MEMOIRS AND PROCEEDINGS

MANCHESTER

LITERARY & PHILOSOPHICAL

SOCIETY.

(MANCHESTER MEMOIRS.)

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.

CONTENTS.

MEMOIRS.

INDEX.

M. = Memoirs.   P. = Proceedings.

I.—The Herbarium of John Dalton.

BY

R. S. ADAMSON, M.A., AND ALISON McK. CRABTREE.

Read February 4th, 1919.

Received for publication, February 4th, 1919.

This herbarium, consisting of eleven volumes of plants dried and mounted by John Dalton, has been in the possession of the Literary and Philosophical Society since 1886. For some reason, however, it seems to have been almost entirely overlooked since then, and had, unfortunately, been allowed to become exceedingly dirty, and to some extent damaged by insects and damp.

The collection was made between the years 1790 and 1828, at the time, that is, of the great outburst of interest and activity in systematic botany that followed on the work of Linnæus and preceded the awakening of morphology and physiology.

Of Dalton's knowledge of botany, and its origin, little seems known. He apparently taught himself as he did in other branches. This science probably brought him into touch with the well-known blind botanist, John Gough, whom Dalton knew during all the time of his residence in Kendal, 1781-1793, and with whom he kept up an intercourse long afterwards.

In his younger days Dalton was evidently much interested in plants and, as this collection testifies, attained a very considerable degree of skill in distinguishing and determining species. That he left this subject for those sciences with which his name is more definitely associated is perhaps not to be wondered at when we remember the position of botanical science at the close of the eighteenth century. The science was completely under the influence of the Linnæan school, and derived its sole inspiration from the then recently published works of the master. Structural and physiological botany were wholly neglected, and geographical botany can hardly be said to have been born till 1805, when Humboldt and Bonpland's work appeared. Botany, indeed, consisted of exact floristic studies, that is to say, of identification and differentiation of species. Though the flora of this country and foreign regions was quite as much studied, if not more, then than nowadays, the result was merely the production of a

catalogue. With the science in this condition, though we can at once understand Dalton's early enthusiasm for plants, it is not to be wondered at that so active and fertile a brain should turn in its maturer period to more fundamental and constructive studies. It was through his botanical studies that he discovered his colour blindness. In a letter he gives a vivid account as to colour sensations when looking at a Cranesbill.

Dalton continued his interest in botany for many years, and through it made a number of friends who were distinguished as botanists. Chief among these is Edward Robson, from whom he received a very large number of the plants in the herbarium. Robson was a draper by trade in Darlington. He was a critical systematic botanist of considerable repute in his time, and though little of his work was original, his name is well known in the contemporary floras. He was a friend and correspondent of Withering, and supplied him with many of the records for the north of England. He also contributed notes and specimens to Sowerby for the first edition of " English Botany." Robson was not only an enthusiastic collector, but also a gardener. Dalton writing in 1798 to his brother,* mentions having spent some hours in examining Robson's " Hortus Siccus " and " Botanic Garden." Many specimens in this collection are derived from this garden. Dalton and Robson continued to exchange plants for some considerable time, and some of these plants sent by Dalton are recorded in Withering's " Arrangement of British Plants," evidently sent through Robson. One of these, *Convolvulus soldanella*, from Walney Island, is definitely attributed to Dalton (Withering, Ed. 3., vol. ii., p. 240, 1796). Another, *Thalictrum majus* (i.e., p. 502), though attributed to Robson refers, as we know from a letter, to plants collected by Dalton.

During his tour in 1797, Dalton refers more than once in his letters to botanical excursions and to botanists. Thus we know that he went to call on Withering, whom, on this occasion, however, he did not see. Also, when in London he visited Curtis, author of the " *Flora Londiniensis*," and famous especially in connection with the " Botanical Magazine." Among numerous other botanical contributors only one other calls for mention : this is Dr. Hull, a native of Manchester, who published in 1799 a " British Flora," at that time, apart from Withering's work which extended to four volumes, the only flora written in English ; certainly the first in a small size.

The herbarium itself would seem to have been started originally with a view to its becoming part of the museum of Mr. Crosthwaite, in Kendal, if we may judge from the following extract

* The original letters in the Society's possession are those referred to.

from Dr. Lonsdale's " Worthies of Cumberland " (p. 70). " Dalton
informs Mr. Crosthwaite that he had 'dried and pressed a good
many plants, and pasted them down to sheets of white paper, . . .
this has induced me to think, that a tolerable collection of them,
. . . would be a very proper object in the museum.' He afterwards
writes, October 4th, 1791 : ' I have at length completed the book
of plants and made an index both to the Linnæan and English
names.' " There can be no doubt that this is the first volume of the
herbarium now in the Society's possession, though from the letters
we know that Dalton sent plants to Crosthwaite. The first
volume is dated 1790, and the plants therein come almost entirely
from the neighbourhood of Kendal. The second (dated 1791) and
third volumes were probably collected at, or about, the same time, and
are also for the most part Cumberland and Westmorland plants.
The fourth volume contains the first record from Manchester, while
the fifth contains most of his Manchester specimens. This would
place the dates of these volumes somewhere about 1793, probably
between 1792-5. The seventh and part of the eighth volumes were
collected during his tour in 1797, a tour which included London,
Somerset, and the Welsh border counties. The specimens in the
remaining volumes are nearly all contributed from friends and
correspondents, and especially from Edward Robson, of Darlington.

Before considering the plants contained in the collection, a few
words might be said about its history. The latest entry in the
volumes is 1829. After this date there is an unfortunate gap in
our knowledge of the collection. It was presumably disposed of
after Dalton's death, but the next reference to it is in 1856, when
Dr. Angus Smith in his memoir* says : " Eleven volumes of a ' Hortus
Siccus ' are in the possession of a Mr. T. P. Heywood, of the Isle of
Man." Of this gentleman and his possession of the collection,
however, no information is forthcoming at the present time. The
next certain date is 1864, when eleven volumes of a " Herbarium "
formed by Dalton were entered in the catalogue of the Manchester
Public Library as being in their possession. The Library was
presented with the " Herbarium " by Canon Parkinson. Though
no exact record of the date of the presentation is available it most
probably took place some time before 1864, probably during the fifties ;
Canon Parkinson died in 1858. The questions arise as to whether the
" Hortus Siccus," possessed by Heywood, and the " Herbarium,"
presented to the Public Library by Canon Parkinson, are one and
the same or different, and if the same how the transference took
place. No direct evidence is available, but in the first volume
of our collection, which is undoubtedly the " Herbarium," as it came
from the Public Library, Dalton has written a somewhat elaborate

* Memoir of John Dalton and History of the Atomic Theory, up to his time,
published as Vol. xiii., 2nd Ser. of the Memoirs of the Literary and Philosophical
Society of Manchester.

title page in Latin, commencing "Hortus siccus sue Plantarum diversarum . . ." Subsequent references do not clear up the matter. In 1874, Lonsdale speaks of a "Herbarium" in the Manchester Public Library, and a "Hortus Siccus" in the possession of Mr. Heywood. The former he had in all probability seen, while the latter entry may well have been copied from Angus Smith. In 1875, Leo Grindon describes ten volumes of the "Herbarium" in the Public Library, but in the Dictionary of National Biography it is stated (v. 5, 1908, p. 429) that "He (Dalton) compiled a 'Hortus siccus' in eleven volumes, possessed a few years ago by Mr. T. P. Heywood, of the Isle of Man ; while his herbarium is still preserved in the Manchester Public Library." This last is the collection under consideration, and was presented to the Literary and Philosophical Society in 1886. Apart from these quotations there does not seem any evidence at all that Dalton made two collections, and considering the evidence that the collection itself affords, and the direct evidence of letters, we may safely conclude that, whatever its history during the period from 1844 till 1858, the "Hortus Siccus" and the "Herbarium" are one and the same.

The collection consists of eleven volumes of varying thickness, consisting of plain paper. The plants are pasted down on the right-hand pages, while the name, in Latin and English, with sometimes, though not always, the source or locality are given on the left-hand pages. In a few cases further notes on points of interest are given. Each volume has at its commencement an index in Dalton's handwriting of the contents, and the first and second volumes, in addition, have a title page in copperplate writing. The last (eleventh) volume is less than half completed, and on some of the blank pages in this volume we have taken the liberty of mounting a small number of loose specimens, some of which were found in a contemporary journal, and some found in a volume in the library, with a slip of paper inscribed "Mr. Dalton." Except in the case of large specimens there are nearly always more than one to each page. Unfortunately this desire to fill each page not infrequently lessens the botanical value of the collection, as many of the specimens are rather small and incomplete.

In all there are 954 entries in the eleven volumes, of which seventy-two are non-vascular cryptograms which have not been studied carefully so far.* The remainder represent 864 different varieties of vascular plants. These, however, include a number of garden plants. The last volume especially consists largely of garden specimens.

The nomenclature employed is apparently that of Withering's "Arrangement of British Plants," at that time the only flora available which was written in English. The third edition of this work, issued

---

* It is hoped that a full examination of these may be made shortly.

in 1796, was, we learn from a letter, presented to Dalton in 1797. This edition was published in four volumes. Dalton's copy, consisting of the last three, which may have been all he possessed, is preserved in the Society's Library ; it contains a certain number of marginal notes in Dalton's handwriting. This edition is specifically referred to in a few entries, e.g., *Verbascum thapso-nigrum*, VI. 15 ; *Geranium lancastriense*, IV. 4.

Of the 864 different plants in the collection, though a certain number were left unnamed, only thirty-seven are wrongly identified, and three of these are misidentifications that were in all the floras of that date : *Delphinium ajacis* as *D. consolida*, *Crocus nudiflorus* as *C. sativus*, and *Bryonia dioica* as *B. alba*. This last one is certainly corrected in the third edition of Withering. Of the other thirty-four, thirteen were specimens sent by friends, whose identification Dalton probably accepted without question. When we consider the very meagre descriptions in the floras at his command and the impossibility of access to authoritatively named specimens, this very small number of errors, redounds the greatest credit to Dalton's botanical skill. His modest estimate, in reference to the first volumes, in a letter to Crosthwaite is amply borne out : " I am not so confident in my abilities as to maintain that I have given no plant a wrong name, but I believe the skilful botanist will find very few, if any, miscalled."

In addition to the names written in Dalton's handwriting, there are a few corrections and emendations in other hands in pencil. Those referring to the vascular plants were the work of the late Rev. W. W. Newbould, the friend and correspondent of Babington, who, we learn from Mr. Charles Bailey, examined the collection in the Public Library in 1885. Newbould, who died in 1886, prepared a manuscript list of the contents, which was given to Mr. Bailey, who was, however, unfortunately never able to make use of it.

The localities for the specimens in the collection are by no means all complete. In many cases, more especially in the later volumes, the records are quite vague or merely consist of the name or initials of the collector or donor. But many are fully localised. It is unfortunate that very few are dated. The first four volumes consist almost entirely of plants from the neigh-bourhood of Dalton's then home in Kendal, and should prove of the utmost value to anyone working at the flora of the north-west of England, though it is impossible here to consider in detail these records. The records from the Manchester district are not very numerous, and consist for the most part of common plants still to be found in the outer suburban regions. Of plants certainly lost from the neighbourhood there is *Osmunda regalis* (IV. 22), labelled as from " Moss Side, near Manchester." This fern has been entirely eradicated from the district. The collection contains a few

specimens from " White Moss, Blackley." Some of the plants occur now in other mosses in the neighbourhood, but in the cases of *Drosera anglica* and *D. longifolia* (I. 32) it is necessary to travel considerable distances to obtain specimens. The White Moss, at Blackley, has now entirely disappeared : indeed, in 1858 Leo Grindon writes of it as having been drained and cultivated for many years. It is not mentioned at all as a locality for the district by either Woods, in his *Flora Mancuniensis,* in 1840, or by Buxton, in the *Botanical Guide,* in 1846. The only other local record, though not one of the Manchester District, which need be mentioned, is that of *Sisymbrium Sophia* (VII. 18), from Tarvin, in Cheshire, which is a station considerably further inland than any mentioned in Lord de Tabley's " Flora of Cheshire," or in Green's " Flora of Liverpool."

Apart from local records, however, the collection contains a number of interesting plants. Among these is a very fine specimen of the now exceedingly rare Ladies' Slipper, *Cypripedium calceolus* (V. 14), from Arncliffe, Yorkshire. This specimen is undated, but as the volume contains most of the Manchester records, and as early in the next volume are plants dated 1797, it was in all probability before that date. If so, the record would antedate those given for this region in Lee's " Flora of West Yorkshire," where 1805 is given.

The collection contains examples of three plants which were at that date claimed as members of the native flora. These are *Potentilla alba* (I. 56), *Helianthemum ledifolium* (II. 16), under the name of *Cistus salicifolius,* and *Euphorbia* " *Characias* " (VII. 230.). The specimens of the last named, though incomplete, are certainly *E. amygdaloides,* and not *E. characias,* which is a S. European species. The plants recorded for Staffordshire and Worcestershire at the end of the eighteenth century were almost entirely large examples of *E. amygdaloides.* The other two, *Potentilla alba* and *Helianthemum ledifolium,* are both contributed by Robson, of Darlington, whom we know cultivated a " botanic garden." As the collection contains other plants labelled as coming from Robson's garden, no information can be gained about the plants.

The following list of the vascular plants is arranged in systematic order. In each case the generally accepted Latin name is given first, this is followed by that used by Dalton, if different. Then follows the English name used and the locality or source of the specimen and any other information in the herbarium. Any additions or remarks not in the collection itself are enclosed in square brackets [ ]. The references to the volume and page are given for each plant ; the number of the volume being first, in Roman numerals, and followed by the page number.

Equisetum	*maximum*	... ...	[Unnamed.] IX. 31.
———	*arvense* ...	... ...	Horsetail. In Mintsfeet, etc. II. 6
			and XI. 29. IX. 31. [Found in
			Society's Journal.]
———	*sylvaticum*	... ...	Common Horsetail. IV. 42.
			Wood Horsetail, near Mostyn. IX. 25.
———	*palustre* ...	.. ...	Marsh Horsetail. Between Stand (?)
			and the Bolton Canal. IX. 31.
———	*limosum*	... ...	IV. 23.
———	*variegatum*	... ...	IX. 31. [Included under *E. arvense.*]
Lycopodium selago		... ...	IV. 18.
———	*inundatum*	... ...	IV. 18.
———	*clavatum*	... ...	Wolf's Claw. IV. 41.
———	*alpinium*	... ...	IV. 18.

Selaginella selaginoïdes—
    Lycopodium selaginoïdes. IV. 18.
Isoetes lacustris   ... ... Miss T. X. 39.
Osmunda regalis   ... ... Flowering Fern. Moss Side, near
    Manchester. IV. 22.
Cystopteris fragilis—
    Polypodium fragile   ... Brittle Polypody. From E.R., of
    Darlington. VI. 26.
Phegopteris Dryopteris—
    Polypodium dryopteris ... From E. Robson. I. 116.
——— *polypodioïdes—*
    Polypodium phegopteris. . From E. Robson. I. 116.
Nephrodium filix-mas—
    Polypodium filix-mas ... Male Polypody. Male Fern. Woods,
    etc. Common. I. 117.
——— *spinulosum—*
    Polypodium cristatum ... Crested Polypody. From E. R.,
    Darlington. IX. 37.
Polystichum aculeatum—
    Polypodium aculeatum. . Prickly Polypody. Cliffwood. From
    E. R., Darlington. IX. 7.
Blechnum spicant   ... . Rough Spleenwort. In the vicinity
    of Kendal. IV. 5.
Asplenium adiantum-nigrum   .. Black Maiden Hair. From E. R.
    IX. 6.
——— *marinum* ... . From E.R., Black Hills, Sunderland.
    IX. 6.
——— *viride*   ... ... From E. R., Darlington. I. 118.
——— *trichomanes—*
    A. trichomanoïdes   ... Common Maiden hair. Clefts of the
    rocks, Cunswick Scar. I. 118.
——— *Ruta muraria* ... ... White Maiden Hair. On old walls,
    etc. VII. 7.

Ceterach officinarum—

  Asplenium ceterach ... Common Spleenwort. About Bristol, presented me by T. Hoyle. Also on the N.E. side of the battlement of Troutbeck bridge, Westmorland. VII. 15.

Scolopendrium vulgare—

  Asplenium scolopendrium Hart's Tongue. The two uppermost in the Old Hall Garden; the other two at Scout's Stile. III. 31.

Cryptogramme crispa—

  Osmunda crispa ... ... Stone Fern. Amongst rocks, etc. Common. III. 19.

———— *Pteris crispa* ... ... Stone Fern. From E. R. III. 22.

Pteridium aquilinum—

  Pteris aquilina ... ... I. 120.

Polypodium vulgare ... ... Common Polypody. Old walls, etc. I. 116.

Botrychium lunaria—

  Osmunda lunaria ... Moonwort. Found betwixt Crawshawbooth and Burnley. V. 32.

Ophioglossum vulgatum ... ... Adder's Tongue. Vicinity of Manchester. V. 3.

Taxus baccata ... ... Yew Tree. About Cunswick Scar. II. 5.

Juniperus communis ... ... Juniper. Near Milnthorp, Westmorland. IV. 17.

Typha latifolia ... ... Great Cat's Tail. IV. 40.

Sparganium ramosum—

  S. erectum ... ... Bur-reed. IV. 34.

———— *simplex* ... ... Burweed. In a ditch near Hullart (?) Hall, with *ramosum*. IV. 10.

Potamogeton natans ... ... Broad leaved Pondweed. In stagnant waters. Common. V. 34.

———— *heterophyllus*—

   P. lucens ... Miss T. X. 58.

   lucens ... ... Miss T. X. 21.

———— *praelongus*—

   P. fluitans ... Miss T. X. 22.

  densus—*P. densum*. Frog's Lettuce. From E. R., Skern, near Darlington. IX. 13.

———— *obtusifolius*—

   P. gramineum. Miss T. X. 23.

  pectinatus—

   P. pectinatum.. Fennel leaved Pondweed. From E. R., Hill Kittles, near Darlington. IX. 13.

Potamogeton (?) *pectinatus*—

    P. marinum ... Sea Pondweed. From E. R., Skern, near Darlington. Fresh-water R. IX. 13. [A small specimen without fruit, probably *P. pectinatus.*]

Zannichellia palustris ... ... Horned Pondweed. From Kendal, By J. Gough. V. 5.

Triglochin palustre ... ... Arrow-headed Grass. (*b*) Near Tarporley. (*e*) Per Miss T. IX. 39.

Alisma plantago ... ... Great Water Plantain. I. 35. By Kent Side, etc. III. 8.

——— *ranunculoides* ... ... Less Water Plantains. From Winandermere Lake, Westmorland. IV. 27.

Sagittaria sagittifolia ... ... Arrowhead. From Cheshire. By G. Crosfield. IX. 34.

Butomus umbellatus ... ... Flowering Rush. In the river, by Lord Pembrokes, at Wilton ; also in some ditches between Leominster and Ludlow. VIII. 2.

Hydrocharis morsus-ranae ... Frogbit. In a pond near Warrington ; in a pond half way from Whitchurch to Wem, Salop, foot road ; again in a pond one mile from Staines, on the Hampton Road. VII. 23.

Phalaris arundinacea ... ... *Fol. var.* Ladies' Traces. In gardens. VIII. 42.

Phleum asperum—

    P. paniculatum ... ... [Specimen lost.] From E. Robson. II. 28.

——— *pratense* ... ... II. 28.

Agrostis tenuis—A. capillaris ... III. 27.

Ammophila arenaria –

    Calamagrostis arenaria. Sea Matweed. Teesmouth. E. R. VI. 7.

Deschampsia cæspitosa ... ... III. 26. [Unnamed.]

Trisetum flavescens—

    Avena flavescens ... ... Oat. Roadsides. V. 3.

Phragmites communis—

    Arundo phragmites ... Common Reed. About the margin of Cunswick Tarn. I. 7.

Cynosurus cristatus ... ... II. 28.

——— *echinatus* ... ... From E. R. II. 28.

Koeleria cristata—Poa cristata... Crested Meadow Grass. From E. R., Darlington. III. 27.

Molinia coerulea—

    Festuca fluitans (?) ... III. 25.

Melica nutans ... ... Mountain Melic. From E. R., of Darlington. VI. 24.

Melica uniflora—
     Milium effusum ...   .   Millet Grass. In woods, etc. III. 25.
                          [Name changed in pencil.]
Dactylis glomerata ... ... Rough Cocksfoot. In pastures. II.
                          28.
Poa annua   ...   . V. 28. [Unnamed.]
———— *nemoralis*   ...   . From E. Robson. V. 13.
———— *compressa*   ...   . From E. Robson. V. 13.
Festuca bromoides   ...   . IV. 24.
———— *ovina* var. *vivipara*   ... *a* and *b* from John Gough, Kendal :
                          c from E. Robson, Darlington :
                          from Lowdore, near Keswick.
                          IV. 35.
Bromus giganteus   ...   . Miss T. III. 10.
———— *asper* ...   . Miss T. X. 39.
———— *sterilis* ...   . X. 38.
———— (?) *commutatus— Bromus* III. 27.
———— *mollis* ...   . III. 3.
Brachypodium sylvaticum—
     Festuca or *Bromus sylvaticus* X. 38.
Nardus stricta ...   . Heaths, common about Darlington.
                          E. R. I. 4.
Lolium perenne ...   . Rye Grass. Roadsides, etc. III. 3.
Lepturus filiformis —
     Rottbellia incurvata   ... Sea Hard Grass. Near Seaton, Co.
                          Durham. E. R. III. 36.
Hordeum murinum ...   . Wall Barley. Roadsides about Lon-
                          don, and in the S. Common.
                          VII. 15.
Stipa pennata ...   . Downy Feathergrass. From James
                          Blackburn's garden, Darlington.
                          VIII. 44.
Heleocharis palustris
     Scirpus palustris ...   ... Club Rush. From E. R., of Dar-
                          lington. VI. 11.
Scirpus caespitosus   ...   . Dwarf Club Rush. White Moss,
                          near Blackley. VIII. 35.
     lacustris   ..   .. Bull Rush. In the Thame, near
                          Oxford. VII. 12.
———— *maritimus*   ...   . About Foulshey Moss. II. 38. [Also
                          as *S. sylvaticus*. IV. 9.]
     sylvaticus   ...   . Millet Cyperus Grass. Skern, near
                          Darlington. E. R. VI. 11.
     compressus
          Schœnus compressus ... Compressed Rush Grass. From
                          E. R., Darlington. IX. 30.
Eriophorum alpinum .   ... From Dr. Hull VII. 5.

Eriophorum vaginatum ... .. Moss Crops. Birch Carr, near Darlington. E. R. VI. 28.

———— *angustifolium*—
E. polystachion ... ... Cottongrass. In marshes. VI. 2.

Rhynchospora alba—
  Schœnus albus ... I. 3.

Cladium mariscus—
  Schœnus mariscus ... I. 6.

Carex dioica ... ... Small Seg. Polam, near Darlington. E. R. VI. 15.

———— *vulpina* ... ... IV. 44.

———— *echinata—C. pilulifera* .. Uncertain. VIII. 17.

———— *remota* ... ... Remote Seg. Polam, near Darlington, E. R. VI. 32. [Unnamed.] VIII. 17.

———— *goodenovii—Carex* .. Miss T. VI. 6.
  and *C. caespitosa* ... Uncertain. VIII. 31.

———— *flacca* (?)— *C. flava* ... In meadows near Mostyn. VIII. 36.

———— *digitata* ... ... Fingered Seg. Hort. Bath. E. R. VI. 31.

———— *pallescens – C. limosa* ... Brown Seg. From E. R., of Darlington. VI. 31.

———— *panicea—C. flava* .. In meadows near Mostyn. VIII. 36.

———— *pendula* ... ... Pendulous Seg. By the trees, near Croft. 3 miles from Darlington. E. R. VI. 31.

———— *strigosa* ... ... Loose Seg. From E. R., of Darlington. VI. 31.

———— *hirta—C. præcox* ... Yellow Seg. From Dunham Park. VIII. 17.

———— *pseudocyperus*—
  C. pendula ... Pendulous Seg. Near Manchester. In watery places. VI. 6.

Carex (?) ... ... XI. 15. [Found loose in Journal.]

Arum maculatum ... ... Wake Robin. By the Turnpike, Scout Scar; plentiful. II. 20.

Lemna minor ... ... Least Duckmeat. In a pool. VII. 20.

———— *polyrhiza* ... ... Miss T. X. 2.

Juncus bufonius ... ... Toad Rush. Near Booth. VIII. 25.

———— *trifidus* .. .. [Specimen lost, seems to have been right from impression.] Trifid Rush. Dr. Smith, from E. R., Darlington. V. 4.

———— *squarrosus* ... ... Moss Rush. On heaths, etc. V. 4.

———— *filiformis* ... ... Miss T. X. 61.

———— *effusus* ... ... Seaves. On heaths, etc.: common. VIII. 25.

  J. glaucus (effusus W') X. 26.

Juncus conglomeratus   ...   ...   Miss T.   X. 19.
———— *maritimus—J. inflexus*...   Hard Rush.   Uncertain.   V. 4.
———— *supinus—J. uliginosus*...   Miss T.   X. 61.
———— *articulatus*   ...   .   Jointed Rush.   In meadows, etc.
                                                VIII. 13.   [*J. lamprocarpus.*]
———— *sylvaticus—*
        J. acutiflorus (acutus)..   Miss T.   X. 26.
Luzula pilosa—Juncus pilosus...   Hairy Rush.   In meadows.   VIII. 43.
———— *sylvatica—*
        Juncus sylvaticus   ...   Wood Rush.   Kent Side Brow, oppo-
                                                site Mints' Foot, etc.   II. 9.
———— *campestris—*
        Juncus campestris   ...   Field Rush.   In pastures : common.
                                                VIII. 12 and XI. 29.   [Found
                                                loose in Journal]
———— *multiflora—*
        Juncus campestris,
                Var. 2 ..   Tall Field Rush.   Brought from
                                                the West of England.   VIII. 16.
Narthecium ossifragum—
        Anthericum ossifragum   Bastard Asphodil.   Turf Bogs.   I. 33.
                                                X. 63.   [Found loose.]
Tofieldia palustris—
        Anthericum calyculatum   On the mountains west side Co.
                                                Durham.   E. R.   I. 33.
(?) *Colchicum autumnale*   ...   ...   Meadow Saffron.   From E. R., Dar-
                                                lington.   II. 23.
Gagea lutea—
        Ornithogalum luteum .   Yellow Bethlehem Star.   Cliffwood,
                                                near Darlington.   E. R.   VI. 15.
                                                IX. 14.
Allium oleraceum   ...   .   Wild   Garlic.   In pastures, etc.
                                                VIII. 28.
———— *oleraceum var. complan-*
        atum—A. carinatum...   Mountain Garlic.   Upon Sea-Maw
                                                Crag, Winandermere Lake.   VI. 1.
———— *ursinum*   ...   .   Ramson.   Hedges.   I. 34.
Fritillaria meleagris...   ...   ...   Fritillary.   From   E. Atkinson's
                                                garden.   VII. 6.
Scilla non-scripta—
        Hyacinthus non scripta   Hyacinth or Harebells.   In fields.
                                                Common.   V. 19.
Ornithogalum umbellatum   ...   Common Bethlehem Star.   Near
                                                Knaresborough.   E. R.   IX. 14.
        pyrenaicum   ...   Spiked Bethlehem Star.   Garden.
                                                M. A.   IX. 32.
Erythronium dens-canis   ...   ...   Dog Tooth Violet.   E. Atkinson's
                                                Garden.   XI. 9.

Asparagus officinalis ... ... Sparagus. In a garden. V. 2.
Polygonatum multiflorum—
       Convallaria multiflora. Solomon's Seal. A garden. VII. 9.
Convallaria majalis ... ... Lily of the Valley. A garden.
       VII. 8.
Paris quadrifolia ... ... True Love. Bottom of Cunswick
       Scar, etc. II. 31.
Leucojum æstivum ... ... May Snowdrop. Garden. IX. 28.
Narcissus pseudo-narcissus ... Daffodil. In Mintsfeet. II. 2.
——— *biflorus* ... ... Pale Daffodil. From E. R., Dar-
       lington. X. 2.
——— *poeticus* ... ... From E. R., Darlington. X. 2.
Tamus communis ... ... Black Briony. Barrowfield Wood, etc.
       III. 4.
Crocus nudiflorus—C. sativus ... Near Manchester. Wild (*a*). (*b, c*
       and *d*) near Moston. Miss T. V. 42.
Iris fœtidissima—I. fœtida ... Stinking Flag. From E. R., Dar-
       lington. IX. 40.
——— *pseudacorus* ... ... Water Flag. About rivulets. VI. 2.
Gladiolus communis ... ... Corn Flag. In a garden. *Curâ*,
       M. Atkinson. XI. 6.
Cypripedium calceolus ... ... Ladies' Slipper. From the marshes
       about Arncliffe in Craven. Pre-
       sented to me by Nancy Wilson,
       of Thornton in Craven. V. 14.
Orchis pyramidalis ... ... Late Flowering Orchis. From
       E. R. II. 12.
——— *ustulata* ... ... Dwarf Orchis. Baydales, near
       Darlington. E. R. IV. 3.
——— *morio* . . .. Female Foot Stones. In Mintsfeet,
       etc. II. 12.
——— *mascula* ... . IX. 26. [Unnamed and no locality
       or source.]
——— *maculata—Orchis* ... IX. 33.
Ophrys apifera ... ... Bee Orchis. From P. Harrison,
       Darlington. VIII. 6.
——— *muscifera* ... ... Fly Orchis. From E. Rothwell's
       garden. Introduced from York-
       shire. VIII. 6.
Habernaria albida—
     Satyrium albidum ... White Satyrion. From E. R., Dar-
       lington. III. 2.
——— *viridis—*
     Satyrium viride... ... Frog Satyrium. Kendal Fell, Scout
       Scar, etc. III. 2.
——— *bifolia—*
     Orchis bifolia ... ... Butterfly Orchis. In meadows
       Pretty common. IV. 3.

Epipactis latifolia—
    Serapias latifolia ... Broad - leaved bastard Hellebore. Below Cunswick Scar, etc. I. 113.

——— *palustris—*
    Serapias longifolia ... White-flowered bastard Hellebore. Found plentifully in a vacant space between Cunswick Stile and Tarn at the bottom of the Scar and near the margin of the Tarn. I. 112.

Listera cordata—Ophrys cordata. Least Twayblade. From E. R. I. 111.

——— *ovata—Ophrys ovata* ... Twayblade. Cunswick Wood. I. 111.

Malaxis paludosa ... ... Marsh Twayblade. From E. R. Near Middleton, Durham. IX. 5.

Salix pentandra ... ... Sweet Willow. From E. Rothwell's garden. VII. 7.

——— *viminalis* ... ... Osier. In the common garden. Up Peat Lane, etc. II. 25.

——— *caprea* ... ... Broad leaved Willow. By Kent Side. II. 14.

——— *herbacea* ... . Herbaceous Willow. (*a*) From E. R., Darlington. (*b*) From Skiddaw (?), the Summit, July 1828. II. 25.

Myrica gale ... ... Miss T. X. 53.

Corylus avellana ... ... Hazle. Woods, etc. From Miss Taylor. II. 13.

Betula alba ... ... Birch Tree. In hedges, etc. VI. 4.

——— *nana* ... ... From E. R. VI. 4.

Fagus sylvatica ... ... Common Beech. In hedges and plantations. Durham. VIII. 11.

Quercus robur Q. femina ... Oak. In woods, etc. VIII. 10.

Humulus lupulus ... ... Hops. In Gloucestershire, Monmouthshire, etc. VIII. 1.

Urtica dioica ... ... Common Nettle. Amongst rubbish, etc.: very common. I. 114. *A* [small diagram] is the sting of a Nettle magnified. It consists of a fine tapering hollow Tube, with a Bag at the End containing a Liquid : when the pointed Tube has punctured the Skin, the Bag compressed at the Bottom squirts up a Quantity of Liquid into the Puncture, and thus occasions the disagreeable Effect.

——— *pilulifera* ... . Roman Nettle. From E. R., Darlington. VI. 13.

——— *urens* ... ... Less Nettle. Amongst rubbish. I. 115.

Parietaria officinalis...   ...   ... Pellitory of the Wall.   On the walls of Chepstow Castle, Monmouth. VII. 8.

Viscum album ...   . Missletoe.   Some orchards in Lythe. II. 21.

Asarum europœum ...   . Asarabacca.   In gardens.   III 37.

Aristolochia clematitis   ...   ... From E. R., Darlington.   X. 1.

Rumex condylodes—R. acutus ... Woods, hedges, etc.   E. R.   X. 4.

      R. sanguineus From E. R.   IX. 16.   [Too young for identification, but probably *R. condylodes.*]

——— *pulcher*...   ...   . Fiddle Dock.   From E. R., Darlington.   X. 5.   [Probably this but too young.]

——— *acetosella*... ...   . Sheep's Sorrel.   Sandy ground.   X. 4.

Oxyria digyna— Rumex digynus. Mountain Sorrel.   Kentmere Hills, to the right.   1806.   X. 6.

Polygonum convolvulus   ...   ... Black Bindweed.   Gardens, etc. I. 42.

——— *aviculare*...   ...   ... X. 10.

——— *hydropiper*   ...   ... Water Pipper, Arsmart, Lakeweed. Rivulets and ditches.   I. 41.

    Polygonum.   ... X. 16.

——— *Persicaria*   ..   ... Spotted Arsmart.   Common.   I. 40.

    P. lapathifolium-pallidum (?) ... Miss T.   X. 34.

——— *amphibium*   ...   ... Perennial willow-leaved Arsmart.   In the canal from Chester to the Mersey.   VII. 18.   I. 39.   [Unnamed, the land form.]

——— *bistorta* ...   . Beetroot.   In Mintsfeet.   II. 22.

——— *viviparum*   ...   ... Small Beetroot.   Near Carr End, Wensleydale.   II. 22.

Beta maritima ...   . Sea Beet.   Sunderland.   E. R.   IX. 14.

Chenopodium album ...   . Common Orach.   Common on heaps of rubbish.   I. 28.

    Atriplex. ...   ... X. 50.   [Probably but specimen too young.]

——— *glaucum*   ...   .. Oak-leaved Goosefoot.   From E. R.   I. 17.   [Probably but not at all a good specimen.]

——— *bonus henricus*   .. Mercury.   About the Tan Pits by the Meeting House Yard.   I. 17.

Atriplex littoralis   ...   . Grass-leaved Orache.   Hartlepool. E. R.   IX. 19.

——— *patula.* var. *angustissima*

Buphleurum tenuissimum Least Thoroughwax.   On the Banks of the Medlock.   VIII. 29.

Atriplex hastata ... . I. 28. [Included under *Chenopodium album*.]

———— *hastata*, var. *Deltoidea* . I. 28. [Included with last under *Chenopodium album*].

———— *portulacoides* ... ... Sea Purslane. Isle of Walney, west coast. V. 14.

Salicornia herbacea — S. fruiticosa Marsh Samphire. From the Isle of Walney. V. 11.

Suaeda maritima

    Chenopodium maritimum Small Glasswort. On the Banks of the Avon below Bristol. VIII. 12.

Salsola Kali ... ... Prickly Glasswort. From E. R. IX. 6.

Montia fontana ... ... Blinks. About the head of Peat Lane (*a*), near Harrogate. (*b*) E. Robson. III. 20.

Stellaria aquatica

    Cerastium aquaticum. Miss T. X. 37.

———— *nemorum* ... ... Broad-leaved Stichwort. Near brooks, etc. IV. 14.

—— *media* *Alsine media*... Chickweed. Gardens, etc. Common. I. 29.

—— *holostea* ... ... Greater Stichwort. In hedges. Common. I. 46 and X. 13. See Vol. I.

———— *graminea* ... ... Hedges, etc. Common. I. 47 and IV. 46. [Found loose.]

—— *uliginosa* ... . Bog Stichwort. From E. R , Darlington. IX. 27.

Cerastium viscosum

    C. vulgatum .. ... Narrow - leaved Mouse-ear. From E. R. IX. 20.

———— *arvense* ... ... Corn Mouse-ear From E. R. VIII. 5. From E. R. IX. 20.

— — *tomentosum* ... ... Woolly Mouse ear. From E. R., Darlington. VIII. 5.

Holosteum umbellatum ... ... Umbelliferous Mouse-ear. Suffolk. E. R. VI. 2.

Arenaria verna ... ... Mountain Chickweed. On mountains. I. 45.

———— *serpyllifolia* ... ... Least Chickweed. Upon dry walls, I. 45.

    Linum radiola

    Stellaria graminea(?). All seed Flax. Uncertain. From S. At. VIII. 30.

———— *peploides* ... ... Sea Chickweed. About Barrow, and the Isle of Walney. V. 17.

Sagina apetala... ... ... Annual Pearlwort. From E. R., Darlington. III. 3 and VII. 28. [Unnamed.]

Sagina procumbens ...   . Chickweed Breakstone. Shannongate
                            Bridge, and other dry places.
                            III. 5.

———— *nodosa*—*Spergula nodosa* English Marsh Saxifrage.   Near the
                            wall to the N.E. of the Lime
                            Kilns upon Kendal Fell, Brigsteer
                            Moss.   I. 48.

Spergula arvensis   ...   . Spurry.   Cornfields, etc.   Pretty
                            common.   I. 48.

Spergularia rubra—
          Arenaria rubra ... (vid. 17.)   Spurrey.   On the sandy
                            hills near Runcorn. It differs much
                            from that growing on the west.
                            See page 17. V. 39.

—— ——   *salina*—
          Arenaria rubra ... Sea Spurry.   Isle of Walney, West
                            Coast. V. 17.

———————   *media*—
          Arenaria maritima,
          media, sive marina. Miss T. X. 44.

Polycarpon tetraphyllum ...   .. Four-leaved Allseed.   In E. Roth-
                            well's garden.   VIII. 19.

Corrigiola littoralis ..   .. Sand Strapwort.   From E. R., Dar-
                            lington. X. 11.

Scleranthus annuus ..   .. Annual Knawel.   On the wall bet-
                            ween Mintsfeet Stile and Mints
                            Bridge ; also on the wall to the
                            left Sedbergh Road, about 1,000
                            yards from the town.   I. 44.

Agrostemma githago ...   . Cockle.   Road to Laverik Bridge,
                            in the field bounding the footroad
                            along the river.   III. 24.

