behind this projects ; its ventral keel is stout, and is roundly depressed beneath. The second segment, except in the middle, is closely punctured ; the petiole is covered with long, the the second segment with shorter, pale hair ; the third thickly, on the apical half, with depressed, dark fulvous pubescence ; the remaining segments are covered thickly with long black hair ; the pygidium is thickly covered with long black hairs all over. The tegulæ are black, very smooth and shining, and sparsely covered with pale hairs.

Comes nearest to the Burmese *M. schlettereri* Magr., and *M. stephani* Magr., but is abundantly distinct.

MUTILLA ELMIRA, *sp. nov.*

Long. 17 mm. ♂.

Comes into Bingham's "Section b^1. on p. 9 and a^2. Basal two abdominal segments red." From *M. unifasciata* it may be known by the scutellum not being "prominent, raised"; by the head and thorax being thickly, not "very sparingly, covered with long, soft hairs"; by the basal two segments being thickly pilose, not merely "very slightly pubescent."

Antennæ stout : the scape thickly covered with long pale hairs ; its apex rufous on the under side laterally : the flagellum stout, thickly covered with a short, stiff, black pubescence and with a pale down. Head coarsely, deeply rugosely punctured, and thickly covered with silvery hair, which is thicker on the front ; below the antennæ it is longer. Antennal tubercles large, smooth and shining. Mandibles rufous in the middle, at the base thickly covered with long fulvous hair. Pro- and meso-thorax thickly covered with pale hair ; on the edge of the pronotum it is thicker, more depressed, and pale fulvous: on the scutellum longer and darker. Mesonotum deeply and coarsely punctured, the two furrows on the hinder half are wide and deep; there is an indistinct keel on the middle at the base. Median segment coarsely reticulated, thickly covered with pale fulvous pubescence: its apex has a gradually rounded slope; the middle basal area is about four times as long as the width at the base; at the base its sides are straight, then oblique on the widened part. Propleuræ, except above, smooth; the middle raised part of the mesopleuræ bearing shallow punctures and thickly covered with fulvous pubescence: the apex of the metapleuræ reticulated. Legs thickly covered with long pale hair: the calcaria white. Wings violaceous; the nervures black; the first cubital cellule at the top is almost double the length of the third; the recurrent nervure is received near the base of the apical third. Abdomen black, thickly covered with long white hair; the basal two segments ferruginous; the apex of the pygidial area is depressed, with a distinctly raised border. The keel on the ventral surface of the petiole is straight, not dilated at base or apex; the sides are strongly punctured; the epipygium is strongly punctured and thickly covered with long black hairs. Tegulæ smooth, large, black with a plumbeous hue; the base and inner side covered with long pale hairs.

Comes near to *M. honorata* here described; but that has the third abdominal segment red and thickly covered with white pubescence; the top of its head is more rugosely punctured and more distinctly reticulated in the middle; the first cubital cellule at the top is not much longer than the third and the abdominal keel is dilated at the base and apex.

MUTILLA AGLAIA, *sp. nov.*

Nigra, abdominis segmento 2-o rufo; alis fusco-violaceis. ♂.

Long. 13 mm.

Comes near to *M. lyrata*, but may be known from it by having only the second abdominal segment red; by the second and third cubital cellules being equal in length at the top, whereas in *M. lyrata* the third is distinctly shorter than the second; by the apex of the radius being less sharply angled; and by the propleuræ wanting the keels.

Head densely covered with white hairs; the front and vertex rugosely punctured, the oral region smooth. Mandibles black, with a red band before the middle; the palpi fuscous, mottled with testaceous. Thorax covered with long fuscous hair; the pronotum and mesopleuræ also with a silvery pubescence. Mesonotum covered all over with large, deep punctures; its two furrows deep; in the middle at the base is an indistinct longitudinal keel. Scutellum coarsely, deeply and irregularly punctured; the punctures longer and more irregular in the middle at the base. Median segment reticulated all over; the basal central area elongated and somewhat triangular at the apex. Pro- and meso-pleuræ smooth; the apex of the metapleuræ reticulated. Legs black; thickly covered with white hair; the calcaria white. Wings smoky-fuliginous, with a violaceous tinge; the nervures, except the apical ones, are deep black; the second cubital cellule at the top is slightly shorter than the third; and is there slightly longer than the space bounded by the recurrent and the second transverse cubital nervures. Abdomen black, the segments thickly fringed with white hairs; the second segment is entirely ferruginous; the petiole blackish, broadly brownish at the apex; the apical segment above is smooth in the middle; the sides punctured and pilose.

MUTILLA LYRATA, *sp. nov.*

Nigra, abdominis medio rufo; alis fusco-violaceis. ♂.

Long. 13 mm.

Comes into Bingham's "Section A. Thorax black, a^1. Abdomen more or less red; and b^1. Wings dark fuscous, with a purple effulgence."

Antennæ black; the scape thickly covered with long white hair and deeply punctured; the flagellum black; the third joint at the apex and the fourth at the base marked with brown; as are also the apical joints, which are distinctly narrowed. Head thickly covered with long, glistening white hair. Front and vertex deeply rugosely punctured; the oral region smooth and shining; the mandibles black, shining, rufous near the middle; the palpi black, thickly covered with white hair. Thorax entirely black; the pronotum and mesopleuræ thickly covered with long white hair. Mesonotum shining, uniformly covered with large deep punctures, sparsely covered with black hairs; the scutellum is similarly punctured, but with the punctures closer together, and it is rather thickly covered with long pale hair. Median segment reticulated, the reticulations larger at the base, which is thickly covered with white pubescence. The propleuræ coarsely punctured in the middle above; on the apex near the middle are three stout longitudinal keels. Mesopleuræ, broadly in the middle, punctured and thickly covered with white hair; the apex of the metapleuræ reticulated. Legs thickly covered with white hair; the calcaria and tarsal spines pale. Wings fusco-violaceous; the costal cellule and an oblique cloud in the first cubital cellule hyaline. Abdomen black; the second and third segments ferruginous; the segments thickly fringed with white hair.

MUTILLA LATHONIA, *sp. nov.*

Nigra, abdominis segmentis 2-o et 3-o rufis; dense albo-pilosis; alis hyalinis, basi fusco. ♂.

Long. 12 mm.

Scape of antennæ thickly covered with silvery hair; the flagellum thick, covered with a pale pile. Front and vertex closely, strongly rugosely punctured; the vertex sparsely, the front thickly covered with silvery pubescence. Face and clypeus smooth and shining; the latter turned up at the apex. Mandibles at the base thickly covered with long white hair; the middle obscure piceous; the palpi black, covered with white pubescence; the tooth on the lower side of the mandibles near the base is large. Thorax thickly covered with white pubescence; the mesonotum uniformly covered with large deep punctures. Scutellum flatly rounded, punctured like the mesonotum, and covered with long white hair. Metanotum reticulated; its apex with an oblique slope, rounded above; the middle area has the basal fourth wider than the rest; the narrowed part is about three times as long as wide. Propleuræ smooth, except above and at the apex; the middle of the mesopleuræ closely punctured and densely covered with pale hair; metapleuræ smooth, its apex reticulated. Legs thickly covered with white hair; the spurs pale, the spines rufous. Wings violaceous, the base fuscous; the first cubital cellule is shortly, but distinctly longer than the third; the first and second recurrent nervures are received shortly beyond the middle. Abdomen black; the second and third segments ferruginous; the apex of the petiole is fringed with golden hair; the others with silvery hair;

the basal two segments covered, but not closely, with large deep punctures; the pygidium is closely punctured, with a smooth line down the middle; the ventral keel is straight; the hypopygium is closely punctured, with a narrow transverse space behind the middle.

Comes into Bingham's "Section *b*^{1}. (p. 9)" and forms a new group; "Abdominal segments 2 and 3 red," after his *a*^{2}.

C. THE GROUP OF M. LEPCHA. Head, thorax, and abdomen black, thickly covered with pale fulvous hair.

MUTILLA LEPCHA, *sp. nov.*

Nigra, dense fulvo-hirta; alis fusco-violaceis; basi fulvo; tegulis testaceis. ♂.

Long. fere 16 mm.

Antennæ short, thick; the last joint distinctly tapering towards the apex; the scape covered with long white hair; the base of the flagellum thickly covered with short, stiff, pale pubescence; the apical joints with a pale pile. The front and vertex bearing all over stout, deep, round punctures; the vertex is sparsely, the front thickly covered with fulvous hair; the face and clypeus thickly with longer, paler fulvous hair. Mandibles rugose at the base, and covered there with long fulvous hair. Thorax entirely black; thickly covered with bright fulvous hair, which is especially thick on the pronotum, the middle of the mesopleuræ and the median segment. Mesonotum rugosely punctured, the punctures running into reticulations; down the middle are two, more or less clearly defined, furrows. Metanotum closely reticulated, thickly covered with bright fulvous pubescence, which is sparser and longer on the apical half. Propleuræ smooth; the top at the base with some large, deep punctures. Mesopleuræ strongly punctured, the punctures hidden by the hair; the base and apex smooth. Metapleuræ smooth; the apex with large, moderately deep reticulations; the lower side at the base with deep, not very large, punctures. Legs black; the calcaria and spines pale; the pubescence pale fulvous. Abdomen black; the petiole covered all over with long, pale fulvous hair; the second segment is very shining, sparsely punctured; its apex narrowly and the third, fourth, and fifth segments broadly and thickly covered with fulvous pubescence; the pubescence on the apical segments is long and black. Wings fulvo-hyaline at the base; the apex from the first transverse cubital nervure, smoky and with a violaceous hue; the apical nervures are pale, the lower ones indistinct.

Comes into Bingham's "Section A, *b*, b^1. Head rounded, not sloping backwards, punctured," but may be known from *M. discreta* Cam., the representative of that section, by the tegulæ not being black and by the fulvous, not white, pubescence.

D. THE GROUP OF M. KHASIANA. Species with the thorax red wholly or in part; the abdomen thickly banded with white or pale fulvous hair.

MUTILLA KHASIANA, *sp. nov.*

Nigra, thorace rufo; alis fuscis, fere violaceis, nervis fuscis. ♂.

Long. 15 mm.

Antennæ stout, distinctly tapering towards the apex; the scape thickly covered with long white hair; the flagellum with a pale pile; the tubercles are rufous.

Head shining; the face and clypeus thickly covered with silvery pubescence, the front and vertex with longer black hair. The vertex is bordered by a shallow, smooth and shining furrow, which is widest behind; the front ocellus is bordered by a smooth furrow; in front of it is a narrow, longitudinal one; the apex of the clypeus is somewhat triangularly depressed in the middle. Mandibles entirely black, shining. Thorax rufous; the sternum black; covered rather thickly with long pale hair. Pro- and meso-notum thickly punctured; the parapsidal furrows are distinct to near the apex; the scutellum is punctured like the mesonotum; the post-scutellum is much more finely punctured. Median segment reticulated; at the base in the middle is an elongated area which is narrowed and rounded at the apex. Propleuræ punctured at the base; on the lower side before the apex are four stout, longitudinal keels; the mesopleuræ similarly punctured; the apex with a few longitudinal keels. Metapleuræ reticulated; the base with deep punctures; the two parts being separated by a smooth, shallow band. Mesosternum closely and strongly punctured; the middle furrowed; the basal half depressed in the middle. Legs thickly covered with white hair; the calcaria pale, the anterior rufous. Wings fuscous, with a slight violaceous tinge; the nervures fuscous, the apical faint; the second cubital cellule at the top is distinctly shorter than the third; the second transverse cubital nervure is straight above, sharply oblique below; the first transverse cubital nervure is sharply oblique, only curved on the lower side. Abdomen shining; the basal four segments thickly covered with silvery hair at their apices; the apical segments thickly covered with long black hair; the petiole and the second segment, except in the middle at the base, strongly punctured.

MUTILLA NIOBE, *sp. nov.*

Long. 16 mm. ♂.

Agrees in coloration with *M. khasiana*, except that the wings are violaceous-black, not fuscous, the nervures and stigma also being deep black; may be known from it otherwise by the tegulæ being strongly punctured.

Scape of antennæ covered with long white hair; hollowed on the under side, the sides of the hollow distinctly margined; the flagellum covered with a close black pile, which is longer and thicker on the apical joints which are distinctly narrowed. Front and vertex coarsely punctured; the ocellar regions smooth; the punctures on the space between them and the eyes running into reticulations; the vertex sparsely covered with long fuscous, the outer orbits with shorter white hair. Mandibles covered with long white hair. Thorax rufous; except the sternum and the lower edge of the pleuræ, which are black. Pro- and mesonotum rugosely punctured and covered with long blackish hair; shining. Scutellum rugosely punctured; sparsely covered with long black hair; the base of the postscutellum smooth. Median segment reticulated; more coarsely in the middle at the base, where there is a smooth depressed area, which is narrowed towards the apex and extends near to the middle; from its apex a keel runs to near the middle of the segment. Pro-pleuræ closely and strongly punctured, except at the apex, where there are four longitudinal keels; on the apex of the mesopleuræ, over the coxæ, are four irregular keels; the metapleuræ regularly reticulated. Legs thickly covered with white hair; the calcaria and tarsal spines pale. Wings violaceous, paler at the base; the nervures deep black, except the apical. Abdomen deep black; distinctly punctured, especially at the base; the basal four segments fringed with long, pale fulvous, the others covered with long black hair.

MUTILLA COERULEO-TINCTA, *sp. nov.*

Nigra, thorace rufo, abdominis basi coeruleo; alis fusco-violaceis, nervis fuscis. ♂.

Long. 12 mm.

Head distinctly narrower than the thorax, black, thickly covered with white hair; the front and vertex coarsely punctured; the vertex in the middle raised; the raised part keeled down the middle and bordered by a smooth, shallow furrow. Clypeus roundly convex, shining, smooth, its apex in the middle incised. Mandibles rufous before the middle; the palpi black. Antennæ stout, distinctly tapering towards the apex; the scape covered with long fuscous hair. Thorax rufous; the breast black. Pro- and meso-notum coarsely punctured; the punctures on the mesonotum somewhat larger, deeper, and more widely separated; the parapsidal furrows are distinct behind. Scutellum distinctly and uniformly punctured. Median segment reticulated; at the base, in the middle, is a smooth area, longer than broad, slightly curved and triangular at the apex. The upper part of the thorax is thickly covered with white hair, which is longer on the scutellum and median segment. Pro- and meso-pleuræ rather strongly punctured; the metapleuræ reticulated above; the middle smooth; the lower part punctured. Mesosternum between the four hinder legs furrowed; the furrow bordered by a keel. Legs black, thickly covered with long white hair; the calcaria pale. The wings are paler at the base; the nervures fuscous; the first transverse cubital nervure is curved; the second is slightly oblique above, sharply oblique below; the apical nervures and the second transverse cubital are thinner. The basal two segments of the abdomen have a distinct bluish tint; the bluish tinge on the others is less noticeable; the basal three segments are thickly fringed at the apex with pale fulvous hair; the other segments are thickly covered with longish black hair.

MUTILLA MONTANATA, *sp. nov.*

Nigra, prothorace, mesonoto, scutello, mesopleurisque supra rufis; alis fusco-violaceis; tegulis rufis. ♂.

Long. 16 mm.

Antennæ short, stout, distinctly tapering towards the apex; the scape covered with long pale fulvous; the flagellum more thickly with short pale pubescence. The middle of the vertex is smooth; the part behind the ocellus is carinate, and with a depression on either side of it; in front is a deeper and wider furrow, which is widest behind; the lateral ocelli are placed on the sides of the furrow bordering the ocellar region. The vertex is covered with long fuscous hair; the front more thickly with pale fulvous hair; the clypeus thickly with silvery hair. Thorax black; the prothorax, the mesonotum and scutellum and the mesopleuræ—broadest in front—immediately under the wings, rufous. Pronotum rugosely punctured; the mesonotum not quite so strongly or deeply, but with the punctures running into reticulations. The scutellum is similarly punctured. Median segment closely and almost uniformly reticulated; the central area at the base is rounded and not much narrowed at the apex. Propleuræ coarsely punctured; the apex smooth; in the hollow are four irregular keels. Mesopleuræ closely rugosely punctured, except below the hind wings, where there is a large smooth space, divided into two by a narrow curved keel. Metapleuræ reticulated. Legs black; calcaria pale; the hair thick, long, and pale fulvous. Abdomen with the basal two segments fringed with a broad belt of pale fulvous hair; the third segment is entirely covered with similar hair; the apical segments are covered with stiff black hair. Wings fuscous with a distinct violaceous tinge; the apical nervures distinctly fuscous.

I here describe a number of species mostly of small size of which the females only are known. The Ceylonese species form a well-marked group of small size, remarkable for having the top, or sides, or both top and sides of the apex of the metathorax more or less spined. The species may be grouped as undernoted.

A. Metathorax not spined.

Abdomen with large orange spots and bands. *amitina.*
[„ „ fulvous marks; the head spined. *consolidata*].
„ „ white marks; the head not spined.
„ „ four white marks on the second abdominal segment. *redacta.*
„ „ two white marks on the second segment. *compactilis.*

Thorax entirely red. *agelia*, *methila*, *dryta*, *martialis.*

Thorax red above, the pleuræ marked more or less with black. *violenta*, *pamphia*, *marcia*, *gnoma*, *emancipata*, *tirhootensis.*

Abdomen with one mark on the second abdominal segment. *phaola*, *edolata*, *parthenia.*

B. The metathorax spined; the vertex more or less rufous.

Abdomen with three marks on apex of second segment. *consolidata.*

Abdomen with one mark on apex of second segment. *persuasa*, *recondita*, *aspera*, *hesitata*, *indocila*, *lethargia.*

MUTILLA AMITINA, *sp. nov.*

Nigra, basi antennarum pedibusque rufis; maculis 2 basalibus 2-i segmenti fasciisque 3-i et 4-i fulvo-aureis. ♀.

Long. 10 mm.

Hab. Ceylon (*Yerbury*).

The scape of the antennæ and the second and third joints rufous; the scape sparsely covered with pale hair. Head black; the lower part of the orbits (broadly behind), the antennal tubercles, and the face, red; the base of the mandibles broadly rufous; the palpi testaceous; the head above the antennæ closely rugosely punctured, and sparsely covered with long black hair. Thorax quadrangular; longer than broad; the prothorax distinctly narrowed; the metathorax rounded. Pleuræ smooth and shining. Legs dark reddish, the femora with a darker tinge; the coxæ and trochanters black; the hair is pale on the femora, more rufous on the tibiæ and tarsi. Abdomen black; on the base of the second segment are two large oval marks (broader than long) of golden-fulvous pubescence; and the whole of the third and fourth segments is similarly coloured; the pygidial area is closely, longitudinally striated, except on the apex.

This species is very closely related to *M. soror* Sauss., with which it agrees in the coloration of the abdomen, but may be easily separated from it by the black head and thorax, and by the scape and the basal two joints of the flagellum of the antennæ being rufous.

MUTILLA CONSOLIDATA, *sp. nov.*

Nigra, vertice, mesonoto facieque rufis; flagello antennarum pedibusque piceis. ♀.

Long. fere 5 mm.

Hab. Ceylon (*Yerbury*).

Scape of antennæ dark testaceous and covered with white hair; the flagellum is lighter in colour, especially towards the apex. Head black, the lower part of the front, the face and oral region dark testaceous; the middle of the vertex with a large rufous mark; it is sharply longitudinally striated, the striæ are sharp and clearly separated and they extend to the top of the front, which is distinctly punctured; the front and vertex are thickly covered with longish black hair. Face and clypeus smooth, laterally covered with long white hair; on either side of the clypeus is a short blunt tooth. Mandibles rufous in the middle, and sparsely covered with long white hair. The head is of the width of the thorax, and is largely developed behind the eyes. Thorax longer than broad, not much longer than the head; black; above rufous, except round the edges; closely rugosely punctured; its sides irregularly marked with six short teeth, the first being placed shortly before the middle; in the centre of the median segment, near the top, is a sharp curved tooth, broad at the bottom, narrowed towards the top Pleuræ smooth and shining. Legs dark piceous, shining, covered with long white hair; the spines dark; the calcaria pale. The basal two segments of the abdomen together are longer than the thorax; black; on the apex of the petiole is a mark of white pubescence, almost round in shape; there is a larger round mark on the middle of the second segment at the apex, and a mark of the size of that on the petiole on either side of it; the other segments are also marked with white in the middle. The last segment is smooth, shining and piceous in the middle and punctured laterally.

Belongs to Bingham's "Section *B*." It is closely related to *M. rothneyi*, but is 3 mm. smaller; its thorax is shorter compared with the head or abdomen, and there are only three longish teeth on the sides of the median segment, while in *M. rothneyi* there are spines all over.

MUTILLA REDACTA, *sp. nov.*

Nigra, mesonoto abdomineque subtus rufis, abdominis segmento 2-o 4-maculato. ♀.

Long. 8 mm.

Hab. Barrackpore (*Rothney*).

Antennæ stout, black, narrowed towards the base and apex of the flagellum; the third joint about twice the length of the fourth. Head, if anything, wider than the thorax; the front and vertex shining, closely and strongly punctured; the mandibles broadly rufous towards the apex. Thorax black; above (including the apex) rufous, except round the edges, which are black; strongly rugosely punctured, the scutellar tubercles large, smooth; the apex has an oblique slope and is reticulated above; the upper edge irregularly dentate; the base of the thorax is distinctly rounded; the apex is more transverse. Legs black; the apices of the tarsi inclining to piceous; the tibial spines black. Abdomen black; the second and following ventral segments rufous, fringed with white hair; the ventral keel is deeply incised in the middle; the base has a rounded, the apex an oblique slope. The petiole bears long fulvous hairs; near the base of the second segment are two oblong white marks, on the apex two smaller roundish ones; on the second segment two square ones, which are larger than the marks on the apex of the second; the pygidium is irregularly longitudinally striated.

Looks like a miniature *M. sexmaculata.* [As the fact is not mentioned by Col. Bingham, it may be pointed out that in *M. sexmaculata* there is, in all the examples I have seen, a small rufous mark on the vertex, and that the mesonotum is covered with stiff golden hairs; the ventral surface of the abdomen too is more or less rufous.]

Note.—In Col. Bingham's table on p. 6 there is an error which may mislead. He states that the four marks on the abdomen of *M. sexmaculata* are on the first segment, whereas they are on the second; the same mistake is repeated in the description on p. 25.

MUTILLA AGELIA, *sp. nov.*

Long. 8—9 mm.

This species and that next described (both from Barrackpore, where they were taken by Mr. Rothney) belong to the group of *M. interrupta*, having the thorax entirely red; the head and abdomen black, the latter with two oval marks of white pubescence, and the third and fourth segments covered with similar pubescence broadly on the sides.

Length 9 mm.; the scape and the second joint ferruginous, the ventral keel projecting in the middle, depressed on either side of the keel. *M. agelia.*

Length 7 mm.; the antennæ entirely black; the ventral keel with the basal third projecting downwards. *M. mithila.*

Scape of antennæ thickly covered with long white hair; the apex and the greater part of the lower side rufous; the second joint of a darker rufous colour; the third joint nearly twice the length of the fourth. Head a little wider than the thorax; strongly rugosely punctured; the front and vertex sparsely covered with longish black hair. Antennal tubercles black. Thorax red; twice the length of the head; the base rounded in the middle, its sides slightly oblique; the apex almost transverse, the sides straight, strongly rugosely punctured above; the apex has a sharp, oblique slope; the basal two-thirds strongly reticulated; the middle with two straight keels, which are clearly separated; the apex in the middle more irregularly and less distinctly reticulated. Pleuræ smooth and shining, the lower half of the meso- thickly covered with silvery pubescence. Legs black, thickly covered with white hair; the calcaria pale; the five tibial spines pale rufous; the tarsal spines are long and pale rufous. Abdomen as long as the head and thorax united; the petiole has the apex closely punctured and fringed with black hair ; the rest bears scattered punctures. On the base of the second segment are two somewhat oval silvery marks ; the third and fourth segments bear broad bands of silvery pubescence on the sides ; the pygidium is finely rugose, and fringed at the sides with long white hair. The ventral keel is rufous, tridentate ; the basal keel triangular, the others more rounded.

MUTILLA MITHILA, *sp. nov.*

Long. 7—8 mm.

Agrees in coloration, markings, and form with *M. agelia*, but is smaller, and may be readily known from it by the ventral keel being straight throughout; the apex of the petiole is fringed with long white hair; the pygidium is more distinctly longitudinally striated, and smooth and piceous at the apex, and the antennæ are entirely black.

Antennæ stout, the scape bearing long white hair ; the flagellum thickly covered with a pale down, and stout; the third joint about one-third longer than the fourth. Head not much wider than the base of the thorax ; the front and vertex rugosely longitudinally punctured, sparsely covered with long fuscous hair ; the tubercles ferruginous. Mandibles broadly rufous on the base ; the palpi dark testaceous. Thorax not quite twice the length of the head ; ferruginous ; the mesonotum rugosely punctured, covered with blackish hairs ; the apex with an oblique slope, and broadly rounded above ; the upper half of the slope reticulated, running below into striæ, which are wide apart ; the lower half is neither punctured nor striated, and is covered with long white hair. Pleuræ smooth and shining ; the apex of the meta- irregularly reticulated ; they are covered with a white pile. Legs thickly covered with white hair; the calcaria pale fulvous; the tarsal spines fulvous; the spines on the hinder tibiæ are blackish. Petiole at the base sparsely covered with long pale hair; the apex fringed with long white hairs; the two marks on the base of the second segment are oval; the third and fourth segments are thickly covered laterally with pale fulvous pubescence; the pygidium is closely, longitudinally striated; the apex smooth and piceous, the sides covered with long pale hair. The ventral keel is not clearly defined, and is straight throughout.

MUTILLA DRYTA, *sp. nov.*

Long. 7 mm. ♀.

Hab. Barrackpore (*Rothney*).

Antennæ black, the scape obscure fuscous; the third joint not much narrowed at the base, about twice the length of the fourth. Head distinctly wider than the thorax; the vertex finely rugose; its apex and the front closely, irregularly, longitudinally striated, running into reticulations; the tubercles are rufous. Thorax fully twice the length of the head, ferruginous; the base distinctly rounded; the apex transverse; the sides slightly and broadly contracted in the middle; strongly, longitudinally, rugosely punctured above; the apex has an oblique, slightly rounded slope, is strongly reticulated and covered with long white hair. Pleuræ smooth; the upper edge of the meta- irregularly reticulated. Legs black; the front tarsi piceous; thickly covered with white hair; the tibial spines white, the tarsal with a more rufous tinge. Abdomen black; the petiole with pale hairs; on the base of the second segment are two oval marks; the third and fourth segments are broadly covered, except in the middle, with silverly pubescence; the apex of the fifth is sparsely covered with pale hair; the apical segment is thickly covered with long silvery hair; the centre is closely and finely rugose.

MUTILLA COMPACTILIS, *sp. nov.*

Nigra, thorace rufo; abdominis segmento secundo maculis duabus segmentoque tertio cinereo-sericeo-notatis; capite mesonotoque dense rugoso-punctatis; metanoto striolato-reticulato. ♀.

Long. 8 mm.

Hab. Barrackpore (*Rothney*).

Head as wide as the base of the mesothorax; strongly, irregularly, closely, rugosely punctured, the punctures in parts running into reticulations; covered with long fuscous hair; the part behind the eyes is slightly longer than they; the face rugose; the clypeus smooth and shining. Mandibles broadly rufous in the middle. Antennal tubercles black. Antennæ stout, the greater part of the flagellum brownish beneath; thickly covered with a minute fulvous pile. Thorax red, twice the length of the head; the base rounded; the sides parallel and becoming narrowed from the middle to the apex, which has a gradually rounded slope. Mesonotum strongly and deeply rugosely punctured, reticulated in the middle; sparsely covered with long black hair; the apex is irregularly, stoutly, longitudinally striolated; the end is almost smooth. Pleuræ smooth, except the upper edge of the metapleuræ. Legs black, thickly covered with white hair; the tibial spines dark, the tarsal bright rufous; the calcaria pale. Abdomen of the length of the head and thorax united; black; the petiole covered with long fuscous hair; its apex smooth; behind the middle of the second segment are two round marks of silvery white pubescence; the third segment is entirely covered with similar pubescence; pygidium shining; the base aciculated; the sides are thickly covered with long silvery hair. The basal ventral segment is rufous: the apical half is roundly dilated.

MUTILLA MARTIALIS, *sp. nov.*

Long. 7 mm. ♀.

Hab. Barrackpore (*Rothney*).

Agrees closely in size and coloration with *M. dryta*; differs from it in having the thorax narrower, longer and more dilated behind; in the petiole being rufous beneath; in its keel not being incised; and in the coxæ being rufous.

Antennæ stout, black, thickly covered with a pale pile; the third joint is nearly twice the length of the fourth; the antennal tubercles large, rufous. Head distinctly wider than the thorax, strongly and deeply punctured; on the front and vertex sparsely covered with short golden hair. Mandibles broadly rufous in the middle. Thorax twice the length of the head; slightly widened at the base and apex; the pronotum shining, obscurely, finely, transversely striated. Mesonotum strongly and deeply rugosely punctured, and sparsely covered with long black hairs; the apex has a rounded slope, is strongly reticulated; the middle reticulations more open, running into irregular longitudinal striæ. Propleuræ irregularly punctured; the apex of the meta- irregularly and indistinctly reticulated towards the apex; the rest smooth and shining. Legs black, inclining to piceous on the femora, the coxæ rufous; the hair white; the calcaria and tibial spines pale; the tarsal spines with a more fulvous tint. Abdomen black; the petiole rufous beneath, its keel straight; on the second segment are two oval marks, near the middle, of silvery pubescence; the third and fourth segments are broadly banded laterally with similar pubescence; the pygidium is obscurely punctured at the base; its apex smooth; the sides fringed with long pale hair.

MUTILLA TIRHOOTENSIS, *sp. nov.*

Nigra, vertice late thoraceque supra rufis; abdomine argenteo-octo-maculato; pedibus nigris, dense argenteo-pilosis. ♀.

Long. 10 mm.

Hab. Tirhoot, Bengal *(Rothney).*

Belongs to Bingham's "Section B: head black, variegated with red or ferruginous; thorax red."

Scape of antennæ thickly covered with pale fulvous hair; the flagellum thickly with pale pubescence. Head developed more than the length of the eyes behind them, rugosely punctured, the punctures round, large, deep; the front and vertex sparsely covered with long, black and pale hairs; between and below the antennæ is a thick mass of long, pale fulvous hair. Mandibles rufous in the middle; the base covered with long pale hair. In the centre of the vertex is a large rufous spot. Thorax red, the lower part of the pleuræ and the breast black; above, irregularly and deeply reticulated all over; the reticulations large and deep, and with thick walls; the apex has an oblique slope, is reticulated only on the top and sides, the rest smooth and with a keel in the middle. Pro- and meso-pleuræ black; the propleuræ reticulated above at the top; the lower half of the mesopleuræ thickly covered with depressed silvery pubescence; metapleuræ rufous, reticulated. Legs black, thickly covered with white hair. Abdomen not much longer than the head and thorax united; black; the basal segment thickly covered with long white hair; on the centre of the second segment are two oval, dark silvery marks; there are two large square ones, clearly separated, on the third; the fourth and fifth thickly covered with long, silvery pubescence, and divided into two by a narrow division. Pygidium smooth and bare in the middle, the sides thickly covered with long black hairs; the ventral surface covered with long black hairs.

MUTILLA VIOLENTA, *sp. nov.*

Nigra, thorace supra rufo; flagello antennarum brunneo; abdomine albo-sex-maculato, subtus rufo. ♀.

Long. 8 mm.

Hab. Ceylon (*Yerbury*).

Head slightly, but distinctly, wider than the thorax, strongly rugosely punctured; in the middle the punctures are stronger, and run into irregular longitudinal striations; is reticulated over the antennæ. Scape of antennæ covered with long silvery hairs; the flagellum is stout, dark rufous, darker, almost black, above; the third joint is not quite the length of the fourth, and is narrowed at the base. Thorax twice the length of the head, slightly irregularly contracted in the middle above, the metathorax slightly wider. The median segment has an oblique slope, is deeply and strongly reticulated, and is darker coloured at the apex; its upper part dentate. Propleuræ and the upper parts of the meso- and meta-pleuræ rufous, smooth and shining; the apical part of the last irregularly reticulated. Legs black, with a slight piceous tint; the calcaria pale; on the hinder tibiæ are five stout, dark rufous spines. Abdomen black, the ventral surface for the greater part ferruginous; the basal segment is sparsely covered with long white hair; the two marks on the base of the second segment are oval; the two on the third segment are larger, are on the apex of the segment, broader than long, and irregularly rounded behind; the marks on the fourth segments are smaller; the pygidium is closely longitudinally striated, and fringed laterally with long pale hair; the ventral keel has a slight curve; the segments are rather thickly covered with long white hair.

MUTILLA PAMPHIA, *sp. nov.*

Nigra, capite dense longe pallide piloso; thorace supra *ferrugineo; abdomine fulvo-quadri-maculato; pedibus nigris.* ♀.

Long: 10 mm.

Hab. Barrackpore (*Rothney*).

