TRANSACTIONS

OF THE

ROYAL SOCIETY

OF

EDINBURGH.

VOL. XXII.

EDINBURGH:

PUBLISHED BY ROBERT GRANT & SON, 82 PRINCES STREET,
AND WILLIAMS & NORGATE, 14 HENRIETTA STREET, COVENT GARDEN, LONDON.

MDCCCLXI.

PRINTED BY NEILL AND COMPANY, EDINBURGH.

THE KEITH, BRISBANE, AND NEILL PRIZES.

The above Prizes will be awarded by the Council in the following manner:—

KEITH PRIZE.

The Keith Prize, consisting of a Gold Medal and from £40 to £50 in Money, will be awarded early next Session (1861–62), for "the best communication on a scientific subject, communicated, in the first instance, to the Royal Society during the Sessions 1859–60 and 1860–61." Preference will be given to a paper containing a discovery.

MAKDOUGALL BRISBANE PRIZE.

This Prize, consisting of a Gold Medal and a sum of Money, will be awarded before the close of the Session 1862–63, under the following conditions:—

1. Competing Essays are to be addressed to the Secretary of the Society on or before 1st November 1862.

2. The competition is open to all men of science.

3. The Essays may be either anonymous or otherwise. In the former case, they must be distinguished by mottoes, with corresponding sealed billets superscribed with the same motto, and containing the name of the Author.

4. The subject proposed by the Council for the Prize of 1862–63 is the following:—

A Biographical Notice of a Scotchman eminent in Science: including an estimate of the influence and importance of his writings and discoveries. As instances of such Biographies which still remain to be supplied, the Council would specify the following names: Sir Robert Sibbald, Sir Andrew Balfour, Maclaurin, Black, Monro *Primus* and *Secundus;* several of the family of Gregory, Sir James Hall, Jameson. The earlier volumes of the Transactions of the Royal Society contain several specimens of able Biographies of the kind here referred to. The Council are anxious to see a continuation of the series.

5. The Council impose no restriction as to the length of the Essays, which may be, at the discretion of the Council, read at the Ordinary Meetings of the Society. They wish also to leave the property and free disposal of the manuscripts to the Authors; a copy, however, being deposited in the archives of the Society, unless the Paper shall be published in the Transactions.

NEILL PRIZE.

The Council of the Royal Society of Edinburgh having received the bequest of the late Dr Patrick Neill of the sum of £500, for the purpose of "the interest thereof being applied in furnishing a Medal or other reward every second or third year to any distinguished Scottish Naturalist, according as such Medal or reward shall be voted by the Council of the said Society," hereby intimate,

1. That the Second Neill Prize, consisting of a Gold Medal and a sum of Money, will be awarded before the close of the Session 1861–62.

2. The Prize will be given for a Paper of distinguished merit, on a subject of Natural History, by a Scottish Naturalist, which shall have been presented to the Society during the three years preceding the 1st February 1862,—or failing presentation of a Paper sufficiently meritorious, it will be awarded for a work or publication by some distinguished Scottish Naturalist, on some branch of Natural History, bearing date within five years of the time of award.

AWARDS OF THE KEITH PRIZE SINCE 1855.

(*Continued from Transactions, Vol. XXI., page iii.*)

15th Biennial Period, 1855–57. Professor Boole, for his Memoir on the Application of the Theory of Probabilities to the Question of the Combination of Testimonies and Judgments.

16th Do. 1857–59. Not awarded.

AWARD OF THE MAKDOUGALL BRISBANE PRIZE.

1st Award of Prize 1859. Sir Roderick Impey Murchison, on account of his Contributions to the Geology of Scotland.

AWARD OF THE NEILL PRIZE.

1st Triennial Period, 1856–59. Dr W. Lauder Lindsay, for his Paper on the Spermogones and Pycnides of Filamentous, Fruticulose, and Foliaceous Lichens.

DIRECTIONS TO THE BINDER FOR PLACING THE PLATES IN THIS VOLUME.

LAWS

OF THE

ROYAL SOCIETY OF EDINBURGH.

AS REVISED 5TH JANUARY 1857.

LAWS.

[By the Charter of the Society (printed in the *Transactions*, Vol. VI. p. 5), the Laws cannot be altered, except at a Meeting held one month after that at which the Motion for alteration shall have been proposed.]

I.

THE ROYAL SOCIETY OF EDINBURGH shall consist of Ordinary and Honorary Fellows. Title.

II.

Every Ordinary Fellow, within three months after his election, shall pay Two Guineas as the fee of admission, and Three Guineas as his contribution for the Session in which he has been elected; and annually at the commencement of every Session, Three Guineas into the hands of the Treasurer. This annual contribution shall continue for ten years after his admission, and it shall be limited to Two Guineas for fifteen years thereafter.* The fees of Ordinary Fellows residing in Scotland.

III.

All Fellows who shall have paid Twenty-five years' annual contribution shall be exempt from farther payment. Payment to cease after 25 years.

IV.

The fees of admission of an Ordinary Non-Resident Fellow shall be £26, 5s., payable on his admission; and in case of any Non-Resident Fellow coming to reside at any time in Scotland, he shall, during each year of his residence, pay the usual annual contribution of £3, 3s., payable by each Resident Fellow; but after payment of such annual contribution for eight years, he shall be exempt from any farther payment. In the case of any Resident Fellow ceasing to reside in Scot- Fees of Non-Resident Ordinary Fellows. Case of Fellows becoming Non-Resident.

* At the Meeting of the Society, on the 5th January 1857, when the reduction of the Contributions from £3, 3s., to £2, 2s., from the 11th to the 25th year of membership, was adopted, it was resolved that the existing Members shall share in this reduction, so far as regards their future Annual Contributions.

A modification of this rule, in certain cases, was agreed to 3d January 1831.

land, and wishing to continue a Fellow of the Society, it shall be in the power of the Council to determine on what terms, in the circumstances of each case, the privilege of remaining a Fellow of the Society shall be continued to such Fellow while out of Scotland.

V.

Defaulters.

Members failing to pay their contribution for three successive years (due application having been made to them by the Treasurer) shall be reported to the Council, and, if they see fit, shall be declared from that period to be no longer Fellows, and the legal means for recovering such arrears shall be employed.

VI.

Privileges of Ordinary Fellows.

None but Ordinary Fellows shall bear any office in the Society, or vote in the choice of Fellows or Office-Bearers, or interfere in the patrimonial interests of the Society.

VII.

Numbers Unlimited.

The number of Ordinary Fellows shall be unlimited.

VIII.

Fellows entitled to Transactions.

The Ordinary Fellows, upon producing an order from the TREASURER, shall be entitled to receive from the Publisher, gratis, the Parts of the Society's Transactions which shall be published subsequent to their admission.

IX.

Mode of Recommending Ordinary Fellows.

No person shall be proposed as an Ordinary Fellow without a recommendation subscribed by *One* Ordinary Fellow, to the purport below.* This recommendation shall be delivered to the Secretary, and by him laid before the Council, and shall afterwards be printed in the circulars for three Ordinary Meetings of the Society, previous to the day of the election, and shall lie upon the table during that time.

X.

Honorary Fellows, British and Foreign.

Honorary Fellows shall not be subject to any contribution. This class shall

* "A. B., a gentleman well skilled in several branches of Science (*or Polite Literature, as the case* "*may be*), being to my knowledge desirous of becoming a Fellow of the Royal Society of Edin- "burgh, I hereby recommend him as deserving of that honour, and as likely to prove a useful and "valuable Member."

This recommendation to be accompanied by a request of admission signed by the Candidate.

consist of persons eminently distinguished for science or literature. Its number shall not exceed Fifty-six, of whom Twenty may be British subjects, and Thirty-six may be subjects of foreign states.

XI.

Personages of Royal Blood may be elected Honorary Fellows, without regard to the limitation of numbers specified in Law X. Royal Personages.

XII.

Honorary Fellows may be proposed by the Council, or by a recommendation (in the form given below*) subscribed by three Ordinary Fellows; and in case the Council shall decline to bring this recommendation before the Society, it shall be competent for the proposers to bring the same before a General Meeting. The election shall be by ballot, after the proposal has been communicated *viva voce* from the Chair at one meeting, and printed in the circular for the meeting at which the Ballot is to take place. Recommendation of Honorary Fellows. Mode of Election.

XIII.

The election of Ordinary Fellows shall take place at the Ordinary Meetings of the Society. The election shall be by ballot, and shall be determined by a majority of at least two-thirds of the votes, provided Twenty-four Fellows be present and vote. Election of Ordinary Fellows.

XIV.

The Ordinary Meetings shall be held on the first and third Mondays of every month from November to June inclusive. Regular Minutes shall be kept of the proceedings, and the Secretaries shall do the duty alternately, or according to such agreement as they may find it convenient to make. Ordinary Meetings.

XV.

The Society shall from time to time publish its Transactions and Proceedings. For this purpose the Council shall select and arrange the papers which they shall The Transactions.

* We hereby recommend ______________________________
for the distinction of being made an Honorary Fellow of this Society, declaring that each of us from our own knowledge of his services to (*Literature or Science as the case may be*) believe him to be worthy of that honour.

(To be signed by three Ordinary Fellows.)

____

____

____

To the President and Council of Royal Society of Edinburgh.

deem it expedient to publish in the *Transactions* of the Society, and shall superintend the printing of the same.

XVI.

How Published.

The Transactions shall be published in Parts or *Fasciculi* at the close of each Session, and the expense shall be defrayed by the Society.

The Council.

There shall be elected annually, for conducting the publications and regulating the private business of the Society, a Council, consisting of a President; Six Vice-Presidents, two at least of whom shall be resident; Twelve Councillors, a General Secretary, Two Secretaries to the Ordinary Meetings, a Treasurer, and a Curator of the Museum and Library.

XVII.

Retiring Councillors.

Four Councillors shall go out annually, to be taken according to the order in which they stand on the list of the Council.

XVIII.

Election of Office-Bearers.

An Extraordinary Meeting for the Election of Office-Bearers shall be held on the fourth Monday of November annually.

XIX.

Special Meetings; how called.

Special Meetings of the Society may be called by the Secretary, by direction of the Council; or on a requisition signed by six or more Ordinary Fellows. Notice of not less than two days must be given of such Meetings.

XX.

Treasurer's Duties.

The Treasurer shall receive and disburse the money belonging to the Society, granting the necessary receipts, and collecting the money when due.

He shall keep regular accounts of all the cash received and expended, which shall be made up and balanced annually; and at the last Ordinary Meeting in January he shall present the accounts for the preceding year, duly audited. At this Meeting, the Treasurer shall also lay before the Council a list of all arrears due above two years, and the Council shall thereupon give such directions as they may deem necessary for recovery thereof.

XXI.

Auditors.

At the Extraordinary Meeting in November, a Committee of three Fellows shall be chosen to audit the Treasurer's accounts, and give the necessary discharge of his intromissions.

The report of the examination and discharge shall be laid before the Society at the last ordinary Meeting in January, and inserted in the records.

XXII.

The General Secretary shall keep Minutes of the Extraordinary Meetings of the Society, and of the Meetings of the Council, in two distinct books. He shall, under the direction of the Council, conduct the correspondence of the Society, and superintend its publications. For these purposes, he shall, when necessary, employ a clerk, to be paid by the Society.

General Secretary's Duties.

The Secretaries to the Ordinary Meetings shall keep a regular Minute-book, in which a full account of the proceedings of these Meetings shall be entered; they shall specify all the Donations received, and furnish a list of them, and of the donors' names, to the Curator of the Library and Museum: they shall likewise furnish the Treasurer with notes of all admissions of Ordinary Fellows. They shall assist the General Secretary in superintending the publications, and in his absence shall take his duty.

Secretaries to Ordinary Meetings.

XXIII.

The Curator of the Museum and Library shall have the custody and charge of all the Books, Manuscripts, objects of Natural History, Scientific Productions, and other articles of a similar description belonging to the Society; he shall take an account of these when received, and keep a regular catalogue of the whole, which shall lie in the Hall, for the inspection of the Fellows.

Curator of Museum and Library.

XXIV.

All articles of the above description shall be open to the inspection of the Fellows, at the Hall of the Society, at such times, and under such regulations, as the Council from time to time shall appoint.

Use of Museum and Library.

XXV.

A Register shall be kept, in which the names of the Fellows shall be enrolled at their admission, with the date.

Register Book.

ERRATA.

Page 41, line 1, *for* 1829 *read* 1859.
... 392, line 11, *for* fasiculata *read* fasiculatum.
... ,, 22, *for* cylindraceus *read* cylindraceum.
... ,, Add to the list *Loxonema sulculosa.*
... 393, line 20, *for* longispina *read* longispinus.
... ,, 22, *for* duplicicosta *read* duplicicostatus.
... ,, 24, *for* Aviculu rugosa *read* Aviculopecten rugosus.
... ,, 28, *delete* Orthis filiaria.
... ,, 19, *for* Athyris gibera *read* Atrypa gibbera ; but it should be conjoined with Orthis resupinata.

CONTENTS.

PART I. (1857–8 & 1858–9.)

PART II. (1859-60.)

PART III. (1860–1.)

TRANSACTIONS.

I.—*An Account of some Experiments on Radiant Heat, involving an extension of Prevost's Theory of Exchanges.* By BALFOUR STEWART, Esq. Communicated by Professor FORBES.

(Read 15th March 1858.)

Division of Subject.

1. This paper consists of two parts, the first of which is confined to describing the experiments performed; while in the second it is attempted to connect these with certain theoretical views regarding Radiant Heat.

2. The experiments were made with a fourfold object; at least, for the sake of clearness, it is well to class them into four distinct groups:—

Group I. Contains those experiments in which the *quantities* of heat radiated from polished plates of different substances, at a given temperature, are compared with the quantity radiated from a similar surface of lamp-black, at the same temperature.

II. Those in which the *quantities* of heat radiated at the same temperature, from polished plates of the same substance, but of different thicknesses, are compared with one another.

III. Those in which the radiations, from polished plates of different substances at any temperature, are compared with that from lamp-black at the same temperature, with regard to the *quality* or *nature* of the heat radiated.

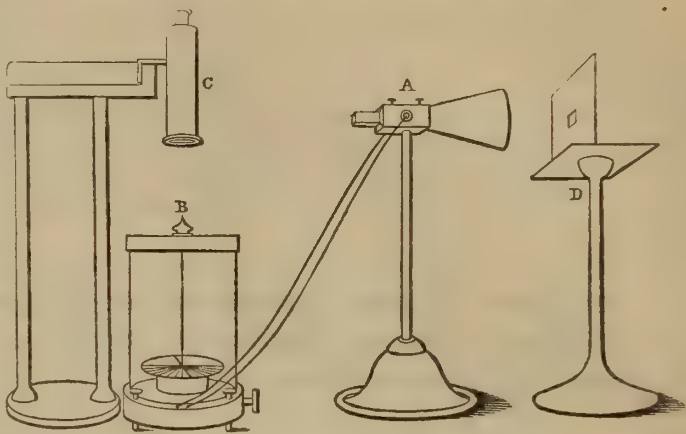
IV. Those in which the same comparison is made between the radiations from polished plates of the same substance, but of different thicknesses.

Instruments used, and Method of using them.

3. I am indebted to the kindness of Professor FORBES for the use of a delicate thermo-multiplier, consisting of the sentient pile, and its attached galvanometer and telescope; as well as for much valuable information with regard to the proper method of using the apparatus.

The following arrangement was adopted for the great mass of the experiments:—

A. Is the sentient pile, with a polished brass cone attached to it, for collecting the rays of heat.
B. Is the galvanometer, the position of its needle being read to $\frac{1}{10}$th of a degree by the telescope C.
D. Is a screen placed before the mouth of the cone in which there is a small hole or diaphragm ·65 inch square. The screen is covered with gilt paper, in order that, should it get slightly heated, it might radiate as little as possible.



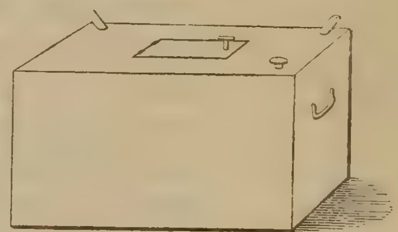
The heated body is placed behind the diaphragm, filling up the field of view from the cone; so that every ray reaching the cone from behind the diaphragm comes from the heated body.

In the following experiments, unless the contrary is mentioned, the distance of the diaphragm from the mouth of the cone is 2 inches.

The dimensions of the cone itself are as follows:—

Length of axis, or distance between centre of mouth and pile, . .	5 inches.
Diameter of mouth or opening, ...	2·6 inches.

The temperature to which the heated body was raised was generally 212°, and the apparatus used for heating it was of the following construction:—



It consisted of a tin vessel, having its top, bottom, and sides double (or a box within a box), and furnished on the top with a lid, also double, by means of which the body to be heated was introduced into the interior. Water was poured into the chamber between the outer and inner boxes, and allowed to boil; and, when the lid was shut, the temperature of the interior was found to rise very nearly to the boiling point; a thermometer placed in the air of the chamber showing a temperature of 200°, and when lying on the bottom, a temperature of 210°. When an observation was to be made, the hot body was taken out, and that surface which lay on the bottom of the inner chamber placed behind the diaphragm, so as to radiate into the cone. In the following experiments, unless the contrary is mentioned, the body has been heated in this manner.

The first swing of the galvanometer needle was taken as representing the intensity of the heating effect; and Professor FORBES has shown, in a paper read before this Society, 2d May 1836, that this will hold up to angles of about 20°, which is the maximum deviation used in these experiments.

Observations were always made with as little sunlight as possible; and under these circumstances, it was ascertained that the stray heat reaching the cone was inappreciable. The needle, it was calculated, reached the limits of its swing about 12 seconds after the heated body had been taken out of the boiling-water apparatus.

Experiments were made to ascertain if the body cooled sensibly during this short period of time, and it was found that its cooling was so trifling as not to interfere in any degree with the results of these observations. In the following experiments, it is therefore assumed that the body remains at its original temperature of 210° while the observation is being made.

Four observations were generally made, and three if they agreed together exceedingly well, but never fewer. Very often the agreement was exact.

First Group of Experiments described.

4. With these remarks, I proceed to describe the experiments belonging to the first group, or those made with the view of comparing the heat radiated from polished plates of different substances with that radiated from a surface of lamp-black at the same temperature.

The reason why lamp-black was chosen as the standard is obvious; for, it is known from LESLIE's observations, that the radiating power of a surface is proportional to its absorbing power. Lamp-black, which absorbs all the rays that fall upon it, and therefore possesses the greatest possible absorbing power, will possess also the greatest possible radiating power. The first substance compared with it was glass.

A. *Glass.*—A piece of plate-glass, ·3 inch thick, having paper coated with lamp-black pasted on its surface next the pile, gave a deviation of 18·1. This may be taken as the radiation from lamp-black.

Three plates of crown-glass, each ·05 inch thick, placed one behind the other, gave	17·7
A single piece of crown-glass of the same thickness gave . . .	16·5

This difference is probably owing to the single plate cooling faster than the three plates. It may be argued that the radiation from glass is very nearly equal to that from lamp-black; and indeed this is already well known.*

B. *Alum.*—Here the boiling-water apparatus could not be used, since alum becomes calcined at a temperature much below 212°; but a self-regulating apparatus, invented by the late Mr KEMP, was employed instead, giving a steady temperature of 98°.

A piece of plate-glass ·18 inch in thickness gave	5·0
A piece of alum of the same thickness gave	5·0

The radiation from alum may therefore be reckoned equal to that from glass.

* See LESLIE's "Inquiry into the Nature and Propagation of Heat."

C. *Selenite.*—At the temperature of 98°—

A piece of selenite ·125 inch in thickness gave	5·1
Under the same circumstances, glass ·18 inch thick gave	5·0

In the boiling-water apparatus,

The same piece of selenite gave	18·0
While blackened glass gave	18·5

The radiation from selenite may therefore be reckoned equal to that from alum or glass.

D. *Mica.*—A small box was constructed, having two windows of mica, the thickness of the mica in the one being ·0009 inch, and of that in the other ·02 inch. This box was filled with mercury (Professor FORBES having suggested the use of that metal, to keep up the temperature, while interfering very little with the radiation). The whole was then set on a glass dish in the boiling-water apparatus.

The radiation from the thin window was,	11·2
While that from the thick window was,	12·7

As it would have been manifestly erroneous to compare these with the radiation from blackened glass lying in contact with the bottom of the apparatus, the thin window was removed, and blackened paper substituted in place of it.

While the thick mica window gave	12·7
The blackened paper gave	13·8

In comparing the radiations from the two windows, they were observed alternately. We see, therefore, that the radiation from mica, especially thin mica, is less than that from lamp-black in the proportion of 11·2 to 13·8, or the heat from thin mica is 80 per cent. of that from lamp-black.

E. *Rock-Salt.*—As in the experiments with rock-salt, it was desirable to obtain results of the greatest possible accuracy, the radiation from the rock-salt was not compared with that from blackened glass; for it was found that glass cooled more rapidly than rock-salt. The following plan was adopted:—

A piece of rock-salt ·18 inch thick (the temperature as in all the previous examples being about 210°), gave	3·2
A canister with water kept boiling, coated with lamp-black,	22·0

In order to estimate how much the rock-salt had cooled during the observation, the following experiment was made, without any diaphragm:—

Rock-salt ·18 inch thick taken to the cone at once, gave	5·1
After cooling for 15 seconds, it gave	4·9

It will be seen from this, that were the rock-salt, instead of cooling during the 12 seconds necessary for the observation, kept at the temperature of 212°, it would not have given more than 3·3, while the hot-water canister gave 22·0.

5. From these experiments, it appears that glass, alum, and selenite, at low temperatures, have an intensity of radiation very nearly equal to that from lamp-black; while mica radiates somewhat less, and rock-salt greatly less. This is shown by the following table:—

TABLE I.

Radiating Substance.	Temperature.	
	212°	98°
Lamp-black, ...	100	
Glass, ...	98	27
Alum, ...		27
Selenite, ...	98	27
Thick mica, ...	92	
Thin mica, ...	81	
Rock-salt, ...	15	

Second Group of Experiments described.

6. I now proceed to the second group of experiments, or those designed to compare together the quantities of heat radiated at the same temperature from polished plates of the same substance, but of different thicknesses.

A. *Glass.*—No direct experiment of this kind was made on glass; for although a thick plate gave a somewhat greater radiation than a thin plate, it was imagined that this was due to the unequal cooling of the two plates. Indirectly, however, we may gather that thick glass radiates somewhat more than thin glass, from the following experiment, which belongs more properly to the fourth group:—

A plate of crown-glass ·05 inch thick, being placed before the cone as a screen, and a similar plate ·05 inch thick, and 3·75 inches square, being used as the source of heat at a distance of 6 inches, and no diaphragm used, the deviation was 0·95*
But when the source of heat was a similar plate ·10 inch thick, the deviation became . . . . 1·45

Such a difference cannot be accounted for by the unequal cooling of the plates; and it would seem to indicate that a small quantity of heat from the interior of the thick plate reached the surface; which heat, having already been sifted by its passage through glass, was easily able to pierce the screen.

In another similar experiment,

One plate of crown-glass ·05 inch thick, gave a deviation of . . .	1·1
Two plates ·05 inch thick, the one behind the other, ...	1·55
Three such plates, ...	1·9

B. and C.—No experiments of this kind were attempted with alum or selenite.

* Without any screen, it was calculated that the intensity of effect would have been equal to about 150°.

D. *Mica.*—Experiments similar to those already described, only at a distance of $2\frac{1}{2}$ inches from the cone, gave—

For mica, ·0009 inch thick (average of two sets of experiments), . .	8·2
For mica, ·02 inch thick (average of two sets of experiments), . .	9·3

The experiments already quoted, which were made at a shorter distance from the pile, gave—

For mica, ·0009 inch thick, ...	11·2
For mica, ·02 inch thick, ...	12·7

E. *Rock-Salt.*—Three pieces of rock-salt were used. Their dimensions were—

	1st Piece.	2d Piece.	3d Piece.
Length, . . .	1·15 inch	2·15 inch	2·5 inch
Breadth, . . .	1·15 ...	1·4 ...	1·4 ...
Thickness, . .	0·18 ...	0·36 ...	0·77 ...

For these pieces, as well as for the other substances, I am indebted to the kindness of Professor FORBES. When placed behind the diaphragm, the farthest off surface was large enough to fill up the field of view,—that is to say, all rays from the cone striking the nearest surface, struck also the surface farthest off; the distance between the two surfaces being the thickness of the piece.

The following are the means of four sets of experiments:—

Radiation from 1st or thinnest piece, ...	3·4
... 2d or middle piece, ...	4·3
... 3d or thickest piece, ...	5·3

This proves that more heat is radiated by a thick than by a thin piece of rock-salt.

The following experiments were devised by Professor FORBES, to confirm the above results.

(*a*.) The second piece of rock-salt was placed obliquely behind the diaphragm, making an angle of 20° with the prolongation of the axis of the cone. A piece of fir-wood of the same dimensions was placed in the same way. The two substances being compared in this position, and also in the usual position behind the diaphragm (viz., perpendicular to the direction of the cone's axis), the following was the result:—

	Oblique.	Usual position.
Rock-salt ·36 inch thick, ...	4·0	4·0
Wood, same size as rock-salt, . . .	9·1	14.1

In order that this experiment may be understood, it may be well to mention, that, when the plate was placed obliquely behind the diaphragm, it did not quite fill up the field of view. Hence the wood gave out less heat to the cone in this than in its ordinary position.

It appears, therefore, that the radiation from rock-salt, in a direction making a small angle with the surface, bears a greater proportion to the corresponding radiation from wood than when both radiations are taken perpendicular to the surface. The reason undoubtedly is, that in the former case the rays come from a greater thickness of the substance, so that their intensity is increased.

(β.) The middle-sized piece of rock-salt was bound tightly to the thickest piece, with a slip of tin-foil between, so that the whole might cool as one piece, and thus obviate any objection that might be brought against the results, founded on the unequal cooling of the plates, owing to their thicknesses being different.

The surface of the middle-sized piece facing the pile, gave . . .	6·3
That of the thickest piece, gave	8·1

The plates, therefore, still retained their inequality of radiation; but the amount from each was increased, owing, no doubt, to reflection and radiation from the tin-foil. The radiation from the tin-foil may be estimated at 1·0, deducting which, we have 5·3 and 7·1; the increase now being due to reflection from the tin-foil.

7. It thus appears, that while the difference between the radiating power of thick and thin glass is so small as not to be capable of being directly observed, there is a perceptible difference between the radiation from thick and thin mica, and a still more marked difference between the radiation from plates of rock-salt of unequal thickness.

But (at least with the thicknesses used) the greatest radiations from mica and rock-salt were still below that from lamp-black, and the radiation from rock-salt greatly so.

The following table exhibits the results of the second group of experiments:—

TABLE II.

Substance.	Radiation from thick plate.	Radiation from thin plate.
Glass, ...	100	100
Mica, ...	100	89
Rock-salt, ...	100	Middle 81 thin 64

Third Group of Experiments described.

8. I now proceed to consider the third group of experiments, or those made with the view of comparing the radiations from various polished surfaces with that from lamp-black, as regards the *quality* of the heat; its quality being tested by its capability of transmission through a screen of the same material as the radiating plate.

A. *Glass.*—In an experiment already described, where a plate of crown-glass ·05 inch thick was used as a screen, and a similar plate of crown-glass as the source of heat—

We had, ...	0·95
A similar plate ·1 inch thick as the source of heat, gave	1·45
Blackened paper attached to a similar surface of plate-glass, ·3 inch thick, the blackened side being next the pile, ...	1·95

Therefore heat from a thin plate of glass is less transmissible through glass than heat from blackened paper.

B. and C.—No experiment of this nature was made with alum or selenite.

D. *Mica.*—The apparatus already described gave—

	Without screen.	With mica screen, ·0025 inch thick.
For window (the window, it will be borne in mind, is the radiating surface), ·0009 inch thick, ...	11·2	2·5
Window ·02 inch thick, ...	12·7	3·2
Blackened paper attached to glass lying on the bottom of the boiling-water apparatus, gave	21·0	6·3

We have therefore the proportion of heat passed by mica screen—

For heat from thin mica window, ...	·223
... thick	·260
... blackened paper, ...	·300

E. *Rock-Salt.*—The thickest piece of rock-salt (thickness ·77 inch) being used as a screen, and the diaphragm withdrawn, in order to give greater results; the middle-sized piece of rock-salt gave—

With screen.	Without screen.
6·1	19·6

The same screen stopped 3 rays out of 12 for *ordinary* lamp-black heat.

This experiment is sufficient to show that rock-salt is much less diathermanous for heat from rock-salt than for ordinary heat. The common opinion, that rock-salt is equally diathermanous for all descriptions of heat, is therefore untenable.

9. From the third group of experiments it appears, therefore, that heat emitted by glass, mica, or rock-salt, is less transmissible through a screen of the same material as the heated plate, than heat from lamp-black; this difference being very marked in the case of rock-salt.

Fourth Group of Experiments described.

10. I now proceed to the fourth group of experiments, or those made with the view of comparing the radiations of plates of the same substance, but of different thicknesses, with regard to the quality of the heat radiated.

A. *Glass.*—It has been already shown (Art. 8), that heat from crown-glass ·05 inch thick is less transmissible through glass, than that from crown-glass ·10 inch thick.

B. and C.—No experiments of the kind were made on alum or selenite.

D. *Mica.*—It has been already shown (Art. 8), that heat from thin mica is less transmissible through a mica screen than heat from thick mica.

E. *Rock-Salt.*—With a screen of rock-salt ·18 inch thick, the following result was obtained:—

Thickest piece of rock-salt, heated to 210°	(thickness ·77 inch), gave .	2·5
Middle sized	(thickness ·36 inch), gave .	1·7
Thinnest piece	(thickness ·18 inch), gave .	1·1

Without any screen, the same pieces gave—

Thickest,	4·9
Middle-sized,	4·1
Thinnest,	3·3
Proportion of heat from thickest piece passed,	·51
... ... middle-sized ...	·41
... ... thinnest ...	·33

A similar experiment, with a screen ·29 inch thick, gave—

	With screen.	Without screen.	Proportion passed.
Thickest piece,	2·6	5·4	·48
Middle-sized,	1·8	4·5	·40
Thinnest,	1·2	3·5	·33

It follows from this, that a screen of rock-salt passes heat from thick, more easily than heat from thin rock-salt.

11. From this fourth group of experiments, we learn that heat from thick plates of glass, mica, or rock-salt, is more easily transmitted by screens of the same nature as the heated plate than heat from thin plates of these materials.

The following table exhibits the results of the third and fourth group of experiments:—

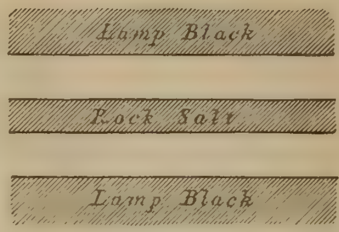
TABLE III.

Source of Heat.	No. of Rays out of every 100 that pass through a screen of the same material as the source of Heat in 1st column, the screen being of only one thickness for each material.	No. of Rays of Lamp-black Heat, out of every 100 that pass through the same screen.
Glass (crown $\frac{1}{20}$th inch thick),	0·66	1·33
Glass (crown $\frac{1}{10}$th inch thick),	1·0	
Mica (thickness ·0009 inch),	22	30
Mica (thickness ·02 inch),	26	
Rock-salt (thickness ·18 inch),	33	82 (Art. 12)
Rock-salt (thickness ·36 inch),	41	
Rock-salt (thickness ·77 inch),	50	

Results deducible from the foregoing Experiments.

12. These experiments, as well as others yet to be described, may be explained by PREVOST'S theory of exchanges, somewhat modified.

In the first place, it would seem to be a consequence of this theory, that radiation must take place from the interior as well as from the surfaces of bodies. For suppose that we have two indefinitely extended surfaces of lamp-black, as in the figure, and between them a plate of rock-salt of a certain thickness, also indefinitely extended; and let the whole be kept at the same temperature. Then, since the temperature of the rock-salt remains the same, it must radiate as much as it absorbs. But a thicker plate of rock-salt, placed under the same circumstances, would absorb more of the heat radiated from the lamp-black, because each ray would have to pass through a greater depth of the substance of the salt; hence a thick plate of rock-salt must radiate more than a thin plate. We see, likewise, the reason for the small radiative capacity of rock-salt to be its small absorptive capacity. In order to prove this deduction from PREVOST's theory experimentally true, the following experiment was devised:—



A boiling-water canister, coated with lamp-black, was put behind the diaphragm, filling up the field of view, and the three pieces of rock-salt heretofore used as sources of heat, were now separately used as screens, being put before the diaphragm, so that the heat from the canister had to pass through their subtance before reaching the cone. The following was the result:—

	Without any Screen.	Screen of Rock-salt, ·18 inch thick.	Screen of Rock-salt, ·36 inch thick.	Screen of Rock-salt, ·77 inch thick.
Radiation from Canister, . .	21·3	17·6	16·8	15·8

The difference between heat absorbed by plate, thickness = ·18 inch, And that absorbed by plate, . . thickness = ·36 inch,	Is 1·2	Mean 1·1
Another similar experiment gives . . .	0·9	
The difference between heat absorbed by plate, thickness = ·36 inch, And that absorbed by plate, . . thickness = ·77 inch,	Is 1·0	Mean 1·1
Another similar experiment gives . . .	1·3	

These should nearly correspond with the differences between the radiations from the same plates, under their ordinary circumstances of position (if the theory be true which asserts that the absorption of such a plate equals its radiation); accordingly we find that

The difference between heat radiated by plate, thickness = ·18 inch,
And that radiated by plate, . . thickness = ·36 inch, Is 0·9

While the difference between radiation of plate, thickness = ·36 inch,
And that ... ... of plate, ... = ·77 inch, Is 1·0
(Art. 6, mean of four sets of experiments).

We see, therefore, that there is an agreement between the two sets of differences, as near as can be reasonably expected.

13. If we now suppose a plate of glass, and not a plate of rock-salt, placed between surfaces of lamp-black, the plate, whether thin or thick, will allow scarcely any heat to pass through it; and, consequently, plates of different thicknesses will all absorb very nearly the same amount,—that is, nearly all that enters them. In this case, therefore, the radiation (which is equal to the absorption) will be very slightly increased by an increase of thickness of the plate. Also the amount

of heat radiated, being equal to the heat absorbed, will be very nearly as great as that from lamp-black.

14. There are, therefore, two peculiarities of the radiation from plates of diathermanous substances, and which are most marked for those substances which are most diathermanous.

1*st*, That the amount of radiation from such plates is less than that from lamp-black.

2*d*, That the amount of radiation from such plates increases with the thickness of the plate.

The correlation between these different properties of bodies is seen from the following table:—

TABLE IV.

Bodies ranked according to their Radiating Capacity (least radiating first).	Bodies ranked according to their Diathermancy (most diathermanous first).	Bodies ranked according to the proportion by which their Radiation is increased by increasing the thickness.
A stratum of heated gas (from Melloni's Experiments),	A stratum of gas.	...
Rock-salt.	Rock-salt.	Rock-salt.
Mica.	Mica.	Mica.
Glass. }	Glass. }	Glass.
Selenite. }	Selenite. }	...
Alum. }	Alum. }	...

15. The reason why radiation has hitherto been supposed to be confined to the surface, or to an exceedingly small distance below the surface of a body now becomes obvious. The effect of coating a surface of polished metal with gum, for instance, is to increase the radiation; but, after a very small thickness of film, an additional coating is powerless to increase the radiation; the reason being, not that radiation is incapable, in all cases, of taking place, except at the surface; but because, such films being exceedingly impervious to heat of low temperatures, the radiation from them is very little increased by increasing their thickness.

Since, therefore, it appears that radiation takes place from the interior as well as from the surface of bodies, the question arises, are we to suppose each particle of each substance to have, at a given temperature, an independent radiation of its own, equal, of course, in all directions? *A priori*, this is the most probable supposition, and it seems likewise to be conformable to experiment.

In an experiment already described,

A plate of crown-glass ·05 inch in thickness being used as a screen, the quantity of heat radiated from crown-glass ·05 inch thick that passed, was	0·95
While of that radiated from crown-glass, ·10 inch thick, there passed	1·45

Another experiment gave—

Quantity of heat from crown-glass ·05 that passed,	1·1
Quantity radiated from two plates of crown-glass, each ·05 inch thick, the one placed loosely behind the other,	1·55

From this we may infer, that the radiation from two plates of glass placed loosely behind each other, is the same as the radiation from a plate of double the thickness, and, consequently, that the radiation from a particle of a substance does not diminish, owing to its being placed in the interior.*

17. Let us now refer to the radiations from rock-salt:—

The radiation from a piece ·18 inch thick, was	3·4
That from a piece ·36 inch thick, was	4·3
That from a piece ·77 inch thick, was	5·3

Now, if we suppose the radiation of a particle in the interior to be as intense as that of a particle at the surface, why, it may be asked (since rock-salt is extremely diathermanous), does not a piece of double the thickness give nearly a double radiation, and so on, the radiation increasing very nearly as the thickness?

If we still hold the doctrine of an equal and independent radiation from every particle, we are shut up to the conclusion that rock-salt must be comparatively opaque to heat radiated by itself,—a result which is abundantly confirmed by experiment.

Thus, while the radiation from rock-salt ·18 inch thick, without any screen, is 3·4, with a screen of rock-salt ·18 inch thick it becomes 1·1.

If, therefore, we have a piece of rock-salt of double this thickness, or ·36 inch thick, we should expect that the radiation from it would be $=3{\cdot}4+1{\cdot}1=4{\cdot}5$. It is, in fact, 4·3. The difference (0·2) being within the limit of error of observation.

In rock-salt, therefore, we may suppose each particle to have an independent radiation of its own, unaffected by its distance from the surface.

18. We see, therefore, that the opacity of rock-salt with regard to heat radiated by itself, is a consequence of the admission, that the radiation from rock-salt does not increase so rapidly as the thickness increases; and this again results from the fact, that the absorption of heat by a plate of rock-salt does not increase so rapidly as the thickness increases. This, again, is due to the fact, that the first part of the plate of rock-salt sifts the heat so that it is more easily transmitted by the second part; and this confirms the results arrived at by Professor Forbes, who, finding that rock-salt stopped heat of low temperature rather more

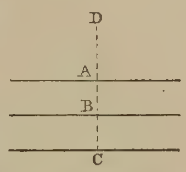
* The idea of this experiment was derived from a remark of Professor Forbes, who suggested that several plates of rock-salt, the one behind the other, might be advantageously substituted for a thick plate of the same material, as giving the very same result.

readily than heat of high temperature, concluded that there are a few rays for which rock-salt is opaque.*

We conclude, therefore, that every body which sifts heat in its passage through its substance, is more opaque with regard to heat radiated by a thin slice of its own substance, than it is with regard to ordinary heat.

19. This conclusion may be also stated thus: We have before proved (Art. 12.) that the radiation of a thin slice of any substance equals its absorption; we now add, that the heat radiated is the same as that absorbed, with regard to quality as well as quantity.

For this expresses the fact, that substances which sift heat are likewise opaque with respect to heat radiated by themselves. For, since the heat which they absorb is manifestly that kind of heat for which they are opaque, if the description of heat radiated is the same as that absorbed, then they will also be opaque with respect to heat radiated by themselves. Considering, therefore, the heat of any temperature to consist of heterogeneous rays, we may state the law thus: "*The absorption of a plate equals its radiation, and that for every description of heat.*"



20. A more rigid demonstration may be given thus:—Let AB, BC be two contiguous, equal, and similar plates in the interior of a substance of indefinite extent, kept at a uniform temperature. The accumulated radiation from the interior impinges on the upper surface of the upper plate; let us take that portion of it which falls on the particle A, in the direction DA. This ray, in passing from A to B will have been partly absorbed by the substance between A and B; but the radiation of the upper plate being equal to its absorption (since its temperature remains the same), the ray will have been just as much recruited by the united radiation of the particles between A and B, as it was diminished in intensity by their absorption. It will therefore reach B with the same *intensity* it had at A. But the *quality* of tne ray at B will also be the same as its *quality* at A. For, if it were different, then either a greater or a less proportion would be absorbed in its passage from B to C, than was absorbed of the equally intense ray at A, in its passage between A and B. The amount of heat absorbed by the par-

* To take a numerical example, let us suppose the heat from a single plate of rock-salt to be $=1$, then the heat from a plate four times the thickness, or (which is the same thing) the heat from four single plates, one behind another, should be nearly four times as much, or $=4$ (if we suppose the heat from each of these four plates to be readily passed by the plates between it and the pile), but the heat from the fourfold plate, instead of being four times as much, is not double of the heat from the single plate; hence, the heat from any of the interior plates of the compound plate is passed with great loss, by the plates between it and the pile. Now, since the absorption of a plate equals its radiation, the reason why the fourfold plate scarcely radiates twice so much as the single one is, that it scarcely absorbs twice as much; and this again is due to the fact, that the heat after it has passed the first plate of the fourfold plate has become sifted, and passes with little diminution of intensity through the other three plates.

ticles between B and C would therefore be different from that absorbed by the particles between A and B. But this cannot be; for, on the hypothesis of an equal and independent radiation of each particle, the radiation of the particles between B and C is equal to that of the particles between A and B, and their absorption equals their radiation. Hence the radiation impinging on B, in the direction of DB, must be equal in quality as well as quantity to that impinging upon A; and, consequently, the radiation of the particles between A and B must be equal to their absorption, as regards quality as well as quantity; that is, this equality between the radiation and absorption must hold for every individual description of heat.

21. The following experiment illustrates this law:—

The quantity of heat radiated from crown-glass ·05 inch thick, which passes through a crown-glass screen, ·05 inch thick, ...	=0·95
While that from plate-glass ·3 inch thick, covered with blackened paper (the blackened paper being next the pile), which passes through the same screen,	=1·95
But, if the surface of crown-glass ·05 inch thick, farthest from the pile be coated with paper, the polished surface being next the pile, then the amount of radiation which passes the screen, ...	=1·85
And if three plates, the one behind the other, of crown-glass, each ·05 inch thick, be used as the source of heat, the surface farthest from the pile of the farthest off plate only being covered with paper, the amount of radiation which passes the screen, ...	=1·95

Such a plate of glass, or series of plates, therefore, by having the farthest off surface coated with paper, gives out heat similar to that from paper or lamp-black; the reason being, that the heat from the paper on the farthest off surface is as much recruited as it is absorbed by its passage through the glass, both as regards quantity and quality; so that the radiation which falls upon the cone is virtually that from paper or lamp-black.

22. There is little difficulty in explaining why heat from a thick plate of any substance should pass more readily through a screen of the same substance than that from a thin plate. The reason is, that the heat from the interior of the thick substance, having been sifted in its passage, is, therefore, now more easily able to pass through a screen of the same substance.

23. We see also why, generally speaking, bodies at the same temperature radiate the same quality of heat; let us, for instance, take a tolerably thick plate of glass, and a surface of lamp-black, and compare them together. Since the plate of glass absorbs nearly all the rays that fall upon it, it will radiate nearly as much as lamp-black; and since the quality of the radiated is the same as the quality of the absorbed heat, its radiated heat will very nearly have the same quality as that which is radiated by lamp-black.

The Influence of the Reflective and Refractive Powers of Bodies on their Radiation considered.

24. Hitherto, in these investigations, no account has been taken of reflection at the surfaces of the plates, because—1*st*, those rays only were considered which

passed perpendicularly, or nearly so, through such plates; and, 2*d*, because the indexes of refraction for the substances experimented on were not very high.

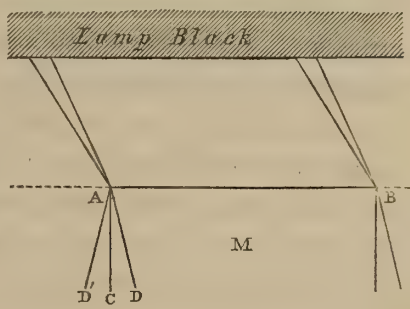
But for rays passing obliquely through such media, or for rays passing in any direction into substances, such as metals, we must take account of reflection from the surface, which will influence materially our results.

Thus, no substance is so opaque for heat as metals, but yet only a small portion of the heat falling on them is absorbed, the rest being reflected back; consequently for such bodies the radiation (which must be equal to the absorption) is very small.

It is also desirable, for another reason, to investigate the laws according to which the reflective nature of the surface of a body influences its radiation. For the question arises, Is the law of an equal and independent radiation of each particle of a body theoretically consistent with equilibrium of temperature? That is, suppose we have any irregularly-shaped inclosure walled round with a variety of substances, and each particle of each substance radiating into the inclosure, from the sides of which it is reflected many times backwards and forwards before it is finally absorbed,—this being the case, will the law of equal and independent radiation, and those of reflection and refraction, so fit with one another, that every particle of the walls of the inclosure shall absorb precisely as much heat as it radiates? It will be endeavoured to show that these laws are so adapted to each other; and I shall select for the proof a definite form and description of inclosure, the conclusions arrived at rendering it highly probable (if not rigidly demonstrating) that the same adaptation will hold good for every inclosure, however irregular or varied.

For those reasons, I shall now endeavour to investigate what connection the radiation of a substance has with the reflective power of its surface; and in doing so (in order to abstract entirely from the effects produced by the variable thickness of the radiating plate), I shall suppose it to be of indefinite thickness; so that all the heat which enters it is absorbed. Our consideration is, therefore, limited to the effects of *one* surface.

25. Let AB be a portion of the line of section of an indefinitely extended surface with the plane of the paper supposed perpendicular to the surface, and let this surface belong to a body (M) of indefinite thickness downwards; also let there be an indefinitely extended surface of lamp-black parallel to this lower surface, as in the figure. Lastly, let the whole be kept at a uniform temperature. In order that the body (M) may be maintained at this temperature, it is necessary that the heat which has left the surface AB, having come from the interior of (M), in the directions contained in any very small angle CAD, shall be replaced by an equal quantity of



heat entering the surface AB, to diverge into the interior through the same small angle CAD. For, by this arrangement, it is clear the particles in CAD get back as much heat as they give out.

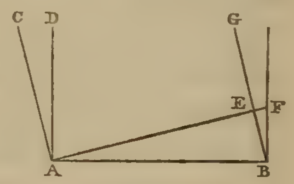
Part of the heat, no doubt, which fell on A in any direction DA, would be reflected back in the direction AD′, making the same angle with the surface as AD; but this loss would be made up for by part of the heat falling on A, in the direction D′A, being also reflected back in the direction AD.

The internal reflection at A being thus compensated for, if the heat that really leaves the medium be also compensated for, then as much heat will be passing at A in the direction AD as will be passing in the direction DA. It will be the same, therefore, as if the body, instead of having a surface at A, were indefinitely extended upwards from A, as well as downwards; in which case, as has been already shown (Art. 20), there will be equilibrium of temperature, provided that the radiation of a particle is equal to its absorption, and that for every description of heat.

Before proceeding further with this investigation, it will be necessary to establish some preliminary propositions.

26. 1*st Preliminary Proposition.*

The heat which falls on the line AB in the directions contained in the very small angle CAD, is the same which falls on AE, perpendicular to EB, through the same very small angle. For every ray which fell on AB passed through AE, with the exception of a small quantity which passed through EF; but the angle EBF being very small, EF is very small compared with AE, and consequently the heat falling on EF may be neglected in comparison with that falling on AE.



It is clear also, that the heat falling on AB is proportional to AB, and to the size of the very small angle CAD.

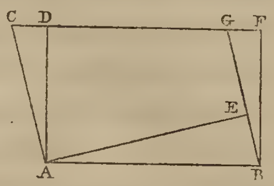
The above will still hold, if, instead of the substance of which AB is the surface being supposed below AB, and the rays falling on it through a vacuum, we suppose the substance to be indefinitely extended upwards, and the rays to originate in the substance itself, and fall on its surface AB.

For, although any ray GE, which falls on E, will be partly absorbed between E and B, it will be as much recruited by the united radiation of the particles between E and B as it was absorbed; so far, indeed, as regards quality and intensity (from what has been already proved, Art. 20), we may consider such a ray to be traversing a vacuum, it being recruited just in proportion as it is absorbed.

It is evident, also, that in this case the quantity of heat falling on AB will be proportional to the size of the very small angle CAD.

27. 2*d Proposition.*

1*st Case.*—If AB represent a surface (the substance being below AB), and CF a surface of lamp-black indefinitely extended (as in Art. 25), from which rays fall on AB through a small angle CAD; then, if AE be drawn perpendicular to GB, the heat that falls on AB will = a constant × AE, whatever be the value of the angle CAB.



For, since the angle CAD is exceedingly small, CD may be considered very small in comparison with CF or CG; therefore the heat which impinges on AB through the angle CAD may be taken to be that which radiates from CG in directions between CA and DA; but, since the radiative power of lamp-black in any direction varies as the sine of the angle which that direction makes with the surface, this will = const. × AE. Hence, if R × CAD be the quantity of heat which falls on AB, when AB is perpendicular to GB, that which falls on it when GB makes any angle GBA with AB, will be R × CAD sin GBA.

If i denote the angle which GB makes with the perpendicular to AB, then the heat impinging on AB will be $R \cos i \times CAD$.

2*d Case.*—If the substance be above AB, and the rays falling on AB originate in the substance, the same formula will hold; for it has been shown, in Prop. 1st, that in this case, the heat falling on AB through the small angle CAD = that which falls on AE through the same small angle; but, since the radiation from the interior of the substance is the same in all directions (each particle radiating independently and equally in all directions), the amount falling on AE will not be affected by the angle which AE makes with the surface; hence the heat falling on AB = const. × AE = const. × sin GBA.

If R′ × CAD = quantity which falls on AB when AB is perpendicular to GB, that which falls on it when GB makes any angle GBA with AB, will be R′ × CAD sin GBA; also the expression corresponding to $R \cos i \times CAD$ will be $R' \cos i' \times CAD$.

28. 3*d Proposition.*

Let a ray strike the surface of a medium, at an angle of incidence $= i$; and another ray at an angle of incidence $i + \delta i$, it is required to find the difference between the two angles of refraction.

Let μ be the index of refraction, then,

$$\sin i = \mu \sin i'$$

Hence,
$$\delta (\sin i) = \mu \delta (\sin i')$$

$$\cos i \, \delta i = \mu \cos i' \delta i'$$

Hence,
$$\delta i' = \frac{\cos i}{\mu \cos i'} \delta i$$

29. I shall also make the following supposition with regard to the laws of reflection and refraction.

1*st*, That if Q represent the quantity of heat falling on the surface of a medium in any direction CA, and aQ be the quantity of heat reflected, then $(1-a)$ Q is the quantity of heat refracted into the medium in the direction AC′. This follows from the law of the conservation of *vis viva*.

2*d*, That if the same heat Q originate in the medium, and strike A in the direction C′A, the quantity reflected back into the medium will be aQ, and the quantity refracted out in the direction AC will be $(1-a)$ Q.

30. These preliminary propositions being established, and suppositions made, let us suppose that heat from the surface of lamp-black strikes the surface AB of the indefinitely thick medium (Fig. Art. 25) through a small angle δi (i being the angle of incidence), by Proposition 2d, the quantity of this heat will be $R \cos i\delta i$; while the part of it which enters the substance we shall call $(1-a) R \cos i\delta i$. These rays will diverge in the substance through an angle $\delta i' = \frac{\cos i}{\mu \cos i'} \delta i$ (Prop. 3).

But the quantity of heat that falls on AB from the interior through this angle will be

$$R' \cos i' \delta i' = R' \cos i' \frac{\cos i}{\mu \cos i'} \delta i = \frac{R'}{\mu} \cos i\delta i,$$

and the portion of this which leaves the medium will be $\frac{(1-a) R' \cos i\delta i}{\mu}$.

Equating this with $(1-a) R \cos i\delta i$, which enters the medium, we have $\frac{R'}{\mu} = R$ or $R' = \mu R$. With this supposition, therefore, the law of an equal and independent radiation of each particle will give us equilibrium of temperature in the particular case under consideration. Had R′ been a function of i', it would have shown that the law of an equal and independent radiation was inconsistent with equilibrium of temperature.

31. Only part, however, of the heat from the lamp-black falling on AB entered into the medium, a portion of it $= aR \cos i\delta i$ being reflected back to the lamp-black, hence the total quantity of heat radiated and reflected which leaves the surface AB through the small angle δi will be $= R \cos i\delta i$, the same as if the substance had been lamp-black, the only difference being, that, in the case of lamp-black, *all this heat is radiated*, whereas in other substances *only part is radiated, the remainder being reflected heat.*

32. Although we have considered only one particular case, yet this is quite sufficient to make the general principle plain. Let us suppose we have an inclosure whose walls are of any shape, or any variety of substances (all at a uniform temperature), the normal or statical condition will be, that the heat, radiated and reflected together, which leaves any portion of the surface, shall be equal to the radiated heat which would have left that same portion of the surface, if it had been composed of lamp-black. And, indeed, we may see, from what has been

already proved, that, should such a state of things only once take place, it would always remain, there being no disposition to alter it.

Let us suppose, for instance, that the walls of this inclosure were of polished metal, then only a very small quantity of heat would be radiated; but this heat would be bandied backwards and forwards between the surfaces, until the total amount of radiated and reflected heat together became equal to the radiation of lamp-black.*

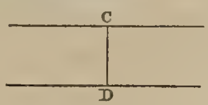
33. The equation $R' = \mu R$ must necessarily hold for every individual description of heat. We have, therefore, two laws necessary to the equilibrium of temperature,—1*st*, That the absorption of a particle is equal to its radiation, and that for every description of heat; 2*d*, That the flow of heat from the interior upon the surface of a substance of indefinite thickness, is proportional *cæteris paribus* to its index of refraction, and that for every description of heat. It will, however, be borne in mind, that the former of these laws has been verified by experiment, while the latter is only deduced from a theoretical investigation. It will also be seen, that by increasing the thickness of the radiating plate indefinitely, the radiation becomes ultimately independent of the diathermancy of the plate and is regulated only by its refractive index.

34. The connection which we have attempted to trace between the refractive and radiative power of a substance, presumes that those rays which we have been considering, have the power of forming wave lengths within the medium under consideration; that is, of being capable of proper reflection and refraction.

It may be, however, that glass and other similar substances are so opaque, with respect to most of the rays of heat of low temperature, as to stop them almost entirely at the surface.

As such rays may, therefore, be conceived to be absorbed within the limit of the physical surface of the medium, the corresponding radiation may be conceived to proceed from this physical surface. To such a case we may perhaps suppose reasoning similar to that of Fourier (as given by Professor Forbes in the

* This will be clearly seen if we consider only those rays that are radiated perpendicular to the surface in the case of two parallel plates of polished metal of the same description radiating to one another. For let r be the common radiation of the point C in direction CD, and of the point D in the direction DC, then since these radiations are bandied backwards and forwards in the directions CD, DC, until they are extinguished, we have the total quantity of heat falling on D in the direction CD (if ar denote the proportion of r reflected after one single reflection) expressed as follows:—



$$\text{Total heat radiated and reflected, falling on D} = \left\{ \begin{array}{c} r + a^2r + a^4r + , \&c. \\ + ar + a^3r + a^5r + , \&c. \end{array} \right\} \begin{array}{l} = r(1 + a + a^2 + a^3) \\ = \dfrac{r}{1-a} \text{ (since } a<1) \end{array}$$

But $1-a$ denotes the absorptive power of the metallic surface (all the heat not reflected being absorbed). Hence, since the radiative powers of bodies are proportional to their absorptive powers (Leslie's Inquiry), 1 being the absorptive power of lamp-black, the perpendicular radiation of a lamp-black point will be $= \frac{r}{1-a}$ which is the very same expression we have obtained for the total heat radiated and reflected together, falling on D, in the same perpendicular direction from the metallic point C.

Philosophical Magazine for Feb. 1833) to be applicable; the intensity of radiation being therefore proportional to the sine of the angle which the direction makes with the surface.

35. Let us now see, in conclusion, whether these investigations seem to point out any connection between internal radiation and conduction.

Now, without in the least affirming that these are identical, there seem to be two points of similarity between them.

1*st*, Since the heat which enters metals is all absorbed at a very small dep th, it follows that the flux of radiant heat from within upon the interior of a metallic surface is derived from a very small depth.

Also, if we allow (what it has been endeavoured to prove, Art. 30) that the flux of heat upon the interior of a surface is proportional to the index of refraction, this flux will be greatest in the case of metals, which may be supposed to have a very high refractive power; besides which, it will, as we have seen, be derived from a very small depth. The radiation of a metallic particle is therefore very great.

Now, if internal radiation be in any way connected with conduction, we might expect that good conducting substances should also be good internal radiators of heat, and we see they are so.

2*d*, The second bond of similarity is this. It seems to be a law that substances are almost invariably more diathermanous for heat of high temperature than for heat of low; consequently, at high temperatures, the radiation of a thin plate or particle of a substance will bear a smaller proportion to the total lampblack radiation of that temperature than at low temperatures. The internal radiations of particles of bodies would therefore diminish at high temperatures (not absolutely, but with respect to the proportion which they would bear to the total radiation of these temperatures). If the same rule holds for metals, and conduction be connected with internal radiation, we should expect that at high temperatures the conducting power of metals would be less than at low temperatures. Now this has been proved to be the case by Professor FORBES.

9*th March* 1858.

II.—*On the Constitution of Flame.* By William Swan, Esq.

(Read 17th January 1859.)

If we examine the flame arising from the combustion of any of the hydro-carbons, such as that of coal-gas, or of a common candle, it will be found to consist of several portions easily distinguishable by the eye, and in which the matter composing the flame exists in very different conditions. There is, *first*, a central non-luminous region, in which the gases are not yet ignited; *secondly*, a blue conoidal envelope, extending from the wick or burner, and gradually thinning out towards the top of the flame; *thirdly*, a more or less luminous conoid, thin towards the bottom of the flame, where it is enveloped by the blue conoid, but thicker towards the top. And *fourthly*, a faintly luminous outer envelope, completely surrounding the other portions of the flame, and greatly developed towards the top.

In the blue part of the flame, where the supply of oxygen is abundant, the carbon seems to undergo combustion in a gaseous state along with the hydrogen. In the interior luminous region, where there is less free oxygen, carbon is disengaged in a solid form, and the brilliant light which is generated arises from the incandescence of its particles. The exterior envelope is supposed to consist of matter which has undergone combustion, but which is still at so high a temperature, as to be incandescent.