Silene cucubalus—
          Cucubalus behen   ... White Corn Campion.   Amongst
                            corn.   III. 10.

          S. inflata, Cucubulus
          behen (?)   ...   ... Langdale, Westmorland.   Miss T.
                            X 54.

———— *maritima*—*S. amœna* ... Sea Campion.   Plentiful on the
                            Lancashire Coast. V. 16.

———— *armeria*...   ...   . Common Catchfly. From E. R. V.
                            16.

———— *anglica* ...   . English Catchfly.   From E. R., Sun-
                            derland. IX. 11.

Silene anglica, var.
  quinquevulnera—
   S. quinquevulnera... Variegated Catchfly. From E. R.,
     Darlington. VI. 23.

———— *conoidea* ... ... Common Catchfly. In E. R.'s gar-
     den, Darlington. From the Cam-
     bridge Botanical Garden. VI. 23.

Lychnis dioica ... ... Campion. Hedges, etc. III. 16.
———— *floscuculi* ... ... Cuckou flower. In meadows. III. 16.
———— *viscaria*—
   var. *Flor. alba. simp.*. Red German Catchfly. From E. R.
     III. 16.

Dianthus armeria ... . Deptford Pink. Deptford, near Sun-
     derland. IX. 21.

———— *deltoides* ... . Maiden Pink. Castleton. IX. 21.

———— *caryophyllus* ... ... Common Pinks. Fountain Abbey.
     From E. R. IX. 43.

———— *barbatus* ... . Sweet Williams. From E. R., Dar-
     lington. IX. 43.

Saponaria officinalis ... ... Soapwort. Croft Bridge, near Dar-
     lington. E. R. VI. 8.

Nuphar luteum
  Nymphaea lutea... ... Yellow Water Lily. From Winan-
     dermere Lake. V. 8.

Nymphaea alba ... . White Water Lily. IV. 33.
Caltha palustris ... . Marsh Marigold. Wet meadows.
     II. 8. XI. 30. [Found loose in
     Journal.]

Trollius europaeus ... ... Locker gowlans. Up by the river
     in Mintsfeet, etc. IV. 8.

Helleborus fœtidus ... ... Bearsfoot. From E. Atkinson's
     garden. Ardwick Green. V. 33.

———— *viridis* ... ... Wild Black Hellebore. About five
     miles from Thornton in Craven,
     and presented to me by Nancy
     Wilson of that place. V. 25.

Delphinium ajacis
  D. consolida ... ... Larkspur. Rare except in flower
     gardens. I. 50.

Clematis vitalba ... ... Travellers' Joy. In Kent, Hants.,
     Wilts, Somerset, Gloucest., Mon-
     mouth., and Hereford it abounds
     in the hedges; did not meet with
     it further north. VII. 21.

Thalictrum alpinum... ... ... Mountain Rue Weed. Near Middle-
     ton, Durham. E. R. II. 34.

Thalictrum majus	... ...	...	Lesser Meadow Rue. Going into Cunswic Wood, Horse Road 'mongst the wood to left. II. 34.
—— *flavum*	... ...	...	Meadow Rue Weed. In Warwickshire, etc. VII. 12.
Anemone pulsatilla	... ...	...	Pasque Flower. From E. R., Darlington. VIII. 41.
—— *nemorosa*	... ...	...	Wood Anemone. Woods, etc. II. 13. XI. 24. [Loose.]
—— *ranunculoides*	...	...	Yellow Anemone. Uncertain. From E. R. VI. 4.
—— *apennina*	... ...	...	Mountain Anemone. From E. Atkinson's garden. VIII. 37.
Adonis autumnalis	.. ..	..	Adonis. A garden specimen. V. 42.
Myosurus minimus	... ...	.	Little Mousetail. Near Darlington. Very rare. E.R. VI. 9.

Ranunculus heterophyllus—

R. *aquatilis*	...	...	Various-leaved Water Crowfoot. In Kent plentifully. II. 24.
—— *sceleratus*	... ...	...	Round-leaved Water Crowfoot. From Foulshaw Moss, Westmorland. IV. 35.
—— *parviflorus*	... ...	...	Small-flowered Crowfoot. Uncertain. Got in my tour, 1797. VII. 21. [Very small specimen.]
—— *flammula*	... ...	...	Less Spearwort. Edge of White Moss, near Blackley. IX. 29.
—— *lingua*	... ...	...	Great Spearwort. From Miss Astley's garden, Duckinfield Lodge. IX. 35.
—— *acris*	... ...	...	X. 49.
—— *bulbosus*	... ...	...	X. 41.
—— *parviflorus*	... ...	...	Small-flowered Crowfoot. From E. R., Darlington. VI. 23.
—— *arvensis—R. parviflorus.*			Miss T. X. 41.
—— *Ficaria*	.. ..	...	Lesser Celandine. In Hedges, etc. Common. VI. 39.
Berberis vulgaris	... ...	...	Barberry. I. 34.
Chelidonium majus	.. ...	...	Celandine. In the lane to Bird's Park. II. 19.

Glaucium flavum—

Chelidonium glaucium..		Yellow Horned Poppy. Sea coast, Ramside, near Ulverston. V. 15.

Meconopsis cambrica—

Papaver cambricum	...	Yellow Poppy. In the lane leading to Bird's Park. I. 57.

Papaver somniferum	Wild Poppy. Gardens, etc. The juice of this plant inspissated by the Heat of the Sun in warm Climates is Opium. I. 58.
—— *dubium*	Long, smooth-headed Poppy. About Lancaster, Runcorn, etc. V. 37.
—— *argemone*	Rough podded Poppy. Near Sunderland. E. R. VI. 19.
—— *hybridum*	Round, Rough-headed Poppy. Near Sunderland. E. R. VI. 19.

Corydalis lutea

Fumaria capnoides ...	A garden. *Curâ*, M.A. VIII. 22.
Fumaria capnoides ...	From Fountains Abbey. VIII. 43.
—— *claviculata*—	
Fumaria claviculata ...	Climbing Fumitory. Castle Hagg, in the hedge, about two yards beyond the end of the N.E. wall. Found also in a hedge between the third and fourth milestones, road to Grayrigg, on the right. I. 79.
Fumaria muralis — F. officinalis .	Fumitory. Cornfields. Gardens, etc. I. 78.

Matthiola sinuata—

Cheiranthus sinuatus..	Prickly-podded Gilliflower. From E R., Darlington. IX. 36. Miss T. X. 42. [An indeterminable specimen under this name.]

Nasturtium palustre

Sisymbrium terrestre...	III. 18.
—— *officinale*—	
Sisymbrium nasturtium	Watercress. Slow streams. I. 75.
aquaticum — sive	
Sisymbrium nasturtium	X. 26.

Arabis perfoliata —

Turritis glabra	Tower Mustard. From E. R., Darlington. III. 33.
Cardamine amara	Bitter Cress. By the Skern, near Darlington. E. R. VI. 9.
—— *hirsuta*	Ladysmock. In fields, roadsides, etc. III. 38.
—— *flexuosa* [?]	Zig-zag Ladiesmock. Reeth. E. R. VI. 9.

Sisymbrium thalianum

Arabis thaliana	Turkey Pod. On the Hedge side by the Canal near Cross Strur? VIII. 15.

Sisymbrium officinale –
　　　　Erysimum *officinale* ... Hedge Mustard. Roadsides. I. 76.
　──────　*sophia* ...   . Flix Weed Water Cress. Near Tarvin,
　　　　　　　　　　　　Cheshire.   VII. 18.
　──────　*alliaria*—
　　　　Erysimum alliaria .. Garlic Wormseed.   In hedges, etc.
　　　　　　　　　　　　VIII. 19.
Erysimum cheiranthoides ...   ... From E. Robson.   I. 76.
　──────　*orientale*—
　　　　Brassica orientalis ... Perfoliate Cabbage.   From E. R.,
　　　　　　　　　　　　Darlington.   VI. 18.
Brassica monensis [?]   ...   ... Isle of Man Cabbage. From E. R.,
　　　　　　　　　　　　Darlington.   IX.¾ 19.   [Poor
　　　　　　　　　　　　specimen with no fruits].
　──────　*arvensis*   ...   . [Under *Erysimum cheiranthoides*]. I.
　　　　　　　　　　　　76.
Diplotaxis tenuifolia—
　　　　Brassica muralis   ... Wild Rocket.   Tinmouth Castle
　　　　　　　　　　　　E. R. VI. 18.
Draba incana ...   . Wreathen - podded   Whitlowgrass.
　　　　　　　　　　　　Found in going from Settle to
　　　　　　　　　　　　Malham Cove over the hills. V. 19.
　──────　*verna*   ...   . Early Whitlow Grass.   Old walls,
　　　　　　　　　　　　etc.   II. 5.
Cochlearia alpina—Cochlearia ... Near the summit of the Kirkstone,
　　　　　　　　　　　　Westmorland. 1829. III. 24.
　　　　C. officinalis. Scurvy Grass.   Below the summit of
　　　　　　　　　　　　Hill Bell.   X. 7.
　──────　*danica*   ...   . Scurvy Grass.   By the Mersey, below
　　　　　　　　　　　　Warrington.   IV. 16.
　──────　*groenlandica*   ...   ... Danish Scurvy Grass.   From Knout-
　　　　　　　　　　　　bery Hill, in Dent.   V. 20.
　──────　*armoracia*   ...   ... Horse Radish.   In a garden. V. 31.
Camelina sativa—
　　　　Myagrum sativum—
　　　　　Moenchia sativa... Gold of Pleasure. vid. Withering 3rd
　　　　　　　　　　　　Edit. From E. R., Darlington.
　　　　　　　　　　　　VI. 9.
Thlaspi arvense ...   . Miss T.   X. 27.
　──────　*alpestre* var. *occitanum*—
　　　　Th. montanum ...   ... Mountain Mithridate Mustard. About
　　　　　　　　　　　　half-way from Settle to Malham
　　　　　　　　　　　　Cove, over the mountains. V. 20.
Lunaria biennis ...   . XI. 8. [Named *Lunaria* in pencil,
　　　　　　　　　　　　no source.]
Teesdalia nudicaulis—
　　　　Iberis nudicaulis   ... Rock Cress. From Dr. Hull. VII. 5.

Lepidium latifolium ... . Dittander Pepperwort. Seaton, Co. of Durham. E. R. VI. 7.

―――― *ruderale* ... . Narrow-leaved Dittander. From E. R., Darlington. Found this plant growing plentifully near the bridge over the Wye at Chepstow. VI. 8.

―――― *campestre*—
  Thlaspi campestre ... Mithridate Mustard. Hedges and roadsides, pretty common. V. 28.

―――― *smithii*—
  Thlaspi hirtum ... From E. R., Darlington. V. 28.

Coronopus didymus—
  Lepidum didymum ... Procumbent Dittander. Near Sunderland. E. R. VI. 8.

―――― *procumbens*—
  Cochlearia Coronopus. Swines Cresses. About the Brewry, Stockbridge, etc. III. 5.

Isatis tinctoria ... ... Wild Woad. By the Wear, at Durham. E. R. VI. 25.

Cakile maritima – *Bunias cakile* .. Sea Rocket. Rampside, near Ulverston. V. 11.

Crambe maritima ... ... Colewort, Sea Cabbage. Isle of Walney, Rampside, etc. V. 10.

Reseda lutea .. .. Near S. Shields, Co. Durham. E. R. I. 52.

―――― *luteola* ... ... Wild Woad. About the Low Mills, etc. I. 51.

Drosera rotundifolia ... ... Mossy bogs. I. 32.

― ― *longifolia* ... ... Long-leaved Sundew. On the White Moss, near Blackley. An old specimen. I. 32.

― ― *anglica*—*D. longifolia*... From Miss Taylor, 1828. (Same place as *D. longifolia*.) I. 32. [Under *D. longifolia*, but apparently recognised as distinct.)

Sedum telephium ... ... Orpine. About houses, on walls, etc. III. 38.

― ― *villosum* ... ... Marsh Stone-crop. Carr end, Wensleydale. V. 30.

―――― *album* ... ... White-flowered Stonecrop. On the common towards Staveley, upon some Craggs about 100 yards from the Road to the right, following the Hedge on entring the common. I. 49.

Sedum anglicum   ...   . [Included with *S. album.*] I. 49.

————— *acre*   ...   . Wall Stonecrop or Pepper.   Walls.
I. 49.

————— *reflexum*   ...   . Coniston Hall.   Miss T.   V. 29.

————— *rupestre*   ...   . St. Vincent's Rock Stonecrop. From
W. Fothergill's garden, Carr-end,
Wensley Dale.   V. 29.

Sempervivum tectorum   ...   ... Houseleek.   On walls, roofs, etc.
IX. 34.

Cotyledon umbilicus ...   . Common Navelwort.   Upon a wall
at Everton, Liverpool, near Bees-
ton Castle, and thence on the road
to Whitchurch, Shropshire ; very
abundant on the sides of the old
walls and hedges.   Observed it in
a few other places in our tour
through England and Wales, but
not so plentiful. 1827. Found
plentiful about Beaumaris and
Bangor, Carnarvonshire, on the
stone walls, particularly at some
elevation.   VII. 22.

Saxifraga oppositifolia   ...   ... From E. R., Darlington.   VIII.
26.   Heath-like Saxifrage.   Ingle-
borough. From P. Harrison. VIII.
42.

————— *stellaris*   ...   . Hairy Saxifrage.   On the hills about
Dent.   IV. 13.

————— *aizoides*—

S. autumnalis (aizoides). Yellow Mountain Saxifrage.   On the
right of the road going down the
hill to Boroughtbridge from
Kendal, and everywhere in West-
morland in high and stoney and
wet situations.   IV. 27.

————— *tridactylites*   ...   ... Rue-leaved Whitlow Grass.   On old
walls, etc.   II. 8.

————— *granulata* ...   . White Saxifrage.   Vicinity of Man-
chester.   V. 7.

————— *hypnoides* ...   . Trifid Sengreen.   On the mountains
about Dent.   V. 24.

————— *mutata*   ...   . A garden.   XI. 33.

Chrysosplenium oppositifolium ... Golden Saxifrage.   Vicinity of Man-
chester.   V. 5.

————— *alternifolium*   ...   ... Golden Saxifrage.   Alternate leaved.
IV. 41.

Parnassia palustris ...   . Grass of Parnassus. In meadows, common.   The advocates of the Linnean or Sexual System may draw a strong argument from the economy of this plant in favour of their hypothesis. The *Antheræ* or Tips of the Chives are successively laid upon the aperture of the seed-bud, each continuing there a day or two, and then falling back quite shrivelled is succeeded by another, till they have all discharged their dust and fertilised the seed-bud. I. 30.

Ribes   rubrum var. *spicatum—*

     R. spicatum   ...   ... From E. R., Darlington.   VI. 4.

————*alpinum*...   ...   ... Sweet Mountain Currant. From E. R. VI. 4.   IX. 8.

Spiræa salicifolia   ...   . Betwixt Colthouse and Hawkshead. This has not hitherto been reckoned indigenous in Britain, but I found it plentiful in the hedges at the above-mentioned place, far distant from gardens.   V. 9. Grasmere. Miss T. X. 59.

——*hypericifolia* ...   . In E. Atkinson's garden.   XI. 21.

——*filipendula*   ...   ... Dropwort.   Going into Cunswick Wood. Horse Road.   II. 33.

———*ulmaria*...   ...   ... Queen of the Meadows.   Meadows, etc., common.   I. 53.

Rubus chamæmorus ...   . Knoutberries. Koutberry Hill, near Lea-yeat.   Dent and Pendlehill. V. 31.

——*fruticosus*   ...   . Common   Bramble,   Bumblekites. Hedges, etc., common.   I. 54.

———*saxatilis*   ...   . Stone Bramble. Bottom of Cunswick Scar. II. 36.

Fragaria vesca ...   . Strawberry. In woods and hedges. III. 38

Potentilla verna...   ...   . Spring Cinquefoil.   From E. R., Darlington. VIII. 15.

——— *erecta—*

    Tormentilla erecta... Septfoil.   Hedges, etc., common. II. 32.

———   *anserina*   ...   . Wild Tansy. Near foot-paths. I. 56.

———   *argentea*   ...   . Silvery Cinquefoil. Plumpton, near Harrogate. E. R. VI. 22.

Potentilla fruticosa ... ... Shrubby Cinquefoil. A garden (*a* and *b*); (*c*)near Middleton in Teesdale, County of Durham. E. Robson. V. 34.

——— *palustris*—

   Comarum palustre... Marsh Cinquefoil. From E. R., Darlington. IX. 37.

——— *alba* ... ... White Cinquefoil. From E. R. I. 56.

Dryas octopetala ... ... Mountain Avens. West side of County of Durham. E. R. VI. 5.

Geum rivale ... ... Water Avens. About Cunswick Scar. I. 55.

Agrimonia eupatoria ... ... Agrimony. Road-sides, common. III. 22.

Alchemilla arvensis—

   Aphanes arvensis ... Parsleypiert. In corn-fields. This specimen is imperfect. IV. 1.

——— *vulgaris* [var. *pratensis*] Ladies' Mantle. In pastures, common. III. 7.

——— *alpina* ... ... Least Ladies' Mantle. (1) Old Hall garden; (2 and 3) upon the summit of Red Pike, opposite Buttermere, in Cumberland. III. 7. St. John's Vale, Keswick. Miss T. X. 53.

Poterium sanguisorba ... ... Burnet. Malham Cove, Gordal Scar, etc., near Settle. V. 21. V. 7 [unnamed].

——— *officinale*—

   Sanguisorba officinalis.. Common Burnet. Pastures, common. I. 8.

Rosa spinosissima ... ... Prickly Rose. From Rampside. V. 12.

——— *rubiginosa* ... ... Sweet Briar. Eglantine. IV. 26.

——— *arvensis?* ... ... White Rose. From Rampside, near Ulverston. V. 12.

Pyrus aria—*Cratægus aria* ... Whitebean Tree. Opposite Arnside, on the coast. V. 26.

——— *aucuparia*—

   Sorbus aucuparia ... Quicken Tree, Roan Tree. Found near 3-mile stone, road to Shap. II. 19.

Cratægus oxyacantha ... ... Hawthorn. Hedges. V. 6. A variety with a red flower. From E. Atkinson's garden, Ardwick Green. V. 6.

Prunus padus ... ... Bird's Cherry. About Spittal, in several places. II. 11.

——— *lusitanica* ... ... Portugal Laurel. Frequently planted in pleasure grounds. XI. 22.

Genista anglica ... ... Needle Furze. Petty Whin. Found about 2 miles beyond Ouse Bridge, Road to Hesket. Middle of June. II. 26.

———— *tinctoria* ... ... Dyers' Weed. Wood Waxen. Pretty common, particularly in pastures a mile distant to the S.E. I. 83.

Ulex europæus ... ... Whins. Furze. Common. II. 11.
Cytisus scoparius—
        Spartium scoparium ... Broom. Plentiful to the E. of the Town. IV. 10.

———— *laburnum* ... ... Laburnum. A garden. XI. 21.

Ononis spinosa... ... ... Thorny Restharrow. Uncertain. (*b*) From Somersetshire. Mr. S. (?) Taylor. I. 82. [(*b*) Placed under *O. arvensis.*]

———— *arvensis* ... . Restharrow. In the meadow to the S.E. of the Castle, near the Foot-walk. I. 82.

Medicago denticulata—
        M. muricata ... ... Medick. From E. R., Darlington. IX. 38.
———— *falcata* ... ... From E. Robson. I. 81. [Doubtful, no fruits on specimen.]

Melilotus officinalis—
    Trifolium melilotus officinalis. Melilot Trefoil. In a tour through the S. and W., uncertain where, but in several places. VII. 16.

        Medicago lupulina.. Trefoil Medick. On Sunderland Ballast hills. From E. R. IX. 4.

Trifolium medium .. .. Long-leaved Trefoil. From E. R., of Darlington. VI. 33.

———— *squamosum*
        T. maritimum ... Teasel-headed Trefoil. Near Wear-mouth. E. R. IX. 15. [Specimen rather young for identification.]

———— *arvense* ... . Hare's Foot Trefoil. From E. R., of Darlington. VI. 33.

———— *striatum* ... ... Soft Knotted Trefoil. From E. R., Darlington. IX. 38.

———— *scabrum* ... ... Hard Knotted Trefoil. From Sunder-land, E. R. II. 27.

———— *suffocatum !* .. ... Yarmouth, E. R. IX. 15.

———— *repens* .. .. White Trefoil. Pastures. II. 27.

———— *fragiferum*... ... ... Strawberry Trefoil. Near Seaton, Co. of Durham. VI. 32.

Trifolium procumbens—

    Medicago lupulina ... See vol. IX., page 4. Melilot Trefoil.
        Miss T. X. 48.

Anthyllis vulneraria ... ... Kidney Vetch, Ladies' Finger. On
    the high and dry pastures, Kendal
    Fell, and amongst the stones about
    Mints Feet. I. 81.

Lotus corniculatus ... ... Bird's Foot Trefoil. Hedges, pastures,
    etc., common. I. 88.

———— *uliginosus—L. major* ... Miss T. X. 43. [Specimens of this
    included under *L. corniculatus.*
    I. 88.]

Onobrychis viciaefolia-

    Hedysarum onobrychis.. Common Saintfoin. On the bridge,
    going out of Oxford, W. VII. 17.

Hippocrepis comosa ... ... Tufted Horse-shoe Vetch. Cunswick
    Scar. III. 21.

Ornithopus perpusillus ... ... Birdsfoot. By the road from the
    Horn Cop (?) on Tenter Fell.
    II. 35.

Vicia hirsuta--

    Ervum hirsutum ... Wild Tare. Miss T. X. 47.

———— *cracca* ... ... Tufted Vetch. Hedges, common.
    I. 86.

———— *orobus—*

    Orobus sylvaticus ... Bitter Vetch. Gamblesby, near Pen-
    rith. From E. R. by P. Harrison.
    VIII. 42.

———— *sylvatica* ... ... Tufted Wood Vetch. Over Laverick
    Bridge to the left by water side.
    I. 84.

———— *sepium* ... ... Bush Vetch. Hedges, etc., very
    common. I. 85.

———— *lutea* . . .. Yellow Vetch. *In horto.* E. R. IX. 10.

———— *hybrida*... ... ... Bastard Vetch. From E. R., Dar-
    lington. IX. 9.

———— *sativa* ... ... Common Vetch. Amongst Corn.
    III. 1.

———— *angustifolia* ... ... X. 24.

———— *bithynica* ... . Rough Vetch. From E.R., of Dar-
    lington. I. 86.

Lathyrus Aphaca ... ... Yellow Vetchling. From E. R., of
    Darlington. VI. 21.

———— *nissolia* ... . Crimson Grass Vetch. From E. R.,
    Darlington. VI. 21.

———— *hirsutus* ... ... Rough-podded Vetchling. IX. 2.

———— *pratensis* ... ... Tare Everlasting. Hedges, etc. I.
    87 and XI. 26. [Loose.]

Lathyrus sylvestris ... ... Narrow - leaved Vetchling. Near
                                Scarboro'. From E. Robson. IX. 3.

——— *montanus* -

       Orobus tuberosus ... Wood Pease. Hedges, etc. Com-.
                            mon. III. 6.

Geranium sanguineum ... ... Cranesbill. At Scoot Stile. IV. 4.

——— *sanguineum* var. *lan-*
       castriense—

       G. lancastriense... Specimen from the Isle of **Walney**
                            (Lanc.). Withering, 3rd. Ed.,
                            Vol. III., p. 600. IV. 4.

——— *nodosum* .. .. Knotty Cranesbill. From E. R.,
                            Darlington. VIII. 34.

——— *phæum* ... ... Spotted Geranium. A garden. V. 41.

——— *sylvaticum*—

       G. nodosum ... ... Miss T. X. 57.

——— *pratense* ... ... Miss T. X. 56.

——— *pyrenaicum* ... ... Mountain Cranesbill. From E. R.,
                            of Darlington. VI. 34.

——— *molle*... ... ... Dove's Foot Cranesbill. Under
                            hedges. III. 0.

——— *pusillum*—

       G. malvæfolium ... Near Darlington. From E.R. IX. 24.

——— *pusillum*—

       sive malvæfolium ... See Vol. IX. 24. Miss T. X. 45.

——— *columbinum* ... ... Long-stalked Cranesbill. From E.R.,
                            of Darlington. VI. 35. From
                            E. R. IX. 17.

——— *lucidum* ... . Shining Cranesbill. Not uncommon
                            on walls, etc. V. 40.

——— *robertianum* ... ... Herb Robert. In hedges, etc. IX.
                            27.

Erodium cicutarium -

       Geranium cicutarium... Hemlock-leaved Geranium. Near
                            Liverpool. V., 38.

——— *moschatum*

       Geranium moschatum .. Musked Cranesbill. From a garden.
                            V. 39.

——— *maritimum*—

       Geranium maritimum.. From E. R. IX. 17.

Oxalis acetosella ... ... Cuckow Bread. Woods and hedges,
                            common. II. 7.

——— *stricta* ... ... II. 7. [Unnamed, *O. corniculata sp.?*
                            added later in pencil.]

Linum catharticum ... ... Purging Flax. About Helsfieldnab.
                            I. 31.

——— *perenne*... ... . Perennial Flax. Baydales, near Dar-
                            lington. E. R. VI. 12.

Polygala vulgaris ... . Milkwort. Wet meadows. I. 80.
Mercurialis perennis ... ... Dog's Mercury. Hedges, etc., common. II. 7.
———— *annua* ... ... French Mercury. Near Sunderland, E. R. II. 9. From E. R., Darlington. X. 7.
Euphorbia helioscopia ... ... Sun-spurge, Wart Wort. Corn-fields, gardens, etc. The juice of this plant is very acrimonious. I. 52.
———— *amygdaloides*—
   E. characias ... ... Red Spurge. On Melbury Heath, on the road from Bristol to Gloucester. pr. Thos. Hoyle. VII. 11.
   E. characias ... ... In a wood on the banks of the Wye, 4 miles above Monmouth, near the mill. VII. 30.
———— *cyparissias*—
   E. amygdaloides ... Wood Spurge. In a garden. IV. 20. [Name written in pencil.]
———— *paralias* .. .. Sea Spurge. Isle of Walney, West Coast. V. 13.
———— *peplus* ... ... Petty Spurge. In gardens and rich soil. III. 19.
———— *exigua* ... ... Dwarf Spurge. In corn-fields near Hales Owen, Salop. IV. 20.
Callitriche stagnalis—
   C. Autumnalis ... Autumnal Stargrass. In ditches, etc. VIII. 11.
———— *hamulata* (?)—
   Potamogeton pusillum In the ditches. Sales-moor. VIII. 22.
———— *autumnalis* ... ... Miss T. X. 9.
Buxus sempervirens ... ... Box. Garden. IX. 11.
Empetrum nigrum ... ... Crowberries. *b* From White Moss, May, 1828. Miss Taylor. IV. 31.
Euonymus europæus ... ... Spindle Tree. In E. Atkinson's garden, Ardwick Green. V. 26.
———— *latifolius* ... ... XI. 10.
Acer pseudoplatanus ... ... Sycamore Tree. In plantations, etc. VIII. 9.
Impatiens noli-tangere .. ... Touch-me-not. In the Old Hall garden. III. 29.
Rhamnus frangula ... ... Alder Buckthorn. From E. R., Darlington. VII. 25 and Castle head (?) Wood, Keswick. Miss T.) X. 60.
Ceanothus sp. ... ... From Mrs. Stephen's garden near Loughborough. XI. 10. [Unnamed. Locality in pencil.]

Tilia europæa ... ... Lime Tree. In plantations. The upper specimen preserved by M. A. V. 18.

Althæa officinalis ... ... Marsh Mallow. Near the new ferry, Monmouthshire. A fine specimen, but spoiled by long keeping. VIII. 10.

Malva moschata ... ... Mallow. Pretty common in fields and on road-sides. I. 77.

——— *sylvestris* ... ... Common Mallow. IV. 39.
——— *rotundifolia—*
        M. sylvestris ... ... Miss T. X. 28.

Hypericum androsæmum ... ... Park Leaves. IV. 30.
        Euphorbia lathyrus I. 119.

——— *perforatum* ... ... Saint John's Wort. Hedges, common. I. 90.

——— *quadrangulum—*
        H. quadrangulare .. St. Peter's Wort. By the rivulet in the meadow beyond the Spittal Wood, near the hedge on the right hand. I. 89.

——— *humifusum* ... ... Trailing St. John's Wort. In the vicinity of Manchester. V. 35.

——— *pulchrum* ... . I. 91.
——— *hirsutum* ... ... Hairy St. John's Wort. At Matlock Bath, etc. I. 89.

——— *montanum* ... ... Mountain St. John's Wort. Cunswick Scar. I. 91.

——— *elodes* ... ... Marsh St. John's Wort. From Dr. Fell, Ulverstone. VIII. 16.

Tamarix Gallica ... ... Tamarix. IX. 17.
Helianthemum canum—
        Cistus marifolius ... Cistus. From E. R., Darlington. III. 20.

——— *canum*, var. *vineale*
        Cistus anglicus ... Hairy Cistus. West side of Co. of Durham. E. R. VI. 10.

— — — *vulgare—*
        Cistus helianthemum. Sunflower. Kendal Fell and Cunswick Scar. III. 20.

— *ledifolium —*
        Cistus salicifolius ... From E. R., Darlington. [This plant was reported to have been found in Somerset.] II. 16.

Viola palustris .. .. .. [Unnamed under *Hydrocotile vulgaris*.] Kersey Moor. IX. 4.

——— *odorata* ... ... Sweet Violet. In hedges, vicinity of Manchester. VI. 0.

Viola hirta ... ... Hairy Violet. From E. R. IX. 9.
——— *riviniana, V. canina* ... Dog's Violet. Hedges, common.
           II. 3. XI. 27 [loose].
——— *tricolor* ... ... Heartsease, Pansies, Three Faces
           under a Hood. Road-sides, very
           common. I. 110.
——— *V. lutea*... ... ... *In horto.* From E. R. IX. 9.
Passiflora cærulea ... ... Passion Flower. A garden. From
           E. R. XI. 5.
Daphne mezereum ... ... Mezereon. In a garden. VII. 14.
Lythrum salicaria ... ... Purple Spiked Loosestrife or Willow
           Herb. I. 50.
Peplis portula ... ... From E. Robson. I. 33. In the
           ditches, Sale's Moor. VIII. 20.
Epilobium augustifolium
    [var. *brachycarpum*].. Rosebay Willowherb. In and about
           gardens. III. 14.
——— *hirsutum* ... ... Great Flowered Willowherb. By a well
           above the Tenters, Fellside. I. 37.
           In a far corner of Mint's Feet.
           N.B.—Several leaves cut off by
           reason of their multitude. III. 15.
——— *parviflorum* ... ... Miss T. X. 16.
——— *montanum* .. ... Smooth-leaved Willowherb. Hedges,
           common. I. 38.
    Epilobium ... ... On Kentmere, High Street, at the
           spring below the summit. III. 14.
           [A small specimen, probably *E.*
           montanum.]
——— *tetragonum* ... ... Narrow-leaved Willowherb. About
           rivulets, pretty common. I. 38.
——— *palustre* ... ... Marsh Willowherb. In marshes. I. 38.
Circæa lutetiana ... ... Enchanter's Nightshade. Moist hedge
           bottoms. I. 2. Bottom of Scout
.
           Scar, S. end. II. 37.
——— *alpina* ... ... [Included under *C. lutetiana.*] II. 37.
Fuchsia triphylla (coccinea) ... From E. Rothwells. XI. 4.
Myrtus communis ... ... XI. 20. [Unnamed.]
Myriophyllum spicatum ... ... Spiked Water Milfoil. From Dr. Hull.
           VI. 20. Miss T. X. 52.
——— *verticillatum* ... Whirled Milfoil. Polam, near Dar-
           lington. E. R. VI. 20. X. 52.
           [Name in pencil only.]
Hippuris vulgaris ... ... Paddow-pipe. In ditches in Wood-
           stock Park, on the reach below
           Conishead Priory, and on Brigsteer
           Moss, by the road from Brathwaite
           Green. VII. 9.

Hedera helix ... ... **Ivy.** Woods, etc., common. V. 1.

Hydrocotyle vulgaris ... ... **Marsh Pennywort.** Near Darlington. From E. R. IX. 4.

Sanicula europæa ... ... **Sanicle.** Cunswick Wood. II. 18.

Eryngium maritimum ... ... **Sea Holly.** Near Whitehaven. III. 39.

——— *campestre* ... ... **Eryngo.** Near Sunderland. E. R. VI. 22. About Sunderland. E. R. VIII. 21.

Myrrhis odorata

    Scandix odorata ... **Sweet Cicely.** In orchards, etc. VIII. 37.

Chærophyllum temulum—Tordylium anthrisius, Caucalis anthrisus ... ... See Vol. I. **Hedge Parsley.** X. 17.

Anthrisius sylvestris—

    Chærophyllum sylvestre .. **Wild Cicely.** In hedges, etc., common. VIII. 14.

Caucalis daucoides ... ... **Five-leaved Bustard Parsley.** Camb. Bot. Gard. E. R. VI. 5.

    C. leptophylla ... ... From E. R., Darlington. X. 10.

——— *anthrisius—*

    Tordylium anthrisius ... I. 27.

Coriandrum sativum ... ... **Coriander.** A heap of rubbish below Stramongate Bridge. I. 24. The Involucrum universale in this specimen to be in some cases *diphyllum*; and as the fruit was not mature when got, the classification is rendered a little doubtful; it had a very strong pungent smell.

Conium maculatum ... ... **Hemlock.** Orchards, etc., common. The whole plant is poisonous, but its virulence is not so great as that of some other British vegetables, or as was formerly imagined: it is used as a medicine. I. 21.

Bupleurum rotundifolium ... ... **Common Thoroughwax.** From E. R., Darlington. VI. 10.

Apium graveolens ... ... **Smallage.** IV. 28. Miss T. X. 62.

——— *nodiflorum—*

    Sium nodiflorum ... I. 26. [A previous entry as "*Sium augustifolium*. Upright Water Parsnip. Slow streams in meadows" has been crossed out by Dalton.] Miss T. See vol. I. X. 33.

Carum carui   ...   .   Common Carraway. From E. R.,
      Darlington.   X. 9.

Sison amomum ...   .   Bustard Stone Parsley. Near Sun-
      derland.   E. R.   VI. 22.*

Sium augustifolium   ...   .   Upright Water Parsnip. In wet places.
      VII. 14.

Ægopodium podagraria   ...   ...   Goutweed.   IV. 24.

Pimpinella saxifraga   ...   ...   About Kendal.   I.   19.   IV. 46.
      [Loose specimen.]

———   *magna*   ...   .   Great Burnet Saxifrage. Woods, dry
      gravelly soil.   I. 19.

Faniculum vulgare—

    Anethum fæniculum ..   Fennel.   IV. 36.

[?] *Crithmum maritimum* ..   ...   Rock Samphire. Uncertain, got out
      of Pickle.   IX. 21.   [A very small
      scrap ; no flower.]

(Enanthe fistulosa—O. fistula ..   Water Dropwort.   VIII. 5.

——— *pimpinelloides*   ...   ...   Parsley Dropwort.   From E. R.,
      Darlington. Also by the shore
      near Ulverstone.   IX. 40.

——— *crocata* ..   ..   Deadtongue. About rivulets. This
      plant, especially its root, is the
      most virulent poison of all the
      vegetables Great Britain produces.
      It may easily be distinguished
      from the other Rundle-bearing
      plants by the very conspicuous
      cups of its florets.   I. 22.

Æthusa cynapium   ...   .   Fools Parsley. Cornfields and gar-
      dens.   I. 27.

Silaus pratensis—

    Peucedanum silaus   ...   Miss T.   X. 36.

Meum athamanticum—

    Æthusa meum ...   ...   Bald Money. Docker Guards, near
      Kendal.   IV. 15.

Angelica sylvestris   ...   .   Wild Angelica. Wet meadows. Com-
      mon.   I. 23.

Pastinaca sativa   ...   .   Wild Parsnip. Common in gardens.

Peucedanum ostruthium—   III. 11.

    Imperatoria ostruthium Common Masterwort.   From E. R.,
      Darlington.   X. 8.

Heracleum sphondylium   ...   ...   Cow Parsnip. Fields and hedges.
      Very common.   I. 25.

Daucus carota ...   .   Wild Carrot. Bird's Nest. North
      end of the Inclosures, road to
      Cunswic Scar. This plant culti-
      vated is the well-known garden
      carrot.   I. 20.

Cornus stolonifera [?]
      C. sanguinea ... ... Dogberry Tree. From a garden. V. 27.

Pyrola minor — P. rotundifolia.. Common Winter Green. Birch Carr, near Darlington. E. R. VI. 12.

————— *secunda*... ... . [Under *P. minor*. Name added in pencil.] VI. 12.

Rhododendron ferrugineum ... XI. 6. [Unnamed.]

————— *ponticum* ... ... A garden. XI. 5.

Andromeda polifolia .. .. Wild Rosemary. Brigsteer Moss. I. 43.

Arbutus unedo ... ... Strawberry Tree. A garden. E. Atkinson. VI. 3.

Arctostaphylos uva-ursi —
      Arbutus uva-ursi ... Bear berries. From Cronkley Fell. From E. R., Darlington. VI. 1.

Vaccinium vitis-idea ... ... Red Whortle-berries. IV. 29.

————— *myrtillus* ... ... Bilberries. IV. 29.

————— *oxycoccus* ... ... Craneberries. IV. 19.

Erica tetralix... ... ... Dutch Heath, All on the Hay Feel. Variety on Brigsteer Moss. I. 36.

————— *cinerea* ... ... Heath. I. 36.

Calluna vulgaris—Erica vulgaris Ling, and variety with white flowers. I. 36.

Primula vulgaris ... ... Primrose. In woods, etc. VIII. 23. XI. 30. [Loose specimen.]

————— *veris* ... ... Cowslip. Dry limestone ground. II. 10.

————— *farinosa* ... ... Bird's Eye. In a moss. Foot-road to Low Groves. H. 15.

Hottonia palustris ... ... Water Violet. Brigsteer Moss. III. 36.

Cyclamen europæum ... ... From a garden. VI. 39.

Trientalis europæa ... ... Chickweed, Wintergreen. On Hamilton, Yorkshire. E. R. VI. 23.