Head as wide as the thorax; the front and vertex thickly covered with long black, intermixed with shorter silvery hair; it is largely developed behind the eyes—more than their length—and is closely and strongly punctured; the punctures large and deep. Antennal tubercles black. Behind and below the eyes the hair is thicker and longer. Scape of antennæ thickly covered with long silvery hair; the flagellum with a pale down; the third joint is about one-quarter longer than the following. Mandibles rufous in the middle; the base thickly covered with long white hair. The thorax not quite twice the length of the head; the pronotum is large, flat above, irregularly punctured, obscure rufous, the sides margined. Mesonotum entirely red; deeply and strongly punctured; the punctures large; the hair is sparse, long and black. The median segment has an oblique slope; the upper part has large reticulations; the lower part is black. The propleuræ piceous and finely striated; the base of the mesopleuræ irregularly striated and punctured; the upper part of the metapleuræ strongly reticulated; the upper edge of the meso- and the upper half of the meta-pleuræ are rufous. Legs thickly covered with white hair; calcaria white; the tibial spines pale rufous, black on the apex. Abdomen deep black; the petiole thickly covered with long white hair; in the middle of the second segment are two fulvous oval marks; on the sides of the third are two square ones of similar colour; pygidium smooth and fringed with long black hairs. The basal ventral segment is rufous; the keel is roundly dilated towards the apex; the second segment has an oblique slope, is piceous in the middle; the sides and apex are strongly punctured.

A distinct species, distinguished by the head and thorax having more and longer hair than usual. It fits best into Bingham's "Section A., *a.*, *a'*.," but the spots are fulvous rather than yellow and golden.

MUTILLA MARCIA, *sp. nov.*

Nigra, mesonoto metanotique apice supra rufis; abdomine albo-sex-maculato; pedibus nigris. ♀.

Long. 7 mm.

Hab. Barrackpore (*Rothney*).

Head slightly wider than the thorax; black, strongly rugosely punctured, running into reticulations, sparsely covered with long black, behind the eyes thickly with white hairs. Thorax twice the length of the head, rounded in front; black; the mesonotum and the upper third of the apical slope of the metanotum ferruginous; strongly and deeply rugosely punctured, more strongly on the apex than on the base; the apex has an oblique slope and is broadly rounded above; it is strongly, irregularly, longitudinally striated; the striæ stronger and irregularly curved on the rufous part, becoming weaker and straighter towards the middle; the apical part is smooth. Pleuræ smooth; black, except for a curved red band on the apex above; the upper edge is rough and irregular; on the upper side of the metapleuræ are four short, blunt teeth; above the apical slope are short, irregular teeth. Legs black, thickly covered with white hairs; the calcaria white; the spines on the hinder tibiæ long and pale. Abdomen black; near the base of the second segment are two oval marks, placed lengthways; on the third segment are two larger oval spots placed across, and on the fourth are two smaller round spots of silvery pubescence; the ventral keel is straight, and not much developed; the sides of the second segment, above in the middle, covered with rufous pubescence.

MUTILLA GNOMA, *sp. nov.*

Nigra, prothorace, mesonoto metanotoque rufis; abdominis segmento 2-o albo-bimaculato; pedibus nigris. ♀.

Long. 5 mm.

Hab. Barrackpore *(Rothney).*

Head slightly wider than the thorax; rugosely punctured, sparsely covered with longish fuscous hair; the antennal tubercles rufous. Antennæ stout, the apex of the scape rufous; the third joint about one-half longer than the fourth. The prothorax is entirely rufous; the mesonotum, metanotum, the upper part of the apical slope and the upper third of the metapleuræ, rufous. The upper part of the thorax is coarsely, longitudinally and rugosely punctured; the upper (red) part of the apical slope is largely reticulated, ending in the top of the black part in elongated areæ, which are rounded below; the lower part is smooth. Pleuræ smooth and shining; the basal keel on the propleuræ rough, irregular; the lower half thickly covered with white hair. Legs black, thickly covered with white hair; the calcaria white; on the tibiæ are five sharp, pale spines. Abdomen black, the base sparsely covered with long pale hair; on the second segment, shortly behind the middle, are two round, silvery-white marks; the sides of the third and the fourth dorsal segments are covered with white hair; the pygidium smooth; the ventral keel is straight.

The eyes are large; the thorax is about twice the length of the head, is rounded in front, more transverse behind. In Bingham's table (p. 4) comes near to *M. ruficrux*, but is distinct from anything described.

MUTILLA EMANCIPATA, *sp. nov.*

Nigra, mesonoto propleurisque rufis; abdomine albo-sex-maculato; pedibus nigris. ♀.

Long. 6 mm.

Hab. Barrackpore (*Rothney*).

Antennæ stout, black; the apex of the scape rufous, the third joint not quite twice the length of the fourth. Head not quite so wide as the thorax; strongly, but not closely, punctured and sparsely covered with black hair; the tubercles rufous; the face testaceous. Mandibles broadly rufous at the base. Thorax short, rounded and slightly narrowed towards the base; the sides straight; the mesonotum strongly rugosely punctured, the punctures large, deep, and running in the middle into reticulations; the apex has an oblique slope and is rounded above; it is black, except above, and is irregularly rugose. Pleuræ black, except the propleuræ and the base of the mesopleuræ, which are ferruginous, the prosternum being also rufous; the mesopleuræ bears a silvery pile; the metapleuræ smooth, not reticulated; the apical half thickly covered with longish white hair. Legs thickly covered with white hair; the tibial and tarsal spines white, with a slight fulvous tinge; the calcaria white. Petiole fringed with long, dark fuscous hair; on the second segment behind the middle are two oval marks of silvery pubescence, and the sides of the third and fourth segments are covered with silvery pubescence; the basal half of the pygidium is punctured, the apical closely, transversely striated; the basal ventral segment has the basal half raised behind, and with an oblique slope towards the middle.

Resembles *M. gnoma;* but is known from it by the base only of the pleuræ being rufous, *gnoma* having the apex of the metapleuræ rufous, and by the thorax being wider compared with the head.

MUTILLA PHAOLA, *sp. nov.*

Nigra, mesonoto rufo; abdomine albo-4-maculato; pedibus nigris, tarsis sordide testaceis. ♀.

Long. 5—6 mm.

Hab. Poona (*Wroughton*).

Head black, not much wider than the thorax, strongly and closely punctured, sparsely covered with long blackish hair; the antennal tubercles large, rufous, shining; mandibles dark rufous, the apex black; palpi testaceous. Eyes moderately large. Antennæ stout; black; the scape at the apex, and more or less below, red; the second joint is entirely red; the flagellum more or less irregularly dark rufous beneath; the third and fourth joints are almost equal in length. Thorax scarcely twice the length of the head; the prothorax distinctly separated and narrowed; the apex is rounded. The meso- and the upper part of the meta-notum dark rufous, strongly and deeply punctured; the apex has an oblique slope, and is rounded above; smooth; black; the upper part with some short striæ and some punctures. The base of the propleuræ rufous; the upper part behind punctured; meso- and base of meta-pleuræ smooth; the apex of the metapleuræ punctured; the punctures large and scattered. Prosternum dark rufous. Legs covered with long white hair; the tarsi are dark testaceous. Abdomen scarcely so long as the head and thorax united; deep black; the petiole covered with long white hair; on the base of the second segment is a spot of silvery pubescence; there is a similar spot, twice its size and rounded behind, on the apex of the second segment; there is a small mark in the middle of the fourth, and a larger one on the fifth; the pygidial area is not defined, and is smooth and shining. The basal ventral segment is triangularly, obliquely depressed at the base and apex ; the middle keel is broad, straight.

Comes near to *M. trimaculata* Cam.

MUTILLA EDOLATA, *sp. nov.*

Rufa, abdomine nigro, segmentis 1—5 vitta apicali albo-sericea ornatis ; pedibus rufis ; capite laevo, nitido, sparse punctato. ♀.

Long. 7 mm.

Hab. Ceylon (*Yerbury*).

Head distinctly wider than the thorax ; broader than long ; behind the eyes as long as them ; smooth, shining, sparsely punctured and covered sparsely with longish black hair ; the antennal tubercles large, smooth and shining. Mandibles rufous, their apices broadly black. Antennæ stout, rufous, thickly covered with a white down ; the third joint narrowed, twice the length of the fourth. Thorax of equal width above ; strongly, longitudinally rugulose, sparsely covered with longish black hair ; the apex has an oblique slope, is smooth, shining, and thickly covered with long fuscous hair. Pleuræ smooth and shining ; the upper half of the metapleuræ punctured sparsely. Legs rufous, and thickly covered with fuscous hair ; the tibial spines coloured like the legs. Abdomen black with a faint violaceous-blue tint ; there is a small square mark on the apex of the first ; a large semi-circular one on the second, a smaller one on the third, and a still smaller one of silvery pubescence on the apex of the fourth abdominal segment ; the pygidium is smooth, testaceous. The sides of the petiole below are broadly rufo-testaceous.

Agrees in size and coloration with *M. hesitata* ; is easily distinguished by the shorter thorax, which is not twice the length of the head as it is in *M. hesitata*, and by the smooth front and vertex.

MUTILLA HESITATA, *sp. nov.*

Ferruginea, abdomine coeruleo, albomaculato; metanoto reticulato. ♀.

Long. 7 mm.

Hab. Ceylon (*Yerbury*).

Agrees in coloration and size with *M. poonaensis* Cam., from Bombay; but may readily be distinguished from it by the median segment being reticulated.

Head slightly broader than the thorax, the front and vertex strongly punctured; the former with blackish, the latter with golden hair; behind the eyes it is about half their length, and is roundly narrowed. Antennal tubercles smooth and shining. Antennæ stout, reddish. Thorax twice the length of the head, slightly narrowed towards the apex; mesonotum rugosely punctured and sparsely covered with golden hair; the scutellar region with black hair. The upper part of the median segment is distinctly, and not very closely, reticulated; the apex is smooth, neither punctured nor reticulated. The propleuræ sparsely punctured above; the lower part at the apex is blackish; the lower part of the mesopleuræ blackish, thickly covered with long silvery hair. Metapleuræ black, rufous round the edges, the lower part thickly covered with silvery pubescence. Abdomen coeruleous; on the base of the second segment is an oblong, white spot; its apex has a broad white band, interrupted in the middle; the fourth and following segments are thickly covered with long black hair; the spot is longer than broad, the base and apex bluntly rounded; the last segment is smooth, its sides bearing long white hair.

MUTILLA PARTHENIA, *sp. nov.*

Nigra, thorace rufo; abdominis segmento 2-o pallide aureo-maculato, apice aureo-piloso; pedibus nigris. ♀.

Long. 6 mm.

Hab. Barrackpore (*Rothney*).

Antennæ black, distinctly tapering towards the apex; the scape covered with pale fulvous hair; the third joint not much longer than the fourth, and narrower than it. Head as wide as the thorax, closely rugosely punctured; sparsely covered with black hair; the antennal tubercles red, punctured above, shining. Mandibles rufous, black at the apex. Thorax strongly rugosely punctured; before the apex is an indistinct transverse furrow; the sides are almost straight; the apex almost transverse; it has an abrupt, slightly oblique slope, and is strongly and closely reticulated. Pleuræ smooth and shining, the propleuræ rugose. Legs black, the hair long and white; there are four pale rufous spines on the tibiæ; the calcaria and the tarsal spines are paler. Abdomen not quite so long as the head and thorax united; black; the basal segment is sparsely covered with long black hair; on the base of the second segment is a spot of pale golden pubescence; its apex, and the third segment entirely, covered with similar pubescence; the pygidium is dark rufous, and is closely longitudinally striated; the ventral keel is rufous and is triangularly incised in the middle.

Comes nearest to the Burmese *M. conjungenda* Magr.

MUTILLA PERSUASA, *sp. nov.*

Nigra, vertice mesonotoque rufis; femoribus piceis; abdomine albo-bimaculato. ♀.

Long. 7 mm.

Hab. Ceylon (*Yerbury*).

Head large, distinctly wider than the thorax; behind the eyes it is twice their length; black; a large red mark, broader than long, with the sides rounded, on the vertex; shining, the front and vertex distinctly, but not very closely, punctured; the punctures closer on the front than on the vertex; sparsely covered with long black hair; the antennal tubercles rufous. Eyes rather small, compared with the head. Mandibles broadly rufous in the middle. The face covered with long white hair below the antennæ. Thorax somewhat quadrangular, rounded at the base and apex; in length, half that of the abdomen, black; the mesonotum rufous, except round the edges; strongly rugosely punctured, sparsely covered with long black hairs; the apex of the median segment above projects into a plate which is broader than long and has, on either side of it, three short, stout teeth. The apex of the segment is shining, sparsely punctured, except on the apex, covered with long pale hair, and with a fine longitudinal keel in the middle. Pleuræ smooth and shining, the apical part of the metapleuræ distinctly punctured, except on the top. Legs black, the femora and the anterior tibiæ piceous; the spines dark rufous, the calcaria pale. Abdomen not much longer than the head and thorax united; black, closely punctured; a spot on the apex of the petiole and a larger, broader one on the apex of the second segment of silvery pubescence; the pygidium strongly punctured, except in the middle, which is aciculated; it is covered with silvery pubescence and with long pale hair; the petiole is covered with long hairs, pale on the base, those on the apex darker.

Belongs to Bingham's "Section B: head black, variegated with red; thorax red," (p. 6) except that with it only the mesonotum is red.

MUTILLA RECONDITA, *sp. nov.*

Nigra, thorace ferrugineo, pleuris apiceque segmenti medialis infra nigris; abdominis segmento 2-o albo-bimaculato; pedibus nigris, tarsis posticis testaceis. ♀.

Long. 5 mm.

Hab. Ceylon (*Yerbury*).

Comes into Bingham's "Section A. *a.* a^1. b^2. b^4.," near to *M. tridungulata.*

Scape of antennæ shining, sparsely pilose, piceous; the base of the flagellum testaceous. Head black; slightly, but distinctly, wider than the thorax; the front and vertex closely, strongly and uniformly punctured; the transverse keels above the antennæ are distinct; on the front in the middle is a narrow longitudinal keel. The sides of the face are rufous. Mandibles rufous. Thorax rufous; the sides parallel; the base and apex rounded; it is about twice the length of the head. Mesonotum strongly punctured, more closely and not so strongly at the apex; the base irregularly striated, the sides uneven. The apex has a rather abrupt oblique slope; it is black, rufous round the edges; the lower part in the middle smooth, the rest reticulated; the upper part has in the centre a bluntly rounded, broad tooth; on either side of this are four short, blunt teeth. Pleuræ smooth, shining, black, rufous round the edges. Legs black, piceous at the base; covered with white hair; the tibial spines pale testaceous, longish, and four in number. Abdomen as long as the head and thorax united; black; the petiole punctured and covered with long pale hairs; behind the middle of the second segment are two oval marks of pale fulvous pubescence; the third and fourth segments are covered with similar pubescence; the pygidium is strongly and closely punctured; the second ventral segment is strongly punctured.

MUTILLA ASPERA, *sp. nov.*

Nigra, vertice mesonotoque ferrugineis; apice abdominis segmenti secundi fulvo-piloso; flagello antennarum subtus brunneo; apice metanoti spinoso.

Long. 7—8 mm.

Hab. Ceylon (*Yerbury*).

Comes into Bingham's "Section B: head black, variegated with red or ferruginous; thorax red" and "*d.* Second abdominal segment with no white spots, but a fascia on apical margin semicircular." This only contains *M. reticulata*, which has no near relationship to the present species and may be known from it by the median segment not being spinose.

Head slightly, but distinctly, wider than the thorax; slightly broader than long; rounded in front, slightly roundly concave behind; black, a large red mark on the vertex broader than long, punctured uniformly; sparsely covered with short blackish hair; the antennal tubercles smooth, shining, red. Mandibles broadly rufous in the middle and fringed with long, pale fulvous hair. Antennæ thickly covered with a pale down, stout, the flagellum brownish beneath. Thorax black, the mesonotum broadly rufous in the middle; it is longer than broad, not much longer than the head; the base broadly rounded; the apex has a broad plate in the centre, almost square, and with a small, stout, square tooth on either side; outside this is a nipple-like tooth. Mesonotum longitudinally rugose in the middle on the basal two-thirds. The apex of the median segment has an oblique slope, and is irregularly, and not very distinctly, reticulated round the sides. Pleuræ smooth and shining; the apical half of the metapleuræ strongly punctured. Legs thickly covered with white hair; the femora and coxæ have a piceous tinge; the tibial spines dark, the tarsal bright rufous, the calcaria pale. Abdomen black, rather thickly pilose; on the apex of the first is a small, on that of the second a larger, tuft of pale fulvous pubescence. Pygidium strongly punctured; the middle smooth and bordered. The basal ventral segment is smooth and shining, dull rufous; there is a narrow oblique keel along the sides, but no central keel.

MUTILLA INDOCILA, *sp. nov.*

Nigra, vertice thoraceque rufis; abdominis segmento secundo albo-maculato; pedibus nigris, femoribus piceis. ♀.

Long. fere 6 mm.

Hab. Ceylon (*Verbury*).

Head as wide as the thorax, broadly rounded in front, transverse behind, with the edges rounded; black; the vertex broadly rufous; strongly punctured, behind the ocelli not so strongly and more closely; sparsely covered with black pubescence. Antennal tubercles rufous; the face rufo-testaceous; the central part clearly separated and triangular. Mandibles rufous, black at the apex. Palpi dark testaceous. Antennæ stout, black, dark testaceous beneath, thickly covered with a pale pile. Thorax rufous, about twice as long as broad, rounded at base and apex; rugosely punctured above and irregularly longitudinally striated on the basal half; the lateral edges are rough; the apex of the median segment above with a spine in the middle; this spine is broad at the base viewed laterally, and narrowed towards the top; near the middle on either side of it are two short, thick spines. Pro- and meso-pleuræ smooth and shining; the metapleuræ black, strongly punctured. Legs black; the femora inclining to piceous; the hair long, dense, and white; calcaria white. Abdomen black; a mark of white pubescence on the apex of the petiole, a much larger one, much broader than long and bluntly rounded behind, on the apex of the second, and one slightly larger than it on the petiole, and one, somewhat square in shape, on the apex of the third segment. The apical segment has no area, is thickly covered with long, pale fulvous hair, and strongly punctured at the base; the basal ventral segment is pale testaceous and has no keel in the middle.

Is nearly related to *M. aspera*, having the same general coloration, but is much smaller and more slenderly built; may readily be known by the central tooth on the median segment not being broad and plate-like.

MUTILLA LETHARGIA, *sp. nov.*

Nigra, capite thoraceque ferrugineis; pedibus nigris, tarsis testaceis; abdominis segmentis albomaculatis. ♀.

Long. 5 mm.

Hab. Barrackpore (*Rothney*).

This species fits best into Bingham's "Section D"; but the head has less black and more red than in most of the species of the group. The spined metanotum, size and coloration indicate its relationship to the Ceylonese *M. aspera*, &c.

Antennæ stout, the flagellum thickly covered with white pubescence, the scape and base of flagellum dark piceous; the third joint narrowed at the base and twice the length of the fourth. Head as wide as the thorax; slightly rounded in front, transverse behind, behind, it is not quite so long as the eyes; the lower edges distinctly margined, irregularly serrate, below the eyes. Antennal tubercles large, smooth, and shining. The face and oral region rufo-testaceous, the middle thickly covered with long, the sides with shorter, white pubescence. Mandibles broadly rufous at the base; the palpi pale testaceous. Thorax twice as long as broad; the sides irregular, not contracted in the middle; on the sides, behind the middle, are six distinct teeth; the basal one is the smallest, the apical one stouter and broader than the others; the upper edge is irregularly toothed; the central tooth being longer, sharper, and more distinct than the lateral, and from its base a narrow keel runs towards the middle of the mesonotum. The apex of the thorax has an oblique slope, is strongly punctured all over, thickly covered with long white hair; the upper third is rufous, the rest black. The pro-, meso-, and base of meta-pleuræ smooth and shining. Legs black, inclining to piceous, covered with longish white hair; the tarsi lighter in colour; the tibial spines four, longish, sharp, pale testaceous. Abdomen deep black; there is a small mark on the apex of the first abdominal segment, a longer, broader one, rounded behind, on the apex of the second, and a smaller one on the apex of the third, of silvery pubescence; the pygidium not defined; the central segment smooth, shining, and rufo-testaceous in colour; the hypopygium is punctured, keeled laterally and rufo-testaceous on the apex.

The following species are only known in the winged or male sex. In the *Ann. & Mag. Nat. Hist.* for August of the present year I have described a number of new species of *Mutillidæ* from India.

MUTILLA FOVEISCUTIS, *sp. nov.*

Nigra, abdomine ferrugineo, basi apiceque nigris; scutello tuberculato, medio lævo, basi foveato; alis violaceis; capite thoraceque dense nigro-pilosis. ♂.

Long. 23 mm.

Hab. Poona (*Wroughton*).

Antennæ distinctly tapering towards the apex; the scape thickly covered with long white hair; the flagellum with a pale pile. The front and vertex are strongly, but not closely, punctured, thickly covered with long black hair; the middle of the front thickly covered with silvery pubescence; the lower inner orbits with a broad belt of silvery pubescence; the face bare, shining; the apex of the clypeus transverse, covered with long hair; obliquely projecting. Mandibles black; the base thickly covered with silvery pubescence, the rest bare, smooth and shining. Thorax thickly covered with stiff black hair; the pronotum broadly at the apex, and the lower side of the mesopleuræ in the middle, thickly covered with silvery pubescence. Mesonotum strongly and deeply punctured; the furrows are deep; between them is a keel which is smooth and shining, and extends to near the base. Scutellum rugosely punctured, its middle smooth, bare and shining; at its base is an oval fovea; its apex is slightly depressed; the smooth part projects over the apex, which has a long, sharply oblique slope. The base of the median segment is raised and has a perpendicular slope, and is separated from the mesothorax by a wide deep space; the segment is opaque, coarsely alutaceous, not reticulated, and is sparsely covered, particularly at the sides, with long black hairs; the central furrow is depressed at the base, where it is furrowed in the middle; it reaches to the top of the slope, becoming gradually narrower; the keels are raised at its apex and are there smooth and shining; the apex has an almost perpendicular slope, and is rounded at the top. Propleuræ rugose, the middle bearing stout striæ, the apex smooth. Mesopleuræ broadly tuberculate at top and bottom, opaque, alutaceous, and covered with black hairs; the upper half of the metapleuræ reticulated, the lower smooth. Legs thickly covered with black hair; the fore calcaria pale. Abdomen ferruginous, the petiole and two-thirds of the apical segment black; the petiole strongly punctured and covered with long black hair, as is also the base of the second segment; the apex of the second, and the third to sixth segments, thickly covered with long orange pubescence; the black part of the last segment is covered with black hairs; its middle is smooth and bare, the apical half of the ventral keel projects as an oblique, somewhat triangular tooth, rounded at the apex; the apical two ventral segments are armed laterally with stout, oblique keels, the basal one being stouter and shorter than the apical.

Comes near to *M. cressida* and *M. 4-carinata*; may be known from both by the fovea on the base of the scutellum, and by the wide and deep depression at the base of the median segment.

MUTILLA QUADRICARINATA, *sp. nov.*

Long. 22 mm. ♂.

Hab. Barrackpore (*Rothney*).

Agrees in size and coloration with *M. sexmaculata* (*cf.* Cameron, *Ann. & Mag. Nat. Hist.*, July, 1899, p. 61), but differs from it by the prothorax wanting the band of white pubescence; by the scutellum wanting the depression in the middle at the base; by the median segment having the pubescence longer, blacker, and more dense; by its apical slope being more rounded, not so shapely oblique; by the hair on the petiole being longer and black; by the tooth on the ventral keel being placed at the end, not in the middle; and by the antennæ being longer and more slenderly built.

Scape of the antennæ covered with long black hair; the flagellum with a pale down. Front and vertex thickly covered with long black hair; the front also with silvery pubescence; the cheeks with a broad band of silvery pubescence. Clypeus bare, shining, its sides and apex obscurely striated; the basal half of the mandibles thickly covered with silvery pubescence. Pro- and meso-thorax thickly covered with long, stiff, black hair. Prothorax coarsely rugosely punctured; the middle of the pleuræ with stout, distinctly separated striæ; the apex smooth. Mesonotum coarsely rugosely punctured; the furrows are wide and deep; between them is a longitudinal keel.

Scutellum pyramidal; its top and base in the middle smooth, shining, glabrous; the rest strongly rugosely punctured and thickly covered with long black hair. The median segment is narrowed at the base, is coarsely reticulated, and is thickly covered with long black hair; the central area reaches to the top of the oblique apex; is widest at the base; the bordering keel is turned up at its apex; the apex of the segment has an obliquely rounded slope, and is coarsely and stoutly reticulated. Mesopleuræ coarsely and closely punctured, thickly covered with black hair, largely tuberculate, through roundly bulging out at the top and bottom, there being a depression between the upper and lower portions. Mesosternum closely and strongly punctured, except at the base which is aciculated. Legs thickly covered with black hair; the hair on the tarsi rufous, and they also bear a fulvous pubescence. Wings dark violaceous, except for some small hyaline streaks in the discoidal and cubital cellules; the second cubital cellule at the top is slightly longer than the third. Abdomen ferruginous; the petiole and the apical segment, except at the base, black; the petiole is coarsely and deeply punctured, and covered with long black hair; the other segments are thickly fringed with orange hair; the hair on the black apical part of the last segment is black. The keel on the lower side of the petiole projects at its apex in a large tooth, which is rounded at the point and broader at the base; the apical ventral segment has an oblique, stout keel bordering the sides; the penultimate segment has a similar, but somewhat larger, keel on its apical half.

MUTILLA CRESSIDA, *sp. nov.*

Nigra, capite thoraceque dense nigro-hirsutis; abdomine ferrugineo, basi apiceque nigris; alis violaceis. ♂.

Long. 18 mm.

Hab. Ceylon (*Yerbury*).

Scape of the antennæ punctured, covered with stiff white hairs; the flagellum with a pale down. Head thickly covered with longish black hair; the front in the middle, the lower part of the cheeks, and the sides of the clypeus, thickly covered with pale silvery depressed pubescence. Front and vertex strongly and deeply punctured, the puncturing more rugose below the antennæ; in the middle of the vertex leading down to the ocelli is a smooth keel. Clypeus smooth and shining; the sides and apex projecting all round, so that the central part appears hollowed out; above it the hair is longer than it is on the vertex. Pronotum rugosely punctured above; the middle with some stout irregular keels; the lower part smooth. Mesonotum strongly and deeply punctured, thickly covered with longish, stiff, black hair; the two furrows are wide and deep; in the middle is a smooth shining keel. The scutellum is raised, rugosely punctured; the middle is obliquely raised from the base to the apex; is smooth and very shining; this central part becomes gradually and slightly wider towards the apex, which distinctly projects; the upper part is bare; the lower fringed with long black hair. The post-scutellum has an oblique slope, is smooth and fringed with long black hair. The median segment bulges out roundly in the middle; it is strongly reticulated except at the sides, which are almost smooth, and bordered on either side by stout longitudinal keels; the central area is two-thirds of the length of the basal division, and does not reach to its apex; the basal fourth is wider than the rest, and has the sides oblique; the apex is rounded. The legs are thickly covered with black hair; the calcaria and tarsal spines are also black. Wings uniformly dark violaceous; the second cellule at the top is slightly longer than the third; the recurrent nervures are both received shortly beyond the middle of the cellules. The abdomen is ferruginous; the petiole is black, strongly punctured, and covered with longish black hair; the ventral keel at the apex ends in a large, stout, oblique tooth; the other segments are thickly fringed with ferruginous hair, and are sparsely punctured; the apical half of the pygidium is black and covered with black hairs.

MUTILLA PILENNA, *sp. nov.*

Nigra, abdominis segmentis 2—5 rufis; alis fusco-violaceis, basi hyalinis; medio scutelli laevo. ♂.

Long. 12 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ thickly covered with white hair; the flagellum opaque. Front and vertex shining, strongly, but not very closely, punctured; the front in the middle thickly covered with long white, the sides and vertex covered more sparsely with long fuscous hair. Face and clypeus smooth and shining; the clypeus slightly obliquely narrowed from the middle to the apex. Mandibles black, thickly covered with long, pale silvery hair; before the middle is a broad red band. Palpi dark fuscous. Pro- and meso-notum closely and strongly punctured, and thickly covered with long, dark fuscous hair. Scutellum hardly raised above the level of the mesonotum, strongly and deeply punctured, except in the middle, which is smooth and shining; the apex of this shining band is widely furrowed. Median segment reticulated, the basal area is wide at the base, being there twice the width of the apex; the wide part becomes gradually narrowed; it is thickly covered with white pubescence, as are also the areæ at its base; the apex of the segment is shining, strongly closely reticulated and sparsely covered with long fuscous hair. Propleuræ rugose above; below are some stout oblique striations. Mesopleuræ rugose, the punctures running into reticulations; the apex smooth; the apical half of the metapleuræ reticulated; mesopleuræ thickly covered with long white hairs. Legs thickly covered with white hairs; the calcaria and spines pale. Wings fusco-violaceous; the base distinctly hyaline; the first cubital cellule at the top is very slightly longer than the second; the first recurrent nervure is received shortly beyond the middle, the second shortly beyond the base of the apical third of the cellule. Abdomen ferruginous; the petiole, except at its apex, and the apical two segments black; the rufous segments are fringed with pale fulvous pubescence; the middle and base with long white hair; the pygidium covered with long pale hair; the apical two ventral segments are stoutly keeled laterally.

MUTILLA IDYIA, *sp. nov.*

Long. 11—12 mm. ♂.

Hab. Barrackpore (*Rothney*).

Agrees in coloration of the body and wings with *M. phænna*; may be known from it by the second cubital cellule not being distinctly longer than the third at the top; by the central area being abruptly wider at the base, not becoming gradually narrowed; and by the striæ on the propleuræ being more widely separated.

Scape of antennæ thickly covered with silvery hair. Front and vertex closely and strongly punctured; the front and the middle of the vertex thickly covered with silvery pubescence. Clypeus smooth, shining and glabrous. Mandibles at the base thickly covered with silvery pubescence; the basal tooth large. Palpi dark fuscous. Pronotum closely rugosely punctured. Mesonotum more shining, the punctures larger, deeper, and more widely separated, and covered with fuscous pubescence. Scutellum rugosely punctured; the middle smooth, shining and glabrous; the smooth part gradually and slightly widened towards the apex. Median segment at the base and middle thickly covered with pale pubescence; the central area has the basal third abruptly widened; the sides of the widened part at the apex oblique. The apex of the segment is closely and strongly reticulated. On the propleuræ are six stout, distinctly separated striæ; the upper pair do not reach to the apex. Mesopleuræ in the middle strongly punctured and thickly covered with white hair. Metapleuræ, except at the base, strongly reticulated. Wings distinctly hyaline at the base behind the transverse basal nervure, the first cubital cellule at the top is equal in length to the second; the first recurrent nervure is received near the base of the apical third; the second shortly, but distinctly, beyond the middle. On the abdomen the apex of the petiole, the second, third, fourth and fifth segments are ferruginous and banded with pale fulvous hair on the apices; the pygidium is punctured, smooth and shining in the middle; the apical two ventral segments are stoutly keeled laterally.

MUTILLA SABELLICA, *sp. nov.*

Nigra, abdomine ferrugineo, basi apiceque nigris; segmento mediali dense albo-piloso; alis fusco-violaceis. ♂.

Long. 14 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ pilose, thickly covered with long white hair, the flagellum with short pale pubescence. Vertex sparsely covered with long white hair; strongly, but not very closely, punctured; the space behind and on the sides of the ocelli smooth; the ocellar region distinctly raised; the front is thickly covered with longish white hair, which hides the texture; the lower orbits and the oral region even more thickly pilose, and with the hair, if anything, longer. Mandibles large, shining; the tubercles large, shining, smooth, rounded; the area between the middle and hinder legs elongate, narrowed gradually towards the apex; the sides stoutly keeled. Mesonotum strongly punctured, the punctures becoming larger towards the apex; at the base is a smooth flat keel in the middle. Scutellum pyramidal, more strongly and deeply rugosely punctured than the mesonotum; its base covered with long black, the apex with longer pale hair. Post-scutellum smooth, the sides covered with long pale hair. Median segment stoutly reticulated; the reticulations smaller and closer on the apex; the base thickly covered with depressed white hair, which almost hides the texture in the middle; the central area is large, wide, and extends to the apex; its apical third at base oblique, densely covered with silvery pubescence, the apex curved; the lower apical tooth large, three times as long as the upper, which is bluntly triangular; the lower basal tooth is large, oblique, and somewhat triangular in shape. The eye incision is rounded on the inner side. Prothorax thickly covered with white hair; above rugosely punctured; the apex of the propleuræ smooth; the base with nine irregular, stout, clearly separated striæ. Mesopleuræ thickly covered with longish white pubescence, strongly, but not very deeply, punctured, the apex smooth. Metapleuræ reticulated, the base smooth. Mesosternum thickly covered with long white hair, its base roundly incised in the middle, the sides appearing as two narrowed and rounded parts; the apical slope is covered with long pale hair. Legs thickly covered with white hair; the calcaria pale; the tarsal spines pale rufous. Wings fusco-violaceous, the extreme base paler; the second cubital cellule at the top is slightly, but distinctly, longer than the third; the second transverse cubital nervure is roundly curved; the first recurrent nervure is received near the base of the apical third; the second near the apical fourth; the second recurrent nervure is obliquely bent at top and bottom, straight; the lower abscissa is the larger. Abdomen ferruginous; the petiole and the apical segment black; the petiole and the base of the second segment are thickly covered with long white hair; the middle segments are fringed with long fulvous hair; the ventral keel has an oblique slope, its apex has a rounded tooth. Pygidium strongly punctured, except in the middle; the hair is long and black; the hypopygium bears two large teeth, which are roundly curved above.

MUTILLA LABIENA, *sp. nov.*

Long. 14 mm. ♂.

Hab. Barrackpore (*Rothney*).

Agrees in form, size, and coloration with *M. sabellica.* The differences between the two are best shown in synoptical form.