When a flame is urged by a blow-pipe, a large supply of oxygen is forced into it. The greater portion of the carbon, which otherwise would have appeared in a solid form, before undergoing combustion, is consumed in a gaseous state. The blue part of the flame thus becomes greatly developed, and appears as a sharp well defined cone; while the faintly luminous envelope surrounding it also assumes a regular conical form. The inner blue and outer faintly luminous cones are well known to chemists as possessing very diverse properties. In the outer cone, from the presence of an excess of oxygen, bodies become rapidly oxidated; while in the inner cone, from the redundance of uncombined inflammable matter, a powerful deoxidizing energy is exerted. Such are the principal facts hitherto recognised regarding the constitution of flame.

Two years ago, when I was engaged in a series of experiments on the prismatic spectra of the flames of the hydro-carbons, my attention became directed to Professor Draper's very ingenious paper, "On the Production of Light by Chemical Action," in the 32d vol. of the *London Philosophical Magazine.* In that paper, the author advances an entirely new view regarding the nature of flame, founded on the principle, that "There is a connexion between the refrangibility of the light which a burning body yields, and the intensity of the chemical action going on; and that the refrangibility always increases as the chemical action increases."* On this principle, Professor DRAPER reasons as follows:—"All common flames, as is well known, consist of a thin shell of ignited matter, the interior being dark, the combustion taking effect on those points only which are in contact with the air. From the circumstances under which the air is usually supplied, this ignited shell cannot be a mere mathematical superficies, but must have a sensible thickness. If we imagine it to consist of a series of strata, it is obvious that the phenomena of combustion are different for each. The outer stratum is in absolute contact with the air, and there the combustion is most perfect; but by reason of the rapid diffusion of gases into one another, currents, and other such causes, the atmospheric air must necessarily pervade the burning shell to a considerable depth; and in the successive strata, as we advance inwards, the activity of the burning must decline. On the exterior stratum oxygen is in excess, at the interior the combustible vapour, and between these limits there must be an admixture of the two, which differs at different depths." Admitting the principle already enunciated, Professor DRAPER adds,—"It follows, that each point of the superficies of every flame, no matter what the combustible may be, must yield all the colours of the spectrum, the violet coming from the outer strata, the yellow from the intermediate, and the red from those within. If we could isolate an elementary horizontal section of a flame, it should exhibit the appearance of a rainbow ring."†

The results I had obtained in my experiments, led me to doubt the correctness of these views; for I found, that while the envelope of a hydro-carbon flame formed an absolutely *continuous* spectrum, extending from about the line C nearly to the line H of FRAUNHOFER, the bright inner cone formed a totally independent spectrum of superior brilliancy, also quite *continuous*, and of still greater extent; and the blue cone had a remarkable interrupted spectrum, peculiarly its own, whose extreme visible portions lay, respectively, between the lines D and E, and close to the line G of FRAUNHOFER. While my experiments thus amply confirmed what was already known regarding the very diverse character of the different portions of a hydro-carbon flame, they at least did not corroborate the idea of the refrangibility of its light, varying from its outer to its inner regions. Thus, the envelope, the blue conoid, and the bright conoid, which successively enclose each other, all produce spectra, having rays corresponding with the lines B and G of FRAUNHOFER; lines which differ greatly in refrangibility. It was, moreover, a matter of perfect indifference, so far as I could ascertain, from what precise point the light was derived. Whether the light were taken from near its outer

* Philosophical Magazine, vol. xxxii., p. 103.

† Ibid., vol. xxxii., p. 104–105.

or inner surface, each conoid always produced its own peculiar spectrum, or rays of the same refrangibility. In describing my experiments, however, I purposely made no reference to Professor DRAPER's peculiar views, for I had not then had leisure to examine them with sufficient care. The object of the present paper is to state the result of a careful repetition of the principal experiments by which Professor DRAPER conceives he has demonstrated the existence, in flame, of concentric layers producing light of varying degrees of refrangibility.

Professor DRAPER's method of analysing the light of a flame, which is exceedingly ingenious, is thus explained by him. "The instrumental arrangement I have employed is as follows:—The rays of the flame, of which the examination is to be made, pass through a horizontal slit one-thirtieth of an inch wide and one inch long in a metallic screen, and are received at a distance of six or eight feet on a flint-glass prism, the axis of which is parallel to the slit. After passing the prism, they enter a small telescope, which has a divided micrometer, and also parallel wires in its eye-piece. Through this telescope the resulting spectrum is viewed."* The reason why the slit is placed horizontally, and the light refracted in a vertical plane, he states to be as follows:—"In this arrangement the slit should be horizontal, and not vertical. So far from its being immaterial which of the two positions is selected, very great advantages arise from the former. If the slit be vertical, the prism, it is true, will separate the constituent colours from one another; but it fails to show their relative position. If it be horizontal, the relative positions of the different colours can be demonstrated; and it can be proved that a horizontal section of a flame is in reality, as has been already remarked, a coloured ring, the red being the innermost colour, and the violet outside; for if this is the order in which the colours occur, the red ring must necessarily have a less diameter than the green, and the green than the violet; and when the prism, set in a horizontal position, separates those colours from each other, the sides of the resulting spectrum ought not to be parallel, but inclined to one another, the breadth being least in the red, and increasing as we pass to the violet end." "This being understood, I may illustrate the facts now to be brought forward by an example of the prismatic analysis of a horizontal element of the flame of a spirit-lamp, it being understood that the prism is at its angle of minimum deviation, and the spectrum seen through the telescope. All the prismatic colours, in their proper order, are visible, the sides of the spectrum not being parallel, the inclination being quite rapid towards the red extremity, the rays of which come from the interior of the flame where the diameter is less. Mere inspection is sufficient to show the rapid approach of the red sides to each other; and I satisfied myself that even in the more refrangible regions there is the same want of parallelism, by rotating the telescope on its vertical axis, so that the vertical wires in its eye-piece might coin-

* Ibid., pp. 101–2.

cide with first one and then the other side of the spectrum." "But further, the yellow space of such a spirit-flame spectrum is crossed by a bright fixed line—Sir David Brewster's monochromatic ray. It is a beautiful example of the principles just pointed out in this method of horizontal analysis, being of much greater width than the rest of the spectrum, and recalling to the imagination the appearance of Saturn's ring when nearly closed, and seen through a telescope of moderate power. This ray, from its superior breadth, must necessarily come from that pale, tawny light which invests the bright part of the flame."* On this statement I will meantime only remark, that while, according to Professor DRAPER, the yellow space corresponding to the line D of FRAUNHOFER, has a much greater width than the rest of the spectrum, and while the inclination of the sides towards the red end of the spectrum is described as being "quite rapid," mere inspection sufficing to observe it, no such marked variation in breadth was observed in the more refracted portions of the spectrum. Professor DRAPER says, he "satisfied" himself that even in the more refrangible regions there is the same want of parallelism by rotating the telescope on its vertical axis, so that the vertical wires in its eye-piece might coincide with first one and then the other side of the spectrum." From this it is obvious that the supposed want of parallelism in the more refracted portion of the spectrum was so small as to be insensible to the unassisted eye, and required instrumental means for its detection. We are told that the breadth of the spectrum was ascertained by rotating the telescope on its *vertical* axis, so as to cause the wires in the eye-piece to coincide, alternately, with first one and then the other side of the spectrum; but we are nowhere informed in what manner the *amount* of the rotation was ascertained. It seems, however, to be highly probable, that since it took place round a *vertical* axis, the readings in the two positions of the telescope would give *the difference of azimuths* of the two sides of the spectrum. It is to be regretted that Professor DRAPER has not described his method of observation more explicitly; for I shall show in the sequel that the validity of his results depends entirely on whether the observations were, or were not, observations of azimuth.

I will now describe my own experiments. The flame to be observed was placed behind a horizontal metallic slit, 0·05 inch in width, and of sufficient length to allow the entire breadth of the flame to be seen. To prevent the disturbing effects of currents of air, the flame was surrounded by a four-sided sheet-iron chimney, having on the side next the slit an aperture covered by a piece of fine sextant glass, through which the light passed to the slit without undergoing any irregular refraction capable of affecting sensibly the results. The prism used was kindly lent me by Professor FORBES. It is a fine flint-glass prism, the workmanship of Secretan of Paris. The instrument employed for observing the spectrum was an excellent theodolite, constructed expressly for

* Ibid., pp. 106–7.

observations of prismatic spectra, by the late Mr JOHN ADIE. The telescope of this instrument is attached to an arm turning on the centre of a divided circle, so that the axis of the telescope is always in the plane of the circle. The stand which carries the prism also turns, independently, on the centre of the circle; so that although the telescope be moved through any angle to observe the rays refracted by the prism, the prism itself suffers no displacement. The prism-stand has screws by which the faces of the prism are made perpendicular to the plane of the circle. The circle was mounted on a temporary, but firm stand, so that its plane was vertical; and the distance of the prism from the flame was 15½ feet nearly. During the observations, the prism suffered no displacement, except the very small one occasioned by turning it round its own axis, to bring it to its positions of minimum deviation for the different rays of the spectrum. The rotation necessary to effect this could not exceed, from the ascertained dispersive power of the prism, an angle of 2°; so that the length of the path of rays proceeding from the flame through the prism to the eye was nearly constant; and hence the apparent distance of the flame, and its angular breadth, was sensibly the same in all positions of the telescope and prism. The telescope has a good object-glass of 1·6 inch aperture; and, with the eye-piece used in the observations, magnified twenty-one times. It is furnished with a micrometer, having a fixed wire in the centre of the field, and a moveable cross of wires.

The observations were made by first carefully adjusting the telescope to focus, and the prism to its position of minimum deviation. By means of a screw connected with the stand, the circle carrying the prism and telescope was moved round a vertical axis until the fixed micrometer wire coincided with one side of the spectrum. The moveable cross was then, by means of the micrometer screw, made to coincide with the other side of the spectrum; and the turns and parts of a turn of the screw read off. From the previously ascertained deviations by the prism for the principal lines of FRAUNHOFER, and the theodolite reading when the slit was viewed directly, it was easy to place the telescope so as to observe rays of any given refrangibility. Those chiefly observed corresponded with the lines B, *b* and G of FRAUNHOFER. It did not seem expedient to observe the extreme rays of the spectrum, as the faint illumination of these rays rendered their observation both difficult and unsatisfactory. The flames first examined were those of coal-gas, burned from a common jet with a single aperture. The spectrum observed was that of the luminous incandescent carbon conoid of the flame. The gas was supplied directly from the street pipes; but it was passed through one of MILNE's regulators, in order to guard against the effects of varying pressure in altering the size of the flame. The flame, although subject to periodical fits of elongation, and slight lateral displacement, speedily returned to a nearly constant condition, and the observations were upon the whole satisfactory. They are exhibited in the following tables:—

Observations of the Breadth of the Spectrum of a Coal-gas Flame.

Line of Spectrum Observed.	First Set of Observations.	Second Set of Observations.	Third Set of Observations.
B	157	125	103
b	152	124	105
G	153	123	102

The numbers in the table are, in the first set of observations, the means of seven micrometer readings, and in the second and third sets, the means of twenty-four and eight readings respectively.

It will be seen that so far from the spectrum increasing in breadth towards its most refracted extremity, the measured breadths at the line G in the blue rays, are actually in every case less than those at the line B in the red rays of the spectrum.*

Having found the flame of gas, notwithstanding every precaution, to be subject to anomalous fluctuations, and being desirous, moreover, to repeat Professor Draper's experiments as faithfully as possible, I next observed the flame of a spirit-lamp fed by alcohol. It will be remembered that the spectrum of the flame of alcohol is that which he describes to illustrate his views. I did not anticipate, however, that such a flame would be convenient to experiment upon, from the faintness of its light; and, in effect, I found it was impossible to illuminate the field, so as to be able to see the wires without rendering the violet end of the spectrum invisible. I therefore observed with faintly illuminated wires on a dark field; and, instead of making contacts with the wires at different points of the spectrum, I varied the mode of observation, by carefully adjusting the wires to the breadth of the spectrum at its red end, and then "sweeping" its whole length. The wires seemed to *fit* the spectrum equally well at all points, so that no variation in breadth could be detected.

In order to avoid the difficulty of observing a faint spectrum, and at the same time to obtain a flame which would remain sensibly of the same size for a considerable time, I devised the following method. Volatile liquids, such as naphtha or turpentine, seemed preferable to the fixed oils, because, from their greater fluidity and freedom from viscid matter, they flow more freely through a cotton wick, and less rapidly impair its transmitting power; while from their volatility, and consequent rapid evaporation, the wick remains cool, and is scarcely at all burned. Both conditions are highly favourable to the maintenance of a constant

* It may be proper, in order to explain the different values for the same line of the spectrum in the different sets of observations, to remark that these were made on different days, and on flames of different dimensions.

flame. There was, however, an inconvenience to be anticipated. Most of the hydro-carbons which burn brightly, such as turpentine, are so rich in carbon that they produce a very smoky flame; and when they are employed to give light, as in the common camphine and paraffine oil lamps, special arrangements are needed for consuming their smoke by directing a powerful current of air against the flame. It was not convenient to adopt any of these arrangements; and it occurred to me that I should obtain a smokeless, but sufficiently brilliant flame by burning a mixture of two liquids, the one rich, and the other poor, in carbon, such as turpentine (C_5H_4) and alcohol ($C_4H_6O_2$). The liquids I selected were common coal naphtha and wood spirit; and I found that a mixture of about three volumes of commercial wood spirit to one volume of coal naphtha produces a flame neither less brilliant, nor more smoky, than that of an ordinary wax taper.*

I may remark, that, for the purpose I had in view, there seems no objection to the use of such a compound liquid as I have described; for I have shown elsewhere that all the hydro-carbons in burning produce similar spectra,—the only difference being, that the spectrum produced by the incandescent solid carbon, or by the envelope of the flame, is brighter in some cases than in others.

The following tables contain the observations made on the flame of a mixture of coal naphtha and wood spirit:—

Observations of the Flame of Coal Naphtha and Wood Spirit.†

First Set of Observations.

Line B.		Line *b*.		Line G.	
	130		138		133
I.‡	135	II.	135	III.	130
	134		136		131
	138		140		129
VI.	135	V.	139	IV.	140
	136		133		133
Means	134·67		136·83		132·67

Mean observed breadth of spectrum = 134·72.

* This flame might be used for household purposes, and probably also with advantage in experiments where an invariable source of light is wanted. The liquids, although both smell disagreeably, emit no perceptible odour in burning.

† Each number in this and the following table is a single micrometer reading.

‡ The observations in this and the following table, on the various lines of the spectrum, were made in the order of the numbers I., II.....VI., in order to eliminate the effect of any gradual change in the dimensions of the flame.

Second Set of Observations.

Line B.		Line *b*.		Line G.	
	125		127		127
I.	126	II.	126	III.	124
	125		128		128
	124		129		127
VI.	130	V.	130	IV.	127
	130		130		124
Means	126·67		128·33		126·17

Mean observed breadth of spectrum = 127·06.

In the following tables the above numbers have been corrected by subtracting the index error of the micrometer = 6·52.

Comparison of Observations.

	First Set of Observations.		Second Set of Observations.	
Mean Breadth.	128·20	Difference from Mean Breadth.	120·54	Difference from Mean Breadth.
Breadth at B, .	128·15	−0·05	120·15	−0·39
„ *b*, .	130·31	+2·11	121·81	+1·27
„ G, .	126·15	−2·05	119·65	−0·89

*The Observed Dimensions of the Flames reduced to inches.**

	First Set of Observations.		Second Set of Observations.	
Mean Breadth.	·20493	Difference from Mean.	·19268	Difference from Mean.
Breadth at B, .	·20484	−·00009	·19206	−·00062
„ *b*, .	·20830	+·00337	·19471	+·00203
„ G, .	·20167	−·00326	·19126	−·00142

* These dimensions were derived from the numbers in the preceding tables by multiplying by 0·0016, the value of a micrometer division in inches; and that was ascertained by observing an accurate inch ivory scale placed in contact with the slit through which the flame was viewed.

These observations completely verify the results obtained with the flames of coal-gas and of alcohol. It will be seen that the greatest observed difference in breadth between the red and blue regions of the spectrum was only ·003 inch, a discrepancy fairly within the limits of errors of observation. The observations, therefore, lead to the conclusion, that the structure which Professor DRAPER supposes to occur in flame has really no existence.

The question now arises, how are we to explain the inequality in breadth of the spectrum, as observed by him? There seems certainly considerable difficulty in accounting for the "rapid inclination of the sides at the red end of the spectrum," which he describes. From the effect of irradiation, every spectrum will appear slightly broader towards the middle, where the light is more brilliant, than towards the ends where it is comparatively feeble; a fact illustrated by my own observations, which exhibit a greater observed breadth at the line *b* of the spectrum than at the lines B and G. Now, as the brightest point,—about the line D,—occurs in the spectrum of a flint-glass prism much nearer the red than the violet extremity, the variation in brightness will be much more rapid from the extreme visible red rays to the line D, than from the line D to the extreme violet rays. Hence we may expect any apparent inequality of breadth, due to irradiation, to be most conspicuous at the red end of the spectrum, where the brightness of the light varies most rapidly. I have not, however, observed any contraction in breadth at the red end of the spectrum, which I should describe as "rapid;" and any notable contraction certainly did not extend beyond the line B.

The apparent want of parallelism which Professor DRAPER conceives he has discovered by instrumental means in the more refracted portions of the spectrum admits however of an easy explanation, if I have rightly understood his method of observation. It will be recollected that this seems, from his description, to have consisted in measuring the difference of azimuths of the two sides of the spectrum. Now, such a process could not fail to give erroneous results; for it may be easily shown, that if

d = the angular horizontal breadth of the spectrum at any point,
z = the zenith distance, and
θ = the observed difference of azimuths of the sides of the spectrum,

$$\text{Sin } \tfrac{1}{2}\,\theta = \sin \tfrac{1}{2}\,d \operatorname{cosec} z;$$

or if d and θ be small,

$$\theta = d \operatorname{cosec} z.$$

Now, z varies from point to point of the spectrum; whence the observed breadth θ would also vary, even although the true breadth d remained constant.

Moreover, the flame would probably be placed about the same level with the observer's eye, so that its zenith distance, when viewed directly, would be nearly 90°. According, therefore, as the light was refracted upwards or downwards, z

or $180° - z$ would be least, and consequently θ would be greatest, for the most refrangible rays: and the spectrum would appear wider towards the more refracted end.

This may possibly explain the difference of breadth in the more refracted regions, as actually observed by Professor DRAPER—a difference confessedly *small* —even although irradiation, by increasing the apparent breadth of the brighter and less refrangible regions of the spectrum, must have produced a slightly compensating effect.

I must not omit referring here to one of Professor DRAPER's observations, which I have completely verified, namely, the greatly superior breadth of the yellow line R of FRAUNHOFER, when observed by his method, compared with the rest of the spectrum. The reason he assigns for this striking phenomenon is unquestionably correct, namely, that the homogeneous yellow light of a flame proceeds from its envelope. It must not be supposed, however, that this fact affords the slightest evidence in favour of his peculiar views regarding the constitution of flame; for I have elsewhere shown,* that the *envelope* of a flame produces light of *all* degrees of refrangibility between the limits (nearly) of the lines D and G of FRAUNHOFER, while rays of precisely the *same* degrees of refrangibility are produced by the *bright interior* conoid of the flame.

I will now advert to an objection which I can imagine may be made to the conclusion I would derive from my observations. It may be argued, that if such a connexion exist between the temperature of combustion, and the refrangibility of the resulting light, as Professor DRAPER assumes, and if he be correct in thinking that the temperature of a flame increases from the interior to the exterior, then there must be a series of strata of different colours, even although observation may fail in detecting them. To this I would reply, that the instrumental means I have employed were certainly capable of detecting any such structure, provided its thickness was not much less than ·005 inch; and if we suppose it confined to such narrow limits, it must cease to be regarded as the general structure of the flame, whose walls greatly exceed such a thickness. If, moreover, we adopt the notion of such an extremely thin stratum of varying colour, it will be difficult to imagine so great a variation of temperature from point to point of its very small thickness as will be necessary to produce the corresponding diversity of colour, which is supposed to exist.

Having now shown that a careful series of experiments have failed to afford any evidence in favour of Professor DRAPER's theory of the constitution of flame, I will next examine the reasoning by means of which he endeavours to demonstrate his views *a priori*. It seems to me that he makes two quite gratuitous assumptions. If we refer to his experiments on the "Production of Light by

* Edinburgh Transactions, vol. xxi., p. 71.

Heat,"* we shall find that an ignited slip of platinum, at the temperature of 1210° Fahrenheit, produced a spectrum extending from the line B nearly to the line F of Fraunhofer. Hence the supposed innermost ring of a flame which produces light of no higher refrangibility than that of the line B, ought, on Professor Draper's principles, to have a considerably *lower* temperature than the platinum slip. Now, considering the well-known extremely high temperature of flame, are we entitled to assume that any luminous portion of it has so low a temperature as 1210° of Fahrenheit?

If, further, we examine the experiments which Professor Draper adduces to prove that increased temperature produces light of increased refrangibility, we shall find that these were either observations of the spectra produced by a strip of platinum whose temperature was varied by transmitting through it a voltaic current of varying power, or observations of the spectra arising from a piece of ignited charcoal brought to a high temperature by means of a stream of oxygen, and then allowed to cool. It was found, in either case, that, as the temperature rose, rays of continually higher refrangibility were produced, which in their turn successively disappeared as the temperature fell. It must, however, be borne in mind that rays of *high* were always accompanied by rays of *low* refrangibility. Thus, when the temperature of the platinum rose from 1210° Fahrenheit to 2130°, the spectrum lengthened from the line F to the line H of Fraunhofer; but at *both* temperatures it reached to the line B in the *red;* and, at the *higher* temperature, it actually extended *farther* than at the lower, towards the extreme red rays of the solar spectrum. It therefore follows, that the higher the temperature, not only the *more* refrangible, but the *less* refrangible are the rays which are produced. This fact, most important in its bearing on the question we are discussing, seems to have been completely overlooked by Professor Draper in his speculations on flame. Assuming that a point at the outer surface of a flame is of higher temperature than one inside, he argues that the outer point will produce rays *exclusively of a certain high degree of refrangibility,* while the inner point will produce *less refrangible rays;* while the correct deduction from his experiments simply is that the outer point will produce a *more extended spectrum* than the inner. The outer point might alone produce light of high refrangibility; but both in common would produce light of low refrangibility. Professor Draper's method of analyzing flame would therefore fail in exhibiting a spectrum with converging sides; for the extreme red rays would be emitted by the outer as well as by the inner regions of the flame; and, consequently, the red end of the spectrum would be of the same breadth as the violet. All, therefore, which can be fairly deduced from his principles is, that the outer regions *may* produce a longer spectrum and a brighter light than the inner; but there seems great reason to doubt whether

* Philosophical Magazine, vol. xxx., p. 349.

the difference of temperature at different points of a flame be really so great as to affect the quality of the light to an appreciable extent.

This will appear, if we adopt a method of examining flame, much simpler than prismatic analysis, and, for the purpose, probably more delicate. I mean simply looking at the flame. If the doctrine of concentric rings of various colours were really true, we should perceive, on looking through the flame in a line passing near its centre, the resultant tint due to the combination of all the colours in nearly equal proportions. But if we looked through the edge of the flame, the line of vision would cut each successive coloured ring more and more obliquely as it passed towards the interior of the luminous matter. We should therefore look through a greater thickness of the inner rings than of the outer. The result would be to give a preponderance to the inner tints, so that the apparent colour of the flame would vary from the middle towards the edges, at first slowly, then more rapidly, until at length, at the edges, we should see only the colour of the very outermost ring. I have failed to detect any such variation of colour in the flames I have examined. I therefore infer that each of the three conoids of a hydro-carbon flame has sensibly the same tint throughout its entire thickness.

In my paper on the spectra of the flames of the hydro-carbons, I have described experiments which lead to the same conclusion, but to which I can only here refer, without entering into details. There is, however, one experiment, which is easily performed, and which I have not before described. By holding a piece of plate-glass over the smokeless flame of a Bunsen lamp, and looking downwards through the glass, a tolerably good horizontal section of the flame is obtained. It is then seen that both the inner blue cone and the envelope of the flame are sensibly homogeneous in colour throughout their entire thickness.

We may also verify a conclusion which I have stated in the paper already referred to, namely, that when common salt is placed in a flame, the envelope alone becomes yellow, while the inner blue cone remains unaltered in colour. This is strikingly apparent on looking down in the manner described, and introducing salt into the flame. The outer mantle changes at once from purple to bright yellow, while the inner blue conoid remains quite unaltered in tint; and this is the case, whether the salt is brought into contact with the outer mantle or the inner conoid. Possibly this phenomenon may be explained by supposing that the sodium of the salt is reduced to the metallic state by the free hydrogen of the inner conoid, and that its vapour burns exclusively in the outer mantle, producing the yellow tint only in that region of the flame.

III.—*On the Gradual Production of Luminous Impressions on the Eye:* Part II. *being a description of an Instrument for producing isolated luminous impressions on the eye of extremely short duration, and for measuring their intensity.* By William Swan, F.R.S.E., Professor of Natural Philosophy in the University of St Andrews.

(Read 4th April 1859.)

In 1849 I presented to the Royal Society of Edinburgh a paper "On the Gradual Production of Luminous Impressions on the Eye." The object of that communication was to investigate the laws of the production of visual impressions. The subject was then new; for although the fact that light requires a certain time to produce its full effect on the eye had been noticed at comparatively early periods, yet no one, so far as I am aware, had attempted to *measure* that time; and the whole subject of the production of visual impressions, regarded as a branch of experimental science, was quite untouched.* I have frequently wished to resume a subject of inquiry which seems to me to merit more attention than it has hitherto received, and which I have not as yet been able to discuss so completely as I could have desired. Various portions of it demand more extended experiments. Among these may be specified, the examination of isolated impressions of shorter duration than my limited instrumental means had enabled me to observe; a more careful determination of the time required for light to produce its complete effect on the eye; and a series of observations on the eyes of various individuals, so that any personal peculiarity of vision, which might affect results derived exclusively from experiments on my own eye, might be eliminated. These, and other subjects of inquiry, I hope sooner or later to overtake; and, indeed, I had anticipated before the end of the present session of the Society to have been able to obtain some experimental results. In this I have been disappointed, owing to the instruments required for my observations having taken a much longer time to make than I had expected.

The observations of impressions of very short duration is attended with much difficulty. The method of observation which I devised in 1848 is to cause a disc, with a sector cut out of it, to revolve with an uniform velocity between the eye and a luminous object. At each revolution a flash of light is perceived as the sector crosses the line of vision,—the time during which each flash acts on the eye depending on the angle of the sector and the velocity of rotation of the disc. The brightness of the resulting visual impression is ascertained by photome-

* See Moigno, "Repertoire d'Optique," vol. ii., p. 563.

trical arrangements, which are fully described in my paper.* By such means I succeeded in measuring the brightness of luminous impressions caused by light acting on the eye for short intervals of time, varying from a tenth to a thousandth of a second.

There are obvious limits to the applicability of this method of experimenting when it is attempted to examine isolated impressions of excessively short duration. To shorten the impression, we may either diminish the angle of the sector or increase the velocity of the disc, but whichever of these methods we adopt, we very speedily arrive at limits which either cannot be overpassed at all, or can only be so at the cost of great inconvenience. The velocity of the disc is absolutely limited. If we attempt to drive it faster than about 10 revolutions per second, the successive flashes become blended into a single impression, more or less uniform; and as the eye no longer distinguishes them as separate, so we can no longer perceive, or measure, their separate intensities. Again, if we shorten the impressions by diminishing the angle of the sector, we quickly arrive at a practical limit from the smallness of the angle required, even with a disc of considerable diameter. This difficulty may be overcome in theory by increasing the diameter of the disc, while the sector is made of the smallest practicable angle; but a very large disc would obviously be an extremely inconvenient instrument to work with.

I have from time to time thought of various mechanical expedients, more or less feasible, for obviating this difficulty, but I have never been sufficiently satisfied with any of them to attempt their construction. Last autumn, however, I devised an arrangement so simple that I resolved to put it in practice. Suppose a disc with a sector cut in it to revolve between the eye and a light 100 times per second. The eye would in every second receive 100 impressions, and if the sector were $\frac{1}{1000}$th of the circumference of the disc, each impression would be made in $\frac{1}{100000}$th of a second; but, from the high velocity of rotation, the observer would be conscious only of an uniform light,—the aggregate of all the nearly instantaneous flashes blended into a single impression. The instrument which I have to describe has for its object to select a *single* impression out of the *hundred*, to convey it to the eye isolated and alone, and to measure its brightness; while the remaining 99 impressions which would have interfered with its effect are intercepted, and excluded from the field of view. From the disc revolving 100 times in a second, the eye will then receive, once a second, a single isolated impression, lasting for the extremely short period of $\frac{1}{100000}$th of a second. This result admits of being obtained by the very simplest possible means; in fact, I have found it unnecessary to employ any mechanical agent whatever, other than the train of wheels by which motion is communicated to the disc.

* Edinburgh Transactions, vol. xvi., pp. 583–587.

The nature of this arrangement will be understood from fig. 1, Plate I., in which A, B, C, *a*, *b*, *c*, represent a train of toothed wheels and pinions driven by a weight suspended from a line, which is coiled round a drum on the axis of the wheel A, and by which motion is communicated to the disc D. The wheels B, C have each 120 teeth, and the pinions *b*, *c*, 12 teeth; so that if B revolve once in a second, C revolves 10 times, and D, 100 times in a second. Apertures I, K are cut in the wheels, which are otherwise *solid*, and the whole is so arranged, that the apertures I, K, the sector S, and the aperture T in a screen H illuminated by a light F, are in the same straight line; so that an observer at E can see the illuminated aperture I through the holes in the wheels and the sector in the disc. Since the wheels B, C, and disc D revolve respectively once, ten times, and a hundred times in a second, if the apertures are *in line* at the commencement of any one second, they will again come into line at the commencement of each successive second. Suppose the wheel B to be removed, the wheel C and disc D continuing to revolve. By the time the disc D has made a single revolution, the aperture K has moved round so far that when the sector S has returned to its original position, the wheel C intercepts the light; and it is obvious that K will not return to its proper position for transmitting light to the eye until the wheel C has made a complete revolution. The effect of the combination of the wheel C and disc D will therefore be to transmit to the eye a single impression at every revolution of C, or at the end of every $\frac{1}{10}$th part of a second. Supposing, as before, that the sector D is $\frac{1}{1000}$th of the circumference, the eye will receive only 10 impressions in a second, each of which has been made in $\frac{1}{100000}$th part of a second. We may now dismiss the disc D from our consideration, and regard the wheel C as a disc revolving 10 times per second, and having an excessively narrow sector cut in it, occupying $\frac{1}{10000}$th of its circumference. By repeating precisely the same reasoning for the wheels B and C as has been employed for the wheel C and disc D, it will be seen that the wheel B will transmit to the eye a single impression at each revolution, or once a second, derived from the wheel C. The wheel B will therefore transmit to the eye a single impression in a second, which has acted on the eye for $\frac{1}{100000}$th of a second, and will thus be equivalent to a disc revolving once a second, and having a sector of only $\frac{1}{100000}$th part of its circumference. It will be seen also, that as the smallest practicable angle for the sector is obviously the same, whatever be the size of the disc, the effect of the arrangement will be to make a disc of a foot in diameter equivalent in efficiency for observing *short* impressions to one of 100 feet in diameter.

It may, at first sight, be supposed that only a single *screen-wheel*, as it may be called, such as C or B, would be required. Such, however, is not the case. The wheel C alone would be insufficient; for when the disc D was driven with high velocities, C would revolve so fast that its transmitted impressions would become blended by their persistence on the retina. The wheel B alone would likewise be insufficient, for the disc D revolves so fast compared with B that the sector S would have returned to its position for transmitting light before the hole I had time to get out of the line of vision.

It is obvious that the arrangement might be extended to any number of wheels, the only remaining practical difficulty being that of driving a train of toothed wheels at very high velocities. If this should render it impossible to observe impressions so short as may be desired, there are two methods which may be adopted. The disc itself may be driven directly by a reaction machine, or Barker's mill, the train of wheels then serving merely as *screens* and registers of the number of revolutions made by the disc. Impressions of very short duration might also be obtained by substituting for the disc a small revolving mirror, like Wheatstone's. The mirror attached, with its plane parallel to the axis on which it revolves, receives the light of a flame which has passed through a narrow slit parallel to the axis, and at a considerable distance from it. The light reflected by the mirror falls upon the surface, whose brightness is to be observed, and illuminates each portion of it for a short interval of time, depending on the width of the slit and the velocity of the mirror. Impressions of extremely short duration could thus be obtained, for a small mirror could be driven at a much higher velocity than a disc, which, from its considerable size, experiences great resistance from the air; and the narrow slit would become equivalent to a sector of corresponding width, cut in a very large disc, revolving with twice the angular velocity of the mirror, and having a radius equal to the distance of the slit from the axis of revolution.

I have designed an instrument on the principles now explained, which has been constructed for me by Messrs James Milne and Son of Edinburgh, and which is represented in fig. 2.

The instrument consists of a solid cast-iron frame A A, carrying a train of wheels B, C, D, E, by which the disc F is driven. Motion is communicated to the wheels by a weight suspended from a cord coiled round the barrel G. Each of these wheels B, C, D, E has 120 teeth; the pinion *b* has 30 teeth, and the remaining three pinions, of which only *d* and *e* are shown in the figure, have each 12 teeth. The wheels B, C, D and the disc F are each 6 inches, and E is 3 inches in diameter.

From the numbers of teeth in the wheels and pinions, it is obvious that for each revolution of the wheel D the wheel E makes 10, and the disc F 100 revolutions; and by means of a train of gas-meter index-wheels H K, to which motion is communicated by the wheel I on the axis of the wheel D,—I and H having the same number of teeth—the number of revolutions made by the disc F is readily ascertained. To facilitate counting the revolutions, the frame carrying the wheels H K turns on a pivot about half-way between H and K, and is pressed by a spring near H against a stud in the frame A, so as to be kept in gear with the wheel I. A lever L turns an eccentric in contact, near K, with the frame carrying the wheels H, K; and, by moving the lever a little to the right or left, the train of gas-meter wheels is instantly put in or out of connexion with the wheel I. The gas-meter wheels having been adjusted by the hand until their indices read zero, they are put in gear with I, and allowed to remain so for a minute or other definite time. The number of revolutions of the disc F in a second will obviously be 6000 times the number of revolutions of the wheel H registered by the gas-meter train in a minute.

The disc F is an accurately turned plate of brass 0·1 inch in thickness, strengthened by a narrow flange round its circumference, rising 0·1 inch from its plane. An arm of brass M O turns on the axis *e*, independently of the disc. In the disc there is cut an aperture at *h f*, embracing 20° of the circumference; but the effective opening is formed by the knife edges *f g* of the moveable arm M O and *h i* of a fixed piece of brass N *h*. The edge *f g* is carefully filed to radiate from the centre of the disc, and N *h* is screwed to the disc, with its edge *h i* fitting accurately to *f g*, so that when the arm M O is moved away from the piece N *h*, the opening *f g h i* forms a portion of a sector of a circle. The piece M O has its surface in the same plane with the edge of the flange, and accurately fits its inner circumference. An arc of 40° is divided on the edge of the flange, and the arm M O carries a vernier reading minutes. It is obvious that the angle of the sector *f g h i* can be accurately ascertained by taking the difference of the vernier readings when the aperture *f g h i* is open and when it is closed. As the disc F revolves with very great velocity, it is essential, in order to avoid vibration, that it should be quite symmetrical about its axis. In order to effect this, a second aperture is made in the disc, and a piece of brass is attached to it, the same as the aperture and piece of brass at N *g*, and placed, respectively, 180° apart from them, but which are not shown in the figure. No light reaches the eye from this second aperture; for by the time the disc has made a half-revolution, the aperture *k*, which transmitted light from *f h*, has moved out of the line of vision. The second aperture, therefore, simply renders the disc symmetrical without affecting the optical action of the machine.

The apertures in the wheels D and E, through which the light, transmitted by the sector *f g h i*, reaches the eye, are represented at *k*, *m*, and *n*. The wheel E has two apertures, *k*, *l*, 180° degrees apart; and D has four apertures, 90° apart, of which only two are seen in the figure. The aperture *l*, as in the case of the disc, is made simply for the purpose of restoring the symmetry of the wheel E, which would be destroyed if the aperture *k* alone existed; and it will be seen that if the apertures *m*, *k*, and the sector *f h*, be adjusted so as to come together into the same straight line, and to allow light to pass through them to the eye, by the time the wheel E has made a half-revolution, so that the aperture *l* has taken the place of *k*, the aperture *m* will have moved out of the line of vision, and thus no light can reach the eye through *l*. Of the four apertures in the wheel D we may employ one only, or two 180° apart, or all four, as may be found most convenient, according to the speed with which the train is driven, the apertures not in use being stopped by plugs of cork.

The photometrical arrangement for measuring the brightness of the luminous impressions transmitted by the revolving disc, and its train of wheels, may either be that described in my former paper on the formation of luminous impressions, or the following arrangements may be adopted :—

1*st*, Let C, D (fig. 3) represent screens having apertures covered with ground-glass, or glass rendered milky-white by arsenic or phosphate of lime, and A, B flames, by which the apertures C, D are illuminated. A piece of transparent parallel glass E is placed so that an observer at F views the aperture C by transmitted, and D by reflected light in apparent contact. The light A remains fixed, while B is moved, until the two apertures appear equally bright. The disc G is now made to revolve, when the aperture C, seen during successive short intervals of time, will appear less bright than before, and the light B must be withdrawn to a greater distance from the screen D, until the equality of the illumination is restored. If the lights emitted by the flames A, B remain constant, the ratio of the brightness of the impression of short duration, transmitted by the revolving disc to that of a complete impression on the eye, will be that of the squares of the distances of the light B from the screen D.

2*dly*, An arrangement which, from an imperfect trial I have made of it, promises to succeed well for comparing the brightness of the illuminated apertures, may be made by cementing together two equal and similar rectangular glass prisms A B C, B C D, so as to form a parallelopiped, by means of a small portion of Canada balsam, which, when the prisms are pressed together, expands into a circular thin film E. The illuminated apertures C′, D′ in the screens are placed opposite to the faces A C, C D, and the observer looks through the face B F. The light transmitted through A C, and falling on B C, will be totally reflected, except the portion which falls on the film of Canada balsam at E, which will be nearly all transmitted to the eye of the observer. The light which is transmitted through the face C D will be totally reflected to the eye by the face B C, except what falls on the Canada balsam at E, which will be nearly all transmitted. The spot E will appear of a different brightness from the rest of the surface B C, except when the light totally reflected by B C is equal in intensity to the sum of the lights transmitted and reflected at E. The spot E will then disappear, owing to the whole surface of B C, including the spot, becoming uniformly bright. Assuming that the light partially reflected at E has a constant ratio to that totally reflected by the rest of the surface B C, and to that transmitted by A C, it is obvious that the squares of the distances of the flame from the aperture D when the spot E disappears will give the ratio of the intensities of the lights transmitted by the aperture C.

3dly, Adopting the arrangement in fig 3, we may compare the illumination of the screens by the following method:—Let the aperture D, whose light is reflected at E, be made larger than the aperture C, or let D be placed so that the distance D E F is considerably less than C E F. Then, by properly adjusting the position of the glass E, the aperture C will be seen projected on the reflected image of D. The distances of the lights A B may then be adjusted, so that the aperture C, seen *through* the reflected image of D, just disappears. The apparent brightness of C will then have a certain ratio to that of D, depending on the power of the observer's eye to discriminate between lights of different intensity; and, as before, the apparent brightnesses of C will be in the ratio of the squares of the distances of the flame B from the screen D when C disappears. From former experience I have found that it requires an almost painful effort of attention to compare the brightness of a surface illuminated by sudden flashes with that of another which is constantly illuminated. The method of observation now described seems to possess the great advantage of substituting mere watching for the disappearance of the flashes in the place of an estimation of equality of brightnesses.

4thly, We may observe the brightness of impressions of short duration by means of a single flame in the following manner:—The disc G transmits flashes from the flame A to the aperture C in a screen, filled with translucent glass. The observer at E looks at C along the edge of another similar piece of translucent glass D. Since illuminated surfaces appear equally bright at all distances and at all inclinations of the visual ray, the ratio of the brightnesses of the aperture at C when the disc revolves, and when it is stationary or removed, will be that of the squares of the distances of the glass D from the flame A, at which the observer estimates C and D as equally bright. By this method of observation, the effect of any want of constancy in the illuminating power of the flame A will be entirely eliminated.

Fig. 2.

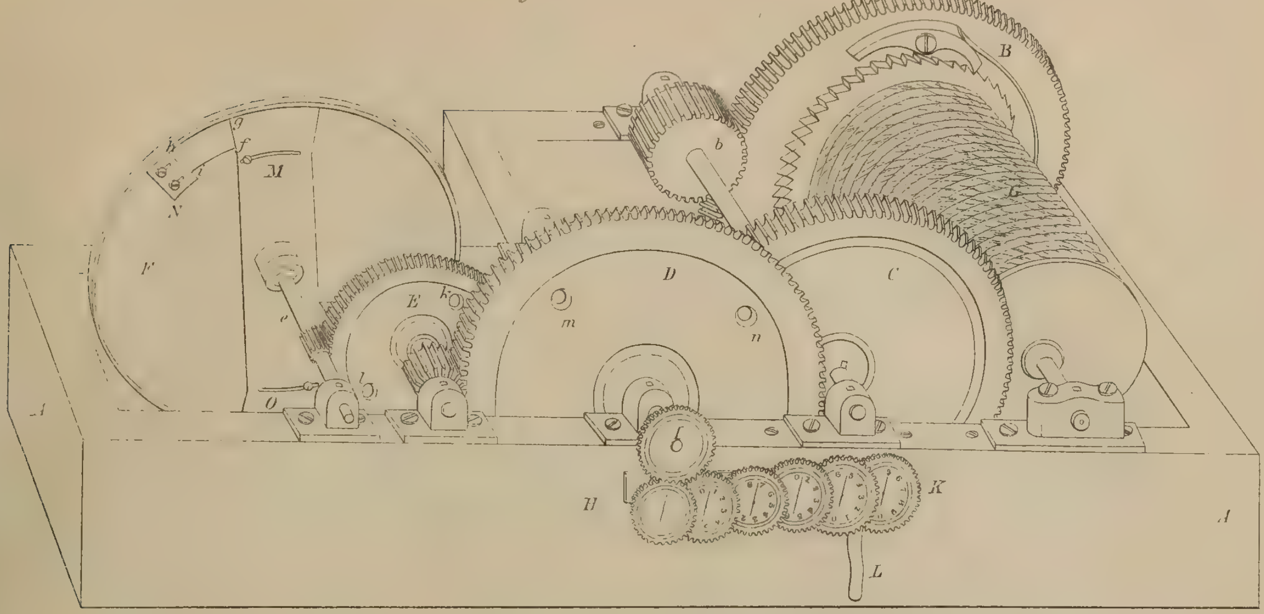


Fig. 1.

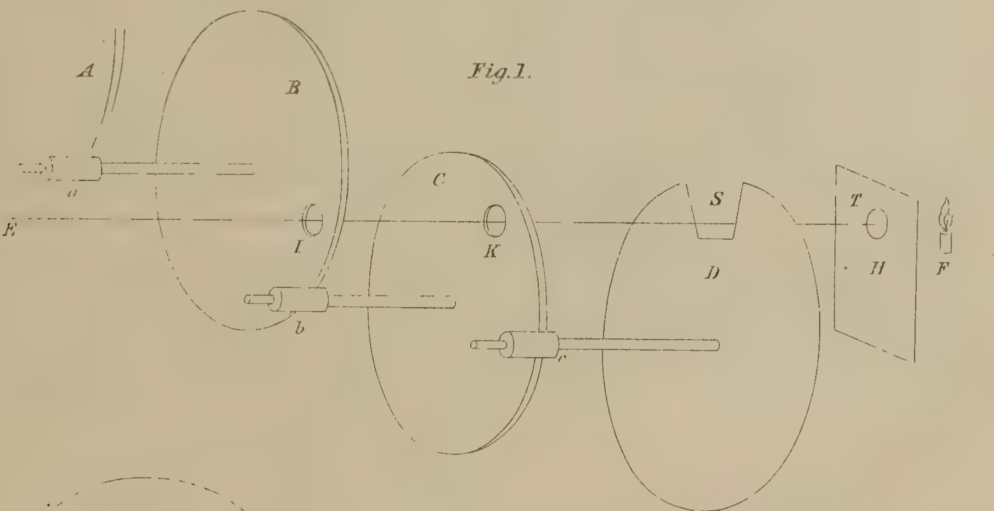


Fig. 3

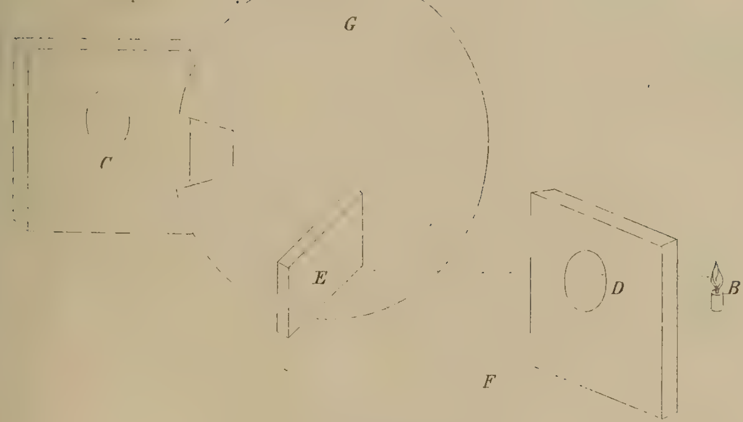


Fig. 4.

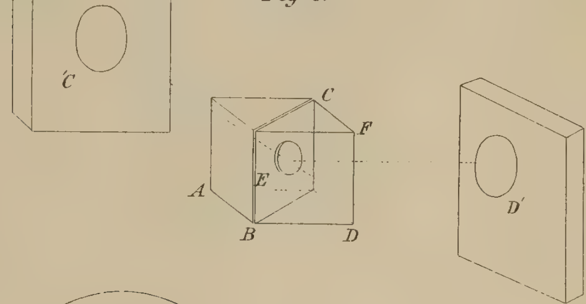
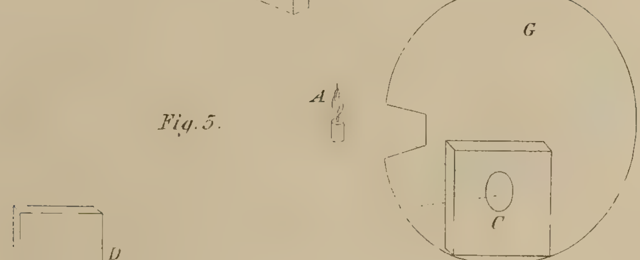


Fig. 5.



IV.—*Notice of an unusual Fall of Rain in the Lake District, in January* 1829. By John Davy, M.D., F.R.S., London and Edinburgh.

(Read 4th April 1859.)

The rain experienced in January of this year has so much exceeded the average quantity, considerable as that is in the Lake District,* that I have been led to consider it worthy of record, especially keeping in mind, that as regards risks from floods, it is not the ordinary, but the extraordinary that is to be guarded against in the construction of all works with which water is concerned as an element of danger.

It may not be amiss to premise, that the year preceding, as to weather, was chiefly remarkable for the mildness of the first quarter, for its high summer temperature, for the unusual cold experienced in November, and this succeeded by a mild December. January set in with weather of the same character, and was without any marked peculiarity, excepting its mildness, till the 9th, when rain commenced, and, with the exception of two or three days, continued to fall more or less heavily till the end of the month.

The maximum and minimum temperature during the month, and the prevailing winds, are shown in the following table, for which I am indebted to Mr Samuel Marshall of Kendal. His observations made in that town are applicable, with certain allowances, to the Lake District generally. I have selected them, having great reliance in his accuracy as an observer:—

Table I.

No.	Maximum Temperature.	Minimum Temperature.	Winds.
1	46°	38°·5	S.W.
2	45	33·5	S.W.
3	45	34	S.W.
4	47	36	S.W.
5	47	40	S.W.
6	43	40	S.
7	45	30	S.
8	34	28	N.E.

* The rain-fall at Lesketh How, Ambleside, in January, during the preceding six years, has averaged 4·22 inches.

In 1853 it was 1·62 inches.	In 1856 it was 6·96 inches.
... 1854 ... 10·54 ..	... 1857 ... 7·73 ...
... 1855 ... 1·68 ...	... 1858 ... 5·35 ...

TABLE I.—*continued.*

No.	Maximum Temperature.	Minimum Temperature.	Winds.
9	37°	30°	N.
10	44	34	S.
11	40	43	S.W.
12	48	45	S.W.
13	50	33·5	S.W.
14	40	36	N.E.
15	38	31	N.E.
16	42·5	33·5	S.E.
17	44	38·5	S.
18	49	40	S.W.
19	49	33	S.W.
20	46	32·5	S.W.
21	49	41	S.W.
22	52	42	S.
23	45	35	S.W.
24	45	37	W.
25	47	41·5	W.
26	48	35	W.
27	43	30	W.
28	46	34	S.W.
29	46	38	S.W.
30	47	36	S.
31	42	31·5	S.W.

During the month, the mean of the barometer was 29·853; its maximum (on the 13th), 30·398; its minimum (on the 23d), 29·097; the mean of the dry-bulb thermometer 40·4°; of the wet-bulb 39·1°; the maximum difference of the two 4°. These averages I owe to the same observer, and they are from observations made in the same place.

In recording the fall of rain, it appeared advisable not to restrict the account to one spot. Through the kindness of correspondents, I have been enabled to extend it to many localities, both in the district and at a distance. The registered results I shall give in a tabular form. The first table will show the days in which rain fell in the month in question, and its amount in the twenty-four hours, at five places, the remotest, Kendal and High Close, not exceeding twenty miles.

TABLE II.

No.	Kendal.	Ibbotsholme, Troutbeck.	The How, Troutbeck.	Lesketh How, Ambleside.	High Close, Grasmere.
1	·175	...	·372	...	·19
2	...	...	...	...	...
3	...	...	...	...	...
4	...	...	...	...	...
5	...	...	...	...	...
6	·010	...	...	...	...
7	...	...	...	...	...
8	...	...	...	...	...
9	...	...	...	...	...
10	...	...	...	...	·03
11	·034	·10	·135	·08	·05
12	·102	·10	·255	·11	·12
13	...	...	·015	...	...
14	...	·05	·018	·03	...
15	...	·03	·028	·75	·08
16	·250	·32	·353	...	·81
17	·170	·32	·360	·40	·35
18	1·980	2·43	3·135	3·65	2·15
19	·230	...	·145	·30	·13
20	...	·13	·085	...	...
21	1·015	2·02	3·125	2·61	1·75
22	...	·70	·818	1·37	1·31
23	·446	68	1·334	·71	1·00
24	·512	·72	1·065	1·06	1·04
25	·274	·15	·568	·26	·11
26	·223	·65	·821	·70	·18
27	·474	·45	·550	·94	·47
28	...	·03	·028	·08	·11
29	·048	·22	·385	·36	·16
30	·505	·68	1·075	·80	·77
31	·066	·32	·205	·40	·14
	6·514	10·10	14·875	14·82	10·95

In the next table will be given, besides the quantity of rain noticed in the Lake District in several localities, that which has been registered in some other parts of the kingdom; the latter for the sake of comparison. The nine localities which stand first, may be considered as belonging to the district, unless Kendal and Whitehaven on its borders be excepted; and all but these last are a few miles only apart, and, with one exception, that of High Close above Grasmere, vary but little in elevation above the sea-level, ranging from about 130 to two or three hundred feet; High Close, probably being 500 feet more.* In one column, the amount of rain which was measured in January, will be found; in the other, the amount for the year, but from some defective information less complete than could be wished,—

	For January.	For the Year.
Kendal,	6·514 inches	40·226 inches.
Ibbotsholme Troutbeck,	10·10 ...	... ...
The How, Troutbeck,	14·875 ...	60·168 ...
Lesketh How, Ambleside.	14·82 ...	63·44 ...
Wray Castle, above Windermere,	9·692 ...	54·269 ...
High Close, above Grasmere,	10·95 ...	58·64 ...
Keswick,	11·168 ...	50·27 ...
Whinfell Hall, Vale of Lorton,	9·042 ...	47·848 ...
Coniston,	12·50 ...	62·71 ...
Paterdale Hall, at the head of Ulswater,	14·8 ...	57·50 ...
Whitehaven,	6·643 ...	... ...
Penzance, Cornwall,	6·48 ...	... ...
Plymouth,	... ...	39·84 ...
Bristol,	... ...	22·70 ...
Sherborne,	3·82 ...	32·73 ...
Bucher, near Kington, Herefordshire,	1·16 ...	27·98 ...
Cambridge,	·36 ...	13·221† ...
York,	1·07 ...	20·49 ...
Mirfield, Yorkshire, about 300 feet above the sea,	1·07 ...	21·13 ...
Scarborough,	·38 ...	16·43 ...
Wakefield,	... ...	25·408 ...
Edinburgh,	1·861 ...	22·67 ...
Hutton, eight miles west of Edinburgh,	5·1 ...	... ...
Observatory, Glasgow,	5·30 ...	... ..
Stornoway Castle, Isle of Lewis,	5·43 ...	40·43 ...

* Since the above was written, I have been favoured, by the direction of Lieut.-Col. JAMES, R.E., with the following " List of Ordnance Survey Altitudes, in the neighbourhood of Kendal, &c. :—

Description of Marks.	Altitudes above the Mean Level of the Sea, Feet.
Bolt in base of N.W. tower of St George's church, Kendal,	149·02
Mark on S.W. angle of Grasmere church,	219·19
Mark on Ambleside church,	163·18
Bolt in N.E. angle of Patterdale church tower,	490·83
Mark on top of east battlement of Netherfield bridge over Seathwaite Beck,	399·05
Bolt in N.W. angle of Keswick church Tower,	319.19
Bolt in west corner of old church, Whitehaven,	29·27
Mark on N.W. corner of Wray church,	309·33
Mark on east face of east battlement of Church Bridge, Troutbeck,	398·77
Mark on stone of door of tower entrance to Troutbeck church,	403·13
Mark on top of rock 10 links, S.E. of Lingmoor, triangle A,	1409·74
Mark on Kirby Quay, west side of Coniston Lake, about 20 chains south of Water-Head Inn,"	144·00

† The Register for December is reported incomplete; yet the total for the year is considered near the truth; so dry a year as this has not been known, I am informed, for a long while. The yearly average of rain there is very low, about 17 inches.

From this table, it appears, that in the instance of the Lake District, the rain-fall for the month, with the exception of two spots, Wray Castle and High Close, increased with advance towards the higher central mountains, in accordance with all former observations, especially those of the late Mr MILLER. If a conjecture may be allowed as to the exceptional spots, I should be disposed to attribute the difference to the position of these places,—one, Wray Castle, standing on a low hill on the western margin of Windermere, flanked by no near mountains; the other, High Close, on an eminence between Langdale and Easdale; these vales, skirted by lofty hills, by their greater elevation, exercising on the atmosphere a much greater cooling effect.

Inequalities of rain-fall throughout the kingdom have been a remarkable feature of the meteorology of last year, and of the present season; this is strongly shown in the table. How singular, that more rain should have fallen in several places in the Lake District in the month than at Cambridge in the whole year!

As the prevailing winds during January were westerly, oceanic, and moist winds, the greater fall of rain on the west coasts is perhaps no more than might be expected, this, according with ordinary experience; it is the remarkable difference of amount in the Lake District that constitutes the speciality, as it now appears, and seems deserving of attention. Probably, were rain-gauges kept in the western highlands of Scotland the fall of rain there amongst the mountains bordering the coast, would be found to be not less, and it may be even greater. The flood descending from the hills which swept away so much of the embankments of the Crinan Canal in Argyleshire may be mentioned in proof; it occurred early in February, after the heavy rains of the preceding month.*

* Since the above was written, I have been favoured by Professor ALLEN THOMSON of Glasgow; with the following return, comprising nineteen years' rain-fall at Stonefield, the residence of COLIN G. CAMPBELL, Esq., in the vicinity of the Crinan Canal, confirmatory of the remark I have made; no doubt, amongst the mountains there, as in the Lake District, the proportion of rain is much larger than at the lower levels.

Yearly Average.		*Average for each Month during these Nineteen Years.*			
1840,	58·6	January,	7·2	December, 1852,	14·35
1841,	61·6	February,	5·7	,, 1854,	14·4
1842,	60·0	March,	4	January, 1849,	12·9
1843,	67·0	April,	3·2	,, 1859,	8·4
1844,	45·8	May,	3	February, 1859,	6·15
1845,	77·3	June,	4·4		
1846,	64·7	July,	4·8		
1847,	59·7	August,	4·4		
1848,	68·9	September,	4		
1849,	62·6	October,	6·4		
1850,	65·7	November,	6·4		
1851,	54·2	December,	7·3		
1852,	66·0	Total for year,	60·8		
1853,	55·3				
1854,	63·8				
1855,	41·4				
1856,	52·4				
1857,	50·9				
1858,	63·3				
Average 60 inches.					

In commencing, I have stated that the fall of rain in January was so much greater than the average for the month as to seem deserving of record; this is strictly correct; yet instances have occurred, since rain-gauges have been kept in the district, of even greater quantities having been registered for the same time. The following table, giving the months in which rain equal to, or exceeding 12 inches, has fallen at Ambleside and Coniston,—at the former since 1848, at the latter since 1837,—is illustrative of the fact; the rain-fall at Kendal and Wray Castle, for the same months, is added for the purpose of comparison:—

TABLE III.