Lysimachia thyrsiflora ... ... Tufted Loosestrife. From E. R., Darlington. IX. 42.

————— *vulgaris* ... ... Yellow Willow Herb. From E. Robson. IV. 45.

————— *nummularia* ... ... Moneywort. Between Chepstow and Tintiern Abbey, Monmouth. VII. 24.

————— *nemorum* ... ... Yellow Pimpernel. About Hawsbridge. III. 2.

Glaux maritima .. .. Sea Milkwort. On the shore at Runcorn, etc. IV. 14. [Unnamed.] X. 8.

Anagallis arvensis ... ... Male Pimpernel. Amongst corn. IV. 1.

Anagallis tenella	Purple Moneywort.
Lysimachia tenella ...	Formerly Brigsteer Moss, Kentmere High Street. I. 14 and IV. 25. [This name not in Dalton's writing.]
Samolus valerandi	Round-leaved Water Pimpernel. Brigsteer and Foulshaw Mosses. II. 15.
Statice limonium	Sea Lavender. About Barrow, on the coast near the Isle of Walney. V. 22. XI. 11. [Loose specimen.]
Ligustrum vulgare	Privet. IV. 16.
Jasminum fruticans	In a garden. From M. A. XI. 34.
Blackstonia perfoliata—	
Chlora perfoliata ...	Perforated Yellow-wort. By the Avon, at the foot of St. Vincent's Rocks. VIII. 3. XI. 31. [Loose.]
Erythræa centaurium—	
Gentiana centaurium ...	Lesser Centaury. IV. 38.
——— *pulchella*	XI. 10.
Gentiana pneumonanthe	Calathian Violet. Miss T. X. 6.
——— *verna*	Vernal Gentian. County of Durham. From E. R. VIII. 4.
——— *amarella*	Fellwort. Upon Kendal Fell about the Tenters and up towards the Lime Kilns. I. 18.
——— *campestris*	Dwarf Gentian. Scout Scar. I. 18.
Menyanthes trifoliata	Buck Bean. In ponds. X. 13.
Villarsia nymphœoides—	
Menyanthes nymphoides.	Fringed Water Lily. From Miss Astley's bot. garden, Dukinfield. IX. 35.
Vinca major	Perrywinkle. In the vicinity of Manchester. V. 30.
——— *minor*	Perrywinkle. In gardens. II. 16.
Convolvulus sepium	Bindweed. In hedges, common in places. V. 35.
——— *soldanella*	Sea Convolvulus. Isle of Walney, W. Coast. V. 10. XI. 32. [Loose specimen.]
Polemonium cœruleum	Jacob's Ladder. III. 35.
Symphytum officinale	Comfrey. In the garden at the Old Hall. IV. 7.
Anchusa sempervirens—	
Borago officinalis ...	Borrage. Garnet House, S.E. side of the outbuildings. I. 13. Evergreen Alkanet. E. R.'s garden, Darlington. VI. 24.*

Lycopsis arvensis ... ... Small Wild Bugloss.   Near Manchester. V. 29.

Pulmonaria augustifolia ... ... Bugloss Cowslips.   From E. R. IX. 11.

——— *officinalis* ... ... Spotted Lungwort. Cliffwood, near Darlington. E. R. VI. 14. From a garden. VI. 42.

Lithospermum purpureo-cærulcum Creeping Gromwell.   On the Banks of the Wye, 4 miles above Monmouth, on high rocky ground. VIII. 13. [Doubtful; a very incomplete specimen.]

——— *officinale* ... ... Gromill. In the garden at the Old Hall. IV. 4.

Mertensia maritima—

 Pulmonaria maritima . Sea Bugloss. Isle of Walney, Ramside, etc. V. 23.

Myosotis cæspitosa ... ... X. 25.

——— *palustris* ... ... X. 25.   See page 11.

——— *arvensis* ... ... X. 11.   XI. 25. [Loose specimen.]

Echium vulgare ... ... Common Viper Grass. Cornfields, etc., about Stourbridge and in Kent. VII. 29.

——— *italicum* ... ... Wall Viper Grass. From E. R., of Darlington. VI. 27. [A bad specimen, probably *E. vulgare.*]

Verbena officinalis ... . Simpler's Joy. In the garden at Old Hall. III. 34.

Ajuga reptans ... ... Bugle. In wet pastures. Also a variety with white flowers. V. 27.

——— *genevensis* ... ... From E. R., of Darlington.   VI. 26.

Teucrium scorodonia ... ... Wood Sage. Woods, hedges. Common, particularly in the Lane beyond the Bird's Park. I. 66.

Scutellaria galericulata ... ... Hooded Willowherb, near Manchester. V. 36.   Miss Taylor. X. 14.   XI. 13.   [Incomplete loose specimen.]

Marrubium vulgare ... ... White Horehound. Roadsides in the Midland and Southern Counties. VII. 16.

Nepeta cataria ... ... Cat Mint. From E. R., of Darlington. VI. 16. In the West of England. VII. 25.

——— *hederacea*—

 Glecoma hederacea ... Ground Ivy. In dry hedges. V. 32.

Brunella vulgaris—

 Prunella vulgaris . ... X. 15.

Galeopsis angustifolia—
       G. ladanum   ...   ... X. 24.
Lamium amplexicaule   ...   ... Great Henbit. From E. R. IX. 22.
    ——— *hybridum—L.dissectum.* From E. R., of Darlington. VI. 29.
             L. dissectum. From E. R. IX. 22.
    ——— *purpureum* ...   . Red Dead Nettle. In kitchen gardens, etc., common. VI. o.
    ——— *album* ...   . White Dead Nettle. In ditches and under walls about the low end of the town. III. 28.
    ——— *galeobdolon—*
       Galeobdolon luteum ... Yellow Archangel. Near Manchester. VIII. 40.
Leonurus cardiaca   ...   . Common Motherwort. IX. 4.
Ballota nigra   ...   . Stinking Horehound. Road-sides in the S.W. of England. VII. 25.
Stachys officinalis—
       Betonica officinalis ... Betony. Common in woods and hedges. I. 67.
    ——— *palustris—*
       S. sylvatica palustris ... Clown's Allheal. Banks of rivers, etc., common. I. 64.
    ——— *sylvatica*   ...   . Hedge Nettle. Hedges, etc. I. 63.
    ——— *arvensis*   ...   . Upright Ground Ivy. Corn-fields. I. 65.
    ——— *lanata* ...   . In a garden near Loughborough, Leicestershire. XI. 3.
Salvia verbenaca   .... Wild Clary. In Oxfordshire. VII. 26.
Melissa officinalis—
       Melittis melissophyllum. Bastard Balm. [Correction of name in pencil.] About Bristol, place uncertain. VII. 26.
Calamintha officinalis—
       Melissa calamintha ... Calamint. Castle walls. III. 32.
Origanum vulgare   ...   . Wild Marjoram. Cunswick Scar. I.68.
    ——— *vulgare,* var.*albiflorum.* [Included with above.]
Thymus serpyllum   ...   . Mother of Thyme. On dry hills, common. I. 70.
Lycopus europæus   ...   . Gypsie, Water Horehound. Below Stockbridge. I. 1.
Mentha rotundifolia ...   . Near Saltburn, Yorkshire. E. R. I. 61.
    ——— *aquatica*   ...   . Water Mint. About rivulets, particularly in the field beyond Spittal Wood, foot-path to Grayrigg. I. 62.
    ——— *citrata—M. nondescripta.* Burgamot Mint. From Ed. Robson. XI. 8.
    ——— *gentilis fol. variegat.* ... Red Mint. Garden. E. R. IX. 5.

Mentha arvensis ... ... Corn Mint. Corn-fields. I. 62. I. 60.
[Unnamed.]
———— *pubescens—M. sativa* ... Curled Mint. By the rivulet running
through the meadows S.E. of the
Castle. I. 61.
———— *sylvestris* ... ... Horse Mint. From E. R. IX. 5.
Clinopodium vulgare ... ... Great Wild Basil. Hedges, etc., com-
mon. I. 69.
Atropa belladonna ... ... Deadly Nightshade. Furness Abbey,
and on the coast opposite Arnside
Point. V. 16. V. 25.
Hyoscyamus niger ... ... Henbane. IV. 31. XI. 28. [Loose
specimen.]
Solanum dulcamara ... ... Bittersweet. In moist hedges, etc.
III. 18.
———— *nigrum* ... ... Common Nightshade. On the roads
about London, Hackney, etc.,
common. VII. 20.
Datura stramonium ... ... Thornapple. In a garden. *Cura*
M. A. VIII. 8.
Verbascum thapsus ... ... Great White Mullein. Castle and
other high stony places. I. 12.
———— *lychnitis* ... ... Hoary Mullein. About Oswestry.
From Mr. Wood, of Leeds. VII. 20.
———— *nigrum* ... ... Black Mullein. From E. R., Darling-
ton. II. 16.
———— *V. thapso-nigrum* ... From E. R.'s garden, Darlington,
via Withering. Ed. III., vol. 2,
page 248. [This specimen is nearer
V. nigrum than *V. thapso-nigrum*.]
VI. 13.
———— *blattaria* ... ... Yellow Moth Mullein. In the com-
mon garden up Peat Lane. The
flowers were white, perhaps it is
some variety. I. 16. [Flowers may
be white.]
Antirrhinum majus ... ... Great Snapdragon. On the rocks at
Hawkston, Salop. VII. 27.
———— *orontium* ... ... Snapdragon. From E. R. IX. 2.
Linaria cymbalaria—
Antirrhinum cymbalaria... Ivy-leaved Toad Flax. Dispensary
Gardens. Cultivated there by the
late apothecary, T. Parker. I. 73.
———— *elatine*
Antirrhinum elatine ... Sharp-pointed Snapdragon. From
E. R. IX. 1 and 8. [Specimen
on p. 8 named in Index only.]
———— *purpurea* ... ... X. 59. [Unnamed.]

Linaria repens [?]—
    Antirrhinum
        monspessulanum ... Sweet smelling Snapdragon. E. R.'s garden, Darlington. VI. 27. [Incomplete specimen without leaves.]
———— *vulgaris*—
    Antirrhinum linaria ... Common Toad Flax. Common in many fields. I. 74.
    Antirrhinum
      linaria var. *Peloria* ... Garden E. R. IX. 1.
———— *minor*—
    Antirrhinum minus... .. Least Snapdragon. By the side of the Avon just below Clifton, at the foot of St. Vincent's Rocks. VII. 28.

Scrophularia aquatica .. ... Miss T. X. 35.
————— *nodosa*—
      Scrophularia ... X. 18.
—————— *scorodonia* ... ... Balm-leaved Figwort. Garden. E. R. IX. 18.
—————— *vernalis* ... ... Yellow Figwort. VIII. 27.

Veronica hederæfolia ... ... Small Henbit. Ditch Bank, etc. IV. 13.
———— *agrestis* ... ... Speedwell. In gardens, under hedges, etc. III. 12.
———— *arvensis* ... ... From Dr. Hull. III. 12. VII. 22. [Unnamed.]
———— *saxatilis* ... ... From E. Robson. IV. 12.
———— *spicata* ... ... Upright Spiked Male Speedwell. From E. R., of Darlington. VI. 24.
———— *hybrida* ... ... Welsh Speedwell. From E. R. VIII. 38.
———— *officinalis* ... ... Male Speedwell. High, barren pastures. III. 12 and III. 40. [Loose specimen.]
———— *chamædrys* ... ... Wild Germander. In hedges, etc., very common. IV. 12.
———— *montana* ... ... From E. R., Darlington. VI. 14.
———— *scutellata* ... ... Narrow leaved Speedwell, Hill-close-scarr? near Darlington. E. R. III. 12 and III. 13. [Unnamed.]
———— *anagallis* ... ... Long-leaved Water Speedwell. IV. 43.
———— *beccabunga* ... ... Brooklime. In slow streams. X. 12. II. 39. [Loose specimen.]
Digitalis purpurea ... . Foxglove. Road sides, etc., very common. I. 72.

Melampyrum pratense   ...   ...   Meadow Cow-wheat.   In woods, etc.,
                                    common. IV. 17. [Ref. as above.]
                                    X. 3.

———   *sylvaticum* ...   ...   Yellow Cow-wheat.   From E. R.,
                                    Darlington.   Rare.   X. 3.

Bartsia odontites—
          Euphrasia odontites ... Red Eyebright.   About soft, watery
                                    places.   I. 71.

——— *alpina (?)* ...   .   West side, county Durham.   E. R.
                                    I. 72.   [A poor specimen.]

Euphrasia officinalis ...   .   Common Eyebright.   In fields, com-
                                    mon.   I. 71.

Pedicularis palustris ...   .   Miss T.   X. 12.

———   *sylvatica—P. palustris* Marsh Lousewort.   In wet meadows.
                                    VIII. 30.

Lathræa squamaria ...   .   Great Toothwort.   Near Gairsford,
                                    Durham.   E. R.   VI. 14.

Orobanche major   ..   ..   Common Broomrape.   Raby Park,
                                    Co. of Durham.   E. R.   VI. 14.

———   *minor*   ...   .   Less Broomrape.   On the grounds at
                                    the foot of the walls within Chep-
                                    stow Castle, plentifully.   VIII. 27.

Pinguicula vulgaris ...   .   Yorkshire   Sanicle.   Wet,   mossy
                                    ground.   II. 23.

Utricularia vulgaris ...   .   Hooded Water Milfoile.   From E. R.,
                                    of Darlington.   VI. 20.

Plantago major ...   .   Great Plantain.   Way-bread Road-
                                    sides.   I. 10.

———   *media* ...   .   Hoary Plantain.   Limestone ground.
                                    I. 10.

———   *lanceolata* ...   .   Ribwort.   Very common.   Pastures.
                                    I. 10.

———   *maritima*   ...   .   Narrow-leaved Plantain.   N.B.—This
                                    specimen is a very small one.
                                    [Large specimen on opposite page
                                    added later.]   IV. 30.

———   *coronopus*   ...   .   Buckshorn Plantain. Seaton.   E. R.
                                    IV. 43.   On the Coast, Ulver-
                                    stone.   IX. 22.   Miss T.   X. 51.

———   *psyllium*   ...   .   In E. Rothwell's garden.   *Curâ*,
                                    Crowther.   XI. 7.

Litorella lacustris   ...   .   [Pencil name only.]   IV. 34.

Sherardia arvensis   ...   .   Little Field Madder.   On St. Vin-
                                    cent's Rocks, Bristol.   By Saml
                                    Taylor. (*a*) Basford, Staffordshire
                                    By J. D. Burton. (*b*) VII. 6.

Asperula odorata	Woodruff. Helsfellnab, Cunswick Wood, etc. II. 17.
—— *cynanchica*	Squinancy-wort. Near Knaresborough. E. R. II. 17. [Pencil name only] Miss T. II. 31.
Galium boreale	Cross Wort Madder. From E. R., of Darlington. No 2 from Hill Ball, Westmorland. VI. 15.
—— *cruciata* —	
Valantia cruciata ...	Crosswort. Hedges. Common. II. 29.
—— *verum*	Yellow Ladies' Bedstraw. Common in dry calcareous soil. VIII. 23.
—— *saxatile—G. montanum* .	Mountain Ladies' Bedstraw. About Cunswick Stile. II. 32.
—— *palustre* var. *Witheringii*	
G. Witheringii (*montanum*)	See Vol. II. 32. Miss T. X. 29.
—— *uliginosum—G. palustre*.	White Ladies' Bedstraw. In ditches, etc. VIII. 24.
—— *aparine*...	Catchweed. In hedges, common. III. 30.
Sambucus nigra—S. niger... ...	Elder. Hedges. I. 29.
—— *ebulus*...	Dwarf Elder. Miss. T. X. 46.
Viburnum opulus	Water Elder. In some hedges. III. 39. III. 40. [Loose.]
Lonicera periclymenum	Woodbine, Honeysuckle. Gardens, hedges, etc. I. 15.
—— *xylosteum*	Upright Honeysuckle. From E. R., Darlington. I. 15.
Adoxa moschatellina	Moschatel. Brow opposite church, hedges and woods. II. 3. XI. 32. [Loose specimen found in journal.]
Valerianella olitoria—	
Valeriana locusta ...	Lamb's Lettuce, Corn Sallad. In the cornfields E. of river near Hawsbridge. IV. 2. Near Bunside Road, opposite to the Tenter Fell Gate. N.B. See another Specimen in the 4th vol. I. 5.
Valeriana dioica	Small Wild Valerian. In the right-hand meadows, up the Peat Lane. III. 37. Miss T. X. 35.
—— *officinalis*	Great Wild Valerian. Very common. I. 5.
Centranthus ruber—	
Valeriana rubra ...	Flower gardens. I. 4.
Dipsacus sylvestris—D. fullonum.	Wild Teasel. In the garden at Old Hall. IV. 5.
D. sylvestris	Miss T. X. 40.

Dipsacus pilosus ... ... Shepherd's Rod.   From E. R., of Darlington. Found it also between Chepstow and Tintiern Abbey, Monmouth and on the Banks of the Wye between Monmouth and Whitchurch, on a rocky place above a Mill in great plenty. 1797. VI. 17. See vol. VI. 17. Miss T. X. 44.

Scabiosa succisa ... ... Scabious. Meadows, common. I. 9.

———— *columbaria* ... ... Lesser Field Scabious.   Limestone pastures, W. of town.   I. 9.

———— *arvensis* ... ... Common Field Scabious. In fields, common. I. 9.

Bryonia dioica — B. alba ... . . Wild Vine. In N. Gough's garden. II. 30.

Phyteuma orbicularis. . ... Round-headed Rampion. From E. R. VIII. 39.

Campanula trachelium ... ... Canterbury Bells. At Hawkston, Shropshire. Sr. Rd. Hills. VII. 19.

———— *latifolia* ... ... Giant Throatwort. Pretty common, particularly on the road towards Laverick Bridge and places adjacent. I. 11.

———— *rotundifolia* ... ... Round-leaved Bell Flower. Road-sides, etc., common. I. 11.

———— *rapunculus* ... ... Rampion. From E. R. IX. 23.

———— *patula* ... ... Field Bell Flower. In Shropshire From J. Jackson, Ketley. VII. 19.

Specularia hybrida—

     Campanula hybrida ... Lesser Venus Looking-glass.   Seeds from Hort. Botan. Cantab. E. R. VI. 22.*

Trachelium cœruleum ... ... From J. Hudwin, Liverpool. XI. 4. [Unnamed. Source entered in pencil.]

Jasione montana ... ... Hairy Sheep's Scabious. High and dry situations. VIII. 18.

Lobelia dortmana ... ... Water Gladiole. From Winandermere Lake, Westmorland. IV. 25.

Eupatorium cannabinum ... ... Hemp, Dutch, or Water Agrimony. Up the River Kent, etc. I. 94.

Solidago virgaurea ... ... Woundwort, Golden Rod. Woods, etc., pretty common. I. 106.

———— *virgaurea*, var.

     cambrica—S.cambrica.. Mountain Golden Rod. On the high pastures between Settle and Malham Cove. V. 24.

Bellis perennis	... Common Daisy. Common. IX. 20.
Aster tripolium	... Near Seaton, Co. Durham. E. R. Two lower specimens from the side of the Avon, below Bristol. I. 101.
Erigeron canadense	... Canada Flea-bane. Near Sunderland. E. R. VI. 28.
——— *acre*	... Blue Flea-bane. From E. R., Darlington. VI. 28. On the walls of Worcester. VII. 17.
Filago germanica	... [Included under *Gnaphalium uliginosum.*] VIII. 7.
——— *minima*—	
Gnaphalium minimum.	Miss T. X. 45.
Antennaria dioica—	
Gnaphalium dioicum ...	Catsfoot. County of Durham. E. R. VI. 5.
Gnaphalium uliginosum ...	... Black-headed Cudweed. Near Hampton Court. VIII. 7.
Gn. rectum	... Upright Cudweed. On the road to Grayrigg, 2½ miles from Kendal. IV. 32.
Inula squarrosa—	
Conyza squarrosa	... Great Flea-bane. Cunswick Scar. I. 107.
——— *helenium*	... Elecampane. In a lane going from Mold to Holywell, Flint. VIII. 3.
Pulicaria dysenterica —	
Cineraria palustris ...	Marsh Fleawort. Lancashire. From G. Crosfield, Warrington. IV. 21.
Inula dysenterica	... Elecampane. Fleabane. Near Manchester. V. 36.
——— *vulgaris*—	
Inula cylindrica	... Small Fleabane. In Hampshire, on the road from London to Salisbury. VIII. 4.
Xanthium strumarium ...	... Less Burdock. From E. R. VIII. 1.
Bidens cernua	... Nodding Double Tooth. In ponds, etc. VI. 3.
——— *tripartita*	... Water Hemp. In wet ground. VII. 10.
Anthemis arvensis	... Corn Chamomile. From E. R. VIII. 41.
——— *nobilis*	... Sweet-scented Chamomile. In a garden. III. 32.
Achillea millefolium	... Common Yarrow or Millfoil. Very common. I. 108.
——— *ptarmica*	... Sneezewort. Goose-tongue. Woods and meadows. I. 108.

Matricaria inodora—

  Chrysanthemum inodorum Field Feverfew. Roadsides. Very common. I. 99.

Chrysanthemum segetum ... ... Corn Marigold. Cornfields, etc. I. 101.

———— *leucanthemum* ... .. Great Daisy. In pastures. I. 100.

———— *parthenium*—

  Matricaria parthenium. Feverfew. About country farmhouses. III. 13.

———— *italicum* ... ... Sunderland. B. Hills. From E. R. I. 100. [?]

Tanacetum vulgare ... ... Tansey. Road to Benson Hall, in the fields to the left rising the hill. I. 105.

Artemisia vulgaris ... ... Mugwort. East side of the river below the town. I. 104.

———— *maritima* ... ... Sea Wormwood. From Witheral, near Corby Castle. Cumberland. IV. 32. Field Southernwood. By the Avon at the foot of St. Vincent's Rocks. VII. 29. [Labelled also *A. campestris.*]

Petasites ovatus [♀]—

  Tussilago hybrida ... Long-stalked Coltsfoot. Plentifu near Manchester. X. 6.

———— *ovatus—Tussilago*

  hybrida (petasites) ... Long-stalked Butter bur. Mintsfeet etc. II. 1.

Tussilago farfara ... ... Coltsfoot. Mintsfeet, etc. II. 4.

Doronicum pardalianches ... ... Wolf's Bane. From E. R. VIII. 39.

Senecio vulgaris ... . Common Groundsel. Gardens, etc. I. 102.

———— *sylvaticus* ... ... Mountain Groundsel. From Staffordshire. Miss T. X. 19.

———— *crucifolius*—

  S. tenuifolius ... ... Miss T. X. 32.

———— *jacobæa* ... ... Ragwort. Pastures, etc. I. 102.

———— *aquaticus* .. .. Broad-leaved Ragweed. In marshy or watery places. III. 17.

———— *saracenicus*—

  S. paludosus ... ... Marsh Ragwort, Bird's Tongue. By the rivulets running under Stockbridge, three fields above. Also about the mill in Preston Patrick, plentiful. [In pencil, "Remember E. R. with a specimen."] I. 103.

———— *paludosus* ... ... Bird's Tongue Groundsel. From E. R. III. 17.

Carlina vulgaris ... ... Wild Carline Thistle. Dry commons and pastures. I. 95.

Arctium minus—A. lappa... ... Burdock. Common, road-sides. Miss T. X. 20.

Carduus eriophorus ... ... Woolly-headed Thistle. From E. R., near Sunderland. IX. 12. From E. R., Darlington. IX. 41.

Cirsium heterophyllum—

    Carduus helenioides ... Melancholy Thistle. In the garden at the Old Hall. IV. 6.

——— *arvense—*

    Serratula arvensis ... Corn Saw-wort. X. 28.

    Serratula arvensis—

        Carduus (?) *arvensis* Smith. X. 39 (?). [This specimen too badly damaged to be identified with certainty.]

Onopordon acanthium ... ... Common Argentine. Found on the road from London to Bristol. This specimen from E. Rothwell's garden. VIII. 26.

Serratula tinctoria ... ... Saw-wort. In the garden at the Old Hall. III. 33.

Centaurea nigra ... ... Matsellon Knapweed. Pastures, etc., common. I. 109.

——— *cyanus* ... ... Bluebottle. In cornfields. VII. 13.

——— *calcitrapa...* ... ... Star Thistle. Near Gravesend, in Kent. VII. 7.

Cichorium intybus ... ... Wild Succory. In a garden. Found it wild in Kent, Surrey, etc. III. 35.

Lapsana communis ... ... Dock Cresses. Ditch banks, etc. I. 92.

Picris hieracioides ... ... Yellow Succory. VIII. 14.

——— *echioides* ... ... Common Ox Tongue. From E. Rothwell's garden. VIII. 21.

Crepis fœtida ... . Stinking Hawksbeard. From E. R., of Darlington. VI. 36.

——— *capillaris—C. tectorum...* Smooth Succory Hawkweed. Walls, roadsides, etc. Pretty common. I. 93.

——— *paludosa—*

    Hieracium paludosum... Near Darlington. E. R. I. 98.

Hieracium pilosella ... ... Creeping Mouse Ear. Dry pastures. X. 5.

——— *aurantiacum* ... ... Golden Hawkweed. Garden. An exotic. IX. 30.

Hieracium boreale—

         H. subaudum   ...   Broad - leaved   Bushy   Hawkweed. Hedges, etc.   Common.   I. 98.

   ———   *umbellatum*   ...   .. Bushy Hawkweed.   Near Sunderland.   E. R.   IX. 18.

Leontodon nispidum ...   . Dandelion.   In pastures.   IV. 11.

Taraxacum officinae—

        Leontodon officinale   ... Common Dandelion.   In pastures, etc.   VII. 23.

Sonchus oleraceus   ...   . Sow Thistle.   In gardens, etc.   I. 97. Miss T.   X. 31.

   ——— *arvensis—S. palustris* ... Sow Thistle.   Banks of rivers.   I. 97.

      S. arvensis   ...   .. Miss T.   X. 30.

Lactuca virosa ...   . Wild Lettuce.   On the road-side from Preston to Chorley.   V. 39.

   ——— *muralis*—

       Prenanthes muralis ... Ivy Leaved Wild Lettuce.   Upon Kendal Fell among the Craggs.   I. 96.

Tragopogon pratense ...   . Go to Bed at Noon.   Near the foot-road to Helsfell Nab, in the field below the barn.   III. 23.

NOTE.—The spelling, etc., of English names and localities is that in the originals.

An alphabetical index has been prepared and is kept with the volumes in the Society's possession.

II.—The Ancient Legend as to the Hedgehog carrying Fruits upon its Spines.

By MILLER CHRISTY, F.L.S.

(Communicated by T. A. COWARD, F.E.S., F.Z.S.)

(Read and received for publication 11th March 1919.)

I.—INTRODUCTION.—Everyone is familiar with the very ancient legend that the Common Hedgehog *(Erinaceus europæus)* is accustomed to roll himself upon fallen apples, figs, grapes, and the like, and to run off home with them sticking on his prickly spines. This tradition has survived for at least two thousand years and is still current. It seems worth while, therefore, to enquire briefly as to the evidence (if any) in favour of its being based on fact ; for there seems, *à priori*, little or no reason to doubt its possibility, at least. In any case, a recent occurrence led me to devote some time to an investigation, and the following remarks are designed to elicit information sufficient to prove whether the legend is really founded on fact or not.

At the very outset, one should bear in mind that the question is one which must be, of necessity, very difficult to settle by observation ; for the Hedgehog is an almost-wholly crepuscular or nocturnal animal, seldom coming abroad till it is at least dusk, when effective observation on such a point is not easy. Thus, even if the carrying of objects in this way were a common habit of the animal, that habit would almost certainly be witnessed very seldom by man, and still more seldom by a trained and reliable observer.

II.—STATEMENTS OF THE OLD CLASSICAL WRITERS.—The earliest writer to give the story currency was (so far as I can learn) Pliny, who wrote about the year 75 A.D. He says :—*

" Hedgehogs lay up food for the winter. Rolling themselves on apples as they lie on the ground, they pierce one with their quills and then take up another in the mouth, and so carry them into the hollows of trees."†

---

* *Nat. Hist.*, lib. viii., cap. 37 (English transl. by Bostock and Riley, ii., p. 308 : Bohn, 1855). Several writers attribute to Aristotle an earlier statement to the same effect ; but I can find nothing of the kind in his writings.

† Præparant hiemi et herinacei cibos : ac volutati supra jacentia poma affixa spinis, unum non amplius tenentes ore, portant in cavas arbores.

Later writers have fathered upon Pliny, and have themselves endorsed, the additional statement that Hedgehogs climb trees and deliberately detach and throw down fruit ; but of this Pliny himself says nothing. I regard it as utterly absurd ; for, so far as I know, the animal has never been known to climb among the branches of trees, though it is agile enough to scramble up an inclined tree-trunk.

Claudius Ælianus, another Latin author, who wrote about the year 250 A.D., tells much the same tale of the Hedgehog : but he applies it to *figs*, instead of apples. He says :—*

" *The Ingenuity of the Hedgehog.*—The Land Urchin† is by nature neither stupid nor unskilled in providing for its own sustenance ; for, inasmuch as it needs food for the whole year and not every season provides fruits, he is said to wallow in places where they dry figs, many of which become impaled on his quills, when he easily carries them to his hole, where he lays them up, so that he can make use of his store when it is not possible to gather fruit from outside."‡

III.—EVIDENCE OF MEDIÆVAL WRITERS.—After a very long interval, both in time and distance, we find Philippe de Thaun, an Anglo-Norman poet of the Twelfth Century, reviving this story of the Hedgehog carrying off fruit, but in connection with *grapes* : not apples or figs. In a " Bestiary " (*circa* A.D. 1120) by him, preserved in the British Museum,§ we read that :—

> " In time of vintage, hedgehog climbs up the vine :
> There to the cluster he comes : the ripest he chooses.
> Then knocks down the grapes—very bad neighbour to do it.
> Then from the vine he climbs down ; on the grapes stretches himself.
> Then on top of them rolls himself, round as a ball.
> When he's well loaded, the grapes stick on him.
> Thus he carries food to his children, by nature."‖

---

* *De Natura Animalium*, lib. iii., cap. x.

† He speaks of it thus to distinguish it from the *Sea* Urchin *(Echinus)*.

‡ *Erinacei solertia.*—Erinaceum terrestram nec imprudentem, nec imperitum parandorum in vitæ usum fructum natura reddidit. Quandoquidem enim cibo, qui per annum duret, indiget, neque quodlibet anni tempus fruges producat, illum in locis, ubi ficus exciccantur, se volutari ajunt, et transfixas ficus, quæ non paucæ spinis inhærent, facile portare, easque in caverna congestas servare, ut inde pomere queat, quum extrinsecus fructus colligere non possit.

§ Cott. MS. Nero. A.V. [fo. 63]. The passage quoted is printed, but incorrectly, in *Archæologia*, xii. (1796), p. 304, and in *Popular Treatises on Science written during the Middle Ages*, edited by Thomas Wright, p. 105 (Hist. Soc. of Science, 1841).

‖ El tens de vendenger, lores munte al palmer,
Là ù la grappe veit, la plus meure seit,
Si'n abat le raisin, mult li est mal veisin ;
Puis del palmer decent, sur les raisins s'estent,
Puis desus se volup, ruunt cum pelote,
Quant est tres ben charget, les raisins embrocet,
Eissi porte pulture, a ses fiz par nature.

The Hedgehog and Apples Legend (as one may call it), was a very favourite subject with the compilers of the Bestiaries and other finely-illuminated Manuscripts of the Early-Mediæval Period, scores of which depict the Hedgehog in the act of either climbing trees or running off with apples, grapes, or other fruits sticking on his back-spines. There are, preserved in the British Museum, in the Bibliothèque Nationale, and in Libraries at Oxford, Cambridge, and elsewhere, many such manuscripts, of the Thirteenth to the Fifteenth Centuries, in which this procedure (real or imaginary) of the Hedgehog is depicted.*

In the Sixteenth and Seventeenth Centuries, most writers on Natural History noticed the old legend, and few or none expressed disbelief in it.

Thus, John Maplet (*d.* 1592) says† of the Hedgehog, that :—

" He is as good a meatesman and catour for him selfe as anything living is. For, when his vittayles be scant or nighe well spent, he getteth abrode to orchards and groaves, where he hunteth after vines and other the best fruite. At the vine (as, likewise, at the apple tree), he playeth his part thus : He goeth up to the boughes and shaketh them [*i.e.*, the grapes and apples] downe. When he hath perceived he hath shaken down inough, he cometh apace downe and gathereth the grapes or apples dispersed abrode togither ; and, when he hath done, he falleth heavily upon the heape and so, almost on everie prickle or brestle, he getteth an apple or grape, and home he goeth."

A few years later, Stephen Batman wrote :—‡

"The urchin is a beaste of purveyance ; for he climbeth upon a vine or an apple tree and shaketh down grapes and apples. And, when they be felled, he walloweth on them, and sticketh his prickles in them, and so beareth meat to his children, in that manner wise. . . . And beside the apples that he beareth on his backe always, he beareth one in his mouth. And, after that he is charged [*i.e.*, loaded with grapes or with apples], if any apple or grape fall out of the pikes in any manner wise, then, from indignation, he throweth away off his backe all the other deal : and oft turneth again to the tree, to charge him again with a fresh charge."

* See, for example, Roy. MS., 12, F. xiii., which is of about the year 1200. It contains (fo. 45) a drawing representing three apple trees, from which many apples have fallen. Among the latter are three Hedgehogs, two rolling on the apples, while the third, laden with eight or ten apples, runs off to his hole in an adjacent bank.

† *A Greene Forest or Natural Historie*, by John Maplet, M.A., fo. 89 obv. (Lond., 1567).

‡ *Barthome his Book*, book xviii., secs. 62-63 (Lond., 1582).

Again, in 1601, Robert Chester (1566-1640), a rhymester, wrote of the Hedgehog* that :—

> "Apples, or pears, or grapes, such is his meate,
> Which, on his backe, he carries for to eate."

In 1620, Conrad Gesner, a Swiss naturalist, wrote in his well-known *History of Animals* :—†

"Hedgehogs, in the autumn, live chiefly in thorny thickets and vineyards. In winter, they hide themselves in hollow trees and live on the food (chiefly apples) which they have stored up during the summer. It is said that the Hedgehog can live for a year without food (Aristotle in his *Wonders*). They lay up food for the winter (like marmots), rolling themselves over apples (or apples and pears according to others, or even dried figs, as Philes says) and running off with them stuck on their spines, holding one only in the mouth, thus carrying them into hollows in trees (Pliny and others)."‡

Of all the versions of the Hedgehog legend which appeared at about this period, the most picturesquely-worded and detailed is certainly that, published in 1607, of quaint old Edward Topsell. He writes of Hedgehogs§ that :—

"In the summer time, they keepe neare vineyards and bushy places, and gather fruite, laying it up against winter.‖ . . . His meate is apples, wormes, or grapes. When he findeth apples or grapes on the earth, he rowleth himself uppon them until he have filled all his prickles, and then carrieth them home to his den, never bearing above one in his mouth. And, if it fortun that one of them fall off by the way, he likewise shaketh of all the residue and walloweth upon them afresh, untill they be all setled upon his backe againe. So, forth he

---

* *Love's Martyr, or Rosalin's Complaint*, Lond. 4to, 1641 (or Dr. Grosart's ed., New Shakespeare Soc., p. 111).

† *Historia Animalium* (Viviparous Quadrupeds) 2nd ed., p. 370 (Frankfort, 1620).

‡ Herinacei in sæpibus dumosis et vineis per autumnum præ cipue diversantur. Conduntur in arbores cavas hyeme, et cibis (pomis præ cipue) per æstatem congestis vescuntur. Echinum aiunt ad annum usque sine cibo durare posse (Aristoteles In *Mirabilibus*). Præ parant hyemi et herinacei (ut mutes alpini) cibos ac volutati supra poma (mala et pira, ut alij : vel etram ischadas, ut Philes) affixa spinis, unum amplius tenentes ore, portant in cavas arbores (Plinius et alienis).

§ *History of Foure-footed Beastes*, p. 278 (1607).

‖ This statement, like that with which Topsell closes, is, I believe, quite inaccurate. The Hedgehog, no doubt, carries home food to its nest, but this is *not* as winter sustenance. On this point, most authoritative modern writers are agreed (see *post*, pp. 12 & 13).

goeth, making a noise like a cart wheele.* And, if hee have any young ones in his nest, they pull of his load wherewithal he is loaded, eating thereof what they please and laying uppe the residue for the time to come."

In 1637, Ulysses Aldrovandus (1522-1605), of Bologna, one of the most distinguished naturalists of his time, says :—†

"The method by which the hedgehog detaches apples from the trees and carries them off to its burrow, stuck upon its spines, has been observed by those who study the things of nature ; also that, if one falls off by the way, the animal, growing angry, throws off all the rest and returns again to the tree."‡

Johan Sperling, a German naturalist of much the same period, says :—§

"*What is the food of the Hedgehog ?*—Apples, pears, grapes, and other fruits. He climbs these trees, throws down the apples and pears, rolls himself upon them till they stick on to his spines. After this, he starts off and hastens to the hollows in trees in which he lives. If a single apple falls off, he immediately casts off all and returns to the tree, where he gathers a new supply."‖

Here, then, we have the testimony of many more-or-less reliable Mediæval writers and illustrators to the effect that the Hedgehog carries home fruits of various kinds impaled on its spines. Their testimony is spread over many centuries and many countries, and relates to at least four different kinds of fruits (namely, apples, pears, figs, and grapes). Without doubt, however, most of these writers were mere copyists who adopted blindly the statements of their predecessors.

IV.—Recent Observations and Opinions.—But evidence on the point does not end here ; for many modern naturalists have expressed their opinions, and some have recorded cases in which Hedgehogs are asserted to have been *actually observed* in the act of transporting fruit on their spines.

---

* This is Topsell's description of the curious squeaky whining grunt to which the creature constantly gives utterance when foraging for food in the woods and hedges at night.

† *De Quadrupedibus Digitalis*, lib. ii. (Bologna, ed. 1637, p. 467).

‡ Ratione pomarum, quæ ab herinaceis decutiuntur ab arboribus et spinis affixa, ad cavernam feruntur, observarunt rerum naturalium scrutatores ; si in itinere unum tantum cadat, animal ira ascensum cætera abjicere, denique ad arborem revertit.