Propleuræ irregularly striated; central area on median segment reaching to the apex of truncation, not triangularly narrowed; the keels on the hypopygium triangularly raised towards the apex. *sabellica.*

Propleuræ regularly and stoutly striated; the central area on the median segment triangularly narrowed, (V-shaped), not reaching to the end of truncation; the keels on the hypopygium not much raised towards the apex. *labiena.*

Scape of antennæ thickly covered with long white hair ; the flagellum with a pale microscopic down. Vertex strongly, but not closely, punctured ; the part at the sides of the ocelli impunctate ; the hair long and white. Front thickly covered with long white hair, which is longer above and between the antennæ. Face smooth, finely transversely striated over the clypeus, which is flat in the middle. Base of mandibles covered with silvery pubescence ; the middle below with long golden hair. Palpi dark testaceous. Pronotum closely punctured and thickly covered with long white hair ; mesonotum more strongly, and not so closely, punctured and thickly covered with fuscous pubescence. Scutellum large, pyramidal, coarsely and deeply punctured ; at the base thickly covered with dark, the apex with much longer white hair ; in the middle on the basal slope is an irregularly twisted, smooth keel. Median segment stoutly irregularly reticulated, except on the sides of the basal area at the base ; the area does not reach quite to the apex of the basal part of the segment, is V-shaped with the apex rounded ; the apical slope is coarsely reticulated with a keel down the middle. Propleuræ obliquely striated ; the apex smooth and raised Mesopleuræ coarsely punctured ; thickly covered in the middle with long white hair ; the apex smooth and glabrous. Mesosternum smooth, shining, sparsely punctured ; the area stoutly keeled down the sides ; the keels converging towards the apex. Legs thickly covered with long white hair ; calcaria white. Wings violaceous ; the first cubital cellule at the top is about one-fourth longer than the second ; the first recurrent nervure is received shortly beyond the middle ; the second in the apical fourth. Abdomen ferruginous ; the petiole and the apical segment for the greater part black ; the middle segments thickly covered with long fulvous hair ; the last segment with the hair paler ; it is smooth down the middle, and is strongly punctured; the oblique lateral keels on the hypopygium stout, and of uniform height throughout; the basal ventral keel is uniformly depressed; the apex is only very slightly more raised than the base.

MUTILLA MORNA, *sp. nov.*

Nigra, apice petioli abdominisque segmentis 2—5 ferrugineis; capite thoraceque dense albo-pilosis; alis violaceis, cellula cubitali 1*-a multo longiore quam 2-a.* ♂.

Long. 14 mm.

Hab. Tirhoot, Bengal (*Rothney*).

Scape of antennæ covered sparsely with long white hair; the flagellum thickly with a fine pile. Front thickly covered with silvery pubescence and with long silvery hair; strongly, but not very closely, punctured; the vertex is similarly punctured and more sparsely covered with long fuscous hair; the ocellar region distinctly raised. Face in the middle smooth, shining, bare; keeled in the middle; above the clypeus is a row of large, deep, round foveæ; the sides and cheeks are thickly covered with long silvery hair. Mandibles at the base thickly covered with silvery hair, the palpi blackish, thickly covered with white pubescence. Pronotum strongly punctured, thickly covered with white hair; the propleuræ smooth and bearing eight stout keels, which are placed at about equal distances from each other, except the lower pair which are more closely approximate. Mesopleuræ thickly covered with silvery hair; the basal half reticulated. Metapleuræ thickly covered with long silvery hair; the base smooth, the apex reticulated. Mesosternum thickly covered with long silvery hair; smooth in the middle; the area is stoutly keeled down the middle and is smooth and shining. Mesonotum shining, strongly, but not very closely, punctured, the base thickly covered with long white hair; the rest of it less thickly with shorter, stiffer, black hair. Scutellum pyramidal, strongly, rugosely punctured, except for a smooth line in the middle on the top; the base covered with long black, the apex with much longer pale, hair. The basal part of the median segment is densely covered with depressed silvery hair, and more sparsely with longer silvery hair; reticulated; the median area has the basal third widened, its sides straight, obliquely narrowed, its apex raised; the apex is closely irregularly reticulated and is thickly covered with long white hair. The first cubital cellule at the top is twice the length of the second; the second transverse cubital nervure has the upper three-fourths roundly curved; the lower part is straight, bullated; the first recurrent nervure is received at the base of the apical third of the cellule; the second nearer the middle. Abdomen thickly covered with white longish pubescence; the apex of the petiole, the second, third, fourth, and fifth segments ferruginous; the pygidium thickly covered with long black hair; the apex in the middle smooth; the ventral keel has a slight rounded curve, and does not project at the base or apex; the lateral keels on the hypopygium not much raised; those on the penultimate segment more distinct.

MUTILLA FUNEBRANA, *sp. nov.*

Nigra, abdomine ferrugineo, petiolo, segmentisque 5—7 *nigris; alis violaceis, basi fere hyalinis.* ♂.

Long. 13 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ thickly covered with long white hair; the flagellum with a pale down. Front and vertex strongly punctured; the former thickly covered with silvery pubescence, intermixed with long silvery hair; the vertex sparsely with long white hair. Face and clypeus smooth and shining; the latter with a deep furrow on the top and with two foveæ on the sides above. Mandibles at the base thickly covered with silvery pubescence; palpi dark fuscous. Pronotum strongly and deeply punctured, except at the base, which is smooth and shining. The apex of the propleuræ is smooth and thickly covered with a white pile; there are nine stout keels equally separated. Mesonotum closely and strongly punctured and thickly covered with stiff black hair. Scutellum rugosely punctured except for a broad smooth line in the middle; its base sparsely covered with black, the rest with long white, hair. Post-scutellum rugose, and covered with long white hair. Median segment at the base thickly covered with depressed silvery pubescence; it is reticulated, except along the sides of the central area, which is not much widened at the base; the keels there are straight; the oblique apical slope is strongly reticulated and covered with long white hair. The base of the mesopleuræ rugose and thickly covered with white hair; the apex of the metapleuræ irregularly reticulated. Mesosternum thickly covered with white pubescence. Legs thickly covered with long white hair; the calcaria white. Wings dark violaceous; the first cubital cellule at the top is slightly, but distinctly, longer than the second; the second transverse cubital nervure is roundly curved; both the recurrent nervures are received shortly, but distinctly, beyond the middle. Abdomen with the second, third, and fourth segments ferruginous, densely covered with white hair; the third and fourth with golden hair on the apex; the last segment with black hair. The ventral keel has a slight, rounded slope from the base to the apex; the hypopygium is smooth at the base; the lateral keels are stout and do not reach the base.

MUTILLA SERENA, *sp. nov.*

Nigra, capite thoraceque dense longe albopilosis, abdominis segmentis 2—4 rufis; alis fusco-violaceis. ♂.

Long. 12 mm

Hab. Barrackpore (*Rothney*).

Scape of antennæ thickly covered with long white hair; the flagellum with a pale down. Vertex strongly punctured, more sparsely at the sides of and behind the ocelli; thickly covered with long white hair; the front is not so strongly punctured and much more thickly covered with longer pale hair. Face smooth, shining, glabrous and broadly carinate in the middle. Clypeus smooth, shining, depressed broadly at the apex and behind, except in the middle. Mandibles at the base thickly covered with silvery pubescence. Pronotum coarsely reticulated; its base smooth; propleuræ rugosely punctured; the middle with widely separated keels; the apex smooth. Mesopleuræ in the middle punctured, the punctures running into reticulations, and thickly covered with long white hair. Apex of metapleuræ irregularly reticulated. Mesosternum thickly covered with long white hair; the metasternal area shining, smooth, stoutly keeled down the middle and less distinctly laterally. Legs thickly covered with white hair; the spurs white; the tarsal spines rufous. Wings uniformly violaceous; the first cubital cellule is, at the top, one-fourth longer than the second; the second transverse cubital nervure is sharply elbowed shortly above the middle; the first recurrent nervure is received near the base of the apical third, the second shortly beyond the middle. Petiole black, except at the apex, shining, punctured, covered with long white hair; the ventral keel has a shallow broad curve, and is slightly more raised at the apex than at the base. The middle segments are covered with fulvous hair; the fifth and sixth with white, the apical with black hair; the hypopygium is stoutly keeled laterally; the keels are not much raised towards the apex. The basal region of the median segment is thickly covered with silvery pubescence, and is reticulated; the central area reaches to the apex of the truncation; the basal third is wider than the rest; the keels there bulge roundly outwardly.

In size and in having only the second, third, and fourth abdominal segments red, this species agrees with *M. cleonyma*; the latter species may be known by the propleuræ being more strongly, regularly and closely punctured; by the central area on the median segment not being so wide at the base; by the penultimate ventral segment being stoutly keeled laterally; and by the second transverse cubital nervure being roundly curved, not elbowed.

MUTILLA CLEONYMA, *sp. nov.*

Nigra, abdominis segmentis 2—4 ferrugineis; medio scutelli laevo; alis fusco-violaceis. ♂.

Long. 13 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ covered with silvery-white pubescence; the flagellum with a black down; its middle joints slightly dilated. Front and vertex closely and strongly punctured; the vertex covered with longish fuscous hair; the vertex in the middle with a broad band of silvery pubescence. Face and clypeus smooth and shining; the former broadly keeled in the middle. Base of mandibles thickly covered with silvery hair; the basal tooth stout. Pronotum strongly and closely punctured, covered with long fuscous hair; the mesonotum with shorter, thicker and darker hair, its punctures are deeper and more widely separated. Scutellum pyramidal, closely and strongly punctured, except in the middle; it is covered with long hair, that on the apex is longer and paler. Post-scutellum aciculated. Median segment reticulated; at the base thickly covered with white pubescence; the basal third of the central area is widened; the lateral keels roundly curved; the apex of the segment is strongly reticulated. On the propleuræ are seven stout, distinctly separated striæ; the second is indistinct, the middle one not half the length of the others. Wings uniformly dark fusco-violaceous; the second cubital cellule at the top is shortly, but distinctly, longer than the third; the first recurrent nervure is received near the base of the apical fourth; the second near the base of the apical third. Legs thickly covered with white hair; the calcaria and spines pale. Abdomen black; the apex of the petiole, the second, third, and the fourth segments, ferruginous; the middle segments fringed with fulvous hair; on the pygidium in the middle is a smooth, slightly raised part; the apex is smooth and depressed in the middle; the hypopygium is keeled laterally at the apex.

In Bingham's table (p. 9) this species forms a new Section: "Second to fourth segments red."

MUTILLA MACULICORNIS, *sp. nov.*

Nigra, dense albo-pilosa; antennis rufo-maculatis; abdomine ferrugineo, apice nigro; alis fusco-violaceis, basi hyalinis. ♂.

Long. 13 mm.

Hab. Barrackpore (*Rothney*).

Antennæ black; the base and apex of the scape and the base of the flagellum rufous; the apical joints of the flagellum brownish beneath; the scape shining, punctured, sparsely covered with white hair; the flagellum opaque, covered with a white microscopic down; the third joint is shortly, but distinctly, longer than the fourth. The front and oral region densely covered with silvery hair; the vertex more sparsely with longer fuscous; the front and vertex strongly, but not very closely, punctured; the antennal keels distinct, sharp. Clypeus smooth and shining, largely projecting above; the lower half obliquely depressed, glabrous, somewhat triangular in shape, the middle depressed; mandibles rufous in the middle; the base punctured, densely covered with pale golden hair; the palpi brown, darker above. Pronotum densely covered with silvery pile, intermixed with long silvery hairs; the mesonotum shining, strongly, deeply and closely punctured, the punctures forming distinct rows; the two furrows are deep, the hair is thick and blackish. Scutellum roundly raised; deeply punctured; covered with long fuscous hair; its apex is oblique; in the middle of the basal half is a smooth shining line, bluntly lanceolate at the apex. Median segment closely reticulated; the basal part thickly covered with depressed silvery pubescence; the central basal area is elongate; the basal third wider than the rest. Propleuræ marked with stout keels, the apex smooth; the central part of the mesopleuræ irregularly punctured, and thickly covered with white hair; the metapleuræ at the base smooth above; the lower part irregularly, and not very strongly, reticulated; the rest distinctly, but not very closely, reticulated. Legs thickly covered with white hair; the spines and calcaria pale. Wings fusco-violaceous; the second cubital cellule at the top is slightly longer, at the bottom twice the length of the third; the first recurrent nervure is received at the base of the apical third; the second in the middle of the cellule. Abdomen ferruginous; the apical half of the penultimate and the whole of the last segment black; all the segments sparsely covered with long white hair; the petiole is rather strongly punctured; its basal teeth are stout; the ventral keel is large; the basal half roundly depressed; the apex projects more and is depressed in the middle; its apical part is longer and projects more than the basal. The pygidium is strongly punctured, except in the middle, which is smooth and shining; its apex is depressed and more or less rufous.

MUTILLA POESIA, *sp. nov.*

Nigra, pronoto, scutello segmentoque mediali rufis; alis fusco-hyalinis, nervis nigris. ♂.

Long. 7 mm.

Hab. Barrackpore (*Rothney*).

In Bingham's arrangement (p. 10) under C this species might form a new "Section c.: Thorax anteriorly and posteriorly red."

Scape of antennæ thickly covered with long white hair; the flagellum thickly with pale down; stout; the third joint shorter than the fourth. Head black; if anything, narrower than the thorax; the front broadly and distinctly furrowed down the middle, strongly and closely punctured, and thickly covered with white hair; the ocellar region raised, the raised part extending behind to the occiput and obscurely punctured; the sides of the vertex strongly punctured. Occiput sharply margined. Pro- and meso-notum shining, strongly punctured; the pronotum red above, except on the outer edges behind and the base laterally; it is thickly covered with longish white hair. Mesonotum shining, strongly and deeply punctured; the furrows obsolete. Scutellum rufous, strongly and deeply punctured and covered with long pale hairs. Metathorax entirely rufous; the median segment strongly reticulated; the basal central area is as long as it is wide; the sides straight; the apex triangular; the keels issuing from the lateral angles are stouter than the others; the area is depressed; the apex has an abrupt oblique slope. The base of the propleuræ punctured, the rest stoutly striated. Mesopleuræ strongly and closely punctured, shining and covered with long white hair. Metapleuræ roundly projecting, strongly and deeply punctured, and covered with long white hair. Legs thickly covered with white hair; the calcaria and tarsal spines pale. Wings fusco-hyaline, short, the radial nervure straight and oblique at the base; the apex roundly curved; the second cubital cellule is irregular, much narrowed at the top: five-angled, distinctly angled in the middle below; the first transverse cubital nervure is straight and sharply oblique, the second is broadly and roundly curved; the third is faint and is angled shortly above the middle. Abdomen deep black; closely and strongly punctured; thickly covered with white hairs; the basal three segments with a fringe of white hair on their apices. Pygidium strongly and deeply punctured. The basal ventral segment strongly punctured, the middle smooth; the hypopygium closely punctured.

MUTILLA LUDOVICA, *sp. nov.*

Nigra, prothorace mesonotoque rufis; flagello antennarum subtus brunneo; abdominis segmentis albo-fasciatis; alis hyalinis, nervis nigro-fuscis. ♂.

Long. 6 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ black; hollowed beneath, the sides sharply keeled; the flagellum brownish, black above; the third and fourth joints are almost equal in length. Head broad, not much developed behind the eyes, which are large. Vertex deeply, but not closely, punctured, shining; the ocellar region raised, depressed in the middle; the front ocellus distinct ; the hinder not so distinctly visible, being placed on the lateral slope of the raised part ; the vertex is sparsely, the front thickly, covered with long white hair ; the latter has a narrow furrow in the middle. Thorax black ; the prothorax and the mesonotum, except behind, red. Prothorax large ; coarsely and deeply punctured and covered rather thickly with white hair ; the upper part of the propleuræ punctured ; the middle with four stout, somewhat oblique keels. Mesopleuræ coarsely and deeply punctured, except behind ; below the middle, behind the punctured part, are some oblique striæ. The apical part of the metapleuræ with shallow, oval reticulations ; on the lower part at the base are three round foveæ in a curve, the middle one being the larger. Mesosternum punctured, thickly covered with longish silvery hair. Wings hyaline ; the basal abscissa of the radius straight, oblique, the apical roundly curved above ; the second cubital cellule at the top is half the length of the third ; the second transverse cubital nervure is roundly curved ; the third cellule is triangularly dilated in the middle ; the third transverse cubital nervure and the second recurrent nervure are faint. Legs thickly covered with white hair ; calcaria pale. Abdomen black, the dorsal surface with a faint, but distinct, blue-violet tint ; the petiole broad ; the sides at the base obliquely projecting into stout teeth, which are curved outwardly at the base ; it is covered with long white hair ; at the apex thickly fringed with silvery pubescence ; the second segment has a similar fringe ; the others are fringed with long hair at the apex and are sparsely haired all over ; the hypopygium is not defined ; the segment is punctured and covered with long black hair. The basal ventral segment is punctured strongly ; the sides have an oblique slope ; the second segment has an oblique slope on the base; the epipygium is strongly and deeply punctured and covered with blackish hair.

Belongs to Bingham's "Section C," and comes near to *M. provida* Cam. The two parapsidal furrows are wide and deep; the scutellum is flat, rounded, and strongly punctured; the median segment has a gradually rounded slope and is coarsely reticulated all over; the central basal reticulation is longer than it is broad, its base squarely dilated, the apex rounded. The tegulæ are dull rufous, paler behind.

MUTILLA OGLANA, *sp. nov.*

Nigra; abdomine ferrugineo, apice nigro; alis fuscis, basi fere hyalinis. ♂.

Long. 11—12 mm.

Hab. Ceylon (*Yerbury*).

Scape above thickly covered with long silvery hair; the flagellum with a fuscous down; the third joint is distinctly longer than the fourth. Front and vertex strongly, but not closely, punctured; the front thickly covered with silvery pubescence, intermixed with long fuscous hair; the vertex sparsely covered with long fuscous hair; between the antennæ and the eyes is a thick patch of depressed silvery pubescence. Clypeus carinate in the middle, smooth and shining. Pronotum rugosely punctured, the base of the propleuræ with stout keels, which reach to shortly beyond the middle. Mesonotum deeply rugosely punctured and reticulated; the punctures larger towards the apex; the furrows deep; the hair thick, black. Scutellum flattish above; rugosely punctured; its middle smooth and shining; post-scutellum finely rugose in the middle. Median segment reticulated, covered with long white hair; the central area wide, bluntly rounded at the apex; the base dilated; the apex has a rounded slope.

Mesopleuræ rugosely reticulated, and thickly covered with long white hair. Metapleuræ reticulated irregularly at the apex. Mesosternum smooth and shining; the sides punctured; the base with a triangular depression. Legs thickly covered with white hair; the calcaria pale. Wings fuscous, with a violaceous tinge; the nervures are fuscous; the second and third cubital cellules at the top are equal in length; the base, especially behind the transverse basal nervure, is hyaline. Abdomen rufous, the apical segment black; the segments at the apex densely clothed with bright fulvous pubescence; the base of the pygidium is strongly punctured, as are also the sides; the middle, except at the base, is smooth; the apex is broadly rufous in the middle. The apex of the ventral keel is depressed; the hypopygium is broadly depressed in the middle to near the base, the depression there being rounded; the outer sides of the segment are rounded; at the base are two foveæ.

MUTILLA ILLA, *sp. nov.*

Nigra, capite thoraceque dense albopilosis; abdomine ferrugineo, apice nigro; alis violaceis, basi hyalinis. ♂.

Long. 8 mm.

Hab. Barrackpore (*Rothney*).

Scape of antennæ sparsely covered with grey hair; the flagellum densely with white down. Front densely covered with silvery pubescence, which hides the sculpture; the vertex closely punctured, covered with longish fuscous hair. Face and clypeus smooth and shining, laterally covered with long white hair. Mandibles broadly rufous behind the teeth. Palpi dark testaceous. Pronotum densely covered with dark silvery hair; punctured; propleuræ irregularly striated, except at the apex. Mesonotum strongly and deeply punctured; covered with blackish hairs. Scutellum roundly convex, rugosely punctured, covered with long blackish hair; the post-scutellum with longer pale hair. Median segment reticulated; the basal part thickly covered with depressed white pubescence; the central area short, its apex triangular; the apical slope is covered with long white hair, and is reticulated; the mesopleuræ, except at base and apex, rugosely punctured and thickly covered with long white hair; the apex of the metapleuræ irregularly reticulated. Legs thickly covered with white hair; the hair on the fore tarsi fulvous; the calcaria pale. Wings fusco-violaceous; the base of both wings hyaline; the radial cellule wide; the basal abscissa of the radius has an oblique slope; the apical one is almost straight; the second cubital cellule is slightly longer than the second on the top; the second transverse cubital nervure is roundly curved; the third sharply angled in the middle. Abdomen ferruginous, the apical segment black; the middle segments thickly covered with bright fulvous pubescence; pygidium densely covered with long fuscous hair; the ventral keel is indistinct, straight, of equal height; the apical two segments without keels.

Forms a new Section in Bingham's table, p. 9: "First to sixth segments red."

MUTILLA FOVEATA, *sp. nov.*

Nigra; abdomine rufo, basi apiceque nigris; alis fuscis, fere violaceis, nervis fuscis. ♂.

Long. 13 mm.

Hab. Ceylon (*Yerbury*).

Head black; thickly covered with long grey hairs and with a silvery down; the front and vertex strongly, but not closely, punctured; the clypeus distinctly keeled in the middle; the top of the keel dilated, and with an elongated fovea in the middle; this part is smooth, shining and glabrous; the sides are thickly covered with silvery hair; the mandibles are rufous in the middle and fringed with long golden hair; they have one large tooth. Palpi fuscous. Antennæ stout; the third joint is slightly longer than the fourth. Pronotum, except at the base, rugosely punctured; the pleuræ slightly hollowed, and indistinctly marked with some stout striations. Mesopleuræ in the middle coarsely punctured, and thickly covered with white hair. Metapleuræ at the base smooth, its lower side indistinctly reticulated; the apex with large reticulations. Mesonotum shining, bearing all over large, deep punctures and covered with moderately long black hair; there are two furrows. Scutellum coarsely rugosely punctured; roundly raised; covered with long hairs, which are fuscous at the base, longer and paler on the apex; in the centre of the basal half is a flat, smooth, shining, cone-shaped space. Median segment reticulated; thickly covered with long pale hairs; the base also with a depressed silvery down; the central area is large and reaches to the middle; its apical half is narrowed; in the centre of the basal half is an indistinct longitudinal keel; the apex of the segment is oblique. Legs thickly covered with white hair; the spurs and spines white. Wings fuscous, slightly violaceous; the nervures fuscous; the second cubital cellule at the top and bottom is longer than the third, especially beneath; the first recurrent nervure is received at the base of the apical third, the second at the base of the apical fourth of the cellule; the second transverse cubital nervure is sharply angled shortly above the middle. Abdomen ferruginous; the petiole, except at the apex, and the apical two segments, black; the petiole is strongly, but not closely, punctured; the middle segments are fringed with long golden hair; the hair on the apical segments is black; the middle of the last segment is glabrous and smooth. The keel on the under side of the petiole is straight, rounded at the base and apex.

MUTILLA ERXIA, *sp. nov.*

Nigra, apice petioli abdominisque segmentis 2—4 *ferrugineis*; *metanoto dense argenteo-piloso*; *alis fusco-violaceis, basi hyalinis.* ♂.

Long. 12 mm.

Hab. Barrackpore (*Rothney*).

Scape sparsely covered with long fuscous hair; the flagellum with a pale down; the third and fourth joints are of equal length. Head thickly covered with silvery pubescence; the front and vertex also with long silvery hair, most thickly on the front; the vertex shining, strongly, but not closely, punctured; the ocellar region raised. Clypeus smooth at the apex, the rest minutely transversely striated; the apex has the sides oblique; the middle slightly waved. Mandibles thickly covered with long fulvous and silvery hair; their middle rufous. Pronotum closely and strongly punctured, and thickly covered with long fuscous pubescence. Mesonotum shining, sparsely covered with stiff fuscous hairs; strongly, but not closely, punctured; the central furrows are wide and deep; the lateral narrower and not so well marked. Scutellum rounded, not much raised above the level of the mesonotum, coarsely and deeply punctured, except in the middle which is smooth, shining and glabrous, the sides are sparsely covered with long black hairs. Median segment thickly covered with depressed silvery pubescence, which almost hides the reticulations; the central basal area has the basal third wide, with the sides straight; from there it becomes narrowed; the sides of the segment are bordered by a shining keel. Propleuræ stoutly, but not closely, obliquely striolated; the mesopleuræ strongly punctured, except at the base and apex; the metapleuræ reticulated, with the base smooth Mesosternum smooth, the sides punctured; the middle with a fine keel. Wings fusco-violaceous, the base almost hyaline; the second cubital cellule at the top is not much longer than the third; the recurrent nervures are received shortly beyond the middle; the radial cellule is wide; the basal abscissa of the radius is oblique, straight; the upper part of the apical has a slight, the lower an acute slope. Legs thickly covered with white hair; the calcaria pale. The apex of the petiole, the second, third, fourth, and base of the fifth segments are ferruginous; the segments fringed thickly with silvery hair; the apical segments also with long, stiff, black hairs; the middle of the pygidium smooth; the apex is reddish and curved upwards. The ventral keel is stout and has a slightly rounded slope; the sides of the two apical segments are bordered by stout keels.

The two following species are from Japan.

MUTILLA MIKADO, *sp. nov.*

Nigra, thorace supra rufo; abdomine longe aureo-piloso. ♀.

Long. 12—14 mm.

Antennæ stout, black, the scape covered with long white hair. Head large, slightly, but distinctly, wider than the thorax; largely developed behind the eyes; rugosely punctured; sparsely covered with long, stiff, black hair. Eyes small. Thorax quadrangular, not very much longer than the head; the sides straight; the base and apex transverse; the sides rounded; above strongly punctured, dark ferruginous, thickly covered with long black hair. Pleuræ black, smooth and shining, bare. Legs black, thickly covered with white hair; the calcaria pale. Abdomen not much longer than the head and thorax united; the apices of the basal three segments thickly fringed with long, pale golden hair.

MUTILLA JAPONICA, *sp. nov.*

Nigra, thorace rufo; pedibus rufis, apice femorum apiceque tibiarum late nigris. ♀.

Long. 7 mm.

Hab. Hakodatè, Japan (*Mr. George Lewis*).

Antennæ black, the apex of the scape and the second joint rufous; the flagellum attenuate at base and apex. Head slightly wider than the thorax; rugosely punctured, sparsely covered with long black hairs. Clypeus projecting obliquely from the base to the apex, the lower part perpendicular; mandibles rufous, the apical part black, long, without a tooth; clearly separated. Thorax with the sides above straight, not contracted; the base above black; rugose, the base and apex bearing long black hairs; the apex has a sharp oblique slope, and is black in the middle above. Pleuræ smooth and shining, sparsely covered with long white hair. Legs rufous; the apical half of the fore femora, and nearly the apical half of the four hinder, the fore tibiæ, except at the base, and nearly the apical half of the four hinder, and the base of the tarsal joints, black; the spines on the four hinder tibiæ are stout and blackish; on the tarsi dark testaceous; the calcaria pale. Abdomen not much longer than the head and thorax united; black, the base of the petiole rufous. An oval mark on the base of the second segment in the middle; the apex of the second segment and the greater part of the third segment covered with pale fulvous pubescence; the pygidium is closely, longitudinally striated; the petiole is rufous beneath; the keel is indistinct.

Comes near to *M. ardescens* Smith; that species may be separated from it by the ferruginous antennæ; by the tips of the femora only being darker; and by the sides of the thorax being "rugose-punctate."

In working through the Khasia Hymenoptera I have noticed the following omissions from the "Fauna of British India."

Mutilla intermedia Saussure, *Ann. Soc. Ent. Fr.*, Tome vii. (1867), 354. Ceylon.

Gorytes fœ Handlirsch, Sitzgunsb. K. Akad. Wiss. Wein, Bd. 104, Abth. 1, p. 890 (1895). 1895-90. Pegu.

If the Nicobar Islands are included in the scope of the work (and they are quite as much part of "British India," politically and zoologically, as Ceylon), the undernoted species should also be included:

Polistes novaræ Saussure, *Reise der Novara, Hymen.* p. 19, f. 13, 14.

Larrada insularis Saussure, *ibid.* p. 73, f. 43.

POMPILIDÆ.

POMPILUS CEYLONENSIS, *sp. nov.*

Long. fere 6 mm.

Hab. Ceylon (*Rothney*)..

This Ceylonese species comes near to *P. taprobanæ*, but is smaller, is more slenderly built, and more densely pruinose all over; the wings are darker coloured all over; the upper half of the apical abscissa of the radius has a much more distinct angle, the upper and lower halves being more distinctly defined; the second cubital cellule at the top is longer compared with the first, and the second recurrent nervure is received distinctly behind the middle.

Antennæ stout, the flagellum densely covered with white pubescence. Head densely pruinose all over, which gives it a white appearance; the eyes hardly converge at the top; the hinder ocelli are separated from each other by a slightly greater distance. Apex of clypeus transverse, the sides oblique. Mandibles rufous, their base black, and thickly covered with depressed silvery pubescence; the palpi are dark brown. Thorax densely covered with silvery pile; the prothorax is obliquely depressed on the apex; the base is distinctly separated from the others. Mesothorax thickly covered with silvery pile; the scutellum and post-scutellum are more shining and minutely punctured; there is a shallow oblique furrow on the mesopleuræ. The median segment has a gradually rounded slope; in the centre is a narrow shallow furrow. Wings fusco-hyaline, darker along the costa; the apex is infuscated from the end of the radial cellule; the radial cellule is wide to the third transverse cubital nervure; the apical abscissa of the radius has two oblique curves; the apex forms an acute angle; the first transverse cubital nervure forms two curves, the upper being more sharply oblique; the second cubital cellule at the top is one-third of the length of the second; the two recurrent nervures are received shortly behind the middle. Legs densely pruinose; the calcaria dark testaceous. Abdomen densely pruinose, the segments darker at the base.

POMPILUS TAPROBANÆ, *sp. nov.*

Niger, dense pruinosus; alis hyalinis, apice fumatis. ♀. Long. fere 7 mm.

One example, Trincomali, Ceylon (*Rothney*).

The lower part of the vertex and the oral region densely covered with a silvery pile; smooth and shining; the eyes at the top are separated by the length of the third antennal joint; the hinder ocelli are separated from each other by a slightly greater distance than they are from the eyes. Middle of clypeus transverse, the sides rounded. Pronotum large, rounded at the base, slightly contracted at the apex. Metathorax densely pruinose; it has a gradually rounded slope to the apex, and has a shallow furrow in the centre, this furrow being wider on the apical slope. Wings hyaline, smoky from the end of the radial cellule; the apical abscissa of the radius has an oblique slope; the basal has the lower part straight, oblique, and has a slightly different slope; the first and third transverse cubital nervures have a gradually, distinctly rounded curve; the second is straight and is oblique; the second cubital cellule at the top is about one-fourth of the length of the first; both the recurrent nervures are received shortly beyond the middle; the second has a rounded curve; the first is oblique, straight. Legs pruinose; the calcaria dark testaceous; the spines black. Abdomen with pruinose bands; subsessile.

In Bingham's table on p. 148 this species comes into "b^4" near *P. subsericeus*, which is a larger species (10 mm.), and may be known from it by the apical abscissa of the radius having only one curve; and by the second cubital cellule on the top being longer compared to the first. The tibial spines are few in number; the front pair have only two. I can discover no tooth on the claws.

CRABRONIDÆ.

TRYPOXYLON PYGMAEUM, *sp. nov.*

Nigrum, flagello antennarum subtus brunneo, tarsis, tibiis anterioribus basique femorum posticorum rufo-testaceis; alis hyalinis, stigmate nervisque fuscis. ♀.

Long. fere 5 mm.

Taken at Barrackpore by Mr. Rothney.

Antennæ stout, narrowed at the base. Front and vertex aciculated, covered with a silvery pile; the face more strongly aciculated; mandibles rufo-testaceous; the palpi testaceous. Thorax black, shining, more or less thickly covered with silvery pubescence; the pronotum with an oblique slope behind, distinctly separated from the mesonotum, which is indistinctly furrowed, except at the base; the median segment is more strongly and distinctly aciculated. Propleuræ closely, minutely and distinctly punctured; in the middle behind, is a deep, narrow, distinct, curved furrow. The base of the mesopleuræ strongly and closely punctured; on the lower part at the base is a short, oblique, deep furrow, which is covered with silvery pubescence; the middle fovea is large and deep. Metapleuræ strongly aciculated; the furrow at the base is curved, moderately wide and deep; on the upper side is a fine keel. Wings clear hyaline, the nervures fuscous. Abdomen black, shining.

This is the smallest of the Indian species, the smallest species hitherto described being *T. buddha*, which is 9 mm. in length. The median segment has no lateral furrows.

EVANIIDÆ.

AULACUS IRIDIPENNIS, *sp. nov.*

Niger, scapo antennarum tibiisque anterioribus rufis; alis hyalinis, macula substigmatali fusca. ♂.

Long. 14 mm.