Date.		Coniston.	Ambleside.	Wray Castle.	Kendal.
		Inches.	Inches.	Inches.	Inches.
October . . .	1838	12·6	...	...	7·032
July	1839	12·4	...	...	8·461
September . .	1839	12·9	...	...	7·437
October . . .	1843	13·1	...	...	7·883
November . .	1843	12·0	...	...	9·109
December . . .	1845	13·6	...	...	9·039
October . . .	1846	14.0	...	...	7·843
November . .	1847	13·2	...	...	8·002
February . . .	1848	14·5	14·19	...	10·237
December . . .	1848	12·0	...	...	7·107
January . . .	1849	13·5	12·30	...	8·439
October . . .	1849	12·0	...	...	7·333
November . . .	1850	12·2	...	9·670	5·722
January . . .	1851	13·3	19·54	13·735	10·057
January . . .	1852	17·6	20·37	15·332	9·886
February . . .	1852	12·0	13·00	10·074	7·907
December . . .	1852	19·9	24·39	18·651	12·766
January . . .	1853	12·0	13·25	10·867	6·696
December . . .	1854	15·3	19·80	12·159	8·129
January . . .	1859	12·2	14·83	9·692	6·514

Such heavy falls of rain as those recorded in this table are perhaps more characteristic of localities exposed to the west and adjoining mountains than even the great yearly averages. Taking Edinburgh as an example of a place on the east coast, it would appear from the register kept by the late Mr ADIE and his sons, from 1795 to the present time, that the greatest monthly fall there during the whole of that period was little more than six inches. This occurred five times—once in January, once in October, and once in each of the three summer months. The greatest amount of rain registered in any one year, that of 1795, was 36·61 inches; the average of the whole 24·55 inches. Stornoway, in the Island of Lewis, affords an example of a locality well exposed to the west, fully open to the sea, but out of the near influence of any mountains. There showers are frequent, but seldom so heavy as those where that influence is exerted. In January, the daily fall of rain registered there was as follows:—

1st,	0·20	inches.	18th,	...	inches.
2d,	0·05	...	19th,	0·05	...
3d,	0·02	...	20th,	0·23	...
4th,	0·05	...	21st,	0·47	...
6th,	0·01	...	22d,	0·14	...
7th,	0·15	...	23d,	0·80	...
8th,	...	...	24th,	0·18	...
9th,	0·11	...	25th,	0·25	...
10th.	...	...	26th,	0·35	...
11th,	0·02	...	27th,	0·15	...
12th,	0·05	...	28th,	0·35	...
13th,	...	...	29th,	0·25	...
14th,	0·01	...	30th,	0·62	...
15th,	...	...	31st,	0·28	...
16th,	0·10	...			
17th,	0·53	...		5.43	inches.

Exceptions there may be to the above remarks, even in localities where the average rain-fall is low,—exceptions which ought to be kept in mind, for the warding off of accidents by floods, but which unfortunately are commonly too soon forgotten after the event. One of the most remarkable that I am acquainted with took place at Scarborough in August 1857. In that year the total fall of rain registered was 29·982 inches, of which quantity 12·67 inches fell in August, and 9·50 inches during the night of the 6th and 7th of that month.* Another exceptional case is a fall of rain that occurred in London and its neighbourhood, on the 15th March 1851, amounting in a few hours to more than an inch, in London to 1·25 inch, at Lewisham to 1·725, which, for those localities, was designated by Mr Glaisher as "extraordinary," and on that account communicated by him to the Royal Society.†

I have made mention of the mildness of the season since November. February, as to weather, was very much a repetition of January, the prevailing winds were the same, and rain was in excess; here, at Lesketh How, 7·29 inches were registered. Now, in the first week of March, spring, judged of by the vegetation, is at least a month in advance; the gardens are gay with flowers. The same advance appears to be general. In a letter, with which I have been favoured by Sir James Matheson,

* The capacity of the rain-guage was limited to 9·50 inches; it is stated to have been overflowing, so the amount registered was below the truth. See "Twenty-Sixth Report of the Scarborough Philosophical and Archæological Society for 1857."

† Proceedings of Royal Society, vol. vi., page 39.

from Stornoway, of the 28th of February, are inclosed the flower of the *ribes sanguineum*, the young leaf of the sweet briar, and of the common fuschia, gathered in the grounds of the castle in rather an exposed situation, and it is stated that the *Loincera tartarica*, the honeysuckle, and Ayrshire rose, are in full leaf. The spawn of the frog I found here in the ditches as early as the 21st of the same month. A writer in the *Evening Mail* of the 4th of March, referring to the mildness of the season, says he heard a nightingale singing in the neighbourhood of Southampton on the evening of the 1st of the month, and that he had previously heard the same birds singing on the 13th of the preceding month in North Storeham Park. I shall mention another proof: in winters of ordinary coldness butterflies are torpid, lose very little of their weight, hardly an appreciable quantity, and when the warm weather of spring sets in, roused into action, they are vigorous and take wing. One that I have had under observation since December, a *Vanissa urticæ*, which then weighed 2·4 grains, has never become completely torpid; it has lost ·54 grains of its weight, and now, though not torpid, is almost inanimate, just opening its wings when warmed, but incapable of flight. Further proof may be offered in the unusual success of the angler in the month of January. The number of charr taken in that month in Windermere was unprecedented; one fisherman, trowling with the minnow, captured, it is said, nineteen dozen, in good condition, equal to those taken in April and May. In November, an adjoining lake, Rydalmere, was frozen over, and there was skating on it! *Lastly*, I may remark, that up to the present time the same inequalities as those already described of excess and deficiency of rain, would appear, from what is stated in the papers, to continue throughout the country; but the deficiency more common than the excess. Thus, whilst here we have had few days of sunshine, in Berkshire and the counties similarly situated drought has prevailed, and to so great a degree as to interfere with the operations of agriculture, the ground having become so parched and hard as hardly to receive the plough.

LESKETH HOW, *March* 8, 1859.

Postscript.

Since the above was written, I have been favoured, through the kindness of my friend Dr LEITCH of Derwent Bank, Keswick, with a register of the fall of rain at Seathwaite, Borrowdale, from 1845 to the present time, kept by Mr JOHN DIXON. The results, it will be seen, are strongly confirmatory of those hitherto obtained, as showing the augmentation of the quantity the nearer the approach to the central part of the district, where the mountains are highest and the valleys deepest. I shall extract the monthly falls when amounting to or exceeding 12 inches, and the fall of each year. The average yearly amount of the fourteen recorded years is the remarkable one of 129·97 inches.

Year.	Rain.
1845,	151·86 inches.
January,	16·81 ...
March,	13·21 ...
August,	15·61 ...
October,	15·17 ..
November,	20·84 ...
December,	24·94 ...
1846,	143·45 ...
January,	17·07 ...
March,	17·85 ...
July,	20·80 ...
October,	25·43 ...
1847,	129·24 ...
September,	13·28 ...
October,	20·52 ...
November,	21·85 ...
December,	20·54 ...
1848.	160·55 ...
February,	30·45 ...
July,	17·76 ...
August,	13·91 ...
October,	17·32 ...
November,	14·07 ...
December,	20·71 ...
1849,	123·64 ...
January,	24·90 ...
July,	16·64 ...
October,	16·14 ...
November,	16·97 ...
1850,	143·26 ...
February,	22·58 ...
April,	15·62 ...
August,	16·22 ...
October,	12·94 ...
November,	22·60 ...
1851,	135·85 ...
January,	28·63 ...
February,	15·33 ...
July,	14·48 ...
August,	13·16 ...
October,	20·38 inches.
1852,	156·70 ...
January,	27·65 ...
February,	20·05 ...
June,	12·33 ...
August,	12.37 ...
November,	17·47 ...
December,	32·83 ...
1853,	113·69 ...
January,	23·12 ..
April,	12·67 ...
July,	19·67 ...
October,	13·25 ...
1854,	136·39 ...
January,	19·61 ...
June,	13·98 ...
September,	12·24 ...
October,	14·62 ...
December,	28·86 ...
1855,	88·31 ...
October,	20·00 ...
1856,	105·52 ...
February,	14·36 ...
June,	12·66 ...
December,	17·80 ...
1857,	116·60 ...
January,	15·12 ...
February,	14·94 ...
December,	20·49 ...
1858,	114·60 ...
January,	13·72 ...
September,	18·39 ...
October,	15·60 ...
December,	15·58 ...
1859,	... ...
January,	23·40 ...
February,	15·80 ...
March,	20·84 ...

V.—*Some Observations on the Coagulation of the Blood.* By John Davy, M.D., F.R.S. Lond. and Edin.

(Read 18th April 1859.)

In a recent work * of an elaborate kind, displaying much ability, its author, Dr Richardson, has endeavoured to prove that the cause of the coagulation of the blood is of a chemical nature, and referable to the escape of a volatile matter, and that the volatile matter is ammonia.

It is not my intention at present to consider the various circumstances which he brings forward in favour of his conclusion. I shall restrict myself to a few observations which I have made, the results chiefly of trials instituted for the purpose of testing his speculations, and of satisfying myself, if possible, on the subject.

If the coagulation of blood depend on the escape of ammonia in any form, that is, however combined, and is purely a chemical phenomenon, it follows, that the escape of the volatile matter being prevented, the blood should remain liquid.

To determine this by experiment does not seem to be a difficult matter, whether as regards the means required or the results to be obtained. The blood I have chosen for trial has been that of the common fowl, obtained by dividing the great vessels in the neck. I have selected it because the blood of birds exhibits the phenomenon in question in the most striking and rapid manner. I shall describe a few of the experiments made.

Experiment 1.—A half-ounce vial† in a few seconds was filled with blood to within a quarter of an inch of its neck, and was immediately closed with a glass stopper. In two minutes coagulation had taken place throughout; now, on withdrawing the stopper, a glass rod, dipped in muriatic acid, was brought near, as a test of ammonia; no fume, not the slightest, was perceptible. The blood, still warm, was next mixed with hydrate of lime; no ammoniacal odour could be detected.

Experiment 2.—Two ounces of blood were received in a glass vessel, into which two drops of aqua ammoniæ had just before been poured; as soon as caught, it was gently moved by inclining the vessel backwards and forwards, to favour the action of the volatile alkali; in less than two minutes coagulation had taken place. A distinct odour of the volatile alkali was emitted, and when a plate of glass,

* The "Cause of the Coagulation of the Blood," being the Astley Cooper Prize Essay for 1856, with Additional Observations and Experiments, &c. By B. W. Richardson, M.D , 8vo, London, 1858.

† The capacity was greater; it held 298 grains of water.

moistened with dilute muriatic acid, was for a short time kept over the vessel, crystals of muriate of ammonia formed on it, that is, after evaporation, and as viewed under the microscope. The clot was of about equal consistence throughout, and tolerably firm; cut into pieces, each piece, tested by the approach of the rod dipped in muriatic acid, showed, by the fumes produced, the presence of ammonia. The serum, which in a few hours had separated from the crassamentum, had an ammoniacal odour.

Experiment 3.—To a mixture of water and aqua ammoniæ, formed of 12 grains of the former and 1 grain of the latter, in a vial of one half-ounce capacity, 277 grains of blood were added as it flowed from the divided vessels; the glass stopper was instantly introduced, and, to secure admixture, the bottle was inverted two or three times. In about two minutes and a-half, coagulation had taken place.

Experiment 4.—277 grains of blood from the same fowl were caught in a larger and thicker bottle, exceeding that used in the preceding experiment by 856 grains (more than double its weight), and exercising therefore a greater cooling influence. This blood coagulated in about three minutes.

Experiment 5.—A small portion of blood from the same fowl fell on a flagstone in the open air, the temperature of which, ascertained by the thermometer, was 40°. Ten minutes after the last had coagulated, this retained its fluidity, and after other ten minutes, it was only feebly coagulated.

Experiment 6.—To a mixture of 13 grains of water, and 14 grains of aqua ammoniæ of specific gravity ·88, in the half-ounce vial, the blood of a fowl as it issued from the divided vessels was added to overflowing; the stopper was immediately introduced. The blood which overflowed, it is remarkable, became tenacious and viscid in less than a minute, even before another portion caught in a separate vessel had coagulated; the latter undergoing the change in about two minutes. The stopper taken out after an hour, the contained blood was found coagulated; the coagulum was soft and easily penetrated, very tenacious and viscid, of a dark colour, and pungently ammoniacal. In twenty-four hours it had become somewhat firmer, and in three days a little more so, showing a slight degree of contraction; but no serum had separated from the clot. A minute portion of it detached, which was not easily effected, owing to the tenacity of the crassamentum, exhibited, under the microscope, a confused appearance; diluted with serum, and stirred, no blood corpuscles were detached, and using a compressor to spread out the little mass, the whole had the aspect of a fine granular tissue. This blood after twenty days experienced little change; and the remark applies equally to the two portions,—that contained in the stoppered vial, and that which overflowed, received into a wine glass and merely loosely covered with tin-foil; both emitted an odour of the volatile alkali, slightly tainted as if from incipient putrefaction; the colour of each had become of a rusty brownish red, but with little change of consistence; no serum had separated. After twenty-eight days, the blood in the vial had become darker and softer and less viscid, whilst that in the wine-glass retained its tenacity and consistence and colour.

These results appear to me clearly to show,—1*st*, That there are no indications afforded of the escape of volatile ammonia during the coagulation of the blood of the fowl, or of its presence in the blood;—2*d*, That the addition of ammonia in a notable quantity does not prevent coagulation;—3*d*, That a sudden reduction of the temperature of the blood, even when fully exposed to the air, has a greater influence in retarding the coagulation than the assigned cause of its fluidity, the volatile alkali, when added.

The few trials I have made with the sesquicarbonate and neutral carbonate of ammonia have given results equally unfavourable, as they appear to me, to the hypothesis. I shall mention briefly two.

Experiment 7.—272 grains of blood were received into the half-ounce vial, containing 12 grains of water and 4 grains of the sesquicarbonate of ammonia. An hour and a-half after, the blood continued fluid; no separation of lymph had taken place, and no change of colour: three quarters of an hour later, it had partially coagulated; this was in its inferior portion, the upper remaining liquid. The bottle was perfectly tight; no air had escaped; none had entered. On the day following, on withdrawing the stopper, the whole was found coagulated: the clot formed was soft and viscid, of a dark hue, and without any separation of serum. Under the microscope, the red corpuscles were distinct, some appearing nearly of their natural form, some elongated, but none in piles. The blood had a strong ammoniacal odour.

Experiment 8.—To 20·5 grains of water, containing 2·9 grains of the neutral carbonate of ammonia, 234 grains of blood were added, in the manner described, and in a vial of the same capacity. Partial coagulation occurred in about twelve minutes, and in fifteen it was complete throughout; the crassamentum was soft and florid. After twenty-four hours, it was a little firmer, but no serum had separated, nor had any exuded after forty-eight hours, when it was of moderate firmness.

Thus it appears that these salts of ammonia, used in small quantities, have the effect of retarding coagulation, analogous in this their influence to most of the salts of the alkalies; and, like them, we know that in a large proportion they prevent it, and yet that on dilution with water coagulation takes place.*

I shall now briefly notice some other experiments which I have made with the same intent as the preceding, viz.:—the testing of the hypothesis advanced, that the presence of ammonia in the blood is the cause of its fluidity. My respect for its author, and the reputation that his work has acquired, induce me to go rather more into details than otherwise I should have felt inclined to do. The experi-

* See my "Researches Physiological and Anatomical," vol. ii., p. 105, for instances.

ments I have to make mention of are of two kinds: one set have for their object to ascertain what is the amount of loss of ammonia from evaporation or volatilization, supposing it to exist in the blood, and it has an opportunity to escape in the act of coagulation; the other set were designed to ascertain the solvent power of ammonia acting on coagulable lymph,—that substance, the passing of which, from the liquid to the solid state, gives rise to the phenomenon under consideration.

Experiment 9.—In the same half-ounce vial as was used in the experiments already described,—the aperture of which was one-thirtieth of an inch in diameter,—13·7 grains of aqua ammoniæ were introduced, carefully weighed, confined by a glass stopper. The stopper was withdrawn; it was replaced after eight minutes, and again weighed; there was no appreciable loss; the thermometer in room 52°. Added 13·95 grains more of the solution of ammonia; after half-an-hour the loss sustained was ·05 grain. There was next added a portion of white of egg, equal in weight to 171·26 grains; after forty-six minutes the loss was ·03 grain. The same immersed in water of 98° for five minutes suffered a loss of ·01 grain.*

In these experiments the specific gravity of the aqua ammoniæ had not been ascertained; it was certainly higher than ·88, having been kept some months, and the bottle holding it repeatedly opened. In the following trials, aqua ammoniæ of the specific gravity named was used.

Experiment 10.—The same vial containing the blood mentioned in experiment number 6, holding 14 grains of aqua ammoniæ, was carefully weighed; the stopper was withdrawn, replaced after ten minutes, and again weighed, the loss experienced was ·01 grain. The case of the balance, in which the vial was left open during the ten minutes, had a strong smell of ammonia.

Experiment 11.—To 214·7 grains of water in the same vial, 16·9 grains of aqua ammoniæ were added; in eight minutes after withdrawing the stopper, the loss sustained was ·01 grain. The body of the vial was now immersed in water at 95°, and kept there for ten minutes; the loss suffered was equal to ·04 grain.

Do not the results of these experiments go far to prove that, even on the supposition of ammonia existing in the blood in a volatile form, no appreciable quan-

* Plunged into water of 210°, the white of egg coagulated, though a large proportion of the ammonia still remained in the solution. A mixture of white of egg and bicarbonate of potash similarly treated, an effervescence occurred, and a coagulation formed. This I notice to show that the presence of an alkali does not prevent the coagulation of albumen by heat, leading to the inference that its liquid state is not owing to the little alkali which it contains. I may mention another fact having the same bearing. A portion of milk, to which a little ammonia had been added, was put by to see how long it would keep sweet, air being excluded, the bottle being filled and well secured with a glass stopper. It was long forgotten; after two or three years it attracted attention. Now, it was found that a film of black matter, which proved to be sulphuret of iron, was formed, covering the whole of the inside of the vial; that the milk had acquired a brown hue, the cream on its surface remaining almost colourless, and that though it was alkaline, yet a small portion of curd had formed

tity can escape in the short period of two or three minutes, which is about the time required for the coagulation of the blood of the fowl?

For trial of the solvent power of the volatile alkali, fibrin was obtained from the blood of the fowl in the ordinary way by washing, but not carried so far as to remove the whole of the colouring matter; an effect in the instance of this blood not easily accomplished. By thorough drying, this lymph or fibrin was found to lose 85 per cent. of water.

Experiment 12.—To a mixture of 134·4 grains of water, and of 44·5 grains of aqua ammoniæ, of specific gravity ·88, 1·2 grain of moist fibrin was added. In twelve days, at a temperature ranging from 50° to 60°, the greater part of it was dissolved. When shaken it became slightly turbid: it had no colour, as if the ammonia had destroyed the very little colouring matter adhering.

Experiment 13.—To a mixture of 127·6 grains of water, and of 5·2 grains of sesquicarbonate of ammonia, 1·1 grain of the moist fibrin was added. In the same time it was only partially dissolved; the undissolved portion was not inconsiderable; it was colourless: the solution was slightly coloured red.

Experiment 14.—To a mixture of 146·2 grains of water, and of 3·1 grains of neutral carbonate of ammonia, 2·8 grains of the moist fibrin were added. The result, in the same time, differed but little from the last, both as regards colour and proportional residue. Moreover, it may be mentioned, that after a month no further alteration in either of the three was appreciable.

Experiment 15.—To a mixture of 1400 grains of water, and of 19 grains of aqua ammoniæ, of specific gravity ·88, 18 grains of moist fibrin were added. The mixture filled the bottle, which was closed with a glass stopper. It was kept at the same temperature as the preceding, and was occasionally shaken. After fourteen days, the fibrin seemed little diminished in bulk; it had become viscid as well as transparent. The former quality was evident from the manner in which it was drawn out when inverted. As the fluid part, it was found, could not be separated by filtration, it not passing through the filtering paper, to ascertain the proportion dissolved decantation was employed. About a half of it was poured off; but even this was not quite free from viscid lymph. Evaporated to dryness, it yielded ·7 grain; the other moiety evaporated yielded 2·8 grains.

Experiment 16.—To a mixture of 1400 grains of water, and of 26 grains of aqua ammoniæ, 19 grains of moist lymph were added, put into a bottle of larger capacity, so as to half fill it only. The object was to see if any marked difference of effect would be produced by the presence of atmospheric air. The result in this respect was negative; as in the former instance, the fibrin was rendered transparent and viscid, and the decanted portion, on evaporation, yielded about the same proportional residue—viz., ·8 grain.

I have made other trials on the solvent power exercised by ammonia on moist fibrin, and both for a longer time and with more ammonia, but with results so much alike, that I do not consider it necessary to detail them. They have all led me to the conclusion, that the volatile alkali, in its action on fibrin, is chiefly remarkable for rendering it viscid, and that its solvent power is inconsiderable.* My results do not perfectly accord with those obtained by Dr Richardson. In all the experiments he describes, quantities of lymph (10 grains) were dissolved, he states, completely in from fifteen to twenty-one days in mixtures of water and ammonia, composed of 1000 grains of the former, and from 5 to 2 grains of the latter, designated by "NH_4O," a proportion this, even the largest, less than that I used. The difference I cannot account for. I thought it possible, that as fibrin freshly separated from the blood, and in its moist state, has a powerful attraction for oxygen, and in part liquifies with evolution of heat when exposed to its action,† that his experiments having been made, as I presume they were, without the exclusion of atmospheric air, the want of concord might thus be explained, but the last trial I have noticed does not support the conjecture. It is possible that the fibrin of birds may be less soluble than that of the mammalia, which he employed. But should it be so, the difference as to degree should not affect the argument. Even Dr Richardson's own results, considering the proportions used of fibrin and ammonia, and the length of time required for the solution, seem to me in no wise to bear out the idea that the volatile alkali can be the solvent of fibrin in the blood in its healthy state.

Dr Richardson, in support of his views, refers to some observations of the late Dr Blair in proof of the existence of ammonia in the blood in disease. On consulting his writings, I find one instance recorded in which this alkali was detected in the blood of a person who had died of yellow fever, but in so small a proportion that none was "yielded by heat alone, and not much on the addition of liquor potassæ."‡ In the majority of instances that he examined the blood from patients labouring under this disease, he found it, contrary to his expectations, normal, its corpuscles unaltered in form, and collected in rouleaux,—a circumstance this, I cannot but think, incompatible with the presence of ammonia,—if its tendency is, as I have found, to render the blood viscid. My own experience, I may mention, as regards the state of the blood in yellow fever, accords with the ampler one of my valued friend. During life, I never found it otherwise than normal; after death, in some cases, I found that "it gave off an ammoniacal odour when mixed with quicklime; whilst in others this odour was not per-

* The fibrin, after solution, appears to be altered in its properties: obtained by evaporation (as the ammonia is expelled it forms as a pellicle) though still soluble in a slight degree in the volatile alkali, it is not rendered viscid, and, in consequence, there is no obstacle in the way of its filtration.

† See "Researches Anatomical and Physiological," vol. ii., p. 343.

‡ "Report on the First Eighteen Months of the Fourth Yellow Fever Epidemic of British Guiana," p. 37.

ceived:" This I have stated in a note to Dr BLAIR'S "Treatise on Yellow Fever" (the epidemic which preceded the one last mentioned), of which I was the editor.

I shall now conclude, briefly remarking, that as the results I have described are opposed to the inference of the coagulation of the blood being owing to the escape of any volatile matter, and, *à fortiori*, of the volatile alkali, the existence of which in the blood even remains to be proved, they leave the phenomenon, as hitherto, a problem for solution, and open to question whether it be the result of loss of vitality, or a chemical result, depending on a new arrangement of elements of the coagulating part, the fibrin, without, as regards their number, any change of their sum.

VI.—*Researches on Radiant Heat.* Second Series. By Balfour Stewart, M.A. Communicated by Professor Forbes.

(Read 18th April 1859.)

Division of Subject.

1. The first part of this paper describes the following groups of experiments:—

Group I. On the effect which roughening the surface of a body produces upon its radiation.

II. On the nature of that heat which is radiated by rock-salt, at 212° F.

III. On the radiation of glass and mica, at high temperatures.

The second, or theoretical portion, of the paper, has reference to the law which connects the radiation of a particle with its temperature, and to Dulong and Petit's experiments on this subject.

There is also an addition of a later date than the rest of the paper on General Diathermancy.

Instruments used, and Method of Investigation.

2. The instruments used, and the method of using them, were much the same as described in the first series of these researches, Art. 3. Should any difference occur in the method of conducting a particular experiment, it will be mentioned when the experiment so performed comes to be described.

First Group of Experiments described.

3. This group of experiments has reference to the effect of roughening the surface of a body upon its radiation. This was suggested to the writer by Professor Forbes. The first substance tried was rock-salt.

A. *Rock-Salt.*—It was found that roughening the surface by means of emery-paper, until it became quite dim, had little or no effect in increasing the radiation, as will be seen from the following statement, embodying the mean result of three sets of experiments.*

The pieces used were the middle piece (thickness = ·36 inch) and thickest piece (thickness = ·77 inch), described in First Series, Art. 6. These pieces were placed at a distance of about 4 inches from the mouth of the polished brass cone, and, in

* In the experiments with roughened surfaces, only one of the surfaces of the substance was roughened, the other being left polished. In *radiation* experiments, therefore, the roughened surface was placed next the pile; while in *transmission* experiments, it was placed furthest from the pile.

order to increase the effect, no diaphragm was used. They were heated in the boiling-water apparatus already described. With this arrangement

The thick piece gave, when polished, a deviation of, ...	21°·1
when roughened, ...	21·8
The middle piece gave, when polished, a deviation of, ...	13·6
when roughened, ...	13·5

4. The next point was to ascertain if roughening rock-salt had any effect upon the *quality* of the heat radiated.

The following table will show that it does not alter the quality of the heat sensibly; its quality being tested by its capacity of penetrating a screen of rock-salt:—

TABLE I.

Source of Heat.	Per-centage of whole Heat which penetrates a Rock-salt Screen thickness ·29 inch.
Rock-salt, ·77 inch thick, polished, . . .	49
... roughened, . . .	51
Rock-salt, ·36 inch thick, polished, ...	42
... roughened, . . .	43

The trifling difference between polished and roughened salt in this table may fairly be attributed to error of experiment. We may therefore conclude, that roughening by emery-paper neither alters the quantity nor the quality of the heat radiated by rock-salt.

5. Again, the transmissive power of rock-salt for lamp-black heat of the temperature 212°, is not sensibly altered by roughening the surface. This will be seen from the following statement:—

	The per-centage of Lamp-black heat transmitted was
With Screen of Rock-salt, thickness ·36 inch, polished,	77
... ... roughened,	77

This result naturally follows from the previous one, for it has been shown (First Series, Art. 19) that the absorption of a plate equals its radiation; and since roughening the surface does not influence the radiation, it ought not to influence the absorption.

6. B. *Glass.*—It is already known that roughening the surface of a plate of glass does not sensibly increase its radiation. It was only necessary, therefore, to ascertain whether roughening the surface of a radiating plate of glass alters the capacity of its heat for penetrating a screen of glass.

Accordingly, a plate of crown-glass, ·05 inch thick, 3·75 inches square, being placed before the cone as a screen, and a similar plate roughened, heated in the boiling-water apparatus, being used as the source of heat, and no diaphragm used,—

The deviation was, ...	$1^\circ{\cdot}0$
When the source of heat was a similar plate, ·10 inch thick, the deviation became,	1·5
And, lastly, when the source of heat was a plate covered with lamp-black, the deviation was, ...	1·9

With the same sources of heat, only the glass polished instead of roughened, these numbers were 0°·95, 1°·45, 1°·95. From the correspondence between these two sets of results, we may infer that the quality of the heat radiated by glass (at least in so far as transmission through a plate of glass can test it) is not altered by roughening the surface of the glass.

7. And from all these experiments, we may infer (what has indeed been already remarked by Professor FORBES), that although roughening its surface with sand or emery-paper renders a body dim for light, yet it still remains specular for heat rays, which, possessing a greater wave-length than those of light, are less liable than the latter to be influenced by scratches or furrows.

Second Group of Experiments described.

8. The second group of experiments has reference to the nature of the heat which is radiated by rock-salt at 212°. Its quality being tested by transmission through

α. A screen of mica.
β. One of mica split by heat.
γ. One of glass.

9. α. *Mica Screen.*—By the mean of three sets of experiments, a mica screen (thickness = ·003 inch nearly) passed about 31 per cent. of ordinary lamp-black heat, while it only passed 18 per cent. of rock-salt heat. Or if we call the proportion of black heat passed by the mica 100, that of rock-salt heat passed will be 58.

10. β. *Split Mica Screen.*—Two sets of experiments agreed in giving 20 per cent. as the proportion of lamp-black heat of 212°, transmitted through a screen of mica split by heat, while the proportion of rock-salt heat transmitted by the same screen was only 15¼ per cent. These numbers are to one another as 100 to 76.

11. γ. *Glass Screen.*—In order to avoid secondary radiation from the screen, which, in this case, absorbs nearly all the heat, two screens of microscopic glass were used, the one behind the other, with an interval between.

Moreover, as in this case, the proportion of heat transmitted is exceedingly small, the following arrangement was adopted to make it measurable.

The experiment consisted of four parts,—

1*st*, The effect of the rock-salt heat upon the pile without a screen was observed by the ordinary galvanometer.

2*d*, The effect of lamp-black heat, also without a screen, was observed by the same galvanometer.

3*d*, The wires of the pile were then transferred to a more sensitive galvanometer, and the effect of lamp-black heat observed, the glass screen being interposed.

4*th*, The sensitive galvanometer and glass screen being retained, the effect of rock-salt heat was lastly observed.

By this method of experimenting, it was merely the relation between the diathermancy of the screen for lamp-black heat and for rock-salt heat that was measured; its absolute diathermancy for either of these heats not being determined. Two sets of experiments, conducted in this manner, gave the following result:—

By the first set, calling the proportion of the whole lamp-black heat which passed the screen 100, that of the rock-salt heat which passed the same screen was 54. And by the second set, these numbers were 100 and 60.

12. As in these experiments with a glass screen the proportion of heat passed is very small, great numerical accuracy cannot be looked for, and the results obtained are valuable, rather as determining the direction and character of a fact, than as measuring the extent to which it holds.

13. It is already well known, that rays of great refrangibility or small wave-length pass through glass and mica more readily than those of an opposite character. The difficulty with which rock-salt heat penetrates these substances, as compared with ordinary heat, might therefore lead us to infer that the wave-length of this heat is greater than that of ordinary lamp-black heat.

14. If, therefore, the heat radiated by rock-salt is of great wave-length, since (First Series, Art. 19) the quality of the heat radiated is the same as that of the heat absorbed, it follows that the heat most absorbed by rock-salt must be heat of great wave-length; and this derives confirmation from a fact noticed by Professor Forbes, viz., that rock-salt passes a somewhat greater proportion of heat of high temperature than of that of low; heat of high temperature possessing a less average wave-length.

15. If we look now to the relative transmission of the two descriptions of heat through mica split by heat, we see that the facility of transmission is yet in favour of ordinary heat, but not so strikingly as with a screen of common mica. This will be seen from the following table:—

Table II.

Nature of Screen.	Transmission of Ordinary Heat, at 212° F.	Transmission of Rock-salt Heat, at 212° F.
Mica, ...	100	58
Mica split by heat, ...	100	76

Compare this with the following table, deduced from the results given by Professor FORBES, in the Fourth Series of his Researches, Art. 9.

TABLE III.

Nature of Screen.	Transmission of Heat from Blackened Brass, at 700° F.	Transmission of Black Heat, at 212° F.
Mica ·015 inch thick, ...	100	52
Mica split by heat, ...	100	64

From a comparison of these two tables, it will be seen that, as tested by the two substances, mica and mica split by heat, rock-salt heat at 212° F. bears to ordinary heat of that temperature a relation similar to that which ordinary heat at 212° F. bears to heat at 700° F.; that is to say, that just as heat of 212° F. has a greater wave-length than heat of 700° F., so rock-salt heat at 212° F. has a greater wave-length than ordinary heat at that temperature. And the *surface stoppage* produced by splitting the mica, telling most powerfully upon heat of high temperature, or small wave-length, while the *stoppage* by *substance* is in the opposite direction, we see how the one effect tends, to a certain extent, to neutralize the other, rendering the proportions of different kinds of heat passed by split mica more nearly alike than those passed by ordinary mica.

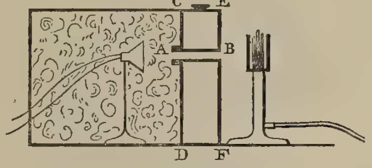
16. All these experiments concur in showing, that heat from rock-salt possesses very great wave-length, and probably heat from a thin plate of this substance, at a low temperature, may be found to possess a greater average wave-length than any other description of heat which can be exhibited.

Third Group of Experiments described.

17. I now proceed to describe the third group of experiments, or those on the radiation of glass and mica at high temperatures.

A. *Glass.*—For the experiments on glass, the following apparatus was used:—

The pile was placed within a box, and surrounded with cotton wadding. The orifice through which radiant heat was admitted into the box consisted of a brass tube A B, blackened in the inside. The diameter of this tube was ½ inch, its length 3 inches, and during the greater part of its length it passed through water, contained in the chamber C E F D. The side of the box (C A D) next the pile was lined with tinfoil. Owing to the small divergence of the rays of heat which had to pass through the narrow tube, the cone might be placed several inches to the left of A without sensibly weakening the effect, and, on the other hand, the source of heat might be placed some distance to the right of B without ceasing to fill up the field of view.



By this means, the distance between the pile and the source of heat being considerable, no currents of heated air from the latter would be able to reach the former; and as the tube A B was blackened in the inside, and passed through water, reflection and secondary radiation would both be avoided. By means of a lid fitting on the tube at A, the aperture might be diminished at pleasure. The pile was connected with a very sensitive galvanometer.

When glass at a high temperature was the source of heat, a very small aperture was sufficient, and thus the advantage was gained of having the whole field covered with glass, all at a high temperature, which could not have been the case had the aperture been large.

Slips of glass about $\frac{3}{4}$ inch broad were used, and were set vertically, just touching a gas flame from a Bunsen's burner. When two slips—one behind the other—were used, the one just touched that portion of the flame next the pile, and the other that portion furthest from it. A cross section of the arrangement is shown above.

A single slip of glass about ·1 inch thick thus heated gave a deviation of 16°·5, while two slips, the one behind the other, gave 18°·5. When the slips were ·05 inch thick these numbers were 29°·1 and 36°·3.

18. From these experiments we may conclude, that at a high temperature, 700° or 800° F., the radiation from two plates of glass, one behind the other, is sensibly greater than that from one—a result which does not hold for glass at 212°. Or the fact may be stated thus:—

The radiation of a single plate of glass bears a smaller proportion to the total radiation at 700° than at 212°.

19. It was next tried whether the capacity of a glass screen for passing heat from blackened copper at 700° was altered by its being heated.

In order to ascertain this, blackened copper at 700° F. was placed behind a slip of glass, and the amount of heat from the copper which passed the glass was observed

Firstly, When the glass was cold.

Secondly, When it was heated to between 700° and 800° F.

20. As in these experiments the considerably fluctuating temperature of the source of heat causes a somewhat large difference between successive observations, and renders necessary a great number in order to arrive at a correct result, it was thought desirable, instead of using momentary deviations, to employ permanent ones. This was done with complete success; the application of the heated copper, or its removal, causing an unmistakeable alteration of the position of the needle.

21. The experiment was then varied in the following manner:—The needle was kept permanently deviated by the heated glass, and the momentary swing due to the application or withdrawal of the heated copper was noticed, and was compared with that occasioned by the hot copper when the glass was cold and the needle at zero.

22. These experiments, which are not, perhaps, individually susceptible of very great exactness, agreed, however, in rendering it probable that glass, owing to its being heated up to about 700° F., does not change its diathermancy for heat of 700° F.

23. B. *Mica.*—The experiments on mica were made with the ordinary galvanometer. A piece of mica, thickness about ·008 inch, being used as a screen, and a diaphragm, ·65 inch square, at the distance of 3 inches from the mouth of the pile, being employed, the mean of two sets of experiments made the proportion of black heat of 200° F. passed by the mica to be 13 per cent. Placing an additional diaphragm of same size $3\frac{1}{2}$ inches beyond the first, and using as a source the temperature of 400° F., the mean of two sets of experiments made the proportion of heat passed by the mica screen to be 21 per cent.

In order to test whether the apparently greater diathermancy of the screen for heat of 400° F. was owing to the difference in the nature of the heat, or to the heat at 400° F. striking the screen more nearly at a perpendicular incidence, and thus experiencing less reflection as well as passing through a smaller thickness of mica, an experiment was made on heat at 200° F., with the arrangement and distance used for heat of 400° F., which seemed to show that this difference of distance does not affect sensibly the proportion transmitted. We may therefore conclude that the difference in the proportions transmitted is owing to a difference of quality in the two descriptions of heat.

24. A cast-iron box was next constructed, having this same plate of mica inserted as a window, so that, while one side of the box consisted merely of a moderately thin plate of cast-iron, the other, except round the edges, was composed of mica. The cast-iron side was then blackened, and the box filled with mercury. A thermometer inserted in the box measured the temperature. At 200° F., with the usual diaphragm 3 inches from the mouth of the pile, the proportion between the radiation of the blackened side and the mica window was, by the mean of 3 sets of experiments, as 100 to 87·8, while at 400° F., with the usual arrangement of 2 diaphragms, the same proportion was 100 : 84·1.

25. Let us endeavour to discuss these results. The radiation from the mica window consists of three portions:—

α. The proper radiation of the mica plate.

β. That portion of the radiation of the mercury which has been able to penetrate the mica plate.

γ. That portion of the radiation of the mica which, striking upon the mercury, is reflected back by it and has penetrated the mica plate.

Now, supposing there was no mercury behind the mica, and that mica between 200° and 400° does not alter its diathermancy as a screen in any respect, let us inquire what ought to have been the result obtained. Then, since the radiation of a thin plate equals its absorption (First Series, Art 19), and since the absorption of this mica plate was 8 per cent. less at 400° than at 200° (Art. 23), its proportional radiation ought to be 8 per cent. less at 400° than at 200°.

26. But the effect of the mercury behind the mica manifestly tends to diminish this difference. For we know that the mica (Art. 23) passes 8 per cent. more of lamp-black heat at 400° than at 200°; it will therefore no doubt pass a greater proportion of the heat from the mercury behind at 400° than at 200°. But we have reason to think that the radiation of mercury is nearly ¼ of that of lamp-black*; consequently we may suppose that owing to this action of the mercury, the proportional radiation of the mica window at 400° is increased about ¼ of 8, that is, 2 per cent. This therefore reduces the difference from 8 to 6 per cent.

27. But the mercury acts in another manner also in the same direction. Had mercury been a perfect reflector, its presence behind the mica would have been equivalent to doubling the thickness of the plate; for it would have sent the whole radiation of the mica that fell upon it back through the mica. But the difference between the proportional radiation at 200° and at 400° is less for a thick plate of mica than for a thin one (indeed, when the plate is indefinitely thick, this difference vanishes, and the proportional radiation is the same at all temperatures); this action of the mercury, therefore, would tend still further to diminish the already diminished difference of 6 per cent. The amount of this action cannot be far from 2 per cent.,† in which case the 6 per cent. would be reduced to 4 per cent.; now 3·7, or, in round numbers, 4 per cent. is the observed difference between the proportional radiation of the mica window at the temperatures 200° and 400°.

28. We see thus that the behaviour of the mica as a screen, compared with its behaviour as a radiator, agrees very well with the supposition which we made in Art. 25, viz., that mica between the temperatures of 200° and 400° does not alter its diathermancy in any respect; a result similar to that which we have already deduced for glass (Art. 22) between somewhat wider limits.

29. Experiments with the same object in view, but of a more direct description, were made upon mica, similar to those already described as having been made upon glass, that is, it was endeavoured to ascertain whether hot mica passed as much heat from hot copper as cold mica; but in these experiments the fluctuation was very considerable, probably owing to the small body of the mica. Never-

* Provostaye and Desains estimated the proportion of heat reflected by mercury to be 77 per cent. The radiation, being complementary to this, may be reckoned to be 23 per cent. nearly.

† It would have been better to have tested, by means of a direct experiment, to what extent the difference between the proportional absorption or radiation of mica at 200° F. and at 400° F. would have been diminished by doubling the thickness of the plate; but unfortunately the plate of mica was so much cut up by being used as a window, as to be unfit for being formed into a double screen.

We see, however, from Art. 37, that while the difference between the proportional radiation of a plate of glass (thickness 1^{mm}) at 100 C. and 390 C. is 9 per cent., the same difference for a plate of double the thickness is only 7 per cent., or 2 per cent. less. We may, therefore, without much risk of error, adopt this difference of 2 per cent. for the mica under experiment.

theless, they confirmed the results above obtained, viz., that mica does not change its diathermancy in any respect owing to its being heated.

30. We may therefore conclude that this property (at least within moderate limits) is common both to glass and mica, and indeed, *a priori*, there appears no good reason why the mere heating of a substance should change its diathermancy. It is the theoretical importance of this property that has induced me to take pains to verify it experimentally, and its importance will be seen from some of the consequences which follow its establishment, which I shall now proceed to discuss.

On the Law which connects the Radiation of a Body with its Temperature.

31. The experiments of Dulong and Petit upon the cooling of two thermometers, one naked, and the other covered with silver, seemed to show that the proportion between the radiations of these two substances was the same at the different temperatures of experiment.

Now, I have endeavoured to prove in these researches—1*st*, That the radiation of a thin plate at any temperature equals its absorption of black heat of that temperature. 2*d*, That the diathermancy of glass and mica (and probably of other substances) is not altered by heating the substances. Again, it is well known that substances are generally more diathermanous for heat of high, than for heat of low temperature; it follows that the radiation of a thin plate of a substance at a high temperature should bear a less proportion to the total radiation of that temperature than at a low temperature.

32. While, therefore, it is likely that the radiation of a silvered thermometer (silver-leaf being quite opaque for all heat) will bear a constant relation to that of a blackened thermometer at all temperatures; we should expect that for a naked thermometer, just as for the mica window, the radiation should bear a somewhat less proportion to the total radiation at a high temperature than at a low. We should therefore expect the radiation of the naked thermometer to increase somewhat less rapidly with the temperature than that of the silvered thermometer. Dulong and Petit, nevertheless, found the rate of increase to be the same for both.

33. Now, in the first place, since glass is exceedingly opaque for heat even of 300° C. (the highest temperature experimented on), the difference we are in search of (analogous to the difference of 4 per cent. in the mica window) would be exceedingly small. But, in the second place, Dulong and Petit had two thermometers, one of which, containing about 3 lbs. of mercury, was used for high, and the other and smaller one for low temperatures. This latter circumstance will complicate or even vitiate their experiments so far as regards this peculiar difference we are treating of.

34. Although, for these reasons, attaching little importance to DULONG and PETIT'S observations, so far as varying diathermancy is concerned, yet it may be well to state that they show, on the whole, a very small difference in the direction which would indicate a superior diathermancy of the glass at a high temperature.

35. Assuming it proved that the proportional radiation of a thin plate is less at a high than at a low temperature, I shall now endeavour to show that this difference increases as we diminish the thickness of the plate. To prove this, it is only necessary to exhibit the following table, given by MELLONI :—

TABLE IV.

	Number of Rays out of 100 passed.			
Thickness of Glass Screen.	Locatelli Lamp.	Incandescent Platinum.	Black Copper, at 390° C.	Blackened Copper, at 100° C.
mm 0·07	77	57	34	12
·5	54	37	12	1
1·0	46	31	9	0
2	41	25	7	0
4	37	20	5	0
6	35	18	4	0
8	33·5	17	3·4	0

36. We have already seen that glass does not change its properties with regard to heat, by being raised to the temperature of 390° C.; it is perhaps, however, too much to conclude, that when heated to the temperature of a Locatelli lamp, its properties would remain unchanged. At all events, in order to make use of the whole of the above table, we may suppose the properties of the glass to remain the same throughout, especially as the results we shall deduce from the supposition will be of the same nature as if we had only extended it to glass at 390° C.

37. Presuming, therefore, that the diathermancy of glass does not alter through its being heated, and allowing 4 per cent. as the proportion of the heat striking it reflected from the first surface of a glass screen, and supposing also the same proportion of the heat which is able to reach the second surface to be reflected from it, we may, on the principle that the proportional radiation of a plate equals its proportional absorption, construct the following table :—

TABLE V.

Proportional Radiation of Glass Plates at different Temperatures (Radiation of Lamp-black=100).

Thickness of Plate.	Temp. of Locatelli Lamp.	Temp. of Incandescent Platinum.	390° C.	100° C.
mm 0·07	16	37	61	84
·5	40	58	84	95
1·0	48	64	87	96
2	53	70	89	96
4	58	75	91	96
6	60	77	92	96
8	61·5	78	92·6	96

38. Let us call the proportional radiation of a glass plate at 100° C. unity, and we derive the following table.

TABLE VI.

Proportional Radiation of Glass Plates at different Temperatures, their respective Proportional Radiations at 100° C. being reckoned Unity.

Thickness of Plate.	100° C.	390° C.	Temp. of Incandescent Platinum.	Temp. of Locatelli Lamp.
mm 0·07	1	·72	·44	·19
·5	1	·88	·61	·42
1·0	1	·91	·66	·50
2	1	·93	·73	·55
4	1	·95	·78	·60
6	1	·96	·80	·62
8	1	·965	·81	·64

39. We see thus that the radiation of thick plates of glass increases most rapidly, and that of thin plates least rapidly, as the temperature increases, and we may suppose, that if we could procure a plate of glass of sufficient tenuity, we might (without heating the plate at all), by finding its absorption for heats of different temperatures, find its radiation at those temperatures, which (if the plate were thin enough) would give us the law of radiation of a glass particle. This law would not increase nearly so fast with increasing temperatures as

Dulong and Petit's law; it may even be that the radiation of a glass particle is proportional to its absolute temperature.

40. But all substances (with the exception of black mica and black glass, whose peculiarity may perhaps be otherwise explained) have the same properties as glass with regard to heat; that is, they are more diathermanous for heat of high than for heat of low temperature. The radiation of thin plates or particles of all substances will therefore increase less rapidly with temperature than that of black surfaces. It may therefore be, that the same law of radiation is common to very thin plates or particles of all bodies; this law (whatever it be) giving, in all cases, a less rapid increase of radiation with temperature than is indicated by Dulong and Petit's law. Had, however, the diathermancy of thin plates of different substances in some cases diminished, and in others increased for heat of high temperature, the law of radiation of a particle could not have been the same for all bodies.

The generality of this law of increased diathermancy of all bodies for heat of high temperatures seems, therefore, to me to argue in favour of the universality of the unknown law of particle radiation which depends upon the former.

41. What, then, does Dulong and Petit's law express? The answer is, It expresses the law of radiation of indefinitely thick plates, and we have shown that it increases faster than the law of radiation of a material particle.

To facilitate the comprehension of this subject as much as possible, I have put it in the following shape. Suppose we have two substances opposite one another, the one having the temperature of 0°, and the other of 100°, the latter will of course lose heat to the former—let us call its velocity of cooling 100.

Suppose, now, that (the first surface still retaining its temperature of 0°) the second has acquired the temperature of 400°; then we should naturally expect the velocity of cooling to be denoted by 400; but by Dulong and Petit's law, it is much greater. The reason of the increase may be thus explained. At the temperature of 100°, we may suppose that only the exterior row of particles of the body supplied the radiation, the heat from the interior particles being all stopped by the exterior ones, as the substance is very opaque for heat of 100°; while at 400° we may imagine that part of the heat from the interior particles is allowed to pass, thereby swelling up the total radiation to that which it is by Dulong and Petit's law.

42. We have thus ascertained—1*st*, That Dulong and Petit's law is not the law of radiation of a material particle; and, 2*d*, That this law increases less rapidly with the temperature than Dulong and Petit's law. But now the question arises, Can any method be indicated of ascertaining experimentally the law of radiation of a material particle?

Now, by continually diminishing the thickness of the plate whose radiation at different temperatures we are ascertaining, we certainly approach nearer and nearer to the desired law, and, by using the method indicated in Art. 37, we may avoid heating this plate at all, and thus overcome one source of experimental difficulty. Yet the thinnest plate we can procure of a substance such as glass or mica acts, to all intents, as an indefinitely thick substance for a great many of the rays of heat—that is, it stops them all. The change, therefore, of the unknown law of particle radiation into Dulong and Petit's law will, to a great extent, have taken place even within this very thin plate; so that, in order to reach the desired law, or even approximate to it, we should have to use much thinner plates than we could possibly procure; and, even without the necessity of heating the films, the experimental difficulty and labour of such an investigation would be very great.

On the other hand, we may suppose that, since a thin film stops so much heat, a portion may be stopped in the physical surface of the body, and the absorption might thus influence the law of reflection of heat from the surface. The amount of this influence depending on the absorptive nature of the particles, we might be able to measure the absorption, and, consequently, the radiation of the physical surface, that is, of a very thin plate.

But, in the first place, the difficulties of such an investigation would be even greater than in the previous case; and, in the second place, the true law of reflection is not yet finally settled.

I am therefore induced to think, that it is nearly hopeless to attempt to ascertain the true law of radiation of a material particle, at least by any method of experimenting depending upon the use of thin plates, or on the change which absorption may be presumed to cause in the amount of heat reflected from the surface of a body.

Edinburgh, *March* 22, 1859.

On General Diathermancy (added 15th June).

43. Circumstances having occurred which may interfere in the meantime with my further experiments on heat, I annex to this paper an account of some experiments made since the date of reading. These were proposed with the view of ascertaining whether diathermancy is confined to rock-salt, or whether other bodies partake of this property. If the latter be the case, the reason why we have not hitherto ascertained it to be so is evidently the difficulty of obtaining crystals of many bodies sufficiently large to operate upon; and if we wish to prove these diathermanous we must do so in a way that does not render necessary the use of large crystals.

44. Now, a body that is transparent for light, forms, when pounded, a white powder, or one that reflects a great deal of light. It will be granted that the rea-

son of this is because we have not only the reflection from the outer surfaces of the crystals, but also from many interior surfaces. Now the same remark is applicable to heat. A body that is diathermanous or transparent for heat should, as a powder, be white for heat, or, in other words, reflect it. But (First Series, Art. 31) the reflection *plus* the radiation of a body at any temperature equals the lamp-black radiation of that temperature. Hence a powdered diathermanous substance ought to radiate less than lamp-black. Accordingly, different substances having been pounded into a fine crystalline powder, made into a paste with water, spread on the two sides of parallelopipedons of wood, dried, and one of the sides, when dry, rubbed over with lamp-black, the following result was obtained :—

TABLE VII.

Radiation at 212°.		
Name of Substance.	White side.	Black side.
Table Salt . . .	83·1	100
White Sugar . .	98·7	100
Alum	100·0	100
Sulphate of Potash .	88·1	100
Nitrate of Potash . .	86·7	100

45. Thus we see that table-salt being white for heat, the radiation of the white side is less than that of the black side ; and further, white sugar and alum being both nearly black for heat, the radiation of the one side is nearly equal to that of the other. We see, moreover, that sulphate of potash and nitrate of potash, especially the latter, are white for heat, although not quite so much so as table-salt. May we not therefore presume that these substances are diathermanous ? There is, moreover, the following method of confirming the testimony in favour of the diathermancy of these substances as derived from this experiment.

46. Table-salt being white for heat, part of the reflected heat will be composed of rays which have been reflected from the internal surfaces of crystals. Such rays have therefore been sifted, having left behind that description of heat which passes with difficulty through rock-salt, and also (Art. 9) through mica. The whole reflected heat from a surface of table-salt should therefore be of a nature which passes more easily through mica than ordinary heat, and (First Series, Arts. 31 and 33) since the sum of the reflected and the radiated heat is equal both in quantity and quality to that from lamp-black, it follows that the radiated heat from table-salt (and probably from other substances white for heat) should, in order to

make up the average quality, have a somewhat greater difficulty in passing through mica than ordinary lamp-black heat. Accordingly, it was found that the diathermancy of a mica screen for heat from table-salt was less than that for ordinary lamp-black heat in the proportion of 92 to 100, while it was less for heat from pounded sulphate of potash in the proportion of 93 to 100, thus confirming the analogy between rock-salt and sulphate of potash. No such difference was observed for heat from sugar.

47. We see also from the above table that the radiation and therefore the absorption of table-salt is 83·1 per cent., leaving 16·9 per cent. for the reflected heat. Now MELLONI found that chalk absorbed 56·6 per cent., and consequently reflected 43·4 per cent. of heat from a Locatelli lamp; and if we suppose table-salt to be at least as white as chalk for heat of that temperature, we must conclude that table-salt is less white for heat of 212° than for heat from a Locatelli lamp, following in this respect the same law as chalk, which, from being nearly black for heat at 212°, becomes comparatively white for heat from a Locatelli lamp. There is also little doubt that table-salt reflects more than 16·9 per cent. of the light that falls upon it. Hence we may conclude generally that powders even of diathermanous bodies are less white for heat of low temperature than for heat of high temperature and for light.

48. It would also seem, that although, comparing one powder with another, there is no relation between apparent whiteness and whiteness for heat, since it was found that very white surfaces of pounded sugar and alum (the particles compressed, not made into a paste with water) reflected little or no heat; yet, comparing powdered surfaces of the same diathermanous body together, there seems to be some relation between their apparent whiteness and their whiteness for heat, insufficient pounding, or any circumstance which diminishes the apparent whiteness, diminishing also its whiteness for heat.

VII. —*Inquiries about Terrestrial Temperature; to which is added an Index to M. Dove's Five Memoirs on the Temperature of the Globe.* By James D. Forbes, D.C.L., F.R.S., Sec. R.S. Ed., Professor of Natural Philosophy in the University of Edinburgh.

(Read 7th March 1859.)

1. To find the numerical law according to which the temperature of a place varies with its latitude, is an empirical problem which has, since the middle of the last century, from time to time engaged attention.

2. Lambert, Mayer, and Kirwan in the last century, De Humboldt, Brewster, Kämtz, and Dove in the present, may be cited amongst those who have investigated formulæ which express, with more or less accuracy, the mean temperature of a place in terms of its latitude.

3. The formulæ proposed are mostly reducible to two types—a variation depending upon the cosine of the latitude simply (that of Sir D. Brewster), and one depending on the square of the same quantity (that of Mayer).

4. There is no doubt a measure of truth in both these assumptions. If we select maritime stations in the northern hemisphere (and these, on the whole, furnish the most numerous class of observations), the simple cosine affords a remarkable approximation to the law of terrestrial temperature. If we take exclusively observations in the interior of continents, then the temperature decreases more nearly with the square of the cosine; and if we include both classes of stations indifferently, the approximation afforded by the latter law seems still to be the best.

5. To De Humboldt, Kämtz, and Dove, we are indebted for the most important accumulations of materials derived from observation for the elucidation of this subject. De Humboldt, however, had the singular merit of giving an empirical generalization of the facts by means of his isothermal lines, which indicate, in a manner equally natural and instructive, the distributionof temperature over the globe, after correction for the elevation above the sea of the places of observation.

6. The same philosopher pointed out with great skill and acuteness the physical influences which prevent the isothermal lines from being everywhere parallel to the equator, such as the irregular distribution of land and water, and the influence of permanent or periodical currents in the ocean and the air.

7. Thus, in his hands, this part of the science of meteorology passed out of the domain of barren mathematical generalization into that of rational physics.

8. Sir David Brewster endeavoured later to show that there are two poles or

centres of extreme cold in the northern hemisphere, connected with the predominant masses of land in Siberia and Arctic America; and he ingeniously suggested that the isothermal lines might form a connected set of double curves, analogous to lemniscates, round these centres as poles. With this assumption, he was led to propose a formula for the mean temperature of any place depending on the product of the sines of its angular distances from the two cold poles. M. Dove contests the existence of two centres of minimum temperature in the annual means; yet his researches make it exceedingly probable that they do exist in winter, as at most seasons there are also two centres of greatest heat in the tropical regions, depending partly on the local accumulation of land, partly on the peculiarity of the marine currents.

9. But the most instructive mode of indicating the climatic irregularities of the globe, subsequently to the isothermal lines of De Humboldt, is Dove's representation of what he calls the "Thermic Anomaly," by means of "Isabnormal Curves."* The principle of these curves is the following:—The average temperature of every tenth parallel of latitude is taken by tabulating its temperature at 36 equidistant points—that is, on every tenth meridian. These numbers are best obtained from the isothermal curves on the plan of De Humboldt. The temperature of any place on the given parallel is then compared with the *mean of the parallel*, and lines are drawn through all those places whose temperature is 1°, 2°, 3°, or more degrees *above* the mean of the parallel; and other curves are drawn through points which are 1°, 2°, &c., *below* the mean of their respective parallels. These deviations + or − from the mean of the parallel are called the "Thermic Anomaly," representing, in fact, all the heating or cooling causes in action at a given place, *independently of its distance from the equator*. The curves so drawn are called the "Isabnormal Curves of Temperature." The whole globe is thus divided into two vast, but not necessarily continuous regions; the one having a temperature higher than the mean due to the latitude, and the other having a temperature below the mean. Centres of *relative* maximum cold, coinciding nearly with the Cold Poles of Sir David Brewster, are found in the regions of Hudson's Bay and of Eastern Siberia.

10. The isabnormal curves may also be formed for different seasons, when they become very instructive. In winter, the relatively cold centres of the northern hemisphere are within the continents, and the relatively warm centres are in the North Pacific and North Atlantic respectively; in summer these positions are reversed, beautifully pointing out the effect of the ocean in equalizing the temperature of the globe.

11. To ascertain the "Thermic Anomaly," M. Dove, of course, required to fix as exactly as possible the mean temperature of every tenth parallel of latitude,

* The Distribution of Heat over the surface of the Globe, &c. Plates IV. and V. 4to. London, 1853

which he did by the method which I have indicated above.* Preliminary to this, he had amassed and discussed an unprecedented amount of observations, as well for the mean annual temperature as for that of each month in the year.† The results form by far the most valuable body of information which we possess on this subject. It is still, however, very much to be desired that M. Dove would add yet another to his various contributions to climatology; and that is a Mercator's chart on a large scale, and well engraved (similar to that of Duperrey for the direction of the magnetic needle), indicating all the places for which he has obtained the mean annual temperature, with that temperature (as reduced by him to the sea-level) engraved in figures on the chart, and the isothermal curves drawn amongst these figures, as M. Erman has so well done with reference to the magnetic declination. At present we are deficient, not only of a precise and easily tested indication of the evidence on which the isothermal curves at any given part of the globe (and especially at sea) are determined, but owing to the small scale and rather rude execution of existing maps, and their occasional disagreement with one another, there is often a difficulty in making them as useful as they might otherwise be. M. Dove must be in possession of all the materials of such a chart; and it is to be hoped that he will add to the benefits which he has already conferred on the science of meteorology by its speedy publication.