§ *Zoologia Physica Posth.*, p. 281 (Leipzig, 1661).

‖ *Quodnam nutrimentum Erinacei sit ?*—Poma, pira, uvæ, & fructus alii.   Hinc arbores ascendit, poma ac pira decutit, in istis sese volutat, ut spinis hærant.   Post ad iter sese accingit & ad cavas arbores, in quibus habitat, properat.   Pomum unum si decidit, mox omnia adjicit, & ad arborem redit, novumque cibum requirit.

At the end of the Seventeenth Century, the old Scottish naturalist, Sir Robert Sibbald, wrote* that the Hedgehog :—"feeds on mice [!], nuts, apples, and pears, which he sticks upon his prickles, and thus carries home to his burrow."†

In 1732, Mons. N. A. Pluche, a French naturalist, wrote :—‡

" Le Herisson fait un autre usage de la commodité de ses piquants. Il se roule sur les pommes, sur les grains de raisin, et sur tous les fruits qu'il peut rencontrer sous les arbres, et emporte sur ses crochets tout le plus qu'il peut.   Il mange ce qui presse le plus, et tache d'avoir des noix pour l'arrière-saison.   Il passe l'hyver à dormir.

In 1760, le Comte de Buffon, the great French naturalist, wrote of the Hedgehog :—§

" Je ne crois pas qu'ils montent sur les arbres, comme le disons les naturalistes, ni qu'ils se servent de leur épines pour emporter des fruits ou des grains de raisin.   C'est avec la gueule qu'ils prennent ce qu'ils veulent saisir ; et, quoiqu'ils y en air un grand nombre dans nos forets, nous n'en avons jamais vû sur les arbres.   Ils se tiennent toûjours au pied."

In 1794, the Rev. Patrick Russell, writing of Hedgehogs, says :—‖

" I have never seen them on trees, but I have certainly seen them transporting grapes on their prickles, as likewise mulberries."

He then proceeds to give a reference to the statement of Ælian quoted at the outset.¶   His own observations (which are very much to the point) must have been made (judging from the context and the nature of his work) at Aleppo, in Asia Minor.

In 1800, George Shaw, M.D., wrote :—**

" It is commonly said that the Hedgehog, in order to transport apples and other fruit to its place of retirement, rolls itself upon them and thus conveys them upon its spines.   Whether this be accurately true, I will not take upon myself to determine.

---

* *Scotia Illustrata, sive Prodromus Historiæ Naturalis*, p. 11 (not the duplicate p. 11), Edinb., 1684.

†. . . Vescitur muribus, nucibus, malis, pyris, quæ aculeis suis insignit et in domicilium suum reponit.

‡ *Le Spectacle de la Nature*, i. (1732), p. 353 (Paris, 7 vols., 1732-51).   There are many later editions and translations.

§ *Histoire Naturelle*, viii. (1760), p. 30.

‖ *Nat. Hist. of Aleppo*, 2nd Ed., edited by Rev. P. Russell, ii., p. 119 *n*. ; Lond., 1794.

¶ See *ante*, p. 2.

** *General Zoology*, i. (1800), p. 544.

In 1814, Johann Friedrich Blumenbach (1752-1840), a German naturalist of good standing, a Professor of Comparative Anatomy in the University of Göttingen, wrote of the "Hedgidog" *(sic)* that :—*

"It undoubtedly impales fruits on the spines of its back, and thus carries them off to its burrow. The ancients observed this long since. Modern writers have discredited the idea, but without any justification : for I have been assured of the fact by three eye-witnesses, whom I believe."†

Further, Capt. Thomas Brown, a Scottish naturalist of some standing in his day (he was a Fellow of the Linnæan Society of London and President of the Royal Physical Society of Edinburgh), records‡ that :—

"During the summer of 1818, as Mr. Lane, the game-keeper to the Earl of Galloway, was passing by the wood of Calscadden, near Garliestown, in [Wigtownshire], Scotland, he fell in with a hedgehog, crossing the road, at a small distance before him, carrying on his back six pheasants' eggs, which, upon examination, he found it had pilfered from a nest hard by. The ingenuity of the creature was very conspicuous, as several of the remaining eggs were holed ; which must have been done when [the hedgehog was] in the act of rolling itself over the nest, in order to make as many [eggs] adhere to its prickles as possible. After watching the motions of the urchin a short time, Mr. Lane saw it deliberately creep into a furze-bush, where the shells of several [other] eggs were strewed around, and which had, doubtless, been conveyed thither in a similar manner."

There is no clue as to the time of day when this observation was made, but it must have been in the evening, between the time when the Hedgehog comes abroad and the time when it gets too dark for any observation of the kind to be possible. Further, this case does not refer (as do all those quoted above) to the transport of fruit, but to the transport, in exactly similar manner, of the eggs of the pheasant (which, for present purposes, we may regard not inappropriately as its fruit !). It is, however, entirely to the point.

Among the more miscellaneous modern English writers on the natural history of mammals, the majority are against the credibility of the old Hedgehog and Apples Legend. Among these are the

---

* *Handb. der Naturgeschicte*, 9th ed., pp. 89-90 (1814).

† Spieszt afferdings (wie die Alten sagen, von den Nevern hinzegehen ohne allen grund bezweiselt, mir aber nun schon von drey ganz zuverlässigen Augenzeugen versichert worden) Früchte an seine Rücken : Stacheln um sie es in sein lager zu tragen.

‡ *Anecdotes of Quadrupeds*, pp. 101-102 (1831). The story appears to have been copied from some newspaper or natural history magazine, but there is no clue as to its original source.

Rev. W. Bingley (*Memoirs of Brit. Quadrupeds*, p. 238: 1809);
J. L. Knapp, *Journ. of a Naturalist*, 3rd ed., pp. 130-134: 1830);
W. MacGillivray (*Brit. Quadrupeds*, p. 119: Naturalists' Libr., 1838);
Capt. Thomas Brown (*Anecd. of Quadrupeds*, pp. 101-102: 1831)*;
J. H. Fennell, *Nat. Hist. of Quadrupeds*, p. 39: 1843): Thos. Bell,
(*Brit. Quadrupeds*, p. 108: 2nd ed. 1874); R. Lydekker (*Roy. Nat.
Hist.*, i., pp. 318-321); H. E. Forrest (*Fauna of Shropshire*, pp. 42-43:
1899); Sir Harry Johnston (*Brit. Mammals*, pp. 55-59: 1903);
J. G. Millais (*Mammals of Gt. Brit. and Ireland*, i., p. 109-122:
1904); and G. E. H. Barrett-Hamilton (*Brit. Mammals*, ii., p. 68:
1911).

Among other testimony, I have that of Mr. J. Edmund Harting,
F.Z.S., a leading authority on the habits of British Mammals, who
writes me that he regards the old Hedgehog and Apples Legend as
"wholly incredible."

A piece of testimony which points in a direction entirely opposite
to most of that given above has been sent to me recently by Miss A.
Hibbert-Ware, F.L.S., who is interested in the little Museum at St.
George's-in-the-East, London.   Writing on 21st November 1918,
she says :—

"I was busy this morning at the Museum, arranging bracken and
leaves round a stuffed fox recently lent, when there came in a Russian-
Polish peasant, who had left his own country thirty years ago.   My
occupation led him to tell me a great deal as to his recollections of the
animals of Russia—foxes, wolves, bears, etc.   Just as he was leaving,
he caught sight of a stuffed Hedgehog in one of the cases.

"'What do you call that animal?' he asked.

"When I had told him, he exclaimed to my astonishment (for I
had heard of the Hedgehog and Apples Legend) :—

"'How often, in Russia, have I seen those little animals walk away
with apples or pears upon their backs.'

"What!" I exclaimed.   "Would you mind repeating what you
said, for it interests me?

"'They come,' he replied, 'to the apples lying on the ground,
below the trees, and roll themselves up into a ball right on the top of
them (imitating his meaning with his hands), and then they walk off
with two or three sticking upon the prickles of their backs.   I have
never seen one content to carry off a single apple only: they always
have two at least.'   In his part of Russia (he added), 'there could be
few or no people who had not seen it done many times.'

"When I asked what he supposed the Hedgehogs did with the
apples, he said he had always supposed they took them to their young.

* He expresses entire scepticism as to the transport of *fruit* by the Hedgehog,
but, somewhat inconsequently, he cites (and clearly credits) a case (see *ante*) of one
having carried off pheasants' eggs on his spines.

Anyway, he had never seen one eat an apple.   In England, he added,
he had never even seen a Hedgehog.

" The man's whole manner had every appearance of sincerity, and
I do not doubt that he himself believed honestly in the truth of what
he told me, whether it was in fact correct or not."

Finally, I have, within the last few weeks, come across a case which
seems still more to the point, having talked with a perfectly-credible
witness, in my own employ, who assures me (whether mistakenly or
not) that *he himself once actually saw a Hedgehog so engaged.* The
circumstances were these :—

I have, in a wood which forms part of the grounds attached to my
house, several large wild crab-trees.   These usually bear heavy crops
of crabs, from which, in most years, excellent jelly and " cheese " is
made.   Last season (1918), the crop was unfortunately very light ; but,
in such an apple-less year, it was, of course, of special value.   On 16th
September, deeming that the crabs were sufficiently ripe to be gathered
and that they were liable to be stolen if left longer, I ordered a ladder
to be brought and I ascended into the tree.   With me was an old
farm-labourer, George Franklin by name, who has worked for me for
six or seven years and is now over eighty years of age.   Like
many old men of the kind who can neither read nor write, he is
remarkably intelligent in regard to matters which are within his
cognizance.   I know him well enough to be able to assert that, in
a direct statement, I would as soon accept his word as that of an
average Prime Minister !   With him (to help in picking up the crabs
as I threw them down) was his grandson, aged about eight.   We had
nearly done, when, finding we had gathered less than a bushel, I urged
them to search further for other crabs which might have become
hidden among the grass and bushes.

" Why, master," [says Franklin in his broad Essex dialect] "you
should leave a few for the poor Hedgehogs."

" Hedgehogs ! " said I, " what do they want them for ? "

" Why," [replied he] " they eat them.   I once saw one carrying
some home on his back."

Instantly the old legend flashed into my mind.   I had not been
even thinking of it previously, so could not possibly have put the idea
into his head ; while probably he has never heard of (and quite
certainly he has never read) Pliny.   Feeling interested, I asked him
for further particulars.   It was (he told me) one evening in the autumn
of an extremely hot and dry summer five or six years ago—no doubt
1914—and probably in October, as the crabs had fallen.   He had
been engaged all day helping in the threshing of a stack of beans, and
was walking home through the fields about six o'clock, just as it was
getting dusk, when, looking over a gate into a meadow, he saw, not
more than three (and, possibly, not two) yards from him, a Hedgehog

shuffling along with some objects on its back. Looking more closely, he was able to make out that these objects were crabs, evidently stuck upon its spines. As the animal was within a few yards of, and was proceeding directly from, a large crab tree growing in a corner of the same meadow, he concluded, very naturally, that it had obtained the crabs from beneath this tree. I know the tree in question very well and have often seen it ; for it grows little more than half-a-mile from my house. Unfortunately he did not follow the Hedgehog to make further investigations, being (he says) anxious to get home to his supper. Thus, he missed an excellent opportunity of carrying further a very interesting observation.

V.—SUMMARY AND CONCLUSIONS —Now, taking the foregoing statements, records, opinions, and observations, and proceeding to examine them critically all together, what scientific value, as evidence can they be said to have (if any) ?

In the first place, it is well to note that, although there are some twenty species of the genus Erinaceus distributed throughout the world, there is, in Europe, one single species only, and that it shows extremely little variation.

In the next place, it should be noted that the Hedgehog-and-Apples legend is at least two thousand years old—more, if it originated with Aristotle, as has been stated; also that it is prevalent throughout practically the whole of Europe. There must have been (one would think) some substratum of actual observed fact, renewed from time to time, to keep any legend of the kind alive so long and to cause it to become so widespread.

Moreover, it is noticeable that, in most cases, the writer of any statement on the matter ascribes to the Hedgehog a partiality for whatever particular kind of fruit is abundant in the region of which he writes—apples and pears in England, France, and Germany ; figs in Italy ; grapes in Central France and Germany ; grapes and mulberries in Asia Minor ; and so on. This is a poor argument on which to base any evidence in support of the ancient legend ; but, so far as it goes, it is worth noting.

Again, the statement by Ælian that Hedgehogs "wallow in places where they dry figs"* has about it a considerable appearance of verisimilitude, being apparently based on actual observation.

One point which the foregoing observations seem to bring out clearly is that (assuming the Hedgehog really does transport fruit in the way stated), it does so less commonly in England than in Central, Southern, and Eastern Europe. The statements of Pliny and Ælian

* See *ante*, p. 2.

among the Ancients, of several among the Mediæval writers quoted, and of Patrick Russell, Blumenbach, Thomas Brown, the Russian Pole interviewed by Miss Hibbert-Ware, my gardener (George Franklin), and others among the Moderns, all seem to bring out this point clearly.   If this surmise proves to be sound, it remains to be shown why the habits of the Hedgehog should differ so notably in different parts of Europe.

Nevertheless, it cannot be denied that most modern writers on Mammals, if they refer at all to the old legend, either dismiss it as too absurd to be worth a moment's consideration or, at least, show themselves decidedly sceptical.

But is the story really so incredible after all?   Are we not apt, in these highly-scientific days, to become too contemptuously sceptical in regard to all ancient legends of the kind, and to forget that, however absurdly improbable they may appear at first sight, not a few of them have been shown to have some genuine basis in fact—often slight, but sufficient to substantiate and justify them.   In all such cases, a cautious scepticism should be, of course, maintained up to a certain point ; but I have never forgotten a dictum to which I remember hearing the late Prof. Huxley give utterance many years ago :— " I have always felt [he said] a horror of limiting the possibilities of things."

Now I will go so far as to say that, on the evidence quoted above, I am ready to believe that the Hedgehog does sometimes carry home fruit stuck upon its spines.   There seems to me nothing inherently impossible, or even improbable, about the story ; for animals have been proved capable of many much more extraordinary acts.

But, before accepting the old legend unreservedly, there is one point which requires first to be considered—Does the Hedgehog ever eat fruit?

As to this crucial question, many contradictory opinions have been expressed.   The truth seems to be that the creature undoubtedly affects, in the main, an animal diet, consisting chiefly of small reptiles, worms, snails, slugs, insects, beetles, birds' eggs, and the like.   In confinement, it will readily eat meat, either cooked or uncooked, bread-and-milk, and many such substances as are usually given to cats and dogs.   Its partiality for eggs has gained for it a very bad name among gamekeepers, poultry-keepers, and such people.   Macgillivray says* that it will "occasionally even enter hen-houses for the purpose [of stealing them]."†   In all probability, however, the robberies of

---

* *British Quadrupeds*, p. 119 (1838).

† Macgillivray does *not* say, however (as Millais asserts : *Mammals of Gt. Brit. and Irel.*, i., p. 117), that the Hedgehog will steal eggs "from beneath the hens, but without otherwise molesting them."

eggs from the nests of game-birds and poultry which are usually ascribed to the Hedgehog are really the work of some other animal.

On the other hand, there is equally little doubt that, on occasion, the Hedgehog will readily subsist on a vegetable diet. Knapp says :—* " In the autumn, crabs, haws, and the common fruits of the hedge constitute its diet." Macgillivray asserts† that it "eats fruits, especially apples that have fallen from the trees." On this point, Mr. Harting favours me with a very pertinent observation of his own .—

" From personal observation [he says], I know that they will feed on fallen fruit. On one occasion, late in September, some years ago, when partridge shooting in West Sussex, I was returning home in the evening and saw at a little distance a Hedgehog at the foot of a crab-tree, busily engaged in mouthing some object which, at the distance, I could not distinguish. I watched it for some time and then, slowly approaching, the Hedgehog scuttled away. At the spot, I found a partially-gnawed crab-apple bearing the marks of teeth on one side, which convinced me that the animal had been feeding on it. So far as I could see, the Hedgehog made no attempt to carry off the crab in its mouth, as a squirrel would have done."

Another observation bearing upon this point has been kindly supplied to me by Miss Gulielma Lister, F.L.S., in whose garden at Leytonstone grows an old medlar tree, beneath which are planted some small holly bushes. When sweeping up the leaves beneath this tree in winter, the old gardener has repeatedly found a Hedgehog rolled up asleep beside a little heap of fallen medlars, which apparently he had gathered together, both the animal and the medlars being deeply buried under a thick bed of leaves. Whether or no the medlars showed any signs of having been gnawed by the creature, I do not know.

Those statements among the foregoing which explicitly mention apples or crabs are of special interest ; for, of all fruits, these are those most commonly mentioned in statements, both ancient and modern, as to the Hedgehog transporting fruits on his prickles. On the whole, it seems clear that the creature does eat fruits of various kinds.

Yet another cognate point which has to be considered is :—Does the Hedgehog lay up a store of food for the winter? Obviously, of animal food, *he could not*. Of vegetable food, however, *he might*, and some writers have stated explicitly that he does.‡ Yet others, of at

---

* *Journ. of a Naturalist*, 3rd ed., p. 130 (1830).

† *Brit. Quadrupeds*, p. 119 (1838).

‡ See, for example, the statements of Pliny (p. 1), Ælian (p. 2), Topsell (p. 4), and others quoted above.

least equal authority, have stated that he does not* ; and I agree with
them. I have seen many nests of Hedgehogs dug out of rabbit-holes
when ferretting in winter ; but none (so far as I can recollect) has ever
been accompanied by a store of winter food.† It is on this account, no
doubt, that the animal's hybernation is by no means complete, and
that he sometimes leaves his winter nest and comes abroad, even on
cold days. Probably the fruit of various kinds which Hedgehogs have
been seen carrying on their spines has been intended by them rather
for immediate consumption than as winter sustenance.

Several friends and correspondents—some excellent naturalists
among them—have advanced to me the argument that, as they have
kept many tame Hedgehogs and have never observed them even
attempting to transport fruit on their spines, the habit cannot be one
they practise in a state of nature. This argument is, I think, entirely
unsound. The habits of animals in nature and in confinement are
often different ; and, in this particular case, it may be urged that a
Hedgehog in confinement, being (in a way) at home, would hardly be
likely to feel a need to carry food home.

From the foregoing, it becomes clear that there are, beyond doubt,
not a few cases, both ancient and modern, in which a Hedgehog has
been *actually seen* carrying objects impaled upon the spines upon its
back—in most cases various kinds of fruit : in one case, eggs of the
pheasant. Unfortunately, none of these observations (though made
by persons whose *bona-fides* is in little doubt) can be regarded as
wholly conclusive, all being to some extent second hand or made by
persons of little education. Nevertheless, taking them in the mass
and viewing them in conjunction with the very ancient and extremely-
persistent legend relating to the matter, it seems to me impossible
longer to doubt that, *at times, at any rate*, the animal really does
transport fruit in the way asserted. Some will, no doubt, attribute
this view to limitless credulity and lack of acute observing powers on
my part. Be that as it may, I have confessed openly the view I take
of the matter.

The whole question can be finally set at rest only by the production
of further definite observations of the same kind as those quoted
above, and made by naturalists of recognised standing or, at least, by
persons of education.

Will any reader come forward and assert that he has himself seen
a Hedgehog in the act of transporting objects stuck upon its spines, or
at least draw attention to further existing records of its having been
seen so to do ?

* See, for instance, Macgillivray : *Brit. Quads.*, p. 119 (1838).

† Miss Lister's observation in reference to the medlars (see *ante* p. 12) looks, how-
ever, like an exception.

[There is yet another legend pertaining to the Hedgehog (and almost as ancient and wide-spread as the fruit-carrying legend)— namely, that it sucks the milk of cows grazing in the fields.

Now, this statement, in the crude form in which it is usually made and understood, is a manifest impossibility. In the first place, no Hedgehog, by stretching up, would be able to reach the teats of any cow of ordinary stature ; and, even if it could do so, the fact remains that the Hedgehog's mouth is far too small to allow it to suck milk effectively from the teats of any such cow.

Nevertheless, the legend in question is probably true in a way, and there is, I think, a perfectly natural explanation as to its origin.

We know well, from the evidence of Hedgehogs kept in confinement, that the animal, is exceedingly fond of milk ; and there can be no possible doubt that, in a state of nature, it would take every opportunity to secure milk. Obviously it could do this only when a cow was lying down. In such case, as is well known, milk often runs from the teats of a milch cow; and there can be little or no doubt, I think, that the milk-sucking legend has originated in the fact of a Hedgehog having been seen sucking drops of milk from the teats of a recumbent cow or from the ground immediately after she has risen.]

For help and advice, I am specially indebted to the following, as well as to others already mentioned :—Dr. Andrew Clark, Mr. A. H. Cocks, Mr. J. Edmund Harting, and Mr. Charles Oldham.

1

2

3

4

COELONAUTILUS TRAPEZOIDALIS, sp. nov.

1-2. Lower Coal Measures, Townhouse, near Colne, Lancs. Nat. size.
3-4. Pendleside Series, Pule Hill, Marsden, Yorks. Nat. size.

III.—On a New Middle Carboniferous Nautiloid.

(Cœlonautilus trapezoidalis).

BY

J. Wilfrid Jackson, F.G.S., Assistant Keeper, Manchester Museum.

In a previous paper " On Mollusca from the Lancashire Coal-Measures,"* I called attention to the fact that Mr. George Wild, in 1892,† erroneously figured a Nautiloid from the " Roof of the Bullion Coal, Townhouse, near Colne," under the name of " *Nautilus subsulcatus*, Salter." Two figures are given by him (pl. II., fig. 5 ; pl. III., fig. 3) representing different views of the same specimen, which now forms part of the Wild Collection in the Manchester Museum.

So far as can be ascertained, Salter never described or referred to a Nautiloid under the name " *subsulcatus* " but Wild was in the habit of attaching Salter's name to species of other authors, for example, *Nautilus cyclostomus* Phillips ; *Goniatites striatus* (J. Sow), etc., have Salter's name appended in Wild's " Reference to the Plates."‡

Nautilus (now *Cœlonautilus*) *subsulcatus* was founded and figured by Phillips in his " Illust. of the Geol. of Yorks. " pt. II., 1836, p. 233, pl. XVII., figs. 18 and 25,§ on a specimen from the Carboniferous Limestone of Bolland, Yorkshire, and the type is now in the British Museum (No. C237, " Gilbertson Collection").

Wild's fossil, however, differs in several important characters, especially in the more depressed and greater relative breadth of the volutions, from Phillips' type-specimen, and, as stated in my previous paper (*op. cit.*, p. 449), belongs to a new species.

Having the specimen with me when on a visit to the British Museum in 1912, I consulted Mr. G. C. Crick as to its affinities and position and he very kindly undertook to draw up a description of the species. He pointed out that its nearest ally appeared to be Fleming's *Nautilus quadratus*,‖ a species assigned by Foord¶ to his genus *Cœlonautilus*, and from the trapezoidal form of the transverse section of the whorl he suggested the name *Cœlonautilus trapezoidalis* for the species under review.

* Geol. Mag., Dec. V., Vol. ix., No. 580, Oct. 1912, pp. 419-453.
† Trans. Manch. Geol. Soc., XXI., 1892, pp. 397 and 400, pl. ii. and iii.
‡ Trans. Manch. Geol. Soc., XXI., 1892, p. 400.
§ Phillips in his " Reference to the plates " (p. 250) calls the species, *N. sulcatulus*, " and Brown, " Foss, Conch.," 1849, p. 36, pl. XXV., f. 8, describes and figures it again under that name.
‖ J. Fleming, " Hist. Brit. Animals," 1828, p. 231.
¶ A. H. Foord, Cat. Foss. Ceph., Brit. Mus., pt. 2., 1891, p. 122.

Since Mr. Crick furnished his description, I have discovered in the Manchester Museum another example of the same species from the Pendleside Series, Pule Hill, Marsden, which is in a more adult stage of growth.   This has necessitated the drawing up of a revised description, as follows.

Description of the Species.

Cœlonautilus trapezoidalis, n. sp.

Nautilus subsulcatus, G. Wild, Trans. Manch. Geol. Soc., vol. XXI., 1892, pl. II., fig. 5 ; pl. III., fig. 3 (not of Phillips).

Sp. Char.—Shell of medium size, rapidly increasing, evolute, composed of about three whorls, rather widely umbilicated, and with a large central vacuity ; greatest width at the umbilical margin ; whorls only just touching, inclusion nil ; umbilicus wide, with steep, step-like sides, and a well defined sub-angular margin (umbilico lateral keel), which becomes somewhat rounded at the fully-adult stage. Whorls trapezoidal in transverse section, about one-fourth wider than high ; indentation nil ; periphery flattened, well-defined, with a distinct raised, broad and slightly concave, band down the centre, on each side of which there is a narrow and rather shallow longitudinal sulcus, limited by the peripherolateral keel ; sides convergent, well defined both from periphery and umbilical zones, their outer half feebly concave, their inner half moderately convex, a median longitudinal ridge being present in early stages and passing away later (see remarks below) ; umbilical zone well defined from the lateral area, almost at right-angles to the mesal plane of the shell.   Body-chamber probably about a volution ; aperture trapezoidal in outline, about one-fourth wider than high ; peristome not present, but, judging from the lines of growth, with a well-marked sinus, on the inner half of lateral area, a prominent crest at the periphero-lateral angle, and a deep hyponomic sinus occupying the greater part of the peripheral area.   Cameræ not very deep ; septa feebly concave ; where the whorl has a transverse diameter of 15 mm. the sutures are 5 mm. apart, at 8 mm. diameter they are about 3 mm. apart ; in the young shell they are somewhat variable ; sutures with a moderately deep lobe extending across the lateral area and a shallow lobe across the peripheral area (in the young stage this lobe is central). Siphuncle close to the ventral surface.   Test composed of two layers, the internal very thick, the external extremely thin; surface ornamented with very fine close-set striæ, which are forwardly inclined and sigmoidally curved on the sides, forwardly projected at the peripherolateral angle, and form a deep, broad, backwardly directed sinus upon the periphery, corresponding with the emargination of the aperture ; these transverse striæ are seen (with a lens) to be crossed by extremely fine regular longitudinal wavy lines on both the periphery and the sides, especially at the periphero lateral keel ; along the middle of the lateral area there are traces of several fine longitudinal ridges on a portion of the largest example.

Measurments :—   I.   II.

                                         (Wild, W669)   (Marsden, L2827)

Greatest Diameter ...	...	35	...	74·5 mm.
Height of outer whorl	...	15	...	25·5
Thickness of outer whorl	...	18·5	...	36 (ca.)
Width of umbilicus (at margin)		13	...	36
Do. do. (at suture)		12	...	29·5
Greatest width of periphery ...		14·5	...	26 (ca.)

REMARKS.—The present species is founded upon the specimen figured by Wild (*loc. cit*), and a larger and more adult example from the Pendleside Series of Marsden, Yorkshire.

Wild's specimen, 35 mm. in diameter, consists of about one and a half whorls, entirely septate, and terminating anteriorly with a septal surface ; the external layer of the test has been entirely replaced by iron pyrites, leaving the thick internal layer in the form of calcite ; the surface of the casts of the septal chambers (cameræ) is densely covered with minute punctæ. This specimen shows the position of the siphuncle in an excellent manner, owing to the weathering of the shell.

The Marsden specimen is 74·5 mm. in maximum diameter and possesses about three whorls ; it is somewhat crushed in places and almost the whole of one side is missing. One portion of the periphery shows several of the suture lines. Judging from the rounding off of the umbilico-lateral angle on the last whorl, and the crowding together of the lines of growth, the shell has evidently reached the adult stage of growth. On the greater part of the specimen the test is well preserved and exhibits the surface-markings in a perfect manner. This specimen illustrates the later life-history of the species, as Wild's example exactly fits the umbilicus.

Affinities and comparison with other species.—Compared with Phillip's type-specimen of *Nautilus subsulcatus* the present species is a more rapidly increasing and relatively broader shell, having its umbilical zone more nearly perpendicular to the mesal plane, and its siphuncle nearer the ventral surface.* Its nearest ally appears to be *Cœlonautilus quadratus*, J. Fleming sp.,† a somewhat variable species from the Lower Limestone Group of the Carboniferous Series of

---

* The dimensions of Phillip's type-specimen, which is entirely septate and for the most part an internal cast, are :—greatest diameter of shell, 66·5 mm. (100) ; height of outer whorl, 27 mm. (40) ; thickness of outer whorl, 25 mm. (37) ; width of umbilicus (at margin), 30·5 mm. (46) ; ditto (at suture of shell), 23·5 mm. (35) ; greatest width of periphery, 19 mm. (28) ; whilst at the diameter of Mr. Wild's specimen, *viz.*, 35 mm. (100), its measurements are :—height of outer whorl, 14 mm. (40) ; thickness of outer whorl, 14 mm. (40) ; width of umbilicus (at margin), 19 mm. (54) ; ditto (at suture of shell), 14 mm. (40) ; width of periphery, 11 mm. (31) (*fide* Crick).

† J. Fleming, Hist. Brit. Anim., 1828, p. 231.   See also A. H. Foord, Cat. Foss. Ceph. British Museum, part 2, 1891, p. 122.

Scotland, but in that form the whorls are more subquadrate in transverse section and usually bear distinct longitudinal lateral grooves (the edge of the umbilicus being separated by a shallow groove from the inflated part of the whorl), whilst the umbilical zone slopes towards the centre of the umbilicus, instead of being perpendicular to the mesal plane of the shell as in the present species.   The same characters distinguish the present species from the form described and figured by J. de C. Sowerby* as *Nautilus subsulcatus* var., from the Coal-measures of Coalbrookdale, Shropshire.

Both *C. subsulcatus* and *C. quadratus* occur in lists of Pendleside fossils from High Green Wood, etc. ;† also in lists of fossils from the Lower Coal-Measures.‡   Specimens in the Manchester Museum (Gibson Collection) hitherto labelled as *C. subsulcatus* have turned out to belong to, at least two species, *viz., Pleuronautilus pulcher* Crick, and another probably new species.   In like manner the Marsden specimen dealt with in this paper, was recorded and labelled as *C. subsulcatus* by Barnes and Holroyd.   It seems, therefore, desirable to expunge *C. subsulcatus* Phil., and probably also *C. quadratus* Flem., from the lists of Pendleside and Coal-measure fossils until authentic specimens are obtained.

Horizons and Localities.—Lower Coal-measures (Roof of the Bullion coal).   Townhouse, near Colne, Lancs. (E coll. Wild, W669). Pendleside Series, Pule Hill, Marsden, Yorks. (E coll. Holroyd, L2827) ; Dr. Wheelton Hind also possesses three specimens of this new species from the Lower Coal-Measures of Shibden, and one specimen from the Millstone Grit Series of Eccup.

* Trans. Geol. Soc. London, vol. V., part 3, 1840, p. 492, and Explanation of Plate xl., fig. 7.
† Davies and Lees, " West Yorkshire," 1878. p. 90 ; Barnes and Holroyd, Trans. Manch. Geol. Soc., XXIV., 1896, p. 90 ; Hind, Quart. Journ. Geol. Soc., vol. 57. 1901, p. 372, etc.
‡ Bolton, Trans. Manch. Geol. Soc., XXVIII., 1904, p. 394 and p. 647 ; and Report of the Mollusca Committee to the Council of the Manchester Geological Society, October, 1910.

IV. On the Superposing of Two Cross-line Screens at Small Angles and the Patterns obtained thereby.

By S. Lees, M.A.

(Read and received April 1st, 1919.)

§1.   The following investigations were originally undertaken by the author at the suggestion of Mr. R. B. Fishenden, Director of the Printing Department, College of Technology, Manchester.

§2.   In certain technical processes it is necessary to superpose two cross-line screens or other screens possessing a regular geometrical pattern. The result is to produce under certain conditions a characteristic pattern, and it is the object of this discussion to explain some of the phenomena produced.

One of the most interesting examples of the effect occurs in the half-tone process of photo-engraving. In this process, the picture to be reproduced is photographed through a half-tone or " process " screen, placed in front of the sensitive plate. The screen consists of two glass plates ruled with parallel lines in black placed at right angles to one another, so that the whole constitutes a series of equal sized small squares, in effect. From the negative a photographic print is made on to a copper plate which is afterwards etched. A print from the copper plate will consist of a series of black dots which increase in size with the depth of tone, until only white spaces remain.*

Several different types of cross-line screens are used in technical processes for photo-engraving ; for example, in the process of intaglio machine photogravure a screen consisting of thin white lines on a black ground is employed. In other cases a screen may be employed which consists of a " chess board " pattern of black and white squares. In this paper, the first type of screen will be described as a half-tone screen, the second type as an intaglio screen, and the third type as a chess board screen.

It is sometimes necessary to reproduce a print from a half-tone block or other picture consisting of dots possessing a regular geometrical pattern. If such a picture be photographed through a cross-line

---

* For technical details see a paper by Mr. Fishenden, Trans. Royal Photographic Society, March 15th, 1915.

screen, peculiar effects may be produced in the resulting negative. The effects depend on the angle which the lines of the cross-line screen make with the lines of dots (or other form pattern) of the original picture. If this angle be small, the effect on the negative is to produce in the reproduction a very coarse pattern of squares or other formation, and this may be so obtrusive as to be more readily observed than the subject.

§3. We shall now consider the effect of photographing through an intaglio screen a half-tone print, taken as consisting of a series of small square dots surrounded by white lines arranged in square pattern. The effect of the intaglio screen will be to produce in the final picture (after the copper plate has been made and used to make a print) a fresh set of white lines or bands forming a pattern of squares, and it is the resulting effect of this set superposed on the set due to the original half-tone print which brings about the result mentioned in the preceding paragraph. It is clear that what we have to analyse, in effect, is the result of superposing two intaglio screens, *i.e.*, screens of transparent bands with dark square spaces ; for only those portions of the white bands of the original half-tone picture can affect a photographic plate, if rays of light passing from them penetrate through the transparent bands of the intaglio screen. We shall therefore first discuss the patterns produced by superposing two intaglio screens of different rulings or pitches, and holding the pair up to the light. The geometrical problem involved is best treated in the following way :—

Let the two screens be denoted by S_1 and S_2. We may consider S_1 as formed by making two sets (X_1 and Y_1) of parallel transparent bands on a blackened plate, the two sets being at right angles to one another, and arranged to produce a series of dark squares. Similarly S_2 may be considered as formed by two sets (X_2 and Y_2) of transparent bands on a second blackened plate, the rulings of these sets not necessarily being the same as those of the first screen. We require the final pattern R of transparent spaces obtained by superposing S_1 and S_2, and holding the double screen up to the light. This pattern R can be obtained by the following operations :—

(i) Make two screens ruled respectively, one with set X_1 only of transparent bands, the other with set X_2 only. Superpose these screens and find the pattern P_1 of transparent spaces obtained on holding the double screen to the light.

(ii) Repeat operations (i) employing two screens ruled respectively with sets Y_1 and Y_2 only. Let the resulting pattern of transparent spaces obtained on holding the double screen to the light be denoted by Q_1.

(iii) Repeat operations described above, using sets X_1 and Y_2. Let the resulting pattern be denoted by P_2.

(*iv*) Repeat operations using sets Y_1 and X_2. Let the resulting pattern be denoted by Q_2.

(*v*) Let small pieces of white paper be cut out exactly corresponding to the transparent spaces of P_1, Q_1, P_2, and Q_2. Let these be arranged exactly as in their corresponding patterns P_1, Q_1, P_2, Q_2, and in their proper positions and superposed (*i.e.*, pasted over one another) on a black background. The final effect will be pattern R, if it is understood that white patches correspond to transparent spaces in R.
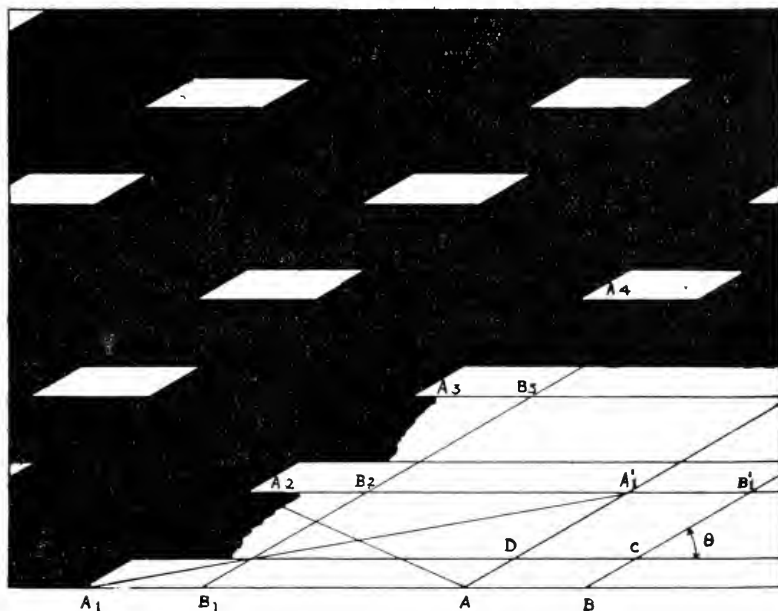
Fig. 1.

To prove the truth of the above constructions, we observe that (*a*) the whole of the transparent spaces of P_1, Q_1, P_2, and Q_2 must form part of R, whilst (*b*) the whole of the transparent spaces of R are included in those of P_1, Q_1, P_2, and Q_2.

We have thus analysed the composite pattern R into *four* simpler patterns, *viz.*, the results of operations (*i*) to (*iv*).