Antennæ short, distinctly thinner at the apex; black; the scape rufo-testaceous; the second joint is thickly pilose; is about one-half the length of the third; both together are about as long as the fourth. Head shining, smooth; the vertex sparsely covered with short fuscous pubescence; the face and lower inner orbits thickly with white pubescence. The clypeus slightly projects in the middle; the apex bluntly carinate in the centre, and oblique. Mandibles on the lower sides fringed with golden hair. The head is not much narrowed behind the eyes; and is broadly rounded ; the occiput is margined. Pronotum at the base triangularly incised ; the middle at the base depressed ; margined ; the surface is marked with stout, widely separated, transverse keels. Mesonotum broadly depressed in the middle ; the sides bearing two lines of stout irregular keels. Scutellum with three large deep basal, and one smaller lateral foveæ ; the apex has a stout transverse keel and a few short, longitudinal, indistinct ones. The sides of the post-scutellum are largely and deeply depressed. Metanotum stoutly, irregularly reticulated Pro- and meso-pleuræ irregularly coarsely rugose ; the apex of the latter irregularly reticulated and broadly depressed ; the metapleuræ rugose at the base ; the rest reticulated. Legs black ; the four front tibiæ rufo-testaceous ; the four hinder coxæ transversely striated. Wings hyaline, iridescent ; the nervures black ; under the stigma is a large fusco-violaceous cloud, which extends to near the cubital nervure ; there are only two transverse cubital nervures, the second is largely bullated ; the first recurrent nervure is almost interstitial, the second is received at the base of the apical third of the cellule ; the first and second discoidal cellules are of nearly equal length. Abdomen smooth and shining.

This makes the second species of *Aulacus* known from Continental India. Like the other Khasia species (*A. bituberculatus*) it belongs to the subgenus *Aulacinus*.

BRACONIDÆ.

BRACONIDES.

SPINARIA TRIMACULATA, *sp. nov.*

Nigra, capite, pro-mesothoraceque pallide flavis, mesonoto nigro-trimaculato; pedibus anterioribus flavo-testaceis ; alis hyalinis, stigmate nigro. ♀.

Long. 7 ; terebra 4—5 mm.

Antennæ black, slightly longer than the body. Front and vertex smooth and shining; the latter covered with long fuscous hair; the face rugose, sparsely covered with long fuscous hair; the clypeus bordered on the lower side with a distinct keel, above with a thinner one; the mandibular teeth black. Thorax smooth and shining; the mesonotal lobes black, except round the edges. Scutellum yellow, except the sides at the base. Postscutellum black. Median segment black, shining and covered with long white hair. Pleuræ smooth and shining; the furrow on the metapleuræ wide, deep, and narrowed in the middle. Wings hyaline, iridescent, their base with a slight fulvous tint; the costa and stigma black, as are also the nervures; the second cubital cellule at the top is more than half the length of the third; the recurrent nervure is interstitial. Abdomen black, except the sides of the petiole and the apical segments, which are testaceous; the base of the petiole is smooth; its apex has two united, somewhat oval, areæ, which have some stout, irregular keels inside. The second segment is raised and stoutly irregularly reticulated in the middle; with a keel down the middle, this keel being smooth and triangular at the base; its depressed sides are obliquely striated on the inner half; the second and third segments are closely rugose, the second almost rugosely striated; the securiform articulation stoutly striated or keeled; the lateral curved branch broader, shallower, indistinctly striated; the apex of the segment laterally is produced slightly behind, and is smooth and shining; the apex of the third is similarly, but more greatly produced; the apex of the segment is depressed; furrowed; the edge is pale; the penultimate segment is depressed, aciculated. The front legs are entirely testaceous; the middle pair testaceous, with the coxæ and trochanters black; the hind legs are entirely black, with the spurs testaceous. The ventral surface testaceous.

A distinct species. The abdominal spines are not so strongly developed as usual.

BRACON PAUPERATUS, *sp. nov.*

Luteus, antennis nigris; alis flavo-hyalinis, macula sub-stigmaticali fusca. ♀.

Long. 10; terebra 9 mm.

Scape of antennæ covered with bright fulvous hairs. Front and vertex smooth and shining; the latter sparsely covered with long fuscous hairs; the frontal furrow is wide and deep; the face thickly covered with long fulvous hair; the upper part of the clypeus is bordered by a distinct keel on the sides. The apex of the mandibles black; palpi fulvous. Thorax smooth and shining; the base of the middle lobe of the mesonotum raised in the middle and bordered by furrows; the furrow on the mesopleuræ is wide, curved, and reaches from the base to the apex; the furrow on the metapleuræ is wide, deep at base and apex. Legs thickly covered with fulvous pubescence. Wings yellowish hyaline, the apex smoky; at the base of the stigma is an oblique cloud which extends to the recurrent nervure and is continued narrowly along the nervure on to the prodiscoidal cellule; the second cubital cellule is not much shorter than the third. Petiole smooth; the central part obscurely shagreened and keeled down the middle; the basal plate on the second segment is smooth; its keel does not reach to the apex; the space on either side of it is obliquely striated; the securiform articulation is longitudinally striated; the apical segments are covered with long fulvous hair.

BRACON FIRMUS, *sp. nov.*

Niger, prothorace, mesonoto, mesopleuris scutelloque rufis; alis fusco-hyalinis, stigmate fusco. ♂. (?)

Long. 7 mm.

Antennæ black; the scape bearing long black hairs; the flagellum almost bare. Front and vertex shining, smooth, the vertex covered with long black hairs; the ocelli bordered by a distinct furrow; the front has a wide and deep furrow, with oblique sides; the face opaque, thickly covered with long fuscous hair; the clypeus is bordered laterally by a wide and deep furrow; the top by a narrow, shallow one. Mandibles rufo-testaceous, their teeth black; the palpi pale testaceous, blackish at the base. Thorax smooth and shining; the pro- and meso-thorax ferruginous, except the mesosternum and a large mark, interrupted narrowly in the middle, on the apex of the mesopleuræ. Metapleuræ thickly covered with long fuscous hair; the basal slope of the mesosternum is red, except for a somewhat triangular black mark on either side at the apex. Legs black, the spurs white; the tibiæ and tarsi thickly covered with white hair. Wings fusco-hyaline; the stigma blackish; the nervures fuscous; the second cubital cellule is distinctly shorter than the third; the second transverse cubital nervure is faint, and is bullated at the top and bottom. The base of the petiole is deeply depressed; the apical part coarsely irregularly punctured, and keeled down the middle; the depressed sides are obliquely striated at the base; the apex rugose; the second segment is irregularly rugosely striated; the triangular base of the central keel, the triangular sides at the base and the apex, smooth and shining; the lateral depression is bordered on the inner side by a stout keel; on the outer edge at the base are four foveæ. Securiform articulation stoutly striated, as are also the furrows on the other segments.

Agrees in coloration with *B. umbratilus* Cam. which may be known from it by the propleuræ being closely punctured and striated at the apex ; by the triangular base of the keel on the second segment being longitudinally rugose ; and by the mandibles being black.

RHOGAS (?) MANDIBULARIS, *sp. nov.*

Nigra, mandibulis, palpis pedibusque pallide testaceis; dimidio apicali tibiarum posticarum nigris; alis hyalinis, nervis stigmateque nigris. ♂.

Long. 9 mm.

Antennæ longer than the body, black, tapering towards the apex ; the scape covered with long black hairs ; the flagellum with a microscopic pile. Face closely, transversely, rugosely striated ; the clypeus finely rugose; its apex rufous. Palpi pale testaceous. Mandibles rufous; the teeth black. Thorax entirely black ; the mesonotum aciculated, covered with a pale microscopic down. Scutellum finely punctured and more thickly pilose than the mesonotum ; the space at the sides of the post-scutellum striated. Median segment with a distinct keel down the middle ; thickly covered with long white hair; the apical half irregularly reticulated. Propleuræ opaque, the base aciculated, the rest closely and finely punctured; the apex obscurely and irregularly striated. Mesopleuræ smooth and shining, the upper part at the base finely rugose ; the metapleuræ above obscurely, below finely and distinctly, punctured. Mesosternum smooth and shining ; furrowed down the middle ; its base oblique with the furrow wider and shallower, and with a fine transverse keel at the apex. The pleuræ and sternum blotched with brown. Legs testaceous, paler at the base; the hinder femora rufo-testaceous; the apical half of the hinder tibiæ and the claws black. Wings hyaline, iridescent; the stigma and nervures black; the upper part of the præbrachial transverse nervure, and the lower part of the first transverse cubital are bullated; the second transverse cubital nervure is faint. The basal three segments of the abdomen are strongly alutaceous; the others smooth and shining; on the middle of the petiole is a keel which extends nearly to the apex; the ventral segments are smooth and shining.

[As I am not by any means certain if the species here described can be included in *Rhogas* I give a generic description of it.

Eyes distinctly incised on the inner side above; the head narrowed behind them. Occiput margined. Antennæ with over 50 joints. Wings with three cubital cellules; the probrachial nervure received shortly behind the middle of the cellule; the anal nervure interstitial. Stigma large; the second cubital cellule longer than broad. Parapsidal furrows distinct. Median segment keeled down the middle. Abdomen subsessile; keeled down the middle at the base; the basal three segments opaque, alutaceous, longer than the apical four, and becoming gradually shorter; the apical segments are smooth and shining. Mandibles short, bidentate.

The eyes are large, parallel, and reach near to the base of the mandibles; the clypeal incision is large; the occiput slightly, but distinctly, roundly incised; there is a short depression on the second and third abdominal segments behind the stigmas, and they are sharply margined at the sides; the third to fifth segments project sharply at the apices laterally; the second transverse cubital nervure is very faint, almost obliterated; the second cellule is slightly shorter than the first and not half the length of the third;

the hind wings have a stigma; their radius and cubitus are distinct; the probrachial nervure is received near the middle of the cellule; the abdomen is flat above; its apical half wider than the basal.]

DELMIRA, *gen. nov.*

Clypeus flat, its apex transverse. Head large, cubital; the occiput not margined; behind the eyes it is largely developed. Mesonotum with two short furrows at the base, where the part between them is raised. Wings with three cubital cellules; the transverse probrachial nervure is received behind the middle of the cellule and distant from the transverse præbrachial; the anal nervure not interstitial, and with a distinct upward curve at the base. In the hind wings the radius and the cubitus are complete; the probrachial nervures—longitudinal and transverse—are obsolete, unless the former be represented by a small upward turned nervure at the base of the wing, which unites with the cubitus, thus forming a small, closed cellule; the radius issues from the præbrachial below the subcostal which is thickened at the apex, this thickened part being incised in the middle above. Abdomen short; the securiform articulation obsolete; the second segment with a deep oblique lateral, and a small transverse depression; hypopygium cultriform.

This genus has the form and appearance of *Bracon*, from which it differs in the form of the clypeus, which is flat and not obliquely bent inwards, so that there is not a semicircular or round space formed by it and the mandibles. It is therefore doubtful if it could be included in the *Cyclostomi* with which it agrees in other respects; it differs from *Bracon* further in the anal nervure not being interstitial; the legs are more densely pilose and the hair is longer than in that genus.

DELMIRA TRIPLAGIATA, *sp. nov.*

Lutea; antennis nigris; alis flavo-hyalinis, fusco-trimaculatis. ♀.

Long. 15; terebra 22 mm.

Antennæ black, stout; the scape covered with long black hair. Front and vertex smooth and shining; the front and occiput covered with long, pale fuscous hair; the front slightly depressed, distinctly furrowed down the middle, the face depressed, broadly keeled down the middle, the keel broadened at the apex; clypeus very smooth and shining. Mandibles sparsely covered with long fulvous hair; the teeth black. Pro- and mesothorax smooth and shining, sparsely covered with long pale hair; metanotum also smooth, and with the hair thicker. Pleuræ smooth and shining, pilose; the part of the meso- under the tegulæ is triangularly raised; the meta- with a wide and deep, curved furrow, issuing from a depression near the base. Mesosternum smooth and shining, furrowed down the middle. Wings yellowish hyaline, the apex infuscated; the apex of the stigma, an oblique cloud at its base reaching near to the recurrent nervure, and an oblique one in the middle of the lower part of the prodiscoidal cellule, fuscous black. Legs thickly covered with long fuscous hair; the apices of the hinder tarsi blackish. Abdomen smooth and shining; the base of the petiole deeply depressed; the centre raised, bordered by a curved furrow; the sides thickly covered with long fuscous hair; the second segment has a deep, wide, oblique furrow on the sides at the base; the middle is indistinctly keeled, and has a short transverse depression shortly beyond the middle; the apical segments are thickly covered with long hair.

ONTSIRA, *gen. nov.*

Occiput margined. Mesonotum trilobate, the middle lobe furrowed in the centre. Median segment with ten clearly defined areæ. Wings with three cubital cellules; the apical abscissa of the radius curved upwards; the transverse probrachial nervure interstitial; the anal nervure interstitial; the hind wings with only one longitudinal nervure. Head cubital; largely developed behind the eyes, but not projecting beyond them laterally. Oral region as in *Bracon;* the mandibles with a sharp apical tooth. Probrachial areolet as long as præbrachial; the radial nervure in hind wings obsolete; the probrachial cellule divided into two by a nervure.

The eyes are prominent and distinctly distant from the base of the mandibles; the antennæ have over twenty joints; the apical ones are broken off; on the under side of the mesopleuræ is a wide longitudinal furrow; the petiole is widely and deeply depressed at the base; the abdominal segments are smooth, without punctures or depressions of any kind; there is no securiform articulation; the separation of the segments is hardly distinguishable; the hinder coxæ at the base have a perpendicular slope and are roundly incised there, and in the centre beneath project into a short, somewhat conical, tooth; the trochanters are rather longer than usual; the four anterior tibiæ are slightly bent at the base; the calcaria are very short; the claws simple. In the hind wings the costal and præbrachial cellules are distinct; the probrachial nervure is united to the præbrachial; and in the middle of the probrachial cellule is an oblique nervure dividing it into two; the radius is obsolete; the cubitus complete, extending to the apex; the probrachial nervure is obsolete; the probrachial and the anal cellules being thus united into one.

This genus comes near to *Doryctes*, with which it agrees in some respects; but may readily be known from it by the transverse probrachial nervure being interstitial and consequently the præbrachial and the probrachial areolets equal in length, and by the probrachial areolet in the hind wings being divided into two by a transverse nervure. In *Doryctes* there are only five areæ on the metanotum, instead of ten as in our genus. Characteristic is the curved apex of the radius and of the base of the cubital nervure.

ONTSIRA RETICULATA, *sp. nov.*

Nigra; tegulis, trochanteribus basique tibiarum albis; tarsis testaceis; alis hyalinis, stigmate nervisque testaceis. ♀.

Long. 6, terebra 3 mm.

Antennæ black; the flagellum densely covered with short stiff pubescence; the scape shining, sparsely haired. Head shining; below the eyes is a large, dirty-testaceous mark; front and vertex sparsely pilose; impunctate; the space over the antennæ is minutely, irregularly striated; there is a shallow, small, round fovea above each antenna; the face is strongly aciculated, especially in the middle; the projecting clypeus is more strongly punctured; over its top is a curved furrow. Mandibles testaceous; the teeth black; the palpi white. Mesonotum opaque, strongly aciculated; the parapsidal furrows transversely striated; in the middle of the central lobe is a shallow, punctured, longitudinal furrow. Scutellar depression large, deep, closely punctured, keeled down the middle. Scutellum closely punctured; the post-scutellum depressed, bordered by distinct keels laterally. The base of the median segment is smooth; down its middle runs a straight keel; on the sides, inside the spiracles, is a curved keel, the curve being towards the centre; in the middle, joined to the central basal keel, is an area, slightly more than twice as long as broad; somewhat triangular in shape and wider at the base; the lateral keels curve inwards; inside, it is closely, transversely striated; at the end of this area is a shorter, almost square one; and outside it is a larger, wider one, which is narrowed on the outer apical half, the keel bounding this part being curved; inside it in the middle are two transverse keels, on the upper outer side are two keels, one straight, the other curved. There are thus four basal, two central and four apical areæ, or 10 areæ in all. Propleuræ finely striated above; the lower part more strongly striated, all the striæ being distinct; the mesopleuræ smooth and shining; the metapleuræ finely rugose. Mesosternum smooth; the central furrow striated. The coxæ black; the anterior obscure testaceous in front; the trochanters white; the femora black; the anterior more or less testaceous; the tibiæ are broadly white at the base; the tarsi rufo-testaceous. Wings hyaline, strongly iridescent; the tegulæ white; the nervures are dark fuscous; the stigma is pale at the base. Abdomen smooth, shining, impunctate, except the raised central part of the petiole, which is distinctly longitudinally striated.

AGATHIDES.

DISOPHRYS ERYTHROCEPHALA, *sp. nov.*

Nigra; capite, prothorace, mesothorace pedibusque anterioribus rufis; alis violaceo-fumatis. ♂.

Long. 10 mm.

Antennæ black; the scape thickly covered with white hair. Front and vertex smooth, shining, impunctate; a stout keel runs from the hinder ocelli to the outer side of the antennæ; the antennal keels are stout; looked at from the front their lower part is triangular. Face and clypeus thickly covered with longish fuscous hair; the clypeus broadly and roundly keeled in the middle; its apex obliquely and roundly depressed; the depression margined above and below; the tops of the mandibles blackish. Prothorax smooth and shining, the upper part of the pronotum stoutly margined; mesonotum smooth and shining, covered with long fuscous hair; the depression at the apex of the central lobe is large, and has at the base two stout keels which are curved backwards in the middle. Median segment depressed at the base; in the middle is a large area wider than long, depressed at the apex, where the bounding keels are stouter; there is a similar, but smaller, area at the apex. The apex of the propleuræ, the curved depression on the mesopleuræ, and the apex of the latter are stoutly striolated; the lower part of the metapleuræ irregularly, stoutly, longitudinally reticulated. Mesosternum thickly covered with fuscous hair; the furrow is wide, crenulated; its apex is black, wider, and has two longitudinal keels, united by a transverse one. Wings uniformly dark, smoky violaceous, with black stigma and nervures; the branch on the second transverse cubital nervure is short and is placed above the middle. Abdomen smooth and shining, the base of the petiole depressed. The anterior legs are entirely rufo-fulvous; the middle pair rufo-fulvous, with the coxæ and trochanters black.

This species comes near to *D. ruficollis* Cam. (*Manchester Memoirs*, vol. xliii. p. 98), but that species may be known from it by the mesonotum only being rufous, not the entire mesothorax, and by the wings being yellowish hyaline.

DISOPHRYS (?) OPHIPPIUM, *sp. nov.*

Nigra ; prothorace, mesonoto, scutello, mesopleurisque supra rufis ; alis fumatis, stigmate nervisque nigris ; pedibus nigris, tarsis anterioribus albis ; tibiis antecis testaceis. ♂.

Long. 8 mm.

Antennæ black ; the scape covered with white hair ; the flagellum thickly with black pubescence. Head smooth and shining ; the face and clypeus thickly covered with white hair ; the clypeal foveæ deep ; the depression below the antennæ deep, triangular ; the two antennal keels stout, laterally oblique. Mandibles and palpi black, thickly covered with white hair. Middle lobe of the mesonotum finely punctured ; a distinct keel down the middle of the basal half ; the furrows are obscurely crenulated. Scutellar depression deep, smooth ; a distinct, sharp keel down its centre ; its centre at the base is raised and bluntly keeled ; the sides and apex above have a raised margin. The base of the median segment is obliquely depressed ; the apex of the segment has an oblique slope, and is bordered above by a stout keel ; the centre is depressed, the sides raised, the top of the raised part narrowed and rounded ; the oblique apex is obliquely striated ; the striæ converging towards the middle. The lower part of the propleuræ is irregularly obliquely striated ; the mesopleuræ black, red at the base and broadly above ; below thickly covered with white hair ; the apex above deeply depressed ; behind the middle is an oblique row of stout, irregular striæ. Metapleuræ finely rugose ; on the basal half are two stout, widely separated keels ; below is a stout angularly curved one ; the apex has some stout, oblique keels. Mesosternum closely punctured ; the central furrow is stoutly crenulated. Legs thickly covered with white pubescence ; the front tibiæ and the base of the middle pair testaceous ; the four anterior tarsi white. Abdomen smooth and shining ; the centre of the petiole raised; the sides carinate. The tranverse cubital nervures converge, but do not touch above; the first is oblique, straight; the second is oblique above and thicker than below.

It is doubtful if this can be regarded as a *Disophrys* inasmuch as the branch on the transverse cubital nervure can hardly be said to exist; in other respects it agrees fairly well with the genus.

OREBA, *gen. nov.*

Fore wings with three cubital areolets; the first cubital areolet not separated from the prædiscoidal; the second transverse cubital nervure emitting a branch from its middle. Face not narrowed to a point; the vertex excavated; a broad keel between the antennæ; the face projecting broadly in the middle. Mandibles with a minute subapical tooth. Mesonotum distinctly trilobate; mesopleuræ with a wide striolated furrow. Metanotum irregularly reticulated; its sides at the apex largely triangularly produced. Legs stout, the claws sub-bifid. Abdomen sessile; the second dorsal segment with a broad transverse furrow.

Head narrower than the thorax; eyes prominent, parallel, not reaching to the clypeal foveæ; face broadly carinate, not separated from the clypeus by a suture; the hollowed part of the front is bordered by a distinct stout keel; the ocellar region is raised; the occiput is not margined. The thorax is largely developed in front of the tegulæ; the propleuræ are deeply excavated on the lower part; the mesosternum broadly excavated. There is a large, clearly defined area in the middle of the median segment, which is triangular at the base. Scutellum roundly raised; the depression at its base deep. Antennæ short, thick; the flagellum pilose, tapering towards the apex.

Legs stout; the tibiæ and tarsi covered densely with short thick hair; the outer fork of the claws is long and curved; the basal one shorter and thicker.

Comes nearest to *Microdus*; may be known from it by the square second cubital cellule; by the second transverse cubital nervure emitting a short thick branch; and by the mesonotum being more distinctly and deeply trilobate. The transverse probrachial nervure is interstitial; the recurrent nervure is received shortly in front of the first transverse cubital.

OREBA PURPUREA, *sp. nov.*

Purpurea, facie coerulea; antennis tarsisque nigris; alis fusco-violaceis. ♀.

Long. 13 mm.

Antennæ not much longer than the head and thorax; distinctly tapering towards the apex, thickly covered with stiff black pubescence. Face and clypeus indigo-blue, spotted at the sides and top with black; the face carinate; the sides of the keel broad, oblique; the sides and upper part thickly covered with short white pubescence; the clypeal foveæ large, deep. Mandibles black, shining. Thorax bright purple, shining; the pleuræ and metanotum sparsely covered with white hair; the mesonotum punctured, but not closely; its base transverse, rounded laterally; the middle lobe is large, its apex triangular, obliquely depressed; the sides of the lateral lobes at the apex have also an oblique slope; there are two straight furrows in the centre of the middle lobe which reach to the base of the apical slope. Scutellum roundly convex; sparsely punctured; the basal depression large, smooth, and bearing three longitudinal keels; the post-scutellum closely punctured. The base of the metanotum depressed; in the middle is a distinctly defined area, slightly wider than long, and raised in the middle at the apex; the rest is irregularly rugose, except for a large area in the centre, which is triangular or lanceolate at the base, and is marked with three transverse keels; the spiracular area is bounded on the inner side by a stout, curved keel. Propleuræ closely punctured; the upper part triangularly raised in the middle; the lower part in the centre deeply depressed and marked with some keels. Mesopleuræ closely punctured; the lower depression deep, wide, striated throughout. Mesosternum closely punctured; the central furrow bearing stout, transverse keels. The upper half of the metapleuræ closely punctured; the lower irregularly, closely, obliquely rugose. Wings dark, smoky violaceous; the nervures black; there is a hyaline mark in the first cubital cellule, and one outside and below the recurrent nervure. The tibiæ and tarsi are thickly pilose; the hinder coxæ closely punctured. Abdomen smooth, shining, glabrous.

ICHNEUMONIDÆ.

PIMPLIDES.

HABROPIMPLA, *gen. nov.*

Areolet oblique, the transverse cubital nervures uniting at the top or shortly appendiculated; the basal abscissa of the radius distinctly curved upwards at the base. Head broader than long; the clypeus separated from the face, obliquely depressed at the apex. Mandibles with two equal teeth at the apex. Mesonotum shining, the parapsidal furrows obsolete. Scutellum rather flat, longer than broad, slightly narrowed towards the apex. Metanotum smooth; the middle stoutly transversely striolated; the sides at the apex stoutly keeled; the spiracles large, linear, of equal width, rounded at the ends and placed shortly behind the middle. Legs stout, formed as in

Pimpla. Abdomen smooth, shining, almost impunctate; the petiole depressed at the base above; tuberculate behind the middle, where the spiracles are; the second, third, and fourth segments with oblique depressions at the sides. The eyes are slightly contracted on the inner side above and margined.

This genus comes near to *Chrysopimpla*, not only in the presence of the yellowish colour, but in the form of the areolet and in the curved apex of the radius: but differs from it in the face not being so elongated; in the much shorter clypeus, which is obliquely depressed at the apex; in the eyes being more distant from the base of the mandibles; in the spiracles being placed more behind the middle of the petiole; in the hinder tarsi being more slender and longer compared with the tibiæ; and in there being no cloud at the apex of the fore wings.

HABROPIMPLA BILINEATA, *sp. nov.*

Nigra; scapo antennarum, scutello, lineis 2 metanoti pedibusque stramineis; alis fulvo-hyalinis, nervis stigmateque nigris. ♂.

Long. 14 mm.

Scape of the antennæ yellow, black above, punctured; the apex with pale hairs; the flagellum thickly covered with short stiff hairs; the basal part brownish beneath; the apical joints slightly dilated at the apices. Head black, except for a yellow mark at the sides near the clypeus; the clypeus and labrum brownish (perhaps a discoloured yellow), the centre of the clypeus broadly black. Mandibles black; the palpi rufous-yellow, covered with white hairs. Face rugosely punctured, the centre indistinctly keeled; the clypeus smooth and impunctate; the front and vertex smooth; the ocelli bordered by furrows. Thorax black; the tegulæ, tubercles, a line on the apical part of the pronotum, narrowed in the middle, broadly dilated at the apex, the scutellum, a line on the sides of the median segment, narrowed at the base, the apex broadly dilated on the inner side before the apex, lemon-yellow. Mesonotum smooth, shining, thickly covered with fuscous pubescence. Scutellum smooth, sparsely covered with long fuscous hair, post-scutellum impunctate, covered thickly with long fuscous hair, separated from the scutellum by a narrow deep depression; the depression at its sides wide, shallow, smooth. Median segment without areæ or keels; the base depressed in the middle; the middle at the base smooth, at the sides obscurely roughened; the middle part stoutly transversely striolated; the apex smooth, impunctate. Pro- and meso-pleuræ smooth, impunctate; the apices of both crenulated; the metapleuræ above and at the apex closely and finely striated. The four front legs are entirely stramineous yellow; the hinder coxæ black; broadly yellow in the middle above; the trochanters yellow, piceous at the apex; the femora black, yellow above; the tibiæ yellow, narrowly black at the base, more broadly at the apex, and the hinder tarsi entirely black. Abdomen black; the sides of the basal three segments broadly, their apices narrowly, the fourth with the sides at the apex, and the apex itself narrowly, and the fifth with the apex at the sides, lemon-yellow; the 2nd—4th abdominal segments yellow. The basal three segments shallowly punctured; the gastrocoeli oblique, narrow, smooth, extending shortly beyond the spiracles; on the base of the third segment is a broad, shallow, oblique depression. The quantity of black on the legs varies, especially on the femora.

CÆNOPIMPLA, *gen. nov.*

Second transverse cubital nervure obsolete, the first short, the cubital nervure in front of it with a sharp, oblique slope; the basal and apical abscissæ of the radius oblique; the transverse basal nervure insterstitial; stigma large. Clypeus not separated from the face by a suture. Mandibles with one longish, sharp, apical tooth. Parapsidal furrows distinct, deep. Scutellum slightly raised, narrowed towards the apex; its sides keeled. Median segment completely and distinctly areolated; the supramedian area longer than broad, its sides oblique at the base; the spiracles are small, circular. Legs normal; the claws simple; the fore tarsi incised at the base. The petiole is broadly raised, the raised part keeled laterally; the upper and lower outer sides are also keeled; the spiracles are placed shortly behind the middle; the second, third, and fourth segments are longitudinally striated, with broad, transverse depressions.

A distinct and somewhat isolated genus. It is easily known by the absence of an areolet, by the parapsidal furrows and by the areolated metathorax. Its general coloration, form and spotted wings, give it the appearance of a *Hemiteles.*

CÆNOPIMPLA RUFICOLLIS, *sp. nov.*

Nigra; prothorace, mesonoto, scutello mesopleurisque supra rufis; alis hyalinis, fusco-bifasciatis, stigmate fusco; pedibus anterioribus pallide testaceis, posticis nigris, basi tibiarum albo. ♂

Long. 5 mm.

Antennæ black; the basal two or three joints dark brownish; the joints thickly covered with short, stiff, black hair. Face and clypeus closely rugosely punctured, and covered with short white hair; the apex of the clypeus rounded, depressed, margined. Base of mandibles black; the middle yellowish, the apex piceous; palpi long, pallid yellow. Thorax rufous; the sterna, the lower part of the mesopleuræ and the whole of the metathorax, black. Mesonotum closely punctured; the middle lobe finely transversely striated; the central lobe is distinctly separated. Scutellum rugosely punctured, narrowed towards the apex. Median segment with all the areæ clearly defined and punctured; the supra median is longer than broad; the base transverse in the middle; the sides oblique; the apex transverse. Pro- and meso-pleuræ closely punctured, striated in the middle; the apex of the mesopleuræ smooth above; the metapleuræ strongly rugose. Wings hyaline; there is a cloud extending from near the top of the transverse basal nervure (broadest on the inner side) to the opposite side of the wing, and a broader one extending right across from near the base of the stigma to the base of the apical third of the radial cellule. The four anterior legs are pale testaceous; the coxæ black at the base; the hinder legs black; the trochanters and base of tibiæ white. Abdomen black; the apices of the first and second segments testaceous; the petiole is almost impunctate above; the middle keels do not extend to the apex; the sides are bordered above and below by keels, and are finely punctured; the second, third, and fourth segments are longitudinally striated, the striæ becoming gradually finer and closer; the transverse depression on the fourth segment is broader and more curved than that on the third; the depression on the fifth is broad, curved, and separated by a longitudinal keel in the middle; the apical segments are densely covered with white hair.

BANCHI.

BALIENA, *gen. nov.*

Areolet small, oblique, the transverse cubital nervures touching above; the lower side angled; the apical abscissa of the radius is curved upwards. Eyes larger than usual; distinctly converging beneath, reaching close to the base of the mandibles. Clypeus small, twice as broad as long; its apex semicircularly depressed. Mandibles broad at the base, narrowed at the apex, which has one tooth. Face roundly convex, reaching near to the lower side of the eyes. Occiput immarginate. Mesonotum trilobate; the middle lobe triangular at the apex. Scutellum large, flat. Median segment elongate, nearly as long as the mesothorax; it has a gradual slope to the apex, has the small, somewhat oval, spiracles in the middle, has no keels, and is closely, but not strongly, reticulated. Legs long, slender; the hinder coxæ large, as long as the petiole, which becomes gradually wider towards the apex; the spiracles on the petiole are circular and are situated shortly before the middle; the apex of the petiole is not curved. Claws bifid. Ovipositor longer than the abdomen, and issuing from a ventral cleft.

The abscissa of the radius is curved upwards at the base; the transverse basal nervure is interstitial; the recurrent nervure is received at the base of the apical third; the second transverse cubital nervure is faint; the recurrent nervure is largely bullated in the middle; the sub-discoidal nervure issues from the middle.

Comes near to *Banchus* and *Exetastes;* the former may be known from it by the pectinated claws: the latter by the different form of the face and clypeus; by the metathoracic spiracles being placed behind the middle; and by the shorter legs.

BALIENA LEPTOPUS, *sp. nov.*

Nigra; pedibus fulvis, coxis nigris, tibiis posticis albis, medio late nigris, apice nigris; alis hyalinis, nervis stigmateque nigris. ♀.

Long. 14; terebra 12 mm.

Antennæ black; the middle broadly clear white; the scape brownish beneath, shining, almost bare. Head black, shining; the face and the lower part of the front yellowish-white, impunctate; the vertex and face sparsely covered with long, pale fuscous hair, and the face also with white pubescence; the apex of the clypeus brownish; the mandibles entirely black, shining; the palpi yellow. The pro- and meso-thorax plumbeous black; the tegulæ, tubercles, scutellum, post-scutellum, and the hinder edge of the mesopleuræ above, yellow; the mesonotum somewhat strongly punctured; the apex of the middle lobe and the inner sides of the lateral transversely striated. Scutellum black and wrinkled at the base; the rest of it with shallow punctures; the post-scutellum impunctate, shining; the depressions at the sides of the scutella smooth; the sides of the scutellum obscurely, longitudinally striated. Median segment opaque; the middle strongly reticulated, more closely at the sides and apex than at the base; the segment has a gradually oblique slope. Pro- and meso-pleuræ smooth and shining; the pro- almost bare, the meso- and metapleuræ thickly covered with long grey hair; the metapleuræ strongly and closely reticulated; the lower separated from the upper part by a narrow, but distinct, curved keel; shortly beyond the middle, touching it on its lower side, is a large, deep, smooth fovea. The four front legs fulvous, the tibiæ of a paler, more yellowish tint, their coxæ black, white in front; the hinder coxæ black;

their sides, inside and out, broadly pale yellow; the basal joint of the hinder trochanters yellow, the apical black; the apex of the hinder femora and the middle of the hinder tibiæ black; the yellow on the apex of the latter being more extended than it is at the base, the apex of the tarsi black. Wings hyaline; the stigma and nervures black; the areolet small; the transverse cubital nervures uniting at the top; the recurrent nervure received in the apical third; the transverse median nervure is interstitial. Abdomen shining, impunctate; the base of the petiole broadly, the apex more narrowly, and the apices of all the other segments, yellow, as is also the ventral surface, except the apex of the petiole, which is black.

TRYPHONIDES.