12. The "Thermic Anomaly," of which I have spoken above, which is nothing else than the expression of the effects of climatic influences not immediately depending on the latitude, is primarily due to the irregular distribution of land and water. Were the earth's surface homogeneously constituted, were it all land or all water, the symmetry of the different meridians would be perfect,—there could be no assignable cause for a variation in the gradation of climate from the equator to the pole depending on the longitude. The isothermal lines would coincide with the parallels of latitude, and the inflections of the isothermal lines, which, in the language of M. De Humboldt, are precisely what the thermic anomaly is in the language of M. Dove, would cease to exist.

13. The irregular intermixture of oceans and continents acts *primarily* by the inequality of the absorption and detention of the solar rays by land and water, and by the laws of conduction and of convection which regulate the internal motion of heat in the one and in the other. But, *secondarily*, the consequences of this irregularity are not less important in producing currents of the air and ocean. Heat

* The Distribution of the Heat of the Globe, &c., p. 13, &c. London, 1853. [The same work was published in German at Berlin. In point of fact, the annual mean temperatures of the parallels are derived by M. Dove from the average of the twelve months separately considered, and projected in monthly isothermal lines. It would probably be preferable to deduce them from the annual curves alone, which rest on a surer basis.]

† See his "Five Memoirs" in the Berlin Transactions, "Ueber die nicht periodischen Aenderungen der Temperatur vertheilung aufder Oberfläche der Erde," and his "Temperature Tables," in Report Brit. Assoc., 1847.

or cold travel to or from the interior of continents, or parallel to their shores, in a manner which physical theories may indicate in a general way, but cannot possibly evaluate with accuracy. Further, the periodical conversion of vast surfaces of salt and fresh water into the state of ice must alter, for a portion of the year, the laws of temperature.

14. The secondary anomalies just referred to are in their nature in a great degree compensatory. If a current of hot water moderates the cold of a Lapland winter, the counter current, which brings the cold of Greenland to the shores of the United States, in a great measure restores the balance of temperature, so far as it is disturbed by this particular influence. The prevalent winds, in like manner, including the trade-winds, though they render some portions of continents on the average hotter or colder than others, produce just the contrary effect elsewhere. Each continent, if it has a cold eastern shore, has likewise a warm western one, and even local winds have for the most part established laws of compensation. In a given parallel of latitude all these secondary causes of local climate may be imagined to be mutually compensatory, and the outstanding gradation of mean or normal temperature will mainly depend—1*st*, Upon the effect of latitude simply; 2*d*, On the distribution of land and water considered in their primary or *statical* effect, which in a first approximation we may conceive to be proportional to their relative areas.

15. Assuming, then, the data with which the tables and charts of M. Dove furnish us, I propose first, to inquire what portion of the average temperature of the globe in each parallel is due to the land, and what to the water, which respectively belong to it. Next, I propose to obtain a formula, empirical, indeed, yet involving the elements of physical geography as data, for expressing the mean temperature of a given parallel, and thence arrive at an approximate answer to the inquiry as to what would have been the equatoreal or polar temperature of the globe, or that of any latitude, had its surface been entirely composed of land or of water,—a result not without interest in cosmical speculations, even if subject to some margin of uncertainty.

16. Every one acquainted with physico-mathematical investigations, especially those of more recent times, is aware that the flexibility of an algebraic formula including several constants is such, that its coincidence with a series of graduated observations must be very cautiously admitted as any proof whatever of the relation of the numbers being otherwise than empirical. My object here being to obtain a formula necessarily involving several constants, but with a certain physical significance, the importance of testing the parts of the formula by independent analogies cannot be overrated. In order, therefore, to show that the result of my labours has been something more than the mere empirical coincidence to which I have referred, it will be necessary to trace the course of the approximation and verification which I adopted.

17. § I. *The gradation of mean temperature from the Equator to the Pole* empirically *represented.*

I have referred to the attempts which have been made during the last hundred years to find an empirical formula showing the gradation of temperature, from the Equator to the Pole, *in the northern hemisphere.* Setting wholly aside, and endeavouring as far as possible to forget for the moment any formulæ of the kind, I started a fresh with the numbers given by M. DOVE in his work already cited (par. 9), and, by a process considerably indirect, I obtained a formula which represents these numbers with greater exactness than perhaps any other yet employed. The form of the expression is indeed coincident with that probably first used by M. KÄMTZ, expressing and suggested by the physical fact, that the temperature of the globe (on an average of all meridians) reaches its maximum, not at the Equator, but somewhat farther north; according to this formula, in lat. 6° 30′ N.

18. The formula (purely empirical) is this:—

$$T = 80^{\circ}\cdot 8 \cos^2 (\lambda - 6^{\circ}\ 30'),$$

where T is the mean annual temperature on Fahrenheit's scale, of the parallel whose latitude is λ.

19. The following table contains a comparison of this formula with numbers derived from M. DOVE's charts and tables:—

TABLE I.

North Lat.	Temp. by Dove's Charts and Tables.	Temp. by Formula.	Difference of Formula.	North Lat.	Temp. by Dove's Charts and Tables.	Temp. by Formula.	Difference of Formula.
0°	79°·7	79°·8	+0°·1	60°	29°·8	28°·6	−1°·2
10	79 ·9	80 ·5	+0 ·6	65	22 ·6	22 ·1	−0 ·5
20	77 ·5	76 ·4	−1 ·1	70	16 ·4	16 ·1	−0 ·3
30	69 ·8	67 ·9	−1 ·9	75	10 ·7	10 ·8	+0 ·1
40	56 ·5	56 ·2	−0 ·3	80	6 ·8	6 ·5	−0 ·3
50	42 ·5	42 ·5	0 ·0	90	2 ·3	1 ·0	−1 ·3

20. On this table I have to remark, that the numbers in the second column for the latitudes 50°, 60°, and 70°, differ by +0°·8, −0°·4, and +0°·4, from those given by M. DOVE at page 14 of his *Distribution of Heat,* &c. The numbers adopted have been deduced from a most careful investigation from M. DOVE's more recent Polar Chart of Isothermal Lines, in his *Klimatologische Beiträge,* published in 1857.* These numbers sensibly diminish a very manifest anomaly in the pro-

* It is by no means an easy matter to deduce the mean temperature of a given parallel correctly from an isothermal chart. What precise method M. DOVE adopted I am not aware. After various attempts, I found the following procedure to be the only satisfactory one. Taking eighteen equidistant meridians (20° apart), I projected the temperatures indicated by the isothermal lines

gression of temperature under the 50th and 60th parallels. The numbers for 80° and 90°, and in a great measure also that for 75°, rest upon a method of graphical interpolation, explained by M. Dove at p. 13 of his *Distribution of Heat*, &c., which I have verified; but it must of course be received with considerable allowance. The formula is least accurate about latitude 30°, evidently depending on certain physical peculiarities which cannot be embraced in so simple an expression.*

21. The numbers in the second column of Table I. are projected in Plate II.

§ II. *The Distribution of Land and Water according to Latitude on the Globe.*

22. It has been stated in the introduction to this paper that the unequal distribution of land and water on the surface of the globe is the leading cause of the irregular distribution of temperature, considered independently of the latitude; in other words, of the Thermic Anomaly. If we are to trace the connection between the temperature of a given parallel and the amount of land on that parallel, it will be convenient to form a table of this amount for every 10° of latitude, both north and south, compared to the entire circumference of the parallel. This is

as perpendiculars erected on a straight line at intervals corresponding to the latitudes at which they intersect the given meridian. An interpolating curve being drawn easily among the extremities of these perpendiculars, the abscissæ corresponding to every 5° of latitude are ascertained and tabulated. The mean of these numbers, taken round the whole circumference, gives the required number for each parallel. I think it worth while to preserve the numbers I have obtained, which are given in the following table, as they may be of service in future inquiries. I may here add, that the character of the climatic gradation in different latitudes is highly instructive. The curves of temperature corresponding to oceanic meridians, such as that of Greenwich, are everywhere decidedly concave to the axis (representing a variation depending nearly on the simple cosine), while those of the continents, such as longitude 120° E., tend to become convex towards the axis in the higher latitudes (inclining to the law of the (cosine)^2), or else they form almost a straight line sloping towards the pole. This is in conformity with what has already been said in par. 4. See also par. 28 below.

Table of Temperatures (Fahrenheit) deduced from M. Dove's Polar Chart of 1857.

Latitude North.	Longitude East of Greenwich.																		Mean.
	0°	20°	40°	60°	80°	100°	120°	140°	160°	180°	200°	220°	240°	260°	280°	300°	320°	340°	
50°	53°	47°	44°	41°·5	39°	36°	33°·5	37°	41°	42°·5	47°	51°	48°	38°	33°	34°·5	44°	54°·5	42°·5
60	45 ·5	40	36 ·5	31 ·5	27 ·5	25	20	22 ·5	28	25 ·5	27	36	29 ·5	21	17	24 ·5	34 ·5	42 ·5	29 ·8
65	40	36 ·5	33	26	23	19 ·5	13	13 ·5	20	18	19	20	17	11	11	22	29 ·5	34 ·5	22 ·6
70	33 ·5	33	29 ·5	22	20	15	6 ·5	6 ·5	12	12 ·5	11 ·5	10	5	2 ·5	8	16 ·5	24	27 ·5	16 ·4
75	26	28	24	18 ·5	16 ·5	10	1	0 ·5	5	6 ·5	5 ·5	3 ·5	−5	−1	5	10 ·5	18	21	10· 75

* The great simplicity of the formula (par. 18) turns upon the accidental circumstance of the zero of Fahrenheit's scale so nearly coinciding with the temperature of the pole, as Sir D. Brewster long ago remarked. The formula would represent the numbers of M. Dove slightly better if a small constant term were introduced; thus, $T = 1^\circ + 80^\circ \cos^2 (\lambda - 6^\circ\ 30')$, and in using any other thermometric scale this might be preferred. This formula becomes

$$T = -17^\circ{\cdot}2 + 44^\circ{\cdot}4 \cos^2 (\lambda - 6^\circ\ 30') \text{ on the Centigrade scale.}$$
$$T = -13^\circ{\cdot}8 + 35^\circ{\cdot}5 \cos^2 (\lambda - 6^\circ\ 30') \text{ on Reaumur's scale.}$$

done in the following table, commencing from the north pole. The proportions were taken by accurate measurement from a three-feet CARY'S globe, with the exception of the Arctic regions, which were measured on an Admiralty polar chart.

TABLE II.

Parallel.	Proportion of Land.	Proportion of Water.
90° North	Unknown.	Unknown.
80 „	Unknown.	Unknown.
75 „	·286	·714
70 „	·483	·517
60 „	·568	·432
50 „	·563	·437
40 „	·445	·555
30 „	·434	·566
20 „	·308	·692
10 „	·234	·766
0 „	·216	·784
−10 South	·204	·796
−20 „	·225	·775
−30 „	·200	·800
−40 „	·040	·960
−50 „	·021	·979

23. The numbers for the land are projected in Plate III., fig. 1, and the curve rudely drawn through them gives an approximation to a physical law of the distribution of sea and land from latitude $+75°$ to latitude $-50°$, a little beyond which occurs the only portion of the known globe where the entire circle of latitude passes through water, since farther south the antarctic land commences. On the other hand, the maximum proportion of land (about *six-tenths* of the circumference) occurs in the northern hemisphere, almost exactly upon the Arctic circle.

§ III. *Hypothesis respecting the Law which Regulates the Temperature in Different Latitudes.*

24. From what has been said (par. 14) it will be understood that I regard the temperature of a given parallel as a function (1) of the latitude, (2) of the proportion of land and water in or about that parallel. Our object, therefore, is to find the form of the function. And if our proceedings shall appear to be in the first instance somewhat arbitrary, the reader is requested to suspend his judgment until he sees the independent confirmations which will be afterwards adduced.

25. The following may be regarded as the more fundamental premises or postulates:—

26. *First*, The law must be that of decreasing temperature throughout, from the equator towards the pole; and the arbitrary formula of par. 18, and the curve

(Plate I.) show that the decrease is least rapid near the equator, becomes more rapid afterwards, and again diminishes somewhat less rapidly (or, at least, its rate does not increase) in the highest latitudes.

27. *Secondly*, The temperature of a given parallel may be considered as compounded of two distinct temperatures; that which would belong to a sphere all of water placed under the same external heating influences as our globe; and that which would belong to a sphere of land in the same circumstances. Or it will be more convenient to consider the sphere of water as the normal condition of the globe, and the influence of the land as a disturbing effect superimposed upon the fundamental condition of an aqueous globe.

28. *Thirdly*, As regards the law of temperature on a sphere of water, which by the second assumption (27) is to be taken as the basis of our calculation, it has been shown in the introductory part of this paper (4), that on those meridians which pass through one of the great oceans—the Atlantic, for example—the decrement of temperature from the equator to the pole follows pretty nearly the formula of Sir D. Brewster or the simple cosine of the latitude; but when the continents are included, it is more accurately expressed by the formula of Mayer or the $(\text{cosine})^2$. These empirical relations are graphically expressed in Plate III., fig. 2, where the relation is shown between the curve of the simple cosine and that of $(\cos)^2$ lat. The lower the power of the cosine used (including proper fractional powers), the more convex is the curve to the axis, or the farther does the tropical temperature advance towards the higher latitudes: the higher powers of the cosine exhibit a more and more rapid decline towards the middle latitudes, while there is a point of contrary flexure, indicating the less rapid rate of diminution as we approach the pole.* The character of these two mathematical laws is well illustrated by the curve of temperature along the meridians of 0° (or that of Greenwich) and 120° E., in the curves of Plate III., fig. 3, the former representing a maritime the other a continental meridian.† The former of these (or the Atlantic climate) has the character of the curve which depends on the simple cosine of the latitude, the latter (the Asiatic meridian) of some higher power of the cosine. It is therefore likely that on an aqueous sphere the temperature will be a maximum sensibly at the equator, and will decline on either side according to a regular law depending on some power of the cosine of the latitude, and it is moreover probable that this power will not differ greatly from unity. Let us, however, consider

* It is to be well observed, however, that in these mathematical curves the commencement and ends of the two curves are made to coincide. They are merely drawn for the purpose of showing the *gradation*, according to one law or the other, from a given temperature to another given temperature. A curve intermediate between the two showing the variation of the fractional power $(\cos)^{\frac{2}{3}}$, the upper portion of which is nearly straight, is added for a purpose which will be immediately explained (33).

† The curves are drawn so as to show the general curvature, without following the minor and sometimes doubtful inflections. In particular, the tropical part of the water meridian may be considered to belong to a longitude a little west of Greenwich, so as to avoid the influence of the African continent.

the power as being in the meantime unknown. The expression for the temperature of the aqueous globe in a latitude λ may be thus expressed :—

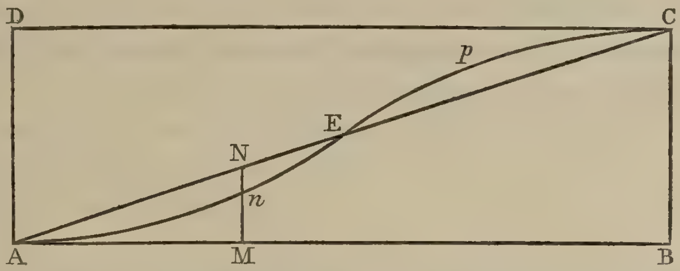
$$T_\lambda = A + B \cos^m \lambda$$

where A, B and m are constants to be found. Of course the equatoreal temperature of the water globe will be A + B, and the polar temperature will be A.

29. *Fourthly*, We will next, as an approximation merely, consider the effect of land in modifying the temperature of a given parallel to be proportional directly to the proportion of land on or near that parallel.*

30. *Fifthly*, The general influence of land on climate is tolerably well known, and may be verified by the study of different climates. In *every* parallel of latitude the effect of masses of land or continents is to exaggerate the variation of temperature due to the seasons. The temperature of the ocean is more nearly uniform than that of continents. But besides this, as a general rule, the presence of continents affects the *mean annual temperature*, exaggerating the character of the climate, whether it be above or below the mean of the globe or hemisphere. It follows from this, that *below* a certain latitude the term in the expression for the mean temperature depending on the amount of land is *additive ; beyond* that latitude it becomes subtractive ; and in one particular parallel it is = 0, or the mean temperature is independent of the distribution of land and water. Thus the accumulation of land in intertropical Africa produces a temperature in excess of the mean of the parallel, while in Siberia the effect of the great concentration of land is precisely the reverse ; the temperature there is below the mean of the

* If it were practicable to go into such details, it is probable that the influence of continents might be more accurately expressed by a different law from one depending on their simple breadth. A narrow land with ocean on both sides will have a slighter peculiarity of climate than if it were attached to a wide continent, and partook of a thoroughly continental character. In like manner, if ninety-nine hundredths of the circumference of the globe in any parallel were land, the small residue of ocean would affect the continental character of the climate even less than in proportion to its small extent. Let the circumference of the globe in any parallel be denoted by the line AB $(=1)$; the fraction representing the land on the parallel by the abscissa AM $(=L)$; let, also, BC express the extreme value of the term which expresses the effect of land on the temperature of the parallel ; then, for any value of L less than unity, the magnitude of the temperature-correction due to land would not be MN but Mn, which increases slowly when L is very small or very great, and most rapidly when $L = \frac{1}{2}$. Such a co-efficient might be adequately represented by such a function of L as



$$\frac{C}{2} \left\{ 1 - \cos \pi L \right\}$$

But such a mode of calculation would be perhaps a needless refinement, as we should have to take into account not only the sum of the land in the parallel, but also its continuity, or the contrary.

parallel. In an intermediate latitude, which seems to be about that of the Mediterranean Sea, these opposite influences are neutralized. These effects may be traced both on the common map of isothermal lines, and in M. DOVE's maps of the "Thermic Anomaly." In the former, the curvature of the isothermal lines is, in tropical countries, usually *concave* towards the equator over the continents,—that of Africa, for example,—but it is convex towards the equator, or the isothermals bend to the south in passing over the continental portions of higher latitudes, as in Siberia. In the maps of the "Thermic Anomaly," the effect of land is still more apparent, being denoted by ovals of relative heat in the continents of the warmer latitudes, while ovals of relative cold occupy the vast northerly areas of Asia and America.

31. *Sixthly*, From an inspection of the above-mentioned charts, it is pretty evident that about the 40th or 45th degree of north latitude is, on an average, that where the distribution of land and water is a matter of indifference as regards temperature. We have seen in the last paragraph that the climatic influence of land increases in both directions from the neutral parallel, as the climate assumes more of the tropical or arctic character. As a first approximation, we will assume that the term depending on the land is effected by the co-efficient $\overline{\cos 2\lambda}$, which makes it *zero* at 45° of latitude, and gives it a positive value below that latitude and a negative value above. Of course, any odd power of $\overline{\cos 2\lambda}$ would answer to the same conditions. Hence the Land term of the formula will, in terms of this and two preceding paragraphs, be thus expressed:—

$$C.\ L.\ \cos 2\lambda$$

where C is a constant expressing the excess of equatoreal temperature on a sphere all land above that of one all water; and L is the fraction of land compared to the circumference of the parallel. It will also be more in accordance with physical principles if we take for L its average value over a certain space north and south of the parallel under consideration.

32. Collecting the terms of the formula, we have

$$T_\lambda = A + B \cos^m \lambda + C.\ L.\ \cos 2\lambda$$

which contains four unknown quantities, A, B, C and m. My next procedure was to obtain these constants by elimination between four equations furnished by DOVE's temperature of the parallels (19). These being projected in a diagram, and an interpolating curve drawn amongst them, the ordinates of that curve* were taken for the latitudes 0°, 30°, 50°, 70° north, as expressing best the course of climate observed in one hemisphere. The equations were (on Fahrenheit's scale)

* It may be satisfactory to add, that the results obtained by using M. DOVE's numbers without any modification lead to an almost identical result when the same latitudes are employed.

$$80^\circ \quad = A + B + \cdot 217\ C$$
$$69^\circ\cdot 5 = A + B \cos^m 30^\circ + \cdot 395\ C \cos 60^\circ$$
$$42^\circ\cdot 7 = A + B \cos^m 50^\circ + \cdot 53\ \ C \cos 100^\circ$$
$$15^\circ\cdot 7 = A + B \cos^m 70^\circ + \cdot 395\ C \cos 140^\circ$$

where it is to be remarked that the numerical co-efficient of the last term is not the fraction expressing the land on the precise parallel, but the mean of three values of the land (graduated by an interpolating curve) extending over a space $\pm 10^\circ$ on either side of the given parallel. This seems to give a truer expression of the climate of the parallel.* I call this factor L′.

33. These equations being solved (m being found by approximation) we have very nearly—

$$T_\lambda = 12^\circ\cdot 5 + 59^\circ\cdot 2 \cos \tfrac{4}{5}\,\lambda + 38^\circ\cdot 1\ L' \cos 2\,\lambda$$

From this we readily deduce what the equatoreal and polar temperatures would be, 1*st*, of a globe covered entirely with water; 2*d*, of a globe entirely of land—

	All Water.	All Land.
Equatoreal Temperature ($\lambda = 0^\circ$) .	71°·7 Fahr.	109°·8 Fahr.
At Latitude 45°	51°·0 ,,	51°·0 ,,
Polar Temperature ($\lambda = 90^\circ$) .	12°·5 ,,	– 25°·6 ,,

§ IV. *Confirmation of the Hypothesis and Formula.*

34. The preceding calculations are founded upon the configuration and climate of the NORTHERN HEMISPHERE alone. I think it important to add, that they were actually made without any anticipation of how they might apply to cases not contemplated in the construction of the formula. The following table shows the

* Thus treated, the numbers of Table II., par. 22, give the following results :—

Latitude.	L Proportion of Land by Equalizing Curve.	L′ Mean of 3 values from $\lambda - 10^\circ$ to $\lambda + 10^\circ$	L′· cos 2λ
75° N.	·29	·30?	–·260
70 ,,	·48	·395	–·303
65 ,,	...	·46	–·295
60 ,,	·58	·52	–·260
50 ,,	·55	·53	–·092
40 ,,	·47	·473	+·082
30 ,,	·40	·395	+·197
20 ,,	.32	·318	+·244
10 ,,	·24	·252	+·237
0 ,,	·21	·217	+·217
–10 S.	·22	·21	+·197
–20 ,,	·22	·205	+·157
–30 ,,	·18	·16	+·080
–40 ,,	.07	·085	+·015

results of a comparison of the approximate formula (33) with M. DOVE's tables for other northern latitudes than those used in constructing it; and also for the southern hemisphere, so far as trustworthy observations extend. Latitudes beyond 75° north cannot be made use of in consequence of our ignorance of the distribution of land and water in those regions.

TABLE III.

Latitude.	Temp. Observation.	Theory.	Difference.	Values from Formula.	
				All Land.	All Water.
75° North	10°·7	13°·5	+2°·8	−9°·6	23°·4
70 „	16 ·4	16 ·5	+0 ·1	−1 ·6	28 ·0
65 „	22 ·6	20 ·8	−1 ·8	...	...
60 „	29 ·8	27 ·5	−2 ·3	18 ·4	37 ·4
50 „	42 ·5	43 ·0	+0 ·5	39 ·9	46 ·5
40 „	56 ·5	58 ·0	+1 ·5	61 ·4	54 ·9
30 „	69 ·8	69 ·4	−0 ·4	80 ·9	61 ·9
20 „	77 ·5	76 ·6	−0 ·9	96 .5	67 ·3
10 „	79 ·9	79 ·6	−0 ·3	106 ·3	70 ·6
0 „	79 ·7	80 ·0	+0 ·3	109 ·8	71 ·7
10 South	78 ·0	78 ·1	+0 ·1	106 ·3	70 ·6
20 „	74 ·1	73 ·3	−0 ·8	96 ·5	67 ·3
30 „	66 ·9	64 ·9	−2 ·0	80 ·9	61 ·9
40 „	54 ·6	55 ·5	+0 ·9	61 ·4	54 ·9

35. I will not now direct attention to the numbers for the northern hemisphere, which may not be thought to coincide better than (or, perhaps, even as well as) might have been anticipated from the range of latitudes used in deducing the formula. But the general close coincidence of the observed with the calculated temperatures in the southern hemisphere offers a confirmation of a very different kind.

36. The lower temperature of the southern hemisphere up to lat. 40°, compared to the northern, has often and justly been attributed to the diminishing amount of land, as the higher temperature of a parallel some degrees north of the equator, than that of the equator itself, is due to the increasing amount of continental surface, especially in Africa. Our formula gives a precise expression to these generalities. And the fidelity of the formula (at least for the lower latitudes) is proved by the

accuracy with which it applies to more than one-half of the surface of the southern hemisphere. Indeed, the distinction between an Empirical and a Rational formula,—one founded on the mere law of continuity, and one on a rational basis,—is well illustrated by applying to this case the purely mathematical law (18), which for the northern hemisphere alone represents the observations there even better than our physical theory as yet does, but which yet egregiously fails when extended to southern latitudes, as the following table shows:—

TABLE IV.

Lat. SOUTH.	Temperature by Empirical Law of par. 18.	Difference from Dove's Table.	Difference according to Rational formula.
10°	74°·3	− 3°·7	+0°·1
20	64 ·7	− 9 ·4	−0 ·8
30	52 ·2	−14 ·7	−2 ·0
40	38 ·3	−16 ·3	+0 ·9

37. With this strong testimony to the reasonableness of our fundamental assumptions as to the influence of land, we may, by using the observed temperatures of *corresponding parallels* in the two hemispheres, obtain an expression for the influence of land in each of those parallels, disengaged from any assumptions as to the effect of latitude in modifying the gradation of temperature on a globe whether composed of land or of water, such as we made in paragraphs (26) and (28) of § 3. This is to be accomplished in the following way:—

38. By our fundamental assumptions of § 3. we attribute to the land and the water of any parallel an influence on the temperature in proportion to their respective extent on that parallel. Thus, for the parallel whose latitude is λ, let L_λ denote the fraction of the circumference composed of land, W_λ the remainder which is covered by ocean; by l_λ and w_λ the temperatures to be found for that parallel on a globe all land and a globe all water respectively; and by T_λ the observed temperature on the given parallel, we have, by hypothesis,

$$T_\lambda = W_\lambda \cdot w_\lambda + L_\lambda \cdot l_\lambda,$$

and as the temperatures will be the same in the same north and south latitudes on a homogeneous sphere of either kind, we may eliminate the unknown quantities w_λ and l_λ between two equations of the above form, furnished by the observed values of T_λ on the corresponding parallels of the two hemispheres. Using the temperatures of the parallels slightly modified from those of M. DOVE in Table I., by drawing an "equalizing curve" amongst them (as in Plate II.), we obtain the following equations of condition:—*

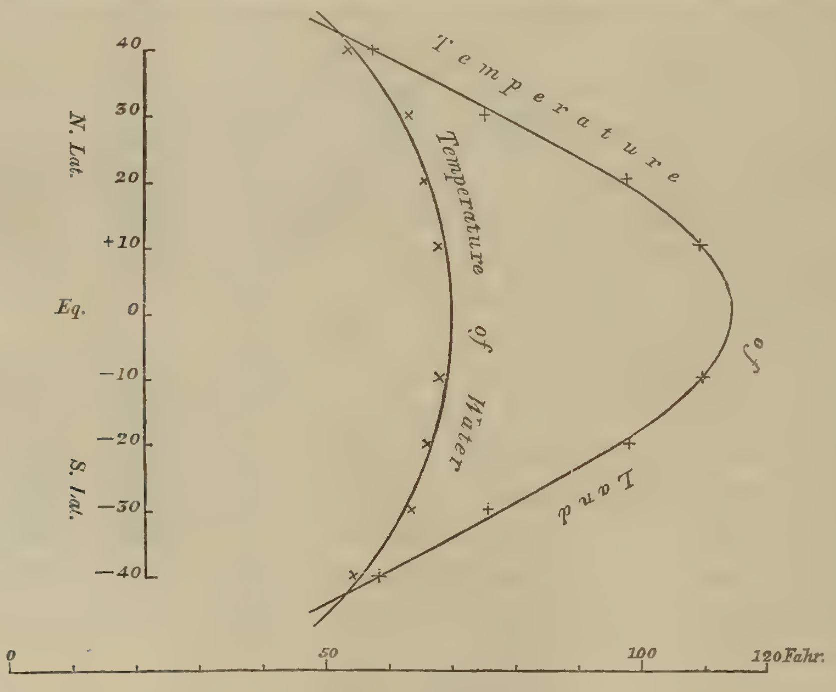
Northern Hemisphere.	Southern Hemisphere.
$80{\cdot}0 = {\cdot}748 \times w_{10} + {\cdot}252 \times l_{10}$	$78{\cdot}2 = .790 \times w_{10} + {\cdot}210 \times l_{10}$
$77{\cdot}3 = {\cdot}682 \times w_{20} + {\cdot}318 \times l_{20}$	$73{\cdot}8 = {\cdot}795 \times w_{20} + {\cdot}205 \times l_{20}$
$69{\cdot}5 = {\cdot}605 \times w_{30} + {\cdot}395 \times l_{30}$	$66{\cdot}7 = {\cdot}840 \times w_{30} + {\cdot}160 \times l_{30}$
$56{\cdot}7 = {\cdot}527 \times w_{40} + {\cdot}473 \times l_{40}$	$55{\cdot}1 = {\cdot}915 \times w_{40} + {\cdot}085 \times l_{40}$

39. By elimination we obtain the following results for *either* hemisphere:—

TABLE V.

Latitude.	Temperature all Water w_λ	Temperature all Land l_λ	Excess due to Land.
±10°	69°·6	110°·7	41°·1
20	67 ·4	98 ·6	31 ·2
30	64 ·8	76 ·7	11 ·9
40	54 ·8	58 ·9	4 ·1

Curves of Land and Water Temperature deduced from a comparison of the Two Hemispheres.



Scale of Temperature.

40. The numbers in this table being projected (as in the figure) for each hemisphere, we obtain two well-defined curves representing the temperatures of a land

* I employ the "equalized" mean values of Land and Water on three adjacent parallels, as in the footnote to par. 32, where these numbers (for the proportion of Land) are designated as L′. But it is worthy of notice that the simple numbers given in Tables I. and II., both for temperature and amount of land, would lead to nearly the same results.

and water sphere up to latitude 40°. The temperature of the equator is obtained by completing the part of the two curves near the vertex. We thus obtain

Latitude.	All Water.	All Land.	Diff.
0°	71°·8	115°·3	43°·5

These numbers, it will be observed, approximate closely to those obtained by a very different process for the temperature of the equator in par. 33, especially as regards a sphere of water.

41. The value of the constant C of par. 31, which defines the maximum effect of the presence of land on the temperature of any part of the globe, is by this latter determination somewhat larger than by our formula of (33). Its value just found is 43°·5, while by the approximate formula it is 38°·1—a difference which, in a research of this kind, must be regarded as not very material. The greater value seems to be most to be depended on.

42. Some indirect considerations still farther confirm the result that this quantity C, the maximum effect of land on the temperature of the equator, can neither greatly exceed nor greatly fall short of 40°. Thus, assuming the formula of (33), if we project M. DOVE's temperatures in a curve in terms of the latitude (as in Plate II.), and set off from them the effect due to the presence of land, as indicated by the term of the formula $C \, . \, L' \cos 2\lambda$, we leave a curve of terrestrial temperature on a water sphere. Now, if we give to C a value much *greater* than 40°, it will be found that this residual curve becomes sinuous and irregular, having three points of contrary flexure instead of one or none at all. This complication is little probable under circumstances of remarkable physical simplicity. Again, if the influence of land were much *less* than that indicated by the value of C=40°, this would be inconsistent with the existing "Thermic Anomaly" in the higher latitudes (as, for instance, in Siberia), where we can hardly suppose a greater cold to reign under existing circumstances than would be the case were the earth entirely composed of land.

43. But one of the most striking confirmations which the argument of (38) affords of the accuracy of our first assumptions in § 3, is with respect to the latitude at which the "Thermic Anomaly" vanishes altogether, or the distribution of land and water ceases to affect the mean temperature of the parallel. We had already (30) deduced from the inspection of the curves on M. DOVE's maps of the northern hemisphere, and *from them alone*, that this critical latitude is between 40° and 45°. The intersection of the curves of land and water temperature in the figure on the last page, deduced almost solely from intertropical temperatures in both hemispheres, point closely to the parallel of $42\frac{1}{2}°$, as that where the two curves intersect, or where the third term of our formula (par. 33) ought to change its sign.* Hence the predominance of water in the southern over the

* It will be recollected that the change of sign was made to coincide with 45°, merely for the purpose of simplifying the formula. (See par. 31.)

northern hemisphere, as it certainly renders the climate colder up to latitude $42\frac{1}{2}°$, ought beyond that parallel to have a contrary effect, such as the rapidly diminishing numbers in the last column of Table V. also indicate.*

Conclusions.

44. Although it might be possible to alter the table of comparisons between theory and observation (Table III., par. 34), by a slight modification of the formula of (33), so as to appear more favourable to our hypothesis, I will not here attempt to do so. I shall be satisfied if I have indicated a method of taking account of the physical features of the globe in relation to climate, in such a manner as more accurate and extended data will enable future writers to render still more exact.

45. Indeed, the trials which I have made to modify the form, or the constants in the formula of temperature, have satisfied me that it cannot at present be materially improved; since what is gained in accuracy in some one point of view is lost in another.

46. The anomalies still indicated in the fourth column of Table III. must therefore for the present remain. Only, it may be remarked, that some of them may disappear by a more correct estimate of the mean temperature of the parallels. In particular, I cannot but think that the temperature corresponding to 60° N. latitude will be found to be too high. It is quite impossible to express, by any ordinary continuous law, the gradation given in M. Dove's table for the neighbourhood of the 60th parallel, taken in connection with higher and lower latitudes. Nor is there any peculiarity in the distribution of land and water which seems likely to account for this, unless it be the sudden closure of the Pacific Ocean a little beyond that latitude, where the Asiatic and American continents so nearly touch. The apparent anomaly may indeed be entirely owing to a deficiency in our information as to the temperature of the atmosphere over the oceanic portions of the globe, which in those latitudes is peculiarly liable to be affected by powerful currents of hot and cold water, as has been already stated.

47. To the presence of these currents must also be ascribed the fact, that the "Thermic Anomaly" does not anywhere vanish (as it is assumed to do somewhere near the 45th degree), and that, consequently, about the parallels of 40° and 50°, we find in a few places of the globe mean temperatures higher or lower than those indicated in the two last columns of Table III., as corresponding to the extreme statical conditions of an entire predominance of land or water. In higher or lower latitudes the "Thermic Anomaly" will be found to be between the limits indicated by those two columns, the oceanic limit being, however,

* "Up to 40° south latitude the temperature of the southern hemisphere is lower than that of the northern; this may not be the case in higher latitudes." Dove,—*The Distribution of Heat*, &c., p. 15.

always the predominating one, as, from the mobility of its parts, might be anticipated.

48. I shall not, I hope, be thought to push the application of the formula too far, if I suggest an explanation of the excess of 2°·8 Fahr., which it gives for the parallel of 75° as in Table III. I might urge that our knowledge of the isothermal lines in that extreme latitude is so limited, as to leave a wide margin of uncertainty in the determination of the mean temperature. This is no doubt quite true. But I attribute to another and a manifest physical cause this apparent anomaly. The amount of the third term of our Formula (par. 33), depends on the measure of the land, and it is of course here subtractive. But in the 75th parallel, though I have estimated the amount of land on the parallel at only 28·6 per cent. of the entire circumference (see Table II., and Plate III., fig. 1), or a diminution of no less than 20 per cent. from lat. 70°, we know how far this is from representing truthfully or practically the physical condition of those Arctic wastes. For all the year, except a very few weeks, it is not too much to say, that three-fourths of the ocean of lat. 75° is encased in solid ice, having the same physical characters superficially (and therefore affecting the climate) in the same manner as the adjacent snow-clad land. We must therefore practically regard the land as forming far more than its due share of the earth's surface in those regions, since the water has lost its convective and equalizing qualities in relation to temperature. Now, we shall find that if we increase the coefficient of the third or land term of the formula from 0·29 to 0·38 (which seems a very moderate expression of the conditions referred to), the excess of calculation in Table III. for lat. 75° *wholly disappears.** I believe, indeed, that it ought to be still farther corrected in the same direction, which would justify us in giving to the pole of a water sphere a temperature slightly higher than + 12.°5, and thus diminishing the negative errors of the formula for lat. 60°–65°, while in lat. 70° the balance would be restored by the sensible effect of the frozen sea. With these suggestions, however, I leave my formula as it at present stands to await farther researches.

* Among other tests to which I have put my hypothesis, I have calculated what *ought* to be the magnitude of the coefficient L′ in the third term of the formula, so that it might in each parallel represent the numbers of Dove (Table I.), supposing the other constants of the formula to be exact.

Pitlochry, *September* 1858.

Postscript.

I have great pleasure in here acknowledging the active assistance which I have derived from Mr BALFOUR STEWART'S great aptitude for calculation in the numerous and irksome eliminations which my inquiries rendered necessary, and of which only a portion are recorded in this paper.

As an appendix to this memoir I add an Index, which I have constructed with no small personal labour, and with every attention to accuracy, of the numerous stations from whence M. DOVE has collected the monthly means of thermometrical observations, often for a long series of years. These are contained in his well-known "Five Memoirs on Terrestrial Temperature" in the Berlin Transactions.

Index to Places mentioned in M. Dove's Five Memoirs "On the Non-Periodic Variations of Temperature on the Earth's Surface."

The Roman Numerals refer to the Number of the Memoir, the Arabic Numerals to the pages of the "Berlin Transactions" where the Temperatures are to be found.

N.B.—The Fifth Memoir was published apart under the title of "Witterungs-geschichte des letzten Jahrzehnts, 1840–50."

ABBREVIATIONS.

N. A. stands for North America.
Afr. " " Africa.
E. I. " " East Indies.
S. A. stands for South America.
Austr. " " Australia.
W. I. " " West Indies.

*The mark * is prefixed to some of the Stations remarkable for the continuity of the Observations.*

TABLE OF REFERENCE-LISTS OF STATIONS IN M. DOVE'S FIVE MEMOIRS.

INDEX.

* I have been unable to verify the reference to "Loudon's Magazine of Natural History" for this entry.

Trans. Roy. Soc. Edin. Pl. II Vol. XXII. p. 80

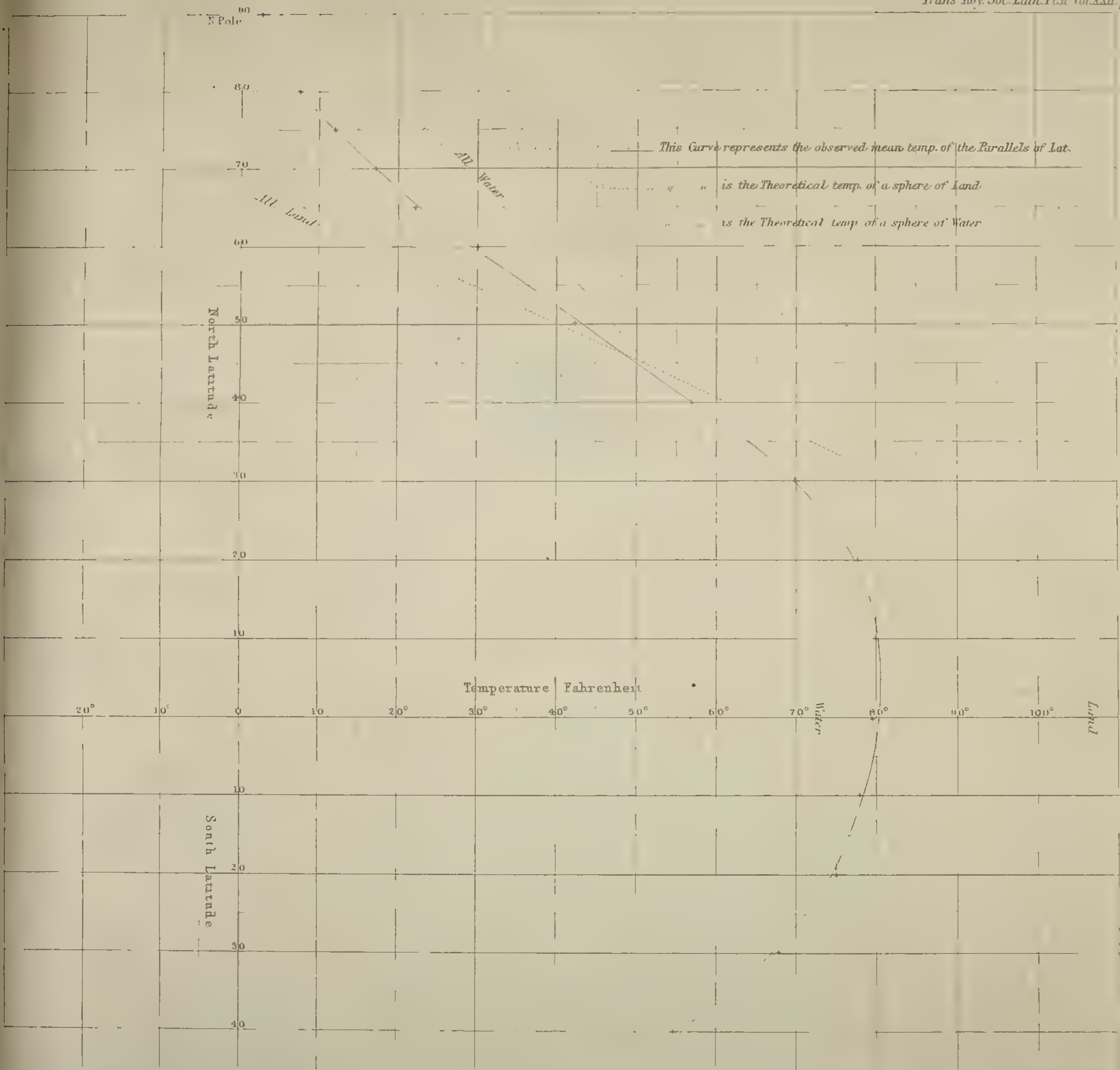


Fig. 1. p. 81

Curve shewing the Proportion of Land to the Circumference of each Parallel of Latitude

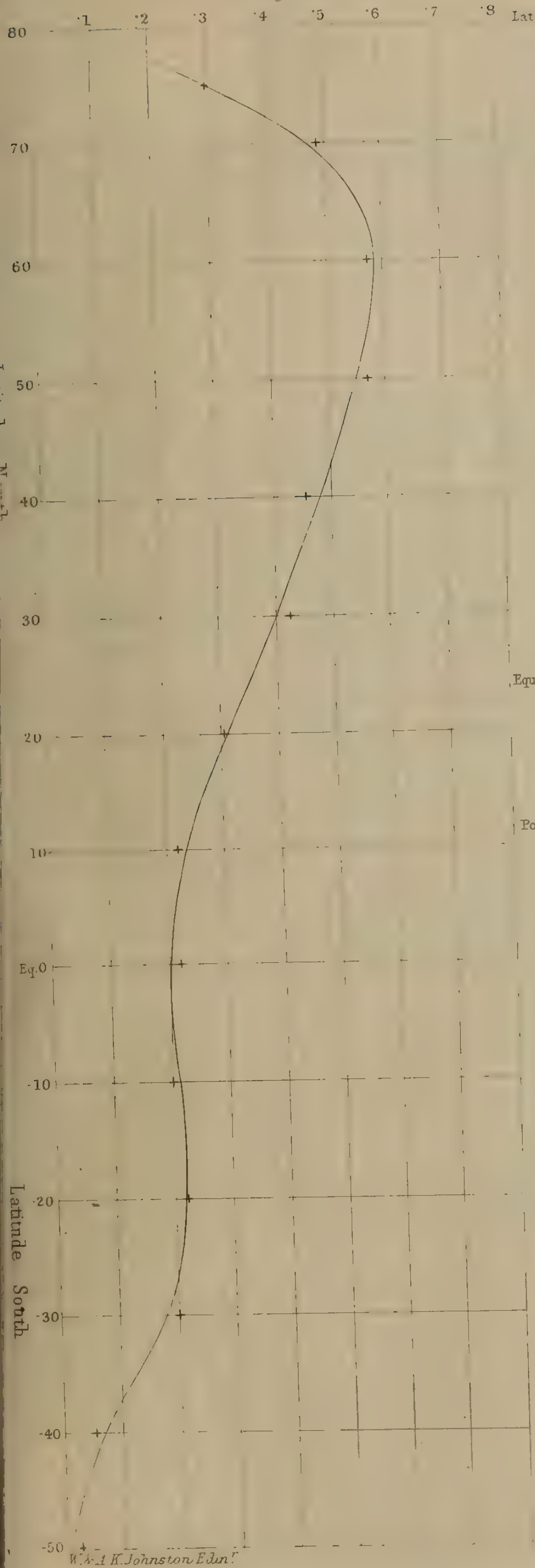


Fig. 2. p. 82.

Curves shewing rate of Variation of a function of the Cosine, cos ½, and cos ² Latitude

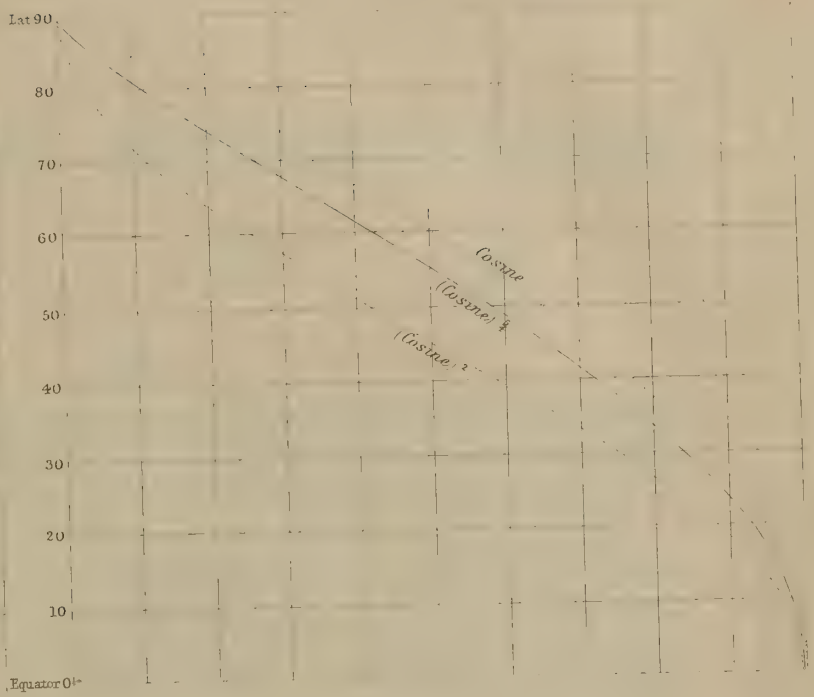
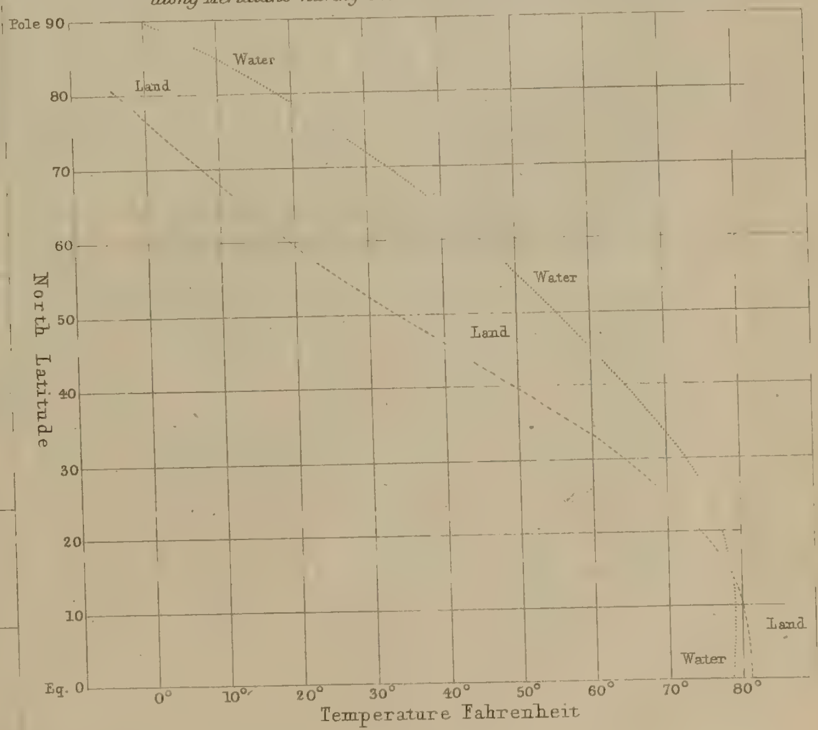


Fig. 3. p. 82.

Examples of Curves of mean Temperature between the Equator & the Pole along Meridians having the Continental and Oceanic Character



W. & A. K. Johnston Edin.

VIII.—*Memoir on the Spermogones and Pycnides of Filamentous, Fruticulose, and Foliaceous Lichens.* By W. Lauder Lindsay, M.D., F.L.S. Communicated by Professor Balfour.

(Read 7th March 1859.)

Preface.

The following Memoir contains the results of researches made during the last three years. My investigations were originally directed to *British* lichens only, but they have subsequently and gradually embraced lichens from all parts of the world. The majority of *Scotch* species examined were collected by myself while on botanical tours in various parts of Scotland during the last ten years. Lowland species were collected chiefly in the counties of Perth, Edinburgh, and Dumfries; but also in Forfar, Fife, and others of the midland counties. In order to study alpine species I made a special tour among the highest of our Scotch mountains in the summer of 1856. I then visited the Braemar Highlands, Ben Lawers, Ben Nevis, and the Coollin Hills, in Skye. I have likewise studied the lichens of Don, now in the possession of Mr M'Nab, of the Royal Botanic Garden, Edinburgh; the lichens collected by Maughan, M'Millan, and others, in the Herbarium of the Botanical Society of Edinburgh; those collected by the late Alexander Menzies, in the Menziesian Herbarium belonging to the Botanic Garden of Edinburgh; those collected by Borrer, Hooker, Carmichael, Gardiner, and others, in the magnificent Hookerian Herbarium at Kew; and I have also examined the valuable herbarium of the University of Edinburgh, under the care of Professor Balfour, and the herbarium of Dr Greville. The examination of specimens in the herbaria of Hooker, Menzies, and Don, has been especially valuable, in so far as they contain species authenticated by the earlier British lichenologists,—lichenologists to whom I am proud to have an opportunity of expressing my deep obligations. I am further indebted for interesting specimens of Scottish lichens—now in my own herbarium—to Mr James Hardy, of Penmanshiel, in Berwickshire,—to Mr Alexander Croall, of Montrose, and to Professor George Lawson, of Kingston, Canada West. The two latter gentlemen supplied me with many alpine species, chiefly from Clova and the Forfarshire hills. For *English* species I am indebted to the kindness of the Rev. W. A. Leighton, of Shrewsbury, who has repeatedly sent me lichens from Shropshire, and Wales, more especially; to Mr William Mudd, of Cleveland, Yorkshire; to Dr Carrington, of Yeadon, near Leeds; and to Dr Deighton, of Clapham, near Lancaster, all of whom have frequently sent interesting Yorkshire lichens; and to Dr Barclay Montgomery, of Penzance, Cornwall, for specimens from the extreme south of England. I have also carefully examined all the specimens (260 in number) contained in the first eight fasciculi of the Rev. W. A. Leighton's *Lichenes Britannici exsiccati*. In addition to which, the Hookerian Herbarium—in studying whose valuable contents I spent a month during last summer—contains a large series of English specimens, collected by Borrer, Turner, Leathes, Hooker, and others. In regard to *Irish* species I have had an opportunity of examining the greater part of the lichens described by Taylor in Mackay's *Flora Hibernica*, as they are contained in the Herbaria of Dr Mackay of Dublin, Mr David Moore of Glasnevin, Dublin, and Mr Isaac Carroll of Cork. For a loan of the herbarium of lichens first named (Taylor's) I am indebted to the kindness of Professor Harvey of Dublin, who also procured for me a loan of the collection of lichens made by Mr David Moore, while attached to the Geological Survey of Ireland. They are chiefly from Antrim and other northern counties of Ireland, and now belong to the Museum of Irish Industry, Dublin. Mr Carroll of Cork has repeatedly sent me large collections of lichens made by himself in the south of Ireland; and Professor Dickie of Belfast has sent me specimens from the north of Ireland. All the Irish collections sent to me have been most interesting, as containing both new forms and new species not hitherto described, or erroneously described and classified.

In regard to *foreign* specimens, my obligations are chiefly due to the Hookerian Herbarium at Kew, which in some respects contains the finest collection of lichens in the world; while in other respects it is second only to that of the *Jardin des Plantes*, Paris. In that herbarium I availed myself of the opportunity of examining specimens from all parts of the world—from the arctic regions, collected by Ross, Beecher, Parry, Lyall; from the antarctic regions, collected by Dr Hooker; from the arctic parts of North America, collected by Richardson, Scoular, and Menzies; from the United States, by Tuckerman, Lea, and others; from Mexico, by Linden and Galeotti; from Peru, by Humboldt; from Brazil, by Gardner; from India, by Drs Hooker and Thomas Thomson, and Messrs Strachey and Winterbottom; from China, by Fortune; from the Philippine Islands, by Cuming; from Java, by Miguel; from Australia and Tasmania, by Dr Hooker, Gunn, and others; from New Zealand, by Colenso; from every part of the world, indeed, to which botanical travellers have penetrated. In the summer of 1857 I went to Norway, for the purpose of studying *in situ* alpine lichens, spending several weeks amid the wilds of Sneehätten and the other alps of the Dovrefjeld range of mountains. I have carefully studied all the specimens (650 in number) contained in the twenty-six fasciculi of Schærer's *Lichenes Helvetici exsiccati*, and also 478 specimens in the first eight fasciculi of Hepp's *Die Flechten Europas*, which is a continuation of Schærer's work just mentioned. *French* species I have studied in NYLANDER'S *Herbarium Lichenum Parisiensium* (Fasc. 1–3, 150 specimens. Paris, 1855). I have also to thank Dr HOOKER for a valuable suite of his antarctic gatherings during the surveying voyage of the "Erebus and Terror," embracing specimens from the Falkland Islands, Auckland Islands, Cape Horn, and New Zealand; Dr A. O. BRODIE for specimens from North America, and Mr DEIGHTON for specimens from California. Most of the lichens above enumerated included separate fragments or duplicates; so that in all I must have submitted to careful microscopical examination—as the basis of the following memoir—many thousand specimens, from every variety of clime, country, and habitat, and in every conceivable state or form. The number of species or specimens cannot be estimated by the number enumerated in the body of the Memoir; the latter only shows the specimens in which spermogones were distinctly found by me, and furnishes no indication of the far larger number examined with equal care, and at the expense of similar time and labour, in which negative results were obtained.

Hitherto, so far as I am aware, no researches have been made, or at least published, in this country with a view to expound the minute anatomy and physiology of the spermogones of lichens, if we except a couple of papers published by myself in the *Quarterly Journal of Microscopical Science.** Nor do I know of any monograph in any language or in any country devoted to this subject. Much has certainly been done by TULASNE,† in his elaborate and valuable "Memoir on the Natural History of the Lichens,"—a memoir to which I owe many and deep obligations. To him I conceive we are indebted for having placed spermogonology on a scientific basis, and by so doing for having raised the lichens, in regard to their anatomy and physiology, at least to equal rank with other cryptogamic families. To a German,‡ moreover (ITZIGSOHN), is due the credit of the discovery of the existence of spermogones in lichens, or at least of an approximation to the first scientific appreciation of their character and functions. Though my own researches were commenced several years ago, I have not hitherto ventured to lay them before the public for a variety of reasons. One of the chief of these was my anxiety to correct or confirm my earlier investigations by more extended observation, especially among foreign specimens of British species; and this I have not had a satisfactory opportunity of doing until last summer at Kew. I lay them now before the Royal Society of Edinburgh, not as claiming to consti-

* 1. Monograph of the Genus *Abrothallus*. (De Not. and Tul., emend.) Read before Section D. of the meeting of the British Association at Cheltenham in August 1856.—*Quarterly Journal of Microscopical Science*. January 1857.

2. On the Structure of *Lecidea lugubris*, Sommfr. Ibid. July 1857.

† Mémoire pour servir à l'Histoire Organographique et Physiologique des Lichens. Par M. L. R. Tulasne, aide-Naturaliste au Museum d' Histoire Naturelle, &c.—*Annales des Sciences Naturelles*, 3d serie. Botanique, vol. xvii., 1852.

‡ Dr HERMANN ITZIGSOHN, whose researches may be found in the *Botanische Zeitung* for 1850–51, *et seq*.

tute a perfect monograph, but simply and humbly as a contribution to a subject hitherto unelucidated in this country. I believe, however, this memoir will be found to contain first descriptions of no inconsiderable number of the spermogones and pycnides of lichens, both British and foreign, as well as many additional instances of lichens possessing two or three forms of reproductive bodies; or, in other words, *pycnides* as well as *spermogones* and *apothecia*. Some of the spermogones and pycnides, which I believed I had discovered and described for the first time, have subsequently been alluded to in the recent publications of Dr NYLANDER of Paris,*—publications which are certainly the most valuable contributions made of late years to lichenology,—that most difficult of all departments of cryptogamic botany. But these organs are seldom fully described by NYLANDER, and hence I have every reason to believe that, in these cases also, the first full expositions of their structure will be found in the following Memoir.