§4. We proceed to discuss the pattern P_1, which is the result of superposing sets X_1 and X_2 of transparent bands, at some angle θ (say). In *Fig.* 1 is shown the effect of superposing two sets of bands and it is seen that the pattern consists of a series of transparent parallelograms

of the type $ABCD$. We shall take the set of bands parallel to AB as being the set X_1, whilst bands parallel to BC constitute the set X_2. Let the width of a transparent band of X_1 be a_1 and the width of a dark band of X_1 be b_1. Let a_2 and b_2 represent the corresponding widths for set X_2. It is easily seen that

$$\left. \begin{array}{ll} AB = a_2 \cosec \theta, & BC = a_1 \cosec \theta, \\ A_1A = B_1B = (a_2 + b_2) \cosec \theta, & AA_1{}^1 = BB_1{}^1 = (a_1 + b_1) \cosec \theta. \end{array} \right\} \quad (i)$$

The pattern P_1 of transparent parallelograms of the type $ABCD$ may be considered as built up of transparent patches arranged in a series of parallel rows. Thus the patches may be regarded as arranged in rows parallel to AA_1, or to AA_2, or to AA_3, etc. The natural grouping of these patches for small values of θ will be optically that corresponding to rows parallel to AA_{n+1} (say), where the point A_{n+1} has the least distance from A, of all the points A_1, A_2, etc. Since the distance $A_1A_{n+1} = nA_1A_2 = n(a_1 + b_1) \cosec \theta$, we find that

$$\begin{aligned} AA^2{}_{n+1} &= \cosec^2\theta \left[(a_2 + b_2)^2 + n^2(a_1 + b_1)^2 - 2n(a_2 + b_2)(a_1 + b_1) \cos \theta \right] \\ &= E \cosec^2\theta \text{ (say)}. \end{aligned} \right\} \quad (ii)$$

For a given value of θ, E is a maximum when

$$n = (a_2 + b_2) \cos \theta \,/\, (a_1 + b_1) . \qquad . \qquad . \qquad . \quad (iii)$$

Assuming that $(a_2 + b_2)$ is not less than $(a_1 + b_1)$, we shall therefore get the best grouping, generally speaking, when the integral number n chosen is that nearest to $(a_2 + b_2) \cos \theta \,/\, (a_1 + b_1)$. As most of the results we wish to investigate immediately become prominent when θ is very small, it follows that, in such cases, we take for n the nearest integer to $(a_2 + b_2) \,/\, (a_1 + b_1)$. Thus if $a_2 + b_2 = a_1 + b_1$, we should take the transparent patches in rows parallel to AA_2.

To simplify the discussion, we shall now assume that $(a_2 + b_2)$ is a multiple of $(a_1 + b_1)$, and we can conveniently denote the multiple by n. In this case, for small values of θ, the rows of patches are parallel to AA_{n+1}. It is worth enquiring for what values of θ this statement will hold.

$$\text{Since } AA^2{}_{n+1} = \cosec^2\theta \left[n^2 + n^2 - 2n^2 \cos \theta \right] (a_1 + b_1)^2 \\ \text{and } AA^2{}_n = \cosec^2\theta \left[n^2 + (n-1)^2 - 2n(n-1) \cos \theta \right] (a_1 + b_1)^2 \right\} \quad (iv)$$

$$\text{it follows that } AA_{n+1} < AA_n, \text{ if } \cos \theta > (2n-1) \,/\, 2n, \\ \textit{i.e.}, \text{ if } \sin \theta < (4n-1)^{1/2} \,/\, 2n. \right\} \qquad . \qquad . \quad (v)$$

Thus when n is large, the range of values of θ for which we can take the same row of transparent patches throughout (*viz.*, AA_{n+1}) becomes small.

§5.   We proceed to discuss the results of §4, when θ is small. When this is the case, the parallelograms typified by $ABCD$ have their sides AB and BC elongated (see equations (ii)) ; whilst assuming that $(a_2 + b_2)$ is a multiple of $(a_1 + b_1)$, the distance AA_{n+1} is given by (iv). But (iv) may be written

$$p_1 = AA_{n+1} = 2n\,(a_1 + b_1)\,\operatorname{cosec}\,\theta\,\sin\,(\theta/2) = n(a_1 + b_1)\,\sec\,(\theta/2)\ . \quad (vi)$$

Since AC approaches the value $AB + BC = (a_2 + b_2 + a_1 + b_1)$ cosec $\theta = (n + 1)\ (a_1 + b_1)$ cosec θ, as θ diminishes ; it follows that with diminishing values of θ, the ratio $AA_{n+1}\ /\ AC$ approaches the limit $2n$ sin $(\theta/2)\ /\ (n + 1)$. Thus the ratio of the pitch AA_{n+1} of the patches along the row AA_{n+1} to the length of a patch diminishes indefinitely with θ. It may be noticed that (vi) approaches the limit $n\,(a_1 + b_1) = a_2 + b_2$. We can sum up these results by saying that the pattern P_1 resolves itself into transparent patches arranged in rows parallel to AA_{n+1}, the pitch p_1 in the direction AA_{n+1} approaching the invariable value $(a_2 + b_2)$, whilst the length of each patch (*i.e.*, AC) increases according to the cosec θ law.

The direction AA_{n+1} clearly bisects the angle $A_1AA_1{}^1$, *i.e.*, it makes an angle $(\pi + \theta)\ /\ 2$ with AB. This is shown in *Fig.* 2. Running parallel to the row of transparent patches given by AA_{n+1}, we shall have a parallel row of patches given by KA_n. This row will be distant

$$p_2 = A_nA_{n+1}\cos\,(\theta/2) =$$
$$(a_1 + b_1)\,\operatorname{cosec}\,\theta\cos\,(\theta/2) = (a_1 + b_1)\,/\,2\sin\,(\theta/2)\ . \quad (vii)$$

from AA_{n+1}, *i.e.*, this is the perpendicular distance between AA_{n+1} and KA_n. Obviously as θ becomes small, the ratio of p_2 to p_1 rapidly increases.   In the particular case when $a_2 + b_2 = a_1 + b_1$, *i.e.*, $n = 1$ we have

$$p_1 = 2(a_1 + b_1)\,\sin\,(\theta/2)\,\operatorname{cosec}\,\theta = (a_1 + b_1)\,\sec\,(\theta/2) \quad . \quad (viiia)$$
$$p_2 = (a_1 + b_1)\,\cos\,(\theta/2)\,\operatorname{cosec}\,\theta = \tfrac{1}{2}(a_1 + b_1)\,\operatorname{cosec}\,(\theta/2) \quad . \quad (viiib)$$

§6.   We now come to operation (ii) of §3, *i.e.*, we have to discuss the effect of superposing the sets of bands Y_1 and Y_2. But Y_1 is exactly the same as X_1 except that its bands are at right angles to those of X_1.   Similarly Y_2 is the same as X_2, except that its bands are at right angles to X_2.   Thus Q_1 is of precisely the same character as P_1, but must be regarded as P_1 rotated through 90°.   Combining Q_1 with P_1 according to operation (v) of §3, we see that for small values of θ we shall get a network of squares of side $p_2 = (a_1 + b_1)\,/\,2\sin\,(\theta/2)$, each square being bounded by the rows of small transparent parallelograms corresponding to P_1 and Q_1, and having a dark interior.   Thus the pattern π_1 corresponding to P_1 and Q_1 combined resembles in its general features the original half-tone plates, *i.e.*, we have dark squares

surrounded by semi-transparent bands or sides.   Obviously as θ diminishes towards zero, the side p_2 of these squares increases indefinitely, and this is the source of the practical trouble referred to towards the end of §2.

Fig. 2.

Fig. 2*a*.

§7.   We have next to discuss the results P_3 of operation (*iii*) of §3, *i.e.*, the effect of superposing sets of bands X_1 and Y_2.   The problem is clearly the same as that discussed in §§4 and 5, except

that θ must be changed to $\theta_1 = \dfrac{\pi}{2} + \theta$.   Thus when θ is small the angle θ_1 of intersection approaches $90°$, and *Fig.* 1 must be amended accordingly.   In this case, it is clear that of all the points $A_1, A_2, \ldots,$ $A_1{}^1, A_2{}^1, \ldots$, the nearest point to A will be $A_1{}^{1*}$ for small values of θ. Thus P_2 consists of rows of transparent patches, these rows being parallel to $AA_1{}^1$, *i.e.*, making an angle $\theta_1 (= 90° + \theta)$ with X_1.   The distance $A_2A_3 (= p_1{}^1)$ between adjacent patches in the same row is clearly $(a_1 + b_1)$ cosec θ_1, whilst the distance between adjacent rows, measured perpendicularly to them is $p_2{}^1 = (a_2 + b_2)$ cosec θ_1 sin $\theta_1 = (a_2 + b_2)$.

$$\text{Thus } \left. \begin{array}{l} p_1{}^1 = (a_1 + b_1) \sec \theta, \\ p_2{}^1 = a_2 + b_2. \end{array} \right\} \qquad . \qquad . \qquad . \qquad . \quad (ix)$$

§8.   The result Q_2 of operation (*iv*) of §3 is easily seen to be equivalent to rotating through $90°$ the pattern P_2 described in §7.   For Y_1 is at right angles to X_1, whilst X_2 is at right angles to Y_2.   We can combine patterns P_2 and Q_2 following the method laid down in operation (*v*), §3, but as θ is made small, there is no outstanding structure in the resultant pattern, as was obtained in §6.   For $p_1{}^1$ tends to the limit $(a_1 + b_1)$, as θ becomes indefinitely small, whilst $p_2{}^1$ has the fixed value $(a_2 + b_2)$.   Thus the combination π_2 of P_2 and Q_2 is not coarser than the coarser of the two original half-tone screens.

§9.   With regard to the pattern π_1 or network of squares described in §6 and resulting from the combination of P_1 and Q_1, we note that the axes of the pattern π_1, *i.e.*, lines parallel to the sides of the squares, make angles $\theta/2$ and $(90° + \theta/2)$ with the bands X_1.   The axes of the pattern resulting from the combination of P_2 and Q_2, however, make angles θ and $(90° + \theta)$ with the bands X_1.

It has to be recognised that when the respective positions of the two superposed screens S_1 and S_2 are given, each of the patterns P_1, Q_1, P_2, Q_2 is exactly defined relatively to the others.   Thus the pattern π_1 resulting from P_1 and Q_1 is defined relatively to the pattern π_2 resulting from P_2 and Q_2.   The effect of displacing the two screens S_1 and S_2 relatively to one another, keeping θ constant is discussed later.

§10.   The pattern R obtained by superposing two intaglio half-tone screens, for which $(a_2 + b_2) / (a_1 + b_1)$ is an integer, is now got by combining the results of §§6 and 8, according to operation (*v*) of §3. It is now seen that when θ is small, the resulting pattern consists of a very coarse framework of squares, each square being bounded by semi-transparent bands or sides, whilst the interior is much darker and

---

* In *Fig.* 1 but with θ (here our θ_1), made slightly greater than $90°$.

consists of a sort of granulated structure as outlined in §8.   Further,
the smaller the angle θ is, the coarser the square framework becomes,
and there is no limit to the size of the squares as θ diminishes
indefinitely.   These results are illustrated in *Figs.* 3 and 4 *(Pl. I.)*,
which exemplify clearly the above analysis.

It should be borne in mind that if $(a_2 + b_2) / (a_1 + b_1)$ is not an integer
it is impossible to get the square framework of R of indefinitely great
coarseness by making θ become indefinitely small.   We shall proceed
to show this.

§11.   We shall assume that $a_2 + b_2 = (n + \epsilon) (a_1 + b_1)$,* where ϵ is a
positive or negative irrational fraction numerically less than 0·5, and n
is an integer.   For simplicity, we shall write

$$a_1 + b_1 = d_1 ; \; a_2 + b_2 = d_2 \quad . \qquad . \qquad . \qquad . \quad (x)$$

so that
$$d_2 = d_1(n + \epsilon) . \qquad . \qquad . \qquad . \qquad . \quad (xi)$$

In this equation, n is to be interpreted as the nearest integer to the
fraction d_2/d_1, which is of course to be taken as having a value greater
than unity.   We can still use *Fig.* 2, and with the value of n just taken,
the transparent patches must still be considered (for small values of θ)
as arranged in rows like AA_{n+1}.   Since now AA_1 is not exactly equal
to A_1A_{n+1}, it follows that the direction AA_{n+1} no longer bisects the
angle $A_1AA_1{}^1$.   It is interesting to trace the variation of the angle
$A_1AA_1{}^1 (= \phi$ say).   Although AA_1 and $AA_1{}^1$ are still given by (i), and
thus vary with θ, yet their ratio remains continually the same.   Thus
for direction purposes, the lengths of the sides in *Fig.* 2 may be con-
sidered as constant.   Regarding A_1A as a fixed line, the point A_{n+1}
will lie on a circle having A_1 as centre.   If ϵ be a positive fraction, the
point A will lie outside this circle and the greatest value that ϕ can
have will be attained when the line AA_{n+1} touches the circle having
centre A_1 and radius A_1A_{n+1}.   This will clearly be the case when

$$\cos \theta = \frac{AA_1{}^1}{AA_1} = \frac{n}{n + \epsilon} \qquad . \qquad . \qquad . \qquad . \quad (xii)$$

If we denote this value of θ by θ_1, we see that the corresponding value
of ϕ is $90° - \theta_1$.   We also see that as θ diminishes down to θ_1, ϕ increases
up to $90° - \theta_1$; as θ further diminishes, ϕ dimishes steadily, until when
$\theta = 0°$, ϕ also becomes 0°.   When, however, ϵ is a negative fraction,
ϕ increases steadily as θ diminishes, and ultimately, when $\theta = 0°$
ϕ becomes 180°.

We shall now find the value of the pitch p_2 (*i.e.*, the perpendicular
distance between the lines AA_{n+1} and A_nK).   Denote by ρ the length

---

* The case of ϵ a simple fraction is discussed in § 20.

Fig. 3.

The effect of superposing two "intaglio" screens (white lines on a black ground) at an angle of $2\frac{1}{2}°$. Pitch of screen 150 lines per inch.

Fig. 4.

Same screens as in Fig. 3, but angle is now 5°.

of the line AA_{n+1}. Whether ϵ be positive or negative we shall have

$$\rho^2 \sin^2 \theta = n^2 d_1^2 + d_2^2 - 2nd_1 d_2 \cos \theta$$
$$= n^2 d_1^2 + (n+\epsilon)^2 d_1^2 - 2nd_1^2 (n+\epsilon) \cos \theta \qquad . \qquad . \quad (xiii)$$

For small values of θ we can put $\cos \theta = 1 - (\sin^2\theta) / 2$, and the above expression reduces to

$$\rho^2 \sin^2 \theta = n^2 d_1^2 \left[\left(1 + \frac{\epsilon}{n} \right) \sin^2 \theta + \frac{\epsilon^2}{n^2} \right]$$

Thus for small values of θ we have

$$\rho \sin \theta = \epsilon d_1 \left[1 + \frac{n^2}{2\epsilon^2} \sin^2 \theta \left(1 + \frac{\epsilon}{n} \right) \right] \qquad . \qquad . \quad (xiv)$$

Also

$$\frac{\sin \phi}{\sin \theta} = \frac{nd_1}{\rho \sin \theta} \text{, whilst } p_2 = \frac{d_2}{n} \sin \phi \operatorname{cosec} \theta.$$

Hence

$$p_2 = \frac{\epsilon d_2}{\epsilon^2 + \frac{1}{2} (n^2 + \epsilon n) \sin^2\theta} \qquad . \qquad . \qquad . \qquad . \quad (xv)$$

and we see that this has the limiting value

$$p_2 = \frac{d_2}{\epsilon} \qquad . \qquad . \qquad . \qquad . \qquad . \quad (xva)$$

when θ becomes zero. Thus the pitch p_2 does not become infinitely great when it reaches its greatest value at $\theta = 0°$.

The result for p_2 can also be obtained by reference to *Fig.* 2*a*, where $A_1 A = (a_2 + b_2) \operatorname{cosec} \theta$, and $A_1 A_{n+1} = n(a_1 + b_1) \operatorname{cosec} \theta$.

Clearly $\qquad \dfrac{n}{2} p_2 . AA_2 = \text{area of triangle } AA_1A_{n+1}$

$$= \tfrac{1}{2}n \ (a_1 + b_1) \ (a_2 + b_2) \operatorname{cosec} \theta.$$

Thus $\qquad p_2 = \dfrac{(a_1 + b_1) \ (a_2 + b_2)}{\rho \sin \theta}$

$$= \frac{d_2}{\sqrt{n^2 + (n+\epsilon)^2 - 2n(n+\epsilon) \cos \theta}} \text{, exactly} \quad . \quad (xvi)$$

From this equation, the equations (xv) and (xva) can be easily deduced.

The results of this section are easily exemplified by taking two intaglio screens of nearly equal pitch, and superposing them at small angles. It will be found that $\theta = 0$ gives a finite pitch corresponding to equation (xva). It will also be found that as θ passes through zero from positive small values to negative small values, the orientation of

the framework of coarse squares appears to change by nearly 180°. This is easily understood from the discussion, already given, of ϕ.

§12.   As a verification of the formula given in (*viiib*) for the pitch of the coarser framework arising when two screens for which $\epsilon = 0$ are superposed, a simple test was made. Two screens of equal rulings (100 transparent lines to the inch) were superposed at such an angle as to give a spacing of 10 semi-transparent bands to the inch for the resulting coarse pattern of squares. The angle was found to be $5\cdot 75°$ (correct to a quarter of a degree). In this case we have $a_2 + b_2 = a_1 + b_1 = 0\cdot 01''$.

Also by (*viiib*), $p_2 = \dfrac{a_1 + b_1}{2}\ \operatorname{cosec}\ \dfrac{\theta}{2} = 0\cdot 1''$

Hence by calculation, $\operatorname{cosec}\dfrac{\theta}{2} = \dfrac{0\cdot 2}{0\cdot 01} = 20\ ;\ \ \theta = 5°\ 43'.$

§13.   The effects obtained by superposing two ordinary half-tone screens, *i.e.*, screens of transparent square spaces with black line boundaries, can be now dealt with. For this discussion, further diagrams are unnecessary. Let the two screens be denoted by $S_1{}^1$ and $S_2{}^1$. We may suppose that $S_1{}^1$ is the negative of S_1 (in §3), and that $S_2{}^1$ is the negative of S_2, without loss of generality. Thus for $S_1{}^1$, the width of the black bands is to be taken as a, whilst the sides of the transparent squares are to be taken as of a length b. Similarly for $S_2{}^1$, using dashed letters for a and b.

We consider $S_1{}^1$ as formed by making two sets ($X_1{}^1$ and $Y_1{}^1$) of parallel black bands on a transparent plate, the two sets being at right angles, so as to produce a series of light squares. Similarly, $S_2{}^1$ is regarded as formed by the two sets ($X_2{}^1$ and $Y_2{}^1$) of parallel black bands, etc. The final pattern R^1 of transparent spaces, obtained by superposing $S_1{}^1$ and $_2{}^1$, and holding the combination up to the light, can be obtained by he following operations (compare with §3):—

(*i*)   Make two screens ruled respectively, one with set $X_1{}^1$ of dark bands, the other with set $X_2{}^1$ only. Superpose these screens and find the pattern $P_1{}^1$ of transparent spaces obtained on holding the combination up to the light.

(*ii*)   Perform opn. (*i*), using $Y_1{}^1$ and $Y_2{}^1$. Let pattern be $Q_1{}^1$.

(*iii*)   ,,   ,, $X_1{}^1$ and $Y_2{}^1$.   ,,   ,, $P_2{}^1$.

(*iv*)   ,,   ,, $X_2{}^1$ and $Y_1{}^1$.   ,,   ,, $Q_2{}^1$.

(*v*)   *Superpose these Screens.* Wherever light can penetrate through $P_1{}^1$, $Q_1{}^1$, $P_2{}^1$, $Q_2{}^1$ simultaneously, there is a transparent space of the final pattern R^1. Notice that this operation is quite different from operation *(v)* of §3.
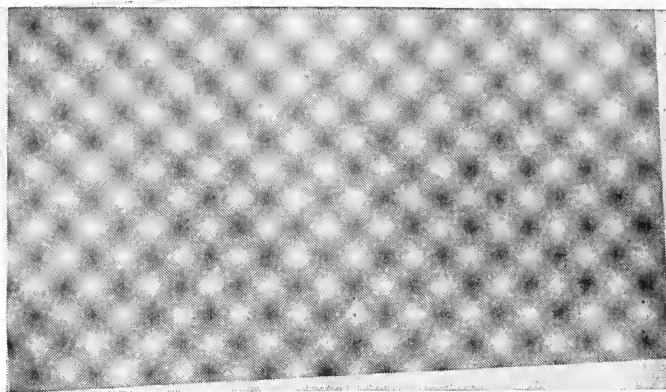
Fig. 5.

Illustrates the effect of superposing screens with black lines on white ground.
Pitch of screens 100 to the inch; angle 2½. (Actually, the screens are
almost of the "chess board" type, but the general effect is clear).
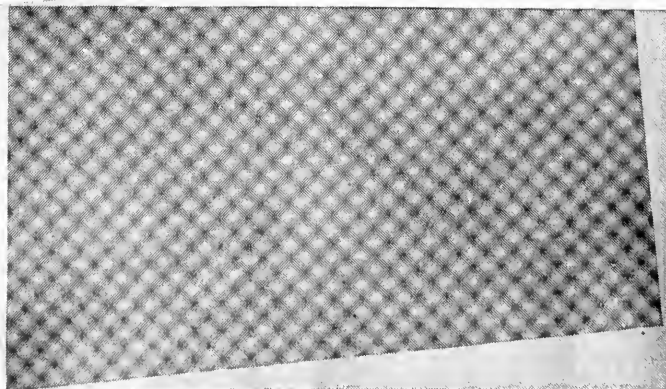
Fig. 6.

Same as in *Fig.* 5, but angle is now 5.

§14. We shall now discuss the results of the operations just described.

The result $P_1{}^1$ of operation (*i*) can be inferred from §§ 4 and 5. The only difference, in fact, lies in the interchanging of the a's and b's. When θ is small, we shall get a series of parallel rows of transparent patches, and the distance p_2 between two adjacent rows (the pitch of the rows) is still given by equation (*vii*), so that $p_2 = (a_1 + b_1) / 2\sin(\theta/2)$. Assuming that $b_1 / (a_1 + b_1)$ is greater* than 0·5 (which is usually the case), the areas of the individual patches will be much greater than those discussed in §§4 and 5 ; for the same value of θ.

§15. Operation (*ii*) of §13 will give the same results as operation (*i*), but rotated through 90°. The results of superposing screens corresponding to $P_1{}^1$ and $Q_1{}^1$, and finding where light penetrates through the combination, will therefore be as follows :—Wherever a row of transparent patches of $P_1{}^1$ is superposed on a row of $Q_1{}^1$ there will be a semi-transparent square area formed. It must be remembered that these rows are themselves much· broader than those discussed in §§4 and 5. The net result of operations (*i*) and (*ii*) together, following the procedure of operation (*v*), is therefore to give a series of semi-transparent squares, inside a black square framework.

§16. Operations (*iii*) and (*iv*) of §13 give results which can be obtained from operations (*iii*) and (*iv*) of §3, by interchanging a's and b's. Confining ourselves to small values of θ, we see from equation (*ix*) that the pitch of the rows of patches in $P_2{}^1$ and $Q_2{}^1$ is $a_1 + b_1$. This, however, will be much smaller than p_2, given by equation (*vii*).

§17. On carrying out operation (*v*) of §13 completely, we see that the effects of $P_2{}^1$ and $Q_2{}^1$ will be to produce on the semi-transparent square areas described in §15, a sort of additional mottling, resulting in a further diminution of the transparent light. The general character of the pattern obtained by superposing two half-tone screens of the ordinary type is well shown in *Figs.* 5 and 6 *(Pl. II.)*.† It is clear that the resulting coarse framework of semi-transparent squares with black edge is an approximate replica (magnified) of the pattern involved in either of the original half-tone screens. This result can be compared with that obtained in §10. The size of the framework obviously varies with θ in exactly the same way as the framework described in §10. It is, however, important to note that the pattern R^1 is not the negative of pattern R ; this is on account of the difference in the operations (*v*) of §3 and §13 respectively.

---

* See § 23.

† Owing to difficulties of reproduction, the effect desired has had to be shown by making use of what are practically "chess-board" screens (see below).

§18.   In the above §§13 to 17 we have assumed that $(a_2 + b_2)$ is a multiple of $(a_1 + b_1)$. It is easy to see, however, that when this is not the case, the formula given in (xv) must be used for p_2. Thus with R^1, as with R, the coarseness of the main pattern of squares does not become infinite, as θ approaches $0°$. The orientation of the pattern is also given by the angle ϕ discussed in §11.

§19.   It has been shown in §§10 and 17 that the resultant pattern R or R^1 resembles the original screens from which it was produced. The same is true of the pattern resulting when two process screens of the "chess board" variety are superposed. The argument is very
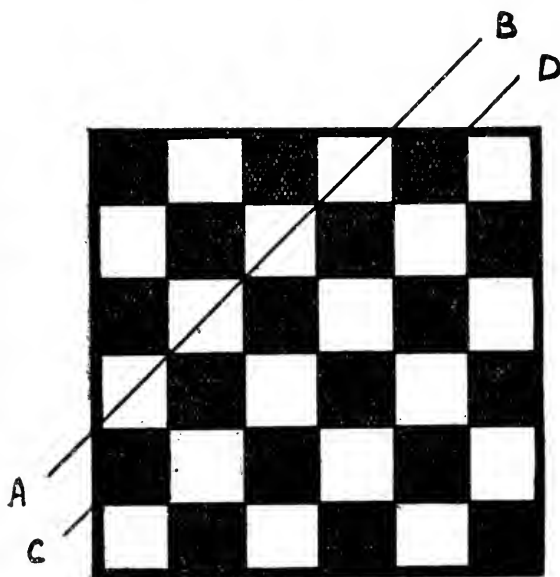
Fig. 7.

simple.   Let *Fig.* 7 represent part of a "chess board" screen, the squares being of side a_1. This screen may be regarded as either

(α) a square framework (of side $a_1 \sqrt{2}$) of transparent lines like AB (of periodically varying width), surrounding a dark interior,

or (β) a square framework (of side $a_1 \sqrt{2}$) of black lines like CD (of periodically varying width), surrounding a transparent interior.

On superposing two such screens, of sides a_1 and a_2 respectively, §10 shows us that the resultant pattern will follow (α) in its features,

Fig. 7*a.*

Illustrates the effect of superposing " chess board " screens. Pitch of screens
100 to the inch. Angle 2½ . (Actually, the screens consist of black round
dots on a white ground.)

Fig. 7*b.*

Same as in *Fig.* 7*a,* but angle is now 5 .

whilst §17 shows us that the pattern will also follow (β). It follows that the resultant pattern must be of the "chess board" type. Assuming that a_2 is an integral multiple of a_1, the pitch of the resulting pattern as obtained from consideration (α) must be, from (vii), equal to $a_1 \sqrt{2} / 2\sin(\theta/2)$. A similar result would hold from consideration (β). But this pitch for small values of θ is measured parallel to the diagonal of a square. Thus the pitch of the resultant "chess board" pattern, when measured in the ordinary way, *viz.*, parallel to a side a_1, is $a_1 / 2\sin(\theta/2)$, and increases indefinitely as θ tends to zero. This result should be compared with equation (vii).

The effect of superposing two chess board screens with equal pitches is shown in *Figs.* 7a and 7b (*Pl. III.*).*

The case of a_2 / a_1 not being integral $(a_2 > a_1)$ can be dealt with on lines exactly similar to those followed in §§ 11 and 18. It is easily seen that generally the side of the "chess board" pattern square plays the part of $(a_1 + b_1)$ in §§ 4 to 18

§20. We can extend the results of §5 to the case where

$$a_1 + b_1 = kd, \ a_2 + b_2 = ld \qquad . \qquad . \qquad . \qquad (xvii)$$

k and l being integers prime to each other. The appropriate diagram for pitches p is shown in *Fig.* 8, which shows the points A of *Fig.* 1 relabelled. Referring to *Fig.* 8, we shall have

$$_1A_1 \ _2A_1 = \ _2A_1 \ _3A_1 = \text{etc.} = (a_2 + b_2) \text{ cosec } \theta,$$
$$_1A_1 \ _1A_2 = \ _1A_2 \ _1A_3 = \text{etc.} = (a_1 + b_1) \text{ cosec } \theta.$$

Now instead of grouping the transparent patches of which the $A's$ are corners, according to rows like $_1A_1 \ _2A_2 \ _3A_3$ (say), we can group them in rows parallel to $_1A_1 \ _kA_1$. It at once follows from equations $(xvii)$ that $_1A_1 \ _1A_1 = \ _1A_1 \ _kA_1, = kld$ cosec. θ. If we regard the four points $_1A_1, \ _1A_1, \ _kA_1, \ _kA_1,$ as typical of a pattern of transparent squares, we see that the corresponding pitches are

$$p_1 = \ _1A_1 \ _kA_1 = 2kld \text{ cosec } \theta \sin(\theta/2) = \ kld \sec(\theta/2) \quad . \quad (xviii)$$
$$p_2 = \ _kA_1 \ N \ = \ kld \text{ cosec } \theta \cos(\theta/2) = \tfrac{1}{2}kld \text{ cosec }(\theta/2). \quad (xix)$$

It should be noticed, however, that we have rows of transparent spaces having directions parallel to LM, passing through every point A on the boundary of, or inside, the parallelogram $_1A_1 \ _1A_1 \ _kA_1 \ _kA_1$. Thus, calling the results just obtained pattern P_1 (as in §3), we shall find on superposing P_1 and Q_1† (according to operation (v) of §3), a whole series of parallel square networks, all having their sides of square given

---

* Owing to difficulties of reproduction, the two screens illustrated are not exactly chess-board types, but consist of black round dots on a white ground.

†Q is, of course P_1 rotated through 90°.
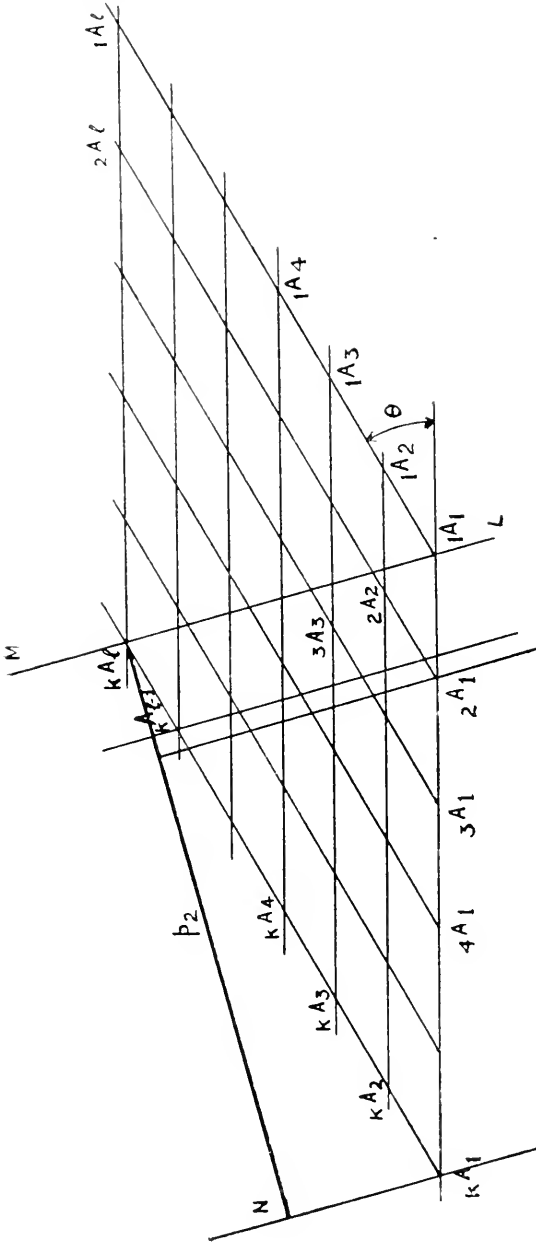
Fig. 8.

by (xix). Each of these square networks will be of the type described in §6, but it is important to note that there will be kl distinct networks of this type, when account is taken of all the points A. These networks of squares of side p_2 can be again regarded as consisting of *two* parallel square networks only One network will have a side p_2/k, the other a side p_2/l. It is clear, however, that on account of the size of p_2, with large values of k and l, it will be difficult for the eye to pick out the regularity of the pattern ; more particularly will this difficulty be emphasised on account of the presence of two sets of parallel networks of pitches p/k and p/l respectively. It must be emphasised, however, that the resultant pattern of P_1 and Q_1 (according to operation (v) of §3) *is* periodic within squares of side p_2, and this can be shown by making θ very small, when the periodicity becomes recognisable.

The effects of adding patterns P_2 and Q_2 to the pattern just described, can be obtained by the procedure given in §§7 and 8, and we have in no way to modify the above argument for the coarse framework of R.

The results given in this section can be obviously applied *mutatis mutandis* to the case of superposing two ordinary half-tone screens. Thus the two sets of square frameworks, consisting of dark boundaries with lighter interiors, will have pitches or sides given by p_2/k and p_2/l respectively ; where p_2 is given by equation (xix).

§21. We shall now briefly discuss the average intensity of light after transmission through two ordinary half-tone screens (*i.e.*, $S_1{}^1$ and $S_2{}^1$ of §13). The results here given must be taken as those averaged over large areas of each plate or screen.

Assuming the uniform intensity of the incident light to be I, the average intensity after passing through a screen ruled only with bands $X_1{}^1$ (§13) will clearly be $I.b_1 / (a_1 + b_1)$. Superposing two such screens at 90° gives us the effect of $S_1{}^1$. Thus after transmission through the half-tone screen $S_1{}^1$, the intensity of the transmitted light is

$$I_1{}^1 = I\, b_1{}^2 / (a_1 + b_1)^2 . \qquad . \qquad . \qquad . \qquad (xx)$$

If the light had been passed instead through $S_2{}^1$, the transmitted intensity would have been

$$I_2{}^1 = I\, b_2{}^2 / (a_2 + b_2)^2 . \qquad . \qquad . \qquad . \qquad (xxi)$$

The final intensity, after passing through both screen $S_1{}^1$ and $S_2{}^1$, is therefore

$$I_3{}^1 = I\, b_1{}^2 b_2{}^2 / (a_1 + b_1)^2 (a_2 + b_2)^2 . \qquad . \qquad . \qquad (xxii)$$

Similarly, if S_1 and S_2 be the negatives of $S_1{}^1$ and $S_2{}^1$, the respective intensities of transmission are

(for S_1 alone), $I_1 = I - I_1{}^1 = I.\ (2a_1 b_1 + a_1)^2 / (a_1 + b_1)^2 . \qquad . \qquad (xxiii)$

(for S_2 alone), $I_2 = I - I_2{}^1 = I. \left(2a_2b_2 + a_2{}^2\right) / \left(a_2 + b_2\right)^2.$. $(xxiv)$

(for S_1 and S_2 combined), $I_3 = I. \left(2a_1b_1 + a_1{}^2\right)$

$$\left(2a_2b_2 + a_2{}^2\right) / \left(a_1 + b_1\right)^2 \left(a_2 + b_2\right)^2. \quad . \quad (xxv)$$

As $I_3{}^1$ is not equal to $I - I_3$, it follows that R^1 is *not* the exact negative of R (see end of §17).

For a true half-tone screen, $I_1 = I_1{}^1 = I/2.$ Thus

$$b_1{}^2 / \left(a_1 + b_1\right)^2 = 0\cdot5, \; i.e., \; b_1 / \left(a_1 + b_1\right) = 1 / \sqrt{2} = 0\cdot707, \; \Big\}$$
$$a_1 / \left(a_1 + b_1\right) = 1 - 1 / \sqrt{2} = 0\cdot293. \; \Big\} \quad . \quad (xxvi)$$

In these cases we should have, after passing two such screens, an intensity (I_3 or $I_3{}^1$) given by

$$I_3 = I_3{}^1 = 0\cdot25. \; I \quad . \qquad . \qquad . \qquad . \quad (xxvii)$$

§22.   We have discussed at some length in the preceding sections the general origin of the coarse square frameworks to be recognised on superposing two half-tone screens of similar type.   The question now arises : what variations will the patterns P_2 and Q_2 (of §3), or $P_2{}^1$ and $Q_2{}^1$ (of §13), produce on their respective final patterns R or R^1, as the two original half-tone screens are relatively displaced, keeping θ constant ?

It has to be recognised that when the respective positions of the two superposed screens are given, the pattern π_2 resulting from P_2 and Q_2 (or from $P_2{}^1$ and $Q_2{}^1$) is defined relatively to the pattern π_1 resulting from P_1 and Q_1 (or from $P_1{}^1$ and $Q_1{}^1$).

Fig. 9 shows the centre lines of the transparent bands X_1 and X_2 (inclined at angle θ) which together produce pattern P_1 of §3.   The corners of the double set of parallelograms here shown are clearly to be regarded as the centres of the transparent spaces of pattern P_1. *Fig.* 10 shows similarly the spacing of the centres of the transparent spaces of pattern P_2 (formed by bands X_1 and Y_2).   In superposing patterns P_1 and P_2 to form part of the final pattern R (according to the rules laid down in §3), obviously the bands X_1 in *Fig.* 10 must coincide with bands X_1 in *Fig.* 9.   One effect of displacing the two original screens S and S, keeping θ constant, is clearly equivalent to sliding *Fig.* 10 over *Fig.* 9, still keeping bands X_1 in both figures in coincidence.

We can similarly make diagrams for the centres of the transparent spaces of patterns Q_1 and Q_2.   In superposing these diagrams the bands Y_1 in both diagrams must coincide (*Figs.* 11 and 12).   Another effect of displacing the two original screens S_1 and S_2, keeping θ
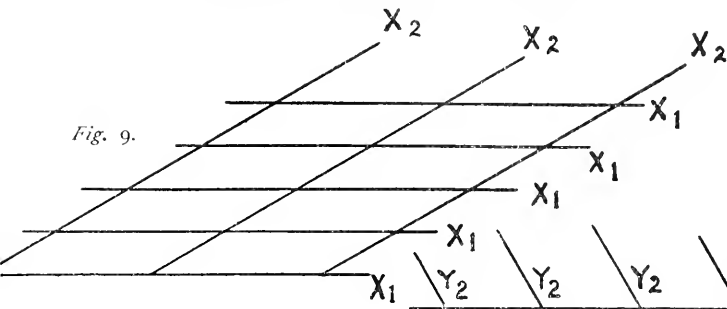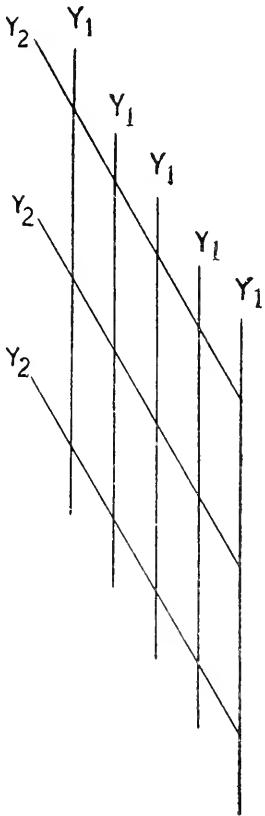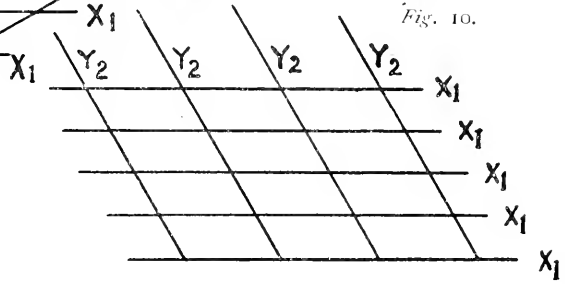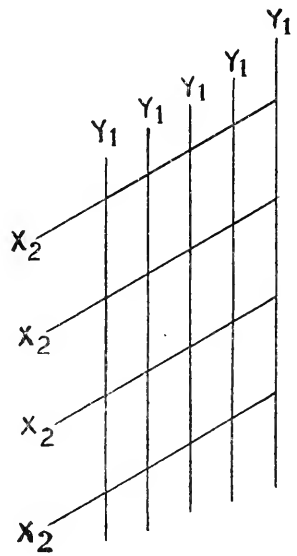
Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

constant, is clearly equivalent to sliding *Fig.* 12 over *Fig.* 11, still keeping bands Y_1 in both figures in coincidence.