MESOLEPTUS ANNULIPES, *sp. nov.*

Niger, flavo-maculatus; antennis pedibusque rufis, coxis trochanteribusque anterioribus flavis, tibiis tarsisque posticis fusco-nigris, basi albis; alis hyalinis. ♂.

Long. 8 mm.

Antennæ slender, not tapering towards the apex; covered with a microscopic pubescence; the scape and base of the flagellum blackish above; the third joint is nearly twice the length of the fourth. Head black, shining; the face, clypeus, mandibles, palpi, and inner orbits in front to nearly opposite the hinder ocelli, yellow; the front and vertex impunctate; the face and clypeus rather strongly, but not closely, punctured; the middle of the face roundly projecting; the mandibular teeth subequal, black. Thorax black, a triangular mark on either side of the base of the mesonotum—the narrow end on the outer side, the scutellum, tegulæ, tubercles, a small mark immediately under the hinder wings, and a somewhat triangular oblique mark in front of the hinder coxæ, yellow. Mesonotum distinctly, but not closely, punctured; there are no furrows. Scutellum roundly convex, yellow, black round the edges, more sparsely punctured than the mesonotum. Post-scutellum impunctate, bare, obliquely widened towards the apex; its base distinctly separated from the scutellum. Median segment with a gradually rounded slope, closely, rather strongly and uniformly punctured, and thickly covered with short white hair. Pleuræ closely punctured, the base of the propleuræ, and the apex of the mesopleuræ on the lower half, smooth and impunctate. Mesosternum closely punctured, the central furrow shallow. The four front legs are pale rufo-fulvous; the coxæ and trochanters are pallid yellow; the hinder coxæ, trochanters and femora, bright rufous; the tibiæ fuscous, darker above, white at the base; the tarsi black, the metatarsus white to near the middle. Wings short, as long as the abdomen; hyaline, slightly smoky at the base; the areolet triangular, the nervures uniting at the top, not appendiculate; the recurrent nervure is received shortly in front of the second transverse cubital, almost interstitial; the transverse median nervure is received shortly in front of the transverse basal. Abdomen smooth and shining; the basal half of the petiole, the base of the second, third and fourth, and the apices of the two apical segments, pale yellow.

The *Tryphonides* are very numerous in the northern parts of the Palæarctic and probably also in the Nearctic zoological regions, but are little known outside them. A large number are known to be parasites on *Tenthredinidæ.*

MESOLEPTUS KHASIANUS, *sp. nov.*

Niger; abdomine rufo, petiolo nigro; pedibus anterioribus *flavo-testaceis, posticis rufis; coxis, apice tibiarum posticarum tarsisque posticis nigris; alis hyalinis, nervis stigmateque nigris.* ♂.

Long 12 mm.

Scape of antennæ yellowish rufous, thickly covered with black hair; the flagellum rufous, darker above, especially towards the apex. Head black; the face, clypeus, base of the mandibles and palpi, yellow; the face darker in the centre; closely and strongly punctured, covered thickly with short fuscous hair; the clypeus with the hair longer and paler; its apex smooth, impunctate; the base with punctures, which are larger, deeper, and more widely separated than those on the face. Mandibles strongly punctured at the base, and thickly covered there with long white hair; the palpi thickly covered with white pubescence. The thorax black; thickly covered with short white pubescence; the tegulæ and the base of the scutellum yellow. Mesonotum closely punctured; the middle at the base slightly raised; the scutellum with the punctures more widely separated at the base; the post-scutellum finely punctured, the base forming a semicircular depression; the sides at the apex are bordered by a distinct keel. The median segment has a gradually rounded slope; is closely and strongly punctured and covered with long white hair; there are no areæ; in the centre at the base are two stout, slightly converging keels; there is a distinct curved keel outside the spiracles. The four anterior legs are pale fulvous, the coxæ and trochanters pallid yellow; the hinder coxæ are black, except at the extreme apex and in the middle beneath; the trochanters are yellow, tinged with rufous; the femora and tibiæ rufous; the apex of the tibiæ and the tarsi black; the spurs testaceous. Wings clear hyaline; the areolet triangular; the nervures uniting at the top; the first straight, oblique; the second curved;

the recurrent nervure is received in front of the transverse cubital, almost touching it; its upper half is broadly curved, its lower straight, oblique; the curved part is broadly bullated at the top and bottom; the second transverse cubital nervure is largely bullated at the bottom; the transverse median nervure is received in front of the transverse median, not touching it. The petiole becomes gradually dilated from the base to the apex; the base has a semicircular depression, inside of which are a few longitudinal striations; beyond this is a shallow, strongly aciculated depression which becomes gradually narrowed to the apex; the second segment is distinctly furrowed on the basal half at the sides; the gastrocœli rufous, shallow, finely striated.

AITHRIS, *gen. nov.*

Head buccate. Eyes large, not converging below; reaching near to, but still distant from, the base of the mandibles; above, on the inner side, there is a distinct rounded incision. The clypeus not defined from the face; the mandibles have two stout apical teeth. Behind, the head is not much developed and is obliquely narrowed; the occiput immarginate. Scutellum flat; the sides stoutly keeled to shortly beyond the middle; there are two foveæ at the base of the post-scutellum. Metathoracic spiracles large, linear; outside them is a stout, obliquely bent keel. Legs stout, the femora thickened; the calcaria short and thick; the last joint of the hinder tarsi as long as the preceding three joints united; the claws stout, simple; there are two spurs on the hinder tibiæ. Wings without an areolet; the first abscissa of the radial nervure straight, oblique; the second curved upwards at the base; the recurrent nervure is curved and is almost interstitial with the transverse cubital; the transverse median nervure is received on the outer side of the transverse basal. Petiole as long as the second and third segments united ; from the middle it becomes gradually dilated ; the small round spiracles are placed shortly beyond the middle ; the upper part of the sides are keeled to the spiracles ; the lower part keeled to the end ; the gastrocœli are obsolete ; the segments become gradually wider towards the apex.

The basal two joints of the flagellum are equal in length ; the mesopleura bulges out broadly in the middle and is broadly depressed behind ; its base has an oblique slope, and is keeled on the top. The antennæ are placed high up on the face, opposite the eye incision ; above them, on the lower part of the front, is a distinct projection which is widened above ; the top deeply depressed in the middle ; the labrum is not exserted. Metanotum not areolated. Ocelli large, placed in a triangle. Abdomen smooth and shining, the second to fourth segments equal in length. The basal joint of the anterior tarsi is incised at the base ; the apical joint is as long as the basal ; the middle ones short and thick ; the calcaria stout, reaching to the middle of the metatarsus.

Belongs to the *Tryphonides* and comes near to *Exochus*, but is abundantly distinct from anything described.

AITHRIS CŒNUTUS. *sp. nov.*

Niger; antennis rufo-testaceis, femoribus, tibiis tarsisque anticis, basique tibiarum posteriorum, dimidio apicali segmenti abdominis secundi segmentoque 3-o flavis ; alis hyalinis, stigmate nervisque fuscis. ♂.

Long. 7 mm.

Antennæ as long as the body, rather stout, not tapering much towards the apex ; thickly covered with short pale hair. Head black ; the apex of the clypeus, and the mandibles broadly at the base, rufo-testaceous; the palpi yellow; the face strongly punctured; the punctures large, deep, and clearly separated; the front and vertex smooth and shining, sparsely and shortly haired; the face rather thickly covered with long pale hair. Thorax black, smooth and shining; the tegulæ, scutellum and post-scutellum, lemon-yellow; the pleuræ and metanotum thickly covered with long pale hair; the propleuræ crenulated at the apex; the mesopleuræ finely punctured; the apical half of the mesopleuræ largely excavated. Mesosternum thickly covered with long fuscous hair; its middle depressed. On the metapleuræ, enclosing the spiracles, are two curved longitudinal keels, which converge towards the apex; the distance between them at the base being greater than at the apical half. Legs black; the anterior legs, except at the base and for a large mark on the femora behind, the middle knees, basal half of tibiæ and tarsi, and the basal two-thirds of the hinder tibiæ, lemon-yellow; the hinder tarsi fuscous. Wings hyaline; the stigma and nervures fuscous. Abdomen smooth and shining, deep black; the apex of the petiole, and the second segment entirely, lemon-yellow.

TILGIDA, *gen. nov.*

Fore wings without an areolet, the only transverse cubital nervure very short, so that the cubital and the radial nervures approach each other very closely; the recurrent nervure is received about four times its length from it; the transverse median is received shortly behind the transverse basal. Eyes very large, their inner orbits straight and converging slightly, but distinctly, on the lower side; the orbits are very little developed behind, and are roughly striated above. Clypeus small, its apex transverse; the labrum is longer than it. Mandibles somewhat triangular at the base, curved, narrowed towards the apex, and bluntly toothed there. Palpi longish. Antennæ long and slender. The fore lobe of the mesonotum is largely raised and does not reach to the middle of the mesonotum, which is depressed behind it. Scutellum large, only slightly roundly raised. The median segment is elongate, has a gradually rounded slope to the apex and has no keels; its spiracles are oval and are placed beyond the middle, half-way between it and the apex in a hollow. Abdomen long and slender; the petiole long and slender, not curved at the apex, longer than the second segment; its spiracles small, round, and placed shortly beyond the middle; the gastrocœli are small, indistinct. Legs long and slender; the hinder coxæ large; the tarsi spinose; their claws long, curved and thickened at the base; the front tarsi are bent at the base; the fore calcaria curved, pilose.

Unfortunately I have only a ♂ of this genus. In the form of the abdomen it does not differ much from *Mesoleptus*, but in other respects it differs completely from that and from any known genus of the *Tryphonides*. It is undoubtedly nearly related to *Baliena*, as is shown by their agreement in the form of the head, thorax, and legs, but differs in the fore wings wanting the areolet.

TILGIDA ALBITARSIS, *sp. nov.*

Nigra; facie, annulo flagelli antennarum late, scutello, post-scutello, apice metanoti basique pronoti flavis; pedibus flavis, coxis femoribusque posticis fulvis; dimidio apicali tibiarum posticarum nigris; alis hyalinis. ♂.

Long. 12 mm.

Antennæ black; the scape and the 13th—25th joints of the flagellum white; the basal joints of the flagellum yellowish beneath. Head black; the face yellow, smooth, covered sparsely with white hair; the base of the clypeus black, the depressed apex brownish; the hairs on the clypeus are longer than those on the face. Mandibles black; the palpi yellow. Mesonotum closely and strongly punctured; the depressed apex obscurely striated. Scutellum covered with large shallow punctures, and sparsely with white hair; the post-scutellum smooth. Median segment closely, and rather strongly, transversely striated, broadly furrowed down the middle of the black part; the yellow apex is finely transversely striated. Propleuræ shining; the base broadly yellow above, more narrowly below. Mesopleuræ obscurely punctured, finely longitudinally striated above at the tubercles, and below in front of the coxæ. Metapleuræ closely obliquely striated, punctured at the base. Mesosternum punctured, covered thickly with fuscous hair, and with a shallow furrow down the middle. The four anterior legs yellow, their tarsi blackish; the hinder coxæ and femora fulvous, the coxæ black at the apex above; the apical joint of the trochanters broadly black above; the apex of the femora, almost the apical half of the tibiæ, and the two apical joints of the tarsi, black. The cubital nervure approaches close to the radial, being united to it near the middle by a short thick branch; the recurrent nervure is received at four times the length of this branch from it. Abdomen black; all the segments broadly yellow at the apex; the petiole rough, smooth at the base, the middle depressed; the gastrocœli pale yellow, distinct, deep; the four apical segments are thickly covered with white hair.

ARTHULA, *gen. nov.*

Antennæ stout, not tapering much towards the apex, 29-jointed. Head not much developed behind the eyes, which are large, parallel, and do not reach to the base of the mandibles. Clypeus small, separated by a suture from the face, its apex obliquely depressed transversely ; the labrum prominent, rounded. Mandibles stout, short, ending in two subequal teeth. Parapsidal furrows distinct. Scutellum large, roundly convex. Median segment with one transverse keel near the base ; its spiracles moderately large, linear, rounded at the base and apex. Wings without an areolet, there being only one transverse cubital nervure; the cubital and radial nervures almost united, the transverse cubital nervures being very short ; the recurrent nervure is interstitial, as is also the transverse median ; the discoidal nervure is obliquely curved on the basal half. Legs elongate, especially the hinder pair, which have the coxæ large ; the basal joint of their trochanters more than twice the length of the apical ; the tarsi spinose ; the metatarsus as long as the other joints united ; the intermediate and hinder tibiæ with two spurs. Petiole curved ; gradually, but not greatly, dilated towards the apex ; the spiracles placed shortly beyond the middle, the second segment triangular, narrow at the base, becoming gradually wider towards the apex, which is transverse ; the gastrocœli indistinct ; the third and following segments are wider than long ; the third, fourth and fifth segments have large depressions on the sides, their middle roundly raised, the hypopygium large, triangular at the apex, flat ; the cerci short, stout, pilose.

The short thick antennæ with comparatively few joints, and the similarity in the alar neuration, might place it near *Acoenites*. In the absence of the ♀, its exact relationship cannot be very clearly defined.

It comes nearest to the *Tryphonides* and is closely related to *Chreusa*, *Hemigaster* and *Macrogaster*, with which it agrees in the neuration of the wings and in the paucity of joints in the antennæ, but may be known from all of them by the median segment having only one transverse keel, and consequently no areaæ; by the metatarsus being longer than all the other joints united; and by the more slender petiole. As, owing to the similarity of the alar neuration, these little-known genera are apt to be confounded, it may be advisable to give a synoptical table of their differences.

A. Middle lobe of the mesonotum triangular, transverse at the base; the legs short, stout, the fore claws bifid.
- Colour black; the median segment areolated all over, the spiracles placed behind the middle of the petiole. *Macrogaster.*
- Colour luteous, the median segment not areolated all over; the spiracles placed in the middle of the petiole. *Chreusa.*

B. Middle lobe of the mesonotum not triangular, rounded at the base; the legs long and slender; the fore claws simple.
- Median segment areolated, the post-petiole distinctly dilated; the metatarsus not longer than the other joints united. *Hemigaster.*
- Median segment not areolated, the post-petiole not dilated; the metatarsus longer than all the other joints united. *Arthula.*

ARTHULA BRUNNEOCORNIS, *sp. nov.*

Nigra; capite thoraceque flavo-maculatis, pedibus nigris, flavo-maculatis; abdomine ferrugineo; alis hyalinis, stigmate fusco. ♀.

Long. 11—12 mm.

Antennæ as long as the abdomen, stout, scarcely tapering towards the apex, dark brownish, darker above; the scape bright lemon-yellow. Head black; the face, clypeus, labrum, and the orbits all round, lemon-yellow; the base of the clypeus, an oblique mark on either side of its base, and the mandibles, except before the apex, black. The face is flat, and closely punctured; the basal part of the clypeus projects slightly and roundly; its apex is obliquely depressed; the front and vertex closely punctured; the former with a broad longitudinal furrow. Thorax black; a broad band on the pronotum, the tegulæ, a mark on the base of the parapsidal furrows, the apical half of the scutellum—the mark narrowed in the middle at the base and apex—, the scutellar keels, post-scutellum, the space at their sides, a large mark on the apex of the median segment, narrow at the base, becoming gradually wider towards the apex, which is obliquely narrowed, the lower part of the propleuræ, the tubercles, a perpendicular mark on the base of the mesopleuræ, narrow above, becoming wider below, an irregular mark under the hind wing, a larger, more irregular, mark on the lower side near the apex, incised in the middle below, and a large mark on the mesosternum, divided in two by the furrow and narrowed at the base, lemon-yellow. Mesonotum opaque, closely punctured; the parapsidal furrows reaching to the middle; the scutellum somewhat more strongly, but not so closely, punctured; the furrow at its base smooth and shining. The base of the median segment finely and closely punctured behind the only transverse keel; the rest of it much more strongly punctured and striated at the base. Pleuræ closely punctured; the middle of the propleuræ strongly irregularly striated. The mesosternum closely punctured; its furrow narrow, crenulated. The four front legs are pale fulvous, yellowish at the base, the coxæ black at the base; the hinder legs are of a darker fulvous; the coxæ and tarsi yellower; the coxæ largely black on the inner and outer side, the former with the black mark at the base, the latter with it at the apex;

the trochanters are largely black above; the femora marked with black above at the base. Wings clear hyaline, the stigma fuscous, the nervures darker. Abdomen dark ferruginous; the petiole in the middle, and the bases of the segments, black.

Manchester Memoirs, Vol. xliv. (1900), *No.* **16.**

XVI. Some Criticisms on the Modern Theory of Solutions.

By Edgar F. Morris, M.A.

Received and read February 20th, 1900.

Received in the present form September 10th, 1900.

The consideration of an osmotic cell depressed below the surface of the pure solvent gives rise to results difficult to reconcile with the theory of solutions. Imagine an osmotic cell of the usual pattern and of unit area filled with a solution and depressed a distance x below the surface of the pure solvent. The osmotic height above the pure solvent must be constant, independent of the depression x of the membrane; otherwise it would be possible by the aid of two such cells to obtain a machine to work in contravention to the second law of thermodynamics.

On the usual hypotheses, the only new forces introduced by the depression x which can alter the equilibrium are the weight of pure solvent in the column of height x and of unit area, and the weight of solvent in the same volume of solution, since the solvent alone can pass and repass freely through the membrane. Since these forces are in equilibrium the weight of solvent in any volume of solution should be the same as that in an equal volume of solvent.

If the solvent be also considered to be in a kinetic state comparable with that of a gas, a relation is obtained

October 9th, 1900.

between the internal pressure and the real osmotic pressure, which, taking the ordinary estimate of the internal pressure of water, gives a figure differing greatly from the ordinary osmotic pressure, even when corrected for the volume actually occupied by the molecules. For, of course, the pressure actually exerted by a solute is not the osmotic pressure, and consequently is not equal to the theoretical gas pressure. If the solvent and solute were associated in any way there would be no difficulty in the explanation.

An osmotic membrane seems to be only a method for keeping two otherwise completely miscible liquids in contact, in such a manner that their surface tension effects can be observed. In discussing such membranes it is essential to know whether the concentration of the solute is the same at all heights of the column.

The considerable differences that are found between the theoretical and actual osmotic pressures are, on this theory, due to self-combinations or decompositions of the molecules of solute and not to interactions between solute and the solvent. Auwers[1] has shewn that in many cases of association the low osmotic pressure is probably due to interaction with the solvent.

The dissociation hypothesis is of much greater importance. The use of the term "dissociation" is most misleading, since it is impossible to separate finite quantities of the ionized bodies without the application of energy. The ions cannot be considered free, as the products of gaseous dissociation are. The system of electrical charges, supposed to account for the ions not diffusing, has been shewn by Prof. Fitzgerald to be impossible.

From a study of the distribution of picric acid between

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[1] K. Auwers, *Zeit. Phys. Chem.* 30 (1899), p. 300—340.

silk and water Walker and Appleyard[1] found that, on the ordinary theory, the picric acid would be 2·7 times more dissociated in silk solution than in water. Such ions would be very strange bodies. Similar results have been obtained by Georgevics. In any case it is impossible for the ions to be more numerous than the atoms. Yet Ramsay found that certain elements in mercury solution (*e.g.*, sodium, potassium, barium, calcium) gave numbers indicating the presence of more ions than atoms. It is perhaps not surprising that although sodium-amalgam contains ions, it is not an electrolyte.[3] On the other hand the factor of ionisation is frequently less than would be expected (*e.g.*, 1·8 instead of 2 for common salt in water).

The most valuable evidence in favour of the theory is the approximate coincidence between the ionisation figures drawn from osmotic and conductivity methods respectively. Since the investigations of pyridine, benzonitrite, nitro-benzene and acetone solutions by Prof. Kahlenberg, A. T. Lincoln, and others, it has been shewn that none of the predicted regularities hold. Electrolytic solutions being obtained with normal osmotic pressures, in others the ionisation increasing with the concentration. In others no limiting values being obtainable. Now if the ions move about independently this should be shewn by the order of the equation for reactions in which they take part. The catalysis of esters is represented by the equation

$$\mathrm{EtOAC + H + H_2O = EtOH + AcOH + H.}$$

The form of the equation for the reaction constant, and its dependence on the figure called number of ions, is well known. But the equation requires that the H ions and water should always simultaneously hit the ester; unless

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[1] Walker and Appleyard (1896), p. 1339. *Jour. Chem. Soc.*

[2] Ramsay (1889), p. 921. *Jour. Chem. Soc.*

[3] Obach, *Pogg. Ann. Supp.* Vol. vii. (1876), p. 280.

the H ion is in some way combined with the water it is difficult to see how this could occur. It is easy to imagine a loose combination of HCl with H_2O, such that a hydrogen and a chlorine atom would be free enough to exert independent kinetic pressures, but yet be bound to move together as a physical whole. Indeed in the theory of gases, the difficulty is to explain how the parts of a molecule can be so lightly joined as not to exert these independent pressures. Structural chemistry has taught us that parts of a chemical molecule may enter into reactions independently of the result of the molecule, and may be more influenced by their environment than by the rest of the molecules to which they are bound ; *e.g.*, reduction of nitro-ethane and nitro-benzene in acid or neutral solutions. Such combinations would be a stage between mixtures and chemical compounds that react as a whole. It is precisely in such cases as the picric acid solution in silk, that one would expect a large measure of independence in the parts of the combination. On this view the HCl and H_2O combination would be regarded as in a strained condition, requiring a further agent such as the electric current, or the presence of a body like an ester, which can combine with H and OH, and remove them from the system and complete the decomposition of the water. In conformity with this view I found that for the lower esters of acetic acid the M of the formula of Harcourt and Essen is about twice as great as that for hydrochloric acid, and that, therefore, the heat change in the action between HCl and water to form these combinations, is about equal to that between the ester and these combinations. Whenever the combination is broken up by the ester, the liberated HCl would meet a water molecule in an infinitesimal time, and the original number of combinations be re-formed.

PROCEEDINGS
OF
THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Ordinary Meeting, October 3rd, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT referred to the loss the Society had sustained through the death of Mr. Arthur Greg and Mr. Henry Simon (ordinary members), and of Professor Bunsen, Sir W. H. Flower, Sir E Frankland, and Professor Friedel (honorary members), since last session.

Dr. C. H. LEES gave an account of the experiments of Professor J. J. Thomson on the different behaviour of the anode and cathode rays under the influence of the same magnetic field, from which had been drawn the conclusion that, in the case of hydrogen, the mass carrying the positive charge is an atom of the gas, whereas the mass carrying the negative charge is the one-thousandth part of an atom.

Professor H. B. DIXON and Mr. J. D. PETERKIN described their recent experiments on the union of nitric oxide and nitrogen peroxide gases. These experiments point to the conclusion that these gases are not inert to one another when mixed together, but partially combine to form gaseous nitrogen trioxide until an equilibrium is established between the rate of combination and the rate of decomposition of the unstable trioxide. The apparatus used in the experiments was exhibited, and a discussion followed which was participated in by several members.

General Meeting, October 17th, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

Mr. Joseph Ingleby, M.I.Mech.E., Marple Bridge; Mr. George Huxley, M.I.Mech.E., Heaton Moor; and Mr. W. H. Todd, Solicitor, Manchester, were elected ordinary Members.

Ordinary Meeting, October 17th, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The SECRETARY read the address which was recently presented by the Society to Sir George G. Stokes, Bart., on the occasion of the jubilee of his tenure of the Lucasian Professorship of Mathematics at Cambridge University, and also the reply received thereto.

Professor DIXON stated that the restoration of Dalton's tomb had been effected under the direction of the Committee appointed, and that there remained a balance in hand of about £27. It was hoped to raise this sum to £50, and to form a vested fund which would provide for any future repairs that might be necessary.

The PRESIDENT announced the presentation to the Society of a relic of John Dalton, in the shape of his diploma of honorary membership of the Edinburgh Medical Society, to which he was elected in 1818.

Mr. R. L. TAYLOR asked whether any member had verified the statement made in Black's lectures that a bar of iron heated to redness by hammering and allowed to cool, would not bear a repetition of the experiment, but would crack, unless in the meantime it had been re-heated in the fire.

Dr. F. H. BOWMAN and Mr. W. H. JOHNSON stated that they had seen the experiment performed.

Mr. THOMAS THORP read a paper on "**Diffraction Grating Films and their Application to Colour Photography,**" and exhibited an apparatus which showed photographs of objects in their natural colours by the aid of gratings, and without the use of pigments or dyes.

Dr. CHARLES H. LEES read a paper entitled: "**On the Electrical Resistance between Opposite Sides of a Quadrilateral, one diameter of which bisects the other at right angles.**"

The paper is published in full in the *Memoirs.*

General Meeting, October 31st, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

Mr. Jocelyn F. Thorpe, Ph.D, Demonstrator and Assistant Lecturer in Organic Chemistry, Owens College, was elected an ordinary member.

Ordinary Meeting, October 31st, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Dr. G. H. BROADBENT introduced the subject of the well at Giggleswick, known for the ebb and flow of its water, and asked whether an explanation of what is locally known as the "silver thread" could be offered by any member. The well consists of a stone cistern, at the top and back of which the water enters from the Giggleswick Scars, there being two small outlets about half-way down each side of the tank and opposite each other.

Under certain conditions there appears extending through the water, from one orifice to the other, a "thread" apparently formed of air.

Professor REYNOLDS suggested that the phenomenon might be explained by the inflow producing a circulation of the water having its vortex parallel between the two outlets, thus permitting a passage of air from one side to the other.

A paper by Mr. PETER CAMERON, entitled: "**Hymenoptera Orientalia; or, Contributions to a Knowledge of the Hymenoptera of the Oriental Zoological Region. Part IX. The Hymenoptera of the Khasia Hills. Second Paper,**" was communicated by Mr. J. COSMO MELVILL, M.A., F.L.S., the specimens described being exhibited.

The paper will be published by instalments in the *Memoirs.*

Miss WINIFRED FARADAY, B.A., read a paper "**On the Question of Irish Influence on Early Icelandic Literature, as illustrated by the Irish MSS. in the Bodleian Library,**" (communicated by Mr. F. J. FARADAY, F.L.S.).

The paper is printed in full in the *Memoirs.*

Professors Toller and Strachan and Mr. Mark Stirrup took part in the discussion.

Ordinary Meeting, November 14th, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. W. E. HOYLE exhibited a series of flint instruments, &c., from Egypt, forming part of a large collection obtained by Professor Flinders Petrie during the past winter in excavating about twenty miles of cemetery in the western desert between Hu and Dendereh, and since presented to the Manchester Museum. These belonged to various periods, from pre-historic to Roman. Certain types of knives with very finely notched edges and forked lance-heads are very characteristic of the prehistoric age. One cemetery dates from the Libyan settlements in Egypt at the close of the middle kingdom, about 2,400 B.C. Here the graves were all shallow pits of the form known as "pan graves," in which the bodies were laid in a contracted position, but not all in the same direction. From this were obtained several of the strings of beads exhibited. The shell bracelets are very characteristic of this period. Another large cemetery at Hu began in the sixth dynasty, and contained, besides pottery, a large quantity of beads. One large necklace of five strings was of amethyst, others were of cornelian and garnet, whilst in the other sets were metal beads, which from their not having corroded were presumed to have contained a considerable proportion of gold. The collection included a large number of pieces of engraved bone, apparently prepared for inlaying, as well as two beautiful diorite saucers, one circular and the other in the shape of a large *Unio* shell. A block of stone about six inches square, with a circle and two cross lines on the top, once formed the upper part of a short stone pillar, and is believed to have been a surveyor's mark.

A short discussion followed, in which Professor W. BOYD DAWKINS remarked upon the similarity between the Egyptian beads and those known as "wampum" by the North American Indians. The knives with serrated edges were probably meant for ceremonial use, *e.g.*, cutting the first incision in a body about to be mummified. The imitation *Unio* shell was an extraordinary production, a model of this kind being almost unique.

Ordinary Meeting, November 28th, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Professor WEISS exhibited some specimens of *Melanospora parasitica* found by Mr. H. Murray at Flixton. This species of *Melanospora* is now known to be parasitic on another fungus, *Isaria farinosa*, which infests the larvæ and pupæ of various insects. The latter fungus (*Isaria*) is now recognised as being another stage of growth of *Cordiceps militaris*, which has been particularly common this autumn.

"**Report on the Marine Mollusca obtained during the Jackson-Harmsworth Expedition to Franz Josef Land, 1896-7.**" by Mr. J. COSMO MELVILL, M.A., F.L.S, and Mr. ROBERT STANDEN.

The paper will be published in full in the *Memoirs.*

Ordinary Meeting, December 12th, 1899.

HORACE LAMB, M.A., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT announced that the Council had made the following awards:—The Wilde Medal for 1900 to Lord Rayleigh, F.R.S., for his numerous and brilliant contributions to mathematical and experimental physics and to chemistry; a Dalton Medal (struck in 1864) to Sir H. E. Roscoe, F.R.S., for his remarkable original researches in chemistry and for his distinguished services to scientific education; the Wilde Premium for 1900 to Professor A. W. Flux for his papers on economic questions read before the Society. It was also announced that Lord Rayleigh had been invited, and had consented, to deliver the Wilde Lecture for 1900.

The PRESIDENT called the attention of the members to the award of the Davy Medal by the Council of the Royal Society to Dr. Edward Schunck, F.R.S. (an ex president and the oldest member of the Society).

[*Microscopical and Natural History Section.*]

Ordinary Meeting, October 9th, 1899.

MARK STIRRUP, F.G.S., in the Chair.

Mr. ISAAC BAYLEY BALFOUR, Regius Keeper, Royal Botanic Garden, Edinburgh, sent for exhibition a collection of plants from the island of Socotra, which included the following :—

A. (Of morphological interest) *Cocculus balfourii*, *Adenium multiflorum*, *Senecio scotti*, *Euphorbia schimperi*, *Pulicaria stephanocarpa*, *Breweria fastigiata*, *Convolvulus filipes*, *Indigofera marmorata*, *Justicia rigida*, *Croton socotranus*, *Lochia bracteata*, *Dicoma cana*, *Neuracanthus aculeatus*.

B. (Of economic interest) *Buxus hildebrandtii*, *Boswellia ameero*, *B. elongata*, *B. socotrana*, *Balsamodendrum socotranum*, *Dracaena cinnabari*.

C. (Of horticultural interest) *Exacum caeruleum*, *E. gracilipes*, *Cystostemon socotranum*, *Jasminum rotundifolium*, *Lasiosiphon socotranus*, *Euryops socotranus*, *Mussaenda capsulifera*, *Begonia socotrana*, *Hypericum tortuosum*.

D. (Of geographical interest) *camylanthus spinosus*, *Coelocarpum socotranum*, *Rhus thyrsiflora*, *Helichrysum aciculare*, *H. nimmoanum*, *H. suffruticosum*, *H. rosulatum*, *H. sphaerocephalum*, *H. gracilipes*.

E. (Interesting trees, shrubs, and herbs) *Odina ornifolia*, *Ficus socotrana*, *Porana obtusa*, *Vogelia pendula*, *V. indica* var. *socotrana*, *Jatropha unicostata*, *Osyris pendula*, *Grewia turbinata*, *Withania riebeckii*, *Cuscuta planiflora* var. *globulifera*, *Achyrocline schimperi*, *Hedyotis stellarioides*, *Haya obovata*, *Dicliptera effusa*.

Mr. PETER CAMERON sent part II. of his paper on the "Hymenoptera of the Khasia Hills," illustrated by a large number of specimens.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, November 6th, 1899.

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

Mr. ROGERS exhibited a large fungus parasitic on the leaves of an Aloe, which grows abundantly on the hill sides, Cape Colony, and which has been described and figured by Mr. George Massee, in the *Gardeners' Chronicle*, October 14th, 1899, as a new species under the name *Montagnella maxima*.

Mr. MARK STIRRUP, F.G.S. exhibited a collection of fossils from the subterranean quarries of the Montagne de St. Pierre, Maestricht. The rock quarried is placed above the chalk and below the tertiaries, and the corals, shells, and zoophytes found indicate a warm climate. He also described the skull of the *Mosasaurus camperi* found there last century, and now in the Natural History Museum, Paris.

Mr. PETER CAMERON exhibited a bug, *Zicrona cærulea*, found by him on a moor at Roworth, near Marple; the species is not common in this country, but has a wide distribution, extending into Japan. The specimen has been presented to Owens College.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, December 4th, 1899.

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

Mr. JAMES COSMO MELVILL read the following notes :

(*a*) "**Notes on two collections of Terrestrial Mollusca from Socotra.**"

The island of Socotra, with the smaller islets Abd-el-Kuri and Brothers, lies almost due east of Cape Guardafui, Somaliland, and is situate at the entrance to the Gulf of Aden, Long. 53° E., Lat. 12° N. The main island is about 100 miles in length by about 50 in breadth.

The terrestrial mollusca of this island and its neighbouring islets (Abd-el-Kuri being about 100 miles from the mainland, and 30 from Socotra), have till lately been studied very cursorily. In 1881, Mr. Godwin-Austen described in the *Proceedings of the Zoological Society* some new forms, and during the past two years Mr. Edgar Smith has given to the world some additional descriptions of new forms collected (1) by Mr. and Mrs. Theodore Bent in 1896-97, and (2) by the recent expedition made by Dr. H. O. Forbes, of the Liverpool Museum, and Mr. Ogilvie Grant, of the British Museum.

Fischer, in his *Manuel de Conchyliologie*, mentions only fourteen species as being known from these islands (1887), these being mainly *Buliminus*, *Ennea*, *Lithidion*, *Otopoma*, *Stenogyra*, and *Planorbis*. The mollusca all belong to the Arabo-East-Ethiopian types, as might be expected, being generically almost identical with the few known from South Arabia (Dhofer and Hadramant), and some of which I was myself privileged to describe in 1895 for the Theodore Bent Expedition, *Buliminus*, *Otopoma*, *Planorbis*, and *Stenogyra* being also in that case the prevalent forms. The same holds good with what is known of the fauna of Somaliland.