Spermogonological investigations are surrounded by many and serious difficulties; and it is perhaps but justice to those botanists who have hitherto avoided the study of the reproductive organs of lichens here to state what some of these difficulties or obstacles are. Prior to the introduction of the microscope bodies so minute as spermogones and spermatia could not possibly have been properly studied. But even at the present day, when microscopes abound, it is to be feared that few of our best lichenologists are well versed in histology and the use of the microscope. It can scarcely be denied, further, that many botanists have been too much mere classificators or name-givers: they have devoted attention too exclusively to the discrimination of species and varieties, to the neglect of minute anatomy and physiology, as studied by the aid of microscopy and chemistry. Continental botanists are infinitely before us in the latter respect: we can show little or nothing in botanical microscopy comparable with the productions of the French school of observers, as published in the "Annales des Sciences Naturelles," or to those of the German school, as given in the "Botanische Zeitung." But the possession of a good microscope, facility in microscopical manipulation, and a familiarity with the general principles or facts of physiological botany, are not the only requisites or qualifications for investigations in spermogonology. The observer must be possessed of unwearied patience and perseverance: he must expect to meet, and he must bring to his task a determination to surmount and conquer, endless difficulties and disappointments. I have now examined carefully, under the microscope, as I have already stated, many

* 1. Synopsis Methodica Lichenum omnium hucusque cognitorum. Paris, 1858.
2. Enumeration Générale des Lichens, avec l'indication sommaire de leur Distribution Géographique. Cherbourg, 1858.
3. Monographia Calicieorum. 1857.
4. Prodromus Lichenographiæ Galliæ et Algeriæ. Bourdeaux, 1857.
5. Essai d'une Nouvelle Classification des Lichens. Cherbourg, 1854.

thousand specimens of lichens from every part of the known world, and *in a large proportion of cases, with negative or unsatisfactory results.* I have frequently examined most anxiously several hundred specimens of a particular genus or species,—for instance, *Peltigera* and *Siphula*,—without once having the good fortune to meet with its spermogones or pycnides. But, on the other hand, in the midst of disappointments of this nature, I have been rewarded occasionally by the discovery of spermogones or pycnides hitherto unobserved and undescribed. It were desirable, further, that the observer should possess an almost unlimited leisure. The time consumed in manipulations so delicate,—researches so intricate,—is incredibly great. KOERBER candidly speaks of leaving such investigations to those "die bei grösserer Musse solche subtile Studien verfolgen können."* It frequently happens that even a small portion of tree-bark or rock contains several lichens belonging to the families of the *Graphideæ*, *Verrucariæ*, and *Lecideæ*. Intermixed with the apothecia of these lichens, and with each other, may be a variety of spermogones and pycnides. The spermogones and pycnides may closely resemble each other in external character, or they may differ considerably. In either case it is often most difficult, if not impossible, at the present stage of our knowledge on the subject, to determine to what species of lichen each kind of spermogone or pycnide is to be referred. This is more especially the case when the organs in question are very minute, black, and cone-like, as in the old genus, erroneously so constituted,—*Pyrenothea*, which is now found to consist almost entirely of the spermogones of other lichens. Such spermogones and pycnides are frequently indistinguishable from certain *Verrucariæ*, parasitic fungi, and even parasitic lichens; and the only means of deciding as to their real nature is by microscopical examination. Again, the spermogones of some lichens, as *Ricasolia herbacea* and *R. glomulifera*, and the pycnides of others, as *Peltigera*, so closely resemble in external appearance the nascent apothecia of the same species as to be indistinguishable therefrom without the aid of the microscope. As a general rule, the parasitic *Sphæriæ*, with which the spermogones and pycnides of lichens are apt to be confounded, are very superficial, removable by the least touch from the surface on which they grow—have a black colour, possess an envelope or capsule formed of hexagonal or roundish cells in a state of close aggregation, and of a dark brown colour, and contain minute, abundant, brownish, simple or 1-septate spores. Sometimes spermogones and pycnides occur alone, unassociated with the apothecia of any species; and it is in such a case, unless in rare instances, equally impossible to say to what lichens they are referable or belong. It is therefore possible, nay perhaps probable, that some of the spermogones and pycnides which I have referred to particular lichens, may be hereafter found, when my researches have been repeated and extended, really to belong not to these, but to other species. And it may also be discovered to what lichens

* Systema Lichenum Germaniæ, von Dr G. W. KOERBER. Breslau, 1855, p. 152.

rightly to refer those spermogones and pycnides which I did not find associated with apothecia. This, however, can only be done by examining a larger number of specimens from different habitats and countries than I have been able to collect or had leisure to study. I offer the present results of my studies merely as a preliminary contribution to lichenological literature, and all that I can venture to hope is, that they may be found useful as a basis for the investigations of those who follow me with ampler means and opportunities of research. It sometimes happens that different specimens of the same lichen from different habitats or countries appear to possess several sorts of spermogones and pycnides; or, associated with a particular species, may be found a considerable variety of these organs. Probably, in the majority of cases, such spermogones and pycnides are really referable to different lichens, and not to the single species to which they apparently belong. But I think there is strong ground for believing that some of the lower lichens are possessed of several forms of reproductive bodies and organs, just as certain of the lower fungi are; at least I have repeatedly met with phenomena which are inexplicable on any other supposition. We now know that the genus *Erysiphe*, belonging to the fungi, has no less than five forms of reproductive bodies or organs; and I have met with many lichens which possess either simply, both spermogones and pycnides, in addition to apothecia, that is, three different forms of reproductive organs, or two or more different forms of spermogones or of pycnides as the case may be. Hitherto it has been customary to refer all such secondary forms of reproductive organs in lichens, when they were observed at all, to parasitic fungi. But this arose from ignorance of the fact that lichens possess other reproductive organs than apothecia. In investigations on the border ground between the lichens and the fungi, there are at present almost insurmountable difficulties. Many of the organisms which we at present regard as the pycnides of lichens may, in the course of subsequent researches, prove to be, or to belong to, fungi; while, on the other hand, the corresponding organs of certain fungi, or certain fungi themselves, may prove to be really the accessory reproductive organs of lichens. The boundary line between the lichens and the fungi is for ever shifting; and it is perhaps at present impossible to fix or determine it. Mycologists and lichenologists alike have given it up as a hopeless task. The old distinction as to the habitat,—lichens being supposed to grow always on *living*, and fungi on *dead* tissues—is utterly absurd. Until lately, it was thought that chemistry had furnished a means of distinguishing these two important cryptogamic families in the presence or absence of starchy matter in the hymenial and other tissues, which in lichens, as a general rule, strike a blue colour with iodine, while in fungi they do not. But Mr Frederick Currey has pointed out that this reaction frequently occurs also in undoubted fungi. Between the higher fungi and the higher lichens the distinction is obvious enough; but between the lower groups of each family the difference gradually becomes imperceptible, until it is lost. How closely, frequently, do *Sphæriæ* resemble *Verrucariæ*, and the spermogones and pycnides of lichens those of the fungi? So intimate is the alliance between the fungi and lichens, that BERKELEY,* in his Cryptogamic Botany, makes his division "*Mycetales*," to include the "*Lichenales*" and "*Fungales*." Many spermogones, it now appears, have been described by the older lichenologists as independent species of lichens: FRIES' genus *Pyrenothea*, and WALLROTH'S *Thrombium*, are chiefly made up of spermogones which belong to various *Lecideæ*, *Graphideæ*, and *Verrucariæ*. Some of these may hereafter be found really to belong to the fungi. Several genera or species of fungi have shared a similar fate, as a consequence of the progress of microscopical mycology, having been found to constitute mere secondary or tertiary forms of fruit of more familiar species; such fungi are *Sclerotium*, *Cytispora*, *Melasmia*, *Phyllosticta*, *Polystigma*, *Phoma*, partly, and many others, according to TULASNE, who is equally distinguished as a mycologist and lichenologist. It were specially desirable that he who studies the spermogones and pycnides of lichens should be a mycologist, as well as a lichenologist; in no other way can he properly interpret and appreciate what he observes. I believe that he only can be a philosophical lichenologist who is comparatively well acquainted with the anatomy and affinities of the fungi and algæ: while it is equally necessary that the mycologist and algologist should possess a competent knowledge of the structure and physiology of the lichens. Indeed, it has perhaps been from a too exclusive study of particular tribes of plants, and a desire to fill their ranks at the expense of their allies or neighbours, that much confusion has been introduced into classification and nomenclature, and much ignorance has prevailed as to the true position of lichens in the scale of vegetable life. Monographers, it is to be feared, work too much in their own favourite fields to arrive at or deduce broad, philosophical, or scientific conclusions or general laws; specialists are apt to take up one-sided, and hence erroneous views. Nor must the student of spermogonology confine himself to the lichens of one country or clime, and still less to herbaria of dried specimens. I have sometimes succeeded in finding, in *foreign* specimens of a lichen, spermogones which were absent in all the *British*, or even *European*, specimens examined by me: for instance, in *Nephromium tomentosum*. Another advantage of the study of foreign species is, that it will serve to exhibit the constancy with which spermogones or pycnides of a particular character occur in the majority of lichens, as well as the constant relation as to site which they bear to the apothecia.

Frequent disappointments must have been experienced by all who have sought for the spermogones of lichens, in so far as they may *fail* to find them oftener than they *succeed*. This arises, in many cases, undoubtedly from ignorance of the relative periods of development of the spermogones and apothecia.

* Introduction to Cryptogamic Botany. By the Rev. M. J. BERKELEY, M.A., F.L.S. London, 1857.

The spermogones must be looked for and examined at a particular stage of their development; otherwise our results cannot fail to be unsatisfactory. They may be too young, and the spermatia are undeveloped; or too old, and the spermatia have all escaped;—the sterigmata may have become sterile and hypertrophied, filling up the cavity of the spermogone; or the body of the organ may have fallen out, nothing being left save a large irregular cavity. Observers are probably too much in the habit of examining only fruited specimens of lichens—thalli-bearing apothecia—in their search for spermogones. But two circumstances must be borne in mind,—*firstly*, That in development, the spermogones normally precede the apothecia; and that, consequently, the former may have disappeared, or have become old and degenerate, by the time the latter have arrived at maturity; and *secondly*, That spermogones are frequently most abundant, or are only found on thalli, or portions of thalli, bearing no apothecia. The only safe rule for the student, therefore, is to examine specimens *in every state*, however unpromising, whether fertile or sterile, old or young; and he should never feel secure in regarding a particular conceptacle as a spermogone or pycnide, unless he see distinctly abundance of *free* spermatia or stylospores. This procedure implies, of course, an immense amount of fruitless labour. I have myself acted on this principle, and followed out this plan; and I regret that I cannot yet indicate to the student any more "royal road" to a knowledge of the secondary reproductive organs of the lichens. He must advance himself slowly and gradually, by sheer plodding industry, and perseverance unconquerable: he must labour patiently for months, aye years, before he sees even dawnings of the interesting and important results, which it may be his good fortune subsequently to achieve.

Considerable discussion has occurred regarding the spelling and use of the words, "*spermogone*" and "*spermatogone*." The former word is that originally introduced by TULASNE to designate the conceptacle containing the linear corpuscles, which he calls *spermatia*. The latter is used by the Rev. M. J. BERKELEY in his "Introduction to Cryptogamic Botany," on the ground that it is etymologically more correct. I confess to a natural repugnance unnecessarily to render even scientific terms pedantic and repulsive; and my desire in this case to retain the simpler of the two words in question is supported by the opinion of the present Professor of Greek in the University of Edinburgh. In a letter to me (of date 15th April 1858), Professor Blackie remarks, "There is not the slightest necessity for your altering *spermogone*, which has the advantage of being shorter. The analogy of the well-known Greek word σπερμολόγος, which you will find in the New Testament (Acts xvii. 18), and other compounds in the commonest dictionaries, are quite sufficient to defend the shorter form." I will therefore, throughout this memoir, make use of the word "*spermogone*" instead of "*spermatogone*."

For the sake of uniformity of arrangement, but by no means as implying my concurrence in his classification and nomenclature, I have adopted, in the following memoir, the names of genera and species used by Dr Nylander, in what are both the most recent, and at the same time most accurate and philosophical, continental works in lichenology.* I do this the more readily, inasmuch as I have not yet elaborated the classification and nomenclature I mean to follow in my forthcoming "Synopsis of the British Lichens."—(Bradbury and Evans, London.) For usefulness of reference to the reader, I beg to append a vidimus of Nylander's arrangement,† so far as it contains genera and species, whose spermogones and pycnides are described in the following Memoir. The genera and families, however, will not be found arranged in the order laid down by Nylander. I have begun with the higher lichens; and I have been guided in the arrangement or sequence of the families and genera more by the similarity of their spermogones, than by general anatomical affinities. It is obviously, however, a matter of no moment how the families and genera follow each other, or are arranged. The point of real importance is, that the spermogones in each family, genus, and species, be fully and distinctly described.

	Family I. *Collemacei.*	*Genera.*
	Tribe 1. *Lichinei*, . . .	Ephebe, Fr. Lichina, Ag.
	Tribe 2. *Collemei*, . . .	Synalissa, DR. Omphalaria, DR. Collema, Ach. Leptogium, Fr. Obryzum, Wallr.
	Family II. *Myriangiacei.*	
	Tribe 1. *Myriangei*, . .	Myriangium, Mont. and Berk.
	Family III. *Lichenacei.*	
Series I. Epiconiodei, . .	Tribe 1. *Caliciei*, . . .	Sphinctrina, Fr. Calicium, Ach. Coniocybe, Ach. Trachylia, Fr.
	Tribe 2. *Sphærophorei*, .	Sphærophoron, Pers. Acroscyphus, Lév.
Series II. Cladoniodei, . .	Tribe 3. *Bæomycei*, . .	Bæomyces, Pers.
	Tribe 4. *Cladonei*, . . .	Cladonia, Hoffm.
	Tribe 5. *Stereocaulei*, . .	Stereocaulon, Schreb.
Series III. Ramalodei, . .	Tribe 6. *Roccellei*, . . .	Roccella, Bauh.
	Tribe 7. *Siphulei*, . . .	Siphula, Fr. Thamnolia, Ach.

* His "Synopsis Methodica Lichenum," and his "Enumeration Générale des Lichens," both published in 1858.

† As given in his "Synopsis," p. 65.

	Family III. *Lichenacei—continued.*	*Genera.*
Series III. Ramalodei, . . *continued*	Tribe 8. *Usneei*, . . .	Usnea, Hoffm. Neuropogon, N. and Flot. Chlorea, Nyl.
	Tribe 9. *Ramalinei*, . .	Alectoria, Ach. Evernia, Ach. Dufourea, Ach. Dactylina, Nyl. Ramalina, Ach.
	Tribe 10. *Cetrariei*, . .	Cetraria, Ach. Platysma, Hoffm.
Series IV. Phyllodei, . .	Tribe 11. *Peltigerei*, . .	Nephroma, Ach. Nephromium, Nyl. Peltigera, Hoffm. Solorina, Ach.
	Tribe 12. *Parmeliei*, . .	Sticta, Ach. Ricasolia, DN. Parmelia, Ach. Physcia, Fr.
	Tribe 13. *Gyrophorei*, .	Umbilicaria, Hoffm.
	Tribe 14. *Pyxinei*, . . .	Pyxine, Fr.
Series V. Placodei, . . .	Tribe 15. *Lecanorei, pro parte*,	Psoroma, Fr. Pannaria, Del. Coccocarpia, Pers. Amphiloma, Fr. Squamaria, DC. Placodium, DC., &c.

The part of Nylander's table given above, refers to the filamentous, fruticulose, and foliaceous lichens,—those whose spermogones are described in this memoir. The other half relates to crustaceous lichens, which include the *Lecanorei*, *Lecidinei*, *Graphidei*, and *Pyrenocarpei* (or *Verrucariæ*).

In the researches on which the following memoir is based, I was in the habit of using the magnifying power 380 of a Nachet's microscope (" petit modèle"), made in 1851, and a micrometer eye-piece made by James Bryson, Edinburgh.

In giving measurements from the French, as I do in a few cases in describing spermogones or their contents, which have been observed by Nylander or Tulasne, but not by myself, I have calculated the French millimetre as equal to $\frac{1}{25}$th of an English inch. The usual calculation hitherto has been $\frac{1}{26}$th; but I believe $\frac{1}{25}$th to be more correct, and to be, therefore, gradually coming into more general use both in France and in this country.

As a sort of key to the following memoir, I beg to subjoin a

Summary of the general characters of Spermogones and Pycnides,† and their respective contained corpuscles, Spermatia‡ and Stylospores.§*

I. Spermogones.

I. *External Form.*—They are generally more or less oval or spherical bodies; sometimes wholly immersed in the substance of the thallus; more frequently partly immersed and partly projecting on the surface of the cortical layer: in some cases, naked and sessile, seated on the surface of the horizontal thallus, or forming the terminations of the ramuscles in the erect fruticulose one. The immersed and semi-immersed spermogones are plunged in the substance of the medullary tissue of the thallus, and they are usually partly covered by the cortical layer, and partly encircled by the gonidic layer.

Spermogones appear on the surface of the thallus, as:—

1. *Punctiform* bodies—In which case they are wholly immersed, the apex alone being visible on the thalline surface; in many *Parmelias*, in *Evernia*, *Roccella*, *Dufourea*, and *Chlorea*.

2. *Conoid* or *Papillæform* bodies—In which case they are semi-immersed; in many *Physcias*, *Umbilicarias*, *Parmelias*, *Placodiums*, *Squamarias*, and *Pannarias*.

3. *Mammillæform* bodies—In which case they are sometimes seated on, or in, special thalline tubercles; in many *Stictas*, *Ricasolias*, and some *Physcias*, *Parmelias*, *Pannarias*, and *Coccocarpias*.

4. *Discoid* bodies—In *Collema* and *Leptogium*.

5. *Wart-like* bodies—In *Ramalina*, *Usnea*, *Thamnolia*, *Ephebe*, and *Stereocaulon*. The papillæform and mammillæform spermogones also frequently become wart-like and very irregular when confluent.

6. *Barrel-shaped* or *tub-shaped* bodies—In *Cladonia*, some *Nephromiums*, *Lichinas*, and *Parmelias*.

7. *Large lecidine* bodies—Whitish in *Placodium circinatum*, var. *ecrustaceum*; brown in a form of *Cladonia papillaria*.

Externally, the spermogones frequently resemble, and are apt to be confounded with,—

a. Nascent apothecia; as in *Ricasolia herbacea*.

b. *Pycnides*.

* From σπέρμα, a seed, and γονή, generation.

† πυκνὸς, compact, or πυκνότης, a compact series (Latin, *Pycnitis*), in allusion to the closely aggregated sterigmata. The designation, *Pycnidis*, which was originally given by Tulasne, is common to similar organs, which occur in various fungi, particularly the *Hypoxyla*.

‡ σπέρμα, ατος, a seed or germ.

§ στῦλος, a pillar (Latin, *Stylus*), and σπορὰ, a seed, from being borne on the end of pedicles or stalk-like filaments, called *Sterigmata*; στήριγμα, a support.

c. *Parasitic fungi*,—especially of the genus *Sphæria*.

d. Minute *Verrucarias*.

e. Parasitic *Lecideæ*—as *L. vermicularia*, *L. alectoriæ*, *L. cladoniaria*, and *L. obscuroides*.

From all these bodies they are only to be distinguished by microscopical examination.

II. *Position* of the spermogones on the thallus, and in relation to the apothecia.

They occur generally on specimens bearing also apothecia; sometimes, however, only on sterile specimens of species whose apothecia are common; and still more rarely on species or specimens never yet found bearing apothecia, as in *Thamnolia vermicularis* and *Dufourea madreporiformis*.

1. *Superficial.*—On the foliaceous, horizontal thallus, usually scattered about the margins of the lobes or laciniæ, as in many *Parmelias* and *Physcias*. In this case they are situated external to the region occupied by the apothecia.

In exceptional cases they are scattered generally over the whole surface, and are then intermixed with the apothecia, as in *Parmelia conspersa*, *P. encausta*, and *P. stygia*. The same occurs sometimes in species with a fruticulose thallus, as in some *Cladonias* and *Roccellas*.

They are sometimes confined to the plicæ of the thallus, as in some species of *Sticta* and *Ricasolia*.

In some *Placodia*, which approach the true crustaceous type of thallus, spermogones are scattered,—isolated, or in groups of two or three,—on the thalline areolæ, central or peripheral, generally the latter, sometimes both.

2. *Marginal.*—In some species with a foliaceous thallus, they are seated directly on the margins of the lobes, to which they give a denticulate character, as in many *Platysmas*, in *Collema* and *Leptogium*, in *Parmelia perforata* var. *denticulata*, *Nephromium tomentosum*, and some forms of *Ricasolia herbacea*. They are also marginal in some species, with a subfoliaceous or fruticulose thallus,—as *Parmelia Fahlunensis*, *P. tristis*, and *Evernia Richardsoni*. In other lichens, they are seated at the ends of cilia or processes given off from the margin of the thallus, as in *Cetraria islandica*, and some forms of *Nephromium tomentosum*.

3. *Terminal.*—In several species or genera, having a fruticulose or filamentous thallus, the spermogones are scattered toward the ends of the thalline segments or ramules, as in *Usnea*, *Ramalina*, *Ephebe*, and *Roccella*. In *Cladonia*, they generally either form the tips of the tapering, simple, or branching podetia, as in *C. rangiferina*, *C. furcata*, and *C. uncialis*; or they fringe, as tooth-like processes, the margins of the scyphi, as in *C. pyxidata*. In some cases they are seated on the same podetia with the apothecia, as in most species with scyphi; in others, they are on different podetia, as in those with a ramose thallus, such as *C. rangiferina*. In both cases, however, they are in close proximity to the apothecia. Some *Cladonias* have spermogones on the surface, as well as the margins of the scyphi.

Others, in addition to terminal spermogones, have barrel-shaped ones, of similar size and form, seated either on the horizontal primary thallus, or on the folioles or squamules which cover the podetia, as in *C. alcicornis*, *C. squamosa*, var. *cœspititia*, and *C. bellidiflora;* or, in the same cases, they occur on the horizontal thallus or the folioles alone.

In some species of *Alectoria* and *Neuropogon*, the spermogones are the terminal bulgings of the ultimate ramules, as in *A. Taylori* and *N. melaxanthus*.

In *Stereocaulon*, they are warts usually crowded in groups at or about the ends of the ramules. In some species, they form a sort of collar round the terminal apothecia.

In *Sphœrophoron*, *Acroscyphus* and *Lichina*, they are seated on or near the tips of the ultimate divisions of the thallus.

In addition to the above normal or usual positions of spermogones, they sometimes occur in the following exceptional situations:—

a. On the exciple of the apothecia, as in *P. conspersa*.

b. On the apothecia themselves, as in *Lichina pygmœa* and *confinis*, and some forms of *Cladonia rangiferina*.

c. In the hypothecial tissue of the apothecium, as in *Celidium fusco-purpureum*. (Tul. Mém. Pl. 14, f. 12.)

III. *External colour* of the spermogones.—In immersed or semi-immersed spermogones, it is generally only the superior portion, or that portion which projects above the surface of the cortical layer of the thallus, that is coloured. In many cases the ostiole alone, or its margin, is the seat of visible colour. The naked or sessile spermogones, however, are usually coloured uniformly all round, the ostiole here, as in all cases, being darker than the surrounding tissues.

The spermogones are generally differently coloured from the thallus, the one being dark and the other light; and this contrast of colour is one reason why the spermogones are frequently so readily visible under the lens. In cases where both thallus and spermogones have a dark or a light colour, the latter are generally with difficulty recognised, as in *Umbilicaria*, *Usnea*, and *Ramalina*. The colour of the spermogone generally passes more or less gradually into that of the surrounding thalline surface. But sometimes the spermogone is distinctly circumscribed, both as to colour and form, as in *Collema* and *Leptogium*, where its brownish-yellow colour contrasts well with the green of the thallus.

The spermogones are:—

a. Black in many *Parmelias*, *Physcias*, and *Roccellas*. Some of them, though black to the naked eye, or under the lens, or when dry, are found to be really *brown* when submitted to the microscope, or when moistened.

b. Brown in *Cladonia*, *Nephromium*, and some *Physcias* and *Parmelias*.

c. Orange-red or *yellow* in several *Physcias* and *Placodiums*.

d. Concolorous with the thallus in *Usnea*, *Ramalina*, *Thamnolia*, *Stereocaulon*, *Ephebe*, and *Lichina*.

IV. *Size of the Spermogones.*—Their diameter varies from $\frac{1}{25}$th to $\frac{1}{500}$th of an inch, many having an average diameter of $\frac{1}{100}$th to $\frac{1}{200}$th.

They appear as extremely minute, microscopic points in many *Parmelias*, in *Evernia*, and *Roccella*. They are visible to the naked eye, or are readily recognized under a simple lens of low power, in many *Ricasolias* and *Cladonias*, and in some *Usneas*, *Ramalinas*, *Physcias*, *Coccocarpias*, and *Placodiums*. They are of an intermediate size in *Sticta* and certain *Physcias*.

V. *Number of the Spermogones.*—They are seldom single and isolated, but this sometimes occurs in the terminal spermogones of *Cladonia*. In some species with a fruticulose thallus, such as *Cladonia rangiferina*, or *C. furcata*, and *Cetraria aculeata*, they are generally in groups of two or three. The papillæform, mammillæform, and wart-like spermogones, are generally grouped in larger number; but they never occur in such numbers as the punctiform ones. The latter sometimes cover the whole surface of the thallus, so as to give it a black-punctate character, as in *Parmelia encausta*, *P. conspersa*, and *P. stygia*.

VI. *Structure of the Spermogone.*—Every spermogone consists of the following parts:—

1. A capsule or envelope.
2. A nucleus, which again is made up of—
   - *a.* Sterigmata, which generate;
   - *b.* Spermatia; and of a
   - *c.* Basal cellular tissue.
3. A central cavity, which opens to the external surface by a more or less minute
4. Ostiole or Pore.

1. The *capsule* or *envelope* is usually more or less thick and tough in its texture. It is made up of cells, sometimes round, but more generally, from their close aggregation and mutual pressure, hexagonal or irregularly angular, oblong or elongated. They are usually more or less thick-walled. Sometimes so close is their apposition, that the outline of the individual cells becomes lost, or is very indistinct. The structure of the capsule may be described, in general terms, as closely resembling that of the exciple of the apothecium and the cortical layer of the thallus. Its colour is as described under that of the spermogone generally. It is very frequently blackish or brownish; indigo in *Pannaria triptophylla*; orange in several *Physcias* and *Placodiums*.

2. The *nucleus* is mainly made up of the closely aggregated sterigmata, which are united by a mucilage, that also occupies the spermogonal cavity. Its texture is dense and more or less horny, frequently to such an extent that it admits of being sectioned in very thin slices. The texture becomes denser and harder

with age. From its density, the nucleus can be frequently readily separated from its capsule and from the thallus by the point of a needle, as in many *Ricasolias* and *Stictas*, where it is comparatively large. Its colour is usually whitish or grayish; sometimes it is rose-coloured; seldom is it so different from that of the surrounding medullary tissue as to be readily distinguished therefrom. At other times, however, this difference or contrast in colour between the nucleus and the surrounding medullary tissues is the only means of distinguishing the former on section of the thallus. In old age, the nucleus frequently falls out spontaneously, leaving a cavity, which is at first not very conspicuous, but which gradually becomes so by being deepened, acquiring a dark colour, and having swollen lips or margins. These cavities, which are sometimes very irregular in form, frequently give the thallus the appearance of being covered over with perforations, more or less closely aggregated, as in *Parmelia saxatilis*, var. *omphalodes*, *P. encausta*, and *P. stygia*.

*a. Sterigmata.**—These are delicate filaments, arranged vertically to the wall of the spermogone, and convergently to its central cavity. They consist either of a single elongated cell, or its ramifications; or of a number of shorter, and usually broader cells in superposition. Hence they are divided into *simple*, and *compound* or *articulated* [*Arthro-sterigmata*, Nyl.] They are so closely aggregated, that, under a low power, they look like mere striæ; and sometimes, under the microscope, they appear united at their bases. Their walls differ much in thickness; they are usually thickest in some arthrosterigmata. They appear to contain a colourless, homogeneous fluid; and their walls are also colourless, generally speaking, though occasionally in age their bases acquire a certain degree of colour. The tissue which they form is very hygrometric, imbibing water with great rapidity and ease.

(1.) *Form a. Simple*, filiform, and 1-cellular, or consisting of the ramifications of a single cell.

Longish in *Ramalina, Lichina, Roccella, Sphærophoron, Stereocaulon, Alectoria*, and *Dufourea*.

Shortish, sometimes almost absent, in *Squamaria*. Simple sterigmata sometimes taper gradually into spermatia, which then appear as terminal joints. They generate spermatia only from their apices. They divide or branch at or near the base only, and their ramifications sometimes resemble digitate processes from basal tubes or filaments. In the old state, the simple sterigma becomes sometimes sterile, elongated, and ramose; and its ramifications form a filamentous network more or less occupying the spermogonal cavity, and resembling that which is found in the spermogone of many *Parmelias* having articulated sterigmata. This is particularly noticeable in some *Cladonias*.

* *στήριγμα*, a support, in allusion to their function of generating the Spermatia.

b. Compound or articulated [*arthrosterigmata*]. Component cells are,—

1. *Short*, broadish, often thick-walled, and numerous in *Sticta*, *Ricasolia*, *Nephromium*, *Pannaria*, *Coccocarpia*, *Placodium*, *Umbilicaria*, *Collema*, *Leptogium*, and some *Physcias*.

2. *Longish*, narrow, mostly thin-walled, and few in *Parmelia*, many *Physcias*, *Evernia*, *Usnea*, *Platysma*, and *Cetraria*.

Like the simple sterigmata, the articulated sterigmata are sometimes ramose, but the ramifications may come off at any point between their base and apex. It is noteworthy, that arthrosterigmata uniformly bear *straight* spermatia, which are given off from both apex and sides, while the simple sterigmata bear spermatia, which are sometimes curved or twisted, sometimes straight. In the case of simple sterigmata, the spermatia are more frequently short, oblong, oblong-oval, or crescentic; in that of arthrosterigmata, they are almost always rod-shaped or acicular. In the arthrosterigmata, the spermatia, though given off from the *sides* of the sterigmatic filament, as a whole, are generated from the *apices* of the individual or component cellules, at more or less irregular angles. Hence they project from the sides of the sterigmata like a series of needles or bristles, numerous in proportion to the number of the constituent cellules of each sterigma. This bristled appearance is, therefore, most marked where the individual articulations or cells are short and numerous, as in *Collema*, *Umbilicaria*, and *Placodium*.

(2.) *Size.*—In *length*, sterigmata vary from $\frac{1}{100}$th to $\frac{1}{2500}$th of an inch, a medium being $\frac{1}{500}$th to $\frac{1}{1000}$th. They are shortest when simple; in some cases so short as to appear absent. In *breadth*, they vary from $\frac{1}{5000}$th to $\frac{1}{20,000}$th; an average being $\frac{1}{8000}$th to $\frac{1}{10,000}$th. Simple sterigmata are usually narrower, as well as shorter, than arthrosterigmata; in them the breadth is sometimes so small as $\frac{1}{10,000}$th to $\frac{1}{20,000}$th. Arthrosterigmata are frequently $\frac{1}{5000}$th to $\frac{1}{6000}$th broad, though sometimes they do not exceed $\frac{1}{12,000}$th. The following micrometrical scale, applied to the *length* of the sterigmata, may assist the reader:—

1. Very short,	From $\frac{1}{2500}$	to $\frac{1}{2000}$	inch.
2. Short,	$\frac{1}{2000}$	$\frac{1}{1500}$	...
3. Shortish,	$\frac{1}{1500}$	$\frac{1}{1000}$	...
4. Medium size,	$\frac{1}{1000}$	$\frac{1}{500}$	...
5. Longish,	$\frac{1}{500}$	$\frac{1}{250}$	...
6. Very long,	$\frac{1}{250}$	$\frac{1}{100}$	...

The cavity of the spermogone, in many lichens,—as in *Parmelia physodes*, *P. saxatilis*, *P. tiliacea*, *P. acetabulum*, *P. perlata*, *P. perforata*, *P. sinuosa*, *P. mutabilis* *P. conspersa*, *P. kamtschadalis*, and in *Ramalina*, *Usnea*, and *Evernia*, almost all having compound or articulated sterigmata,—is occupied more or less by a lax network of very delicate anastomosing filaments. These would appear to be hypertrophied, sterile sterigmata; at least, the elongated ramose sterigmata of *Cladonia* seem to me to furnish a key to their true nature. They spring from among the spermatiferous sterigmata, which they greatly exceed, both in length and tenuity. Their extremities are usually more or less knobbed or bulging.

b. Spermatia are solid bodies, colourless and transparent; homogeneous, having no contents and showing no septa; generally more or less linear in form, and of equal thickness throughout; never quite spherical; of extreme tenuity; exhibiting great uniformity in size and shape; devoid of cilia or other appendages; possessing Brownian or molecular movements in water; having no power of germination; never intermixed with oil globules, but imbedded in a mucilage.

These essential characters it is of importance to bear in mind, especially in contrasting, as to function, *spermatia* with *stylospores*.

Form a. Straight.—1. Rods with obtuse ends, or needles with pointed ends, in all species with arthrosterigmata. This, therefore, is the commonest form of spermatium.

2. Oblong, oval-oblong or ellipsoid in *Ramalina*, *Lichina*, and *Ephebe*.

b. Curved.—1. Shortish; sickle-shaped or crescentic; of equal thickness throughout, and with blunt ends, or thickest in the centre; with pointed ends in *Cladonia*, *Roccella*, *Stereocaulon*.

2. Long; twisted or vermiform in *Squamaria*.

Size.—The *length* of the spermatia varies from $\frac{1}{500}$th to $\frac{1}{15,000}$th of an inch, a medium or average being $\frac{1}{3000}$th to $\frac{1}{5000}$th. Sometimes, though rarely, as in *Parmelia tiliacea* occasionally, they are twice as long when attached as when free. But, in such cases, it would appear that, when thrown off from the sterigmata, they divide into two equal segments. Their breadth is most frequently about $\frac{1}{20,000}$th to $\frac{1}{30,000}$th, or it is so small as scarcely to admit of measurement. The following micrometrical scale, applied to the *length* of the spermatia, may assist the reader:—

1. Very minute,	$\frac{1}{15,000}$	inch to	$\frac{1}{10,000}$
2. Minute,	$\frac{1}{10,000}$	...	$\frac{1}{8000}$
3. Smallish,	$\frac{1}{8000}$	...	$\frac{1}{5000}$
4. Medium size,	$\frac{1}{5000}$	...	$\frac{1}{3000}$
5. Longish,	$\frac{1}{3000}$	...	$\frac{1}{1000}$
6. Very long,	$\frac{1}{1000}$	...	$\frac{1}{560}$

Position on the Sterigmata.—They are given off from—

a. Apices only, in simple sterigmata.

b. Apices and sides, in compound or articulated ones.

Development.—The spermatium first appears as a minute, papillar bulging of the apex of the sterigmatic filament or cell. This papilla gradually becomes elongated, and when maturity has been arrived at, a line of separation becomes marked, and the spermatium falls from its parent cell and base of support. Each sterigmatic cell would appear to give off in succession many spermatia; hence the infinite numbers in which the latter are found in the spermogonal cavity.

Emission or expulsion from the Spermogone.—When thrown off from the sterigmata, the spermatia accumulate in the central cavity of the spermogone, and gradually escape by the ostiole or pore. The emission or expulsion takes place under the influence of moisture, and its mechanism is the same in principle as that which regulates the expulsion of the spore from the thecæ and apothecia. The nucleus or sterigmatic portion of the spermogone imbibes water with great rapidity and avidity, swelling much; while the capsule or envelope does so much less readily and more slowly. The result is, that under the influence of moisture, a considerable pressure is exerted by the latter upon the former, the spermogonal cavity is contracted in size, and its contents,—the spermatia and the mucilage in which they are imbedded,—are squeezed out of the ostiole with considerable force, frequently, indeed, as if in a cloud or stream.

3. *Cavity.*—The spermogonal cavity is simple in the majority of lichens; but it is divided into a series of compartments or loculi, with more or less sinuous walls, in some *Physcias, Coccocarpias, Usneas, Ramalinas, Thamnolias, Stereocaulons,* and *Neuropogons.*

It contains a mucilage, which is usually colourless; but which is rose-red in some *Cladonias.* In this are imbedded the spermatia. The cavity is sometimes occupied by a net-work of anastomosing filaments, which arise from among the spermatiferous sterigmata, and which appear themselves to be hypertrophied, sterile, modified sterigmata. In age, the sterigmata frequently encroach upon the spermogonal cavity so much, by becoming elongated and hypertrophied, that it is frequently at length obliterated.

4. *Ostiole or Pore—Form.*—It is normally regular and round; but in the old state it is very frequently stellate-fissured, or otherwise irregular in its outline. In wart-shaped spermogones it is also frequently elongated and irregular. In position, it is central, one being seated on the apex of each spermogone. But when the spermogones are confluent, the ostioles are frequently so also, or a mass of confluent spermogones may be dotted over with an irregular series of foramina or ostioles, as in the case of *Alectoria Taylori*, and *Neuropogon melaxanthus.* The ostiole may be either flat,—that is, even with the surface of the thallus,—papillæform, or depressed; or it may possess all three forms in the same species, or even specimen. But the papillæform ostiole is more common than either of the other two. It is frequently surrounded by, or seated in the centre of, a round areola, as in many *Stereocaulons, Sphærophorons,* and *Parmelias.*

The lips or margins of the ostiole in the young and mature state are seldom very prominent; but in the old state they are frequently swollen, coloured, and prominent.

Size.—The ostiole is generally very minute; invisible without the aid of the lens, and even with its aid, difficult of detection, as in many *Parmelias*, *Physcias*, *Evernias*, &c. In some cases it is so large and patent as at once to be recognised under the lens, as in *Cladonia*, some *Parmelias*, &c.

Colour—is generally blackish or brownish; in some *Physcias* and *Placodiums* it is orange-red; and in *Usnea* and *Ramalina* it is concolorous with the spermogone and thallus, and hence is extremely inconspicuous. In exceptional cases it is pruinose, as in *Physcia pulverulenta*, in which species, also, it is sometimes of a rose-red colour.

VII. *Chemical Characters.*—No portion of the spermogonal tissues ever gives a blue reaction with iodine, as the thecæ and other elements of the hymenial tissues of the apothecia do. But the spermatia are rendered sometimes more distinct by being coloured a deep reddish-brown.

VIII. *Function* of the Spermogone.—It is generally *supposed*, by continental observers, that the spermogones are the analogues of male organs; but no impregnatory or fecundating influence on the spore has yet been distinctly observed or proved. In connexion with speculations as to their function, it is important to note:—

1. The universality of the occurrence of spermogones in lichens.
2. Their intimate relation, as regards position, to the apothecia.
3. Their priority in development over the apothecia.
4. The general resemblance of the spermatia to the spermatozoids of other cryptogams, though they are destitute of all appendages.
5. The differences in form and structure between spermatia and spores. The former are solid, homogeneous, of extreme tenuity, elongated, colourless, of almost uniform shape and size. The latter are hollow, with heterogeneous contents, frequently septate, usually spherical or oval, shortish, frequently coloured, varying greatly in size and form.
6. The absence of germinative power in spermatia.
7. The relative size of the spermatia and spores,—the former being infinitely more minute.
8. The relative number of spermatia and spores,—the former being infinitely more numerous.

IX. *Effects* on Classification, &c., of the discovery of Spermogones.—What are now ascertained to be spermogoniferous states of many lichens were regarded by the older lichenologists as separate varieties, species, and even genera; hence the discovery of spermogones has been the means, *inter alia*, of greatly reducing the number of lichens, and of simplifying their classification and nomenclature.

II. Pycnides.

The Pycnides of lichens may be described generally as externally resembling in form, colour, site, &c., the spermogones, from which they can be distinguished only by microscopical examination. The essential difference lies in the character of the contained corpuscles—the *stylospores*, though the sterigmata also differ from those of the spermogones to this extent, that they are almost always simple, shortish, and stoutish, generating the stylospores only at their apices. The pycnides consist, like the spermogones, of a—1. Capsule; 2. Nucleus, made up of sterigmata, with *stylospores* instead of *spermatia* however; 3. Cavity; and 4. Ostiole. They resemble outwardly, and are frequently mistaken for—*a*. Spermogones; *b*. Minute *Verrucarias ; c*. Parasitic Fungi; and *d*. Parasitic *Lecideæ*, such as those mentioned under the head of spermogones. From all of these bodies they can only be distinguished by careful microscopical examination.

They resemble the organs known as *Phoma*, *Septoria*, *Diplodia*, &c., which, according to TULASNE, belong, as secondary reproductive organs, to various thecasporous fungi. Their occurrence, alike in fungi and lichens, is a strong link binding together in close alliance these two great cryptogamic families. They are more plentiful in the lower than in the higher,—in crustaceous than foliaceous, lichens,—or, in other words, in those species most nearly approaching, in other particulars of their organization, the fungi. In crustaceous species they usually occur as very minute black perithecia, resembling the apothecia of *Verrucaria*. But in the higher lichens, they are frequently much larger, more closely resemble the spermogones, and are variously coloured, as in *Peltigera* and *Alectoria*. In the first-named genus they are marginal, like the apothecia; in the other, they are seated sometimes as warts on the thalline filaments, or in the axils of their ramifications.

Pycnides are sometimes associated both with spermogones and apothecia; sometimes with apothecia alone, no spermogones being present. Occasionally, pycnides and spermogones occur without apothecia, as in some species of *Strigula;* and sometimes pycnidiferous states of lichens are found just as spermogoniferous states are,—without either of the other forms of reproductive organs.

The distinction between pycnides and spermogones is, to a certain extent, one of convenience,—one depending on the difference in character of the contained corpuscles,—not one as yet founded on essential differences in function, inasmuch as the function of neither can yet be said to be thoroughly established or understood. Hence it may hereafter appear that some organs now denominated pycnides should be really regarded as spermogones, as those of *Peltigera* and *Alectoria*, and perhaps, though less likely, the converse,—that some organs now regarded as spermogones should be looked upon as pycnides, as those of *Lichina!*

Stylospores have the following distinctive characters:—

Form is very variable; but they are usually pyriform or oval. Generally they resemble spores in appearance. They are hollow bodies, with contents which are, at least, partly oily. They are usually found intermixed also with oil globules of various sizes. Occasionally they are septate, like many spores. Sometimes they retain their sterigmata as caudate appendages, shrivelled, but still distinct. Their colour is sometimes a pale yellow.

Size, like form, is variable. The length varies from $\frac{1}{1000}$th to $\frac{1}{4000}$th of an inch, and the breadth from $\frac{1}{4000}$th to $\frac{1}{6000}$th. Their size is therefore much greater in every dimension than that of the spermatia. At the same time, they are much fewer in number than the spermatia.

They are given off from the apices only of the sterigmata, and they are said by NYLANDER to possess the power of germinating.

Function of the Pycnides and Stylospores.—Founding solely or chiefly on their alleged power of germination, the stylospores are described in the latest continental work on lichens (NYLANDER'S "Synopsis") as *sporoid* bodies, that is, resembling spores, both in form and function. According to this view, we should regard the pycnides as secondary or supplementary apothecia. I have not, however, seen this germination of the stylospores for myself; neither have I observed impregnation of the spores by the spermatia; and though I am inclined, so far as my own observations have gone, to the views regarding the functions of the spermogones and spermatia, pycnides and stylospores,—which I have above enunciated as those taken by continental observers,—all that I feel warranted at present in advancing is, that I believe both spermogones and pycnides, in some way not yet fully established, to subserve the purposes of reproduction in lichens.

FAMILY I. USNEÆ.

GENUS I. USNEA, *Hoffm.*

The spermogones of this genus are extremely difficult of discovery, from their being of the same colour as the thallus, and from the ostiole being pale and inconspicuous; moreover, they are seldom met with. I have examined hundreds of specimens in every state, and from all manner of habitats, without success, and I had despaired of ever finding its spermogones, when, about two years ago, I succeeded in discovering them in abundance in a specimen of *U. barbata*, var. *hirta*, Fr., in LEIGHTON'S "Lichenes Britannici exsiccati." I have subsequently found them more plentifully in foreign specimens of the same species. I am now in a position to announce that the variety *hirta* of the older authors is, in great part at least, simply a spermogoniferous state or condition. It is partly also a state in which sorediiferous, instead of spermogonal, warts are abundant. These two separate kinds of warts can seldom be safely distinguished otherwise than by microscopical examination. I am not aware that, at the period of my discovering the spermogones of *Usnea*, I had been anticipated in my observations by any previous author. KOERBER says distinctly, "Spermogonien sind bis jetzt weder an dieser noch den andern arten aufgefunden worden."* Since the date of my original observations,

* "Systema Lichenum Germaniæ," "Die Flechten Deutschlands," von Dr G. W. KOERBER. Breslau, 1855. P. 3. (Sub *U. florida*, L.)

the spermogones of *Usnea* would appear to have been noticed by Dr NYLANDER of Paris, who, however, has as yet given no full or precise account thereof.

These spermogones are tubercles or warts, varying greatly in size and form, which are scattered abundantly (when they occur at all) along the ultimate ramuscles of the thallus, near their tips especially. To these they give the very rugose or warted appearance, which they not unfrequently bear, especially in var. *hirta*. They occur sometimes also on the cilia, which diverge from the margins of the large flat apothecia. They are, as I have already stated, concolorous with the thallus, and the ostiole can rarely be detected, unless when it is, as is seldom the case, black-punctate. Their nature, however, can be readily determined by placing one or two of them in a drop of water between glass slides under the microscope, while subjecting them to moderate pressure. The emission of myriads of small needle-like spermatia will at once remove all doubt as to their nature. Sometimes the spermogonal warts are isolated; more frequently they are confluent and irregular. Their cavity, too, though sometimes simple, is generally sinuous or compound, branching into numerous narrow compartments. Externally, the spermogones of *Usnea* resemble those of *Ramalina*, which are somewhat better known and more abundantly met with. The sterigmata, which converge towards the centre of the spermogonal cavity from its internal walls, are either simple and linear, or composed of a few linear, delicate cells or articulations, as in many *Parmeliæ*. These cells bear, on their apices, rod-shaped spermatia, varying from $\frac{1}{4000}$th to $\frac{1}{6000}$th long, and having a breadth of about $\frac{1}{25,000}$th. Associated with the ordinary sterigmata are numerous elongated, ramose, delicate, sterile filaments, such as occur in *Ramalina*, and in several *Parmeliæ*. NYLANDER describes the spermatia as rather thicker at one end, which thicker end is the one attached to the sterigma, and therefore lowest. This I have not specially noticed. The spermogones of *Usnea* are sufficiently and well illustrated by those of its species, *U. barbata*, which is to be found all over the world.

SPECIES 1. *U. barbata*, Fr.

Specimen 1.—Var. *hirta* (or *spermogonifera*, pro parte). LEIGHTON'S "Lich. Brit. exsicc." No. 1. (Engl. Bot., Plate 1354). Haughmond Hill, Shropshire. On the two right-hand specimens in my copy, both of which are dwarfed, deformed, much warted, and of a very dark greenish-gray colour: in fruit. In one specimen the spermogonal warts are chiefly scattered over the cilia, proceeding from the margins of the apothecia; in the other they cover the sterile ramuscles, especially about their extremities. In site and external appearance the spermogones are extremely like those of *Ramalina scopulorum*, Ach., and *R. polymorpha*, Ach. They are generally confluent, large, and irregular, and are among the most distinct spermogones I have ever observed in this genus. Their envelope is composed of hexagonal or roundish cells, constituting a tissue resembling that of the epidermis or cortical layer of the thallus, and having either a greenish or brownish colour. The internal tissue is dense, white, and hygrometric, as it is in the majority of lichens; and the cavity is full of viscid mucilage, in which are imbedded the free spermatia thrown off from their sterigmata on reaching maturity. The latter corpuscles are straight and linear; sometimes very short, not exceeding $\frac{1}{6000}$th to $\frac{1}{8000}$th long, sometimes long and acicular, attaining a length of $\frac{1}{4000}$th. The breadth in both cases is generally the same, being about $\frac{1}{25,000}$th. The sterigmata are sometimes simple and linear, ramose at base, or coming off in a digitate manner from basal filaments or tubes. At other times, and more generally, they are composed of a few—occasionally of numerous—articulations, which are delicate, linear, longish cells. These articulations or component cells, however, differ greatly in size and shape. They may be short and oval-oblong, or spherical, or elongated, and with very irregular outline. Moreover, they are articulated to each other at very irregular angles, and the whole sterigmata have frequently, therefore, a very zigzag and irregular outline. In the older spermogones are to be found masses of projecting elongated hypertrophied sterile ramose filaments, having quite the characters of those which occur in *Ramalina*, in *Parmelia physodes*, *P. tiliacea*, and many other lichens.

Specimen 2.—Van Dieman's Land; collected by Dr J. D. HOOKER, 1856. In the Hookerian Herbarium, Kew (sub nom. *U. florida*, Ach.). This is also var. *hirta*, a name, I think, which should, to avoid errors and misconceptions, be retained solely for spermogoniferous warted states of *U. barbata*. It is not of itself a good variety, for rough warted spermogoniferous states may occur equally in the varieties *florida*, *ceratina*, *plicata*, and *hirta* of authors, though they are most abundant in the latter variety. The spermogones are here abundant on the small ramuscles which diverge as cilia from the margins of the apothecia; and also on the small transverse ramuscles, which are given off by the erect (or pendent) main ramules in the neighbourhood of the apothecia. The warts are small and indistinct, and seldom, though occasionally, is the ostiole distinguishable. The spermatia are delicate needles, about $\frac{1}{6500}$th to $\frac{1}{4000}$th long. The sterigmata are very delicate, and either subsimple or slightly ramose; composed of two or three longish, delicate, linear articulations, as in *Parmelia saxatilis*, *P. physodes*, &c. Accompanying the spermogonal warts, but generally on separate ramuscles, are servediiferous warts, which are at once distinguishable on microscopical examination.

Specimen 3.—Also var. *hirta*; dwarf form. Tasmania. Antarctic Expedition, 1839–43. Collected by Dr HOOKER (sub nom. *U. florida*, Ach.): in abundant fruit. The main ramules give off very numerous transverse ramuscles. The latter, about their tips, are frequently roughened by indistinct, small spermogonal tubercles. They are so small as to be apt to be overlooked. The spermatia and sterigmata are as described in No. 2. But the latter sometimes also consist of simple linear, but irregular cells, which come off from basal tubes, lodged in the capsule or walls of the spermogone, as digitate prolongations. This capsule or envelope is of a tissue, which is either pale yellow or colourless.

Specimen 4.—Var. *hirta*. On the white oak of California. Collected by Mr DEIGHTON, 1857. The ramuscles are roughened over with warts, which, however, are chiefly sorediiferous. The spermogones are sparingly scattered about the tips of the ramuscles as elongated, flattish, pale warts, with ostioles of the same colour as the thallus. The sterigmata are very délicate and indistinct, of single, linear, elongated cells, subdigitately ramose at base. No free spermatia were found, the spermogones being chiefly old.

Specimen 5.—Rio Janeiro, 1846–51. Sent to HENRY PAUL, Esq. A few spermogones occur on the long and abundant cilia proceeding from the margins of the apothecia, as well as on the ramuscles diverging at right angles from the main branches of the thallus. They are either distinctly tuberculated, or they merely form fusiform swellings of the filiform ramuscles. The ostioles are pale and large; the tissue surrounding them still paler.

Specimen 6.—Ceylon. WALKER. In Hookerian Herb., Kew. Scattered about the tips of the ramuscles are tubercles, with pale brown disk-like ostioles, resembling young apothecia; these appear to be spermogones; but they are old, and contain no free spermatia. The tubercles are generally surrounded by a pale collar or ring of thallus. The last two specimens both belong to the var. *florida*, Fr.

GENUS II. NEUROPOGON, *Nees and Flot.*

The only species of this genus, *N. melaxanthus*, resembles the *Usnea florida*, Ach., than which, however, it is much stronger, coarser, and more deeply coloured. This is only what we should expect from its habitat and geographical distribution, the genus being peculiar to the arctic and antarctic regions. The fruit, which is abundant, and the spores, are those of *Usnea barbata*, while the spermatia and sterigmata are similar, though somewhat longer. Instead of being tubercles, the spermogones constitute irregular fusiform swellings of the tips of the ultimate ramuscles, which are very black. These swellings are dotted over with minute perforations, which are the ostioles of the confluent compound spermogones. I can see no valid reason for dissociating *U. melaxanthus* as a genus from *Usnea*, nor from another closely allied lichen, which NYLANDER places in *Alectoria*, *A. Taylori*, and which has precisely similar spermogones, though the thallus is somewhat more simple.

SPECIES 1. *U. melaxanthus*, Ach.

Specimen 1.—Hermite Island, Cape Horn. Antarctic Expedition, 1839–43. Dr HOOKER. The plant has a deep brownish-red colour, and very black apices, which contain the peculiar spermogones above described. The envelope of the spermogones is of a pale brown cellular tissue. The spermatia are delicate needles, about $\frac{1}{2000}$th to $\frac{1}{3000}$th long, with a breadth of about $\frac{1}{25,000}$th. NYLANDER describes them as thicker at one end. The sterigmata are very delicate, and composed of longish, linear, somewhat irregular cells, from the apices of which are given off the spermatia. The sterigmata resemble those of *Parmelia tiliacea*, and other *Parmeliæ*. NYLANDER describes them as simple and linear!

GENUS III. CHLOREA, *Nyl.*

The spermogones of this genus,—at least if *C. vulpina*, the only species I have had an opportunity of examining, may be taken as a type,—are more allied to those of *Evernia*, than of *Usnea* and *Neuropogon*, with which NYLANDER associates it. The species named has altogether more of an everniiform than an usneiiform aspect. The spermogones are black or brown points or papillæ according as they are immersed or superficial, scattered on the angles of the laciniæ about their extremities, and conspicuous from contrast with the beautiful lemon-yellow colour of the thallus. The spermatia are straight, rod-shaped, or acicular. NYLANDER describes them as slightly thicker or "fusiform-incrassate" at one end. They vary in size from $\frac{1}{2000}$th to $\frac{1}{4000}$th, with a breadth of about $\frac{1}{25,000}$th. The sterigmata are simple, linear, somewhat irregular cells, ramose at the base; or they are composed of a few delicate linear cells or articulations, as in *Usnea* and *Neuropogon*. Their length varies from $\frac{1}{1000}$th to $\frac{1}{1500}$th.

SPECIES 1. *C. vulpina*, Nyl.

(*Synonyms.—Cornicularia*, SCH. Enum. 6; *Evernia*, KÖRB, 41; FRIES. L. E. 24, exs. 142; MASS. Lich. Ital. exs. 1 Pp. *Parmelia*, Ach.) Occurs in North America as well as in Europe.

Specimen 1.—On the bark of the *Wellingtonea gigantea*, California; the specimen exhibited in the Crystal Palace, Sydenham, February 1857; J. HARDY. In fruit. The spermogones are brown tubercles, which give the laciniæ a very rugose, warted character; they are sometimes very large and distinct. The sterigmata are elongated, linear cells, subdigitately ramose at base. The spermatia are about $\frac{1}{2500}$th long. On the same thallus occurs, as it frequently does, the parasitic *Phacopsis vulpina*, Tul. (HEPP. exs. 474). The apothecia of this Parasite are generally confluent, and form very large and irregular black warts or tuberculated masses, placed usually near the base of the thallus, or on the larger laciniæ only. Besides, its spermogones have not yet been discovered, and its apothecia can scarcely, therefore, be confounded with the isolated brown or black spermogones of *C. vulpina*.

Specimen 2.—HEPP. exs. 474 (sub *Phacopsis vulpina*, Tul., which is parasitic on its thallus). Bark of old larches, and on old palings, about St Moritz, Switzerland. Here the spermogones are minute, black tubercles, scattered along the angular edges of the laciniæ, and indistinguishable from nascent apothecia, unless by microscopical examination. The spermatia and sterigmata are among the largest and most distinct I have seen. Both are somewhat hazy or granular, and the basal portions of the sterigmata are brown. The bases of the latter are very closely agglomerated, and merge into the brown, dense, cellular tissue of the envelope. The sterigmata are simple cells, elongated, having a very irregular outline, coming off subdigitately from basal tubes.

Specimen 3.—Rocky Mountains, DRUMMOND; north-west coast of America, DOUGLAS; in Hookerian Herb., Kew. The spermogones extend a considerable distance down the laciniæ. They are wholly immersed, and exhibit on the surface only their small, black, papillæform ostioles. The spermatia are about $\frac{1}{4000}$th long, with a breadth of $\frac{1}{25,000}$th. The sterigmata are about $\frac{1}{1500}$th long, and consist of a few delicate, linear, irregular cells or articulations.

Specimen 4.—SCHÆRER exs., No. 390 (sub *Parmelia*); on firs in the Alps; on right-hand specimen in my copy (ed. alt. immut., 1840). The spermatia are about $\frac{1}{3000}$th long; the sterigmata either linear, single cells, or of a few articulations; about $\frac{1}{1000}$th to $\frac{1}{1200}$th long.

Specimen 5.—Germany; in Herbarium Bot. Soc. Edin. The spermogones are abundant as greenish or greenish-brown tubercles, with a black tip. The spermatia are about $\frac{1}{3000}$th to $\frac{1}{4000}$th long. The sterigmata are as described in No. 4.

FAMILY II. RAMALINEÆ.