Either of the slidings of *Fig.* 10 over *Fig.* 9, or of *Fig.* 12 over *Fig.* 11, may be zero in special cases of the relative displacements of S_1 and S_2.

We also see that when the corners of the parallelograms shown in *Figs.* 9, 10 and 11 are fixed, owing to the mutual positions of S_1 and S_2 being absolutely specified, then also are the corners of the parallelograms of *Fig.* 12 specified. Thus the positions of the centres of the transparent spaces of Q_2 are defined, when those of the centres of the transparent spaces of P_1, P_2 and Q_1 are given. In other words, the spacing of the pattern Q_2 is dependent on the spacings of the patterns P_1, P_2, and Q_1. More generally, the spacing of any one of these four patterns is determined uniquely by those of the other three.

However, if it is recognised that for small values of θ, the pitches $p_1{}^1$ and $p_2{}^1$ of equation (ix) are small compared with p_2, it will be seen that the displacements referred to will not materially modify the main or coarse framework of squares, and this is readily verified by experiment (see also analytical discussion in Appendix).

§23.   *Conclusion.* The author has discussed in this paper the general characteristics of the patterns obtained on superposing two half-tone plates of like type, at small angles. More particularly, the cases of (i) intaglio, (ii) ordinary half tone, and (iii) "chess board" screens have been discussed. In these cases, it is shown that the coarse square framework which arises is similar in type to that of each of the constituent screens. Formulæ for the pitches of the coarse square frameworks are deduced, and it is shown that if the pitches of the original screens are to one another in the ratio of simple whole numbers, a coarse square framework arises, whose pitch varies as cosec ($\theta/2$), and thus become infinite when θ tends to zero. In other cases, it is shown that the pitch remains finite always.

It has to be remembered that all kinds of groupings of the transparent spaces forming the final pattern are possible theoretically, but the ones taken for consideration are those that force themselves on the eye.

An important point brought out in the paper is that the resultant pattern R of two intaglio screens S_1 and S_2 is not the negative of the pattern R^1 which is the result of superposing screens $S_1{}^1$ and $S_2{}^1$ which are the negatives of S_1 and S_2 respectively.

The important cases which arise when θ is large are not discussed in this paper. The questions of framing rules for obtaining the best

resultant pattern R for photo-reproduction purposes, and the corresponding value of θ, are not investigated. Such work would seem to be largely a matter for experiment as well as theory, and is engaging the attention of Mr. Fishenden and the author.

Finally, the author would like to give his thanks to Mr. Fishenden for the assistance he has given in preparing plates, etc., and thus enabling the theory to be tested ; also for many suggestions in connection with the paper.

The author would also thank Mr. L. J. Mordell for valuable criticisms concerning the Appendix.

APPENDIX.

The effect of such displacements, as are referred to in §20, can be discussed analytically as follows (see *Fig.* 13) :—

Let the centre of a black square of the screen S_1 be denoted by O, and through O take two axes Ox, Oy parallel to the sides of the square (and therefore mutually at right angles). After superposing screen S_2
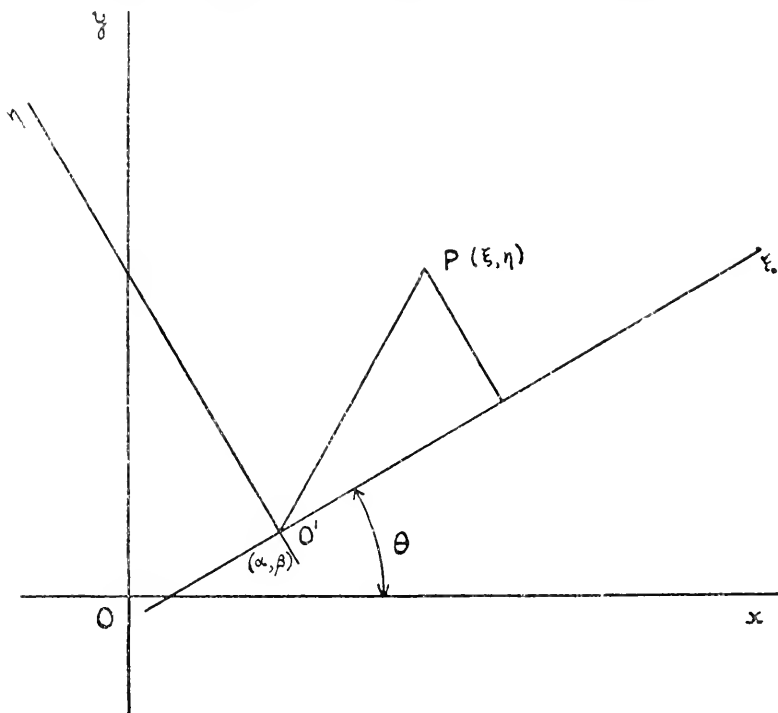
Fig. 13.

on screen S_1, let the centre O^1 of a black square of S^1 have the co-ordinates (a, β) relative to Ox, Oy. Through O^1 draw axes $O^1\xi$, O^1u parallel to the sides of the squares of S^1. These axes will be mutually at right angles, and $O^1\xi$ can be taken as making the angle θ with Ox. For simplicity in the following discussion, we shall put

$$\left. \begin{array}{l} a_1 + b_1 = \gamma_1, \\ a + b = \gamma. \end{array} \right\} \qquad . \qquad . \qquad . \qquad . \qquad (i)$$

If a point P have co-ordinates (ξ, η) relative to $O^1\xi$, $O^1\eta$, then its co-ordinates (x, y) relative to Ox, Oy will clearly be given by

$$x = a + \xi \cos \theta - \eta \sin \theta, \Big\}$$
$$y = \beta + \xi \sin \theta + \eta \cos \theta, \Big\} \qquad \qquad (ii)$$

If the point P coincide with some point $_mO_n^1$, which is the centre of another black square of S^1, and which has co-ordinates $\xi = m\gamma_1$, $\eta = n\gamma_1$, where m and n are integers, then

$$x = a + \gamma_1 \, (m \cos \theta - n \sin \theta), \Big\}$$
$$y = \beta + \gamma_1 \, (m \sin \theta + n \cos \theta). \Big\} \qquad \qquad (iii)$$

We shall assume that γ is a commensurable fraction p/q (where p and q are integers) of γ_1; also that $\cos \theta$ and $\sin \theta$ are commensurable, and equal respectively to r/t, s/t, where r, s and t are integers. We can then write

$$x = a + \frac{\gamma_1}{t} \, (mr - ns) = a + \frac{q}{pt} \, \gamma(mr - ns), \Big\}$$
$$y = \beta + \frac{\gamma_1}{t} \, (ms + nr) = \beta + \frac{q}{pt} \, \gamma(ms + nr). \Big\} \qquad (iv)$$

It is, of course, assumed that the fractions p/q, r/t, s/t are expressed in their lowest terms. Since

$$(r/t)^2 + (s/t)^2 = 1 \qquad \qquad \qquad (v)$$

we may take it from the theory of numbers, that t is always odd, whilst one of r and s is odd, the other even. Further r is prime to s.

We see from equations (iv) that if m and n are multiples of pt (or if a common factor f is present in the numerator and denominator of $q \,/\, pt$, we can take m and n multiples of pt/f), then we can write

$$x = a + M\gamma \, \Big\}$$
$$y = \beta + N\gamma \, \Big\} \qquad \qquad \qquad (vi)$$

where M and N are integers.

Thus relatively to a new origin having co-ordinates $x = M\gamma$, $y = N\gamma$, we find that $x = a$, $y = \beta$, exactly as in *Fig.* 9. From equations (iv) we see further that every time either m or n is increased by pt/f, ξ and η are both increased by multiples of $pt\gamma_1/f$, and we get new values of M and N satisfying (vi). Thus we have established the fact that with a square framework of lines defined by

$$\xi = M_1\gamma_1 \, pt/f, \, (M_1 = \ldots -2, -1, 0, 1, 2, \text{etc.}), \, \Big\}$$
$$\eta = N_1\gamma_1 \, pt/f, \, (N_1 = \ldots -2, -1, 0, 1, 2, \text{etc.}), \, \Big\} \qquad (vii)$$

the pattern R *exactly* repeats itself in each square, independently of (a, β), and we need therefore only consider one square.

It may be noticed that if f exists, it is the factor common to q and t.   If the G.C.F. of p and r be f^1, and of p and s be f^{11}, then we can reduce the framework given by *(vii)*.   For if f^1 and f^{11} be other than unity, we shall have, on account of *(iv)*, x increasing by a multiple of γ whenever m is increased by pt/ff^1, and similarly y increasing by a multiple of γ whenever n is increased by pt/ff^{11}. Thus within the framework of lines given by

$$\begin{aligned}\xi &= M_1{}^1\gamma_1\, pt/ff^1, \ (M_1{}^1 = \ldots -2,\ -1,\ 0,\ 1,\ 2, ..), \\ \eta &= N_1{}^1\gamma_1\, pt/ff^{11}, \ (N_1{}^1 = \ldots -2,\ -1,\ 0,\ 1,\ 2, ..), \end{aligned} \bigg\} \quad . \quad (viii)$$

the pattern R *exactly* repeats itself in each rectangle.   Further, this framework is the *least* framework within which we have the whole of the pattern R represented.

It may also be observed that if the whole of the pattern R be divided up into rectangles according to the scheme *(viii)*, we shall have for each rectangle $(pt)^2/f^2f^1f^{11}$ points (x,y) of the general type ${}_mO_n{}^1$ (*i.e.*, centres of black squares of S^1) to be associated with each rectangle.   Boundary points can be settled by any convenient convention.   Corresponding to each of these points there will be a point (a^1, β^1), where $a^1 < \gamma$, $\beta^1 < \gamma$, satisfying

$$\begin{aligned}x &= a^1 + M^1\gamma, \\ \gamma &= \beta^1 + N^1\gamma, \end{aligned} \bigg\} \qquad . \qquad . \qquad . \qquad . \qquad (ix)$$

where M^1 and N^1 are integers.   The points (a^1, β^1) clearly be within or on a square Σ given by $x = 0$, $x = \gamma$, $y = 0$, $y = \gamma$.   These points may be termed *representative points* for the point (a, β).   We see that the representative points of those points ${}_mO_n{}^1$, to be associated with each rectangle given by *(viii)*, will cover every possible representative point for the given position of S^1.

Representative points (a^1, β^1) possess the property that any displacement of O^1 from $(x=a, y=\beta)$ to $(x=a^1, y=\beta^1)$, keeping θ constant, produces the same pattern R in another part of the plane.

Further, of these $(pt)^2/f^2f^1f^{11}$ points (a^1, β^1), no two (corresponding to two points ${}_{m1}O^1{}_{n1}, {}_{m11}O^1{}_{n11}$) associated with the same rectangle of the series *(viii)*, can coincide.   For if this were the case, a displacement of S, so that ${}_{m1}O_{n1}$ was changed to ${}_{m11}O_{n11}$ (still keeping θ constant) would produce exactly the same pattern R in exactly the same place ; so that the pattern R would be periodic in a framework of rectangles *less* than those given by *(viii)*.   This is, however, impossible.   Thus there are $(pt)^2/f^2f^1f^{11}$ *different* representative points in Σ.

We shall now discuss the representative points obtained when O^1 coincides with O, *i.e.*, when $a = 0$, $\beta = 0$.

First, let us assume that the factors f^1 and f^{11} are unity.   In this case we have $(pt)^2/f^2$ representative points to consider.   Assume that

γ is made up of pt/f units (each of length $\gamma f/pt$) ; then γ_I is made up of qt/f units. Taking any pt. $(\xi = \mu\gamma_\mathrm{I}, \ \eta = \nu\gamma_\mathrm{I})$ where μ and ν are integers, we see that the corresponding values of x and y in terms of the unit referred to, are

$$\left.\begin{aligned}
x &= \xi \cos\theta - \eta \sin\theta = \frac{\mu qt}{f}\frac{r}{t} - \frac{\nu qt}{f}\frac{s}{t} = \frac{q}{f}\ (\mu r - \nu s),\\
y &= \xi \sin\theta + \eta \cos\theta = \frac{\mu qt}{f}\frac{s}{t} + \frac{\nu qt}{f}\frac{r}{t} = \frac{q}{f}\ (\mu s + \nu r).
\end{aligned}\right\} \qquad . \qquad (x)$$

Thus x and y are given by whole numbers. On subtracting multiple of γ (also whole numbers) to get the positions of the representative points, we again get whole numbers.

Thus the whole of the representative points will be on some or other of the points of intersection of the series of squares given by

$$x = \frac{\mu^\mathrm{I} f \gamma}{pt}, \ y = \frac{\nu^\mathrm{I} f \gamma}{pt}, \qquad . \qquad . \qquad . \qquad (xi)$$

where μ^I and ν^I can have any integral values, positive or zero, *less* than pt/f. Associated with a square of side γ there will be $\left(\dfrac{pt}{f}\right)^2$ such points. As there are $\left(\dfrac{pt}{f}\right)^2$ *separate* representative points, it follows that the points (xi) give *all* the representative points, in this case (when f^I and f^II are unity).

By similar reasoning, we can show that when f^I or f^II is different from unity, the squares (xi) *include* all the representative points. Further, whilst some of the points given by (xi) are *not* representative points, points of the form*

$$x = \mu^\mathrm{II} \frac{f f^\mathrm{I} f^\mathrm{II}}{pt}\cdot\gamma, \ y = \nu^\mathrm{II}\frac{f f^\mathrm{I} f^\mathrm{II}}{pt}\ \gamma, \qquad . \qquad . \qquad (xii)$$

are representative points ; where μ^II and ν^II are either zero or any positive numbers less than $pt/f f^\mathrm{I} f^\mathrm{II}$. Without being able to specify more directly the positions of the representative points, we can assert that they are not more widely spaced than the points given by (xii).

If now we remove the restrictions on $\mu^\mathrm{I}, \mu^\mathrm{II}, \nu^\mathrm{I}$ and ν^II, so that they may now be any positive or negative integers (and zero), we easily see that in the general case when O^I does not coincide with O_I, that the lines

$$x = a + \frac{\mu^\mathrm{I} f \gamma}{pt}, \ y = \beta + \frac{\nu^\mathrm{I} f \gamma}{pt}, \qquad . \qquad . \qquad . \qquad (xiii)$$

* Notice that since f^I is prime to f^II, $pt/f f^\mathrm{I} f^\mathrm{II}$ is an integer.

give a network of squares, the corners of which (when inside the square Σ of side γ) *include* all the representative points of the point (a, β). The points given by

$$x = a + \frac{\mu^{11} ff^1 f^{11}\gamma}{pt}, \quad y = \beta + \frac{\nu^{11} ff^1 f^{11}\gamma}{pt}, \qquad . \qquad . \quad (xiv)$$

provided they lie in (or on) Σ, are *all* representative points.

Equations (*xiii*) define $(pt/f)^2$ points, whilst (*xiv*) define $(pt/ff^1 f^{11})^2$ of the representative points, the total number of which is $(pt)^2/f^2 f^1 f^{11}$.

Considering then, only displacements of O^1 inside the square Σ, we see that if the pattern R is to remain unaltered in design, O^1 must always coincide with a representative point of the original position (a, β) of O^1.

Equations (*iv*) show us that we still get periodicity of the pattern R within a rectangle, provided $q \cos \theta/p$ and $q \sin \theta/p$ are commensurable (*e.g.*, $q/p = \sqrt{5}$, $\cos \theta = 2 / \sqrt{5}$, $\sin \theta = 1 / \sqrt{5}$). Whenever this condition is not satisfied, there is no periodicity in the pattern, *i.e.*, no finite displacement of S^1 over S will produce the same pattern R in the same place. Thus any displacement of O^1, from one point in such a square to another point in the same square, will produce a pattern R totally different (*i.e.*, it cannot be made to coincide with the original pattern by a finite displacement of R).

In such cases as these (and they are the most general) it is *strictly* impossible to talk of the pattern R as being defined by θ alone; the relative co-ordinates of O^1 to O should also be specified.

Disregarding all cases when $\theta = 0$, we can examine some simple cases where periodicity in pattern R exists. The coarsest set of representative points is obtained when

$$q/p = \sqrt{5}, \frac{r}{t} = 2/\sqrt{5}, \frac{s}{t} = 1/\sqrt{5} \qquad . \qquad . \quad (xv)$$

(these values of r and s can be interchanged). In this case, from equation (*iv*), we see that the pattern R is periodic in a square framework of size γ_t. Thus for a given position of O^1 within a square of side γ, there is no other position for O^1 inside the square, which will reproduce R in any part of the plane. Similarly when

$q/p = \sqrt{m_1^2 + n_1^2}$, $\frac{r}{s} = \frac{m_1}{n_1}$; m_1 and n_1 being integers. The next simplest case is where

$$p = 1, \frac{r}{t} = \frac{4}{5}, \frac{s}{t} = \frac{3}{5} \qquad . \qquad . \qquad (xvi)$$

Here again r and s can be interchanged. In this case, $f = f^{\mathrm{I}} = f^{\mathrm{II}} = 1$, and equations (*xiv*) show that the representative points for a given position (a, β) of O^{I} within the square of side γ are given by

$$x = a + \mu^{\mathrm{II}}\frac{\gamma}{5}, \quad y = a + \nu^{\mathrm{II}}\frac{\gamma}{5}, \qquad . \qquad . \qquad . \quad (xvii)$$

where μ^{II} and ν^{II} are integers chosen so as to make the points (xy) lie in or on the square of side γ. Thus the side of the squares defined by (*xvii*) is of length $\gamma / 5$.

In all other cases, the distribution of representative points will be finer than that given by (*xvii*).

These results show that where periodicity of the pattern R (or R^{I}) exists, the representative points will be so finely distributed, except for the cases just mentioned, that we may for practical purposes discuss the pattern as depending only on θ.

The most general case is that in which either $\gamma_{\mathrm{I}} / \gamma$, or $\cos \theta$ and $\sin \theta$ (or all of these) are incommensurable in such a way that there is no periodicity in the pattern R (or R^{I}). In this case for a given (a, β) there will be a doubly infinite series of representative points (corresponding to the doubly infinite series of points ${}_m O_n{}^{\mathrm{I}}$). We shall not attempt to discuss the distribution of these points, beyond the following :—

(*i*)   To any point (a, β) inside the square of side γ there will be a doubly infinite number of representative points $(a^{\mathrm{I}}, \beta^{\mathrm{I}})$ inside the square.

(*ii*)   A displacement of (a, β) to any of these points $(a^{\mathrm{I}}, \beta^{\mathrm{I}})$ will give *exactly* the same doubly infinite series of representative points, but of course the points ${}_m O_n{}^{\mathrm{I}}$ to which these correspond, will have changed.

(*iii*) If $(a^{\mathrm{I}}, \beta^{\mathrm{I}})$ be a representative point of (a, β), then the point $(a^{\mathrm{II}}, \beta^{\mathrm{II}})$, where $a^{\mathrm{II}} = \dfrac{(a^{\mathrm{I}} - a)}{N}$, $\beta^{\mathrm{II}} = \dfrac{(\beta^{\mathrm{I}} - \beta)}{N^{\mathrm{I}}}$, N and N^{I} being integers, is also a representative point of (a, β). Thus the representative points inside the square of side γ are infinitely crowded everywhere.

We are thus entitled to say that although we can never get, in such a case, exactly the same pattern R on displacing O^{I} from (a, β) to $(a^{\mathrm{I}}, \beta^{\mathrm{I}})$, unless $(a^{\mathrm{I}}, \beta^{\mathrm{I}})$ is a representative point of (a, β) ; yet we can always find some part of the plane where the new pattern R will differ

as little as we please from the original pattern (suitably displaced).   In this sense then, we can say that R depends only on θ.

In concluding this Appendix, it may be mentioned that periodic frameworks, of the kind we have been discussing, are well known in the Theory of Numbers and in the Theory of Doubly Periodic Functions, under the heading *Zahlengitter*.   The author has not been able to find any evidence that *Zahlengitter* have been discussed from the optical point of view.

HENRY WILDE, D.Sc., D.C.L., F.R.S.

·

V.—HENRY WILDE.

BY

Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E.

HENRY WILDE, the eldest child of a working mechanic, was born in Manchester in 1833. When Henry was sixteen he was left without parents, and had the charge of a younger brother, Joseph, and a sister. The brothers were apprenticed to an engineering firm. Henry soon showed considerable skill, and before he was of age he obtained a position of some responsibility in the works. His leisure hours were devoted to study, especially of electricity; and he constructed electrical machines and made experiments with electrical kites and the electro-deposition of metals. He soon realised the great possibilities of the industrial applications of electricity, and decided in 1856, when he was twenty-three, to set up in business as a telegraph and lightning-conductor engineer. He first had an office in Cross Street, Manchester; but in 1861 he removed to 2, Winter's Buildings, St. Ann's Church Yard.

An important fact in the life of Henry Wilde was the friendship of his brother-in-law, Mr. George Cliff Lowe, silversmith, of 26, St. Ann's Street, Manchester. They became partners, and the firm of Wilde and Co. was established, with a works in Mill Street, Ancoats.

Lightning Conductor Expert.

In 1861 his attention was directed to the danger of having lightning conductors near water and gas pipes, especially when the pipes were made of lead, a metal that may be easily fused by side flashes. He advised that in all cases lightning conductors should be metallically connected with the pipes, which is now the general practice. Wilde established a local reputation as a lightning conductor expert, and in a Lancashire factory town was known as " t'thunder an' leetnin' mon."

Telegraphy.

At the time that Wilde commenced business, commercial telegraphy was fast developing, and he saw that an alphabetic system was likely to be adopted by works and business houses. He devoted five years to the design and manufacture of suitable transmitters and receivers worked by magnetos, and succeeded in producing an ingenious system, which was a rival to that of Sir Charles Wheatstone. The Universal Private Telegraph Company, which used the Wheatstone system, brought an action against Wilde for infringement of its patents; but the action was dismissed with costs.

The use of Wilde's ABC system was so encouraging that it was decided to extend the sale of the apparatus by the formation of a limited liability company. A prospectus was issued with the object of forming the Globe Telegraph Company, Limited, with a capital of £100,000. The chief object of the company was to establish " a system of private telegraphic communication between Public Offices, Police, Fire and Railway Stations, Banks, Docks, Mines, Manufactories, Merchants' Offices, etc." Only about two hundred shareholders were obtained, and £5 per share was called up. To carry out the intentions of the company it was necessary, in accordance with the Telegraph Act of 1863, to have an Act of Parliament. This was obtained in 1864, but the legal expenses were so heavy that the bulk of the called-up capital was required to settle them. About forty firms, including Messrs. Platt Brothers of Oldham, Messrs. Strutt of Belper, Messrs. George Crossland & Son of Huddersfield, Messrs. William Jessop & Sons of Sheffield, and Messrs. Rylands of Manchester, used Wilde's instruments and found them easy to work and of considerable utility. The Telegraph Act of 1868 enabled the Government to acquire, work and maintain electric telegraphs, and the Act as amended in the following year practically gave the Government a monopoly in telegraphic business. Against this Wilde petitioned, and in his evidence before a Select Committee, he claimed that his patent rights would be greatly depreciated, if not entirely destroyed, by the Act. He further urged that his new system of laying and working subterranean wires would have no chance of adoption. Much to his disappointment, the Committee decided against his claims, and the Globe Telegraph Company ceased its business.

Electric Generators.

An important consequence of Wilde's work in telegraphy was his patent of 1863, which related to an improved machine for producing electric currents. To understand the position of the inventor, it will be necessary to review very briefly the previous history of the subject. In 1831 Faraday rotated a copper plate between the poles of a permanent magnet and so produced induced electric currents. The effect was increased by replacing the permanent magnet by an electro-magnet. Faraday may therefore be regarded as the real first inventor of a machine for obtaining electric currents by the rotation of a copper armature in a magnetic field produced either by a permanent magnet or an electro-magnet. The immediately succeeding inventors, Pixii (1832), Sexton (1833), and Clarke (1834) used armatures with bobbins wound with wire and permanent magnets. All such machines are called magneto-electric, or simply magnetos. The first great step in their improvement did not come until 1856, when Siemens introduced the shuttle-wound armature.

This type of armature (See *Pl. I., Fig. 1*) Wilde adopted, and he described the details of his machine in a paper with the title, " Experimental Researches in Magnetism and Electricity," which was communicated to the Royal Society by Faraday in 1866.   The magneto is shown in the upper part of *Fig. 2*.   Two blocks of cast iron D and D, and two pieces of brass of the same length were fixed together with brass bolts, so that a hollow cylinder—which he termed the " magnet cylinder "—was formed, having a hole of $1\frac{5}{8}$ in. in diameter.   The armature core was of cast iron, on which was wound 163 feet of copper wire 0·03 in. diameter.   The U-shaped steel magnets A were 8 in. long, 1 in. wide, and $\frac{1}{4}$ in. thick.   Each magnet was about 1 lb. in weight, and able to support 10 lbs.   The armature was rotated at 3,000 revolutions per minute by the belt M.   Experiments were made with a varying number of magnets, and what Wilde called " the quantity of electricity produced " was measured by a tangent galvanometer (see Appendix A).   This magneto was used to excite electro-magnets, the largest having limbs 2 ft. long and $3\frac{1}{2}$ in. diameter.   With four steel magnets in position on the magneto, 1,088 lbs. was required to detach the keeper of the electro-magnet, this being 27 times the weight that the combined four magnets were able to support.   This he regarded as a paradoxical phenomenon, which appeared to him to be a new principle in electro-magnetism.

The second part of the 1866 Royal Society paper is especially interesting and important in connection with the history of electrical generators.   It relates to " A new and powerful generator of dynamic electricity," and describes the construction of a new magneto and of three machines with electro-magnets. The magneto was fixed to the top of the electro-magnetic machine, and its electro-magnet B (see *Fig. 2*) was excited by the current from the magneto.   The armature of the electro-magnetic machine was driven by the belt M[1].   Further details of the four machines are given in Appendix B.   They are classified according to the size of the bore of the magnet cylinder, which in the three electro-magnetic machines was $2\frac{1}{2}$, 5 and 10 ins. respectively.   The 10-in. machine was provided with two armatures, one for " intensity " and the other for " quantity."   With this large machine, using the intensity armature, Wilde was enabled to produce a strong arc light.   He used a Foucault arc lamp provided with a parabolic reflector 20 ins. in diameter. This was placed on the top of his works, and cast shadows of the flames of the street lamps a quarter-of-a-mile away on the neighbouring walls.   He says : " When viewed from that distance, the light was a very magnificent object to behold, the rays proceeding from the reflector having all the rich effulgence of sunshine."   A piece of photo paper exposed to the light for 20 seconds at a distance of 2 feet from the light was darkened as

much as a piece of the same kind of paper when exposed for one minute to the direct rays of the sun at noon on a very clear day in March.

These electro-magnetic generators had a very serious defect. The eddy and other currents in the armature, being converted into heat, produced a rise of temperature of 300°F. and upwards. Wilde found that the smaller generators ran cooler than those of larger size; but even the former, during long runs, got so hot as to endanger the insulation. At a works where it was desirable to run the machines for days and nights without a stop, water was passed round hollow brass segments forming part of the armature cylinder, and the hot water produced was used to feed the steam boilers. In order to obtain sufficiently large currents it was necessary to run a number of the small generators in parallel. This led to a number of difficulties. Although the armatures of the machines were driven with equal-sized pulleys from the same countershaft by belts, the want of perfect synchronism prevented efficient parallel running. Wilde tried gearing a pair of machines together, and he then made his most important discovery. He ran the machines as alternators. When the armatures were so clutched that the currents were in the same phase, the sum of the currents was obtained in the main circuit; but when they were clutched together so that the currents were in opposite phase, no current resulted. He found now that when the clutch was unfastened and the machines were run disconnected from one another, the armatures were pulled into phase, and they ran perfectly in parallel, so that no mechanical gearing was necessary. Wilde had thus discovered that alternators can run in parallel when synchronous. The full importance of this was not realised until electrical engineering was more developed. Subsequently, John Hopkinson showed that it was mathematically possible; and now the parallel running of alternators is in everyday use at supply stations.

With the threefold object of obtaining a generator that would heat less, that could be driven at a lower speed, and in which the pulsations of the rectified current would not be so marked, Wilde designed and constructed electro-magnetic machines of a type entirely different from those previously described. The details are given in a paper read before this Society in 1873. The shuttle-wound type of armature was abandoned, and he used one with 16 cylindrical bar magnets. The originator of this type of armature is claimed for King in 1846. *Fig.* 3 shows the details of the machine. To each of the circular frames of cast iron are fixed 16 electro-magnets. They are wound with insulated copper wire and are joined up so that in the two circles the adjacent poles and those opposite are of different polarity. The armature bobbins are fixed on a heavy disc of cast iron. Four of the bobbins are connected to a commutator; the alternating
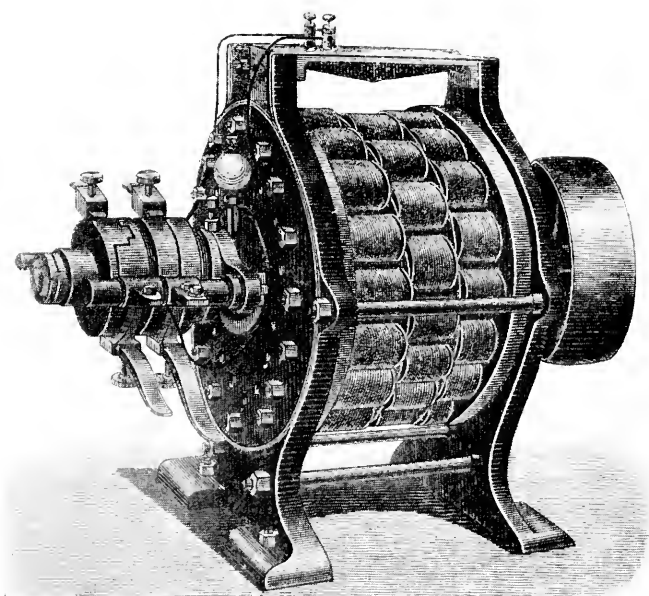
Fig. 3.

Wilde's second type of Dynamo.

current is there rectified and furnishes an exciting or *minor* current for the electro-magnets. The remainder of the armature bobbins supply an alternating current that is collected by the brushes on the slip-rings. This *major* current may, if desired, be rectified by replacing the rings by a second commutator. When driven at 500 revolutions per minute the machine melted 8 feet of iron wire 0·065 in. in diameter or ran two arc lamps in series. At 1,000 revolutions per minute 12 feet of iron wire 0·075 in. diameter could be fused. A comparison between the power of the new machine and that of the 10 in. old type showed that it was capable of giving a double amount of power with less than one-fourth of the weight of materials necessary to construct the 10 in. machine.

Henry Wilde had thus produced two commercial types of generator, which could be used to replace the primary batteries used in electro-chemistry, and for arc lighting.

Between 1866 and 1877 he sold machines for the following purposes :—

	No. of Machines.
Electric light for lighthouses and searchlights	8
Electric light for photographic purposes	1
Electro-deposition of metals	94
Electrical bleaching of sugar and of linen	2
	105

Electro-Chemical Work.

The great demand for machines for electro-chemical purposes revived Wilde's interest in these applications of electricity, and he commenced experiments in his works. In 1871 he secured a patent for the coppering of iron tubes so that they were protected against corrosion; and the firm did a considerable business in supplying coppered tubes. In six years (1871-1877), 25,726 iron tubes and 1,521 steel " doctors " were coppered.

In 1875 Wilde secured a patent of very considerable importance. which became very remunerative. It was for the purpose of making the rollers used in calico printing. An iron roller is first coated with a thin layer of copper in a hot cyanide bath, and afterwards is mounted so as to be capable of being revolved vertically in a solution of copper sulphate. This enabled a much higher current density to be used and the rate of deposition to be greatly increased; and yet a very good quality of copper could be obtained, which was of even thickness. The specification also included a screw propeller for keeping the electrolyte at a uniform density. The patent was applied in a number of works, and was ultimately sold to the Broughton Copper Company Limited in 1880, who extended its use for the coating of hydraulic rams, etc. Two years previously, Henry Wilde had entered into an agreement with Sir Joseph C. Lee of Manchester for the use of the patent process of coppering.

After the Broughton Copper Company had taken over the patents, it was alleged that Sir Joseph Lee had infringed these patents. This led to a costly legal action, in which the defendant was defeated.

Dr. Wilde's association with the Elkingtons led to an important use of his machines. Richard Elkington may be regarded as the founder of the electro-plating industry in England. He and his cousin Henry opened a large electro-plating works in Birmingham in 1841. They soon realised that dynamos must be substituted for primary cells, and they tried the primitive machines then available. In 1865 G. R. Elkington, junior, patented a process for the electrolytic refining of copper, which is identical in principle with that used at the present day. He adopted the use of Wilde's machines, and his firm paid a royalty of £300 per annum for a number of years to Messrs. Wilde & Co. Messrs. Elliott of Pembrey, near Swansea, who took over the refining process from the Elkingtons, also used Wilde's machines. One of these was capable of giving 900 lbs. of copper in 24 hours. As the electrolytic refining process extended, Wilde obtained other users of his machines abroad. These included the Mansfield Mining Company of Eisleben and Messrs. Stern of Oker.

Extension of Patents. Litigation.

In 1877 Henry Wilde petitioned the Privy Council to extend his dynamo patents of 1863 and 1865. He had the advantage of the evidence of the eminent engineer, F. J. Bramwell, who made the claims of the patentee very clear. The result of the petition was that the patents were extended until 1884.

When the Gramme dynamo was introduced into this country, Wilde brought an action against the British agents for infringement of his patent. The agents obtained the opinions of F. H. Holmes, who for twenty-five years had been engaged in designing and constructing dynamos, S. A. Varley, one of the first to use residual magnetism for the excitation of electro-magnets, and Fontaine and Werdemann, well-known inventors. Their evidence was so strong, and threw so much doubt on the priority of Wilde's inventions, that Wilde found it advisable to withdraw his action.

Henry Wilde's fondness for litigation grew with his years, and in 1902 he brought a regrettable action against the late Professor S. P. Thompson and the printers and publishers of Thompson's standard treatise on " Dynamo-electric Machinery." The plaintiff claimed an injunction to restrain the defendants from asserting that Henry Wilde " is not the inventor of the generator of dynamic electricity known as the Dynamo or attributing such invention to any person or persons other than the Plaintiff," and claimed damages and costs. The report of

the action will be found in *The Electrician*, vol. 50, 1902-3. It was brought before Mr. Justice Buckley in the Chancery Division of the High Court of Justice, who ordered that the statement of claim be struck out on the ground that it disclosed no reasonable basis of action. The action was dismissed with costs against the plaintiff. Against this decision Henry Wilde appealed, but without success.

Electric Searchlights.

One of the applications of Wilde's machines already mentioned was for the purpose of providing electrical energy for arc lamps. The first idea was to use arc lamps in lighthouses; but when the buildings were isolated there was difficulty in providing motive power for the dynamos. Wilde supplied a machine to the Commissioners of Northern Lighthouses for the purpose in 1866, and in the following year one to the United States Lighthouse Board. In 1873 Wilde directed the attention of the Admiralty to the advantages of electric searchlights for naval purposes. Experiments were made at Spithead, extending over a year. They were especially arranged so as to ascertain whether the searchlight would be a useful protection against torpedo boats. The experiments were so successful that three warships, the Minotaur, the Alexandra and the Temeraire were fitted with Wilde's apparatus. The report of Admiral Sir Beauchamp Seymour stated that the searchlights were of very great value for navigation, signalling, and general naval manoeuvres. Wilde also introduced his inventions to the Mercantile Marine service, but the Admiralty claimed the exclusive use of the lights. After the loss of the Titanic, Dr. Wilde communicated two papers to the Society: "On Searchlights for the Mercantile Marine," and "On Searchlights and the Titanic disaster," in which he strongly urged the compulsory international use of searchlights at sea.

Aerodynamics and Aviation.

The tenth volume of the third series of the Memoirs of the Manchester Literary and Philosophical Society is of special interest in connection with the activities of Wilde in 1887. It contains five papers by him, two of which relate to the efflux of air through orifices. The first paper attracted the attention of Osborne Reynolds, who in the same volume has an article "On the Flow of Gases," in which he gives a theoretical explanation of the experiments of Wilde.

The experiments mentioned above were really the sequel of a number that he had begun as early as 1860, with the view of finding some means of solving the problem of aerial flight. Numerous trials were made on the discharge of steam and of air at pressures from 10 lbs. to 120 lbs. per square inch directly into the atmosphere from orifices of various forms. He also experimented on the reactive force produced by the explosion of a mixture of coal gas and air contained in a cylinder of steel.

The result of his many tests made with a view to the possibilities of aviation showed that the solution of the problem was not to be found in the discharge of gases through orifices. He then turned his attention to screw propellers, and used vanes from 1 to 4 feet in diameter, driven at velocities up to 2,000 revolutions per minute, but the results were not sufficiently encouraging to him. He remarked: "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."

Magnetic Researches.

On the expiration of the patents relating to the dynamo in 1884, Dr. Wilde retired from business. He was then fifty-one years of age, and vigorous; and he decided to devote his time to scientific research. During twelve years (1885-1897) his experimental work chiefly related to magnetism.