Among the most interesting forms collected by the Forbes-

Grant Expedition, 1898-99, is a *Buliminus* (*mirabilis* Sm.) partuloid, with bidentate peristome, the smaller *B. rotundus* Sm. being also similar, and remarkable. The subgenus *Ovella* has several representatives in *B. longiformis* and several others of the group in which oblique, bizarre, zebra-like markings are conspicuous, the peristome being only slightly thickened. In fact, the genus *Buliminus* is the most highly represented here. Several very highly sculptured *Lithidion*, and large *Otopoma*, are among the operculates, while of *Stenogyra* there are large, but plain, varieties.

One peculiarity in the Socotran land mollusca seems to be a total absence of *Helicidæ* proper. *Ennea* is present in one or two peculiar forms, whilst, among fluviatile species, a *Planorbis* seems to abound, and the almost cosmopolitan *Melania tuberculata* L.

(*b*) "**Note on** *Conus clytospira* **Melv. and Stand.**"

This very fine addition to the genus *Conus* has just been described in the *Ann. & Mag. N. H.*, December, 1899. It combines the graceful form and size of *C. gloria maris* Chemn. (perhaps its nearest congener) with *C. episcopus* Hwass, the markings of which it much assimilates.

Referring to a revision of the section *Cylinder* of *Conus*, propounded by myself in 1885, I should suggest that this new species (*C. clytospira*) form a separate section by itself, which section would be amply characterised by the extended spire, increasing longitudinally $1\frac{7}{8}$ in. in the type specimen, and also by the indented upper whorls, a character not noticed in any other species of *Cylinder* proper. The extreme attenuation of the last whorl seems distinct from all other species save *C. gloria-maris*. *C. clytospira* should, therefore, be placed between the *Textilia pyramidalia* (to which *C. gloria-maris*, *C. pauluccia*, and *C. legatus* are referred, as well as *C. pyramidalis*) and the *Aulici*, subdivision (*a*) *Episcopi*, to which *C. episcopus* Hwass belongs.

The new species was discovered about September 7th, 1899, by Mr. F. W. Townsend, in the Arabian Sea, 100 miles due west of Bombay, adhering to the Eastern Telegraph Company's cable, which had been hauled up from 45 fathoms, as it needed repairing. Two examples occurred, both somewhat imperfect, of similar form and style of marking, but different in coloration, one being much paler than the other, but a third specimen was unfortunately missed, this being reported as at least 7 inches in length, whilst the type is barely 5 inches.

The discovery of this marvellous species, one of the most select not only of all *Coni* but of all marine molluscs, is sufficient to mark an epoch.

Mr. MARK STIRRUP, F.G.S., exhibited, for comparison with Mr. Melvill's arctic shells, a collection made by him at Tromsoe, the shells of the same species being all larger.

Mr. MARK SYKES, F.R.M.S., drew attention to the *Agave americana*, planted in 1841 at Winthorpe, near Newark, which flowered for the first time this summer and then withered up.

Ordinary Meeting, January 9th, 1900.

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

The thanks of the members were voted to the donors of the books upon the table.

Mr. THOMAS THORP exhibited two film-gratings of a ruling designed to weaken the direct image and to condense the illumination in the spectra of the first and second order, and thus to compete with the prism spectrum in brilliancy.

The PRESIDENT (Professor H. LAMB, F.R.S.) read a paper entitled **"Geometrical Representation of the Relation between Wave-Velocity and Group-Velocity.**

The paper is printed in full in the *Memoirs.*

Professors REYNOLDS and BOYD DAWKINS and Mr. STROMEYER participated in the discussion which followed the reading of the paper.

Ordinary Meeting, January 23rd, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Mr. C. E. STROMEYER, M.Inst.C.E., read a paper on "**The Formation of Minerals in Granite.**"

This paper is printed in full in the *Memoirs.*

A discussion followed the reading of the paper, which was participated in by the President, Professor Boyd Dawkins, Dr. C. H. Lees, and others.

A paper entitled "**Notes on some Jurassic Plants in the Manchester Museum,**" by A. C. SEWARD, M.A., F.R.S., was communicated by Professor F. E. WEISS.

This paper is printed in full in the *Memoirs.*

Mr. Charles Bailey, Professor Boyd Dawkins, and Mr. Hoyle took part in the ensuing discussion.

General Meeting, February 6th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

Mr. WILLIAM GOLDTHORPE, Chairman of Salford Hundred Quarter Sessions, was elected an ordinary member of the Society.

Ordinary Meeting, February 6th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

The PRESIDENT nominated Messrs. H. W. FRESTON and C. E. STROMEYER to be auditors of the Society's accounts for the session 1899-1900.

A paper entitled "**On the Conditions for the Propagation of a Solitary Wave,**" was read by Mr. R. F. GWYTHER, M.A.

This paper is printed in full in the *Memoirs.*

Mr. GWYTHER also read a paper "**On the motion of the Fluid Particles in a class of cases of Steady Motion.**"

This paper is printed in full in the *Memoirs.*

A paper on "**Internal Migration in England and Wales, 1881-91,**" was read by Professor A. W. FLUX, M.A., in which he gave an account of the results of an examination of the net inward and outward movement in each registration district of England and Wales in the interval between the censuses of 1881 and 1891. The movement of the two sexes separately was taken, as differences in intensity and direction for males and females were not infrequent. Of the 54 registration counties (the Ridings of Yorkshire being separately considered) 40 showed net efflux for both sexes, and seven others for one of the two sexes; of the 632 districts 124 only showed net influx of population taking the sexes together, this figure being reduced to 119 for males and raised to 136 for females. The net movements within the various counties involved a transference of about 304,000 males and 350,000 females from one district to another. Movement from a district in one county to one in another county involved a transference of about 172,000 males and 230,000 females, whilst some 418,000 males and 201,000 females left the country. The previously observed greater migratory tendency of the female seems at any rate partly due to the fact that when migration is tested by records of birth-places the excess of migratory males are not included, owing to their removal beyond the limits of the kingdom. Measuring intensity of movement by the proportion of net migration to mean population, the absorption is most marked in London suburbs, and in those of some provincial towns in only a slightly less degree, and especially is marked in conveniently situated watering-places at the seaside, Bournemouth heading the list. The absorption into growing industrial towns is less strongly shown than might have been anticipated. These movements indicate some amelioration of the evils of life in crowded cities. The districts from which efflux has been strongest are found in the south-west, in Wales, on the Scotch border, and in north-east Yorkshire and Lincolnshire. A cartogram illustrating the movement was exhibited.

Special Meeting, February 13th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The President, in making the presentations of the Wilde and Dalton medals, and of the Wilde premium, said :

"The Wilde Medal for 1900 is awarded to Lord Rayleigh, for his numerous and brilliant contributions to Mathematical and Experimental Physics, and to Chemistry. These extend over so wide a field that it is difficult to make a selection which, without being too long, shall escape the risk of omitting things equally important with those specially commemorated. Accepting this risk, however, mention may be made, in the department of Mathematical Physics, of his investigations on the general theory of Vibrations, which are included with many other original matters in the great work on 'Sound'; on the theory of Diffraction in Optics, and its bearing on the resolving power of optical instruments ; on the scattering of light by small particles ; on Waves in Liquids ; on Capillary Phenomena ; on the approximate calculation of electrical and other constants ; and on the distribution of alternating currents in conductors. And in this Society, which claims a share in the early history of Thermodynamics and of the Theory of Gases, it would be specially inexcusable to pass over the highly original work which Lord Rayleigh has done and is still doing in this connection.

His experimental investigations have been closely connected with the theoretical researches above referred to. Special mention may perhaps be made of the classical electrical determinations made in the Cavendish Laboratory at Cambridge, and of a long series of papers on the superficial phenomena of liquids, including the elucidation of the nature of superficial viscosity.

In Chemistry, again, Lord Rayleigh's discoveries are the result of his theoretical investigations. From the theory of thin spherical elastic shells he deduced a correction which must be applied in the weighing of gases in glass globes by Regnault's method. This correction enabled him to determine experimentally the true densities of oxygen and hydrogen, and finally to establish beyond doubt the atomic weight of oxygen. In determining the density of nitrogen by this method, he first showed that 'atmospheric' nitrogen was denser than 'chemical' nitrogen, an anomaly which might be explained by the existence of some inert gas heavier than nitrogen in the atmosphere. This explanation he verified, in conjunction with Professor Ramsay, by the isolation of argon from the air."

"A Dalton Medal (struck in 1864) is awarded to Sir H. E. Roscoe, F.R.S., on whom it had been bestowed for his remarkable original researches in Chemistry, and for his distinguished services to scientific education.

Among his many researches, stress may be laid on the investigations carried out, at first in conjunction with Professor Bunsen, on the chemical action of light; the results obtained are not only of great theoretical interest, but have given a practical means of measuring the chemical intensity of different sources of light. Of still more importance are the researches by which he proved that the substance known to chemists since the time of Berzelius as vanadium was really a compound, and that the true vanadium (which he was the first to isolate) is a member of the nitrogen family of elements.

Secondly, it is desired to recognise the great influence exerted by Sir Henry Roscoe on the progress of Science, both by his long-continued efforts to extend and reorganise the system of scientific education in this country, as well as by the valuable educational works he has written.

Lastly, among his many services to this Society, it is appropriate to mention his careful study and elucidation of Dalton's note-books in the Society's possession, by which he has made clear for the first time the origin and growth of Dalton's atomic theory."

"The Wilde Premium for 1900 is awarded to Professor A. W. Flux, M.A., for his papers on 'The Costs of Sea Transport in proportion to Values of Cargoes,' and 'The Fall in Prices during the past Twenty Years,' printed in vol. xli. of the *Memoirs*."

The presentations were briefly acknowledged by Lord Rayleigh, Sir H. E. Roscoe, and Professor Flux.

Lord RAYLEIGH then delivered the Wilde Lecture on "**The Mechanical Principles of Flight.**"

The lecture is printed in full in the *Memoirs*.

General Meeting, February 20th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

Mr. R. J. Flintoff, Littleborough, and Mr. J. R. Ragdale, Whitefield, were elected ordinary members.

Ordinary Meeting, February 20th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

A discussion was held on the composition and durability of paper used in making modern books, periodicals, and newspapers.

Mr. F. NICHOLSON opened a discussion on the flight of birds, with special reference to the influence of the tail in directing the bird's movements, both vertically and horizontally.

Mr. EDGAR F. MORRIS read a paper entitled "**Some Criticisms on the Modern Theory of Solutions.**"

This paper has been modified by the author and will be printed in the *Memoirs*.

A discussion arose upon the paper, in the course of which Mr. R. L. Taylor remarked upon the anomalous position occupied, according to the modern theory, by ions of hydrogen, chlorine, hydroxyl, and alkaline metals in dilute acids, alkalies, and salts, whereby properties of a conflicting character were ascribed to these substances. Several other members, including the President, also joined in the discussion.

Ordinary Meeting, March 6th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

Dr. F. H. BOWMAN brought to the notice of the members the results of a series of experiments recently made in regard to the preservation of milk or cream by aeration. Sterilised air is aspirated through the milk or cream in suitable vessels, and after aeration for about twenty minutes in the sterilised air at ordinary temperature it is found that the milk or cream will keep sweet for from eight to ten days, though absolutely unchanged in composition in any way. The same milk or cream unaerated will become sour in about two or three days. This discovery renders it possible for milk or cream to be kept or distributed in a perfectly pure and natural condition without the aid of any preservatives or antiseptics.

A paper "**On the Production of Nitric Acid from Air by means of the Electric Flame**," by A. McDOUGALL, B.Sc., and F. HOWLES, B.Sc., was read by the latter.

The paper is printed in full in the *Memoirs*.

Various pieces of the apparatus used in the experiments were exhibited, photographs of the larger parts being thrown on the lantern screen. A discussion followed the reading of the paper.

Ordinary Meeting, March 20th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

There being no paper before the meeting, a discussion took place on the principles underlying Michelson's "echelon" spectroscope, in which a spectrum of a very high order is produced by half-a-dozen fairly thick plates of glass, so placed that their edges form a series of steps.

General Meeting, April 3rd, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

Dr. John T. Nicolson, Manchester, was elected an ordinary member of the Society.

Ordinary Meeting, April 3rd, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

A paper on "**Aerial Locomotion**" was read by HENRY WILDE, F.R.S.

This paper is printed in full in the *Memoirs.* It was illustrated by a series of lantern slides showing the earlier attempts at mechanical flight; and was followed by a discussion.

The problem of the rising of birds from the ground being referred to, Mr. F. J. FARADAY gave an account of an incident noticed by him at Kenilworth Castle, on June 24th, 1899. A number of dead and partially decayed rooks were observed lying at the bottom of the Dungeon Turret, which, being open to the sky, is fully illuminated throughout, though the level of observation is a considerable height from the bottom. There is no means of ascent or descent, ingress or egress, presented by the enclosing walls. The area of the enclosed space is about 16 by 20 feet, and the position is at the north-east corner of Cæsar's Tower. Careful observation revealed the fact that two living birds of the same species as the dead ones were standing on the floor of the pit, amidst the remains of their predecessors, in what was evidently proving a death-trap to the birds which descended. The two living birds seemed dazed, and pebbles were thrown down with a view to disturbing them and inducing them to escape by flying. One of the birds being hit on the back started on an upward flight, ascending in a constantly widening spiral. When nearly on a level with the observers the increase in the orbit of flight resulted in collision with one of the containing walls, and the bird instantly fluttered down to the floor of the dungeon again. The bird, apparently, was not injured by its collision with the wall; the failure of the attempt to escape seemed to be due solely to the loss of the momentum and of the upward draft, so to speak; with the result that the force of gravity asserted itself over the momentum. One of the youngest members of the party observing seemed to express accurately the phenomenon by instantly exclaiming, "The poor thing has not room to fly in."

ANNUAL GENERAL MEETING, APRIL 24TH, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

James Dewar, M.A., LL.D., F.R.S., Fullerian Professor of Chemistry in the Royal Institution, London; James Alfred Ewing, M.A., F.R.S., Professor of Mechanism and Applied Mechanics, Cambridge; Andrew Russell Forsyth, M.A., Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics, Cambridge; James Geikie, D.C.L., LL.D., F.R.S., Murchison Professor of Geology and Mineralogy, Edinburgh; Ernst H. P. A. Haeckel, Professor of Zoology, Jena; Henrik Anton Lorentz, Professor of Physics, Leiden; Robert Ridgway, Curator of the Department of Birds, U.S. National Museum, Washington, U.S.A.; and Beauchamp Tower, M.Inst.C.E., 5, Queen Anne's Gate, London, S.W., were elected honorary members.

Miss Winifred Faraday. B.A., late Fellow of the Victoria University, Member of the Icelandic Society of Copenhagen, Lecturer in English Philology at the Manchester High School for Girls, Ramsay Lodge, Slade Lane, Levenshulme, was elected an ordinary member.

The Secretary announced, in accordance with Rule 22 of the Articles of Association, that the names of John Burke, William Isaac Chadwick, Maurice Julius Langdon, and Samuel

Ogden had been erased by the Council from the register in consequence of non-payment of their subscriptions.

The Annual Report of the Council and the Statement of the Accounts were presented, and it was moved by Mr. Thomas Thorp, seconded by Dr. Charles Lees, and resolved :—"That the Annual Report, together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings*."

It was moved by Mr. H. E. Schmitz, seconded by Mr. E. F. Morris, and resolved :—"That the system of electing Associates of the Sections be continued during the ensuing session."

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

President: HORACE LAMB, M.A., LL.D., F.R.S.

Vice-Presidents: OSBORNE REYNOLDS, M.A., LL.D., F.R.S., CHARLES BAILEY, F.L.S., WILLIAM BOYD DAWKINS, M.A., F.R.S., JAMES COSMO MELVILL, M.A., F.L.S.

Secretaries: FRANCIS JONES, F.R.S.E., F.C.S., ALFRED WILLIAM FLUX, M.A.

Treasurer: J. J. ASHWORTH.

Librarian: WILLIAM EVANS HOYLE, M.A., M.Sc., F.R.C.S.

Other Members of the Council: HAROLD B. DIXON, M.A., F.R.S., FRANCIS NICHOLSON, F.Z.S., J. E. KING, M.A., R. L. TAYLOR, F.C.S., F. J. FARADAY, F.L.S., C. E. STROMEYER, M.Inst.C.E.

Ordinary Meeting, April 24th, 1900.

HORACE LAMB, M.A., LL.D., F.R.S., President, in the Chair.

The thanks of the members were voted to the donors of the books upon the table.

A paper on "**Selections from the Correspondence of Lieutenant-Colonel John Leigh Philips, of Mayfield, Manchester**, Part II.," was read by W. BARNARD FARADAY, LL.B.

This paper is printed in full in the *Memoirs*.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, January 15th, 1900.

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

Mr. Leonard William Hunt was elected an Associate.

A communication was submitted from the Royal Microscopical Society on "The Standardisation of the sub-stage and of the internal diameters of the draw-tubes of Microscopes."

Mr. MARK L. SYKES, F.R.M.S., exhibited photographs and specimens illustrating seasonal dimorphism in some South African butterflies of the genus *Precis*, worked out by Mr. Guy A. K. Marshall; also photographs and specimens of a butterfly from Mashonaland and Durban, bearing mimetic resemblance to the common and distasteful *Limnas chrysippus*, the two varieties occurring together.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, February 12th, 1900.

THOMAS ROGERS, in the Chair.

Mr. John R. Ragdale was elected an Associate.

Mr. MARK L. SYKES, F.R.M.S., made a communication on "The Elimination of extraneous micro-organisms from Vaccine Lymph," and exhibited a series of poured culture plates obtained from the Government laboratories, illustrating the process by which the Bacteria in vaccine lymph are destroyed.

The micro-organisms found in vaccine lymph and the variola of smallpox were described, and illustrated by slides and photographs. Although a considerable number of species of bacteria, Fovulæ and other organisms are to be found, no specific bacillus peculiar to smallpox has positively been discovered, although several investigators have claimed to have identified it. Of the many organisms found in vaccine lymph, and these vary greatly, some may be pathogenic but all are not so, and none has far been discovered which has an effective influence on the lymph as a vaccine material. The presence of certain bacteria in vaccine lymph is evidence of its impurity, and is the cause of pathogenic results, such as syphilis and erysipelas, which sometimes follow vaccination.

By the present method of glycerinating the lymph, adopted by the Government, the danger of pathogenic results following vaccination is rendered almost impossible. For the purpose of obtaining stores of lymph young healthy female calves are taken, their abdomens thoroughly cleansed, shaved and sterilised, and afterwards inoculated in a number of incisions with calf lymph which is proved to be free from bacteria. At the end of five days the resulting vaccine vessicles and lymph are removed, under aseptic conditions, and transferred to sterilised tubes; the calf is then killed and a post-mortem examination made by a veterinary surgeon. Should it be found that the calf has been suffering from any form of disease, the whole of the lymph obtained from the animal is destroyed. But if it is shewn to have been a perfectly healthy animal, the lymph is thoroughly triturated by a mechanical process, and afterwards mixed up with definite proportions of chemically pure glycerine and distilled water. The resulting emulsion is then stored in sealed tubes and microscopically examined periodically. At the end of four weeks' time the lymph is found to be free from micro-organisms of every kind and to be perfectly pure.

The advantages claimed for the system are the production of a vaccine lymph which is absolutely free from pathogenic and other micro-organisms, the impossibility of transmitting disease by means of the lymph, the ease by which the glycerinated emulsion may be used and handled, the length of time (six to eight months) during which the material will remain pure, and the great increase in the amount of lymph emulsion available for vaccination purposes; the elimination of the bacteria and the addition of glycerine in no way interfering with its effectiveness as a vaccine, but rather rendering it more efficient.

The series of culture plates which were exhibited, shewed the presence of many hundreds of colonies of several species of micro-organisms in the lymph which had not been mixed with glycerine, and the gradual reduction in the numbers of these colonies in glycerinated lymph at the ends of lengthening periods, until at the last, in a culture plate which had been poured at the end of four weeks after glycerination, the lymph was shewn to be perfectly pure, all micro-organisms of every kind having been eliminated.

Especial thanks were expressed to Dr. S. Monckton Copeman, of the Local Government Board, for the provision of the culture plates and a number of photographs exhibited.

[*Microscopical and Natural History Section.*]

Ordinary Meeting, March 12th, 1900.

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

Mr. MARK STIRRUP, F.G.S., exhibited specimens of Magnetite from Hey Tor, Devonshire, and Granite, with exceptionally large Felspar crystals, from the same neighbourhood.

Mr. MARK L. SYKES exhibited under the microscopes rotifers, *Stephanoceros* and *Floscularia*, mounted by a new method, shewing the tentacles expanded as in life.

[*Microscopical and Natural History Section.*]

Annual Meeting, April 23rd, 1900.

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

Mr. PETER CAMERON exhibited a specimen of the larvæ of the oil beetle (*Meloe*), which are found on the flowers of the Coltsfoot, &c. These larvæ are parasitic on bees, and are thus conveyed into the nests.

Also an Indian Wasp, with a female *Stylops* or probably a *Xenos* sticking out of the abdomen.

Mr. THOMAS ROGERS exhibited a number of Australian Mosses collected by Mr. Whitelegge, including five new species named by Karl Müller:—(1) *Dawsonia polytrichoides;* Hurstville, Sidney. (2) *Pilotrichum whiteleggiarum;* Bull's Head Bay, Sidney. (3) *Bouchia whiteleggii;* Cape Mull, Sidney. (4) *Campylopus whiteleggii;* Lum Cove River. (5) *Weissia whiteleggeana;* Sugar Loaf Bay.

The following Officers and Council were elected for the next session, 1900-1901:—

President: CHARLES BAILEY, F.L.S.

Vice-Presidents: JOHN BOYD, JAMES COSMO MELVILL, M.A., F.L.S., MARK STIRRUP, F.G.S.

Treasurer: MARK L. SYKES, F.R.M.S.

Secretary: THEODORE SINGTON.

Council: JAMES F. ALLEN, G. H. BROADBENT, M.R.C.S., ROBERT E. CUNLIFFE, W. E. HOYLE, M.A., M.Sc., M.R.C.S, HENRY HYDE, THOMAS ROGERS, CHARLES H. SCHILL, JOHN WATSON.

ANNUAL REPORT OF THE SESSION ENDING 23RD APRIL, 1900.

The Session just over has been quite equal to any of the preceding ones in the number and interest of the papers, communications, and exhibits brought to the meetings. One

Associate, Mr. Blackburn, has resigned, and one Member and one Associate have been elected, Mr. John R. Ragdale and Mr. Leonard W. Hunt.

The Section now consists of the following Members and Associates :—

Members.—J. J. ASHWORTH, CHARLES BAILEY, F.L.S., JOHN BOYD, HENRY BROGDEN, G. H. BROADBENT, M.R.C.S., Dr. BROWN, M.A., EDWARD COWARD, ROBERT E. CUNLIFFE, HASTINGS C. DENT, F.L.S., Dr. A. HODGKINSON, C. J. HEYWOOD, J. COSMO MELVILL, M.A., F.L.S., W. E. HOYLE, M.A., FRANCIS NICHOLSON, F.Z.S., MARK STIRRUP, F.G.S., C. H. SCHILL, JOHN RAGDALE.

Associates.—J. F. ALLEN, Dr. BOOTH, JOHN BUTTERWORTH, PETER CAMERON, PETER CUNLIFFE, L. W. HUNT, HENRY HYDE, JOHN MULLEN, THOMAS ROGERS, THEODORE SINGTON, WILLIAM STANLEY, MARK L. SYKES, F.R.M.S., JOHN WATSON.

Annual Report of the Council, April, 1900.

The Society began the session with an ordinary membership of 150. During the present session 9 new members have joined the Society; 4 resignations have been received, and the deaths have been 2, viz.: Mr. ARTHUR GREG and Mr. HENRY SIMON. This leaves on the roll 153 ordinary members. The Society has also lost 6 honorary members by death, viz.: Professor R. W. BUNSEN, For. Mem. R.S.; Sir J. W. DAWSON, C.M.G., F.R.S.; Sir W. H. FLOWER, K.C.B., F.R.S.; Sir E. FRANKLAND, K.C.B., F.R.S.; Professor C. FRIEDEL; and Professor P. WAAGE; as well as one corresponding member, viz.: Mr. EDWARD JOSEPH LOWE, F.R.S. Memorial notices of these gentlemen (except the last) appear at the end of this report.

The Treasurer commenced the year with a balance in favour of the Society of £140. 0s. 7½d. (including £74. 19s. 11d. balance of the Wilde Endowment Fund), and reports that the total balance, exclusive of the amount still owing by the Natural History Fund, but including the Wilde and Joule Funds, at the bankers and in hand, at the close of the year, is £153. 1s. 2d.

The re-cataloguing of the library has been continued during the session, 3,835 volumes having been catalogued, stamped, and pressmarked, 3,573 of these being serials, and 262 separate works. There have been written 1,572 catalogue cards; 1,280 for serials, and 292 for separate works. The total number of volumes catalogued to date is 23,854 for which 7,055 cards have been written. All the serial publications contained in the library have now been catalogued, and also the separate works relating to Geology and Palæontology.

Increasing use is made of the library for reference purposes, but the number of volumes consulted is not recorded. During the session, 205 volumes have been borrowed from the library, as compared with 122 volumes in the previous session; it is hoped that, as the card catalogue now affords every facility for quickly finding any work required, members will make further use of the valuable collection of books possessed by the Society.

Attention has continued to be paid to the completion of sets, with the result that 58 volumes or parts have been obtained which render 29 sets complete, whilst 66 volumes have been acquired which partly complete 18 sets. These 124 volumes, with the exception of 25 purchased, were presented by the respective societies publishing them. Since the commencement of the re-cataloguing of the library, a total of 769 missing volumes has been obtained, resulting in the completion of 77 sets, including the following:—*Nature*; *Philosophical Magazine*; *Journal of the Geological Society*; *Annals and Magazine of Natural History*; *Sitzungsberichte der mathematisch-physischen Classe der K. Bayerischen Akademie der Wissenschaften*; *Annales de Chimie et de Physique*; *Memorie della R. Accademia dei Lincei*; *Nova Acta Academiæ Cæs. Leop.-Carolinæ*; *Report of the Smithsonian Institution*; *Report of the U. S. Naval Observatory*; *Report of the U. S. Coast Survey*; *Report of the U. S. Geographical Surveys West of the 100th Meridian*; *Annual Report of the U. S. Geological Survey*; *Report of the Geological and Geographical Survey of the Territories.*

Comparatively little binding has been done, 383 volumes having been bound in 266, whilst 50 volumes have undergone repair.

A record of the accessions to the library shows that, from April, 1899, to March, 1900, 679 serials and 29 separate works were received, a total of 708 volumes. The donations during the session (exclusive of the usual exchanges) amount to 28 volumes and 730 dissertations; 1 book has been purchased (in addition to the periodicals on the regular subscription list).

During the past session the Society has arranged to exchange publications with the following: Department of Geology and

Natural Resources of the State of Indiana, Indianapolis; Société des Amis de l'Université de Clermont-Ferrand.

Early last summer the attention of the Council was called to the state of Dalton's tomb in Ardwick Cemetery. Owing to lack of repair the paving round the tomb had sunk, allowing water to lie, and the railings were rusted from want of paint. The Council, deeming the proper preservation of Dalton's tomb a matter of concern to the Society, appointed a Committee to raise funds to enable them to put the monument in a thorough state of repair. The Committee issued a circular to members of the Society and others asking for subscriptions for this object, further publicity being kindly given by the local press, and subscriptions were received to the amount of £54. 10s. 0d. During last summer the repairs were executed and the railings were scraped and painted, and the Committee have great pleasure in reporting that after payment of expenses they have a balance of £30. This sum the Council have undertaken to invest and administer in accordance with the object of the fund. A balance sheet with a list of subscribers is appended.

The Society was represented by Mr. R. F. Gwyther on the occasion of the Jubilee of the Professorship of Sir George Gabriel Stokes, Bart. The address sent to Sir George Stokes, and his reply, were as follow :—

[ADDRESS.]

To Sir GEORGE GABRIEL STOKES, Bart.,
Fellow and President of Pembroke College,
M.A., LL.D., Sc.D.,
Lucasian Professor of Mathematics in the
University of Cambridge.

The members of the Manchester Literary and Philosophical Society, in offering their heartiest congratulations on the occasion of the Jubilee of your tenure of the Lucasian Professorship, are at one with the whole scientific world in expressing their admiration of the signal services which, during these fifty years, you have rendered to the cause of Science.

Although the occasion is rare, we do not celebrate to-day merely length of years, since to you it has been given, by opening new fields of research, to add distinction to a chair already illustrious beyond others.

We admire the force and originality with which you have attacked so wide a range of subjects with such conspicuous success. Your directing influence has been felt and acknowleged by the most notable among the workers in Science. We remark with gratitude that you were among the first to recognise the work of our late fellow-member Joule.

We have counted you as one of our Honorary Members since 1851, and we look back with pleasure to the occasion, in 1897, when you delivered before the Society the first Wilde Lecture on "The Nature of the Röntgen Rays."

It is our earnest wish that you may yet be spared for many years to exhibit those qualities which have made your name famous.

(Signed) J. COSMO MELVILL, *President.*
OSBORNE REYNOLDS,
ARTHUR SCHUSTER,
CHARLES BAILEY,
WILLIAM H. JOHNSON, } *Vice-Presidents.*
R. F. GWYTHER,
FRANCIS JONES, } *Hon. Secretaries.*

25th April, 1899.

[REPLY.]

LENSFIELD COTTAGE, CAMBRIDGE,
30th Sept., 1899.

DEAR Sir,

The Literary and Philosophical Society of Manchester have added to the favours they have already bestowed on me by presenting to me, on the occasion of the celebration of my Jubilee as Professor, a congratulatory Address most beautifully illustrated and bound.

The way in which such services as I have been enabled to make towards the advancement of Science are mentioned in the Address, is, to my mind, an indication of a warmth of attachment which binds me closer than ever to your Society, now so long established, and privileged to look back on such men as Dalton and Joule as among its former members.

For such residue of life as may yet be left me, I shall ever prize that beautiful Address, and I desire to convey to the Society my most hearty thanks.

I am, Dear Sir,
Yours very faithfully,
(*Signed*) G. G. STOKES.

J. COSMO MELVILL, Esq.,
President of the Literary and
Philosophical Society of Manchester.

On behalf of the Society, Professor J. Willard Gibbs presented the following letter to the Connecticut Academy of Arts and Sciences, on the occasion of the hundredth anniversary of its foundation, held October 11th, 1899:—

The Council of the Manchester Literary and Philosophical Society send most cordial greeting on the occasion of the centenary of the Connecticut Academy of Arts and Sciences.

They recall the great services which the Academy has rendered, not only in the encouragement of scientific research within its own borders, but also by the singular merit of its publications, many of which they feel will rank as permanent landmarks in the history of science.

The Council feel that they can express no better wish than that the Academy may continue to flourish in a manner worthy of its past traditions.

(Signed) HORACE LAMB, *President.*
R. F. GWYTHER, FRANCIS JONES, } *Hon. Secretaries.*

The Council has awarded:—

The Wilde Medal for 1900 to the Rt. Hon. Lord Rayleigh, F.R.S., for his numerous and brilliant contributions to mathematical and experimental physics and to chemistry.

A Dalton Medal (struck in 1864) to Sir Henry Enfield Roscoe, F.R.S., for his remarkable original researches in chemistry, and for his distinguished services to scientific education.

The Wilde Premium for 1900 to Professor A. W. Flux, M.A., for his papers on "The Costs of Sea Transport in proportion to Values of Cargoes," and "The Fall in Prices during the past Twenty Years," published in the Society's *Memoirs.*

Lord Rayleigh was appointed to deliver the Wilde Lecture.

The Medals and Premium were presented and the Wilde Lecture was delivered on Tuesday, February 13th, 1900.

A resolution recommending the continuance of the system of electing Associates of Sections will be submitted at the Annual Meeting.

Professor ROBERT WILHELM BUNSEN was elected an honorary member of this Society on the 17th of April, 1860. In a letter addressed to the writer of this notice Bunsen expressed his lively sense of the honour which the Society had done him, an honour which he specially valued as connecting his name with one of the oldest scientific societies in the country, and in this way also with the name of one of the most illustrious of chemical discoverers, John Dalton.

Bunsen was born in Göttingen in 1811, and died in Heidelberg in August, 1899. He therefore attained the patriarchal age of 88, and had for upwards of half a century devoted himself wholly and ungrudgingly to the service of science. To enumerate all his discoveries, much less to give an account of them, would be here out of place. All that can be attempted is to give an idea of the character of his life's work, and to point out in a few words the position in the world of science which his work has won for him. In the first place, then, Bunsen was not only a great investigator and a wonderful experimentalist, but also a distinguished and devoted teacher. And, after all, perhaps his work as a teacher forms his greatest claim to the gratitude of posterity. For his influence on the younger generation of chemists and physicists was so potent, and spread over so wide an area, that its results may be truly said to vie with those of his most brilliant experimental investigations. The main characteristics of these investigations are, in the first place, their wide scope, for they relate to almost every one of the numerous branches of chemical enquiry, and, in the second place, their accuracy and the experimental skill with which they are carried out. Naturally, therefore, each of these investigations has become classical; each is a model of its kind, and the problem proposed by each is solved with a completeness and mastery which makes further work on the subject superfluous. Bunsen's personal character was that of the simple-minded striver after truth, of a man devoted heart and soul to the unravelling of nature's secrets. In the quiet of his laboratory he opened out fields of investigation which have already borne fruit of undreamt-of value. His researches on spectrum analysis have given to the world a new heaven and a new earth, for they have enabled us to ascertain the chemical composition of the sun and the far distant fixed stars, whilst they show us secrets of the earth's crust which have hitherto been hidden from our sight.