GENUS I. RAMALINA, *Ach.*, *Fr.*

As a general rule, the spermogones of this genus resemble those of *Usnea*. They are irregular tubercles of the same colour as the thallus, sometimes isolated, but more frequently confluent, scattered over the laciniæ, especially about their extremities. Spermogonal warts are the cause of the very rugose, deformed character of the laciniæ in several species; for instance, in *R. scopulorum* and *R. polymorpha*, in dwarf specimens of which they are especially abundant. The ostiole is generally pale and inconspicuous; under moisture it is usually semi-translucent, and more easily recognisable. It is sometimes, more generally in foreign than British species and specimens, black-punctate, and then it is comparatively distinct and easily seen on the pale green thallus. Where the laciniæ are round or filiform, the spermogones are scattered over the whole surface; where they are flattened, as in the *ampliata* form of var. *fraxinea*, they are sometimes confined to the rugæ, with which the thallus is frequently marked. The size of the spermogones varies greatly; their diameter generally ranges from $\frac{1}{60}$th to $\frac{1}{150}$th. In *R. calicaris*, var. *fraxinea*, it is $\frac{1}{80}$th to $\frac{1}{60}$th; in *R. scopulorum* $\frac{1}{80}$th to $\frac{1}{130}$th. The envelope is either of a pale brown or green, or it is colourless; its component tissue is cellular, and similar to that of the cortical layer of the thallus. The cavity is simple or compound, and divided into sinuosities or compartments; the latter apparently in the case of confluent spermogones. The internal tissue is white, horny, and dense, as contrasted with the loose, white, medullary tissue in which they are imbedded. The sterigmata are very delicate, short, linear cells, sometimes ramose at the base, of equal width with the spermatia, which are given off as terminal cells. Sometimes, though rarely, they appear to be subarticulate, several long, linear, delicate cells coming off from a central, principal, or trunk cell near its base. Their length varies from $\frac{1}{750}$th to $\frac{1}{1500}$th, frequently averaging $\frac{1}{1000}$th. Associated or intermixed with the ordinary sterigmata are numerous elongated, ramose, very delicate filaments, which fill up the cavity of the spermogone, and occur so constantly as to constitute a characteristic feature of the spermogones of this genus. NYLANDER regards these anastomosing filaments as a point of distinction between this genus and *Dufourea*. The spermatia are short and oblong; sometimes, though rarely, ellipsoid. Their breadth is about $\frac{1}{20,000}$th; their length varies from $\frac{1}{5000}$th to $\frac{1}{10,000}$th, averaging about $\frac{1}{7000}$th.

In *R. ceruchis*, a species from central America, the spermogones differ somewhat from those of the British *Ramalineæ*. They are here black, cone-like bodies, either directly seated on the thallus, or placed on thalline warts or tubercles. The difference, however, is more apparent than real; and, altogether, this is an exceptional or anomalous species. It is only the ostioles which are black and papillæform, and the envelope of a deep indigo blue colour; the whole internal structure is that of the spermogones of British species of *Ramalina*. There is a remarkable uniformity in regard to the structure or contents of the spermogones of this genus,—a circumstance which, taken along with the uniformity in character of the spores, leads me to suggest that all our British species, at least, of *Ramalina*, should be associated in a single species,—call it by what name we may.

SPECIES 1. *R. calicaris*, Fr.

A cosmopolite, which has been found in some of its numerous varieties or forms equally in Europe, Africa, America, Asia, and Australia.

Specimen 1.—Var. *fraxinea*, Fr. Broad form of laciniæ (form *ampliata* of authors). On trees, Glen Cluny, Braemar, August 1856, W. L. L.; no apothecia. Laciniæ marked by prominent, decussating rugæ or plicæ. On these the spermogones occur generally in closely aggregated, irregular groups, and most abundant about the extremities of the laciniæ. The ostioles are generally of the same colour as the thallus; sometimes of a darker green, but never very conspicuous. The spermatia are about $\frac{1}{6500}$th long; the hypertrophied ramose filaments are abundantly intermixed with the ordinary sterigmata. The apices of the latter generally bulge somewhat, resembling, in this character, the paraphyses of most lichens.

Specimen 2.—Sub *Alectoria tuberculata*, Tayl., in Hookerian Herb., Kew; Peru, on trees in arid situations; Monte Christo, Columbia. This lichen has broadish, flattened laciniæ, and is apparently referrible to the same variety as No. 1. The surface is abundantly warted over with both spermogonal and soredic tubercles; hence, probably, the source of the name given it by TAYLOR.

Specimen 3.—HEPP. exs. 167, var. *ampliata;* in fruit; on old fruit-trees. The smallest and lowest specimen in my copy has spermogones, scattered over the edges and towards the ends of the laciniæ, as yellowish tubercles. The envelope is of a pale brown, or colourless.

Specimen 4.—Teneriffe; in Hookerian Herb., Kew. The segments of the thallus are linear or narrow, but flat. The margins are roughened or warted over with spermogonal warts, whose ostioles are either pale or black-punctate. In the latter case they are easily discoverable. The spermatia are about $\frac{1}{7000}$th long; the sterigmata $\frac{1}{1000}$th. The greater frequency of the black-punctate condition of the ostiole in foreign, than in British specimens, is one great reason why the spermogones of the former are generally more easily recognised.

Specimen 5.—Philippine Islands, CUMING; in Hookerian Herb., Kew; sterile segments of thallus linear and flat. The spermogones are marked by a central brown pore or ostiole; they are scattered over the surface of the laciniæ about their tips; they are here easily discoverable under the lens. The spermatia are about $\frac{1}{7000}$th long; the sterigmata $\frac{1}{750}$th to $\frac{1}{1000}$th.

Specimen 6.—Sub *Lichen calicaris*, Linn., in Herbarium Linnæi, preserved in the Library of the Linnæan Society of London. The thallus is dotted abundantly over with spermogones, the ostioles of which are minute black dots or points.

Specimen 7.—Forfarshire; T. DRUMMOND, in Hookerian Herb., Kew; a form passing into *R. scopulorum.* The thallus is very dark, and is covered with spermogones. In *R. calicaris*, the cellular capsule or envelope of the spermogone is generally about $\frac{1}{1500}$th thick.

SPECIES 2. *R. scopulorum*, Ach.,

Which is nearly as widely distributed over the world as *R. calicaris*, being found in Europe, Africa, Asia, and Australia.

Specimen 1.—Isle of Bute; in Hookerian Herb., Kew; a small, delicate form, with round filiform segments. These are abundantly warted over, especially near their tips, with spermogones, having black-punctate ostioles. Hence these organs are here easily recognisable on the pale lemon-yellow thallus. The size and form of the spermogones vary greatly. The sterigmata are about $\frac{1}{1000}$th long, and sub-ramose at base; the spermatia sub-ellipsoid, about $\frac{1}{9000}$th long, with a breadth of $\frac{1}{20,000}$th.

Specimen 2.—Rocks on the sea-coast, between Burntisland and Aberdour, Fife; collected May 1856, by Dr MURRAY LINDSAY. Spermogones are abundantly scattered over the exceedingly deformed, rigid, dark-coloured segments of the thallus, as very irregular warts, paler than the thallus, generally flattened on their surface; having an ostiole concolorous with the thallus, or paler, never black.

Specimen 3.—Kinnoull Hill, Perth; rocks on summit, overlooking the Tay, W. L. L. A small, rigid, dwarf, dark-coloured form, as in No. 2. Some specimens are quite free from spermogones, others have them in abundance, as in No. 2.

Specimen 4.—LEIGHTON's exs., No. 2. Engl. Bot. 688; on rocks, South Stacks, Holyhead, Anglesea; sterile. Spermogones are abundant in both specimens in my copy; large and small forms of thallus. They are generally confluent, and very irregular in form; occasionally having a blackish ostiole. The spermatia are about $\frac{1}{7000}$th long, and sterigmata about $\frac{1}{1000}$th. Many of the latter are really ramose, giving off linear elongated branches or cells near their base. The hypertrophied anastomosing filaments are very abundant and distinct in the right-hand specimen in my copy.

Specimen 5.—Forfarshire, T. DRUMMOND; in Hookerian Herb., Kew (sub nom. *R. fraxinea* var. *fastigiata*). Segments very much warted over with spermogones, having black ostioles.

Specimen 6.—Miss HUTCHINS; apparently from Ireland; in Hookerian Herb., Kew. Spermogones abundant, but pale and inconspicuous. The thallus here is terebrate, or pierced by foramina, and marked by lacunæ. I have noticed this condition in many other British specimens of this species, so that it can scarcely be regarded as a good specific character,—as in TAYLOR's *R. terebrata*. In another specimen, also from Miss HUTCHINS, in the same Herbarium, the ostioles of the spermogones are black-punctate.

Specimen 7.—Rocks, Scilly Islands, DICKSON; in Hookerian Herb., Kew. Flat linear segments, showing a transition to *R. calicaris*. These are dotted over with spermogones, which, from having black-punctate ostioles, are easily seen.

Specimen 8.—Probably from the coast of Appin, Argyleshire, CARMICHAEL; in Hookerian Herb., Kew. Spermogones abundant, and with black ostioles. They are pale and inconspicuous in other specimens marked from the Hebrides.

Specimen 9.—Lundie Crags, about ten miles from the sea (near Dundee), GARDINER, 1844; in Hookerian Herb., Kew. The thallus is of a very dark green, almost black; the spermogones pale.

Specimen 10.—GREVE DE LECQ., Jersey, 1851; in Hookerian Herb., Kew. The thallus is of a pale lemon-yellow, probably the result of age and desiccation. The tips and bases of the segments of the thallus are black, while the thallus is studded over with patches of black. The spermogones are abundant, with largish black ostioles, occasionally resembling somewhat the spermogones of *Neuropogon melaxanthus*.

Specimen 11.—Teneriffe, rocks near the Mesa de Mota, 1849; BOURGEAU Pl. Caner., No. 351. Spermogones abundant, and with black ostioles.

Specimen 12.—St. Vincent, point of Mount Veredi, 2500 feet high; and Cape de Verde; VOGEL. Segments flat, and of a very dark brownish-red colour. The margins of the laciniæ are fringed with spermogonal warts. Nos. 11 and 12 are in the Hookerian Herb., Kew.

Specimen 13.—Rocks on the Island of Potoo, China, 1856, FORTUNE. In fruit, spermogones abundant, pale.

Specimen 14.—WELWITZSCH exs., 36, on granite rocks; 37, *β. b.* Cabo da Rocca, Estremadura; 38, γ. Cabo da Rocca,—all in Portugal. Both sterile and fertile segments are warted over with spermogones, having black ostioles. This and No. 13 are in the Hookerian Herb., Kew.

Specimen 15.—SCHÆRER exs., 554; maritime rocks, shores of the Atlantic; PELVET. The spermogones are abundant, flattish, very variable as to size, and marked by a pale ostiole, which is only visible on close examination. The spermatia are $\frac{1}{8000}$th long; the sterigmata $\frac{1}{2000}$th to $\frac{1}{1500}$th.

Specimen 16.—SCHÆRER exs., 603 (sub var. *humilis*); rocks on coast of Corsica; Requien; in fruit. This seems merely a maritime form of *fastigiata* var. of *R. calicaris.* The spermogones are abundant about the ends of the thalline segments; they are elongated, irregular in form, and marked by a pale gray or greenish ostiole.

In *R. scopulorum*, it will be observed that the spermogonal ostiole is more frequently black than in *R. calicaris.* It may sometimes be confounded with a small, black, punctiform *Sphæria*, whose perithecia are occasionally scattered over the surface of the thallus. The subarticulate sterigmata, which occur occasionally, resemble those of *Cladonia*, except that they are distinctly composed of several cells, instead of being a single ramose one. This is perhaps the best species in which to study the spermogones of *Ramalina.* So abundant are these bodies on it, and so constantly do they occur, that I regard this species mainly as a spermogoniferous maritime form of *R. calicaris.*

SPECIES 3. *R. polymorpha*, Ach.,

Which occurs in Africa, as well as in Europe. I do not know on what principle this is separated as a species from *R. scopulorum.* I regard it simply as a dwarf, deformed, spermogoniferous state, and referrible to *R. calicaris.* Its spermogones are precisely those of *R. calicaris* and *R. scopulorum.*

Specimen 1.—LEIGHTON exs., No. 73; on Whitestone Cliff, near Thirsk, Yorkshire. The thallus is dwarfed, deformed, and of a very dark colour; the segments are thick, and are abundantly warted over with the spermogones of *R. scopulorum.* The hypertrophied, ramose, sterile filaments are here abundant and distinct,—more so generally in this species and in *R. scopulorum* than in *R. calicaris*

Specimen 2.—Welwitzsch exs., No. 39; Cabo da Rocca, Estremadura, Portugal; in Hookerian Herb., Kew. Fruit (that of *fastigiata* var. of *R. calicaris*), abundant. This I refer to the *fastigiata* section of *R. calicaris;* it is simply, as in No. 1, a dwarf deformed state, abundantly warted over with spermogones.

Species 4. *R. terebrata*, Taylor.

This I do not regard as a separate species, but would refer it, as a variety, to *R. calicaris.*

Specimen 1.—Falkland Islands; Antarctic Expedition, 1839–43; Dr Hooker. Its spermogones externally, as well as their spermatia and sterigmata, are those of *R. calicaris.* The spermogones are scattered about the ends of the narrow flat laciniæ: they are sparingly distributed, and are small, flattened, distinct tubercles, having no visible ostiole. The spermatia are almost atomic as to size, about $\frac{1}{10,000}$th long, and oblong. The elongated anastomosing filaments are so abundant as almost to hide the ordinary short spermatiferous ones. The spermogonal envelope is of a pale greenish-brown colour.

Species 5. *R. homalea*, Ach.,

Which grows in Australia and California.

Specimen 1.—California; in Hookerian Herb., Kew. The segments of the thallus are flattish, resembling those of *Roccella fuciformis* somewhat. The spermogones are scattered, chiefly on the edges of these laciniæ, and towards their tips, as black, punctiform, immersed bodies. They frequently become confluent, and, in old age, are sometimes very large, irregular, and maculiform.

Species 6. *R. ceruchis*, Ach.

(Syn. *Desmazieria*, Mont.; *Usnea*, Mont.; *Borrera*, Ach.).

Specimen 1.—Chili, Cuming; in Hookerian Herb., Kew. The segments of the thallus are dotted over with large, black, roundish bodies, seated either directly on the thallus, or placed on thalline warts or tubercles; they are frequently confluent, and are then very irregular in form. The body of the spermogone is wholly immersed. The envelope is of a deep indigo-blue. The spermatia are about $\frac{1}{5000}$th long, with a breadth of $\frac{1}{20,000}$th; the sterigmata about $\frac{1}{1500}$th long. The cortical layer of the thallus is frequently eroded at irregular intervals, the white medullary tissue being thereby exposed. This gives rise to an appearance somewhat similar to that possessed by var. *articulata* of *Usnea barbata*, in which the central, white, medullary thread is exposed by decortication, at intervals, of the thalline filaments or ramules. When this erosion occurs, the spermogone remains intact, and it then appears as a prominent, large, black papilla, contrasting well with the white medullary tissue which surrounds it. This plant also bears some resemblance, in its general aspect, to *Neuropogon melaxanthus.* "Lying without adhesion," says TWEEDIE, apparently, of this curious lichen (in Herb. Hook.), "on laxe sands at Iquique, Peru, 2-3000 feet, where clouds often hang. Tint to sand green from a distance. One other minute yellow lichen on old bones, and a cactus on lofty rocks on the coast. No other plant on coast for 14 leagues inward, and then three only on the west mountains!"

Specimen 2.—Var. *gracilior*, Nyl. (Syn. *Usnea tumidula*, Nyl.); Coquimbo, CUMING; in Herb. Hooker, Kew. Its segments are round, narrow, and filiform, and the whole plant has the aspect of *R. calicaris*, var. *canaliculata*, Fr., or of *R. linearis.* The spermogones are large, black, round superficial bodies, sparingly scattered about the ends of the ramules. This specimen also bear apothecia.

GENUS II. DUFOUREA, *Ach., Nyl.*

In this genus the spermogones are minute, black, punctiform, immersed, scattered about the angles of the erect thallus. The black points indicate the ostioles, which lead to the immersed body of the organ; they vary greatly in size, and are generally flattish, though sometimes papillæform. The spermogones, externally, closely resemble those of *Roccella.* As in *Ramalina*, the sterigmata are short, simple, linear cells; but they are much more irregular in outline, and are generally of greater diameter; they are generally similarly sub-ramose at base. Their length varies from $\frac{1}{2000}$th to $\frac{1}{8000}$th long. But, unlike *Ramalina*, there are no elongated, anastomosing, sterile filaments intermixed. The spermatia also differ remarkably from those of *Ramalina.* They are linear, long, and slender, about $\frac{1}{2000}$th long, and slightly curved.

SPECIES 1. *D. madreporiformis*, Ach.

Specimen 1.—Switzerland; in Herb. Hooker, Kew. The angles about the ends of the ramules are dotted over with the minute black points which mark the ostioles, and which become brown when moistened. The spermatia are about $\frac{1}{2000}$th long, with a breadth of $\frac{1}{25,000}$th; they are very slender and beautiful, straight, or more generally slightly curved. The sterigmata are irregular dilatations of simple cells, or digitate prolongations of basal tubes. Sometimes, though rarely, they are composed of two or more simple irregular cells or articulations. In general they resemble those of *Lecanora subfusca.*

Specimen 2.—SCHLEICHER exs., No. 67, 1814 (sub *Lichen madreporiformis*, WULFF. HALL., No. 1962); on top of Mount Letscherberg; in Herb. Hooker, Kew. The spermogones occupy the position they do in *Sphærophoron compressum*, than whose spermogones, however, they are larger and not so crowded. They are generally scattered in groups of two or three together, near, but not on, the apices of the segments of the thallus. There are no spermogones in the specimen in SCHÆRER's exs. in Herb. Hooker. I have not met with apothecia on any specimens I have examined. The sterigmata vary greatly in length, being sometimes not above $\frac{1}{6000}$th to $\frac{1}{8000}$th long, and at other times $\frac{1}{2000}$th to $\frac{1}{3000}$th.

Specimen 3.—SCHÆRER exs., 85 (sub *Cladonia*); on the ground on calcareous alpine heights. Intermixed with the spermogones, as above described, are numerous black, superficial, easily removable, conical minute bodies, which appear to be the pycnides of a fungus. They contain small, ellipsoid, or oval stylospores, on longish, linear, irregular delicate sterigmata.

GENUS III. DACTYLINA, *Nyl.*

The spermogones resemble those of *Dufourea* in being black, punctiform, and immersed, scattered about the tips and along the sides of the erect podetia-like expansions of the thallus. The spermatia, however, are chiefly straight, linear, and smaller—about $\frac{1}{6000}$th long; and the sterigmata, though generally simple, are sometimes composed of a few articulations.

SPECIES 1. *D. arctica*, Hook.

(Syn. *Dufourea* of older authors.)

Specimen 1.—FRANKLIN'S first voyage; in Herb. Hooker, Kew; sterile. The plant consists of very large podetia, coming off like fingers from a horizontal branch or stem. The spermogones are scattered about the apices of these erect, digitate offshoots of the horizontal thallus, as well as along their sides, generally in groups of a dozen, or more. They are wholly immersed, and their presence is indicated by very minute black points. They occur equally on sterile and fertile podetia. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, with a breadth of $\frac{1}{25,000}$th. The sterigmata are frequently about $\frac{1}{3000}$th long, and are either simple linear cells, variously bulging in their walls, or composed of two or three linear elongated cells or articulations.

Specimen 2.—Rocky Mountains, America; Cape Ross; Melville Island, Captain PARRY; Koby Sound, BEECHEY; in Herb. Hooker, Kew. Spermogones occur on all these specimens, especially on those with a smooth thallus, for in some the thallus is much wrinkled and lacunose, apparently from desiccation in an arid habitat.

GENUS IV.—ALECTORIA, *Ach.*, pro parte, *Nyl.*

The most common and familiar species of this genus, *A. jubata*, is interesting, inasmuch as, like *Peltigera*, it possesses pycnides instead of,—perhaps in addition to,—spermogones. I have never met with the latter, whereas I have several times found the former occupying the position, and having the outward semblance, of the latter. These bodie sare spherical or fusiform warts or dilatations, generally seated at the junction of several thalline filaments or branches. They are large and conspicuous when they occur at all, which is rare, and are apt to be mistaken for apothecia. The sterigmata are linear, simple, ramose at the base, as in *Ramalina*, and about $\frac{1}{1000}$th to $\frac{1}{1200}$th long. Each gives off from its apex an oval or pyriform stylospore, irregular in shape, and closely resembling similar corpuscles in the pycnides of *Peltigera*. They vary in length from $\frac{1}{6000}$th to $\frac{1}{9000}$th, their breadth being frequently so small as $\frac{1}{10,000}$th.

In other species, spermogones of the ordinary characters occur. In *A. lata* they are minute, black, flattish tubercles or warts, scattered along the edges and about the ends of the delicate filiform ramuscles of the thallus. The spermatia are straight, linear, and very small, their length being about $\frac{1}{10,000}$th, their breadth $\frac{1}{20,000}$th. The sterigmata are also linear, short, and simple, of equal width with the spermatia, which appear as terminal cells, having a length of about $\frac{1}{2000}$th to $\frac{1}{3000}$th. In *A. Taylori* the spermogones are quite of a different character, and assimilate those of *Neuropogon*. They constitute fusiform irregular swellings of the black apices of the ultimate ramuscles of the thallus, which swellings are studded over with numerous minute perforations or ostioles. Their cavity is generally compound or sinuous, a result of the confluence of many spermogones. The spermatia and sterigmata are similar to those of *Usnea* and *Neuropogon*, though considerably larger and more distinct than those of the former genus. NYLANDER describes the spermatia of *Alectoria* as slightly thickened at both ends, or slightly constricted or thinner in the middle. This I have not specially observed.

SPECIES 1. *A. jubata*, Ach.,

Which is widely distributed over the world, occurring in Europe, America, and Asia.

Specimen 1.—SCHÆRER exs., No. 496 (sub *Parmelia jubata* δ *cana*); on trunks of firs, Mount Gurnigel. Spermogonal warts are abundant at the angles and junctions of the thalline filaments. The form and size of the contained corpuscles, which I venture to call stylospores, are so irregular and variable, that they have the aspect rather of the bodies just named as they occur in *Lecidea Smithii*, *L. Walrothii*, *Peltigera*, and in other lichens, than of true spermatia, while the conceptacles in which they occur have rather the external aspect of spermogones than of pycnides. In many of the stylospores there is a dark spot like a nucleus, which is probably a rudimentary septum, a phenomenon which is never observed to occur in true spermatia. The spermogonal warts here are abundant, black on the surface, irregular in outline, and generally flattened.

Specimen 2.—SCHÆRER exs. 392, associated with *Evernia divaricata*, Ach.; on the trunks of trees in alpine woods, Switzerland. The spermogonal warts are precisely as above described. The stylospores are oval or pyriform, about $\frac{1}{6000}$th to $\frac{1}{9000}$th long, with a breadth of about $\frac{1}{10,000}$th, of minute size, therefore, compared with those of *Peltigera*. The sterigmata are linear, simple, ramose at base, as in *Ramalina*, with a length of about $\frac{1}{1000}$th to $\frac{1}{1200}$th.

SPECIES 2. *A. lata*, Tayl. Nyl.

Syn. *Cornicularia*, Tayl.

Specimen 1.—Mexico; in Herb. Hooker, Kew. The plant has the aspect of *A. ochroleuca*. The spermogones are plentiful, and easily seen. They are small, brown, flattish tubercles or warts, varying in size, scattered about the edges and towards the tips of the delicate, filiform, thalline ramuscles. Their bodies are immersed in the thallus, and from the fact of the latter being semi-translucent, the depth of their immersion can be readily seen. The spermatia and sterigmata are as I have already described, and resemble those of *Ramalina*.

SPECIES 3. *A. Taylori*, Hook.

Specimen 1.—Kerguelen's Land; Antarctic Expedition, 1839–43; Dr HOOKER. In its spermogones, as in its thallus or general aspect, this plant resembles *Neuropogon*, as already described. The spermatia are delicate needles, about $\frac{1}{2000}$th long, resembling those of *Parmelia tiliacea*, *P. physodes*, and other *Parmeliæ*. The sterigmata also resemble those of *P. tiliacea* in being composed of a few delicate linear cells or articulations; others are, however, simple cells, sub-ramose at base. The spermatia and sterigmata are among the most beautiful with which I am acquainted. A parasitic punctiform *Lecidea*, which is apt to be mistaken for spermogones, occurs on the smooth and thicker part of the thalline ramules. I am not aware that it has hitherto been noticed or described, and I therefore propose for it the, at least provisional, name of *Lecidea alectoriæ*, in reference to its habitat. It occurs also, however, on *Nephromium cellulosum*, Ach. It consists of minute round black points, sparingly scattered, flat or depressed, never papillate; they are wholly immersed in the thallus of the *Alectoria*, and having no thallus of their own, the apothecia may be said to constitute the plant. They resemble, in external aspect, the *Lecidea vermicularia*, which is parasitic under similar circumstances on *Thamnolia vermicularis*, but from which it differs in the characters of the spore, which is three-septate, and oval or ellipsoid. The thecæ are like those of *L. vermicularia*, being obovate and sac-like, irregularly and suddenly bulging, and not tapering gradually into a pedicel below as in the majority of thecæ. There are no distinct paraphyses. This parasite occurs also on the back or lower surface of the apothecia of *A. Taylori*. The spores of *A. Taylori* are those of our British *Usnea barbata*, and to the genus *Usnea*, in which it was formerly placed, I am inclined to refer it along with the allied *Neuropogon melaxanthus*.

GENUS V. EVERNIA, *Ach. Nyl.*

The spermogones of this genus are usually punctiform and immersed, of a black or brown colour, scattered about the ends of the laciniæ on their flat surface, or on their angular edges. They resemble those of many of the *Parmeliæ*, but are generally smaller. Sometimes they are more superficial or prominent, constituting wartlets or tubercles. Occasionally they are seated on wart-like or papillar elevations of the thallus, or they are surrounded by an inconspicuous thalline ring, giving them a pseudo-papillate character. They are marginal in *E. Richardsoni*, to the lobes or laciniæ of which they give a denticulate or nigrociliate character, as in *Platysma nivale*. Occasionally also they occur on tooth-like prolongations from the margin of the laciniæ, in which event they resemble the spermogones of *Cetraria islandica*. The spermatia are straight, linear, rod-shaped, and small, varying from $\frac{1}{4000}$th to $\frac{1}{8000}$th, averaging $\frac{1}{4000}$th to $\frac{1}{5000}$th. The sterigmata are ramose, and consist of a few delicate linear cells or articulations; they vary in length from $\frac{1}{750}$th to $\frac{1}{1200}$th. Associated with them occasionally are ramose, elongated, sterile filaments, like those of *Ramalina*.

SPECIES 1. *E. furfuracea*, Mann.,

Which is very widely distributed over the world, occurring in Europe, Africa, Asia, and America.

(Syn. *Borrera*, Ach.; *Physcia*, Schær. En. 10; *Parmelia*, Schær.)

Specimen 1.—Ingleborough, Yorkshire, 1855; coll. by Dr DEIGHTON. The spermogones are the minute black points or spots scattered over the smooth, light-gray ends of the laciniæ; the spermatia are very small, only about $\frac{1}{8000}$ long.

Specimen 2.—SCHÆRER exs., 387 (sub *Parmelia*); on trunks of trees in alpine woods. The spermogones are to be found, as in No. 1, only on the smooth tips of the laciniæ; on the furfuraceous ones none can generally be discovered. The extreme points of the laciniæ are generally of a deep brown colour, and are apt to be mistaken for spermogones, like those of the genus *Cladonia*. The spermatia are about $\frac{1}{4000}$th long; the sterigmata are very irregular, articulated, about $\frac{1}{1000}$th to $\frac{1}{200}$th long. The elongated, anastomosing, sterile filaments resemble those of *Parmelia physodes*, or *Ramalina*.

Specimen 3.—Near Vera Cruz, Mexico; Peak of Orizaba, 11,000 feet high, 1838; coll. by J. LINDEN, No. 98; in Herb. Hooker, Kew. The spermogones are black or deep brown points, closely resembling those of *Parmelia physodes*. The spermatia are about $\frac{1}{4000}$th long, with a breadth of $\frac{1}{25,000}$th, and are delicate needles. The sterigmata are about $\frac{1}{750}$th to $\frac{1}{1000}$th long, and consist of a few linear articulations, as in *P. physodes*.

Specimen 4.—Peak of Orizaba, Mexico; on oaks and pines, at 9000 to 10,000 feet; coll. H. GALEOTTI, 1840; in Herb. Hooker, Kew. The spermogones are brown points, sometimes on wart-like elevations of the thallus, or surrounded by a small thalline ring, which gives the appearance of a papilla.

Species 2. *E. prunastri*, Ach.,

Which is less widely distributed than *E. furfuracea;* but which, nevertheless, occurs in Europe, Africa, and America.

Specimen 1.—On North Berwick Law, near Edinburgh, August 1855; W. L. L. Its spermogones precisely resemble those of the preceding species, being black or brown points, abundantly scattered over the laciniæ towards their tips. Their bodies are wholly immersed, with a simple cavity. Here the spermogones are apparently old, as they contain no free spermatia. Korber describes a minute parasitic *Sphæria* as occasionally occurring on the thallus, and which is apt to be confounded with or mistaken for the spermogones.

Species 3. *E. Richardsoni*, Hook.

(Sub *Cetraria.*)

Specimen 1.—Polar Seas; Dease and Simpson, Fort Enterprise; in Herb. Hooker, Kew. Spermogones abound along the margins of the laciniæ as minute brown tubercles, giving them a denticulate or nigro-ciliate character, as in *Platysma nivale.* When seated on small tubercles, spines, or cilia, which project from the margins of the laciniæ, as is sometimes the case, they closely resemble the spermogones of *Cetraria islandica.* They are very variable as to size. No free spermatia are found in any of them; they are apparently either old or degenerate. The character of the spermogones is, I think, at least one strong reason for associating this plant with *Cetraria* rather than *Evernia;* and I therefore am of opinion that Nylander has erred in altering Hooker's arrangement.

Species 4. *E. Ashneh* (?).

(Syn. *Borrera.*)

Specimen 1.—Saharunpore, 1850; Dr Jameson, in Herb. Royal Botanic Garden, Edinburgh. The name and place in classification of this plant do not appear to have been yet determined. From its general aspect,—its apothecia and its spermogones,—I am inclined to place it under this genus, beside *E. prunastri* and *E. furfuracea.* The apothecia resemble those of *E. prunastri*, and are scattered about the ends and over the surface of the laciniæ. Its spermogones are punctiform, immersed, deep brown, scattered especially about the tips of the laciniæ.

FAMILY III. Roccelleæ.

GENUS I. Roccella, *Bauh.*

The spermogones are generally in the form of minute black points, scattered more or less abundantly over the flattened or round segments of the thallus. The black points in question are the ostioles, the bodies of the organs being wholly immersed in the thallus. These punctiform ostioles are usually flat on the surface, sometimes depressed, seldom papillæform. Sometimes they are surrounded with a pale ring or collar of the thallus, and then they assume a pseudo-papillæform aspect. In this case they may resemble the nascent apothecia. The spermogones are frequently confluent, sometimes becoming very irregular, even maculiform. When spermogones do occur, they are usually very distinct, and easily recognised, from the contrast of their black colour with the pale reddish-yellow or buff colour of the thallus. In some cases they are most abundant towards the tips of the ramules; at other times they are scattered over the whole surface, or nearly from base to apex,—usually, however, of sterile ramules. Their cavity is simple. Their size varies considerably, their diameter being, in *R. tinctoria*, $\frac{1}{170}$th to $\frac{1}{130}$th, and in *R. Montagnei* $\frac{1}{430}$th to $\frac{1}{320}$th. The spermatia are linear, delicate, generally curved more or less, but sometimes also straight and rod-shaped: in both cases they are obtuse at the ends, and of equal thickness throughout. Their length varies from $\frac{1}{1500}$th to $\frac{1}{4000}$th, averaging about $\frac{1}{3000}$th, with a breadth of from $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. The sterigmata are linear, simple, delicate cells, ramose at the base, as in *Ramalina*, and sometimes of equal width with the spermatia. They vary in length from $\frac{1}{1500}$th to $\frac{1}{3000}$th, with a breadth of from $\frac{1}{10,000}$th to $\frac{1}{20,000}$th.

SPECIES 1. *R. tinctoria*, Ach.,

Which has the widest geographical range of any species of this genus, occurring alike in Europe, Africa, America, and Asia.

Specimen 1.—St Ouen's Bay, Jersey, 1851; in Herb. Hooker, Kew. The plant appears to me rather referrible to *R. phycopsis*. The tips of the laciniæ are frequently dotted over with brown punctiform spermogones.

Specimen 2.—Mauritius; Cape of Good Hope, 1822, Dr THOM; both in Herb. Hooker, Kew. In both cases the spermogones are abundant as brown points.

Specimen 3.—"Lima thickest Orchella weed," imported from the west coast of South America into London and Liverpool for the British Orchill manufacture; given me by Messrs BENJAMIN SMITH and SON, Orchill manufacturers, London, 1851. The spermogones are sparingly scattered in groups over the laciniæ, and among the warts bearing the apothecia, in the form of minute, round, black, chiefly depressed points, resembling in external aspect the spermogones of *Parmelia tiliacea* or *P. physodes*. In some specimens, instead of being depressed or flat, the ostioles are papillæform or wart-like. They are then larger, rough on the surface, perched on thalline papillæ, isolated, or grouped two or three together on a large, distinct, thalline wart. The segments of the thallus are sometimes roughened over with these spermogonal warts. Sometimes the ostioles become confluent, and assume various irregular forms, especially stellate or lirellæform appearances. In this case they are apt to be confounded with warts bearing apothecia, which frequently assume similar appearances. The microscopic structure at once distinguishes them. These warts, both spermogonal and apothecial, are frequently pruinose, or covered by a fine dust, derived from the surface of the thallus, which pruina obscures their naturally black surface. Sometimes the black ostiole is sunk in the thalline wart, which forms a pale, sub-prominent margin around it. But more generally, as I have already mentioned, it is flattened or convex. The spermatia in all the different forms of spermogone just described are very beautiful and delicate, about $\frac{1}{1500}$th to $\frac{1}{2000}$th long, and curved or twisted like those of the *subfusca* group of *Lecanoras*. They are borne on the apices of linear delicate sterigmata, which are sub-ramose at the base, and are closely aggregated. The form of the immersed body of the spermogone is spherical, its cavity simple, and the internal tissue, though originally white, becomes brown with age.

SPECIES 2. *R. fuciformis*, Ach.,

Which, though not quite so extensively distributed as the preceding species, yet occurs in Europe, Africa, and America.

Specimen 1.—SCHÆRER, exs., 553; maritime rocks, shores of the Atlantic; PELVET. One large segment of the thallus is studded over with prominent, irregular, black tubercles, which are old spermogones, containing no free spermatia.

Specimen 2.—Imported from Lisbon into Liverpool under the name of "Chickenweed," for the British Orchill manufacture; sent by Rev. W. A. LEIGHTON, April 1856. The spermogones are sparingly scattered towards the extremities of the laciniæ, as largish, black, distinct points. The spermatia and sterigmata differ considerably from those which occur in the spermogones of African specimens. The former are oblong or rod-shaped, very minute, resembling those of *Ramalina*, being about $\frac{1}{6500}$th to $\frac{1}{8000}$th long; the sterigmata also being like those of *Ramalina*.

Specimen 3.—Imported for the British Orchill manufacture, probably from the west coast of Africa; used in the manufacture of Orchill, under the name of "mixed Orchella weeds," by Messrs ROBINSON, Huddersfield. Many of the specimens, at least, are corticolous, for they are found with small portions of the twigs of trees or bushes attached. The spermogones are abundantly scattered over the laciniæ as minute, round, brown points. These points or ostioles sometimes are surrounded by a pale thalline ring or margin, and they then somewhat resemble young apothecia. The spermatia are generally sickle-like or curved, not twisted or vermiform, about $\frac{1}{3000}$th long. The sterigmata are longish, linear, simple, delicate. In some specimens, in abundant fructification, the spermogones are unusually large and distinct, scattered among the apothecia. The spermatia are rod-shaped or straight, about $\frac{1}{6500}$th long. The sterigmata are short and sub-ramose at base. Occasionally the apothecia are dotted over with black, punctiform, depressed spermogones; they are rendered distinct, when they occur, from contrast with the white-pruinose disk of the apothecia. These spermogones have the usual characters of such as ordinarily occur on the thallus. The spermatia are small and curved, about $\frac{1}{6500}$th long, generated on the apex of simple or sub-simple short sterigmata. Hence it would appear, that in different specimens of the same species, apparently from the same locality or habitat, the spermatia and sterigmata differ considerably in character. This, however, is a phenomenon we constantly meet with in lichens. On some of the twigs on which the *Roccella* grows, I also find associated with the degenerate lirellæ of a *Graphis*, resembling *Graphis scripta*, a number of small, round, black spermogones, apparently belonging thereto. The spermatia are curved, like those of the *Roccella*, about $\frac{1}{4000}$th long, and borne on the apex of short, linear, simple sterigmata.

Species 3. *R. Montagnei*, Bél.

Occurs in equinoctial Africa, India, and Java. This and the following species are intermediate, in regard to the characters of the thallus, between *R. tinctoria* and *R. fuciformis*.

The spermogones are quite those of the species just named. Indeed there is considerable uniformity in the species of *Roccella*, in regard, at least, to the external character of the spermogones. Here they are scattered either on the general surface, and especially towards the tips of the laciniæ, or on the angles of the laciniæ, when these exist.

Specimen 1.—Aden, on twigs and rocks; top of Dhemsen Mountain, 1700 feet high, 1847; Dr Hooker, in Herb. Hooker, Kew. Some specimens closely resemble, in the characters of the thallus, the genus *Ramalina*, in which it has been inadvertently placed in the Hookerian Herbarium.

Specimen 2.—Madras, plentiful on the trunks of the *Mangifera indica;* ex. Herb. Montagne; in Herb. Hooker, Kew. Old spermogones, with lacerate-fissured black ostioles, are scattered about the ends of the laciniæ.

Specimen 3.—Java, Lobb; in Herb. Hooker, Kew. The sorediiferous tips of the segments of the thallus are dotted over with punctiform spermogones, having quite the characters of those of *R. tinctoria*.

Specimen 4.—Imported, under the name of "Angola Orchella weed," from the Portuguese settlements of Angola, on the west coast of Africa, into London and Liverpool, for the British Orchill manufacture; sent by Messrs Benjamin Smith and Son, Orchill manufacturers, London. The plant grows on the twigs of trees and shrubs about the sea-coast. The laciniæ are frequently angulose or terete-compressed. I find two forms of spermogones. The one occurs as minute dark brown points, dotted over the surface of the laciniæ, generally in large groups or masses. The other is in the form of large, round, or irregular, prominent, superficial, black tubercles, sparingly scattered, and resembling young apothecia. In the former the spermatia are curved, delicate, or of great tenuity, about $\frac{1}{4000}$th to $\frac{1}{3000}$th long; the sterigmata short and unassociated with elongated, ramose, sterile filaments. In the larger form of spermogones, on the other hand, the spermatia are generally short, thickish, and rod-shaped, or straight; the sterigmata longer, and accompanied by delicate, anastomosing, elongated filaments, as occurs in *Ramalina*. It is interesting to note that there is a similar diversity in the characters of the apothecia in this species, and, indeed, in most or all the species of *Roccella*. In none, perhaps, is this diversity so easily studied as in *R. tinctoria*. A similar difference in the form of the spermatia occurs in *Opegrapha vulgata*, in which they are found of all intermediate degrees of size and shape between short, straight, rod-shaped, and longish, graceful, crescent-like spermatia. On some of the twigs on which *R. Montagnei* grows, occur minute, black, punctiform spermogones, containing rod-shaped spermatia about $\frac{1}{8000}$th long, borne on short, linear, delicate sterigmata, which appear referrible to some of the *Graphideæ*.

SPECIES 4. *R. phycopsis*, Ach.,

Which occurs equally in Europe and Africa. As I refer *R. Montagnei* to the *fuciformis* or flat-lobed type, I am inclined to refer this species to the *tinctoria* or round-lobed form.

Specimen 1.—Among the mixed Orchella weeds sent by Messrs ROBINSON of Huddersfield, and probably collected on the west coast of Africa. The laciniæ are angulose or terete-compressed, and are dotted over with spermogones having all the aspect of those of *R. tinctoria*. In some spermogones the spermatia are straight, rod-shaped, and about $\frac{1}{3000}$th long; while in others on the same specimen they are slightly curved. In both cases they are of great tenuity, and are borne on closely aggregated, delicate, linear, simple sterigmata.

SPECIES 5. *R. intricata*, Mont.

Specimen 1.—Coquimbo; in Herb. Hooker, Kew. Spermogones are abundant, as largish, distinct, superficial, black points, frequently surrounded by a ring or collar of the thallus. In the latter case they may resemble nascent apothecia. The spermatia are straight or slightly curved, about $\frac{1}{3000}$th long, with a breadth of $\frac{1}{25,000}$th; the sterigmata are short, simple, ramose at base, and about $\frac{1}{1500}$th long.

SPECIES 6. *R. mollusca*, Ach.

(Sub *Dufourea*. Syn. *Dufourea pruinosa*, Nees.)

This species, which is a native of the Cape of Good Hope, differs from other species of the genus, both in its general aspect somewhat, and in its possessing *terminal* instead of *lateral* apothecia. Its spermogones are, however, quite those of the other species I have just described.

Specimen 1.—In Herb. Hooker, Kew. The spermogones are minute, round, black, flattened spots, which are the ostioles of immersed nuclei. They are scattered over both sterile and fertile segments of the thallus, especially about the tips, but are most abundant on the former. The spermatia are straight or slightly curved, about $\frac{1}{4000}$th long, with a breadth of $\frac{1}{25,000}$th; while the sterigmata are simple, somewhat irregular, short, linear cells, sub-ramose at base, with a length of $\frac{1}{3000}$th to $\frac{1}{4000}$th, and a breadth of $\frac{1}{9000}$th to $\frac{1}{10,000}$th. Both spermatia and sterigmata closely resemble those of the preceding species.

FAMILY IV. Siphuleæ.

This is altogether an anomalous and puzzling family, whose place in classification is, as yet, only provisional, from none of its species having been found bearing apothecia. In the typical genus *Siphula*, I have never found even spermogones; but I have had the opportunity of examining only *S. ceratites*, Fr., which grows in northern Europe (Lapland), Asia (the Himalayas), and in arctic America. In *Thamnolia*, however, I succeeded in finding spermogones several years ago, and, at the time of their discovery, I was not aware that my observations had been anticipated by any previous author. Nylander has, since that date, referred to its spermogones in some of his publications; but he has not as yet fully described them. His observations, however, so far as they go, do not quite correspond with my own. The only species I have examined is *T. vermicularis*, which grows in arctic or alpine parts of Europe, Asia, and America.

GENUS I. Thamnolia, *Ach.*, *Schærer.*

This curious genus has been hitherto included in the genus *Cladonia;* but the character of its spermogones at once separates it. In *Cladonia* the spermogones are generally terminal, and of a different colour from the thallus, the spermatia curved, and the sterigmata short and simple. In *Thamnolia* the spermogones are lateral and concolorous with the thallus, the spermatia rod-shaped and straight, and the sterigmata longish and articulated. The spermogones are the large, irregular, prominent warts, frequently scattered over the thallus,—of the same colour therewith, and having no conspicuous ostiole. They must be comparatively familiar to lichenologists; but it is seldom that the spermatia and sterigmata can be found; at least I have examined several dozens of specimens from every variety of habitat, and, though I long suspected these warts of being spermogones, I have only been able to satisfy myself as to their true character—by discovering the spermatia and sterigmata—in a single instance. Nylander's description of the spermogones does not at all agree with my observations. He says they resemble the perithecia of an *Endocarpon*. Now, I have never found them punctiform and immersed, as this description would imply; but his words might apply perfectly to a minute, punctiform, parasitic *Lecidea*, *L. vermicularia*, *mihi*, which I have frequently found growing on the thallus. Again, the spermatia appear to me to be simply linear and rod-shaped, of equal width throughout; while NYLANDER describes them as slightly thickened at both ends. This difference in our observations might arise from his using higher magnifying powers than I am in the habit of employing. Probably this character, if it exists, is not a very prominent one. In respect of size and thickness of walls, the arthrosterigmata of this genus, like those of *Bœomyces*, are intermediate between those of *Sticta* and those of *Parmelia*,—the sterigmata in the latter having longer and fewer articulations or cells; those in the former genus being altogether broader and stronger, the component cells being more cubical, and having much thicker walls.

SPECIES 1. *T. vermicularis*, Schærer.

(Syn. *Cenomyce*, Ach.; *Cladonia*, D.C.; *Cladonia α maurocrea β vermicularis*, KÖRB. 26.)

Specimen 1.—SCHÆRER exs. 86 (sub *Cladonia vermicularis α subuliformis.*) On the ground in alpine situations; Switzerland. The specimen includes two forms of the plant, viz., a larger, coarse, and turgid form, corresponding to the var. *turgida* of *Cladonia uncialis*, and a smaller, ordinary, vermicular form. It is on the former, more particularly, that the spermogones occur. This is the only case in which I have as yet satisfactorily seen the spermatia and sterigmata of the spermogones. The latter occur abundantly as largish, prominent, roundish, flattened, or irregular warts, of the same colour as the thallus, with an obscure, central, stellate-fissured ostiole. The internal walls are formed of arthrosterigmata, resembling those of *Sticta* and *Collema*. They consist of short, thick-walled cells, irregularly articulated so as to give the whole sterigma a very zigzag outline. The spermatia are small, rod-shaped, about $\frac{1}{6000}$th long, with a breadth of $\frac{1}{20,000}$th, bristling over the sterigmata, as in the genera above named, and attached to the apices of the individual articulations or cells. In external aspect the spermogones are somewhat analogous to those of *Usnea* and *Ramalina*; but they are generally isolated and sparingly scattered in *Thamnolia*.

Specimen 2.—Falkland Islands; Antarctic Expedition, 1839-43; Dr HOOKER. The hollow, vermicular, creeping stems are dotted over with minute, black, round, immersed bodies, frequently depressed or flattened, which bear a close resemblance to the spermogones of *Roccella*. These, however, are the parasitic apothecia of a *Lecidea*. The thecæ are irregularly obovate, bulging here and there from pressure by the contained spores, not tapering below into a pedicel, but sac-like, and resembling the thecæ of *Arthonia*. They do not give a blue reaction with iodine. The spores are eight in each theca, brown, 1-septate, oblong-oval, with a constriction opposite the septum, which gives them a figure-of-eight appearance. I am not aware that this parasite has been hitherto described; and I therefore venture to propose for it, in allusion to its habitat, the name of *Lecidea vermicularia.* It closely resembles, in external aspect, the parasitic *Lecidea alectoriæ,* which inhabits the thallus of *Alectoria Taylori,* whose spores, however, are 3-septate.

Specimen 3.—Falkland Islands; Dr HOOKER; in Herb. Hooker, Kew. A few thalli bear the parasite above described. Its spores are soleæform, resembling those of *L. Smithii,* about $\frac{1}{2000}$th to $\frac{1}{1500}$th long by $\frac{1}{4000}$th broad.

Specimen 4.—Var. *taurica,* which is merely a short, turgid, spermogoniferous form, as described in No. 1; Cairngorm, Aberdeenshire Highlands; in Herb. Hooker, Kew; in very large handsome patches. There are here associated both soredic and spermogonal warts: the former can at once be distinguished, on microscopic examination, from young spermogonal warts, where spermatia occur; but when the spermogones are old, as in this case, the distinction becomes very difficult. Here the spermogonal warts are comparatively large, and resemble the young apothecia of *Lecanora parella* somewhat. They have a distinct, ring-like margin, and a pale brown, disk-like ostiole, which becomes semi-pellucid on being moistened. In the young state they are mere thalline papillæ, with a brown apex, which is the round ostiole. An annotator in Herb. Hooker remarks, in regard to these warts, of date 1810, [probably Dr TURNER],—"Can this be the fruit of *Bæomyces vermicularis?* HUTTON had two or three morsels besides; but I could not get more from him, as he had promised them to Mr GISBORNE. I thought the best of them looked much like the tubercles of *B. roseus.*" It is most interesting to note here the association of this species under, or in, the genus *Bæomyces;* for the spermogones of *Thamnolia* and *Bæomyces,* as I have already pointed out, bear a marked resemblance. In my researches I have constantly been struck with the extreme accuracy of the older lichenologists, an accuracy remarkable in the absence of that now all-important aid to the observer, the microscope. It has been customary to decry the classifications of the older authors on lichenology, and to abolish their nomenclature; but I do not hesitate to avow my preference both for their classification and nomenclature, as contrasted, at least, with the modern systems of the German school, if, at all events, we may take the monographs of BAYRHOFFER and KÖRBER as types or specimens thereof! In addition to the soredic and spermogonal warts above described, there occasionally, though more seldom, occur warts which appear to be bullosities of the thallus,—large, very rugose, and irregular; they are dotted over with black, punctiform bodies, which, though I have not detected in them the characteristic spores, I have no hesitation in referring to my *L. vermicularia.*

I have found spermogonal warts in specimens collected by myself on Lochnagar, Cairngorm, and Ben M'Dhui, Braemar; on Ben Lawers, Perthshire; and on the Dovrefjeld range of mountains in Norway. I have also met with them occasionally in the following valuable suite of specimens contained in the Hookerian Herbarium at Kew:—

1. Small or ordinary form: Huamantonge, and on the Pampas of the Cordillera, South America; Port Louis, Dr Hooker; Franklin's first voyage; Port Bower; the mountains of Canlochan, Clova, Gardiner, 1844; hill above the Corrie of Clova, Gardinnr, 1843; Ben Aven, Braemar, spreading over *Cetraria aculeata* and *Trichostomum lanuginosum*, Gardiner of Dundee.

2. Short, turgid form, var. *taurica* of authors: Bomasas, Garkmäl, on the Himalaya, 16,000 feet high, ex. Herb. Strachey and Winterbottom; Lehon; Spruce's "Lichenes Pyrenæi;" British North America; Melville Island, Sir E. Parry; Hartz Mountains, Dr Nöhden; Ben Lawers; Mael Graedha, 1810, coll. by Borrer.

FAMILY V. Bæomyceæ.

GENUS I. Bæomyces, *Pers.*

In this genus the spermogones are with great difficulty visible, and are seldom to be met with. I have seen what I regard as the spermogones—for I have not been able perfectly to satisfy myself—only in a single instance, in *B. placophyllus*. There they occur on the horizontal or flat foliose thallus, as punctiform, immersed, black or brown bodies, somewhat irregular in form. The spermatia are very minute, rod-shaped, or oval; the sterigmata very narrow, delicate, and consisting of numerous short cells or articulations. In respect to the size of these individual articulations, and their general thickness, the arthrosterigmata of *Bœomyces* are intermediate between those of *Collema* or *Sticta*, and those of *Parmelia*, as, indeed, I have already pointed out under the head of *Thamnolia vermicularis*.

Species 1. *B. placophyllus*, Ach.,

Which grows in northern Europe, and northern America.

Specimen 1.—Near Blair Atholl, 1810; Borrer, in Herb. Hooker, Kew. The horizontal thallus is studded over with minute, black, punctiform, or irregular bodies,—immersed in the thalline tissue,—which appear to be its spermogones, but in which I could find no free spermatia nor distinct sterigmata, so that I am in doubt as to their nature. Here there is no fructification (apothecia). The thallus is parmelioid, thick, foliaceous, buff-coloured.

Species 2. *B. roseus*, Pers.

The most familiar species of the genus, perhaps, which occurs in Europe, America, and New Zealand. Its arthrosterigmata are the most delicate known in lichens as to thickness, being only about $\frac{1}{8000}$th to $\frac{1}{12,000}$th broad.

Species 3. *B. rufus*, Ach.

(Syn. *B. rupestris*, Pers.; *Biatora byssoides*, Fries.,; *Sphyridium fungiforme*, Schrad., Körb., 273.)

Like *B. roseus*, this species occurs alike in Europe, America, and New Zealand. Körber describes its spermogones as small, brown warts, sometimes comparatively distinct, with oval spermatia.

Species 4. *B. icmadophilus*, Ach.

(Syn. *Lecidea*, Ach.; *Biatora*, Fries.; *Lichen ericetorum*, Smith Engl. Bot., 372; *Lecidea æruginosa*, Schær. exs., 216; *Icmadophila æruginosa*, Scop., Körb., 151).

This species has a comparatively wide geographical distribution, occurring in Europe, North America, and India. Körber says, he never found separate or isolated spermogones in this species. But once, on making a section of an apothecium, in a part of the hypothecial tissue he came unexpectedly upon a number of atomic, linear bodies, endowed with a molecular movement, having all the appearance of spermatia. He evidently means to imply, that the spermogones here are sunk in the hypothecium below the hymenium of the apothecium; for he throws out the suggestion, that they may stand in the same relation that those of *Celidium fusco-purpureum* do according to Tulasne.* I have found this position of the spermogones in one or two instances only; but I suspect that it is not so uncommon as we are at present led to believe. In such a position, spermogones are extremely apt to be overlooked, and it were well, I think, that the attention of future observers in spermogonology should be directed to this circumstance.

FAMILY VI. Sphærophoreæ.

GENUS I. Sphærophoron, *Pers.*

The spermogones may be described, in general terms, as small but distinct black or brown cones or tubercles, either perched singly on the tips of the ultimate ramuscles, as in *S. coralloides*, or scattered in groups along the zigzag or angular edges of compressed, flattened segments, as in *S. compressum*. They are sometimes dotted over the angles of the ramuscles in *S. coralloides*; but this is very rare, while it is a general phenomenon in *S. compressum*. In *S. coralloides*, the cone form predominates, with a brown colour; in *compressum*, the flattened tuberculated form with a black colour. In the former, the shape is intermediate between the barrel-like spermogone of *Cladonia* or *Cetraria*, and the papilla of *Sticta*

* "Mémoire pour servir a l'Histoire Organographique et Physiologique des Lichens." By M. L. R. Tulasne, Aide-naturaliste au Muséum d'Histoire Naturelle, Paris. Annales des Sciences Naturelles, 3d Series, vol. xvii., Botanical Part, 1852, p. 121; Plate 14, f. 12.

or *Parmelia*. In the latter species (*compressum*), the spermogone is frequently a mere flattened wart. In both, the spermogones are usually very distinct, from the contrast of their colour with the pale gray, or buff-yellow, waxy tint of the thallus. Sometimes they are scattered over the under surface, which is paler or whiter than the upper, as in some forms of *compressum*, in which case they are still more distinct. The ostiole is generally very minute and imperceptible; but frequently also it is large and patent. In the latter case, the spermogone may present the appearance of a flattened cone with a depressed apex, or of a brown or black ring, as is frequent in *compressum*. Moreover, in the old state of the spermogone, the nucleus sometimes falls out, leaving irregular, saucer-shaped cavities. The ramuscles bearing spermogones are generally much more narrow and delicate than those bearing apothecia, which latter indeed are not unfrequently fastigiate or thickened in *tenerum* and *coralloides*. Gentle pressure in a drop of water, between glass slides, of one of the spermogones, causes the emission of myriads of spermatia, which are minute corpuscles, oblong, rod-shaped, or subellipsoid,—generally straight, but sometimes slightly curved;—they are obtuse at the ends, and vary in length from $\frac{1}{6500}$th to $\frac{1}{10,000}$th, with a breadth of about $\frac{1}{20,000}$th. The sterigmata are short, linear, simple cells, subramose at the base, and of equal breadth with the spermatia. They resemble those of *Cladonia*, and are about $\frac{1}{1200}$th to $\frac{1}{1500}$th long, with a breadth of $\frac{1}{20,000}$th. Sometimes they are composed of a few delicate linear cells or articulations. Sometimes intermixed with the ordinary spermatiferous sterigmata are numerous elongated, sterile, anastomosing filaments, resembling those of *Ramalina*. The spermogonal envelope is usually of a brown cellular tissue. LINK makes a very careless and improper use of the term "*Sporangium*," as applied to the reproductive organs of *Sphærophoron*, a term which is usually applied only to the spore cases of Ferns and Mosses. He evidently refers to the apothecia rather than to the spermogones, when he says,—"Constat sporangium e thecis appositis, parallelis, ut in Opegrapha, aliisque quæ tamen fatiscunt et indumentum pulveraceum quo distinguitur constituunt."* The figure he gives is, moreover, very bad and unlike nature.

SPECIES 1. *S. coralloides*, Pers.,

Which has a wide geographical range, being found in Europe, Northern America, the Antarctic Regions, and the Canary Islands. TULASNE seems to have been singularly unsuccessful in discovering the spermogones of this species, which he describes as similar, in site and structure, to those of *S. compressum*. They are, in almost all the specimens examined by myself, solitary and apical, large and cone-like, while those of *compressum*, according to my observations, are lateral, grouped, flattened, and irregular.

* "De Sphærophori Sporangio Observatio." By H. F. LINK, p. 465, Plate xi., fig. 2. 'Linnæa," vol. vii. Berlin, 1832.

Specimen 1.—Glen Dee, Braemar, on quartz boulders; in abundant fruit; August 1856, W. L. L. The spermogones are abundant on the tips of the smaller ramuscles, which surround those bearing apothecia. They are deep brown, cone-shaped bodies, with an imperceptible pore or ostiole; they are generally single, one on each ramuscle; occasionally they are grouped in twos or threes. In general appearance they somewhat resemble the spermogones of *Cetraria islandica*. The spermatia are straight and rod-shaped, about $\frac{1}{6500}$th to $\frac{1}{8000}$th long. On first emerging from the spermogone, they frequently appear sub-ovoid or ellipsoid, probably from their being coated with some of the spermogonal mucilage in which they are imbedded. In other specimens, on granite, the spermogones are somewhat older; they appear as deep brown rings, occupying the same site as above mentioned. Here the ostiole is large, round, and patent, as in *Cladonia*. The envelope, as in the former case, consists of a deep brown cellular tissue. The sterigmata are sometimes composed of a few delicate linear cells or articulations. The spermatia are even smaller than those above described, being only about $\frac{1}{10,000}$th, and they are more frequently sub-ellipsoid in form.

Specimen 2.—On boulders of granite and other rocks; roadside opposite Invercauld, Braemar, August 1856, W. L. L.; sterile. Here the spermogones are old; the cones are flattened on the apex; the ostiole large and patent, with a prominent, brown, thick margin, and depressed occasionally so as to give the spermogone a saucer-like appearance.

Specimen 3.—On rocks of mica slate and gneiss, Craig-y-Barns, Dunkeld, April 1856, W. L. L. Young spermogones are abundant on the brown tips of the ultimate ramuscles.

Specimen 4.—Walls, Ingleby Park, Cleveland, Yorkshire, 1856, collected by W. Mudd. The spermogones are here sparingly scattered on the brown tips of the most delicate ramuscles; they are papillar, with an imperceptible ostiole, and are easily recognised from the contrast of their deep brown colour with the pale waxy-gray of the thallus.

Specimen 5.—Straits of Magellan, Whinnie; in Herb. Hooker, Kew. The plant is sterile, and the whole thallus is much warted and deformed. The tips of all the innumerable terminal ramuscles of the much-branching thallus are studded with black, papillar spermogones.