He was a great student of the works of the early investigators in the subject of terrestrial magnetism, and was especially attracted to the theory of Halley, the astronomer and contemporary of Newton, that the variation of the magnetic compass could be explained by the rotation within the earth of magnetic matter. This led him to design an apparatus that he called a " Magnetarium." It consisted of two concentric spheres, as shown in *Fig.* 4 (one half of the outer sphere being removed to show the inner). The inner sphere, which is 16 ins. in diameter, is wound over its whole surface with insulated copper wire. The outer sphere, two inches greater in diameter than the inner one, has its inner surface covered with iron wire gauze, over which is wound a magnetising coil. The spheres were mounted on axles as shown, and they could be revolved at different rates of speed by turning the handle, which operated gearing. The axles are supported on a semi-circular brass meridian mounted between rollers fixed to a vertical support. All observations of dip and variation were made by bringing the station under test beneath an upper small circular table on which a dip needle or declination compass can be placed. The magnetising coils were connected in parallel to a small magneto, and by variable resistances the currents in the two circuits could be adjusted. In order to represent more accurately the distribution of the earth's magnetism, it was found necessary to cover the spaces representing the oceans with thin sheets of iron and to fix the inner globe at an inclination of $23\frac{1}{2}$ degrees to the axis of the terrestrial sphere. The train of wheels was so arranged that the internal sphere lost 12′ for each revolution of the terrestrial globe, and this was taken as equivalent to 32 years. It was found possible by this magnetarium to represent fairly well the distribution of magnetism in time and place.

Fig. 4.
The Magnetarium.

The influence of temperature upon the magnetic properties of iron, nickel, and cobalt was studied with the help of a specially designed magnetometer, which is in the possession of the Society.

Wilde was interested in finding the limit of magnetisation as tested by the method of traction, and obtained the value of 29·67 kilos per square centimetre.

Wilde's Use of Bode's Law.

The German astronomer, J. E. Bode (1747-1826) directed attention about 1776 to a remarkable empirical rule, now generally known as Bode's Law. The rule states that the relative values of the series of numbers :—

$$0 + 4 = 4$$
$$3 + 4 = 7$$
$$6 + 4 = 10$$
$$12 + 4 = 16$$
$$24 + 4 = 28 \text{ etc.}$$

are the same as the relative distances of the planets from the sun.

Henry Wilde contended, in a paper before the Society about forty years ago, that a law of a similar kind should apply to the atomic weights. This early paper was followed at various times by twelve others; in that of 1913 he gave a revised table including all the more recently discovered elements, for which he found places in his table.

Tenacity of purpose was one of the most marked traits in Wilde's character. It is exhibited in an extraordinary degree in his obsession over Bode's Law. He regarded it as a great fundamental law of the universe, and devoted several of his astronomical papers to its advocacy. The last of all his papers, published by the Society when he was eighty-three, relates to the atomic weight of tellurium; in it he maintains that the atomic weight of this element must be exactly 128, as required by his tables.

Henry Wilde and The Literary & Philosophical Society.

Wilde was elected a member in 1859 when twenty-six years of age; and in the following year he gave a short communication relating to the ABC telegraph of Sir Charles Wheatstone. It was not until his retirement from business in 1884 that he became actively associated with the Society. His means had become ample, chiefly owing to the success of his electro-chemical patents. When Sir Henry Roscoe and other members of the Society wished to raise a sum of money for the extension and improvement of the house, Wilde contributed £100 and in the following year £400 for this purpose. He then undertook the cost of putting the old portion of the building into sound repair, and added a new portico and a storeroom. All the work was done under his direction, at a cost of £1,500. In 1893 he wrote a letter to the Council in which he said: "As the Society is so

closely identified with the history of the method of generating
electricity . . . I shall be pleased to defray the cost of wiring
up and supplying the necessary fittings in the parts of the house
where gas can be replaced with advantage by the electric light."
This was followed by other gifts. For two years (1894-1896) he
was President of the Society. During this period " with the
object of maintaining the high character which the Society has
so long held in the estimation of the scientific world and to
increase still further its means of usefulness," he had decided
to endow the Society with £8,000 to be devoted to the following
and other purposes:—(1) to provide the salary of an assistant
secretary and librarian; (2) to award a gold medal, a premium,
and to provide an honorarium for a yearly lecture; (3) to com-
pensate for the loss of income due to the abolition of an entrance
fee; and (4) to remit half or the whole amount of the subscrip-
tions of fifteen members.*

In 1902 he gave the Wilde lecture " On the Evolution of the
Mental Faculties in relation to some Fundamental Principles of
Motion."

Benefactions and Gifts.

In addition to Dr. Wilde's liberality to the Society, and in accor-
dance with his resolve to dispose of the greater part of his
capital during his life-time, he made important benefactions to
other institutions. To the Paris Académie des Sciences in 1897 he
gave £5,500, the annual interest of which was to be applied as
a prize for the author of a discovery or work in Astronomy,
Physics, Chemistry, Mineralogy, Geology or Mechanics. The
prize was to be international and retrospective. In 1900 he con-
tributed £1,500 to the Benevolent Fund of the Institution of
Electrical Engineers. The University of Oxford has most of all
been favoured. In 1898 Wilde gave £10,000 to the University
to institute a Readership in Mental Philosophy, and a further
sum of £3,000 to establish a scholarship to be called the John
Locke Scholarship for Mental Philosophy. In 1908 Wilde
founded a Lectureship in Natural and Comparative Religion, the
endowment being £4,000. In the following year he provided £600
for the purpose of founding an annual lecture on Astronomy and
Terrestrial Magnetism, in honour and memory of Edmund Halley,
sometime Professor of Geometry and Astronomer Royal. By his
will Henry Wilde bequeathed the residue of his estate, after some
bequests, to the University of Oxford: the sum amounted to
about £10,000.

The full extent of his benefactions and gifts cannot be com-
pletely recorded. He presented to the Science Museum, South
Kensington, a magnetarium, a separately-excited and a multipolar
dynamo, and a set of ABC instruments. To Oxford Uni-
versity were given a Crossley gas engine, a Wilde's early type
dynamo, and two multipolar machines and other electrical

---

* Some of these conditions are not now in operation.

apparatus. Owens College received the gift of a set of Wilde's machines; and the Manchester Grammar School was also provided with two dynamos.

Personnel of the Works.

Henry Wilde's association with Mr. G. C. Lowe, Silversmith, Jeweller, Chronometer and Watch Maker, and Electroplater, of St. Ann's Square, Manchester, has already been mentioned.   It was the capital furnished by Mr. Lowe that enabled the firm of Henry Wilde & Co. to be founded, with works at 37, Mill Street, Ancoats, Here the ABC instruments were made.   They needed careful and accurate construction with small tools; the manufacture of the dynamos required much larger plant. After the death of Mr. Lowe, Wilde continued the business without a partner.   He was faithfully assisted by his younger brother, Joseph.   An agreement was made between the brothers whereby Joseph received a salary and a commission.   Joseph, unlike his brother, was not robust, and he died at a relatively early age.   He was well known in Sale, where he lived, as a reserved and intelligent man.   An adopted nephew of Joseph's, W. F. Hobday, acted as bookkeeper to the firm.   Another assistant was Robert Marsh.   He served the firm for a long term of years, and became well-known in connection with the installation of the dynamos and with general experimental work.   On Henry's retirement, Joseph went into partnership with John Hill, who was the works manager, and the Electric Engineering Company was formed; but this partnership was dissolved in 1884.

Honours.

In 1886 Henry Wilde was elected to a Fellowship of the Royal Society of London; and in 1900 the degree of D.Sc. of the Victoria University was conferred upon him.   Three years later he received from Oxford University the D C.L.   In 1885 he was awarded by the Council of the International Exhibition held in London a gold medal for his inventions.   The medal of the Royal Society of Arts and the Dalton medal of this Society he refused to accept, because he did not agree with the reasons given for these honours.

Photograph.

Wilde had a strong objection to being photographed; but his personal friend Mr. Alfred Brothers, one of the best-known of the early photographers, overcame this objection. From the negative some prints were known to exist : one was the property of Joseph Wilde, and it passed into the possession of Mr. J. W. Winstanley of Sale, who has kindly allowed this to be reproduced.   Another one was given by Henry Wilde to Professor H. B. Dixon, who has presented it to the Society.   The photograph is of Wilde when he was about fifty-six.

Conclusion.

Henry Wilde's many inventions establish his position as a pioneer in Electrical Engineering; but it is not easy to give a just estimation of his scientific work. It must be remembered that he was a self-educated man. He was a great student of the earlier writers on science and philosophy, and his papers are full of quotations from them. He never realised the great advances that were being made in electrical science and the application of the laws of energy. Had his mental disposition been such as to tolerate guidance, his later work would have been of greater value, and he would have been saved from regarding as paradoxes experimental facts that could easily be explained. Although he cannot rank with Dalton and Joule, yet in the history of the affairs of the Society he held a unique position, and his benevolence at a critical time must ever be remembered.

Henry Wilde married Miss Lowe, the sister of his partner. She died about eighteen years ago, and there were no children. Henry died on March 28th, 1919, at the age of eighty-six, at The Hurst, Alderley Edge. He and his wife are buried at Bunbury in Cheshire.

APPENDIX A.

Galvanometer used by Wilde.

The tangent and sine galvanometer used by Wilde in his experiments with his magnetos, which is in the possession of the Society, is a fine instrument of brass as designed by Pouillet. It was made by Ruhmkorff of Paris. It has a compass box of $6\frac{1}{2}$ ins. diameter and a brass hoop $12\frac{1}{2}$ ins. in diameter. As a sine galvanometer, its readings can be taken to 2 minutes by a vernier; as a tangent galvanometer, tenths of a degree can be estimated. There are two coils, each of 0·15 ohm. When in series, the constant as a tangent instruments in the field of the earth has been determined for me by Dr. A. Ferguson to be about 0·13. Assuming that Wilde used the two coils in series, the maximum current obtained from his magneto when the four magnets were in place was only about one-fifth of an ampere.

APPENDIX B.

Details of Wilde's Early Machines.

(A) *Magneto-Electric Machine (No 2).* Bore of cylinder, $2\frac{1}{2}$ ins.; length; 12 ins. Armature wound with 67 feet of insulated wire 0·15 in. diameter. This gives an armature resistance of about 0·027 ohm. The field consisted of 16 magnets 12 ins. long, each 3 lbs. in weight and capable of supporting 20 lbs.

(B) *Electro-Magnetic Machine (No. 1).* Bore and length of magnet cylinder as in (A). Magnet limbs of boiler plate $12\frac{1}{2} \times 9 \times 3\frac{1}{8}$ in. Wound with 700 feet of insulated copper wire 0·15 in. diameter. (R = 0·28 ohm.).

(C) *Electro-Magnetic Machine (No. 2).* Bore and length of magnet cylinder double that of (B), namely 5 ins. and 25 ins. respectively. Magnet wound with 1.170 feet of wire weighing 390 lbs. Armature with 84 feet of wire weighing 28 lbs.

(D) *Electro-Magnetic Machine (No. 3).* Dimensions of bore and length of magnet cylinder double those of (C). Each limb of the electro-magnet was of rolled iron $48 \times 39 \times 1\frac{1}{2}$ ins. Weight of electro-magnet exclusive

of magnet cylinder, 1·5 tons. The magnet was wound with 13 wires of 1/8 in. diameter in parallel. Total length of multiple cable 4,800 feet. Total weight of coils 1·3 tons. Weight of magnet cylinder 1·1 tons. Two armatures were provided, which were interchangeable:—

(1.) "Intensity" Armature, wound with 376 feet of 13 wires of ⅛ in. diameter in parallel. Total weight of wire, 232 lbs. Armature weight, 0·3 ton.

(2.) "Quantity" armature, wound with 67 feet of copper plate, each 6 ins. wide, 4 plates in parallel. Weight of copper, 344 lbs. Total weight of armature, 0·35 ton.

The total weight of the dynamo was 45 tons. It was 80 ins. long, 2 feet wide, and 5 feet high.

Wilde tested his machines by the length of iron wire of stated thickness that could be heated to redness or the thickness that could be melted. The following values of voltages, current, and output have been deduced by Mr. A. Adamson for me from Wilde's experiments:—

(A) 3 ins. of iron 0·04 in. diameter heated to redness. Machine at 2,500 revolutions per minute. 15 amperes, 1·7 volts, 25·5 watts.

(B) 24 ins. of iron 0·04 in. diameter heated to redness. Excited by (A), both 2,500 r.p.m. 15 amperes, 13·6 volts, 204 watts. Excited by (A), both at 2,000 r.p.m. 8 ins. of wire of 0·04 in. melted. 30 amperes, total e.m.f. 20·5 volts.

(C) 15 ins. of iron of 0·075 in. melted by estimated current of 64·7 amperes.

(D) Armature at 1,500 r.p.m. No. 1 magneto with six magnets used to excite (C), and the current from (C) excited (D).

Quantity armature:—
 15 ins. iron 1/4 in. melted; 390 amperes.
 15 ins. copper 1/8 in. melted; 450 amperes.

Intensity armature:—
 21 ft. wire 0·065 in. heated to redness.
 29 amperes, 105 volts, 3,045 watts, 4·1 horse-power.
 7 feet iron 0·065 in. melted; 52 amperes, 143 volts.

APPENDIX C.

List of the Chief Publications of Henry Wilde.

" On some new and paradoxical Phenomena in Electro-magnetic Induction, and on a new and powerful Generator of Dynamic Electricity (The Dynamo-electric Machine)." *Roy. Soc., Proc.*, 1886. *Phil. Mag.*, 1867. *Phil. Trans.*, 1867.

" On the Electric Condition of the Terrestrial Globe, and on the Absolute Character of the Law of Definite Electrolysis." *Phil. Mag.*, 1868.

" On a Property of the Magneto-electric Current to Control and render Synchronous the Rotations of the Armatures of a number of Electromagnetic Induction (Dynamo) Machines." *Phil. Mag.*, 1869. *Memoirs,** vol. 30, 1887.

" On the Influence of Gas- and Water-Pipes in determining the Direction of a Discharge of Lightning." *Phil. Mag.*, 1872.

" On the Origin of Elementary Substances, and on some new Relations of their Atomic Weights." *Manchester Proc.*, vol. 17, 1878. *Memoirs*, vol. 30, 1878.

" On some Improvements in Electro-magnetic (Dynamo) Machines." *Phil. Mag.*, vol. 45, June. 1873.

" On the Velocity with which Air rushes into a Vacuum, and on some Phenomena attending the Discharge of Atmospheres of Higher Density into Atmospheres of Lower Density." *Memoirs*, vol. 30, 1885. *Phil. Mag.*, 1886.

" On the Efflux of Air as modified by the Form of the Discharging Orifice." *Phil. Mag.*, 1886. *Memoirs*, vol. 30, 1886.

" On the Causes of the Phenomena of Terrestrial Magnetism, and on some Electro-mechanism for exhibiting the Secular Changes in his horizontal and vertical Components." *Roy. Soc. Proc.*, 19 June, 1890. (*Complete paper was privately printed.*)

" On the unsymmetrical Distribution of Terrestrial Magnetism." *Roy. Soc. Proc.*, 22 January, 1891.

" On the Influence of Temperature upon the Magnetisation of Iron and other Magnetic Substances." *Roy. Soc. Proc.*, 11 June, 1891.

" On the Influence of the Configuration and Direction of Coast Lines upon the Rate and Range of the Secular Magnetic Declination." *Memoirs*, vol. 38, 1894.

" On the Relations of the Secular Variation of the Magnetic Declination and Inclination at London, Cape of Good Hope, St. Helena, and Ascension Island, as exhibited on the Magnetarium." *Roy. Soc. Proc.*, 1 March, 1894.

" On a Magnetometer for showing the Influence of Temperature on the Magnetisation of Iron and other Magnetic Substances." *Memoirs*, vol. 39, 1895.

" On the Multiple Proportion of the Atomic Weights of Elementary Substances in relation to the Unit of Hydrogen." *Memoirs*, vol. 39, 1895.

" On the Evidence Afforded by Bode's Law of a permanent Contraction of the *Radii Vectores* of the Planetary Orbits." *Memoirs*, vol. 39, 1895.

" On Helium and its Place in the Classification of Elementary Substances." *Memoirs*, vol. 40, 1896. *Phil. Mag.*, November, 1895.

" On the indefinite quantative Relations of the Physical and Chemical Forces." *Memoirs*, vol. 40, 1896.

" On the Spectrum of Thallium and its Relation to the Homologous Spectra of Indium and Gallium." *Roy. Soc. Proc.*, vol. 43, 20 April, 1893.

" On Aerial Locomotion." *Memoirs*, vol. 44, 1900.

" On the Evolution of the Mental Faculties in relation to some fundamental Principles of Motion (the Wilde Lecture)." *Memoirs*, vol. 46, 1902.

" On the Atomic Weight of Radium and other Elementary Substances." *Phil. Mag.*, November, 1895.

" On the Atomic Weights and Classification of the Elementary Gases, Neon, Argon, Krypton, and Xenon." *Memoirs*, vol. 46, 1902.

" On the Resolution of Elementary Substances into their Ultimates and on the Spontaneous Molecular Activity of Radium." *Memoirs*, vol. 48, 1903.

" On some Points of Chemical Philosophy involved in the Discovery of Radium and the Properties of its Combinations." *Memoirs*, vol. 51, 1907.

" On the Atomic Weight of Radium." *Memoirs*, vol. 52, 1907.

" On the Moving Force of Terrestrial and Celestial Bodies in relation to the Attraction of Gravitation." *Memoirs*, vol. 53, 1909. *Phil. Mag.*, October, 1909.

" On a new Binary Progression of the Planetary Distances, and on the Mutability of the Solar System." *Memoirs*, vol. 54, 1909. *Phil. Mag.*, April, 1910.

" On Celestial Ejectamenta: The first Halley Lecture, delivered before the University of Oxford in May, 1910." Clarendon Press, Oxford, 1910.

" On the Origin of Cometary Bodies and Saturn's Rings." *Memoirs*, vol. 55, 1910. *Phil. Mag.*, November, 1911.

" On the Periodic Times of Saturn's Rings." *Memoirs*, vol. 55, 1911. *Phil. Mag.*, November, 1911.

" On Search Lights for the Mercantile Marine." *Memoirs*, vol. 56, 1912.

" On Search Lights and the ' Titanic ' Disaster." *Memoirs*, vol. 57, 1913.

" On some new multiple Relations of the Atomic Weights of Elementary Substances; and on the Classification and Transformations of Neon and Helium." *Memoirs*, vol. 57, 1913. *Phil. Mag.*, October, 1913

---

* The word " *Memoirs* " refers to those of the Manchester Literary and Philosophical Society.

"An Egyptian Meteorite." *Memoirs*, vol. 61, 1017.
"On the Atomic Weight of Tellurium in relation to the Multiple Propor-
tions of the Atomic Weights of other simple bodies." *Memoirs*, vol.
61, 1917.

APPENDIX D.

Henry Wilde's Chief Patents.

1858.

293   Connecting the ends of lightning conductors and submarine telegraph
cables.

1861.

858   Electro-magnetic telegraphs, etc.
1994 Electro-magnetic telegraphs, etc.
      Specifies several types of generators.
2997 Magneto-electric telegraphs.
      The momentary currents may be used for telegraphing through
      uninsulated cables.

1862.

3246 Electro-magnetic telegraphs, etc.
      Overhead wires are made by twisting several fine copper wires
      round a core of steel. To prevent the singing of the wires,
      they are connected to their supports by thongs of leather, etc.,
      in such a way that the thong is maintained at the same tension
      as the line.

1863.

516   Electro-magnetic telegraphs.
      Describes a magneto with shuttle-wound armature. The poles
      of the U-shaped permanent magnets are uppermost. The
      alternating currents are produced with too great rapidity for use
      in telegraph lines, so they are turned in one direction by a com-
      mutator and then reversed by a more slowly revolving commu-
      tator before they are sent to the step-by-step telegraph instru-
      ments.

3006 Electric telegraphs.
      Iron wires are varnished and placed within iron pipes. The
      wire are supported and separated by perforated earthenware
      cylinders. Special insulated joints are provided. To prevent
      the pipes from being flooded, they are laid on an incline and
      drained by syphons. Junction boxes are provided where neces-
      sary.
      The generator of No. 516 (1863) is used for signalling
      through uninsulated submarine conductors. Electro-magnets
      may be used in place of the permanent magnets and excited by
      a voltaic battery or a small magneto. The generators may be
      used for producing the electric light, etc.

1200 &
2764 Electric telegraphs.

1865.

1412 Producing and applying electricity, etc.
      The current may be used to produce the heat necessary for the
      working of metals, by connecting the terminals to the insulated
      rolls between which the bar or plate to be heated passes.
      The machines may be used to prevent the fouling of ships'
      bottoms, a current being passed down the copper, etc., bottom
      of the ship through water to insulated metal in the water
2762 Electric telegraphs.
      Generator armature of cast iron with a slot extending through
      it for three-quarters of its length for the prevention of eddy-
      currents. Wound with ribbon sheet copper and sheet gutta-
      percha, and surrounded with strong bands.

1866.

3209   Electro-magnetic and magneto-electric machines.
        Relates to the new generator with a multipolar armature.   A
        special type of commutator is described.

1867.

842   Arc Lamps.

1871.

1511   Coating of iron with copper.

1873.

618   Producing and regulating electric light.   Improvements on No. 842
        (1867).

        Arc Lamp. The carbons are made to approach or recede
        from each other by means of a right- and left-handed screw.
        Each screw can be actuated independently. so as to keep a
        fixed focus.

        Holophote. A lens or parabolic reflector is mounted on a
        platform which carries the lamp. The platform may be revolved
        about a vertical spindle by the use of a worm gearing.   The
        platform may be tilted as desired by a hinge and screw.

1874.

1554   Excavating coal. etc.
        Transmission of electric power. A reciprocating electric motor
        is described. which may be used for cutting coal.

1875.

4515   Making printing rollers.

1878.

3250   Producing and regulating electric light.
        Arc Lamp. Two vertical carbons near each other.   One
        carbon holder is pivoted at its lower end. and by an electro-
        magnet the carbons are separated at the top and the arc is
        struck. When current is off an opposing spring brings the tops
        into contact.

5197   Electric light apparatus.
        Improvements in previous patent.

1228   Induction coils.

1880.

5008   Improvements in dynamos.

1882.

2256 &
3834   Arc Lamps.

PROCEEDINGS

OF

THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

General Meeting, October 1st, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Dr. R. S. WILLOWS, M.A., *c/o Messrs. Tootal Broadhurst Lee Co., Ltd., 56, Oxford Street, Manchester*, was elected an Ordinary Member of the Society.

Ordinary Meeting, October 1st, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Mr. C. L. BARNES, M.A., drew attention to the recent accessions to the Society's Library, and a vote of thanks was accorded the donors of the books upon the table. The following were amongst the recent accessions to the Society's Library :— " *Selections from the Prose, Verse and Sketches of the late Thomas Kay, of Stockport* " (8vo., Stockport, 1918), presented by the Trustees of Thomas Kay ; " *Decennial Index to Chemical Abstracts—Authors, L-Z* (8vo., Easton, Pa., 1918), purchased ; and " *A Bibliography of Fishes*," Vol. I., by Basford Dean, enlarged and edited by Charles R. Eastman (8vo., New York, 1917), presented by the Trustees of The American Museum of Natural History.

Mr. C. L. BARNES, M.A., brought to the notice of Members a number of copies of " *The Ladies' Diary* " and " *The Gentlemen's Diary*" for 1794 and later years. These diaries, in the Society's possession, contain answers to mathematical questions written by Dalton whilst a teacher at Kendal.

Professor F. E. WEISS, D.Sc., F.R.S., drew attention to a paper read by Dr. Thomas Percival before the Society on February 18th, 1784, and published in Volume II. of the *Memoirs* (p. 114).

In this paper, entitled **"Speculations on the Perceptive Power of Vegetables,"** Dr. Percival attempted to show by several analogies of organisation, life, instinct, spontaneity and self-motion, that plants, like animals, are endued with the powers both of perception and enjoyment. This paper attracted considerable attention both in England and abroad and a free translation of it, accompanied by comments by an anonymous writer, was published in Franfurt in 1790 under the title :—"*Also hätten Pflanzen Vorstellungen und Bewusstsein ihrer Existenz.*" A copy of this translation is in the Library of the University of Manchester.

Professor Weiss gave a brief account of our present knowledge of some of the phenomena described by Dr. Percival and pointed out that the analogies between the perceptive powers of plants and animals indicated by Dr. Percival could be still further extended at the present time.

General Meeting, October 15th, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Mr. EDWARD ADOLPH EASON, *Stoneleigh*, *Sale*, and Mr. HERMANN WOOLLEY, *Victoria Bridge*, *Manchester*, were elected Ordinary Members of the Society.

Ordinary Meeting, October 15th, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

A vote of thanks was passed by Mr. P. E. B. Jourdain for the gift to the Society of a large medallion of Dalton, formerly in the possession of his grandfather, Dr. Charles Clay, who was elected a member of the Society in 1841. The medallion was exhibited at the meeting.

Mr. J. WILFRID JACKSON, F.G.S., exhibited a beautiful example of a leaf-shaped bronze sword lent by Mr. W. J. Millner, the owner, through the kindness of Mr. H. P. Hornby. The sword was unearthed by the plough in April, 1917, on Copthorne Farm, Pilling, Lancs. It is $27\frac{1}{2}$ inches long and the flanged hilt-plate has twelve rivet holes, six down the centre, and three in each of the wings; **five of**

the rivets are still in position. The blade has a well-marked mid-rib and is ornamented on both faces by twelve finely engraved lines in two series of six, running the entire length of the blade on each side of the mid-rib.

Mr. Jackson also reported the discovery of quartz-pebble beds in the Carboniferous Limestone of Caldon Low, Staffs. These pebble beds form the dip slope of the Low on its N.N.W. side, overlooking Cauldon village. At the latter place, a large series of fossils, reminiscent of the " Brachiopod Beds," of Castleton, etc., has been obtained by Mr. W. E. Alkins. The beds here apparently follow the pebble-beds in true sequence. Specimens of the quartz-pebble beds from Caldon Low and of the pebble-bed present in the Castleton district were exhibited, and the relation of the latter to the local "Brachiopod Beds " was pointed out. The two pebble-beds differ greatly in composition, that of Caldon Low being made up almost entirely of rounded pebbles of veinstone-quartz with fragments of chert, while that of Castleton consists of carboniferous limestone pebbles. Quartz-pebbles are said to occur occasionally in the latter.

Dr. H. G. A. HICKLING, F.G.S., drew attention to some of the more recent geodetic work in relation to the figure of the earth, more especially as bearing on the problem of isostasy. Some of the chief criticisms were considered in the light of the geological evidence as to movements of the earth's crust.

General Meeting, October 29th, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Miss ANNIE DIXON, *Broadwater, 43, Pine Road, Didsbury, Manchester*, was elected an Ordinary Member of the Society.

Ordinary Meeting, October 29th, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

A vote of thanks was accorded to Mr. C. E. Stromeyer, M.Inst. C.E., for the gift of his book, entitled " *Unity in Nature —an Analogy between Music and Life* " (8vo., London, 1911).

Professor C. A. Edwards, D.Sc., read a paper entitled
" The Hardness of Metals."

The author gave an account of various methods of
making hardness determinations, and described a new
apparatus which was designed for making hardness tests at
high temperatures. He also gave data showing that the
hardness of pure solid elements is a periodic function of
their atomic weight.

Ordinary Meeting, November 12th, 1918.

The President, Mr. William Thomson, F.R.S.E., F.I.C., F.C.S.
in the Chair.

Professor G. Elliot Smith, M.A., M.D., F.R.S., conveyed
to the Society his regret, that owing to illness, he was unable to
be present to read his paper entitled **" The Retention of
certain so-called Simian Features in the Human
Brain."**

The human brain retains in a definite and unmistakable
form every feature which has hitherto been claimed to be
distinctive of apes. Not only so, but it retains the
specialised forms of these features that are distinctive of
the Anthropoid Apes, reproducing even quite trivial and
apparently unessential details of the arrangements revealed
in the brains of Chimpanzees and Gorillas.

Emphasis was laid upon the fact that the retention of a
large operculated *sulcus lunatus* (the so-called simian
sulcus) was not necessarily an indication of defective brain
development. Although such exact reproduction of the
features of the occipital end of the Gorilla's brain is most
often found in the poorly developed cerebrum of the more
primitive peoples, it may persist even in brains of excep-
tional development in European people of high culture.

Captain D. M. S. Watson, R.A.F., spoke on **" Biology and
War."** After referring to the use of much of the theory
of natural selection in the apologies of militarism and
pointing out the confusion always present in the minds of
those who so use it, the speaker referred very briefly to
the various types of evolutionary changes exhibited by
phylitic series of animals known from palæontological evi-
dence, and pointed out that such evidence of this kind
as is available suggests that natural selection has only
played a very limited part in the actual progress which has
occurred in animal structure.

Ordinary Meeting, November 26th, 1918,

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Professor H. LAMB, M.A., D.Sc., F.R.S. read a paper entitled " The Movement of the Eye."

The theory of the movements of the eye, as developed by Helmholtz, includes some results of great interest to mathematicians as well as to physiologists.   Unfortunately they have scarcely become familiar to mathematicians, who have been apt to regard the whole matter as outside their province.   The analytical investigations of Helmholtz are moreover long and intricate, and have doubtless been an obstacle to mathematicians and physiologists alike.

The author had found that with the help of one or two propositions in the theory of rotation, now well known, the whole question can be treated in a simple and purely geometrical manner, without the use of a single mathematical symbol.   The only difficulties which remain are those of ordinary spherical geometry.   These (such as they are) are intrinsic to the nature of the subject, and cannot be avoided.

The paper consisted of an exposition of the subject from the above point of view.   By the aid of diagrams, the classical theorems of Euler and Sir W. Hamilton on rotation were explained, and used to illustrate Listing's law, which governs the positions of the eye ball when the gaze is directed to various parts of the field.

Finally, the apparent distortion of straight lines, and the theory of those lines which are *apparently* straight were considered.   The eye is necessarily imperfect in these respects, and in obeying Listing's law effects a compromise, which is probably the best admissible.

———

Ordinary Meeting, December 10th, 1918.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Mrs. MARGARET WHITE FISHENDEN, M.Sc, (late Beyer Fellow of the Manchester University), read a paper on " The Efficiency of Domestic Fires and the Effects of certain ' Coal Saving ' Preparations."

The experiments included determinations of:

(1) The "radiant efficiency," or the percentage of the total calorific value of the coal burned, which entered the room as radiation.

(2) The distribution of radiation.

(3) The volume of air passing through the room.

(4) The amount of heat passing away above the ceiling level in the hot flue gases.

(5) The heating of the room air.

Three different grates gave radiant efficiencies of 21, $24\frac{1}{2}$, 24% respectively; the radiant efficiency was not dependent upon the draught, even over such wide limits as from one to nine changes of air per hour. The maximum intensity of radiation was found (upwards) at an angle of about 60° to the horizontal through the centre of the fire.

The amount of heat contained in the hot flue gases passing up the flue above the ceiling varied from about 55% of the total calorific value of the fuel burned for draughts of about 20,000 cubic feet per hour (nine changes), to about 15% for one change per hour. The heat used in warming the room air was very small, generally below 10%.

Certain advertised preparations, solutions of which were claimed when previously sprayed upon the coal, greatly to increase the efficiency of fires, had been analysed and found to consist chiefly of common salt. Their use was found to have no effect whatever either upon the radiant efficiency, the duration of burning, or the rise of air temperature produced by coal fires.

Ordinary Meeting, January 7th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Joule Centenary Meeting.

(Dr. James Prescott Joule was born in Salford on the 24th of December, 1818.)

Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S., gave an account of " The Work and Influence of Joule."

At the outset, the lecturer stated that the Society had hoped to secure on this occasion an address from a distinguished member of the Society who had known Joule well, personally. Unfortunately, this had not proved possible, and he had been asked at very short notice to fill the gap. In the short time

available, it was impossible to review the great series of researches made by Joule during his long and busy life but attention would be confined to the first five years (1838-43) of Joule's scientific career which began at the age of nineteen, and an endeavour would be made to trace during this period the gradual growth of Joule's power of experimentation and of philosophic insight. In this, he had been greatly assisted by the able memoir on the work of Joule published by the late Professor Osborne Reynolds in the Memoirs of the Society.

This period was in some respects the most fruitful and inspiring in Joule's lifetime for it included his remarkable researches on the transformations of energy in the voltaic cell, the dynamo and motor and his first measurement of the mechanical equivalent of heat.

A brief account was at first given of Joule's researches to improve the electromagnetic engine for the generation of power and of his investigations in electromagnetism. These investigations had an important bearing on his later work, for his electromagnetic engine, used both as a dynamo and motor, was an indispensable adjunct in his later researches, while the familiarity he had gained in the accurate measurement of the work done by his engine proved later of great value.

At this stage Joule had appreciated the great importance of accurate measurement of his electrical and mechanical magnitudes. He had designed a special galvanometer for measurement of current in terms of the voltameter of Faraday and adopted definite standards of resistance. It was the use of these standards that made possible his later far-reaching deductions.

After completing his work on the electromagnetic engine, Joule attacked the problem of the laws of heating of the electric current and proved for the first time that the heating effect was proportional to the square of the current. In this research, he investigated the heat emission in electrolytes as well as in conductors and this led to a series of researches in which he traced the various factors to be taken into account to evaluate accurately the energy emitted in an electrolytic cell. He then proceeded to determine the total heat emitted by his voltaic battery for the consumption of one pound of zinc and compared it with the heat developed by the combustion of one pound of zinc in oxygen. After surmounting numerous difficulties, he was able to show conclusively the remarkable fact that the chemical heat of combination was equal to the heat developed by the same chemical change through the intermediary of the voltaic battery. At this early stage, he had thus proved the equality and convertibility of chemical, electric and heat energy, and had laid the experimental foundation for the great subsequent generalisation of the conservation of energy.

It is clear, however, that at this time Joule did not appreciate the full significance of his results, but was inclined to consider them as a proof of an electric theory of Davy and Berzelius, viz.: that the chemical heat of combination was a direct consequence of the combination of charged atoms.   It was not until some time later that he modified this view and began to appreciate the underlying relation between these different forms of energy.

Then followed his research to prove the electric current generated by his electromagnetic engine obeyed the same laws of heating as the voltaic current, and his direct measurement of the heating effect produced by the magneto-electric current by the expenditure of a measured amount of work.   This gave him for the first time an approximate measure of J — the mechanical equivalent of heat, and he was able to verify the relations between heat and work when his electromagnetic engine acting either as a dynamo or motor was placed in a battery circuit.

A brief reference was made to his subsequent elaborate investigations to determine the mechanical equivalent of heat by the compression of gases and by friction.

The lecturer drew attention to the remarkable experimental power exhibited by Joule in these early researches, and the refined methods he had introduced for the accurate measurement of current, heat and work.   Few men, at the age of twenty-five, have exhibited such powers of accurate measurement and ability to overcome experimental difficulties, or have shown such a record of masterly pioneer researches.

A brief discussion was given of the reasons why the full recognition of the fundamental importance of Joule's earlier researches was so long delayed and of the difficulties experienced by Lord Kelvin in reconciling Joule's conclusions with the work of Carnot on "Heat Engines."   Adjustment of views on both sides was necessary before the foundations of the new science of thermodynamics were securely laid, and before the great principle of the conservation of energy was generally recognised.

Professor Haldane Gee exhibited and described some of the apparatus used by Joule in his researches.   These included his first electromagnetic machine, parts of his later engines, an electromagnet of great lifting power, a reading microscope used for the calibration of delicate thermometers, and a tangent galvanometer.   Lantern slides of larger pieces of apparatus preserved in Manchester were shown.   Special reference was made to the entries in Joule's laboratory note-books dealing with the discovery of the law of electric heating and the many thousands of measurements connected with the mechanical equivalent of heat.

Included with the manuscripts and other Joule memorials that have been collected is a letter from James Clerk Maxwell expressing the following opinion of the labours of Joule :—" There are only a very few men who have stood in a similar position and who have been urged by the love of some truth, which they were confident was to be found though its form was as yet undefined, to devote themselves to minute observations and patient manual and mental toil in order to bring their thoughts into exact accordance with things as they are."

Ordinary Meeting, January 21st, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

A discussion took place on " **The means by which the Society may promote most effectively the Advancement and Application of Learning in Manchester."**

The PRESIDENT, in introducing the discussion, referred to the great tradition of the Society, and the important part which it had played in the history of Manchester during the past century, and especially to the very notable contributions to scientific knowledge which has been made by some of its members.

Professor F. E. WEISS, D.Sc., F.R.S., in opening the discussion said that the Council had invited a number of representatives of the Industries of Manchester, in addition to those who were members of the Society, in the hope that the Society might have the benefit of their suggestions and criticisms in the effort which it desired to make to enlarge its sphere of public usefulness.   As a member of the University he welcomed the opportunity of expressing the hope that the Society might prove of special value as a meeting ground where the members who occupied more academic positions might have the advantage of discussion with the business people of Manchester.

Among the suggestions put forward by various speakers were the following :—

1. That while the Society should retain its present functions as a learned Society, its members might meet with others interested in the advancement of Science for informal discussion in the rooms of the Society. Such gatherings might be held in the middle of the day or in the evenings, and light refreshments should be obtainable on these occasions.

2. That special lectures, by eminent men, on scientific
subjects of general interest should be arranged from
time to time.

3. That addresses, on the practical applications of
Science, by scientific men engaged in industry should
be invited.

4. That the Presidents of the various scientific societies
in Manchester might be made Associate or Honorary
Members during their periods of office, and that
such societies should be invited from time to time
to hold special meetings of general interest in the
Society's house.

5. That facilities might be arranged for Members to
consult the library in the evenings, and that arrange-
ments might be made whereby members of other
Societies should be able on certain terms to use the
library.

General Meeting, February 4th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S.,
in the Chair.

Mrs. KENNETH LEE, *The Old House, Ashley Heath, Hale,
Cheshire :* and Mr. LEONARD E. VLIES, F.I.C., F.C.S., *Brant-
wood, Wilbraham Road, Manchester, S.W. :* were elected
Ordinary Members of the Society.

Ordinary Meeting, February 4th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S.,
in the Chair.