One line of investigation which Bunsen pursued with great success has a special interest for the members of this Society; it is that of the laws of the absorption of gases by liquids. Early in the century this subject attracted the special attention of John Dalton, who, first alone, and then in collaboration with Wm. Henry, enunciated the laws which express the relation between the quantity of gas absorbed and the pressure under which that absorption takes place. Bunsen, using the delicate and much more accurate methods of modern research, extended these early experiments of the Manchester chemists. He ascertained the limits within which Dalton and Henry's law expressed the truth. He showed that within certain limits and with certain gases and liquids the law holds good, and he determined with great accuracy the coefficients of absorption of upwards of a score of gases.

In conclusion, it may be said with truth that as an investigator Bunsen was great, that as a teacher he was greater, but that he was greatest of all as a man, of whom to have been a friend was a privilege and an honour.

H. E. R.

In the death of Sir JOHN WILLIAM DAWSON, K.C.M.G., LL.D., F.R.S., F.G.S., this Society has lost one of its most distinguished honorary members, who spent a long life of 79 years in working out various important geological problems, and in laying the foundations in Montreal of that great institution, the McGill University. Born in 1820 in Picton, Nova Scotia, he studied in the University of Edinburgh, and returning home devoted himself to the study of the geology of Nova Scotia and New Brunswick. These were embodied in his great book, "Acadian Geology." In 1842 and ten years later he materially aided Sir Charles Lyell, acting as his guide in Nova Scotia. Since 1843 he has contributed largely to the Proceedings of the London Geological Society and to many other scientific societies. In addition, he has published separate books on various subjects, the most important of which are connected with North American geology. His two volumes on the Devonian and Carboniferous Flora of Eastern North America, published by the Geological Survey of Canada are the standard works on the subject. He was the discoverer of the *Eozoon canadense* in the Laurentian Limestones, which he considered to be the oldest known form of animal life, and not a mere inorganic aggregation of minerals. He wrote also numerous books intended for the instruction of the people, such as, the "Story of the Earth and Man," "The Dawn of Life," "The Origin of the World," "Fossil Men and their Modern Representatives," "The Chain of Life in the Geological Time," and others in which he took the side of orthodoxy against the doctrine of evolution as expounded by Darwin ; they are full of interesting facts and do not present a trace of polemic rancour. His book on his travels in Egypt and Syria is an excellent popular exposition of the geology and physical geography of those countries in relation to Biblical history. We cannot fail to admire the indomitable energy of a man who did all this multifarious work while he was fully occupied in the administration of a great University.

In 1850 Sir William Dawson was appointed principal of the McGill University, an office which he held to 1893. The tenure of his office was remarkable for the progress which the University made, and for the work which he did outside the University in the general education of Canada. It is little less than miraculous that he should have been able to spare time from his administrative duties to carry on investigations in geology and geography. He was fortunate in receiving in his lifetime due honour for his work. He was Fellow of the Royal and Geological Societies. In 1882, the Lyell medal of the Geological Society in London was awarded to him and he occupied the chair of the American Association for the Advancement of Science. He received the degree of LL.D. from the University of Edinburgh in 1884, as well as the honour of knighthood, and was elected in the following year President of the British Association for the Birmingham meeting. In 1886 this Society elected him an honorary member. He received many other signs of recognition, and died full of honours, having lived to the full a long and active life. It would be improper to close this notice without saying that he was beloved by his friends, and remarkable for his gentleness to everyone with whom he came into contact. He passed away on November 19th, 1899, and his loss will be very widely felt on both sides of the Atlantic. W. B. D.

By the death of Sir WILLIAM HENRY FLOWER, K.C.B., F.R.S., natural history has lost a gifted and conscientious worker, and the philosophy of museum arrangement an enthusiastic and successful exponent. Born in 1831, the son of Mr. Edward Fordham Flower, the well-known opponent of the bearing-rein, he inherited a love for and an interest in the animal world. He was educated for the medical profession, and, after a distinguished career as a student, joined the Army Medical Department and served in the Crimean War. On his return to England he filled for several years the post of Lecturer in Anatomy at the Middlesex Hospital. Here he discharged the additional duties of Curator of the Museum with such ability that, in 1861, he was appointed to the charge of the Hunterian Museum in the Royal College of Surgeons, a position which he held for nearly four-and-twenty years, when he succeeded Sir Richard Owen as Director of the Natural History Museum.

The life work of Sir William Flower falls naturally into two divisions: original zoological researches and the organization and management of museums. His scientific studies dated from a period anterior to the publication of the "Origin of Species," and, with that candid and judicious temper which always distinguished him, he at once realised the value of the new generalisation, and stood side by side with Huxley, Rolleston, Humphry, and Turner in the battle for their convictions.

In the forefront of his purely zoological labours must undoubtedly be placed his researches upon the Cetacea. These huge animals can only be adequately studied by those who have the resources of large and wealthy institutions at their disposal, and this was the case with Flower for practically the whole of his career. Of these advantages he availed himself to the full, and strove to give not merely to specialists but also to the general public the fruits of his study. With this view he arranged that series of combined skeletons and models in the Natural History Museum, which is the admiration and the envy of every similar institution in the world. Among other groups of Mammalia we must notice his discoveries that in the Marsupials only one molar is preceded by a milk tooth, and that the large extinct Thylacoleo was not a carnivore but of herbivorous habits; he also published an improved classification of the Carnivora based on the structure of the base of the skull, and his attempt to apply a systematic terminology to the varied forms of the mammalian liver was an elaborate and suggestive piece of anatomical research.

The study of the Mammalia naturally led on to that of mankind, and Sir William Flower's anthropological writings are of no slight importance. In particular, his "Catalogue of the Specimens in the Museum of the Royal College of Surgeons" (1879 and 1884) has already taken rank as a classic in this department. One of the most striking of his many discourses was entitled "Fashion in Deformity," and has been published as a separate work and enjoyed the complimentary, if unprofitable, distinction of an American reprint. In it the author repeats with intensified emphasis the indictment brought so long ago as 1650 by J. Bulwer against the "deformed thief" fashion for defacing and clipping nature's coin "instampt with her image and superscription on the body of men," showing that the civilised are little, if at all, less guilty than the uncivilised races in this respect.

It is, however, no derogation to Sir William Flower's eminence as a naturalist, and to the value of his scientific work, to say that it is pre-eminently as a museum curator and as an exponent of the value and dignity of museum work that he will chiefly be remembered by posterity. He tells us that he began his experiences as a curator in early boyhood, when his collections were "contained in a large, flat, shallow box with a lid," for which he made with his own hands "cardboard trays which filled and fitted the bottom of the box and kept the various specimens separate." He lived in museums, worked for museums, thought over their methods, aims, and organisation, and in several valuable addresses gave to the world his ripest judgments for the instruction and guidance of his successors. To these utterances and to his personal influence is largely due the fact that the vocation of a museum curator occupies a higher place in public estimation than it did a few years ago. One of his main principles was the absolute separation of what may be called the study collections from the show collections. The former should, he maintained, be as extensive as possible, and should be placed where they can be made as readily available as possible for the use of specialists. The latter should be strictly limited, having regard to the extent of the space available; every specimen should be so placed that it is distinctly seen, and should be there for some definite purpose which should be clearly set forth on its label. This is the ideal after which curators are now everywhere striving, though the "art of arranging museums" is still in its infancy. Flower's experience of museum work enabled him to appreciate its difficulties. In every curator, however humble, he recognised a colleague, and nothing could exceed the kindness and consideration with which he gave counsel and sympathy to all who sought it.

As the result of a long life devoted to the public service it was natural that honours and distinctions should fall to him. He was President of the Anthropological and Zoological Societies, and in 1889 of the British Association. In 1898 he was elected President of the International Zoological Congress, though failing health compelled him to decline the honour. He received numerous honorary degrees and was a Correspondent of the Institute of France. He was made C.B. in 1887 and K.C.B. in 1892. In October, 1898, he retired from administrative work, but did not long enjoy his well-deserved leisure, for he died on July 1, 1899. He was elected an honorary member of this Society on April 30th, 1889. W. E. H.

By the death last summer of Sir EDWARD FRANKLAND, K.C.B., F.R.S., the country lost a man of commanding genius, whose name will be honoured among those of the greatest English chemists of the past.

Born at Churchtown, Lancashire, in 1825, young Frankland was educated at the Lancaster Grammar School. He was apprenticed to a chemist and druggist in Lancaster, and began there the study of the science he was so greatly to enrich. In 1846 Dr. Lyon Playfair was appointed Professor of Chemistry in the Museum of Practical Geology, and his first assistants were Dr. Kolbe and Frankland. Frankland's first paper, written in conjunction with Kolbe, was on the constitution of propionic acid; he proved that ethyl cyanide is readily converted into propionic acid by the action of alkalies or acids. Part of the summer of 1847 was spent by Kolbe and Frankland at Marburg, where Bunsen allowed them to work in his laboratory. As a result of this work a second paper was published on the conversion of cyanogen into oxatyl, and a definite proof was afforded of the identity of the nitriles with the cyanides of the lower radicals. This research not only gave a method for the synthesis of many new bodies, but it afforded the means whereby a systematic classification of the organic acids was first rendered possible. Simultaneously with this research the authors examined the action of potassium on ethyl cyanide and prepared ethane; they considered the chloride which they prepared from ethane to be isomeric and not identical with ethyl chloride from alcohol, and therefore that free methyl and ethyl hydride were also isomeric—an error afterwards corrected by Schorlemmer.

In the autumn of 1847 Frankland was appointed teacher of

Chemistry in the newly-started Queenwood College, Hants. Here he met Tyndall and began a friendship which largely affected the life and work of both. At Queenwood, though much occupied in teaching, Frankland began his great work on the isolation of the alcohol-radicals by the action of zinc on the organic iodides. In the autumn of 1848, Frankland and Tyndall went to Marburg to study with Bunsen, and here the analyses of the new gases prepared by Frankland were performed. In the following year he went to Liebig's laboratory at Giessen, where he isolated the radical "amyl," and prepared and examined amyl hydride (iso-pentane). While at Marburg he first prepared zinc methyl and zinc ethyl and tried the action of water upon them. Frankland writes: "On pouring a few drops of water upon the residue, a greenish-blue flame several feet long shot out of the tube, causing great excitement among those present. Professor Bunsen, who had suffered from arsenical poisoning during his researches on cacodyl, suggested that the spontaneously inflammable body, which diffused an abominable odour, was that terrible compound . . . and that I might be irrecoverably poisoned." Zinc amyl was first prepared at Giessen, and the further work upon organo-metallic compounds was prosecuted at Owens College and afterwards in the Royal Institution.

After teaching chemistry for a short time at the College for Civil Engineers at Putney, Frankland stood for the chair of chemistry in the newly-established institution founded by the trustees of John Owens, at Manchester, in 1851. The list of selected candidates included Dr. John Stenhouse, F.R.S., a pupil of Liebig's and one of the founders of the Chemical Society, and F. Crace-Calvert, who had been assistant to Chevreul, and was then professor of chemistry in the Manchester Royal Institution. But the brilliant achievements of Frankland secured his election at the early age of 26.

In the chemical laboratory of the old College building in Quay Street, Frankland carried out some of his most famous work. In 1852 he presented to the Royal Society the important memoir "On a new series of organic bodies containing metals." In this paper he announced the discovery of stannous ethide and of mercuric methiodide; but the most important announcement contained in this paper is that of the law of atomicity of the elements. These are his words: "It is sufficiently evident, from the examples just given, that such a tendency or law prevails, and that, no matter what the character of the uniting atoms may be, the combining power of the attracting element, if I may be allowed the term, is always satisfied by the same number of these atoms."

A second memoir on organo-metallic bodies appeared in the *Phil. Trans.* for 1855: in this paper a full account of the preparation and properties of zinc ethide is given. In the following year appeared the important memoir "On a new series of organic acids containing nitrogen;" and in 1857 Frankland published his work on the reactions of ammonia and its analogues on zinc ethide. In the following year he presented to the Royal Society the first paper by J. A. Wanklyn, his pupil and assistant at the Owens College, in which the discovery of sodium methide and potassium ethide was announced.

In 1857 Frankland resigned the chair of chemistry at the Owens College, and was elected professor at St. Bartholomew's Hospital. In 1863 he was elected professor in the Royal Institution, and in 1865 was appointed professor of chemistry in the Royal School of Mines, where he held the chair till his final retirement from teaching in 1885.

In 1859 Frankland gave the Bakerian Lecture before the Royal Society, describing the preparation of stannic ethide. In 1863 Frankland was joined by B. F. Duppa, who continued to work with him for several years in the laboratory of the Royal Institution. Their first joint paper describes the preparation of the dangerous compounds mercuric methide and ethide. The *Phil. Trans.* for 1862 contains Frankland's paper on the organo-boron compounds, a subject he returned to in 1876.

The synthetical researches on the acids of the lactic and the acrylic series, made in conjunction with Duppa, were carried out between 1862 and 1866. The constitution of these acids was then first definitely established. Then followed the important work on the reactions of ethyl sodaceto-acetate, which has become so fruitful in organic syntheses. A vast number of new compounds have been formed from acetic ether by Frankland's method.

While at Owens College Frankland greatly improved the apparatus designed by Bunsen for gas analysis, by combining with it Regnault's method of gas measurement. In Frankland's apparatus the determinations of gaseous volumes are independent of the temperature and pressure of the external atmosphere. With this apparatus Frankland made many analyses of the air, including samples collected at the summit of Mont Blanc, which he ascended with Tyndall in 1859.

Frankland began his long series of researches on the analysis and purification of water when he succeeded Hofmann, in 1865, at the Royal School of Mines. Hofmann had undertaken to analyse monthly and to report to the Registrar-General on the waters supplied to the metropolis, and Frankland was asked to continue these reports. He was thus led to examine the various methods of water analysis then in use, which he found untrustworthy. For two years he worked on this difficult problem, in attacking which he had the advantage of the skill and devotion of his pupil, H. E. Armstrong. In 1868 Frankland was appointed a member of the Royal Commission to enquire into the pollution of rivers and the domestic water supply of Great Britain. The chemical investigations arising out of this enquiry occupied Frankland for many years, and although they took him away from the pursuit of pure chemistry, their importance to the country can hardly be exaggerated.

An experiment which Frankland made on the rate of combustion of candles on the summit of Mont Blanc, led him to undertake an elaborate investigation on the effect of pressure on combustion. He proved that oil and candles burn as quickly under reduced pressure but give less light, the loss of light not being due to imperfect combustion.

Frankland was elected a member of this Society in 1851, on the same day as the late Professor W. C. Williamson. In the following year he published in our *Memoirs* "Contributions to the knowledge of the manufacture of gas," a paper which is of the highest interest even to-day. In 1853, Frankland was elected into the Royal Society, which awarded him a Royal Medal in 1857 for his researches on the organo-metallic bodies carried out in Manchester. In 1894 Frankland received the Copley Medal of the Royal Society; he was made K.C.B. in 1897. In 1899 the Wilde Medal was bestowed on him by this Society, of which he was elected an honorary member in 1869.

H. B. D.

CHARLES FRIEDEL, whose death occurred at Montauban on April 20th, 1899, was born on March 12, 1832, at Strassburg, in which town his father was a banker. His mother was a daughter of the French mineralogist, Prof. G. L. Duvernoy.

He was educated at the Protestant High School, and afterwards attended lectures at the Strassburg University. Being the only son, it was his father's wish that he should enter the business, with a view of eventually succeeding to the management, and he therefore discontinued his studies. It soon became apparent that he had no aptitude for the banking-house, and, his propensity for science being so pronounced, his father permitted him to continue his studies.

In 1852 he went to his grandfather Duvernoy, at Paris, where he applied himself to the study of mineralogy, and made the acquaintance of Senarmont, through whose influence he was, in 1856, appointed curator of the mineralogical collections at the École des Mines. He also worked in the laboratory of his fellow-countryman, Wurtz, then Professor at the École de Médecine, between whom and himself there grew up a friendship which was only ended by death. It was in the laboratory of Wurtz that Friedel commenced and carried out his well-known researches on ketone. In 1876 he was appointed Professor of Mineralogy at the Sorbonne, where, in 1884, he was called to succeed his late master and friend, Wurtz, in the Chair of Organic Chemistry.

Friedel was twice married. In 1856 he married Emilie Koechlin, by whom he had one son and four daughters. Their union was a very happy one, though not destined to be of long duration, for his wife died in 1871 at Montreux, whither she had gone in hopes of the cure of incipient lung trouble. Paris being at the time besieged by the Germans, Friedel remained in ignorance of his sad loss until the capitulation of the city. In 1873 he espoused Louise Combes, daughter of the Director of the École des Mines and a friend of his first wife; a son was born to them in 1874.

Amongst the honours conferred on Friedel may be mentioned the Membership of the Institut (Académie des Sciences) in 1878, the Davy Medal of the Royal Society in 1880, and the degree of D.C.L. of Oxford in 1894. He was elected a foreign member of the Chemical Society in 1876, and an honorary member of this Society in 1892.*

PETER WAAGE was born 29th June, 1833, at Flekkefiord, South Norway. He first studied for the medical profession, but on entering the University of Christiania in 1857 he was attracted to the study of chemistry and mineralogy, and in 1858 he won the gold medal of the University for a memoir—"The theory of Radicals of oxygen-acids." Waage continued his chemical studies under Bunsen at Heidelberg, and in 1862 he was appointed Professor of Chemistry at Christiania in succession to Professor A. Strecker.

His most notable achievements were the series of studies on chemical affinity and the action of mass, carried on in conjunction with his colleague (and brother-in-law), Professor C. M. Guldberg. These studies are classical in chemistry, and have had an immense effect on the modern development of chemical theory. Waage also took an active part in the application of science to economic and sanitary problems. He devised a process for the preparation of fish-meal which was used by Nansen on the "Fram"; and a

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* Fuller notices of his life are to be found in *Nature*, vol. 60, p. 57; *Ber. Deut. Chem. Gesell.*, Jahrg. 32, pp. 3721-44, with portrait.

factory has been founded at Drammen to carry out his process for sterilising milk. Waage long laboured to find a practical method for determining the amount of alcohol in beer, and proposed that the State should tax beer in proportion to its alcoholic strength. A bill has been proposed to carry out this plan. Waage was elected an honorary member of this Society on April 17th, 1894, and his death took place on January 13th, 1900.

H. B. D.

The death of ARTHUR GREG, on May 11th, 1899, of pneumonia and pleurisy, removed from our midst another member of a family closely associated with what is best in the life of our community, and one also who was related to many who have taken an active interest in our Society in the past.

His father, Robert Hyde Greg, M.P. for this City from 1839 till 1841, who during the Corn Law agitation rendered great assistance to the League, was one of the founders of the Manchester Mechanics' Institution, a member of the Geological Society, and also of our Society, to which he contributed several papers on literary subjects, amongst others an important one "On the Site of Troy and the Trojan Plain" published in the *Memoirs* for 1824, and another "On the Round Towers of Ireland," published in the same volume.

The subject of our notice had been for over forty years resident at Eagley, Bolton, and was head of the firm of Messrs. J. Chadwick and Brother, thread manufacturers. He served on the old Astley Bridge Local Board, and on the District Council which succeeded it, and, when the district was included in the extended borough of Bolton, was appointed alderman of the ward. He was one of the first volunteers in the district, and only recently retired with the honorary rank of captain.

Like other members of the family, Arthur Greg was most anxious to be useful to those around him in his generation. He was elected a member of this Society on November 1st, 1881, and was in his 64th year at the time of his death.

F. N.

HENRY SIMON, who died from an affection of the heart on July 22nd, 1899, was elected a member of the Society in April, 1886. He was born at Brieg, in Silesia, in June, 1835, and inherited from his father an active business-like disposition, and from his mother, who attained some distinction as an authoress, considerable power of literary discrimination. His youthful mind was, moreover, greatly influenced by his uncle Heinrich Simon, a leading democratic member of the Prussian Parliament, who, in consequence of the revolution of 1848, removed to Switzerland, whither he was shortly followed by his nephew.

Henry Simon was educated first at the cantonal public school at Zürich, then at the University of Breslau, and subsequently at the Federal Technical College, Zürich. After completing his College studies and his term of military service he worked for some time as draughtsman for a large engineering firm at Magdeburg.

In 1860 he came to England, and in due course was naturalised as a British subject. At first his business was chiefly connected with railways, but it is with the great improvement effected in the process of corn-milling, by crushing the grain between rollers instead of grinding it, that his name is chiefly associated. The advantages of his system were speedily recognised, and it is stated that there are now enough such mills at work to grind four times the average quantity of wheat annually grown in these islands.

Other departments of industry in which Mr. Simon took an active part had for their object not merely, perhaps not mainly, the improvement of manufacturing processes, but also the amelio ration of the conditions of life. Such were the "Simon-Carves bye-product coke ovens," which avoided the loss of tar and ammonia, consequent upon the older and cruder methods, and also had a beneficial effect upon the surrounding vegetation by eliminating the discharge of sulphurous fumes.

The Manchester Labourers' Dwellings Co., the Manchester Crematorium, and the Manchester Pure Milk Supply Co.—in all of which he was a moving spirit—, though commercial in form, were purely philanthropic in aim.

Mr. Simon's name was familiar in musical circles from the active interest he took in the Hallé concerts, and it is no secret that he assisted in the negotiations which led to Dr. Richter's engagement as conductor. His devotion to the literature of his native land was manifested by the endowment of a chair of German in the Owens College.

He was an extensive reader, and one of his occupations was to select passages to be used as daily mottoes for a calendar which he had regularly issued for some years before his death. This was eminently characteristic of the man, both in form and matter. The year, month, and day were given in bold figures, without a trace of decoration, which might have detracted from its utility. Beneath were a few legible lines containing a pithy saying or aphorism, culled with the utmost catholicity of taste from writers of all ages and opinions; stimulating, consolatory, or humorous—deep and true, without a trace of cant—, a reflex of the man as he appeared to those who were privileged to have more than a passing acquaintance with him. W. E. H.

NOTE.—The Treasurer's Accounts of the Session 1899-1900 of which the following pages are summaries, have been endorsed as follows :

April 10th, 1900. Audited and found correct.

We have also seen, at this date, the certificates of the following Stocks held in the name of the Society:—£1,225 Great Western Railway Company 5% Consolidated Preference Stock, Nos. 12,293, 12,294, and 12,323; £258 Twenty years' loan to the Manchester Corporation, redeemable 25th March, 1914 (No. 1564); £7,500 Gas Light and Coke Company Ordinary Stock, (No. 6389); and the Deeds of the Natural History Fund, of the Wilde Endowment Fund, those conveying the land on which the Society's premises stand, and the Declaration of Trust.

(Signed) HENRY W. FRESTON.
C. E. STROMEYER.

MANCHESTER LITERARY AND

Dr. *J. J. Ashworth, Treasurer, in Account with the*

	£ s. d.	£ s. d.
To Cash in hand, April 1st, 1899		65 0 8½
To Members' Subscriptions :—		
Half Subscriptions, 1898-99, 3 at £1. 1s. cd.	3 3 0	
,, ,, 1899-1900, 6 ,, ,,	6 6 0	
Subscriptions :— 1896-97, 3 at £2. 2s. od.	6 6 0	
,, 1897-98, 4 ,, ,,	8 8 0	
,, 1898-99, 8 ,, ,,	16 16 0	
,, 1899-1900, 115 ,, ,,	241 10 0	
,, 1900-01, 4 ,, ,,	8 8 0	
To Wilde Endowment Fund :—		290 17 0
Half Subscriptions, 1899-1900, 10 at £1. 1s. cd.	10 10 0	
Subscriptions, ,, 3 ,, £2. 2s. od.	6 6 0	
Admission Fees	12 12 0	
To Contributions from Sections :—		29 8 0
Microscopical and Natural History Section, 1899-1900	5 5 0	
Physical and Mathematical Section, 1899-1900	2 2 0	
To Use of the Society's Rooms :—		7 7 0
Transfer from Wilde Endowment Fund, 1809-1900		50 0 0
To Sale of Publications		20 4 6½
To Dividends :—		
Natural History Fund	59 4 2	
Joule Memorial Fund	7 9 10	
To Income Tax Refunded :—		66 14
Natural History Fund	2 0 10	
Joule Memorial Fund	0 5 0	
		2 5 10
To Bank Interest		0 16 1
		£532 13 2
1900.—April 1. To Cash in Williams Deacon and Manchester & Salford Bank, and in hand		£28 15 3

WILDE ENDOWMENT

	£ s. d.
To Balance from 1898-99	74 19 11
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	355 5 0
To Remission of Income Tax, 1899	12 5 0
To Bank Interest	1 8 4
	£443 18 3
1900—April 1. To Cash in Manchester and Liverpool District Bank	£124 5 11

NATURAL HISTORY

	£ s. d.
To Dividends on £1,225 Great Western Railway Company's Stock	59 4 2
To Remission of Income Tax, 1899	2 0 10
To Balance against this Fund, April 1st, 1900	82 11 11
	£143 16 11

JOULE MEMORIAL

	£ s. d.
To Balance, April 1st, 1899	23 7 10
To Dividends on £258 Loan to Manchester Corporation	7 9 10
To Remission of Income Tax, 1899	0 5 0
	£31 2 8

PHILOSOPHICAL SOCIETY.

Society, from 1st April, 1899, to 31st March, 1900.

Cr.

	£	s.	d.	£	s.	d.
By Charges on Property :—						
Chief Rent (Income Tax deducted)	12	9	8			
Income Tax on Chief Rent	0	8	7			
Insurance against Fire	13	17	6			
Repairs to Building, &c.	2	11	2½			
By House Expenditure :—				29	6	11½
Coals, Gas, Electric Light, Water, Wood, &c	23	1	5			
Tea, Coffee, &c., at Meetings	11	9	6			
Cleaning, Sweeping Chimneys, &c.	3	10	2½			
By Administrative Charges :—				38	1	1½
Housekeeper	59	0	0			
Postages, and Carriage of Parcels and of "Memoirs"	39	9	5			
Stationery, Cheques, Receipts, and Engrossing	10	4	9			
Printing Circulars, Reports, &c.	15	19	6			
Illuminated Address to Sir G. G. Stokes, Bart.	5	5	0			
Miscellaneous Expenses	4	18	2			
By Publishing :—				134	16	10
Honorarium for Editing the "Memoirs," 1899-1900..	50	0	0			
Printing "Memoirs and Proceedings"..	147	18	1			
Wood Engraving and Lithography (except Natural History Plates)	21	1	0			
By Library :—				218	19	1
Books and Periodicals	38	0	11			
Library Appliances	1	10	0			
By Natural History Fund :—				39	10	11
(Items shown in the Balance Sheet of this Fund)				43	3	0
By Joule Memorial Fund :—						
(No Expenditure this Session.)						
By Balance at Bank	18	15	3			
,, ,, in Treasurer's hands	10	0	0			
				28	15	3
				£532	13	2

FUND, 1899—1900.

	£	s.	d	£	s.	d.
By Assistant Secretary's Salary, April, 1899, to March, 1900				138	0	0
By Maintenance of Society's Library :—						
Binding and Repairing Books	45	11	4			
Periodicals to complete sets	5	14	6			
				51	5	10
By Gold Medal and Engraving Same and Dalton Medal				19	6	0
By Wilde Premium for Selected Memoirs				15	15	0
By Premium to Lecturer				15	15	0
By Transfers to the Society's Funds :—						
Subscriptions of Members	16	16	0			
Entrance Fees	12	12	0			
Use of Society's Rooms	50	0	0			
				79	8	0
By Cheque Book				0	2	6
By Balance at Bank, April 1st, 1900				124	5	11
				£443	18	3

FUND, 1899—1900.

	£	s.	d.
By Balance against, April 1st, 1899	100	13	11
By Natural History Books and Periodicals	35	18	6
By Plates for Papers on Natural History in "Memoirs"	7	4	6
	£143	16	11

FUND, 1899—1900.

	£	s.	d.
(No expenditure this Session.)			
By Balance, April 1st, 1900	31	2	8
	£31	2	8

Professor H. B. Dixon, F.R.S., in account with the Dalton Tomb Fund.

	£	s.	d.		£	s.	d.
3 Subscribers of £3. 3s.	9	9	0	Repairing Tomb, as per Contract ……………	22	15	0
2 ,, £2. 2s.	4	4	0	Printing and Postages…	1	15	1
24 ,, £1. 1s.	25	4	0				
1 ,, £1. 0s.	1	0	0				
23 ,, 10/6 …	12	1	6				
4 ,, 10/- …	2	0	0				
1 ,, 6/7 …	0	6	7				
1 ,, 5/- …	0	5	0	Balance in Bank ………	30	0	0
	£54	10	1		£54	10	1*

Subscribers of £3. 3s. 0d.—Ludwig Mond, F.R.S.; Edward Schunck, F.R.S.; Henry Wilde, F.R.S.

Subscribers of £2. 2s. 0d.—Ivan Levinstein; G. S. Woolley.

Subscribers of £1. 1s. 0d.—Rt. Hon. Lord Mayor of Manchester (W. H. Vaudrey); G. B. Armstrong; J. J. Ashworth; Charles Bailey; Ald. Sir W. H. Bailey; Rt. Hon. A. J. Balfour, F.R.S.; N. Bradley; R. D. Darbishire; Prof. H. B. Dixon, F.R.S.; Ch. Dreyfus; Sir E. Frankland, K.C.B., F.R.S.: C. J. Heywood; W. H. Johnson; W. W. Kirkman; Prof. H. Lamb, F.R.S.; J. Cosmo Melvill; Prof. O. Reynolds, F.R.S.; John Robinson; Sir H. E. Roscoe, F.R.S.; Louis Schwabe; Thomas Vickers; H. Woolley; S. B. Worthington; a few admirers, per W. Oxley.

Subscriber of 1. 0s. 0d.—Alfred Simpson.

Subscribers of £0. 10s. 6d.—G. H. Bailey; Harry Baker; J. H. Beckett; Prof. P. Phillips Bedson; F. B Benger; J. B. Bindloss; F. H. Bowman; Prof. J. Campbell Brown; Messrs. Calvert and Co.; J. E. Cornish; Arthur Harden; Messrs. Hardman and Holden; P. J. Hartog; Francis Jones; Ald. A. McDougall; Bertram Prentice; Arthur Shearer; Prof. A. Smithells; R. A. Tatton; R. L. Taylor; Prof. W. C. Williams; Thomas Worthington; W. B. Worthington.

Subscribers of £0. 10s. 0d.—Standen Paine; Ald. J. Thompson; J. Walmsley; E. Williams.

Subscribers of less amounts.—W. E. Hoyle, 6/7; J. C. Cain, 5/-

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**Additional Subscription.*—Alfred Rée, 10/6.

THE COUNCIL
AND MEMBERS
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

(Corrected to September 8th, 1900.)

President.

HORACE LAMB, M.A., LL.D., F.R.S.

Vice-Presidents.

OSBORNE REYNOLDS, M.A., LL.D., F.R.S.
CHARLES BAILEY, F.L.S.
W. BOYD DAWKINS, M.A., F.R.S.
J. COSMO MELVILL, M.A., F.L.S.

Secretaries.

FRANCIS JONES, F.R.S.E., F.C.S.
A. W. FLUX, M.A.

Treasurer.

J. J. ASHWORTH.

Librarian.

W. E. HOYLE, M.A., M.Sc., F.R.S.E.

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HAROLD B. DIXON, M.A., F.R.S.
FRANCIS NICHOLSON, F.Z.S.
J. E. KING, M.A.
R. L. TAYLOR, F.C.S.
F. J. FARADAY, F.L.S.
C. E. STROMEYER, M.Inst.C.E.

ORDINARY MEMBERS.