Specimen 6.—Russian America, 1837, and North-west America, Douglas; in Herb. Hooker, Kew. The spermogones are here arranged as in *compressum;* they are few, and scattered on the angles about the ends of the ramuscles, as well as seated on their apices. This may be regarded as a transition form between *coralloides* and *compressum*. A specimen from Jamaica, Wilson, also in the Hookerian Herbarium, is labelled *compressum* by Nylander himself; it certainly has the spermogones of the latter: but the thallus has all the aspect of that of *coralloides*. In American specimens, the thallus generally branches much, and is long and lax. In *S. coralloides*, the ramuscle, at its tip, generally suddenly bulges out or becomes thickened below the insertion of the barrel,—or cone-like, spermogone.

SPECIES 2. *S. fragile*, Pers.,

Which has nearly as wide a geographical range as the preceding species, of which indeed I regard it but as a variety. The plant is cæspitose and dwarf; its ramuscles single, or branching little, and closely aggregated.

Specimen 1.—MOUGEOT and NESTLER's exs., No. 263; in Herb. Royal Botanic Garden, Edinburgh. The spermogonal papillæ are isolated and terminal, precisely as in *S. coralloides*.

Specimen 2.—Craig-y-Barns, Dunkeld, 1856, W. L. L.; sterile. The spermogones are young, and constitute the brown tips of the simple closely aggregated ramules.

SPECIES 3. *S. tenerum*, Laur.

If it is not to be considered but a variety of *S. coralloides*, it is very closely allied, both in the general aspect of its thallus, and in the site and structure of its spermogones. The latter are terminal and isolated, each being seated on the tip of one of the extremely narrow, linear, delicate ramuscles.

Specimen 1.—Hermite Island, Cape Horn, Antarctic Expedition, 1839–43, Dr HOOKER. The spermogones are minute, black, round tubercles, with an inappreciable ostiole; they are smaller and darker than, but otherwise of the same character as, those of *S. coralloides*. The spermatia are rod-shaped or sub-ellipsoid, about $\frac{1}{8000}$th to $\frac{1}{10,000}$th long, and are given off from the apices, as well as sides, of the delicate indistinct sterigmata, which are composed of a few delicate linear cells or articulations, and are sub-ramose at base. Some specimens have branches somewhat short and thick; in them the spermogones occur in the form of clustered warts, resembling those of *Stereocaulon*.

Specimen 2.—Lord Auckland Islands, Antarctic Expedition, 1839–43, Dr HOOKER. Abounds both in apothecia and spermogones. The ramules bearing the former are strong and fastigiate, scarcely ramose; those bearing the latter are filiform, extremely delicate, and very ramose. The spermogones are black papillæ or warts precisely as described in No. 1. The spores are quite those of *S. coralloides*, an additional argument for merging in this species *S. tenerum*.

SPECIES 4. *S. compressum*, Ach.,

Whose geographical range is, at least, as extensive as that of *S. coralloides*, occurring in Europe, America, the African Islands, and Australia.

Specimen 1.—Tasmania, Antarctic Expedition, 1839–43, Dr HOOKER. The thallus is of a pale-yellow on one surface, the upper, which is convex; whitish on the under surface, which is somewhat concave; the edges of the segments are much notched. Scattered along the notched edges, especially towards the extremities of the branches, and on their under or pale surface, are the spermogones, which are round, black, flattened warts. In some, the ostioles are small or imperceptible, more generally they are distinct, and frequently they are so large and patent that the spermogones have the aspect of mere rings. Sometimes the body of the spermogone falls out, leaving an irregular saucer-shaped cavity. In foreign specimens, this species is very distinct from *S. coralloides* in the aspect of its thallus, and in the character of its spermogones, at least as to their external appearance and site. But in British specimens this is less evident; most British specimens of *S. compressum*, so-called, are, however, really referrible to *S. coralloides*. The spermatia of *S. compressum* are sub-oblong or rod-shaped, sometimes sub-ellipsoid, generally obtuse at the ends, about $\frac{1}{8000}$th to $\frac{1}{10,000}$th long. They are borne on the apices of extremely delicate, linear, simple sterigmata, ramose at the base, and resembling those of *Cladonia*. The spermogonal walls, internally, give rise, in addition, to a number of ramose, elongated, anastomosing filaments, like those of *Ramalina*.

Specimen 2.—Lord Auckland Islands, Antarctic Expedition, 1839–43, Dr Hooker; in fruit. The spermogones are the same as those which occur in Tasmanian specimens, and described in No. 1. They are chiefly scattered on ramules destitute of apothecia; but they also occur, to a minor extent, on the small ramules, which frequently come off below the apothecia. The envelope is of a bluish cellular tissue. The sterigmata are extremely delicate and indistinct, and branch only from the base. Ramose elongated filaments are very abundant, filling the cavity of the spermogone. The spores are those of *S. coralloides*.

Specimen 3.—New Zealand; Auckland Islands, Dr Hooker; Van Dieman's Land; Tasmania, Gunn; in Herb. Hooker. The spermogones are always scattered over the under pale or channeled surface, where there is a distinction between the two surfaces. There would seem to be a gradual transition between *S. coralloides* and *S. compressum*, in regard to the character of the ramules and spermogones.

Specimen 4.—Port Famine, in Herb. Royal Botanic Garden, Edinburgh, is beautifully studded over with very distinct spermogones.

Specimen 5.—Connemara, 1805, Dr Mackay; Miss Hutchins, 1810, probably also from Ireland; in Herb. Hooker, Kew. The thallus is pale and waxy, and the spermogones are undoubtedly those of *S. compressum*. As a general rule, they are more abundant in this species than in *S. coralloides*. Körber, indeed, seems to believe that they never occur in the latter; at least he remarks, "Spermogonien sind bis jetzt nur bei *S. compressum* aufgefunden worden."

Specimen 6.—North-west America. Spermogones scattered, few, isolated about the angles and end of the sterile ramules; Cotopaxi, Jameson; Jamaica, Purdie; New Granada, Purdie; Cape Horn, Dr Hooker, sterile specimens abundantly spermogoniferous; Falkland Islands, Dr HOOKER, thallus much deformed; Van Dieman's Land, FRASER; New Holland, FRASER; Tasmania, Asbestos Hills, GUNN; Van Dieman's Land, GUNN,—all these specimens are in the Hookerian Herbarium, Kew. However variable the thallus, the disposition of the spermogones is always the same. In Van Dieman's Land specimens, the apothecia are sometimes seated in the axils of divergent spermogoniferous ramules.

Specimen 7.—Var. *australe*, Laur.; New Holland, SIEBER; an authentic specimen of LAURER'S plant, from the Rev. CHURCHILL BABINGTON, in Herb. Hooker, Kew; also, New Zealand, COLENSO, in Herb. Hooker. This is a large handsome plant, but certainly only an exaggerated form of *S. compressum* The spermogones occupy the same position that they do in *S. compressum*, being scattered about the ends of the ramules, on the angles and prominences, which abound thereon. But the ends of these ramules vary considerably in character. Sometimes they are broad and fastigiate, at other times simple and narrow. In the latter case, the spermogones are generally terminal and isolated, as in *S. coralloides*. Whether isolated or grouped, they are largish, black, round, semi-immersed bodies, generally very distinct, especially if, as is frequently the case, the thallus is pale gray, or cream-coloured, and waxy. The spermatia are oblong or rod-shaped and straight, or they may be very slightly curved; their length averages $\frac{1}{8000}$th, and their breadth $\frac{1}{20,000}$th. The sterigmata are simple, linear, very delicate, ramose below, as in *Ramalina*; their length averages about $\frac{1}{1200}$th to $\frac{1}{1500}$th, and their breadth $\frac{1}{20,000}$th, or, in other words, they are of equal width with the spermatia.

GENUS II. ACROSCYPHUS, *Lév.*, *Tul.*,*

In external characters, the spermogones are closely allied to those of *Sphærophoron*, especially of *S. coralloides*, being seated on the tips of sterile ultimate ramuscles. Their character is sufficiently represented by that of the spermogones of the single species of the genus, *A. sphærophoroides*.

SPECIES 1. *A. sphærophoroides*, Lév.,

Which appears peculiar to the mountains of Mexico and India.

Specimen 1.—Wallanchoon, Sikkim, Himalayas; alpine region, at an elevation of 13,000 feet; Dr HOOKER, in Herb. Hooker, Kew; both apothecia and spermogones abundant. The spermogones occur at the ends of sterile ramuscles, which are frequently fastigiate, and very much warted; the irregular warts resembling those of some *Stereocaula*. The spermogones are punctiform, brown, most irregular in form and size; these are ostioles leading to immersed, compound spermogones. The spermatia are oblong or sub-ellipsoid, about $\frac{1}{7000}$th long, with a breadth of $\frac{1}{20,000}$th, and very abundant, on articulated sterigmata.

* Mém. Lich. t. 15, f. 10–12.

FAMILY VII. Stereocauleæ.

GENUS I. Stereocaulon, *Schreb.*

The spermogones are very irregular warts, which sometimes cover the sterile ramules about their ends; sometimes are seated immediately below the apothecia, to which, when aggregated circularly, they form a kind of collar. Soredic warts also occur abundantly on the different species of this genus; but the spermogonal ones are generally distinguishable, without having recourse to microscopic examination, by their black or brown ostioles, which are generally round, stellate, or triangular, according to their age. These ostioles lead into the body of the spermogone, which is wholly immersed in the warts in question. The internal tissue is sometimes blue, and this colour shines through the thin walls of the spermogone. Hence, the ostiole has occasionally the appearance of being seated in the centre of a bluish-black spot or areola, as in *S. argus.* The envelope or capsule is of a pale brown cellular tissue usually; the cavity simple or sinuous, frequently the latter. So abundant occasionally are spermogonal warts as to constitute what have been described by the older authors as distinct varieties, *e.g.*, var. *stigmatea* of *S. tomentosum* of Flotow. But, on the other hand, they are frequently recognisable with great difficulty, and are seldom to be met with. I have examined many hundred specimens of species of *Stereocaulon*, without having met with the spermogones more frequently than a few times. Sometimes the spermogones are terminal, and resemble nascent apothecia. The sterigmata are simple and short, frequently sub-spherical; the spermatia are either straight and rod-shaped or slightly curved. They vary in length from $\frac{1}{2000}$th to $\frac{1}{8000}$th, averaging about $\frac{1}{4000}$th to $\frac{1}{5000}$th, with a breadth of $\frac{1}{20,000}$th to $\frac{1}{25,000}$th.

Species 1. *S. paschale*, Fr.,

Which occurs in Europe, America, and Asia.

Specimen 1.—Hill heaths above Bonhard, Perth, July 1855, W. L. L. The spermogones occur on specimens bearing no apothecia, as small brown warts, scattered about the ends and along the sides of the ultimate ramules. They somewhat resemble small apothecia, are flattened, round, or irregular, with a round ostiole, generally of the same colour as the wart, and indistinct in its outline. The envelope is of a brown cellular tissue. The spermatia are rod-shaped or oblong, about $\frac{1}{8000}$th long. The sterigmata are short, simple, bulging; sometimes resembling a series of papillæform or nipple-shaped cells, at other times longer and subdigitate.

Species 2. *S. alpinum*, Laur.,

Which is found in Europe and Asia, but which I regard only as a variety of the preceding species.

Specimen 1.—Ben Nevis, August 1856, W. L. L. This is a tall slender form of the thallus, laxly ramose, and sparingly covered with granules. The spermogonal warts occur both on sterile ramules and on those bearing apothecia. The spermatia are about $\frac{1}{6500}$th, some of them being curved.

SPECIES 3. *S. denudatum*, Flk.,

Which grows in Europe, America, and Asia; but which, like *S. alpinum*, I consider a mere variety or state of *S. paschale*. The stem is very naked inferiorly, being destitute of the granules or scales which usually clothe it.

Specimen 1.—County Antrim; D. MOORE of Glasnevin, in Herb. ISAAC CAROLL of Cork. The spermogones are abundant on large warted sub-spherical or irregular dilatations of the ends of the ramules, none of which bear apothecia. These spermogonal warts occupy the site, and appear morphologically to take the place, of apothecia. The ostioles are brown, immersed, and punctiform. The spermatia are either straight and rod-shaped, or curved; many of them are the latter. Their length is about $\frac{1}{5000}$th, their breadth $\frac{1}{20,000}$th; their sterigmata short and simple, as in *S. paschale*.

SPECIES 4. *S. ramulosum*, Sw.,

Which grows in America, equatorial Africa, Polynesia, and Australia; a large and handsome species.

Specimen 1.—Tasmania, Antarctic Expedition, 1839–43, Dr HOOKER. Both apothecia and spermogones abound. The latter are large, round, flattened warts, scattered about the ends of the sterile ramuscles, or seated immediately below the apothecia, round which they form a sort of neck or collar, as in *S. argus*. They have a bluish-black colour on the surface, and are marked by stellate-fissured black ostioles. In this state they have greatly the appearance of the young apothecia of *Sphærophoron coralloides*, in process of fissuring of their capsule or exciple. Internally, the spermogones consist of a congeries of sinuous cavities. The spermatia are very delicate and curved, about $\frac{1}{2000}$th long, borne on the apices of simple vesicular sterigmata. The short lateral branches proceeding from the main stems frequently terminate in capitular or bullose dilatations; these are full of medullary tissue—white and lax—and they cannot therefore, on microscopic examination at least, be mistaken for, or confounded with, spermogonal warts.

SPECIES 5. *S. argus*, Taylor.

Specimen 1.—Campbell's Island, Antarctic Expedition, 1839–43, Dr HOOKER. The apices of the sterile ramules are irregularly tuberculated; this tuberculated dilatation consisting of a series of small flattened warts of the same colour as the thallus, each separate wart being pierced centrally by a black minute ostiole, which is round, triangular, or stellate. This ostiole is usually surrounded with a halo, which is bluish-black, from the colour of the internal tissue in old spermogones shining through that part of the envelope which is thinnest. These warts are also occasionally scattered in groups of two or three round the branches bearing the apothecia, and immediately below the latter, to which they then appear as collar-like appendages. The spermatia are abundant, thickish, curved, about $\frac{1}{4000}$th long, on simple vesicular sterigmata.

FAMILY VIII. CLADONIEÆ.

GENUS I. CLADONIA, *Hoffm.*

The spermogones of *Cladonia* are mostly barrel-shaped, long or short, narrow or bulging; generally of the same colour as the apothecia, and with a distinct large round ostiole. The barrels are largest and best marked when terminal, as in *C. furcata;* shortest and most tuberculiform when on the margin of scyphi, as in *C. pyxidata.* In the latter case, they are frequently flattened on the top, and irregular in form. They sometimes form a denticulate fringe of the margin of the scyphi, which may either be comparatively regular, or more or less irregular. In species with branching podetia, terminating in tapering points, the spermogones are generally seated on the ends of the ultimate ramuscles, of which they constitute the brown points, which are erect in *C. furcata;* nodding, or erect also, in *C. rangiferina.* In species with simple podetia, which terminate in scyphi, the spermogones are seated generally on the margins of these scyphi. In some species with a large horizontal and foliose thallus, and which seldom bear podetia, they are seated directly on the folioles of the thallus. But they also occur in species with scyphiferous podetia, seated directly on the squamules or folioles, with which these are frequently more or less plentifully covered; especially in deformed and sterile states, as in *C. bellidiflora.* Sometimes they are seated directly on the sides of the podetia themselves, as in the *cervicornis* variety of *C. gracilis*, and in *C. amaurocrœa.* Occasionally they occur on digitate prolongations of the margins of the scyphi, as in *C. bellidiflora* and *C. pyxidata;* and, lastly, they are sometimes, though rarely, studded over the apothecia themselves, as in one instance in *C. rangiferina.* In scyphiferous species, in which they are usually grouped on the margins of the scyphi, they may occur isolated and terminal on their *cornuta* form or variety—a sterile spermogoniferous one with long, simple, tapering podetia. When terminal, the spermogones are generally single or isolated; when occurring on the margins of scyphi, they are grouped in numbers of from two to five in *C. gracilis,*—five to twelve in *C. pyxidata.* The size of the spermogones varies greatly: in *C. rangiferina* they have a diameter of $\frac{1}{200}$th, with a length of $\frac{1}{150}$th; but in *C. furcata* they are generally much larger in all their dimensions. As a general rule, they are greatly smaller and more delicate in arctic and antarctic specimens, than in specimens of the same species from temperate countries. Their envelope is generally thin, and of a brown cellular tissue. The deep brown colour of the spermogones—or brownish-red in species with scarlet apothecia—contrasts well with the pale straw-yellow or gray of the thallus, and renders them particularly conspicuous in this genus. The line of junction between the spermogone and the thallus is readily seen, and the sudden bulging of the barrel-shaped organ adds to this effect. The cavity of the spermogones is generally simple; but I have seen it sometimes sub-compound or divided into several obscure compartments or sinuses, as in *C. macilenta*. This cavity contains abundance of mucilage, in which are imbedded the spermatia. In species with scarlet apothecia, and occasionally also in those with brown fruit, as sometimes in *C. pyxidata*, this mucilage has a rose tint. The emission of the spermatia can readily be studied, by placing the spermogoniferous tips of the ramuscles of *C. rangiferina* or *C. furcata* in a drop of water between glass slides, and subjecting them to moderate pressure under the microscope. The genus *Cladonia* is, therefore, a good one in which to examine the spermogones and their contents. There is a remarkable uniformity throughout the whole of the species of *Cladonia*, in regard to the form and size of the spermatia and sterigmata. The former are, in all cases, curved when free, though they sometimes appear straight, or nearly so, while yet attached. They are somewhat crescent-shaped, that is, they are pointed or acute at the ends, and thicker in the centre. Their length varies from $\frac{1}{3000}$th to $\frac{1}{5000}$th, their breadth from $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. They are sometimes so short as $\frac{1}{6000}$th to $\frac{1}{8000}$th. They must not be looked for in old spermogones, with large gaping ostioles, from which they have long since escaped. While attached to their sterigmata, they are sometimes double the size they are when free, a phenomenon that is of frequent occurrence in lichens. The sterigmata are, in all cases, very delicate, linear, simple cells, very ramose at the base, varying in length from $\frac{1}{1000}$th to $\frac{1}{3000}$th, with a breadth of $\frac{1}{20,000}$th. With age they become elongated and sterile, filling the whole cavity of the spermogone, while, at the same time, they frequently acquire a brown tint. Occasionally, though rarely, elongated, hypertrophied, sterile filaments project from among the ordinary spermatiferous ones, as in *C. rangiferina* in one or two instances. Spermogoniferous forms include many, at least, of the puzzling and anomalous varieties of species of *Cladonia* described by the older authors.

Species 1. *C. pyxidata*, Fr.,

A cosmopolite; occurring almost in every quarter of the globe hitherto explored.

Specimen 1.—Old wall, Caerlaverock Road, Dumfries, August 1856, W. L. L. A deformed and degenerate form, with very large podetia, and scyphi covered with furfuraceous scales. The spermogones are roundish, brown, distinct tubercles, borne on small digitate prolongations from the margins of the scyphi, and having a perceptible ostiole. The interior contains a very beautiful and abundant lake-coloured mucilage. The spermatia are chiefly straight.

Specimen 2.—Moors on hills east of Sligachan, Isle of Skye, August 1856, W. L. L. Spermogones are abundant on the margins of the scyphi, as largish, distinct, tub-shaped or globose warts, of a deep brown colour, with distinct ostioles, some of them very large and gaping, round, triangular, or stellate. The spermatia are all curved, apparently of equal thickness throughout, and about $\frac{1}{3000}$th long.

Specimen 3.—Kinnoull Hill, Perth, March 1856, W. L. L. The spermogones fringe plentifully the sterile scyphi as small, spherical, brown cones or warts.

Specimen 4.—Siberia, Soongarica; collected by KARELIN and KIRILOFF, 1840; in Herb. Hooker, Kew. No apothecia, but with spermogoniferous scyphi.

Specimen 5.—Road to Wellington Falls, Van Dieman's Land; MOSSMAN, 1850; in Herb. Royal Botanic Garden, Edinburgh. No apothecia, but with spermogoniferous scyphi.

Specimen 6.—SCHÆRER exs. 52 (sub *C. pyxidata*, *a. polyscypha*, *B. exigua*); on the trunks of trees; no apothecia. This is simply a spermogoniferous state. There are no spermogones on the short scyphiferous podetia; but barrel-shaped ones are seated on the tips of simple, cylindrical, elongated podetia, which resemble those of *gracilis* or *macilenta*.

Specimen 7.—SCHÆRER exs. 53 (sub *a. polyscypha*, *C. simplex*); on the ground and the trunks of trees; in abundant fructification. The spermogones are abundant on the margins of the scyphi, as small barrel-shaped or conoid bodies.

Specimen 8.—SCHÆRER exs. 58 (sub *γ. longipes*, *E. tubæformis*); on the ground in woods. This is simply a spermogoniferous state; it bears no apothecia. The spermogones are small pale brown cones or tubercles, sparingly fringing the very irregular denticulate scyphi.

Specimen 9.—SCHÆRER exs. 268 (sub *ξ. communis*); in damp and shady places. The spermogones are large barrels on the margins of broad scyphi.

SPECIES 2. *C. fimbriata*, Fr.,

Likewise a cosmopolite; it seems to me to be but a form of the preceding species, marked by toothed scyphi, the margins of which sometimes bear small secondary podetia.

Specimen 1.—Bogin, County Derry, D. MOORE, in Herb. Carroll; with deformed apothecia. This is merely a spermogoniferous form of *C. pyxidata*, in my opinion, though it is the form which NYLANDER refers to his *fimbriata*. The spermogones occur on the diaphragm, as well as the margins of the scyphi, as short, distinct, brown tubercles. The spermatia are all slightly curved, crescent-shaped, about $\frac{1}{4000}$th long, with a breadth of $\frac{1}{25,000}$th. The sterigmata are very ramose and delicate, about $\frac{1}{1500}$th long, with a breadth of $\frac{1}{20,000}$th.

Specimen 2.—Craigie Hill, Perth, April 1856, W. L. L. The spermogones are seated on small prolongations from the margins of the scyphi.

Specimen 3.—Falkland Islands, Dr HOOKER, in Herb. Hooker, Kew. Besides marginal spermogones, apothecia are abundant, and are quite those of *C. pyxidata.*

Specimen 4.—Road to Wellington Falls, Van Dieman's Land, MOSSMAN, 1850; in Herb. Royal Botanic Garden, Edinburgh. No apothecia, but spermogoniferous scyphi.

Specimen 5.—SCHÆRER exs. 589 (sub *β. longipes, η. denticulata*); in woods. The name *denticulata* would appear to have been given in allusion to, or in consequence of, the spermogoniferous fringe of the scyphi, which is precisely like that so common in *C. pyxidata.* The spermatia are $\frac{1}{4000}$th long.

Specimen 6.—SCHÆRER exs. 640 (sub *β. ochrochlora*); on the ground in the valley of the Mittenwald, Upper Bavaria. The spermogones are large barrels, which are seated in groups of two or three on the edge of the narrow scyphi which terminate the podetia. The sterigmata, with the spermatia attached, measure about $\frac{1}{1500}$th to $\frac{1}{2500}$th long; they become brown when old and sterile.

Specimen 7.—Long Island, United States, May 1856, Dr A. O. BRODIE. The spermogones are small irregular barrels or cones, fringing the scyphi, precisely as in *C. pyxidata.*

SPECIES 3. *C. cornuta*, Fr.,

Which is said to occur in Europe, Asia, and America; it appears to me to belong partly to *C. pyxidata*, and partly to *C. gracilis.*

Specimen 1.—Craig-y-Barns, Dunkeld, April 1856, W. L. L. This seems referrible to *C. pyxidata.* The spermogones are few, but large and distinct, brown barrels, occurring on the margins of the scyphi.

SPECIES 4. *C. degenerans*, Flk.,

Which occurs in Europe, Asia, and America; it does not appear to me to deserve to rank as a distinct species, but to belong to *C. pyxidata*, *C. gracilis*, and *C. squamosa*, if not to other species.

Specimen 1.—SCHÆRER exs. 275 (sub *E. euphorea*, Flk.); on stones, Gastern. This is referrible to *C. gracilis.* The spermogones are large barrels, three or four of which are seated on the margins of each of the small narrow scyphi, which terminate the short slender podetia. No. 274 (sub *E. aplotea*, Flk.), from the same locality in my copy, is not distinguishable from No. 275, either as to its thallus or spermogones.

Specimen 2.—Kollong, Khasia, Himalayas; temperate region, at an elevation of 5000 feet; collected by Dr HOOKER and Dr THOMAS THOMSON. The spermogones are abundant and large. Another specimen, also in the Hookerian Herbarium, NYLANDER seems to refer to *squamosa*, but it is really intermediate between *squamosa* and *furcata.* It has abundance of large spermogones, on dark-brown dingy degenerate podetia.

Species 5. *C. cenotea*, Schær.,

Which grows in Europe and North America; it seems to me to belong to *C. pyxidata.*

Specimen 1.—Schærer exs. 71; on the ground and the putrid trunks of trees, in hilly and alpine regions, Switzerland. There are no apothecia; the scyphi are not much dilated, and the spermogones are marginal, and precisely of the characters of those of *C. pyxidata.*

Specimen 2.—(sub *C. trachiata*, Fr.) Mahourat; Spruce's "Lich. Pyrenæi;" in Herb. Hooker, Kew. The podetia are sub-digitately divided above, and are covered throughout with an abundant gray pruinosity. The spermogones here, too, are those of *C. pyxidata.*

Species 6. *C. gracilis*, Fr.,

Like *C. pyxidata* and *C. fimbriata*, a cosmopolite. It has two principal varieties, *verticillata*, Fr., which occurs in Europe, America, and Australia, and *cervicornis*, Ach., which is confined in its range to Europe.

Specimen 1.—Blaeberry Hill, Perth, April 1856, W. L. L. The spermogones occur on the margin of the small scyphi, which terminate the long slender podetia; they exactly resemble those of *C. pyxidata.*

Specimen 2.—Lion's Face, 1844, and Sidlaw Hills, 1846, Forfarshire; Gardiner of Dundee; in Herb. Hooker, Kew. Plant bears both apothecia and spermogones; the latter as in No. 1.

Specimen 3.—Tasmania, Antarctic Expedition, 1839–43, Dr Hooker (sub *Cenomyce ecmocyna*, Ach., var. *a.;* the var. *gracilis* of Nylander). This is a long, delicate, graceful form, the podetia being simple and cylindrical, and abundantly clothed with scales or folioles. The spermogones are few, terminal, isolated, short, deep-brown, barrel-shaped organs, closely resembling those of *C. furcata* or *C. rangiferina.* The ostiole is large and distinct.

Specimen 4.—Falkland Islands, Antarctic Expedition, 1839–43, Dr Hooker. The thallus is much broken up; the spermogones are few and old, scattered on the margins of the scyphi. There are no free spermatia. The sterigmata are elongated and hypertrophied, filling the cavity of the spermogone; they are very delicate, linear, and ramose at the base.

Specimen 5.—Var. *elongata*, Fr. and Nyl., Disco Island; Lyall, 1854. A very long and graceful form, with abundant spermogones.

Specimen 6.—Schærer exs. 67 (sub *β. hybrida*, *C. elongata*); on the ground in alpine districts. The spermogones occur on the ends of elongated, sterile podetia; they are largish and barrel-shaped, but are old. The sterigmata are elongated, hypertrophied, and very ramose, filling the cavity of the spermogone, as in No. 4; a phenomenon which is common in the old spermogones of all the *Cladonias.*

Specimen 7.—SCHÆRER exs. 641 (sub *β. turbinata squamulosa*); in woods in the valley of the Lauen. The spermogones are small pale-brown barrels or flattened cones, fringing the terminal scyphi like so many teeth. The ostioles are very distinct; the spermogones are old, and contain no free spermatia.

Specimen 8.—Var. *verticillata*, Fr., which occurs in Europe, America, and Australia; New Zealand, Antarctic Expedition, 1839–43, Dr HOOKER. Specimen associated with *C. aggregata*. The spermogones are small, barrel-shaped, brown tubercles, with distinct ostioles, occurring on the margins of the scyphi. The spermatia are curved and very delicate; about $\frac{1}{6000}$th to $\frac{1}{4000}$th long.

Specimen 9.—Var. *verticillata*, SCHÆRER exs. 62 (sub *C. verticillata*, *A. dilatata*); on ground in alpine districts, Switzerland. The spermogones are precisely as in No. 8.

Specimen 10.—Var. *cervicornis*, Ach. (*syn. Cladonia* or *Cenomyce cervicornis* of authors); Morven, Braemar, Professor DICKIE of Belfast; in Herb. meo. The spermogones fringe the small, cup-like, dilated ends of the short narrow podetia, which spring at right angles from the horizontal foliose thallus.

Specimen 11.—Var. *cervicornis;* top of Muckish Mountain, County Donegal, Ireland, Professor DICKIE; in Herb. meo. The podetia are very deformed, short, thick, and covered with warts or processes. The spermogones are dotted over the podetia themselves, as well as seated on the warts or processes just mentioned.

Specimen 12.—Var. *cervicornis;* Blaeberry Hill, Perth, April 1856, W. L. L.; very abundant; seldom bearing podetia or apothecia; in cæspitose thick tufts. On the margins of the scyphi, which terminate some of podetia, are a few broad, bulging, sub-spherical spermogones, with gaping ostioles.

Specimen 13.—Var. *cervicornis;* Ben Nevis, 1856, W. L. L. Large barrel-shaped spermogones occur, growing upright from the horizontal folioles, as well as fringing the scyphi on the longish delicate podetia. They are apt to be confounded with the numerous abortive apothecia; but their more regular form, and the presence of the ostiole, generally suffice to distinguish the spermogones.

Specimen 14.—Var. *cornuta;* Craig-y-Barns, Dunkeld, 1856, W. L. L. No apothecia; but largish, barrel-shaped, distinct spermogones fringe the scyphi.

Specimen 15.—SCHÆRER exs. 66 (sub *β. hybrida*, *B. simplex*); on the ground in alpine districts. Large, barrel-shaped spermogones fringe the scyphi, and are sometimes intermingled with apothecia on the same scyphus.

SPECIES 7. *C. squamosa*, Hoffm.,

Like *C. pyxidata*, *C. fimbriata*, and *C. gracilis*, a cosmopolite. Indeed the genus *Cladonia* contains at least as many cosmopolite species as any other lichen-genus. There is great variety in *C. squamosa* in the form of the thallus, and equal variety in the site of the spermogones. They may be isolated and terminal; seated on the ends of long graceful cylindrical podetia, as in KÖRBER's var. *β asperella;* or grouped on the margins of very irregular dilacerate scyphi, or seated on longish prolongations from the margins of the same scyphi. In all these cases, however, they are barrel-shaped, and as in the species already described.

Specimen 1.—Blaeberry Hill, Perth, April 1856, W. L. L. The spermogones are terminal, as in KÖRBER's var. *β. asperella.* Ben Nevis, August 1856, W. L. L. Here also they are terminal on podetia resembling those of *C. gracilis.*

Specimen 2.—Hills east of Glen Callater, Braemar, August 1856, W. L. L. Apothecia and spermogones occur on the same podetia, but on different branches thereof; the spermogones being placed on the higher ones. The ostioles are very large and patent; the envelope is of a dense brown cellular tissue. The spermatia are curved, about $\frac{1}{4000}$th long, nearly straight while attached to their sterigmata.

Specimen 3.—Australian Alps, MÜLLER, 1855; in Herb. Hooker, Kew. The plant seems rather referrible to *C. gracilis;* it is simple, and scarcely squamose. The spermogones are as above.

Specimen 4.—SCHÆRER exs. 74 (sub *C. ventricosa, a. microphylla, C. cymosa*); on the ground and on decayed tree-trunks, in woods, Switzerland. Small but very distinct barrel-shaped spermogones are studded over the ends of very irregular ramose ramules.

Specimen 5.—SCHÆRER exs. 73 (sub *C. ventricosa, a. microphylla, B. prolifera*); on the ground and decayed trunks of trees, in woods, Switzerland. The spermogones are terminal, as in *C. furcata.*

Specimen 6.—Var. *anomœa* (*syn. Scyphophorus anomœus*, Hook., E. B. 2d ed., p. 91, Tab. 2283; 1st ed. *Lichen anomœus*, T. 1867; Hook. Br. Flora, 238, vol. ii.); Kelly's Glen, D. MOORE; in Herb. Carroll. No apothecia. Spermogones terminal, young, contain no free spermatia.

Specimen 7.—Var. *cæspititia*, Ach.; occurs in Europe and America. SCHÆRER exs. 280 (sub *C. ventricosa, γ. fungiformis*); in woods, Switzerland. The spermogones are seated directly on the folioles or scales of the horizontal thallus; they are barrel-shaped; blackish or deep brown; large and distinct, and have certainly a fungoid aspect. The spermatia and sterigmata have the usual character; many of the latter in old spermogones are elongated and hypertrophied.

SPECIES 8. *C. alcicornis*, Flk.,

Which grows in Europe, Africa, and America. This species is of great interest, as being one of the lichens in which ITZIGSOHN first discovered the existence of spermatia.* He, however, described these corpuscles as *Spermatozoids*, endowed with animal motion. This motion is now proved beyond a doubt to be merely the Brownian movement of minute particles of matter, organic or inorganic alike, in a fluid. The barrel-shaped spermogones are here generally seated directly on the

* Botanische Zeitung, p. 913. 1850.

folioles of the horizontal thallus. The diameter of the spermogone is about $\frac{1}{78}$th. The spermatia are generally curved when free, but frequently straight while attached. I can draw no good distinction between *C. endiviæfolia*, the *cervicornis* variety of *C. gracilis*, and this species. They appear to me to differ essentially only as to the size of the folioles of the horizontal thallus, while podetia are rare in all. Certainly the spermogones are the same in all three. I should feel inclined to bring them all under *C. pyxidata*. Podetia, bearing both apothecia and spermogones, in a specimen in LEIGHTON'S exs. 15, are quite those of *C. pyxidata*.

Specimen 1.—LEIGHTON exs. 15; Haughmond Hill, Shropshire; Engl. Bot. 1392. The spermogones are on the margins of the podetial scyphi; they are largish, deep brown, barrel-shaped, and quite those of *C. pyxidata*. On the lower or paler surface of the folioles of the horizontal thallus are scattered sparingly, in the right-hand specimen in my copy, distinct black cones or papillæ, semi-immersed. These are pycnides, but unassociated with either apothecia or spermogones of any kind. I have great hesitation in regarding them as belonging to this *Cladonia*, inasmuch as I have not elsewhere found them in this genus. I am therefore rather inclined to look upon them as accidental parasites. They contain stylospores, oval or oblong-oval, generally more or less curved, but very irregular in form.

Specimen 2.—(Sub nom. *C. damæcornis*, Ach.); Suffolk; in Herb. British Museum, London. It has abundance of large barrel-shaped spermogones, scattered on the folioles of the horizontal thallus.

Specimen 3.—In Herb. Menziesian, Royal Botanic Garden, Edinburgh; habitat not given. It possesses only spermogoniferous podetia; which is generally, if not always, the case in Scotch specimens also.

Specimen 4.—Aldborough, Sir T. GAGE; in Herb. British Museum. Spermogones as in No. 2.

Specimen 5.—SCHÆRER exs. 455 (sub *C. foliacea, a. alcicornis*); near Vire; PELVET. The spermogones here also are seated directly on the folioles. The spermatia are about $\frac{1}{4000}$th long, the sterigmata, with spermatia attached, $\frac{1}{1500}$th.

SPECIES 9. *C. endiviæfolia*, Fr.

Specimen 1.—LAVINGE, 1814; Observation Inlet, SCOULER; in Herb. Hooker, Kew. The spermogones are sometimes distributed on the surface, sometimes on the margins of the thalline folioles; occasionally on the edges of the cup-shaped terminations of very irregular and deformed podetia, which rise directly from the surface of the larger folioles. They are precisely those of the preceding species, from which the present appears to me to differ in no essential respect.

SPECIES 10. *C. Papillaria*, Hoffm.,

Which occurs in Europe and North America. This is altogether an anomalous and exceptional species, which is arranged in a sub-section by itself, *Pycnothelia*, Duf. Its spermogones, however, resemble those of *C. pyxidata*.

Specimen 1.— Appin and Ben Nevis; in Herb. Hooker, Kew. The podetia are largish and irregular, with abundant spermogones and apothecia.

Specimen 2.— Schærer exs. 511 (sub *A. clavata*); heaths or moors, Switzerland. The spermogones are mostly old; they are small, distinct, brown cones or papillæ, scattered in groups on the sides of the large irregular podetia. The spermatia are about $\frac{1}{3000}$th long, chiefly straight or very slightly curved; many of the sterigmata are hypertrophied and elongated.

Specimen 3.—Schærer exs. 512 (sub *B. molariformis*, Hoffm.). Here the spermogones are somewhat differently disposed. They are largish, brown, distinct, irregular, flattened tubercles, seated directly on the thallus, like the apothecia of a *Lecidea*. The spermatia and sterigmata are as in all *Cladonias*. The former are crescent-shaped, and about $\frac{1}{4000}$th long; the latter, with spermatia attached, measure about $\frac{1}{1500}$th.

Species 11. *C. bellidiflora*, Schær.,

Which inhabits cold, alpine, or sub-alpine regions in Europe and America. The spermogones of this and other species with red apothecia do not differ, except in colour, from those of species such as *C. pyxidata*, having brown fruit. Nor do the spores differ. Indeed, it admits of doubt whether the mere colour of the apothecia should be regarded as at all a good distinctive mark of sections or species of *Cladonia;* for the apothecia are occasionally indiscriminately red or brown in the same species. I am of those who would abolish the distinction, and would merge the phæocarpous and erythrocarpous sections of Nylander into one.

Specimen 1.—Ben Nevis, Aug. 1856, W. L. L.; form *polycephala* of Körb., p. 29. A few tub-shaped spermogones occur on the apices of narrow long cylindrical podetia,—the stronger podetia bearing on their summits apothecia. Spermogones also occur on the margins of indistinct scyphi. In some deformed sterile states they are abundantly scattered over the podetia towards their apices, as large, distinct, brown, broad-based cones, with a very patent ostiole. In other podetia, which are very foliose or squamulose, the large tub-shaped spermogones—among the largest indeed I have ever seen—are seated directly on these squamules or folioles, especially near the ends of the podetia. The cavity contains abundance of rose-coloured mucilage, in which are imbedded curved spermatia, about $\frac{1}{4000}$th long. The sterigmata are of the usual characters, as described in *C. pyxidata*. It is note-worthy that the colour of these spermogones externally is *brown*, and that their envelope consists of a *brownish* cellular tissue. Their cavity is simple.

Specimen 2.—Schærer exs. 39 (sub *C. bellidiflora*, *B. ampullifera*); on ground and stones in alpine districts, Switzerland. The scyphi bear no apothecia; but are spermogoniferous, their margins being fringed with dark brownish-red spermogones, like small barrels or cones flattened on the top, or somewhat irregular. Red mucilage abounds in their cavity.

Specimen 3.—Kelly's Green, Ireland, D. Moore; in Herb. Carroll, Aug. 1853. The folioles of the horizontal thallus are studded over with the apothecia and spermogones of *Lecidea cladoniaria*, Nyl., which occur also on the scales of the podetia from the base to their apex. The apothecia are black, discoid, semi-immersed, resembling those of *L. oxyspora*, as it occurs on *Parmelia saxatilis*, *P. conspersa*, and *Platysma glaucum*. The spermogones are minute, brown or black, punctiform, scattered among the apothecia. The spermatia are largish and ellipsoid, resembling those of *Lecidea abietina*, and are borne on very short, simple, linear sterigmata. I refer to *L. cladoniaria* here only with a view to show that there is no danger of confounding either its apothecia or spermogones with the spermogones of *Cladonia bellidiflora*.

Species 12. *C. cornucopioides*, Fr.,

A cosmopolite species. I must confess my inability to perceive any good distinctive marks between this and the preceding or following species. Indeed, I regard *C. bellidiflora* as a type or species, including *C. cornucopioides*, *C. macilenta*, *C. digitata*, and *C. deformis*, just as I hold *C. pyxidata* to embrace *C. fimbriata*, *C. degenerans*, *pro parte*, and *C. cornuta*. *C. cornucopioides* is the familiar *C. coccifera* of older authors.

Specimen 1.—Falkland Islands; Antarctic Expedition, 1839–43, Dr Hooker. Spermogones occur on the margins of the scyphi, as small, but distinct, round, flattened, brown tubercles, pierced with distinct ostioles. They are all old, and contain no free spermatia.

Specimen 2.—Var. *pleurota*, Flk. A cosmopolite variety; appears to me to be merely a spermogoniferous form, bearing the same relation to *C. cornucopioides* that *fimbriata* does to *C. pyxidata*. The spermogones are red; the apothecia few. Scotland; collected by Alexander Menzies himself; in Menziesian Herb., Royal Botanic Garden, Edinburgh.

Species 13. *C. macilenta*, Hoffm.,

Likewise a cosmopolite. This is the familiar *filiformis* of the older authors. Körber's var. *clavata*, p. 31, is probably a spermogoniferous state:—"thallo clavato-ventricoso subulato substerile."

Specimen 1.—Ben Nevis, Aug. 1856, W. L. L. From the ramules bearing apothecia there sometimes branch off, a little below the apothecia, spermogoniferous ramuscles, bearing at their ends, in groups of three or four, brown barrel-shaped spermogones.

Specimen 2.—Schærer exs. 33 (sub *C. filiformis*, *A. cornuta*); on peaty earth. The margins of the cup-like, dilated ends of the podetia are fringed with large barrel or cone-shaped, deep-brown spermogones, generally in groups of four or five. The cavity is apparently compound and sinuous—a phenomenon that is unusual in the *Cladonias*.

Specimen 3.—SCHÆRER exs. 36 (sub *C filiformis*, *D. ramulosa*). The spermogones are as in No. 2, but smaller.

Specimen 4.—Var. *polydactyla*, Flk., which occurs in Europe and America. SCHÆRER exs. 454 (sub *C. incana*, *γ. polydactyla*); near Vire, PELVET. The spermogones are brownish-red barrels, grouped in three or four, on the margins of the narrow closed cups in which the podetia terminate. The spermatia are about $\frac{1}{4000}$th long; and the sterigmata $\frac{1}{1500}$th.

SPECIES 14. *C. digitata*, Hoffm.,

Which occurs in Europe, Asia, and America, and which, I think, stands in the same relation to *C. bellidiflora* or *C. cornucopioides* that *C. fimbriata* does to *C. pyxidata*.

Specimen 1.—Ben Nevis, Aug. 1856, W. L. L. The plant is more or less deformed; it is scyphiferous, but the scyphi have seldom an equal or even edge. More generally they are ragged and lacerated; sometimes give off a series of irregular digitate prolongations from their margins. The spermogones are beautiful scarlet flattened cones, seated on the margins of the scyphi, or of the prolongations therefrom just described. Their envelope consists of a dense reddish cellular tissue. *C. digitata* graduates sometimes into the following species.

SPECIES 15. *C. deformis*, Hoffm.,

Almost a cosmopolite, occurring in Europe, Asia, America, and Australia. As a general rule, it is not found bearing apothecia, but occasionally spermogones are met with.

Specimen 1.—Howth, August 1853, MOORE; in Herb. Carroll; no apothecia. This seems to me merely the *cornuta* form of *C. bellidiflora*, such as occurs abundantly on Kinnoull Hill, Perth, and Craig Vinean, Dunkeld. The spermogones are small scarlet cones, fringing the occasional obscure terminal scyphi.

Specimen 2.—SCHÆRER exs. 49 (sub *a. vulgaris*, *c. gonecha*, Ach.); in alpine regions, Switzerland. The left-hand podetium in my copy (ed. alt. immut., 1842) is dotted over, especially inferiorly, with small, black, round cones, which are pycnides. The stylospores are largish, distinct, very numerous, and very variable as to form; the sterigmata are short and simple. Their position would lead me to look upon them as parasitic rather than as belonging to the plant on which they occur,—because, 1. I have found them only in another instance—*C. Papillaria*; 2. Their situation is not that of the spermogones of *C. deformis*; and 3. Their colour and general character differ *in toto* from those of the said spermogones.

SPECIES 16. *C. uncialis*, Hoffm.,

Which occurs in Europe, America, and Asia. This and the species to follow are characterized by the absence of scyphi; in them the spermogones are terminal and more prominent than in those which have preceded.

Specimen 1.—Moors about the Stro Rock, Isle of Skye, Aug. 1856, W. L. L. The spermogones are generally in groups of two or three, constituting or crowning the terminal horns of the podetia: their brown colour, in contrast with the straw-yellow of the podetia, renders them very distinct. They vary in length, being elongated and subfusiform or subspherical. The ostioles are large and patent in the older ones. The spermatia are chiefly straight—all the attached ones are; some are slightly curved; their length is about $\frac{1}{6500}$th.

Specimen 2.—Hills east of Glen Callater, Braemar, Aug. 1856, W. L. L. The spermogones are distinctly-bulging barrel-shaped organs, with a perceptible ostiole. Their spermatia, as in No. 1, are straight or curved—the former while attached; their length is about $\frac{1}{6000}$th.

Specimen 3.—Ben Lawers, Aug. 1855, Dr GILCHRIST of Dumfries. The barrel-shaped spermogones bulge most superiorly; their base or pedicel is narrow. But there is always a distinct line of separation between the spermogone and podetium, both in respect to colour and thickness.

Specimen 4.—Rorrie Moor, near Forfar, A. CROALL of Montrose; in Herb. Hooker, Kew. Has the same spermogones as in No. 3.

Specimen 5.—SCHÆRER exs. 82 (sub *C. stellata a. uncialis*); on ground in the Alps and valleys of the Jura. Exs. 513 (sub *C. stellata β. ceranoides*); on the ground on moors; has its spermogones on the horns or tips of large handsome podetia. Lake-coloured mucilage abounds in their interior, and this is noteworthy, seeing that the spermogones themselves are *brown*. The spermatia are crescent-shaped, and about $\frac{1}{4000}$th long; the length of the sterigmata is about $\frac{1}{2000}$th. Exs. 514 (*b. adusta*) has the spermogones just described.

SPECIES 17. *C. turgida*, Hoffm.,

A native, according to NYLANDER, of Europe, Asia, and America. I look upon it simply as a form, and a very ill-marked form frequently, of the preceding species, the podetia being usually shorter, thicker, darker, and considerably deformed. NYLANDER places *C. turgida*, in his classification,* between *furcata* and *rangiferina*.

Specimen 1.—Summit of the Bassies, Clova, 1843, GARDINER; in Herb. Hooker, Kew (sub nom. *C. uncialis β. turgida*). Possesses spermogones only, which are precisely those of *C. uncialis*.

* Enumération générale des Lichens, p. 95. Cherbourg, 1858.

Specimen 2.—SCHÆRER exs. 83 (sub *C. stellata* γ. *obtusata*), and 84 (δ. *turgida*), both on the ground in alpine regions, Switzerland. Have old spermogones, containing no free spermatia, which are also quite those of *C. uncialis*.

Specimen 3.—Kamkola, Sikkim, Himalaya, alpine region, about 15,000 feet high, Dr HOOKER; in Herb. Hooker, Kew. Appears also simply a turgid form of *C. uncialis*. It possesses spermogones, but no apothecia.

SPECIES 18. *C. amaurocrœa*, Flk.,

Which occurs in Europe, Asia, America, and Australia; it is closely allied also to *C. uncialis*, from which it differs chiefly in its more compound or ramose thallus.

Specimen 1.—Var. *capitellata*, Bab. in "Flora of New Zealand," (HOOKER fils.), (syn. *C. capitellata*, Bab.); New Zealand, COLENSO; in Herb. Hooker, Kew. The apothecia and spermogones are quite those of *uncialis*. The latter are generally terminal and erect, but they also occur occasionally scattered on the sides of the ultimate ramuscles of the thallus, from which they project peg-like at right angles. The spermatia are always curved when free; their length is about $\frac{1}{4000}$th, with a breadth of $\frac{1}{20.000}$th. When attached, however, they are frequently straight and very long—at least double the length of the free spermatia, a circumstance I have already more than once pointed out as occurring in lichens. The sterigmata are long and filiform—ramose below; their length is about $\frac{1}{1000}$th to $\frac{1}{1500}$th.

SPECIES 19. *C. furcata*, Schær.,

A cosmopolite species, having two main varieties—*racemosa*, Schær., and *pungens*, Ach., both of which occur alike in Europe, Asia, and America. The spermogones of this species are generally among the largest and most distinct of those of *Cladonia*. The ostiole also is usually large and easily perceptible. The spermatia are generally curved, and about $\frac{1}{4000}$th, sometimes only $\frac{1}{6000}$th, long.

Specimen 1.—Craigie Hill, Perth, April 1856, W. L. L.; with apothecia. The thallus is of a dark-brown, and the brown terminal spermogones are not, therefore, so easily recognised as in species with a straw-coloured thallus. They are here short, broad, and bulging.

Specimen 2.—Suffolk, Ben Cruachan, 1810, BORRER; in Herb. Hooker, Kew; are spermogoniferous only, as is the case in a specimen from Wales in Herb. British Museum, London.

Specimen 3.—Ingleby Park, Cleveland, Yorkshire, 1856; coll. W. MUDD. The podetia are slender, ramose, and closely aggregated; the spermogones small, and sometimes on apices, slightly nodding, as in *C. rangiferina*.

Specimen 4.—(Sub *Cenomyce bacillaris*, Ach.) Falkland Islands, Antarctic Expedition, 1839–43, Dr HOOKER; in Herb. meo. The spermogones are abundant as the short, bulging, barrel-shaped apices of the bifurcate extremities of the ultimate ramuscles. Specimens (sub nom. *C. gracilis*) from the Falkland Islands and Cape Horn, coll. by Dr HOOKER, and in Herb. Hooker, Kew, seem to be the same plant, which is here spermogoniferous only. The ramules are frequently black, straggling, and very delicate.

Specimen 5.—Pic d'Orizaba, Cordillera (Vera Cruz), Mexico, at an elevation of 11,000 to 12,000 feet; coll. by H. GALEOTTI, 1840, No. 6906; also from the same locality, 1838, coll. by J. LINDEN, No. 102; both in Herb. Hooker, Kew; spermogoniferous.

Specimen 6.—SCHÆRER exs. 22, Switzerland; associated with *Cetraria islandica*. The spermogones are large distinct barrels.

Specimen 7.—Var. *racemosa*, Sch.; on old walls, Caerlaverock Road, Dumfries, August 1856, W. L. L. The podetia are dark-coloured, and are covered with furfuraceous granules, scales, or folioles, from base to apex. The spermogones are short, and sometimes so broad and subspherical as to resemble young apothecia. They crown the delicate ultimate ramuscles, which are lax and patent. The spermatia are chiefly straight, and about $\frac{1}{6500}$th long. Some of the sterigmata are subarticulate, consisting of a few linear cells, placed in superposition, or branching off laterally in groups, in which case the sterigmata are very ramose, and somewhat longer than usual.

Specimen 8.—Var. *racemosa;* LEIGHTON exs. 16, Haughmond Hill, Shropshire; a few apothecia. The spermogones are chiefly old, containing no free spermatia. The sterigmata are very irregular in form, and thickened.

Specimen 9.—Var. *racemosa;* Sandhills, Newcastle, County Down, Ireland; Professor DICKIE. The plant is dwarf, deformed, and bears no apothecia. The spermogones are few, young, and contain no mature or free spermatia.

Specimen 10.—Var. *racemosa;* rocks, Mount Wellington, Van Dieman's Land, MOSSMAN, 1850; in Herb. Royal Botanic Garden, Edinburgh. Plant spermogoniferous only.

Specimen 11.—Var. *racemosa;* SCHÆRER exs. 80 (sub *C. fruticosa α. racemosa*); on the ground in woods, Switzerland; also exs. 81 (*δ. furcata*). In both, the spermogones have the usual characters.

Specimen 12.—Schooley's Mountains, North America, July 1856, Dr A. O. BRODIE. Spermogones have the characters of those of British plants or specimens.

Specimen 13.—Singalelah, Sikkim, Himalaya, alpine region, at an elevation of 11,000 feet; Chongtan, Sikkim, temperate region, at 8000 feet; Lachoong, Sikkim, temperate region, at 9000 feet—all collected by Dr HOOKER. Churra and Khasia, subtropical region, at 4000 feet; Kollong, Khasia, temperate region, at 5000 feet; coll. by Drs HOOKER and THOS. THOMSON; all spermogoniferous, but bearing no apothecia. New Zealand, Dr JOLLIFFE; thallus very white and delicate, and minutely scaly. St Domingo, SCHOMBURGK; very pale, thin, delicate podetia. Jamaica; 4–6 inches tall. Ohio, Lea; Cedar Swamp, near Urbana; spermogones abundant and distinct. Boston. Switzerland, near Chateaû d'Oex. FRANKLIN'S first journey;

British North America (sub nom. *C. furcata*, var. *subcrispata*, Nyl., and *C. crispata*, Ach., Nyl., both of which seem referrible to *racemosa*); apothecia and spermogones both well formed. All the specimens comprised in No. 13 are in the Herb. Hooker, Kew.

Specimen 14.—Var. *pungens*, Ach. (syn. *C. pungens*, Delise, Hook. British Flora, 235; Körb., 35; *C. furcata* ε. *rangiformis*, Sch. Enum. 202; *C. furcata* γ. *fruticosa*, Sch. exs. 459). This variety graduates into *racemosa*, and both into *C. rangiferina*. They are chiefly distinguished usually by their squamulose surface, gray colour, and ramose character. Blaeberry Hill, Perth, April 1856, W. L. L. The podetia vary much; some are turgid, thick, short, and covered profusely with scales or folioles; others are long, lax, and have more of the usual character of *furcata*. The turgid pale form closely resembles *C. rangiferina*, from which it is sometimes scarcely distinguishable. In all forms the spermogones are brown barrels, seated on erect apices of the ramuscles; they differ much in size, being short and broad, or elongated and narrow.

Specimen 15.—Var. *pungens*; old road to Caerlaverock, Dumfries, on a wall, April 1856, W. L. L. The podetia are of a light gray colour, and covered inferiorly with squamules, superiorly with granules. The spermatia are straight, and of unusual length; the sterigmata are also longer than usual—some of them being articulated, as in No. 7, which is nearly identical with this variety also as to the thallus.

Specimen 16.—Var. *pungens* (sub *Bæomyces pungens*), Thetford; also Esher Common, Surrey; in Herb. Hooker, Kew. Spermogones abundant.

Species 20. *C. rangiferina*, Hoffm.,

A cosmopolite species, and one of the most familiar of the *Cladonias*. Its chief varieties, according to Nylander, are *sylvatica* L. and *alpestris*, L.; like their type, both are cosmopolites. The spermogones are quite the same in the varieties as in the type. These varieties have not, I think, any good distinctive characters, unless in regard to the height, strength, and ramoseness of the thallus; in *alpestris*, the thallus is very ramose, and the ramuscles densely aggregated and thyrsiform. In general terms, the spermogones of this species are those of *C. furcata*, both in regard to site, appearance, and structure; they are uniformly, however, smaller in all their dimensions. The apices of the ramuscles on which they are seated, or which they constitute, are frequently nodding, but frequently also erect, as in *furcata*. In arctic and antarctic specimens especially, the ramuscles of the thallus are extremely attenuated, and the spermogones are correspondingly so; in this case the latter are linear or ellipsoid bodies, giving a nigro-corniculate character to the tips of the ramuscles. The spermogones are generally grouped two or three together, in consequence of the bifurcation or further division of the ends of the ramuscles. Their cavity is simple. Their diameter is about $\frac{1}{200}$th; their length $\frac{1}{150}$th or $\frac{1}{160}$th.

The spermatia are about $\frac{1}{3000}$th to $\frac{1}{4000}$th long; their breadth about $\frac{1}{30,000}$th. The spermatiferous, or ordinary sterigmata, are sometimes associated with sterile, hypertrophied, ramose filaments, as in *Ramalina;* but the latter are seldom or never so long or so ramose as in that genus.

Specimen 1.—Blaeberry Hill, Perth, April 1856, W. L. L. Abounding in apothecia, as well as spermogones. The ramuscles, or their divisions, which bear the spermogones, are as erect as those which bear apothecia. The nodding apices bear only sterile or abortive spermogones; the latter are of the same thickness as their pedicels, whereas the fertile spermogones always bulge out distinctly, and generally show a perceptible terminal ostiole. The ramuscles bearing spermogones and those bearing apothecia are intermixed; when the former ramuscles are longer than the latter, the spermogones are frequently found drooping over the apothecia.

Specimen 2.—Hills east of Glen Callater, Braemar, August 1856, W. L. L. Both apothecia and spermogones occur. The plant is large and coarse; the podetia vary in tint from straw-yellow to leaden-gray; they are also very granular and rough; sometimes covered with mealy warts. The spermogoniferous ramuscles are erect. The spermatia are either straight or curved, about $\frac{1}{4000}$th to $\frac{1}{5000}$th long; the sterigmata are sometimes sub-articulate and very ramose; long, linear, extremely delicate cells being given off in place of branches.

Specimen 3.—Ben Lawers, August 1855, Dr GILCHRIST. No apothecia. Here the nodding apices are all spermogoniferous; the spermogones being linear and elongated rather than barrel-shaped. The thallus is dark-gray.

Specimen 4.—Long Island, North America, May 1856, Dr A. O. BRODIE. The spermogones are abundant, short, and inconspicuous. The spermatia are very small but curved, about $\frac{1}{8000}$th long; the sterigmata are also very short, about $\frac{1}{3000}$th long, becoming, with age, sterile and brown. The podetia are sometimes covered from base to apex with irregular bullose warts; the latter are perforated here and there as if with ostioles, and they then closely resemble the spermogones of some crustaceous lichens; but their internal structure is only that of the thallus. The apothecia on the same deformed podetia are frequently single, and are sometimes studded over with spermogones, which project at right angles like pegs, or radii from the spoke of a wheel.