Mr. C. L. BARNES, M.A. drew the attention of members to
a paper on " Mozart," which appeared in Volume XIII. (1770-
1775) of the Philosophical Transactions of the Royal Society,
published in 1809. This paper, written by the Hon. Daines
Barrington, F.R.S. and entitled "Account of a Very Remarkable
Young Musician," describes several tests through which young
Mozart was put during a visit to England in 1764, when he was
about eight years of age.

The PRESIDENT exhibited a celluloid eyepiece from a German gas mask, the inner surface of which had been treated in such a manner that moisture would not condense on it and thus interfere with vision.

A paper by Mr. R. S. ADAMSON, M.A. and Miss ALISON McK. CRABTREE, entitled **"The Herbarium of John Dalton,"** was read.

This paper is printed in full in the *Memoirs*.

———

Ordinary Meeting, February 18th, 1919.

The President, Mr WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Dr. H. F. COWARD, F.I.C., and Mr. J. WILFRID JACKSON, F.G.S., were nominated Auditors of the Society's Accounts for the Session 1918-1919.

Mr. C. E. STROMEYER, M.Inst. C.E., made a short communication on a captured German gun in which a shell had exploded in the breach, the pressure of the explosion having produced ripple markings on the inner surface of the shell.

The HONORARY SECRETARY read a paper by Dr. H. WILDE, F.R.S., **"On the Mutual Relations of Natural Science and Natural Religion."**

Mr. J. WILFRID JACKSON, F.G.S., read a paper entitled **"'Shell-Pockets' on Sand Dunes on the Wirral Coast, Cheshire."**

The paper consisted of a short account of "Shell-Pockets" in general, and contained remarks on the age of the buried land surfaces in the neighbourhood.

Mr. JACKSON also read a paper entitled : **"On a New Middle Carboniferous Nautiloid** (*Cœlonautilus trapezoidalis.*)**"**

This paper is printed in full in the *Memoirs*.

———

General Meeting, March 4th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Mr. EDWARD HARDCASTLE, *Bramall Mount, Davenport, Stockport;* and Mr. ARTHUR TINDELL HOPWOOD, *9, Stamford Road, Chorlton-cum-Hardy, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, March 4th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S.,
in the Chair.

The PRESIDENT exhibited a model of a Voltaic Pile—to be presented to the Society by Mr. Edward Hardcastle.

A paper by Mr. F. H. CARR, B.Sc., F.I.C. entitled "**The Post-graduate Training of the Works Chemist**," was read.

The author said that the comparative dearth in this country of highly competent technical chemists had frequently given rise to discussions, but these had as a rule been critical rather than constructive. He suggested that there was scope for Institutions devoted primarily to the post-graduate training of chemical students who intended to specialise in the applied aspects of their science. In such institutions, instruction would be given not only on a wide variety of technical processes for the manufacture of chemicals, and in operations in each technical department, from the drawing office and the power house to the special chemical plants, but also in the whole question of economic and statistical control of works processes.

The chemicals produced should cover an extremely wide range, and should be such as might be required in relatively small quantities such as existing manufacturing firms would not find it worth while to produce. In this way the Institutions in question might, in course of time, accumulate stocks of chemicals comparable in variety with those in the possession of certain German firms on whose resources research chemists in all parts of the world have had to rely.

Ordinary Meeting, March 18th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E.. F.I.C., F.C.S.,
in the Chair.

Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., read a paper entitled "**The Bird's Brain**."

Professor G. ELLIOT SMITH stated that it has always been an enigma that, in spite of their very scanty equipment of obvious cerebral cortex, birds should display, in their powers of tactile, visual, and acoustic discrimination, their associative memory, and their ability to learn by individual experience, such outstanding evidence of functions such as are intimately associated in mammals with the activities of the cortex. The explanation of this apparent discrepancy between the morphology of the brain

and the bird's aptitude to profit by experience is provided by the fact that a great part of the structure usually called "corpus striatum" is cortical in origin and in its fibre-connections. The structures called by Edinger "hyperstriatum" (Kappers's "neostriatum") and "epistriatum" (Kappers's "archistriatum") are composed of modified cerebral cortex ; and the former represents not only the neostriatum (nucleus caudatus and putamen) of the mammalian brain, but also the primordial neopallium or true cerebral cortex. The clue to the interpretation of these homologies is provided by the archaic reptilian brain that has survived in *Sphenodon*, in which is displayed with diagrammatic clearness the formation of a great cortical ingrowth into the lateral venticle. The reason for this curious transformation is the expansion of the lateral edge of the pallium under the influence of a suddenly increased influx of sensory fibres (tactile, visual, and acoustic) from the thalamus. In virtue of the principle of neurobiotaxis (Kappers), this cortical overgrowth remains moored as near as possible to the incoming thalamic fibres: hence the development of the "dorsal ventricular ridge" (Johnston). In mammals, the whole of the newly modified cortex does not become drawn into the ventricular ridge : part of it remains upon the surface, free to expand and develop into the neopallium ; the rest becomes transformed into nucleus caudatus, putamen, and nucleus amygdalæ. But in birds the whole mass becomes intraventricular, and represents not merely the neostriatum, but also the rudimentary neopallium.

Mr. T. A. COWARD read a paper by Mr. MILLER CHRISTY, F.L.S., on "**The Ancient Legend as to the Hedgehog carrying Fruit upon its Spines.**"

This paper is printed in full in the *Memoirs*.

March 24th, 1919.

A CONVERSAZIONE was held at the Society's House on the invitation of the President and Council. Cards of invitation were issued to Members and to others not directly connected with the Society.

Sir HENRY A. MIERS, M.A., D.Sc., F.R.S., Vice-Chancellor of the Victoria University of Manchester, gave a DEMONSTRATION of "**Some Features of the Growth of Crystals.**"

THE EXHIBITS included :—" Radio-active minerals, and some of the principal apparatus used in the investigation of Radio-activity," by Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S. ; a "Collection of Dalton Apparatus and Manuscripts," by Professor W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E. ; and "Apparatus used in Psychological Investigations," by Mr. T. H. PEAR, M.A., B.Sc.

Extraordinary General Meeting, April 1st, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

At this Extraordinary General Meeting, summoned in accordance with the Articles of Association, the following resolutions of the Council were submitted to the Society:—

1. "That a new honorary office of Curator be instituted—the holder to be *ex officio* a member of the Council."

2. "That the number of ordinary members of the Council be increased from six to nine."

These resolutions were adopted.

Ordinary Meeting, April 1st, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

Mr. S. LEES, M.A., read a paper entitled **"The Superposing of Two Cross-line Screens at Small Angles and the Patterns obtained thereby."**

This paper is printed in full in the *Memoirs*.

A paper on **"Electrolytic Iron Deposition"** was read by Lieut. W. A. MACFADYEN, M.C., B.A.

The investigations were carried out with a view to finding the best means of obtaining hard and adherent deposits of iron on worn steel mechanism parts, so that the latter could be returned to use, instead of being scrapped.

Deposition from dilute, cold, aqueous solutions of Ferrous Ammonium Sulphate, containing 50 to 100 grams of the salt per litre, gave excellent results, but the process was very slow.

Solutions of intermediate concentrations gave poor results, but concentrated solutions of 300 to 400 grams of the salt per litre, gave results as good as those obtained in the dilute bath, and about 7 times as rapidly. The acidity of the solution should be kept about ·005 Normal with respect to Sulphuric acid; *i.e.*, if concentrated Sulphuric acid of Sp.G. 1·827 be used, as addition, ·1467 cc. per litre of solution must be added. Subsequent additions must be made at intervals, as the acidity diminishes under working conditions.

If the cold, concentrated solution be heated to 60 to 70 degrees Centigrade excellent deposits were obtained at current densities of from 60 to 160 Amperes per sq. ft., *i.e.*, up to 50 times the rate at which deposits can be obtained from the cold dilute solution.

The best acidity for the hot bath is from ·01 to ·02 Normal, obtained by adding up to ·5867 cc. of the strong acid per litre of solution.

The addition of powdered wood charcoal to both hot and cold baths has a good effect on the deposits, in preventing deposition of hydroxides on the cathodes; and on the solution, by largely preventing the oxidation of the iron salt.

Heat treatment of iron deposits on steel bases has a beneficial effect, the deposited iron being toughened and the adhesion greatly strengthened. Annealing at above 900° C. is necessary to produce this effect, and case-hardening and further heat treatment such as quenching and tempering may then be carried out if desired.

Annual General Meeting, April 29th, 1919.

The President, Mr. WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S., in the Chair.

The Annual Report of the Council and the Statement of Accounts were presented, and it was resolved :—

" That the Annual Report together with the Statement of Accounts, be adopted, and that they be printed in the Society's *Proceedings*."

Mr. J. WILFRID JACKSON and Mr. J. H. WOLFENDEN were appointed Scrutineers of the balloting papers.

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

President : G. ELLIOT SMITH, M.A., M.D., F.R.S.

Vice-Presidents : W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E. ; FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.; R. L. TAYLOR, F.C.S., F.I.C. ; WILLIAM THOMSON, F.R.S.E., F.I.C., F.C.S.

Secretaries : GEORGE HICKLING, D.Sc., F.G.S. ; H. F. COWARD, D.Sc., F.I.C.

Treasurer : W. HENRY TODD.

Librarian : C. L. BARNES, M.A.

Curator : W. W. HALDANE GEE, B.Sc., M.Sc.Tech.

Other Members of the Council : FRANCIS NICHOLSON, F.Z.S. E. L. RHEAD, M.Sc.Tech., F.I.C. ; F. E. WEISS, D.Sc., F.R.S., F.L.S. ; A. LAPWORTH, D.Sc., F.R.S., F.I.C. ; KENNETH LEE ; C. E. STROMEYER,, M.Inst.C.E. M.Inst.M.E.; W. M. TATTERSALL, D.Sc. ; H. W. KEARNS, B.Sc., J.P. ; LEONARD E. VLIES, F.I.C. F.C.S.

General Meeting, April 29th, 1919.

The President, Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., in the Chair.

Mr ERIC N. ALLOTT, *Balliol College, Oxford:* Dr. EDWARD ARDERN, F.I.C., Chief Chemist to the Rivers Committee, Manchester Corporation, *Priors Lee, Urmston, near Manchester;* Mr. LIONEL BLUNDELL, Assoc. M.C.T., Aniline Dye Manufacturer, *Hillside, Prestwich Park, Manchester;* Mr. LOUIS ANDERSON FENN, B.Sc., Research Physicist to Messrs. Isaac Braithwaite & Son, Kendal, *Dalton Hall, Victoria Park, Manchester;* Mr. SAMUEL ERNEST MELLING, F.I.C., Public Analyst, County of Chester, Boroughs of Congleton, Wigan, etc., *The Cliff, Higher Broughton, Manchester;* and Professor FRANK LEE PYMAN, D.Sc., Ph.D., Professor of Technological Chemistry, *The College of Technology, Manchester;* were elected Ordinary Members of the Society.

Ordinary Meeting, April 29th, 1919.

The President, Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., in the Chair.

A vote of thanks was accorded the donors of the books upon the table. These included three papers : " *Parallels in Dante and Milton* " (8vo., Manchester, 1917), " *Curiosities in the Divina Commedia* " (8vo., Manchester, 1918), and " *James Joseph Sylvester* " (8vo., Manchester, 1919), by C. L. Barnes, M.A. ; and " *Marine Boiler Management and Construction* " (*5th edit.*), (8vo., London, 1919), by C. E. Stromeyer, M.Inst.C.E.

A paper entitled **"Some Features in the Growth of Crystals"** was read by Sir HENRY A. MIERS, M.A., D.Sc., F.R.S.

The author stated that crystals not only change their form during growth by the development of new faces, but often display a tendency to appear first as needles and then in regular forms, seeming to pass through two stages. Experiments were made by the author many years ago in an attempt to determine the concentration of the solution in contact with a growing crystal, the refractive index being measured by the method of total internal reflection. These experiments led to the conclusion that in a cooling supersaturated solution stirred in an open trough, a sudden change in refractive index takes place at a definite temperature and that this is due to the sudden appearance of new crystals or to the suddenly increased growth of the crystals already present. Enclosed in a sealed tube and shaken, the solution yields a shower of crystals at this temperature alone, although, for example, in the case of sodium nitrate, it is about 10 degrees below that of

saturation.   Further experiments on a large number of aqueous solutions and binary mixtures, such as salol mixed with betol, confirmed the conclusion that a super-saturated solution passes at a definite temperature into a condition (the labile state) in which spontaneous crystallisation can be induced by mechanical means whereas above this temperature (the metastable state) crystals only grow by inoculation of the solution with crystalline germs.

Crystals only appear along the line of scratch made by a *clean* rod in a super-saturated solution if the solution is in the labile state : in the metastable state the crystals only appear if the rod is contaminated with crystal germs.

The complete freezing point diagram of a binary mixture therefore shows " supersolubility curves " or curves of spontaneous crystallisation, in addition to the ordinary freezing point curves and in the area between them the liquid is in the metastable state. Mixtures of Monochloracetic Acid and Naphthalene led to the determination of three supersolubility curves for Monochloracetic Acid corresponding to the spontaneous crystallisation of three different modifications of this substance.

The difference between the rapidly growing needle in the labile solution, and the slowly growing regular crystals when the solution becomes metastable, was illustrated by drops of crystallising solutions (especially potassium bi-chromate) viewed on the screen with a projection microscope.

Extraordinary General Meeting, May 13th, 1919.

The President, Professor G. ELLIOT SMITH, M.A., M.D., F.R.S., in the Chair.

At this Extraodinary General Meeting, summoned in accordance with the Articles of Association, the following resolutions of the Council were submitted to the Society :—

" The Council of the Literary and Philosophical Society welcomes the proposal of the Chemical Club by which the Club expresses its desire to become merged in the Society and cordially approves that proposal."

" To enable the Club to fulfil its present obligations to all its Members up to the close of their present session (March 31st, 1920) the Council would agree to all those Members having the use, during the current year, of the Society's rooms and library on the same terms as its own Members, and would give permission to Members of the Club to attend the Society's meetings, subject to the payment to the

Society of the existing balance of the current annual
Subscription of the Club together with the effects of
the club."

These resolutions were adopted.

While the Council could not at once proceed to the
enlargement of the Society's House it would use its
best efforts to promote such improvements in the
near future.

General Meeting, May 13th, 1919.

The President, Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.,
in the Chair.

Miss FLORENCE SEAFIELD GRANT, M.A., B.Sc., Geography
Specialist, Whalley Range High School, *17, Gardner Road,
Prestwich :* Miss RONA ROBINSON, M.Sc., Research Chemist,
Moseley Villa, Mitford Road, Withington, Manchester ; and Dr.
ALAN FERGUSON, Lecturer in Physics in the College of
Technology, *The College of Technology, Manchester :* were elected
Ordinary Members of the Society.

Ordinary Meeting, May 13th, 1919.

The President, Professor G. ELLIOT SMITH, M.A., M.D., F.R.S.,
in the Chair.

Professor G. Elliot Smith presented to Professor Sir ERNEST
RUTHERFORD a DALTON MEDAL (struck in 1864), awarded to
him by the Council in recognition of his brilliant researches in
Physical Science.

Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.,
read a paper entitled "**Recent Evidence on Atomic
Structure.**"

On the nucleus theory of atomic structure, the atom
is supposed to consist of a massive nucleus carrying a
positive charge, surrounded at a distance by a compensa-
ting distribution of negative electrons. For distance up to
10^{-12} cms., the nucleus is supposed to have such small
dimensions that it may be regarded as a point charge. The
careful experiments of Geiger and Marsden on the large
angle scattering of α rays in passing through matter are in
close accord with this theory and show that within the limit
of experimental error the forces between the α particle and
the nucleus vary as the inverse square of the distance. In
addition, the variation of the number of scattered particles

with velocity is in good agreement with the inverse square law. On the nucleus theory, the collision of a swift atom, like an a particle, with a light atom of matter gives rise to very intense forces due to the close approach of the two nuclei in a direct impact. In a collision of a swift a particle of mass 4 with a hydrogen atom of mass 1, the hydrogen nucleus should be set in swift motion with a maximum velocity 1·6 times that of the a particle. Marsden has shown that such swift H atoms can be detected by the scintillations on a zinc sulphide screen at a distance in hydrogen about four times greater than the range of the a particle. Since in such collisions, the nuclei must approach within a distance of the order of 10^{-13} cms., the distribution and number of the H atoms set in motion should throw light on the dimensions of the nuclei and on the magnitude of the forces involved.

In order to examine these points, a metal disc coated with radium C. served as a powerful source of homogeneous a radiation. The a rays after passing through a column of hydrogen were stopped by a silver plate and the scintillations observed on the zinc sulphide screen beyond were due to swift H atoms set in motion by the a particles. If the nucleus of the a particle and H atom could be regarded as point charges at such small distances, the beam of H atoms should be very heterogeneous with regard to velocity and H atoms of low velocity and short range should preponderate. The distribution with velocity of the H atoms was found to be very different; for with a rays of range 7 cm. the H atoms appeared to be projected mainly in the line of the a rays and to be of nearly equal velocity. For a particles of lower velocity, the beam of H atoms became more heterogeneous with regard to velocity, but in all cases the actual number was greatly in excess of that to be expected on the simple theory. The results indicated that each a particle of range 7 cms. in air shot at a perpendicular distance of 2.4×10^{-13} cms. from the H nucleus set the latter in swift motion nearly in the direction of the a particle. The general results were in accord with the view that the a particle must have dimensions of the order of the diameter of the electron (3.6×10^{-13} cms.), and that the forces between the nuclei augmented rapidly for distances less than 3.4×10^{-13} cms. Such a conclusion is in accord with general ideas of the nucleus structure of helium which must be complex probably containing four H nuclei and two negative electrons.

The velocity of the H atoms were measured and found to be in good accord with the value expected from the theory of impact.

General calculation shows that the range of the lighter atoms set in swift motion by close collisions with α particles should be less than that of the α particle if the recoiling atom carries two charges, but should exceed the range of the α particle if the atom carries unit charge. A number of bright scintillations were observed in air and oxygen and carbon dioxide beyond the range of the α particles. The equivalent range of these recoil atoms was found to be about the same in air and oxygen and about 1·3 times that of the incident α particle. The same general effects were observed in these gases as in hydrogen. The recoil atoms appear to be projected mainly in the direction of the α particles and are more numerous than is to be expected from the simple theory of point charges. The nuclei of the atoms of oxygen and nitrogen appear to have a radius almost twice the diameter of the electron.

An interesting effect was observed in passing α particles through dry air but not in dry oxygen or carbon dioxide. Not only were bright scintillations observed in air due to singly charged atoms of nitrogen and oxygen of range 1·3 times that of the α particle, but a number of fainter scintillations appeared whose range was about four times that of the α particle. These long range scintillations were of about the same brightness as H atoms produced under corresponding conditions and were observed for 'about the same distance. The number of these scintillations in dry air was about the same as the number of H scintillations observed when 6 cms. pressure of hydrogen is added to oxygen.

As a result of a series of experiments it was found that these long range atoms in air arise from the impact of α particles with nitrogen atoms and presumably are either atoms of hydrogen or atoms of mass 2 disrupted from the nitrogen nucleus. From general radioactive data, it appears probable that the nitrogen nucleus of mass 14 consists of three helium nuclei of mass 4 plus two hydrogen nuclei or one of mass 2. The general results derived receive an explanation if it be supposed that the H nuclei are satellites of the main nucleus of mass 12 extending to a distance about twice the diameter of the electron from the centre. It is hoped later to determine the mass and velocity of the large range atoms in nitrogen, but the experiments are difficult unless very intense sources of radiation are used. Taking into account the great energy of motion of the α particle, it is to be anticipated that under the intense forces brought into play in such close collisions the nuclei should be much deformed and under favourable conditions disrupted into two or more constituents.

MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

Annual Report of the Council, April, 1919.

The Society had at the beginning of the Session an ordinary membership of 145. Since then nine new members have joined the Society, seven members have resigned, and two members have died. There are, therefore, at the end of the session, 145 ordinary members of the Society.

By the death on March 28th of Dr. Henry Wilde, D.C.L., D.Sc., F.R.S., the Society has sustained the loss of its oldest member and most munificent benefactor.

Fifteen papers have been read at the meetings during the year; four shorter communications have also been made.

A **Joule Centenary Meeting** was held on January 7th, 1919 when Professor Sir ERNEST RUTHERFORD, gave an address on "**The Work and Influence of Joule,**"and Professor W.W. HALDANE GEE described some of the principal pieces of apparatus used by Joule in his researches and exhibited some of his original manuscripts and note books.

On January 21st, 1919, a Special Meeting of the Society was held and a discussion took place on "**The means by which the Society may promote most effectively the Advancement and Application of Learning in Manchester.**"

Among the suggestions put forward by various speakers were the following :—

1. That while the Society should retain its present functions as a learned Society, its members might meet with others interested in the advancement of Science for informal discussion in the rooms of the Society. Such gatherings might be held in the middle of the day or in the evenings, and light refreshments should be obtainable on these occasions.

2. That special lectures, by eminent men, on scientific subjects of general interest should be arranged from time to time.

3. That addresses, on the practical applications of Science, by scientific men engaged in industry should be invited.

4. That the Presidents of the various scientific societies in Manchester might be made Associate or Honorary Members during their periods of office, and that such societies should be invited from time to time to hold special meetings of general interest in the Society's house.

5. That facilities might be arranged for Members to consult the library in the evenings, and that arrangements might be made whereby members of other Societies should be able on certain terms to use the library.

On March 24th a Conversazione was held in the Society's House and was greatly appreciated by a large gathering. A short address was given by Professor G. ELLIOT SMITH, and exhibits were provided by Sir Ernest Rutherford, Professor W. W. H. Gee and Mr. T. H. Pear.

The Society commenced the session with a balance in hand, from all sources, of £78 6s. 1d., the amounts standing at the credit of the various accounts on March 31st, 1918, being as follows :—

At credit of Wilde Endowment Fund £182	13	10
„ „ Joule Memorial Fund 74	16	1
	257	9 11
Bank Overdraft on Society's Fund 179	3	10
Balance 31st March, 1918....................£ 78	6	1

The balance in hand at the close of the Session amounted to £6 5s. 6d., the amounts standing at credit of the various accounts on the 31st March, 1919, being:—

At credit of Wilde Endowment Fund £171	0	4
„ „ Joule Memorial Fund 93	9	4
	264	9 8
Bank Overdraft on Society's Fund 258	4	2
Balance 31st March, 1919...................£ 6	5	6

The Wilde Endowment Fund, kept as a separate banking account, shows a balance due to the Fund of £171 0s. 4d. in its favour, as against a balance in hand of £182 13s. 10d. at the end of the last financial year.   £350 of the Wilde Endowment Fund is invested in War Loan.

The Librarian reports that during the Session 271 volumes have been stamped, catalogued and pressmarked; 258 of these were serials, and 13 were separate works, 35 catalogue cards were written: 20 for serials, and 15 for separate works. The total number of volumes catalogued to date is 38,107 for which 14,100 cards have been written.

The library continues to be satisfactorily used for reference purposes.   283 volumes have been borrowed from the library during the past year. The number of books borrowed during the previous year was 280 and during 1916-17, 284.

During the year 93 volumes have been bound in 92 covers. In the previous Session the corresponding numbers were 207 volumes in 165 covers.

The additions to the library for the Session amounted to 270 volumes: 258 serials, and 12 separate works. The donations (exclusive of the usual exchanges) were 18 volumes; 3 volumes were purchased in addition to those regularly subscribed for.

The donations to the Society's Library during the Session include gifts of books by the Trustees of the British Museum (Natural History), the Meteorological Office, London, and Mr. T. A. Coward, Mr. C. E. Stromeyer, and the Manchester University Press.

The Society has purchased Vol. xvi. of the Royal Society's Catalogue of Scientific Papers.

During the Session the eleven volumes of Dalton's Herbarium have been renovated and catalogued by Miss A. McK. Crabtree and Mr. R. S. Adamson and a paper dealing with the history and contents of the herbarium and Dalton's botanical work was read before the Society on February 4th.   A special case is to be provided for the housing of the volumes.

The Society is greatly indebted to Mr. P. E. B. Jourdain, for the valuable gift of a large medallion of Dalton which was previously in the possession of his grandfather, Dr. Charles Clay, who was elected a member of the Society in 1841.

Mr. E. Hardcastle has presented to the Society a model of Volta's Original Pile.

The Committees appointed by the Council during the year were as follows:—

House and Finance.

The PRESIDENT	Mr. FRANCIS NICHOLSON.
Mr. C. L. BARNES.	Mr. W. H. TODD.
Mr. FRANCIS JONES.	Dr. H. G. A. HICKLING.
Mr. R. L. TAYLOR.	

Editorial.

The PRESIDENT.	Mr. T. A. COWARD.
Dr. H. G. A. HICKLING.	Mr. R. L. TAYLOR.
Prof. W. W. HALDANE GEE.	The ASSISTANT SECRETARY.

Wilde Endowment.

The PRESIDENT.	Mr. W. H. TODD.
Mr. FRANCIS JONES.	Mr. R. L. TAYLOR.
Dr. H. G. A. HICKLING.	

Special Library Committee.

The PRESIDENT.	Mr. FRANCIS NICHOLSON.
Mr. C. L. BARNES.	Prof. S. J. HICKSON.
Prof. W. W. HALDANE GEE.	Mr. FRANCIS JONES.
Mr. R. L. TAYLOR.	Dr. H. G. A. HICKLING.
The ASSISTANT SECRETARY.	Prof. F. E. WEISS.

Publications Committee.

The PRESIDENT.	Mr. C. L. BARNES.
Dr. W. M. TATTERSALL.	Dr. H. G. A. HICKLING

NOTE.— The Treasurer's Accounts of the Session 1918-1919 have been endorsed as follows :

April 4th, 1919.   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 ; £7,500 Gas Light and Coke Company Ordinary Stock (No. S/1960) ; £100 East India Railway Company's 4% Annuity Stock (No. 4032) ; 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 Declarations of Trust.

Leases and Conveyances dated as follows :—

> 22nd Sept., 1797.
> 23rd Sept., 1797.
> 25th Dec., 1799.
> 25th Dec., 1799.
> 22nd Dec., 1820.
> 23rd Dec., 1820.

Declarations of Trust :—

> 24th June, 1801.
> 23rd Dec., 1820.
> 8th Jan., 1878.

Appointment of New Trustees :—

> 30th April, 1851.

We have also seen Bankers' acknowledgment of the investment of £600 in the 5% War Loan :—1 Bond for £200, No. 28787 ; and 3 Bonds for £100 each, Nos. 71826/7 and 366270 ; and 2 Bonds for £50, Nos. 131577 and 31358.

We have also verified the balances of the various accounts with the bankers' pass books.

(Signed) { J. WILFRID JACKSON.
            { H. F. COWARD.

MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Dr. W. Henry Todd, Treasurer, in Account with the Society, from 1st April, 1918, to 31st March, 1919. **Cr.**

Dr.

	£ s. d.	£ s. d.	£ s. d.
To Balance, 1st April, 1918 ...			10 0 0
To Member's Subscriptions:—			
Half Subscriptions, 1914-15, 1 at £1 1s. 0d.	1 1 0		
1915-16, 2 ,,	2 2 0		
1916-17, 2 ,,	2 2 0		
1917-18, 1 ,,	1 1 0		
1918-19, 12 ,,	12 12 0		
Subscriptions:— 1913-14, 2 at £2 2s. 0d.	4 4 0		
1914-15, 4 ,,	8 8 0		
1915-16, 4 ,,	8 8 0		
1916-17, 6 ,,	12 12 0		
1917-18, 11 ,,	23 2 0		
1918-19, 90 ,,	189 0 0		
1918-19, 2 at £1 1s. 0d. (½ year)	2 2 0		266 14 0
To Sale of Publications:—			
Memoirs and Proceedings...	13 9 2		
Catalogues ...	0 6 6		
Copies of the "Centenary of Science"	0 3 0		
Dalton's Works, etc....	6 7 9		20 6 5
To Transfers from Wilde Endowment Fund:—			
Rent of Rooms ...	50 0 0		
Entrance Fees ...	12 12 0		
Half Subscriptions ...	17 17 0		
Cheque Book ...	0 4 2		80 13 2
To Dividends:—			
Natural History Fund	43 12 10		
Joule Memorial Fund	13 12 0		
Wilde Endowment Fund	12 5 0		69 9 10
To Refunded Income Tax, 1918			91 4 0
To Deduction from Subscription to "Chemical Abstracts,"			0 3 6
To Sale of Waste Paper ...			3 12 3
To National Insurance Act deductions			2 3 4
To Overdraft at Williams Deacon's Bank, April 1st, 1919...			164 14 10
			£709 1 4

Cr.

	£ s. d.	£ s. d.	£ s. d.
By Overdraft at Williams Deacon's Bank, March 31st, 1918			104 7 9
By Charges on Property:—			
Chief Rent ...	9 4 1		
Income Tax and Inhabited House Duty...	1 18 8		
Insurance against Fire ...	11 0 0		22 2 9
By House Expenditure:—			
Coal, Gas, Electric Light, Water, etc. ...	37 19 0		
Tea, Coffee, etc., at Meetings ...	24 2 9		
Cleaning, Washing, etc. ...	5 13 1		
Replacements ...	5 1 11		
Repairs, etc. ...	3 2 1		
Vacuum Sweeper ...	2 5 0		78 3 10
By Administrative Charges:—			
Caretaker and Housekeeper ...	81 0 0		
Extra attendance at Meetings ...	3 0 0		
Postages, Carriage of Parcels, "Memoirs" ...	25 16 5		
Stationery, Cheques, Receipts, Engrossing, etc. ...	8 15 5		
Insurance against Liability ...	0 13 2		
National Health Insurance Stamps...	4 2 4		
Miscellaneous Expenses ...	1 4 5		124 11 0
By Publishing:—			
Printing, "Memoirs and Proceedings," and Illustrations, Circulars, etc. ...			236 14 9
By Library:—			
Periodicals (except those charged to Natural History Fund)			13 7 6
By Bank Interest on Overdraft			7 3 3
By Natural History Fund:—			
(Items shown in Balance Sheet of this Fund)			14 13 6
By Wilde Endowment Fund:—			
Dividend Refunded (War Loan)	12 5 0		
Returned Income Tax Refunded	70 1 3		82 6 3
By Balance in Treasurer's hands ...			25 10 0
			£709 1 4

JOULE MEMORIAL FUND, 1918-1919. (Included in the General Account, above.)

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1918	74	10	1	By Balance, 1st April, 1919	93	9	4
To Dividends:—							
Dividend on £100 East India Railway Company's 4% Annuity Stock...	4	17	0				
Interest on £250 5% War Loan Stock...	8	15	0				
	13	12	0				
To Refunded Income Tax, 1918	5	1	3				
	£93	9	4		£93	9	4

NATURAL HISTORY FUND, 1918-19. (Included in the General Account, above.)

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1918	100	18	8	By Natural History Periodicals	11	10	6
To Dividends on £1,225 Great Western Railway Company's Stock...	43	12	10	By Subscriptions:—			
To Refunded Income Tax, 1918	16	1	6	Palæontographical Society, 1916	1	1	0
				Lancashire & Cheshire Fauna Committee, 1918	1	1	0
				Ray Society, 1919	1	1	0
					3	3	0
				By Balance, 1st April, 1919	145	19	6
	£160	13	0		£160	13	0

WILDE ENDOWMENT FUND, 1918-1919.

	£	s.	d.		£	s.	d.
To Balance, 1st April, 1918	182	13	10	By Assistant Secretary's Salary...	150	0	0
To Dividends on £7,500 Gas Light and Coke Company's Ordinary Stock	158	10	0	By Maintenance of Society's Library:—			
To Refunded Income Tax, 1918	70	1	3	Binding Books	21	16	7
To Interest on £350 War Loan Stock	12	5	0	By Transfer to Society's Funds:—			
				Rent of Rooms	50	0	0
				Entrance Fees	12	12	0
				Half Subscriptions...	17	17	0
					80	9	0
				By Cheque Book...	0	4	2
				By Balance in Bank, April 1st, 1919	171	0	4
	£423	10	1		£423	10	1

THE COUNCIL AND MEMBERS
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.

1918 - 19.

President.

WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.

Vice=Presidents.

T. A. COWARD, F.Z.S., F.E.S.
W. W. HALDANE GEE, B.Sc., M.Sc.Tech., A.M.I.E.E.
SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.
FRANCIS JONES, M.Sc., F.R.S.E., F.C.S.

Secretaries.

R. L. TAYLOR, F.C.S., F.I.C.
GEORGE HICKLING, D.Sc., F.G.S.

Treasurer.

W. HENRY TODD.

Librarian.

C. L. BARNES, M.A.

Other Members of the Council.

MARY McNICOL, M.Sc.
FRANCIS NICHOLSON, F.Z.S.
E. L. RHEAD, M.Sc.Tech., F.I.C.
G. ELLIOT SMITH, M.A., M.D., F.R.S.
F. E. WEISS, D.Sc., F.L.S., F.R.S.
R. S. ADAMSON, M.A., B.Sc.

Assistant Secretary and Librarian.

R. F. HINSON.

Acting Assistant Secretary and Librarian:

A. McK. CRABTREE.

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 Professor '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.)*

1901. (April 22.) " Sur la Flore du Corps Humain." By Dr. ELIE METSCHNIKOFF, For.Mem.R.S. *(38 pp.)*

1902. (Feb. 25.) " On the Evolution of the Mental Faculties in relation to some Fundamental Principles of 'Motion." By Dr. HENRY WILDE, F.R.S. *(34 pp., 3 pls.)*

1903. (May 19.) " The Atomic Theory." By Professor F. W. CLARKE, D.Sc. *(32 pp.)*

1904. (Feb. 23.) " The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A. *(42 pp.)*

1905. (Feb. 28.) " The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." By Dr. D. H. SCOTT. F.R.S. *(32 pp., 3 pls)*

1906. (March 20.) " Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S. *(32 pp.)*

1907. (February 18.) " The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E. *(20 pp., 5 pls., 5 text-figs.)*

1908.   (March 3.)   "On the Physical Aspect of the Atomic Theory."   By Professor J. LARMOR,   Sec. R.S. *(54 pp.)*

1909.   (March 9.)   " On the Influence of Moisture on Chemical Change in Gases."   By Dr. H. BRERETON BAKER, F.R.S.   *(8 pp.)*

1910.   (March 22.)   " Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

―――

SPECIAL LECTURES.

1913.   (March 4.)   " The Plant and the Soil."   By A. D. HALL, M.A., F.R.S.

1914.   (March 18.)   " Crystalline Structure as revealed by X-rays."   By Professor W. H. BRAGG, M.A., F.R.S.

1915.   (May 4.)   " The Place of Science in History."   By Professor JULIUS MACLEOD, D.Sc.

―――

Awards of the Dalton Medal.

1898.   EDWARD SCHUNCK, Ph.D., F.R.S.
1900.   Sir HENRY E. ROSCOE, F.R.S.
1903.   Prof. OSBORNE REYNOLDS, LL.D., F.R.S.
1919.   Prof. Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.

LIST OF PRESIDENTS OF THE SOCIETY.

Date of Election

1781. PETER MAINWARING, M.D., JAMES MASSEY.

1782-1786. JAMES MASSEY, THOMAS PERCIVAL, M.D., F.R.S.

1787-1789. JAMES MASSEY.

1789-1804. THOMAS PERCIVAL, M.D., F.R.S.

1805-1806. Rev. GEORGE WALKER, F.R.S.

1807-1809. THOMAS HENRY, F.R.S.

1809. *JOHN HULL, M.D., F.L.S.

1809-1816. THOMAS HENRY, F.R.S.

1816-1844. JOHN DALTON, D.C.L., F.R.S.

1844-1847. EDWARD HOLME, M.D., F.L.S.

1848-1850. EATON HODGKINSON, F.R.S., F.G.S.

1851-1854. JOHN MOORE, F.L.S.

1855-1859. Sir WILLIAM FAIRBAIRN, Bart., LL.D., F.R.S.

1860-1861. JAMES PRESCOTT JOULE, D.C.L., F.R.S.

1862-1863. EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

1864-1865. ROBERT ANGUS SMITH, Ph.D., F.R.S.

1866-1867. EDWARD SCHUNCK, Ph.D., F.R.S.

1868-1869. JAMES PRESCOTT JOULE, D.C.L., F.R.S.

1870-1871. EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

1872-1873. JAMES PRESCOTT JOULE, D.C.L., F.R.S.

1874-1875. EDWARD SCHUNCK, Ph.D., F.R.S.

1876-1877. EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

1878-1879. JAMES PRESCOTT JOULE, D.C.L., F.R.S.

1880-1881. EDWARD WILLIAM BINNEY, F.R.S., F.G.S.

1882-1883. Sir HENRY ENFIELD ROSCOE, D.C.L., F.R.S.

1884-1885. WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.

1886. ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.

1887. BALFOUR STEWART, LL.D., F.R.S.

* Elected April 28th ; resigned office May 5th.

Date of Election.

1888-1889. OSBORNE REYNOLDS, LL.D., F.R.S.

1890-1891. EDWARD SCHUNCK, Ph.D., F.R.S.

1892-1893. ARTHUR SCHUSTER, Ph.D., F.R.S.

1894-1896. HENRY WILDE, D.C.L., F.R.S.

  1896.   EDWARD SCHUNCK, Ph.D., F.R.S.

1897-1899. JAMES COSMO MELVILL, M.A., F.L.S.

1899-1901. HORACE LAMB, M.A., F.R.S.

1901-1903. CHARLES BAILEY, M.Sc., F.L.S.

1903-1905. W. BOYD DAWKINS, M.A., D.Sc., F.R.S.

1905-1907. Sir WILLIAM H. BAILEY, M.I.Mech.E.

1907-1909. HAROLD BAILY DIXON, M.A., F.R.S.

1909-1911. FRANCIS JONES, M.Sc., F.R.S.E.

1911-1913. F. E. WEISS, D.Sc., F.L.S.

1913-1915. FRANCIS NICHOLSON, F.Z.S.

1915-1917. SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.

1917-1919. WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C

  1919.   G. ELLIOT SMITH, M.A., M.D., F.R.S.

1919-   Sir HENRY A. MIERS, M.A., D.Sc., F.R.S.

MEMOIRS AND PROCEEDINGS

OF

THE MANCHESTER
LITERARY & PHILOSOPHICAL
SOCIETY, 1918-1919

CONTENTS.