Date of Election.	
1870, Dec. 13.	Angell, John, F.C.S., F.I.C. 6, *Beaconsfield, Derby Road, Withington, Manchester.*
1896, Jan. 21.	Armstrong, Frank. *The Rowans, Harboro' Grove, Harboro' Road, Ashton-on-Mersey, Cheshire.*
1895, Jan. 8.	Armstrong, Geo. B. *Clarendon, Sale, Cheshire.*
1887, Nov. 16.	Ashworth, J. J. 47, *Faulkner Street, Manchester.*
1865, Nov. 14.	Bailey, Charles, F.L.S. *Ashfield, College Road, Whalley Range, Manchester.*
1888, Feb. 7.	Bailey, Alderman Sir W. H. *Sale Hall, Sale, Cheshire.*
1895, Jan. 8.	Barnes, Charles L., M.A. 10, *Nelson Street, Chorlton-on-Medlock, Manchester.*
1894, Jan. 9.	Beckett, J. Hampden, F.C.S. *Corbar Hall, Buxton.*
1896, April 14.	Behrens, George B. *The Acorns*, 4, *Oak Drive, Fallowfield, Manchester.*
1895, Mar. 5.	Behrens, Gustav. *Holly Royde, Withington, Manchester.*
1898, Nov. 29.	Behrens, Walter L. 22, *Oxford Street, Manchester.*
1868, Dec. 15.	Bickham, Spencer H., F.L.S. *Underdown, Ledbury.*
1896, April 14.	Bindloss, James B. *Elm Bank, Eccles, Lancs.*
1896, April 28.	Bolton, Herbert, F.R.S.E. *The Museum, Bristol.*
1861, Jan. 22.	Bottomley, James, D.Sc., B.A., F.C.S., 220, *Lower Broughton Road, Manchester.*
1896, Oct. 6.	Bowman, F. H., D.Sc., F.R.S.E. *Mayfield, Knutsford, Cheshire.*
1896, Feb. 18.	Bowman, George, M.D. 594, *Stretford Road, Old Trafford, Manchester.*
1875, Nov. 16.	Boyd, John. *Barton House, Didsbury Park, Didsbury, Manchester.*
1889, Oct. 15.	Bradley, Nathaniel, F.C.S. *Sunnyside, Whalley Range, Manchester.*
1894, Mar. 6.	Broadbent, G. H., M.R.C.S. 8, *Ardwick Green, Manchester.*
1896, Nov. 17.	Broderick, Lonsdale, F.C.A. *Somerby, Wilmslow, Cheshire.*
1861, April 2.	Brogden, Henry, F.G.S., M.I.Mech.E. *Hale Lodge, Altrincham, Cheshire.*
1889, April 16.	Brooks, Samuel Herbert. *Slade House, Levenshulme, Manchester.*
1860, Jan. 24.	Brothers, Alfred, F.R.A.S. 78, *King Street, Manchester.*

Date of Election.	
1886, April 6.	Brown, Alfred, M.A., M.D. *Sandycroft, Higher Broughton, Manchester.*
1846, Jan. 27.	Browne, Henry, M.A. (Glas.), M.D. (Lond.), M.R.C.S. (Lond.) *The Gables, Victoria Park, Manchester.*
1889, Jan. 8.	Brownell, T. W., F.R.A.S. 64, *Upper Brook Street, Manchester.*
1889, Oct. 15.	Budenberg, C. F., M.Sc., M.I.Mech.E. *Bowdon Lane, Marple, Cheshire.*
1872, Nov. 12.	Burghardt, Charles Anthony, Ph.D. 35, *Fountain Street, Manchester.*
1894, Nov. 13.	Burton, Wm., F.C.S. *The Hollies, Clifton Junction, near Manchester.*
1899, Feb. 7.	Chapman, D. L., B.A. *Owens College, Manchester.*
1854, April 18.	Christie, Richard Copley, M.A. *Ribsden, near Bagshot, Surrey.*
1895, April 9.	Claus, Wm. H. 31, *Mauldeth Road, Fallowfield, Manchester.*
1895, April 30.	Collett, Edward Pyemont. 7, *Wilbraham Road, Chorlton-cum-Hardy, Manchester.*
1884, Nov. 4.	Corbett, Joseph. *Town Hall, Salford.*
1895, April 30.	Cornish, James Edward. *Stone House, Alderley Edge, Cheshire.*
1859, Jan. 25.	Coward, Edward, Assoc.Inst.C.E., M.I.Mech.E. *Heaton House, Heaton Mersey, near Manchester.*
1899, Mar. 7.	Crombie, Charles H., B.A. 163, *Chorlton Road, Brooks's Bar, Manchester.*
1895, Nov. 12.	Crossley, Wm. J., M.I.Mech.E. *Openshaw, Manchester.*
1876, April 18.	Cunliffe, Robert Ellis. *Croft, Ambleside.*
1899. April 11.	Darbishire, O. V., B.A., Ph.D. *Owens College, Manchester.*
1853, April 19.	Darbishire, Robert Dukinfield, B.A., F.S.A. 1, *St. James' Square, Manchester.*
1895, April 9.	Dawkins, Wm. Boyd, M.A., F.R.S., Professor of Geology. *Owens College, Manchester.*
1894, Mar. 6.	Delépine, Sheridan, M.D., Professor of Pathology. *Owens College, Manchester.*
1879, Mar. 18.	Dent, Hastings Charles, F.L.S., F.R.G.S. 20, *Thurloe Square, South Kensington, London, S.W.*
1887, Feb. 8.	Dixon, Harold Bailey, M.A., F.R.S., Professor of Chemistry. *Owens College, Manchester.*
1898, Oct. 18.	Donovan, E. W., M.I.Mech.E. *Hilton House, Prestwich, Lancs.*

Date of Election.	
1899, April 11.	Earle, Hardman A. 40, *Oughton Road*, *Birkdale*, *Lancs.*
1883, Oct. 2.	Faraday, F. J., F.L.S., F.S.S. *Ramsay Lodge*, *Slade Lane*, *Levenshulme*, *Manchester.*
1900, April 24.	Faraday, Miss Lucy Winifred, M.A. *Ramsay Lodge*, *Slade Lane*, *Levenshulme*, *Manchester.*
1897, Oct. 19.	Faraday, W. Barnard, LL.B. *Ramsay Lodge*, *Slade Lane*, *Levenshulme*, *Manchester.*
1900, Feb. 20.	Flintoff, R. J. *Haxby*, *Crumpsall Lane*, *Crumpsall*, *Manchester.*
1895, April 30.	Flux, A. W., M.A., Professor of Political Economy. 57, *Parsonage Road*, *Withington*, *Manchester.*
1897, Nov. 30.	Freston, H. W. 6, *St. Paul's Road*, *Kersal*, *Manchester.*
1898, Nov. 29.	Gamble, F. W., D.Sc. *Owens College*, *Manchester.*
1900, Feb. 6.	Goldthorpe, William. *Brook House*, *Burnage Lane*, *Levenshulme*, *Manchester.*
1896, Nov. 17.	Gordon, Rev. Alexander, M.A. *Memorial Hall*, *Albert Square*, *Manchester.*
1897, Jan. 26.	Grossmann, J., Ph.D. *Harpurhey Chemical Works*, *Harpurhey*, *Manchester.*
1875, Feb. 9.	Gwyther, Reginald F., M.A., Fielden Lecturer in Mathematics. *Owens College*, *Manchester.*
1890, Feb. 18.	Harker, Thomas. *Brook House*, *Fallowfield*, *Manchester.*
1895, Nov. 12.	Hartog, Philippe Joseph, B.Sc., F.C.S., Demonstrator in Chemistry. *Owens College*, *Manchester.*
1890, Mar. 4.	Henderson, H. A. *Eastbourne House*, *Chorlton Road*, *Manchester.*
1889, Jan. 8.	Heywood, Charles J. *Chaseley*, *Pendleton*, *Manchester.*
1895, Mar. 5.	Hickson, S. J., M.A., D.Sc., F.R.S., Professor of Zoology. *Owens College*, *Manchester.*
1884, Jan. 8.	Hodgkinson, Alexander, M.B., B.Sc. 18, *St. John Street*, *Manchester.*
1898, Nov. 29.	Hopkinson, Alfred, Q.C., M.A., Principal of Owens College. *Fairfield*, *Victoria Park*, *Manchester.*
1896, Nov. 3.	Hopkinson, Edward, D.Sc., M.Inst.C.E. *Oakleigh*, *Timperley*, *Cheshire.*
1889, Oct. 15.	Hoyle, William Evans, M.A., F.R.S.E., Keeper of the Manchester Museum. *Owens College*, *Manchester.*
1899, Oct. 17.	Huxley, George, M.I.Mech.E. 20, *Mount Street*, *Manchester.*
1899, Oct. 17.	Ingleby, Joseph, M.I.Mech.E. *Ingleside*, *Marple Bridge*, *near Stockport.*

Date of Election.	
1896, Nov. 17.	Jacob Edwin. 64B, *Hamilton Terrace, London, N.W.*
1870, Nov. 1.	Johnson, William H., B.Sc. 26, *Lever Street, Manchester.*
1896, Oct. 20.	Jones, A. Emrys, M.D. 10, *St. John Street, Mancheser.*
1878, Nov. 26.	Jones, Francis, F.R.S.E., F.C.S. *Manchester Grammar School.*
1891, Nov. 17.	Joyce, Samuel, Electrical Engineer.
1886, Jan. 12.	Kay, Thomas. *Moorfield, Stockport, Cheshire.*
1891. Dec. 1.	King, John Edward, M.A., High Master, *Manchester Grammar School.*
1895, Nov. 12.	Kirkman, W. W. *The Grange, Timperley, Cheshire.*
1893, Nov. 14.	Lamb, Horace, M.A., LL.D., F.R.S., Professor of Mathematics. 6, *Wilbraham Road, Fallowfield, Manchester.*
1899, Feb. 7.	Lawrence, W. T., B.A., Ph.D. *Owens College, Manchester.*
1895, Nov. 12.	Lees, Charles Herbert, D.Sc. Demonstrator in Physics. *Owens College, Manchester.*
1895, Mar. 5.	Levinstein, Ivan. *Hawkes Moor, Wilbraham Road, Fallowfield, Manchester.*
1857, Jan. 27.	Longridge, Robert Bewick, M.I.Mech.E. *Yew Tree House, Tabley, Knutsford, Cheshire.*
1896, Nov. 3.	Lynde, James Henry, M.Inst.C.E. *Buckland, Ashton-on-Mersey, Cheshire.*
1898, Nov. 29.	McConnel, J. W., M.A. *Wellbank, Prestwich, Lancs.*
1866, Nov. 13.	McDougall, Arthur, B.Sc. *Fallowfield House, Fallowfield, Manchester.*
1859, Jan. 25.	Maclure, Sir John William, Bart., M.P., F.R.G.S. *Whalley Range, Manchester.*
1875, Jan. 26.	Mann, J. Dixon, M.D., F.R.C.P. (Lond.), Professor of Medical Jurisprudence at Owens College. 16, *St. John Street, Manchester.*
1896, Oct. 20.	Massey, Leonard F. *Openshaw, Manchester.*
1864, Nov. 1.	Mather. William, M.Inst.C.E., M.I.Mech.E. *Iron Works, Salford.*
1873, Mar. 18.	Melvill, James Cosmo, M.A., F.L.S. *Brook House, Prestwich, Lancs.*
1896, Nov. 3.	Milligan, William, M.D. *Westbourne, Wilmslow Road, Rusholme, Manchester.*
1881, Oct. 18.	Mond, Ludwig, Ph.D., F.R.S., F.C.S. *Winnington Hall, Northwich, Cheshire.*
1894, Feb. 6.	Mond, Robert, M.A., F.C.S. *Winnington Hall, Northwich, Cheshire.*
1899, Mar. 7.	Morris, Edgar F., M.A., F.C.S. *Greg House, Barrington Road, Altrincham, Cheshire.*

Date of Election.

1873, Mar. 4. Nicholson, Francis, F.Z.S. 84, *Major Street*, *Manchester.*

1900, April 3. Nicolson, John T., D.Sc. 7, *Athol Road*, *Alexandra Park*, *Manchester.*

1889, April 16. Norbury, George. *Hillside*, *Prestwich Park*, *Prestwich*, *Lancs.*

1884, April 15. Okell, Samuel, F.R.A.S. *Overley*, *Langham Road*, *Bowdon*, *Cheshire.*

1895, Nov. 12. Pennington, James Dixon, B.A., M.Sc. 254, *Oxford Road*, *Manchester.*

1892, Nov. 15. Perkin, W. H., jun., Ph.D., F.R.S., Professor of Organic Chemistry. *Owens College*, *Manchester.*

1885, Nov. 17. Phillips, Henry Harcourt, F.C.S. 200, *St. George's Road*, *Bolton*, *Lancs.*

1900, Feb. 20. Ragdale J. R. *The Beeches*, *Whitefield*, *near Manchester.*

1888, Feb. 21. Rée, Alfred, Ph.D., F.C.S. 301, *Wilmslow Road*, *Fallowfield*, *Manchester.*

1869, Nov. 16. Reynolds, Osborne, LL.D., M.A., F.R.S., M.Inst. C.E., Professor of Engineering, Owens College, 19, *Ladybarn Road*, *Fallowfield*, *Manchester.*

1880, Mar. 23. Roberts, D. Lloyd, M.D., F.R.S.E., F.R.C.P. (Lond.), *Ravenswood*, *Broughton Park*, *Manchester.*

1864, Dec. 27. Robinson, John, M.Inst.C.E., M.I.Mech.E. *Westwood Hall*, *Leek*, *Staffs.*

1897, Oct. 19. Rothwell, William Thomas. *Heath Brewery*, *Newton Heath*, *near Manchester.*

1893, Mar. 21. Schill, C. H. 117, *Portland Street*, *Manchester.*

1896, Nov. 17. Schmitz, Hermann Emil, B.A., B.Sc. *Manchester Grammar School.*

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., Professor of Physics. *Owens College*, *Manchester.*

1898, Jan. 25. Schwabe, Louis. *Hart Hill*, *Eccles Old Road. Pendleton*, *Manchester.*

1895, Nov. 12. Shearer, Arthur. 36, *Demesne Road*, *Alexandra Park*, *Manchester.*

1890, Nov. 4. Sidebotham, Edward John. *Erlesdene*, *Bowdon. Cheshire.*

1890, Jan. 21. Sidebotham, James Nasmyth, Assoc.M.Inst.C.E. *Parkfield*, *Groby Place*, *Altrincham*, *Cheshire.*

Date of Election.	
1895, Nov. 12.	Southern, Frank, B.Sc. *Burnage Lodge, Levenshulme, Manchester.*
1896, Feb. 18.	Spence, David. *Pine Ridge, Buxton.*
1896, April 14.	Stanton, Thomas E., M.Sc., Professor of Engineering. *University College, Bristol.*
1894, Jan. 9.	Stevens, Marshall, F.S.S. *Bolton Lodge, Eccles, Lancs.*
1894. Nov. 13.	Stirrup, Mark, F.G.S. *High Thorn, Stamford Road, Bowdon, Cheshire.*
1897, Nov. 30.	Stromeyer, C. E., M.Inst.C.E. *Steam Users' Association,* 9, *Mount Street, Albert Square, Manchester.*
1895, April 9.	Tatton, Reginald A., Engineer to the Mersey and Irwell Joint Committee. 44, *Mosley Street, Manchester.*
1893, Nov. 14.	Taylor, R. L., F.C.S., F.I.C. *Central School, Whitworth Street, Manchester.*
1873, April 15.	Thomson, William, F.R.S.E., F.C.S., F.I.C. *Royal Institution, Manchester.*
1896, Jan. 21.	Thorburn, William, M.D., B.Sc. 2, *St. Peter's Square, Manchester.*
1896, Jan. 21.	Thorp, Thomas. *Moss Bank, Whitefield, near Manchester.*
1899, Oct. 31.	Thorpe, Jocelyn F., Ph.D., Demonstrator in Organic Chemistry. *Owens College, Manchester.*
1899, Oct. 17.	Todd, W. H. *Greenfield, Flixton, near Manchester.*
1897, Jan. 26.	Tristram, James Floyd, M.A., B.Sc. 180, *Princess Road, Moss Side, Manchester.*
1879, Dec. 30.	Ward, Thomas. *Wadebrook House, Northwich, Cheshire.*
1873, Nov. 18.	Waters, Arthur William, F.G.S. *Sunny Lea, Davos Dorf, Switzerland.*
1892, Nov. 15.	Weiss, F. Ernest, B.Sc., F.L.S., Professor of Botany, Owens College. 4, *Clifton Avenue, Fallowfield, Manchester.*
1895, April 9.	Whitehead, James. *Lindfield, Fulshaw Park, Wilmslow, Cheshire.*
1859, Jan. 25.	Wilde, Henry, D.Sc., F.R.S. *The Hurst, Alderley Edge, Cheshire.*
1899, Feb. 7.	Wilkins, A. S., M.A., Litt.D., LL.D., Professor of Latin. *Owens College, Manchester.*
1859, April 19.	Wilkinson, Thomas Read. *Vale Bank, Knutsford, Cheshire.*
1888, April 17.	Williams, Sir E. Leader, M.Inst.C.E., M.I.Mech.E. *Spring Gardens, Manchester.*
1896, Dec. 1.	Wilson, George, D.Sc. *Owens College, Manchester.*

Date of Election.	
1889, April 16.	Wilson, Thomas B. *Holly Vale House*, *Mellor*, *near Marple*, *Cheshire.*
1860, April 17.	Woolley, George Stephen. *Victoria Bridge*, *Salford.*
1863, Nov. 17.	Worthington, Samuel Barton, M.Inst.C.E., M.I.Mech.E. *Mill Bank*, *Bowdon*, and 37, *Princess Street*, *Manchester.*
1865, Feb. 21.	Worthington, Thomas, F.R.I.B.A. 46, *Brown Street*, *Manchester.*
1895, Jan. 8.	Worthington, Wm. Barton, B.Sc., M.Inst.C.E. 2, *Wilton Polygon*, *Cheetham Hill*, *Manchester.*
1897, Oct. 19.	Wyatt, Charles H. *Chelford*, *Cheshire.*

N.B.—Of the above list the following have compounded for their subscriptions, and are therefore life members:—

Bailey, Charles, F.L.S.
Bradley, Nathaniel, F.C.S.
Brogden, Henry, F.G.S.
Johnson, William H., B.Sc.
Worthington, Wm. Barton, B.Sc.

HONORARY MEMBERS.

Date of Election.	
1892, April 26.	Abney, Sir W. de W., K.C.B., D.Sc., F.R.S. *Rathmore Lodge, Bolton Gardens South, S. Kensington, London, S.W.*
1892, April 26.	Amagat, E. H., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Honorary Professor, Faculté des Sciences, Lyon. 34, *Rue St. Lambert, Paris.*
1894, April 17.	Appell, Paul, Membre de l'Institut, Professor of Theoretical Mechanics, Faculté des Sciences. *Paris.*
1887, April 19.	Armstrong, Wm. George, Lord, C.B., D.C.L., LL.D., F.R.S. *Newcastle-on-Tyne.*
1892, April 26.	Ascherson, Paul F. Aug., Professor of Botany. *Universität, Berlin.*
1889, April 30.	Avebury, John Lubbock, Lord, D.C.L., L.L.D., F.R.S. *High Elms, Down, Kent.*
1892, April 26.	Baeyer, Adolf von, For. Mem. R.S., Professor of Chemistry. 1, *Arcisstrasse, Munich.*
1896, Feb. 9.	Baker, Sir Benjamin, K.C.M.G., LL.D., F.R.S. 2, *Queen Square Place, Westminster, London, S.W.*
1886, Feb. 9.	Baker, John Gilbert, F.R.S., F.L.S. 3, *Cumberland Road, Kew.*
1895, April 30.	Beilstein, F., Ph.D., Professor of Chemistry. *8th Line, N. 17, St. Petersburg, W.O.*
1886, Feb. 9.	Berthelot, Marcellin, For. Mem. R.S., Membre de l'Institut, Professor of Chemistry, Secrétaire perpétuel de l'Académie des Sciences. *Paris.*
1892, April 26.	Boltzmann, Ludwig, For. Mem. R.S., Professor of Physics. *K. K. Universität, Vienna.*
1886, Feb. 9.	Buchan, Alexander, M.A., LL.D., F.R.S., F.R.S.E. 42, *Heriot Row, Edinburgh.*
1888, April 17.	Cannizzaro, Stanislao, For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Chemistry. *Reale Università, Rome.*
1889, April 30.	Carruthers, William, F.R.S., F.L.S. 14, *Vermont Road, Norwood, London, S.E.*

Date of Election.	
1866, Oct. 30.	Clifton, Robert Bellamy, M.A., F.R.S., F.R.A.S., Prof. of Natural Philosophy. 3, *Bardwell Road*, *Banbury Road*, *Oxford*.
1887, April 19.	Cornu, Marie Alfred, For. Mem. R.S., Membre de l'Institut, Professor of Physics. *École Polytechnique*, *Paris*.
1892, April 26.	Curtius, Theodor, Professor of Chemistry. *Universität*, *Kiel*.
1892, April 26.	Darboux, Gaston, Membre de l'Institut, Professor of Geometry, Faculté des Sciences, Secrétaire perpétuel de l'Académie des Sciences. 36, *Rue Gay Lussac*, *Paris*.
1894, April 17.	Debus, H., Ph.D., F.R.S. 4, *Schlangenweg*, *Cassel*, *Hessen*, *Germany*.
1888, April 17.	Dewalque, Gustave, Professor of Geology. *Université*, *Liége*.
1900, April 24.	Dewar, James, M.A., LL.D., F.R.S., Fullerian Professor of Chemistry. *Royal Institution*, *Albemarle Street*, *London*, *W*.
1892, April 26.	Dohrn, Dr. Anton, For. Mem. R.S. *Zoological Station*, *Naples*.
1892, April 26.	Dyer, Sir W. T. Thiselton, K.C.M.G., C.I.E., M.A., F.R.S., Director of the Royal Botanic Gardens. *Kew*.
1892, April 26.	Edison, Thomas Alva. *Orange*, *N.J.*, *U.S.A*.
1895, April 30.	Elster, Julius, Ph.D. 6, *Lessingstrasse*, *Wolfenbüttel*.
1900, April 24.	Ewing, James Alfred, M.A., F.R.S., Professor of Mechanism and Applied Mechanics. *Langdale Lodge*, *Cambridge*.
1889, April 30.	Farlow, W. G., Professor of Botany. *Harvard College*, *Cambridge*, *Mass.*, *U.S.A*.
1900, April 24.	Forsyth, Andrew Russell, M.A., Sc.D., F.R.S., Sadlerian Professor of Pure Mathematics. *Trinity College*, *Cambridge*.
1889, April 30.	Foster, Sir Michael, K.C.B., M.P., M.A., M.D., LL.D., Sec. R.S., Professor of Physiology. *Trinity College*, *Cambridge*.
1892, April 26.	Fürbringer, Max, Professor of Anatomy. *Grossherz. Universität*, *Jena*.
1892, April 26.	Gegenbaur, Carl, For. Mem. R.S., Professor of Anatomy. 57, *Leopoldstrasse*, *Heidelberg*.
1900, April 24.	Geikie, James, D.C.L., LL.D., F.R.S., Murchison Professor of Geology and Mineralogy. *Kilmorie*, *Colinton Road*, *Edinburgh*.

Date of Election.	
1895, April 30.	Geitel, Hans. 6, *Lessingstrasse, Wolfenbüttel.*
1892, April 26.	Gibbs, J. Willard, For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Mathematical Physics. *Yale University, New Haven, U.S.A.*
1894, April 17.	Glaisher, J. W. L., Sc.D., F.R.S., Lecturer in Mathematics. *Trinity College, Cambridge.*
1894, April 17.	Gouy, A., Professor of Physics, Faculté des Sciences. *Lyons.*
1894, April 17.	Guldberg, Cato M., Professor of Applied Mathematics. *Christiania, Norway.*
1900, April 24.	Haeckel, Ernst, Ph.D., Professor of Zoology. *Zoologisches Institut, Jena.*
1894, April 17.	Harcourt, A. G. Vernon, M.A., D.C.L., F.R.S., V.P.C.S., Lee's Reader in Chemistry, Christ Church. *Cowley Grange, Oxford.*
1894, April 17.	Heaviside, Oliver, F.R.S. *Bradley View, Newton Abbot, Devon.*
1892, April 26.	Hermite, Ch., LL.D. (Edin.), For. Mem. R.S., Membre de l'Institut. 2, *Rue de la Sorbonne, Paris.*
1892, April 26.	Hill, G. W. *West Nyack, N. Y., U.S.A.*
1888, April 17.	Hittorf, Johann Wilhelm, Professor of Physics. *Polytechnicum, Münster.*
1892, April 26.	Hoff, J. van't, Ph.D., For. Mem. R.S., Professor of Chemistry. 2, *Uhlandstrasse, Charlottenburg, Berlin.*
1892, April 26.	Hooker, Sir Joseph Dalton, G.C.S.I., C.B., D.C.L., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *The Camp, Sunningdale, Berks.*
1869, Jan. 12.	Huggins, Sir William, K.C.B., LL.D., D.C.L., F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.). 90, *Upper Tulse Hill, Brixton, London, S.W.*
1851, April 29.	Kelvin, William Thomson, Lord, G.C.V.O., M.A., D.C.L., LL.D., F.R.S., F.R.S.E., For. Assoc. Inst. Fr. (Acad. Sci.). *Netherhall, Largs, Ayrshire.*
1892, April 26.	Klein, Felix, Ph.D., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Mathematics. 3, *Wilhelm Weber Strasse, Göttingen.*
1894, April 17.	Königsberger, Leo, Professor of Mathematics. *Universität, Heidelberg.*
1895, April 30.	Lacaze-Duthiers, F. J. Henri de, For. Mem. R.S., Membre de l'Institut, Professor of Zoology and Comparative Anatomy. 7, *Rue de l'Estrapade, Paris.*

Date of Election.

1892, April 26. Ladenburg, A., Ph.D., Professor of Chemistry. 3, *Kaiser Wilhelm Strasse*, *Breslau.*

1887, April 19. Langley, S. P., For. Mem. R.S. *Smithsonian Institution*, *Washington*, *U.S.A.*

1892, April 26. Liebermann, C., Professor of Chemistry. 29, *Matthäi-Kirch Strasse*, *Berlin.*

1887, April 19. Lockyer, Sir J. Norman, K.C.B., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.) *Science School*, *Kensington*, *London*, *S.W.*

1900, April 24. Lorentz, Henrik Anton, Professor of Physics. *Hooigracht*, 48, *Leyden.*

1892, April 26. Marshall, Alfred, M.A., Professor of Political Economy. *Balliol Croft*, *Madingley Road*, *Cambridge.*

1892, April 26. Mascart, E. E. N., For. Mem. R.S., Membre de l'Institut, Professor at the Collège de France. 176, *Rue de l'Université*, *Paris.*

1889, April 30. Mendeléeff, D., Ph.D., For. Mem. R.S., *Université*, *St. Petersburg.*

1895, April 30. Mittag-Leffler, Gösta, D.C.L. (Oxon.), For. Mem. R.S., Professor of Mathematics. *Djursholm*, *Stockholm.*

1892, April 26. Moissan, H., Membre de l'Institut, Professor at the École Supérieure de Pharmacie. 7, *Rue Vauquelin*, *Paris.*

1894, April 17. Murray, Sir John, K.C.B., LL.D., D.Sc., F.R.S. *Challenger Lodge*, *Wardie*, *Edinburgh.*

1894, April 17. Neumayer, Professor G., For. Mem. R.S., Director of the Seewarte. *Hamburg.*

1887, April 19. Newcomb, Simon, For. Mem. R.S., For. Assoc. Inst. Fr. (Acad. Sci.), Professor of Mathematics and Astronomy. *Johns Hopkins University*, *Baltimore*, *U.S.A.*

1894, April 17. Ostwald, W., Professor of Chemistry. 2/3, *Linnéstrasse*, *Leipsic.*

1892, April 26. Perkin, W. H., LL.D., Ph.D., F.R.S., V.P.C.S. *The Chestnuts*, *Sudbury*, *Harrow.*

1894, April 17, Pfeffer, Wilhelm, For. Mem. R.S., Professor of Botany. *Botanisches Institut*, *Leipsic.*

1892, April 26. Poincaré, H., For. Mem. R.S., Membre de l'Institut, Professor of Astronomy. 63, *Rue Claude Bernard*, *Paris.*

Date of Election.	
1892, April 26.	Quincke, G. H., For. Mem. R.S., Professor of Physics. *Universität, Heidelberg.*
1892, April 26.	Raoult, F. M., Corr. Memb. Inst. Fr. (Acad. Sci.), Professor of Chemistry. 2, *Rue des Alpes, Grenoble.*
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), F.R.S., F.R.A.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Terling Place, Witham, Essex.*
1900, April 24.	Ridgway, Robert, Curator of the Depattment of Birds, U.S. National Museum. *Brookland, District of Columbia, U.S.A.*
1897, April 27.	Roscoe, Sir Henry Enfield, B.A., LL.D., D.C.L., F.R.S., V.P.C.S., Corr. Memb. Inst. Fr. (Acad. Sci.). 10, *Bramham Gardens, Wetherby Road, London, S.W.*
1889, April 30.	Routh, Edward John, D.Sc., F.R.S. *Newnham Cottage, Queen's Road, Cambridge.*
1894, April 17.	Rowland, Henry A., For. Mem. R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). Professor of Physics. *Johns Hopkins University, Baltimore, U.S.A.*
1889, April 30.	Salmon, Rev. George, D.D., D.C.L., LL.D., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.). *Provost's House, Trinity College, Dublin.*
1894, April 17.	Sanderson, Sir J. S. Burdon, Bart., M.A., M.D., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Regius Professor of Medicine. *University, Oxford.*
1892, April 26.	Sharpe, R. Bowdler, LL.D., F.L.S., F.Z.S. *British Museum (Natural History), Cromwell Road, London, S.W.*
1892, April 26.	Solms, H Graf zu, Professor of Botany. *Universität, Strassburg.*
1869, Dec. 14.	Sorby, Henry Clifton, LL.D., F.R.S., F.L.S., F.G.S. *Broomfield, Sheffield.*
1851, April 29.	Stokes, Sir George Gabriel, Bart., M.A., LL.D., D.C.L., F.R.S., Corr. Memb. Inst. Fr. (Acad. Sci.), Lucasian Professor of Mathematics. *Lensfield Cottage, Cambridge.*
1886, Feb. 9.	Strasburger, Eduard, D.C.L., For. Mem. R.S., Professor of Botany. *Universität, Bonn.*
1895, April 30.	Suess, Eduard, Ph.D., For. Mem. R.S., For. Assoc. Inst. Fr. (Acad. Sci.), Professor of Geology. 9, *Africanergasse, Vienna.*

Date of Election.	
1868, April 28.	Tait, Peter Guthrie, M.A., F.R.S.E., Professor of Natural Philosophy. 38, *George Square, Edinburgh.*
1895, April 30.	Thomson, Joseph John, M.A., Sc.D., F.R.S., Professor of Experimental Physics. 6, *Scrope Terrace, Cambridge.*
1894, April 17.	Thorpe, T. E., C.B., Ph.D., D.Sc., LL.D., F.R.S., P.C.S. *Government Laboratory, Clements Inn Passage, Strand, London, W.C.*
1900, April 24.	Tower, Beauchamp, M.Inst.C.E. *Warley Mount, Brentwood, Essex.*
1894, April 17.	Turner, Sir William, M.B., D.C.L., F.R.S., F.R.S.E., Professor of Anatomy. 6, *Eton Terrace, Edinburgh.*
1886, Feb. 9.	Tylor, Edward Burnett, D.C.L. (Oxon.), LL.D. (St. And. and McGill Colls.), F.R.S., Professor of Anthropology. *Museum House, Oxford.*
1894, April 17.	Vines, Sidney Howard, M.A., D.Sc., F.R.S. Sherardian Professor of Botany. *Headington Hill, Oxford.*
1894, April 17.	Warburg, Emil, Professor of Physics. *Physikalisches Institut, Neue Wilhelmstrasse, Berlin.*
1894, April 17.	Ward, H. Marshall, D.Sc., F.R.S., Professor of Botany. *Botanical Laboratory, New Museums, Cambridge.*
1894. April 17.	Weismann, August, Professor of Zoology. *Universitat, Freiburg i. Br.*
1889, April 30.	Williamson, Alexander William, Ph.D., LL.D., F.R.S. V.P.C.S., Corr. Memb. Inst. Fr. (Acad. Sci.) *High Pitfold, Shottermill, Haslemere, Surrey.*
1886, Feb. 9.	Young, Charles Augustus, Professor of Astronomy. *Princeton College, N.J., U.S.A.*
1888, April 17.	Zirkel, Ferdinand, For. Mem. R.S., Professor of Mineralogy. *Thalstrasse, 33, Leipsic.*
1895, April 20.	Zittel, Carl Alfred von, Professor of Palæontology and Geology. *Universität, Munich.*

CORRESPONDING MEMBERS.

Date of Election.	
1850, April 30.	Harley, Rev. Robert, Hon. M.A. (Oxon.), F.R.S., F.R.A.S. Hon. M.R.S. Queensland. *Rosslyn*, *Westbourne Road*, *Forest Hill*, *London*, *S.E.*, and *The Athenæum Club*, *London*, *S.W.*
1882, Nov. 14.	Herford, Rev. Brooke, D.D., 91, *Fitzjohn's Avenue*, *Hampstead*, *London*, *N.W.*
1859, Jan. 25.	Le Jolis, Auguste-François, Ph.D., Archiviste-perpétuel of the Soc. Nat. Sci. Cherbourg. *Cherbourg.*

Awards of the Wilde Medal under the conditions of the Wilde Endowment Fund.

1896. Sir GEORGE G. STOKES, Bart., F.R.S.
1897. Sir WILLIAM HUGGINS, K.C.B., F.R.S.
1898. Sir JOSEPH DALTON HOOKER, G.C.S.I., C.B., F.R.S.
1899. Sir EDWARD FRANKLAND, K.C.B., F.R.S.
1900. Rt. Hon. LORD RAYLEIGH, F.R.S.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.
1900. Sir HENRY E. ROSCOE, F.R.S.

Awards of the Premium under the conditions of the Wilde Endowment Fund.

1897. PETER CAMERON.
1898. JOHN BUTTERWORTH, F.R.M.S.
1899. CHARLES H. LEES, D.Sc.
1900. Prof. A. W. FLUX, M.A.

THE WILDE LECTURES.

1897. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S. (*28 pp.*)

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S. (*46 pp.*)

1899. (Mar. 28.) "The newly discovered Elements; and their Relation to the Kinetic Theory of Gases." By Prof. WILLIAM RAMSAY, F.R.S. (*19 pp.*)

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S. (*26 pp.*)

Manchester Memoirs, Vol. xliv. (1899-1900).

ADDENDA.

Omitted from the List of Honorary Members:—

1899, April 25. Palgrave, R. H. Inglis, F.R.S., F.S.S. *Belton, Great Yarmouth.*

1899, April 25. Ramsay, William, Ph.D., F.R.S., Professor of Chemistry. 12, *Arundel Gardens, Notting Hill, London, W.*