Specimen 5.—Tasmania, Antarctic Expedition, 1839–43, Dr HOOKER. Both apothecia and spermogones occur, the latter only sparingly, however. The spermogoniferous ramuscles are stellate-patent or erect; they are sometimes short, thick and rigid, and fastigiately ramose, and then the spermogones constitute little horns or teeth, crowning their apices. This form of thallus agrees with the vars. ϵ. *alpestris* and β. *incrassata* of SCHÆRER, Enum. p. 203. In the more common form of the plant, the ultimate ramuscles and spermogones are much more narrow and delicate than those in British specimens. The spermatia are generally straight, about $\frac{1}{6000}$th to $\frac{1}{8000}$th long; some of them are slightly curved, thickish, and short. The sterigmata are frequently of the same thickness as the spermatia, which, indeed, appear given off as ultimate joints or articulations, as in *Ramalina;* they are frequently of a brown colour in old age. Elongated, sub-simple, or sub-ramose filaments also frequently, especially in the older spermogones, project from among the ordinary spermatiferous ones into the cavity of the spermogone, which they fill, as in *Ramalina.*

Specimen 6.—Falkland Islands, Antarctic Expedition, 1839–43, Dr Hooker. The plant more resembles our British plant than Dr Hooker's Tasmanian specimens; the thallus is of a pale straw-yellow colour, granular or mealy on the surface, resembling herein Swiss or Norwegian specimens of var. *alpestris.* Many of the sterile ramuscles are not at all coloured at the apex; in others the spermogonesare short and degenerate, or abortive. The spermogones are frequently black; their ostiole is generally patent and large; the ramuscles, on which they are seated, are always erect, never nodding. They are in some specimens associated with apothecia, which are quite those of our British plant.

Specimen 7.—Wallanchoon, Sikkim, Himalaya, alpine region, at an elevation of 13,000 feet; Jongri, Sikkim, alpine region, at 12,000 feet; Lachoong, Sikkim, temperate region, at 4000 to 7000 feet, with apothecia; Lachen, Sikkim, alpine region, at 14,000 feet; Kambachen, Sikkim; Yongma Valley, East Nepal; all collected by Dr Hooker, and all in Herb. Hooker, Kew. All the specimens are spermogoniferous.

Specimen 8.—Var. *portentosa,* Duf., Nyl.; summit of Lion's Face, 1844, Gardiner; Pentland Hills, 1828, sender's name not given; also a specimen from Gardiner, habitat not given; all in Herb. Hooker, Kew. This variety appears merely a form with a coarse thick thallus, the spermogoniferous ramuscles being short and closely aggregated.

Species 21. *C. retipora,* Flk.

This is one of the most beautiful of Australian and Tasmanian lichens, in consequence of the reticulated or fenestrated character of the thallus.

Specimen 1. — Tasmania, Antarctic Expedition, 1839–43, Dr Hooker. Its spermogones are precisely similar, in site and structure, to those of the preceding species, but they are smaller, and always erect. They are frequently so minute, as to be with difficulty recognised even under the lens; and are sometimes so rare, that a great many specimens may be examined without finding them. They are grouped as little, dark-brown horns, on the apices of the broad cancellated podetia.

Species 22. *C. aggregata,* Sw., Eschw.

(*Syn. Dufourea ocllodes,* Taylor); occurs in equatorial Africa, America, Asia, and Australia.

In the character of its thallus, it closely resembles the preceding species. TAYLOR has associated this species with *Dufourea*, but very erroneously, I think; for the spermogones and spermatia, as well as the apothecia and spores, are those of *Cladonia*. Its spermogones and their contents are as described under *C. rangiferina* and *C. retipora*.

Specimen 1.—Falkland Islands, Antarctic Expedition, 1839–43, Dr HOOKER. Both apothecia and spermogones are abundant. The podetia or divisions of the thallus bearing these different forms of reproductive organs differ remarkably in size and form. Those bearing apothecia are broad, short, thick, fastigiate superiorly; the apothecia are much more crowded than in *C. rangiferina*, whose apothecia they otherwise resemble. The podetia or ramules bearing spermogones, on the other hand, are narrow and delicate, ramose, much attenuated and elongated towards the apices, which generally bifurcate or divide into two or three patent erect ramuscles or horns, each of which bears a single oblong or barrel-shaped spermogone, generally longer than, but otherwise resembling, the same organ in *C. rangiferina*. It is the podetia bearing apothecia chiefly that are retiporous and spongiform, as in *C. retipora*.

Specimen 2.—Tasmania, Antarctic Expedition, 1839–43, Dr HOOKER. In some specimens, I have seen delicate narrow podetia dividing at the apex into two terminal ramules, one thick and bearing apothecia, the other attenuated and bearing only spermogones. Other specimens were spermogoniferous only; the podetia were as strong, dark-coloured, and thick, as those usually bearing apothecia, sometimes even fastigiate superiorly. The spermogones are shorter than in Falkland Island specimens, and grouped in tufts.

Specimen 3.—New Zealand, Antarctic Expedition, 1839–43, Dr HOOKER. Both apothecia and spermogones are abundant; sometimes they occur on different divisions of the same ramules, sometimes on different ramules. The ostioles of the spermogones are generally visible. The podetia are usually smooth, seldom retiporous. The spermatia are curved and very delicate, of the same size and form as in *C. rangiferina*. The sterigmata are also those of the species just named; and besides the ordinary spermatiferous ones, sterile ramose filaments also occur, which, however, are seldom much longer than the fertile sterigmata. The chestnut or brown colour of the thallus at once distinguishes *C. aggregata* from *C. retipora* or *C. rangiferina;* but it may sometimes be confounded with states of *C. furcata*.

FAMILY IX. PELTIGEREÆ.

GENUS I. NEPHROMIUM, *Nyl.*

The spermogones of this genus resemble the *Pycnides* of *Peltigera*, in their site and external characters. They are marginal, brown, obtuse tubercles or cones; sometimes seated directly, like so many teeth, on the margin of the lobes of the thallus; sometimes seated at the ends of tooth or fringe-like prolongations from the margin of the thallus. In the latter case, they are generally more barrel-shaped than cone-like, and they resemble, though they greatly exceed in size, the spermogones of *Cetraria islandica.* The ostiole is frequently very distinct, especially if the spermogone is moistened; the cavity is simple. There is this difference, however, between the *spermogones* of *Nephromium* and the *Pycnides* of *Peltigera*, that the former have true spermatia and arthrosterigmata, while the latter have stylospores on simple sterigmata. The spermatia are straight and rod-shaped, about $\frac{1}{8000}$th long, with a breadth of $\frac{1}{20,000}$th to $\frac{1}{25,000}$th. They are sometimes also slightly curved, in which case they resemble those of *Cladonia.*

SPECIES 1. *N. tomentosum*, Hoffm.,

Which occurs in Europe and Northern America. I have not been successful in finding spermogones in British or European specimens; and in foreign specimens I have found them in very few instances. They are comparatively rare. They are generally small brown knobs, cones, or tubercles, smooth on the surface, rounded and obtuse, pierced by a central pore.

Specimen 1.—SCHÆRER exs. 259 (sub *Peltigera resupinata, a. tomentosa*); in alpine woods, on trees and stones. The spermogones are distinct nodules or tubercles, seated either directly on the margins of the thallus, or on irregular and lacerate-edged prolongations from the margins of the lobes. They are of a paler reddish-brown than the rest of the thallus. The spermatia are rod-shaped or sub-ellipsoid, $\frac{1}{5000}$th long and $\frac{1}{20,000}$th broad, seated on arthrosterigmata, which are among the thickest I have seen, consisting of short, broad, thick-walled cells or articulations.

Specimen 2.—Lachen, Sikkim, Himalaya, temperate region at an elevation of 10,000 feet, Dr HOOKER; with apothecia. The thallus, at its edges, is divided into, or marked by, a number of long tooth-like segments or prolongations, each of which bears at its extremity a large, barrel-shaped, very distinct or prominent spermogone. The latter organs resemble those of *Cetraria islandica*, or the *Cladonias*, but are greatly larger. They are deep-brown externally, the ostiole very distinct, or becoming so under moisture. The cavity is simple; the spermatia are abundant, straight, and rod-shaped, about $\frac{1}{8000}$th long and $\frac{1}{25,000}$th broad, seated on the apices and sides of longish articulated sterigmata, which resemble those of *Sticta* and *Collema.* This specimen is sub nom. *Nephroma resupinatum*, in Herb. Hooker, Kew, and appears to be var. *helveticum*, Ach., which occurs in Europe, America, Asia, Mexico, and the Isle of Bourbon.

GENUS II. NEPHROMA, *Ach.*, pro parte, *Nyl.*

It resembles, in the character of its spermogones, the foregoing genus, from which NYLANDER separates it, apparently in consequence solely of the different character of their gonidia. In *Nephromium*, according to NYLANDER, the gonidia, or rather bodies representing gonidia, upon which he bestows the name *gonima*, consist of granules without a cell-wall, and which are chiefly bluish; in *Nephroma*, on the other hand, true gonidia occur, which have a distinct cell-wall and contents. In a word, the one genus differs anatomically from the other, as *Pannaria* does from *Psoroma*. The separation seems to me a most unnatural and unnecessary one.

SPECIES 1. *N. arcticum*, Fr.,

A large handsome species, which inhabits the arctic and antarctic regions. NYLANDER describes it as possessing small rod-shaped spermatia, seated on arthrosterigmata, as in *Nephromium tomentosum*.

GENUS III. PELTIGERA, *Hoffm.*

Spermogones containing true spermatia,—that is, spermatia having the usual characters,—do not occur in *Peltigera;* but there are sometimes found marginal tubercles, resembling the spermogones of *Nephromium*, containing sporoid corpuscles. The latter are regarded as spermatia by TULASNE; and as stylospores by NYLANDER, with whom I concur. It appears to me very desirable to draw a distinction between spermogones and pycnides in regard to the character of their corpuscles, and to call *spermatia* corpuscles of uniform size, and generally more or less linear form; and *stylospores* those which are variable in size, and generally more or less oval or pyriform. I have acted throughout the present monograph on this principle, in describing spermogones and pycnides respectively. This is a classification or nomenclature of convenience, and as yet provisional. It is quite unconnected with any view or theory as to the physiological functions of these corpuscles, and the organs which contain them. Viewing them by this light, then, the marginal tubercles of *Saltigera* are, in my opinion, *Pycnides*. There are not wanting, however, circumstances or analogies favourable to TULASNE's idea. He draws attention to the fact, that in *Nephromium*, bodies having the same site and same external aspect contain true spermatia seated on arthrosterigmata; he argues that the contained corpuscles in *Peltigera* merely differ in form; and he infers that in this genus, therefore, we must regard the conceptacles which contain these bodies as spermogones. The pycnides, then, of *Peltigera* are largish brown marginal tubercles, closely resembling the young apothecia, which are likewise marginal. They are so rare, however, that I have not once been fortunate enough to meet with them, and I therefore owe my descriptions to TULASNE.* The diameter of the organ in *P. polydactyla* is from $\frac{1}{170}$th to $\frac{1}{140}$th. The stylospores are generally oval or pyriform, varying in length from $\frac{1}{1000}$th to $\frac{1}{4000}$th, with a breadth usually of $\frac{1}{5000}$th to $\frac{1}{6000}$th; they frequently contain distinct oil globules in their in-

* Mém. Lich., p. 200, Plate IX.

terior,—a phenomena unknown in ordinary or true spermatia. The sterigmata, each of which bears at its apex a stylospore, are simple, linear, ramose at the base, resembling those of *Lichina;* their length being sometimes so great as $\frac{1}{300}$th to $\frac{1}{500}$th, their breadth $\frac{1}{2500}$th.

Species 1. *P. canina*, Hoffm.

The tubercles which constitute the pycnides are generally very obtuse, and so closely resemble young apothecia as to be readily mistaken therefor. They are usually, however, of a deeper brown colour. The cavity is simple and very narrow. The sterigmata are somewhat irregular in outline, and ramose at the base; they are almost solid, from thickening deposit in the interior of the cells which constitute them. Each sterigma gives off in succession a series of stylospores. The contents of these stylospores are semifluid, and almost homogeneous; they become dark brown in iodine water, while the cell-wall, which appears thick, is only coloured yellow. The greatest dimension of the stylospores is from $\frac{1}{2000}$th to $\frac{1}{1000}$th; the least from $\frac{1}{2500}$th to $\frac{1}{4000}$th. The length of the sterigmata is about $\frac{1}{500}$th to $\frac{1}{300}$th, with a diameter of $\frac{1}{2500}$th. Berkeley takes the same view, apparently, as Nylander and myself in regard to the character of the corpuscles, which we all agree in calling *stylospores*,—at least equally with similar corpuscles which occur in *Lecidea Smithii* and other lichens.

Species 2. *P. polydactyla*, Hoffm.

The diameter of the pycnides is from $\frac{1}{170}$th to $\frac{1}{140}$th. The stylospores are smaller than those of the preceding species, but otherwise the same; their length is about $\frac{1}{4000}$th; their breadth about half as much; they are oval, slightly curved, with very obtuse ends. From the characters of the thallus, apothecia, and spores, I am led to refer this species to *canina*, and the character of the pycnides confirms me in this opinion.

Species 3. *P. rufescens*, Hoffm.

This and the two preceding species are all cosmopolites. The pycnides are as described in *P. canina* and *P. polydactyla.* The stylospores are oval, about $\frac{1}{3500}$th to $\frac{1}{2000}$th long, and $\frac{1}{6000}$th to $\frac{1}{5000}$th broad. This species I refer partly to *P. canina* and partly to *P. horizontalis*, unless we look upon all the British *Peltigeras* as mere varieties of one species, which I am greatly inclined to do. This genus wants simplification in regard to its species, which certainly pass into each other, and in this respect it is in the same category with *Umbilicaria* (*Gyrophora*), *Ramalina*, and *Usnea*.

GENUS IV. Solorina, *Ach.*

In this genus I have not yet succeeded in finding spermogones or pycnides belonging thereto, though I have occasionally met with sundry parasites closely resembling them, and for which they might be mistaken.

SPECIES 1. *S. saccata*, Ach.,

Which grows both in America and Europe. The sterile thallus is sometimes covered over with black cones or tubercles, partly immersed, and with a distinct ostiole. These may readily be mistaken for spermogones; but their contents at once reveal their true nature. They are found to be perithecia, containing brown 3-4-septate oblong-oval spores. This is the *Sphæria urceolata*, SCHÆRER (in HEPP. exs. 475, f. 2), on limestone rocks on the Pilatus, Switzerland; and *Endocarpon psoromoides*, HOOK. and LEIGHTON, at least *pro parte*. This parasite, again, is apt to be confounded with *Verrucaria psoromia*, NYL., which has simple, ellipsoid, colourless spores (*Phacopsis psoromoides*, HEPP. exs. 475, f. 1, *Verrucaria*, BORRER, E. B. 2612, f. 1.)

SPECIES 2. *S. crocea*, Ach.,

Which occurs in Europe, America, and frigid or northern Asia.

Specimen 1.—Brandon Mountain, Kerry, Ireland, CARROLL; Wicklow, D. MOORE, in Herb. Carroll. On one specimen there is a number of large black cones, resembling the pycnides of *Dichæna rugosa*, evidently parasitic, and having no relation to the *Solorina*, further than that they grow on it. They are closely aggregated or grouped on the surface of the thallus, to which they give a very irregular warted character. The stylospores are very large—about $\frac{1}{750}$th to $\frac{1}{600}$th long and $\frac{1}{3000}$th broad—apparently normally 1-septate, colourless, full of granular or grumous matter.

FAMILY X. CETRARIÆ.

GENUS I. CETRARIA, *Ach., Nyl.*

NYLANDER has retained three species in the old genus *Cetraria*, viz., the fruticulose species,—placing those having a flat, broad, Parmelioid thallus in a separate genus,—*Platysma*. Undoubtedly, both groups are comparatively natural; still it admits of doubt how far it is advisable to constitute two genera, rather than merely two sections of a single genus. The spermogones differ somewhat in the two groups or genera. In *Cetraria* they are more of the character of those of *Cladonia* than in *Platysma*. They are barrel-shaped organs, seated on the apices of the ultimate ramuscles of the thallus, as in *aculeata*, or on cilia, fringing the margins of the laciniæ, as in *Islandica*. In neither case are they very conspicuous, unless on careful examination. They are of the same colour as the thallus; hence the line of separation or junction of the thallus and spermogone is not so distinct as in *Cladonia*. Neither are they so large nor so distinctly barrel-shaped as in that genus. They vary greatly in length, being sometimes short and broad, at other times long and narrow. Where the marginal cilia are very short or wanting—in *C. Islandica*—the spermogones appear seated directly on the margins of the laciniæ, like so many teeth, resembling the spermogones of the *Platysma* group. The thallus of *C. aculeata* terminates in delicate ramuscles or spinules, the tips or horns of which are formed by its spermogones. These organs are generally very delicate and minute, with difficulty recognised even under the lens, or until subjected to pressure in water between glass slides under the microscope, when the emission of myriads of spermatia betrays their true character. The length of the spermogone in *C. aculeata* scarcely exceeds $\frac{1}{400}$th to $\frac{1}{500}$th. The cavity is usually simple. The spermatia are straight and linear, about $\frac{1}{3000}$th to $\frac{1}{7000}$th long, with a breadth of $\frac{1}{25,000}$th to $\frac{1}{30,000}$th. The sterigmata are generally composed of a few linear delicate cells or articulations; occasionally they are simple, or consist of single cells, as in *Platysma*.

SPECIES 1. *C. Islandica*, Ach.,

Which is almost a cosmopolite, occurring in Europe, America, and Asia (northern Himalayas).

Specimen 1.—Large form of thallus, with broad laciniæ; var. *b. platyna*, KÖRB. 44; Ben Macdhui, Braemar (Cairntoul side), August 1856, W. L. L. The margins of the laciniæ are chiefly naked; the marginal cilia are so short that the spermogones appear directly seated on the margins of the laciniæ as denticulate warts or tubercles, not distinctly barrel-shaped.

Specimen 2.—Summit of a hill near Kinsale, Ireland; coll. by J. SULLIVAN; in Herb. Carroll, who says—“This is rare in Ireland; I have never observed it.” The plant bears no apothecia, as is generally the case also in British specimens; but it is abundantly furnished with marginal cilia, many of which are spermogoniferous. The latter are tipped with small, short, deep-brown barrel-shaped warts. The sterile cilia are generally longer, more wavy, and have pale apices. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, and $\frac{1}{30,000}$th broad. The sterigmata are shortish, and consist of a few oblong or linear articulations, as in many of the *Parmeliæ*.

Specimen 3.—HEPP. exs. 169; among moss on the Hütli, Switzerland; abundant in fructification on St Moritz. The spermogoniferous marginal cilia are short, but numerous. The sterigmata are of a few articulations, or sub-simple.

Specimen 4.—SCHÆRER exs. 22 (sub var. *vulgaris*), Switzerland. The marginal cilia are short, and not terminating in a distinct barrel; many of them are bifid, trifid, or proliferous. The spermatia are delicate needles of medium size, that is, about $\frac{1}{4000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are short, indistinct, broadish, and of a few articulations.

Specimen 5.—Ben Lawers, June 1856, W. L. L. The spermogones are seated on longish marginal cilia; they are broader, or bulge more, towards their apex than base, and they vary much in length. Some of the cilia are bifid, or irregularly knobbed at the ends; these are always abortive or sterile. The function of these cilia is generally considered to be merely to act as pedicels to the spermogones. TULASNE speaks of two or three spermogones sometimes being united; this I have never seen.

Specimen 6.—Mount Forster, near the top, Cape Horn; Dr HOOKER; in Herb. Hooker, Kew. The spermogoniferous marginal cilia are long and prominent. This and the preceding belong to var. *crispa*, Ach.

SPECIES 2. *C. aculeata*, Fr.,

Which occurs in America and Europe. The very ramose branches of the thallus divide at their summit into very delicate ramuscles, short and divaricate, some of which resemble cilia or spinules. Some of the latter, again, have black or very deep-brown bulging tips; and these, under the lens, are found to be oval or oval-truncate spermogones, resembling the barrel-shaped ones of *Cladonia rangiferina*. The length of the spermogone scarcely exceeds $\frac{1}{400}$th to $\frac{1}{500}$th, and that of its support or pedicel is about $\frac{1}{130}$th. The spermatia are usually from $\frac{1}{3000}$th to $\frac{1}{4000}$th long, and $\frac{1}{20,000}$th broad. The terminal spinules here are analogous in function to the marginal ones in the preceding species. The thallus of the plant varies greatly in regard to the number and ramoseness of its branches, and the quantity of the spermogoniferous or sterile spinules.

Specimen 1.—LEIGHT. exs. 3, Haughmond Hill, Shropshire. The spermatia and sterigmata are so minute as to be with great difficulty seen. The ciliate-spinulose varieties, described by various authors, are probably chiefly spermogoniferous states of the plant similar to this.

GENUS II. PLATYSMA, *Hoffm.*, *Nyl.*

In this genus the spermogones generally occur as black or brown tubercles or cones, scattered on the crisped margins of the thalline lobes, to which they give more or less of a denticulate or nigro-ciliate character, as in *P. nivale, cucullatum, ciliare,* and *juniperinum*. This has not escaped the older lichenologists, who have described such spermogoniferous states as varieties. Sometimes the spermogones occur on prolongations of, and from, the margins of the thallus, and occasionally, though very rarely, they are scattered on the flat surface of the thallus, as brown, grain-like bodies, seated on pale, inconspicuous, thalline papillæ, as in a form of *sepincola*. They are frequently very distinct and easily seen, from the contrast of their dark colour with the beautiful lemon-yellow of the thallus, as in *nivale* and *cucullatum*. The cavity of the spermogone is simple; the envelope deep-brown, of regular, distinct, roundish cells. The sterigmata are generally formed of a few irregular articulated cells. The spermatia are straight and linear, about $\frac{1}{4000}$th long, with a breadth of $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. NYLANDER describes them as either thickened at one or both ends, and he divides the species of *Platysma* into sections, according as their spermatia have the one or other character. This I have not specially noticed. But either NYLANDER or his printer makes a strange mistake, in his " Prodomus" or " Synopsis," in regard to the names of the species having spermatia thickened at one or both ends. In the former volume (p. 49), he arranges under,—

A. " Spermatia versus apicem modo alterum fusiformi-incrassatula,"

P. cucullatum and *P. nivale;* and under,—

B. " Spermatia apice utroque leviter fusiformi-clavata,"

P. juniperinum, *glaucum*, and *sepincolum*.

In his Synopsis, again (p. 37), he gives, as instances of,—

I. " Spermaties aciculaires un peu épaissies en fuseau à l'une de leurs extrémités (spermatia acicularia versus alterum apicem leviter fusiformi-incrassatula),"

P. glaucum and *P. juniperinum;* and, of—

II. " Spermaties aciculaires très légèrement épaissies en voisinage de leurs extrémités (spermatia versus utrumque apicem levissime fusiformi-incrassata),"

P. nivale and *P. cucullatum!*

There is surely some typographical error to account for such a manifest contradiction !

SPECIES 1. *P. nivale*, L.,

Which occurs in northern America, as well as in Europe. Its spermogoniferous states constitute the var. *b. denticulata* of SCHÆRER. (Enum., p. 14, " Thali ora nigro-denticulata.")

Specimen 1.—LEIGHT. exs. 43; Clova, Scotland. The spermogones are deep-brown or black, minute, round, prominent warts, fringing the crisped edges of the laciniæ, or seated on tooth-like prolongations from their margins. The ostiole is inconspicuous. The spermatia are rod-shaped, about $\frac{1}{4000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata consist of a few irregular articulations.

Specimen 2.—SCHÆRER exs. 19; Switzerland. Spermogones as in No. 1.

Specimen 3.—Disco Island, Arctic America, Dr LYALL, 1852; no apothecia; spermogones abundant. FRANKLIN's first journey; broad-lobed form of thallus. Both apothecia and spermogones abound. In Herb. Hooker, Kew.

Specimen 4.—Lochnagar, Braemar, Professor DICKIE; specimen closely resembles *P. cucullatum*, and is apparently a transition form.

Specimen 5.—Sugar-loaf Mountain, County Wicklow, Ireland, in which country it is very rare; D. MOORE, in Herb. Carroll; no apothecia, but spermogoniferous.

Specimen 6.—Plants of Braemar, No. 394, coll. by A. CROALL of Montrose; source of Dee, August 1855; spermogones as in No. 1.

SPECIES 2. *P. cucullatum*, Hoffm.

The close ally and frequent companion of the preceding species. On the Norwegian mountains. I almost always found these two species growing in the same tuft. Indeed they would appear to graduate into each other. Their apothecia and spermogones are quite alike, as are also their spores and spermatia. The spermogones are deep-brown minute tubercles, fringing the crisped margins of the laciniæ, precisely as in *nivale;* they are generally flatter and more irregular as to size than in the species just named.

Specimen 1.—SCHÆRER exs. 18; Switzerland. The spermogones are chiefly seated about the apices of the laciniæ. The spermatia are rod-shaped; the sterigmata articulated, thickish, short; their bases pale-brown, as is also the cellular tissue of the envelope.

Specimen 2.—Arctic Coast, Garray Island, 1850, Captain PULLEN; Kotzebue Sound, BEECHEY; apothecia abundant. In all these specimens, which are in Herb. Hooker, Kew, the spermogones are as above described, or as described in *P. nivale.* In a specimen from Norton Sound, the Rev. CHURCHILL BABINGTON remarks, that the "upper part of the thallus is sparingly fringed with black teeth."* This he does not at all seem to be aware is the ordinary spermogoniferous state of the plant.

SPECIES 3. *P. juniperinum*, L.,

And its var. *pinastri*, Scop.; both of which occur in America and Europe. Its spermogones are similar in site, appearance, and contents, to those of the two preceding species, being small black warts or points, fringing the crisped borders of the lobes; seldom so numerous or so closely aggregated as to give a nigro-denticulate character to the thallus, as in *P. nivale.* They are generally easily distinguishable, from the contrast of their dark colour with the beautiful yellow of the thallus. KÖRBER describes the spermatia "as almost club-shaped." They have always appeared to me to be simply needle-shaped, and if there is any deviation from the linear form, it is probably very slight and unimportant.

Specimen 1.—SCHÆRER exs. 20 (sub var. *a. terrestris*). The spermogones are brown; they are most abundant in the right-hand specimen in my copy. The envelope is deep-brown, of regular, distinct, roundish cells. The spermatia are delicate needles of medium size, longer than in the two preceding species. The sterigmata are short, thick, and composed of a few indistinct articulations.

Specimen 2.—West coast of North America; on twigs; FRANKLIN's first voyage; Arctic Islets, Sir E. PARRY; all in Herb. Hooker, Kew.

SCHLEICHER's exs. No. 52, 1810; Alps; P. de Cauteret, Pyrenees, SPRUCE's

* SEEMANN's Botany of the Voyage of H.M.S. Herald, during 1848–52, p. 47. Enumeration of the Lichens of Norton and Kotzebue Sounds. By Rev. CHURCHILL BABINGTON.

"Lich. Pyrenæi;" approaches *β. virescens*, TUCKERM. One specimen has spermogones in little black tufts dotting over here and there the margin of the lobes. Alps of Dovrefjeldt, 1828; Sommerfeldt Itin. Some specimens are nigro-denticulate with spermogones, as in *P. nivale*. The above species are all contained in Herb. Hooker, Kew.

SPECIES 4. *P. citrinum*, Tayl.,

A native of Java; a beautiful species, with a broad-lobed lemon-yellow thallus. The spermogones are marginal, minute brown tubercles, resembling, but scarcely so prominent as, those of *P. nivale*.

SPECIES 5. *P. glaucum*, Hoffm.,

Which occurs in Europe, America, and Asia. KÖRBER says, "Spermogonien sah ich noch nicht," and certainly they are not very common.

Specimen 1.—Sierra de Estrella, Portugal; WELWITZSCH, "Crypt. Lusitan." No. 116. The thallus approaches var. *fallax*, Sch., in the division of its lobes into laciniæ, which again have their margins frequently studded over with isidioid growths. The spermogones are marginal, crowded, indistinct, minute, brown tubercles, which add to, though they seldom of themselves give, a denticulate character to the margins of the lobes.

Specimen 2.—Var. *fallax* of authors; Scotland; in the Menziesian Herbarium, Royal Botanic Garden, Edinburgh. The plant bears no apothecia; the lobes are laciniate, and their margins isidiiferous. Some of the specimens belong, undoubtedly, to *Parmelia perlata*, with which this *Platysma* is frequently confounded, especially the var. *fallax* of the latter with var. *ciliata* of the former. The spermogones of the *Parmelia* are, however, quite different from those of the *Platysma*. They are punctiform, black, immersed, and scattered on the flat surface of the lobes of the thallus near their margin. In this Scotch specimen of var. *fallax* there are no spermogones; but a few occur in a specimen of the same var. from the west coast of North America, 1787; collected by ALEX. MENZIES himself. Apothecia occur at the ends of the laciniæ; the margins of which laciniæ and lobes are very isidioid. The tooth-like isidia are sometimes tipped with spermogones; but the majority of them are sterile. American specimens of some other *Platysmæ* are occasionally spermogoniferous, while British specimens are not,—such is *P. sepincolum*.

SPECIES 6. *P. lacunosum*, Ach.,

Its spermogones are marginal, as in the preceding species, between which and *P. ciliare* it is intermediate in regard to their size and appearance.

Specimen 1.—West coast of North America; Oregon, SCOULER; in Herb.

Hooker, Kew. The spermogones are longish, brown, irregular tubercles or warts, frequently becoming enlarged and deformed.

Specimen 2.—On trees and pales, New England, U. S. America; TUCKERMANN, No. 6, exs. (sub *Cetraria lacunosa*, *β. Atlantica*). The margins of the lobes are studded over with chiefly degenerate spermogones, which do not give so characteristic a fringe or denticulate appearance as in *P. ciliare*. Besides being marginal, the spermogones are frequently studded over the flat surface of the lobes near their margin. Cambridge, Massachusetts; on pales; TUCKERMANN; in Herb. Menzies, Royal Botanic Garden, Edinburgh. The spermogonal fringe of the lobes is similar to that in *P. ciliare*, but the spermogones are smaller. Sometimes they are studded over projections from the margins of the thallus.

SPECIES 7. *P. ciliare*, Ach.

It is frequently confounded with *P. sepincolum*, but is distinguishable by its marginal spermogones, which are very distinct, constant, and crowded, and which give the thalline lobes a peculiar warted appearance. Its name has been conferred, it would appear, not in allusion to its spermogones, which might earn for it the name rather of *denticulata*, but on account of occasional marginal fibres,—strong, darkish, and branching,—with which it is also furnished.

Specimen 1.—Schooley's Mountains, North America, June 1856; Dr A. O. BRODIE. The spermogones are largish brown cones or warts; more abundant, more distinct, and more constant, than in any of the other species of *Platysma*. The thallus is greenish-gray, smooth and shining above, whitish and lacunose below; the laciniæ are sometimes narrowish. The spermogones somewhat resemble those of *P. sepincolum*, which, however, I have met with only on the surface, not on the edges, of the thallus. The spermatia are acicular, and about $\frac{1}{4000}$th long; the sterigmata are simple, or of a few articulations.

Specimen 2.—Cambridge, Massachusetts, TUCKERMANN; in Herb. Menzies, Royal Botanic Garden, Edinburgh; with apothecia. The spermogones are very distinct, barrel-shaped organs, seated on the ends of cilia, or tooth-like projections from the margin of the thallus. They thus somewhat resemble the spermogones of *Cetraria Islandica*, but are much shorter. The ordinary form of spermogones occurs in TUCKERMANN'S exs. No. 5; on trees and pales, New England, U. S. America.

SPECIES 8. *P. sepincolum*, Hoffm.,

Which occurs in Europe, America, and Asia.

Specimen 1.—On trees, Ingleby Park, Cleveland, Yorkshire, 1854; collected by W. MUDD. The spermogones are abundant as small olive-brown prominent round tubercles or papillæ; superficial or sub-pedicellate; seated on slight pale papillar elevations of the thallus, scattered on the flat surface of the lobes near their margin. Occasionally, but rarely, they would appear to occur on the crisped and curled margins themselves; in which case, it is impossible to distinguish them from those of the preceding species. The cavity of the spermogones is simple, regular, round; the envelope consists of a brownish or olive-coloured cellular tissue. The spermatia are rod-shaped or acicular, and about $\frac{1}{8000}$th long, on the apices chiefly of short, simple, inconspicuous sterigmata.

Specimen 2.—Owhyhee, Sandwich Islands, 1794; collected by ALEX. MENZIES; in Herb. Menzies; and also California, 1793; both in Herb. Royal Botanic Garden, Edinburgh. The margins of the lobes are fringed with small brown or black tooth-like spermogones, as in *P. ciliare*, to which MENZIES's plant may perhaps really belong.

FAMILY XI. UMBILICARIÆ.

GENUS I. UMBILICARIA, *Hoffm.*

There is great uniformity in this genus in regard to the internal structure, or the contents, of the spermogones. In all the species the sterigmata are articulated, and the spermatia very numerous, short, and rod-shaped. Externally the spermogones vary somewhat. They are always more or less immersed in the substance of the thallus; but their ostioles exhibit every gradation of form between the papilla and the mere point. Their colour externally is usually black, and, as a general rule, they are easily seen in proportion as the thallus is light-gray or copper-coloured. Sometimes the spermogones are largish flattened cones, or even tubercles, with a depressed apex. These cones may be perched on papillar elevations of the thallus, which render them still more prominent. Sometimes they are apparent on the surface of the thallus as mere immersed black points, flat or depressed. Round these points, which are the ostioles, the cortical layer of the thallus may be ruptured or fissured in a radiating manner, or the thallus may form a sort of ring round the black punctiform ostiole. This ostiole is usually simple, round, very minute, and inconspicuous. But in old spermogones it frequently becomes gaping and very prominent, irregular in form, triangular or stellate-fissured. The thallus sometimes appears dotted over with largish irregular black perforations, which are the ostioles of old spermogones. Moreover, the nucleus or body of old spermogones frequently falls out, and irregular saucer-like cavities are left. The size of the spermogones varies greatly. They may be so minute that they are scarcely visible even under the lens, as in *U. polyphylla*; or they may be very large and distinct, as in some forms of *U. vellea*, *U. hirsuta*, and *U. cylindrica*. In *U. proboscidea* their diameter is $\frac{1}{80}$th to $\frac{1}{130}$th; in *U. erosa* $\frac{1}{170}$th to $\frac{1}{260}$th; and in *U. hirsuta* their depth is $\frac{1}{100}$th to $\frac{1}{260}$th. They are generally scattered in large numbers about the margins of the lobes on their flat surface; sometimes they are scattered among the apothecia; at other times they are met with only on specimens or thalli bearing no apothecia. The envelope is brown or black, and very thin, being formed of hexagonal or roundish cells. The internal tissue is grayish and horny; and the body of the spermogones is easily enucleated with a needle. The cavity is simple, and more or less spherical. The arthrosterigmata are longish, as in *Sticta* and *Collema*, ramose, and densely aggregated into a more or less compact tissue; they are made up of short, roundish, or cubical cellules, which become thickened by deposits on their internal walls. Their length in *U. pustulata* is $\frac{1}{350}$th to $\frac{1}{500}$th; their breadth varies from $\frac{1}{8000}$th to $\frac{1}{10,000}$th. The spermatia are rod-shaped bodies, seated on the apices and sides of the sterigmata; their length is about $\frac{1}{8000}$th to $\frac{1}{10,000}$th; their breadth $\frac{1}{25,000}$th to $\frac{1}{30,000}$th.

Species 1. *U. pustulata*, Hoffm.,

Which occurs in Europe, Africa, and northern America. It is the type of a section distinguished by 1-spored thecæ, constituting the genus *Lasalia*, Mér., and including the two following species—*U. papulosa* and *U. Pennsylvanica.* Its spermogones are usually isolated, obtuse, very prominent, black cones, round which the cortical or epidermic layer of the thallus is sometimes ruptured or raised; their diameter is about $\frac{1}{50}$th to $\frac{1}{60}$th.

Specimen 1.—Dartmoor; in Herb. Hooker, Kew. The specimens from this station are very large,—the thallus being as handsome as in specimens collected by me on the Norwegian mountains, and more so than those got in the Isle of Skye (base of the Coolin Hills). The spermogones are abundant, but there are usually no apothecia. On one specimen, however, from the "Two Tors on Dartmoor, near Chagford, Aug. 1836," the apothecia, as well as the spermogones, abound.

Specimen 2.—Labrador; in Herb. Hooker, Kew. Both apothecia and spermogones are plentiful and distinct. The spermatia are about $\frac{1}{10,000}$th long, with a breadth of $\frac{1}{25,000}$th. The sterigmata are about $\frac{1}{500}$th to $\frac{1}{350}$th long, with a breadth of $\frac{1}{10,000}$th, articulated as in *Sticta* or *Collema.*

Specimen 3.—Sierra de Gerez, Portugal; Welwitzsch, Crypt. Lusit., No. 107; with apothecia; in Herb. Hooker, Kew. The spermogones are superficial, large, distinct papillæ, scattered over the pale-gray pustules of the thallus. Sometimes these papillæ seem immersed, from being surrounded by a collar of the cortical layer of the thallus, which they fissure in a stellate-radiate manner. Occasionally the spermogones are mere immersed black points.

Specimen 4.—Puerto de Leiteriegos, Durieu, "Plant. select. Hisp.-Lusit.," No. 58; in Herb. Hooker, Kew. Apothecia are plentiful; the spermogones are scattered about the margins of the pale-gray thallus as large, distinct, black papillæ, with a distinct round or regular ostiole.

SPECIES 2. *U. papulosa*, Ach.,

Which occurs in North America and in the Himalayas. It closely resembles, in its thallus, apothecia, and spermogones, the preceding species, and I know of no good distinctive marks, such as to justify their separation as species.

Specimen 1.—British North America; United States; North Carolina; Lemel Mountain, Pennsylvania; in Herb. Hooker, Kew. The spermogones are plentiful as minute black papillæ, scattered in groups towards the periphery of the thallus. The spermatia are rod-shaped, $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad, on arthro-sterigmata, as in *U. pustulata*.

Specimen 2.—Schooley's Mountains, North America; July 1856; Dr A. O. BRODIE. Apothecia and spermogones abundant, but the former are chiefly degenerate. The thallus is of a light-gray or brownish-gray tint, on which the minute, black, papillar spermogones are easily recognised. They appear to the naked eye as very small black grains, scattered all over the thallus, including its pustular elevations, but most abundant about the margins of the thallus. They more resemble the spermogones of *U. polyphylla* than of any other species of *Umbilicaria*. The ostioles are invisible even under the lens. The sterigmata are irregular in outline, and are composed of short, broad, thick-walled irregular cells. The spermatia are as described in No. 1.

SPECIES 3. *U. Pennsylvanica*, Ach.

Specimen 1.—White Mountains, North America; TUCKERMANN; in Herb. Menzies, Royal Botanic Garden, Edinburgh. The thallus is of a pale-brown, darkest about its margins. The spermogones are paler than the thallus; hence they appear scattered abundantly about the margins of the thallus as white sago-like grains. They are large papillæ,—among the largest spermogones I have met with in *Umbilicaria*,—and they have a distinct brown, round, or irregular ostiole.

Specimen 2.—FRANKLIN's First Journey; in Herb. Hooker, Kew. The spermogones are plentiful about the periphery of the thallus, as distinct black papillæ, with stellate-fissured ostioles.

SPECIES 4. *U. Mühlenbergii*, Ach.,

Like the two preceding species, a native of North America. This and the following species have 8-spored thecæ and simple spores.

Specimen 1.—White Mountains, North America; TUCKERMANN; in Herb. Menzies, Royal Botanic Garden, Edinburgh; and its var. *β alpina;* with apothecia. Spermogones are plentiful about the margins of the thallus as small, distinct, flattish papillæ, of the same colour as the thallus, or not greatly darker, with ostioles more or less distinct.

Specimen 2.—Rocky Mountains, North America; in Herb. Hooker, Kew. Spermogones are abundant as black papillæ, with central roundish pores or ostioles. The spermatia and sterigmata are as described in the preceding species.

SPECIES 5. *U. polyrrhiza*, L.,

Which occurs in Europe and Asia. This is the familiar *Gyrophora pellita*, Ach., of the earlier lichenologists.

Specimen 1.—Hills above Loch Freuchie, Amulree, Perthshire, May 1856, W. L. L.; no apothecia. The spermogones are plentiful, especially about the periphery of the thallus, as small papillæ, of the same colour as the thallus. Hence they are not easily seen, and this, therefore, is one of the worst species in which to study the spermogones of *Umbilicaria*. These papillæ are pierced by a very minute, round, or stellate-fissured ostiole. In many cases there are no papillæ, and the ostioles then appear directly to perforate the thallus, which may appear studded over with patent, black, irregular perforations, as in *P. saxatilis*, var. *omphalodes*.

Specimen 2.—Lochnagar, Braemar, August 1854; Plants of Braemar, A. CROALL, No. 197; with abundant apothecia. The spermogones are chiefly sub-marginal, punctiform, depressed, and inconspicuous. In other specimens from the same locality, collected by Mr CROALL (in Herb. meo), but not bearing apothecia, the margins of the thallus are studded over with minute depressions, which appear to be old spermogones. Papillar spermogones occasionally occur, pierced by a black, minute, round, or irregular ostiole. The body of the spermogones has in some cases fallen out, leaving saucer-shaped cavities, with turgid black irregular borders.

Specimen 3.—Highlands of Scotland, 1778, collected by ALEX. MENZIES; in Herb. Menzies, Royal Botanic Garden, Edinburgh. The thallus is very pale; hence the black apothecia are well seen by contrast of their colour. The spermogones are also distinct, but they are chiefly old and deformed.

Specimen 4.—North-west America (sub nom. *G. pellita* and *G. vellea*); in Herb. Hooker, Kew. Spermogones are plentiful about the periphery of the thallus, as small black papillæ, scarcely distinguishable, however, on the dark-olive, or brown thallus.

SPECIES 6. *U. polyphylla*, Hoffm.,

Which occurs in Europe, America, and Asia, with its var. *deusta*, Ach., Fr., which inhabits Europe and Asia at least.

Specimen 1.—Ben Macdhui, Braemar, August 1856, W. L. L. This appears to be a transition form into *U. hyperborea*, but the thallus is not yet pustular or warted. I may here mention, that most of the British species, at least, of *Umbilicaria*, pass into each other, as regards the thallus and apothecia; while the spores and spermatia are essentially the same in all. I therefore prefer, with

Leighton,* to regard them as varieties of one species, rather than to look upon them as separate species. This specimen is associated with forms of *U. hyperborea*, which are generally referred by authors to *U. erosa*. The spermogones are abundant on some of the lobes, as very minute indistinct papillæ.

Specimen 2.—Roadside walls, opposite Invercauld, Braemar, August 1856, W. L. L.; no apothecia. The spermogones are minute black cones, with a deep-brown cellular envelope, and rod-shaped spermatia, about $\frac{1}{5000}$th long.

Specimen 3.—Lochnagar, Braemar, July 1855, Alex. Croall; Plants of Braemar, No. 392; no apothecia. Spermogones are scattered indiscriminately over the thallus as small, indistinct black papillæ, with no perceptible ostiole. From the dark colour of the thallus, and the fact that the spermogones are generally more or less of the same tint as the thallus, and hence not easily distinguished, this is a bad species, like *U. polyrrhiza*, in which to study the spermogones of *Umbilicaria*.

Specimen 4.—Howden Gill, Cleveland, Yorkshire, 1854; coll. W. Mudd; no apothecia. Spermogones are plentifully scattered all over the thallus, but they are most minute black papillæ, scarcely visible even under the lens. Their walls are deep-brown; their spermatia and sterigmata distinct, and of the characters described in the foregoing species.

Species 7. *U. hyperborea*, Hoffm.,

And its var. *arctica*, Sommerf., which occur in Europe and America.

Specimen 1.—Hepp. exs. 116, sub *Gyrophora; syn.* Moug. and Nestler's exs. 1047; on granite rocks, St Moritz; with apothecia. Spermogones are scattered over the copper-coloured thallus, as black cones or papillæ, largish and distinct, some flattened, a few depressed, others slightly raised. The envelope is of a deep-brown hexagonal cellular tissue; the spermatia and sterigmata are as in *U. pustulata*, and the other species already described.

Specimen 2.—Brandon Mountain, County Kerry, Ireland, D. Moore; in Herb. Carroll. The surface of the thallus consists of, or is marked by, a series of convolutions, so arranged as to appear like an agglomeration of warts. On the tops of these are perched the spermogones, as small black papillæ, with sub-prominent ostioles. The cortical layer of the thallus is often eroded, exposing the subjacent white medullary tissue. The spermogones on such portions of thallus are very distinct, as round brown points, seated on the tops of whitish pulvinuli. The spermatia are about $\frac{1}{5000}$th to $\frac{1}{6000}$th long; the sterigmata are longish and distinct.

Specimen 3.—North-west Passage, Parry; Walden Island, Parry; in Herb. Hooker, Kew. In one of Parry's specimens spermogones are abundant.

* "Monograph of the British Umbilicariæ." By the Rev. W. A. Leighton.—*Annals of Nat. History*, Oct. 1856; and reprinted as a separate pamphlet.

SPECIES 8. *U. erosa*, Hoffm.,

Which occurs in Europe and America. This appears to me a particularly bad species, inasmuch as all the *Umbilicarias* are liable to erosion of the margins of the thallus, though this is greatest in the preceding species, to which *U. erosa* ought chiefly to pertain as a variety. Next to *U. hyperborea*, erosion of the thallus is common in *U. proboscidea* and *U. cylindrica*. Though spermogones are usually abundant in *U. erosa*, they are not easily seen, from being of the same colour as the thallus, or from their minute size. They are papillæform or punctiform; immersed; with a diameter of $\frac{1}{170}$th to $\frac{1}{260}$th. The cavity is simple; the envelope black, and moderately thick; and the internal tissue ash-gray.

Specimen 1.—Ben Macdhui, Braemar, August 1856, W. L. L. Spermogones are abundant and distinct as black cones or papillæ, scattered about the margins of the pitchy or bronze-coloured thallus. They are intermediate in size, between those of *U. cylindrica* and *U. polyphylla*; the spermogones of the latter species being the smallest I have met with in *Umbilicaria*. The ostiole is generally distinct, round, chink-like, triangular or stellate-fissured, according to age; in the older spermogones it is large and patent. The spermatia are rod-shaped, and about $\frac{1}{8000}$th long. Another specimen from the same locality has more the character of *U. cylindrica*; but the margin of the thallus is decidedly and distinctly erose. The spermogones are mostly old; the ostiole is large and saucer-like, surrounded by a turgid black border. The thallus seems roughened over with a multitude of little saucers, which are most profusely scattered about the edge of the lobes.

Specimen 2.—Ben Nevis, August 1856, W. L. L. Old spermogones are here also abundant, especially about the periphery of the thallus. They have large saucer-like ostioles.

Specimen 3.—Hills east of Sligachan, Isle of Skye, August 1856, W. L. L.; apothecia abundant. This appears to be a mere form or state of *U. hyperborea*. The spermogones are large black warts or papillæ, scattered over the bronze-coloured thallus. The spermatia are about $\frac{1}{8000}$th long; the sterigmata irregular, thickish, composed of short roundish cells or articulations.

Specimen 4.—Highlands of Scotland, 1778; collected by ALEX. MENZIES; in Herb. Menzies, Royal Botanic Garden, Edinburgh. This plant, too, has quite the aspect of *U. hyperborea*, except as to the erose or cribriform thallus. It is beautifully studded over with spermogones.

Specimen 5.—Mangerton, County Kerry, Ireland; coll. ISAAC CARROLL. Thallus much deformed. The spermogones are minute black papillæ; of the old ones nothing remains but the irregular gaping ostiole. The cavity seems frequently multiple, apparently from coalescence of several spermogones Associated with the ordinary spermatiferous sterigmata are numerous long, hypertrophied, sterile filaments, somewhat as in *Ramalina*, but neither so long nor so ramose. The ordinary sterigmata are about $\frac{1}{1000}$th to $\frac{1}{1500}$th long; the spermatia $\frac{1}{10,000}$th long, and $\frac{1}{30,000}$th broad.

Specimen 6.—Shores of Loch Muick, Braemar, August 1854; A. CROALL. The margins of the thallus are covered with a mass of papillar elevations, apparently of the thallus itself, and not differing in colour therefrom, each pierced by a distinct round or irregularly fissured ostiole. These are the spermogones which are not easily seen, from being concolorous with the thallus.

Specimen 7.—From DON'S Herbarium, now in the possession of Mr MACNAB, Royal Botanic Garden, Edinburgh; habitat not given. Spermogones are abundant as large, distinct, cone-like warts, scattered among the apothecia, with generally an indistinct stellate-fissured ostiole.

Specimen 8.—Achtermannshöhe, Hartz Mountains, Germany; coll. HAMPE, 1846; exs. No. 7. The thallus is referrible to *U. hyperborea;* the apothecia resemble those of *U. polyrrhiza.* Spermogones are abundant as very minute black points.

Specimen 9.—SCHÆRER exs. 153; on granitic rocks; Alps, Switzerland. The spermagones are scattered generally over the thallus as black elevated papillæ, pierced by an indistinct ostiole.

SPECIES 9. *U. proboscidea*, DC.,

Which occurs in Europe, America, and Asia. This appears to me a particularly ill-marked species, which is partly referrible to *U. polyphylla*, *U. hyperborea*, and *U. cylindrica.*

Specimen 1.—Iceland; in Herb. Hooker, Kew. The thallus is of a very pale-grayish colour, and has submarginal largish black spermogones, whose diameter is from $\frac{1}{80}$th to $\frac{1}{130}$th.

SPECIES 10. *U. cylindrica*, L. Fr.,

Which occurs in Europe, America, and New Holland. This is a species or variety —according to the view taken of the classification of the *Umbilicarias*—comparatively well-marked, when it bears its characteristic marginal fibres or cilia; but these are frequently absent, in which case it passes into the preceding species, and others.

Specimen 1.—Top of Ben Lawers, Perthshire, June 1856, W. L. L. The thallus is gray, thick, and much curled or gnarled. Spermogones are especially abundant on specimens bearing no apothecia; in them they are scattered generally over the whole surface, while in specimens with apothecia they are chiefly confined to the margins. They are distinct black papillæ or cones, varying greatly in size, some of them very large. In the older spermogones the ostioles are large, gaping, and sometimes saucer-shaped; in the younger ones they are sometimes triangular, chink-like, or stellate-fissured. In other specimens from the same locality, the spermogones are very minute papillæ, scarcely conspicuous; or there is merely a round black spot, perforated by an ostiole. This is an excellent species in which to study the spermogones of *Umbilicaria*. The spermatia are rod-shaped and short. The sterigmata are composed of short, thick-walled, roundish cellules.

Specimen 2.—Top of Ben Lomond, August 1855, W. L. L. Spermogones are here also abundant, as largish sub-prominent cones or papillæ.

Specimen 3.—Morchone (or Morven), Braemar, August 1856, W. L. L. The spermogones are very abundant, and occur in a great variety of forms. In one specimen, which is polyphyllous, much curled and convex, the ostioles are very patent, and surrounded by a prominent black edge. They give the thallus the appearance of being studded over with a series of black perforations. In another specimen, where the thallus is of an ashey-gray colour, the spermogones are prominent as minute black papillæ, with an indistinct ostiole. In others, the spermogones are old, hypertrophied, and degenerate; they have no ostiole, and appear as black, flat, large irregular disks or tubercles, scattered irregularly over the surface of the thallus, to which they give a curiously warted character. They are generally most abundant and best marked in specimens destitute of apothecia. Sometimes, again, the spermogones are black cones, seated on the flattened apex of a second and larger cone formed of the thallus; and these double cones are frequently very distinct when the thallus is of a pale colour.

Specimen 4.—Hills above Loch Freuchie, Amulree, Perthshire, May 1856, W. L. L. Apothecia abundant; marginal cilia long and strong. The thallus is light-coloured; the spermogonal papillæ black and distinct; the ostiole distinct, stellate-fissured, but not very large.

Specimen 5.—Ben Lawers, August 1855, Dr GILCHRIST; no apothecia. Thallus being pale-gray, the spermogones are easily seen; they are distinct large black papillæ, scattered chiefly about the margins of the thallus; many of them are irregular, flattened, large, and hypertrophied. The spermatia are about $\frac{1}{8000}$th long, and very abundant.

Specimen 6.—Lochnagar, Braemar, July 1855, A. CROALL. The margins of the thallus are almost naked; and the plant approaches *U. proboscidea*. The spermogones are large cones or tubercles, darker than the thallus, with a round, elongated or stellate-fissured ostiole.

Specimen 7.—Top of Muckish Mountain, County Donegal, Ireland, Professor DICKIE. The thallus is chiefly monophyllous; its margin fringed with short, coarse, rudimentary fibres; the colour gray, the surface cracked, the consistence leathery. There are no apothecia. Spermogones are abundant and distinct, from contrast with the pale colour of the thallus; they are small, black papillæ. The spermatia are $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad.

Specimen 8.—Disco Island, Dr LYALL, 1854; in Herb. Hooker, Kew; has both apothecia and spermogones.

Specimen 9.—LEIGHTON exs. 95 (sub *U. varia* var. *proboscidea*, *a.* LEIGHT.), Clova; with apothecia. The spermogones are black cones, pretty well seen on the grayish thallus.

Specimen 10.—SCHÆRER exs. 143 (sub *U. polymorpha*, *a. cylindrica*, *A : Syn. Lichen crinitus*, LIGHTFOOT); on the Grimsel, Switzerland. The spermogones are submarginal, distinct, black cones or papillæ.

SPECIES 11. *U. vellea*, L., Fr.,

Which occurs in Europe, Abyssinia, the Canary Islands, and America. The thallus is usually pale in colour; hence the spermogones are easily seen. It properly, I think, ought to include the following species, *U. hirsuta.*

Specimen 1.—Sierra de Estrella, Portugal, WELWITZSCH, "Crypt. Lusit.," Nos. 108 and 120. The spermogones are abundant, as small, black points, which are the ostioles of wholly immersed spermogones. The spermatia are about $\frac{1}{8000}$th long, and $\frac{1}{25,000}$th broad; the arthrosterigmata have the same character as in all the preceding species.

Specimen 2.—Luz, Pyrenees, SPRUCE'S "Lich. Pyrenæi." The spermogones are largish black papillæ, scattered about the margins of the thallus, surrounded by a pale thalline ring. This and the preceding specimen are in Herb. Hooker, Kew.

SPECIES 12. *U. hirsuta*, DC.,

Which is found equally in Europe, America, and Asia. If it is not a form of the preceding, it is very closely allied. (*vide* SCHÆRER exs. 137–40. MOUGEOT and NESTLER, 344 and 1144.)

Specimen 1.—HEPP. exs. 117 (sub *Gyrophora*); on granitic rocks, St Moritz; on upper and right-hand specimen in my copy; with apothecia. Spermogones are abundant about the periphery of the thallus, which is copper-coloured; they are large, distinct, elevated cones of the same colour as the thallus, except the ostiole, which is black, and round, or irregularly stellate-fissured. The body of the spermogone is easily enucleated, leaving an irregular saucer-like cavity.

Specimen 2.—SCHÆRER exs. 137, sub *U. depressa a. hirsuta*, SCH.; on granitic rocks, Alps of Switzerland. Spermogones abound about the margins of the thallus as small, obscure blackish cones, closely grouped. They occur also in SCHÆRER'S exs. 138 (sub *C. vulgaris*), very indistinct; in 139 (sub *D. abortiva*), deformed and old; in 140 (sub *F. rupta*), large, distinct, and grouped.

FAMILY XII. Parmeliæ.

GENUS I. Sticta, *Ach.*

The spermogones in this genus are more or less immersed in the tissue of the thallus, their presence being indicated on the surface of the thallus generally by a minute, punctiform brown ostiole. This ostiole may be flattened, slightly elevated, or depressed. It is also frequently seated on the apex of thalline papillæ, varying in size, and which, when confluent, as occasionally happens, may even assume the character of large irregular tubercles. Moreover, frequently in the same species, and even in the same specimen, the ostiole may be flat, depressed or papillæform. Now, it is of importance to bear this in mind, inasmuch as Nylander describes the spermogones of *Sticta* as always and altogether immersed, and this he regards as a distinguishing character of *Sticta*, as contrasted with his genus *Ricasolia*, whose spermogones are mammillar tubercles. This I do not regard as a good, because by no means a constant, character. In regard to their spermogones, as to their thallus and apothecia, *Sticta* and *Ricasolia* pass into each other, and are inseparably united and intermingled. The division is purely arbitrary, and hence unnatural. In both genera the spermatia and sterigmata are precisely the same. In few species of either genus do the spermogones always maintain the same unvarying character. Though normally or generally punctiform, they may be occasionally papillæform; and though usually papillæform, they may be sometimes punctiform. Hence, I will speak of a form of spermogone *predominating* in certain species. With this explanation or reservation, I would say that the punctiform spermogone predominates in *S. pulmonacea*, *sylvatica*, *linearis*, *carpoloma*, *aurata*, *orgymœa*, *faveolata*, *filicina*; the papillæform in *S. endochrysa*, *obvoluta*, *argyracea*, *damæcornis*, *xanthosticta*, *cinereo-glauca*, *glabra*, *Freycinetii*, and *laciniata*: while the spermogones may be either flat, depressed or papillæform in *S. flavicans*, *D'Urvillei*, and *flabellata*. In *S. obvoluta*, and *damæcornis*, the papillæ are sometimes large, with a conspicuous brown ostiole; and they then resemble nascent or young apothecia. The spermogones of *Sticta* are sometimes easily seen on the beautiful yellow or glaucous thallus, from the contrast with the deep-brown colour of the largish ostiole. This ostiole, however, in the young and mature state, is generally more or less minute; and, added to its minute size, it is sometimes of so pale a colour that it is apt to be overlooked. Sometimes it is large and disk-like, flat or depressed, especially when crowning large papillæ. With age, it expands, and when the nucleus or body of the spermogone falls out, as frequently happens, it may become saucer-shaped, with ragged, generally thickened and dark-coloured, margins. In this state, the ostioles of old spermogones sometimes have the aspect of black rings or disks, as occasionally in *S. aurata*. However large or small the ostiole or external protuberance of the spermogone, its body is almost in all cases a large white kernel of a dense horny tissue, which becomes gelatinous and semipellucid in water. From its density, it can easily be enucleated with the point of a needle, and I have already stated, that it sometimes falls out of itself. The diameter of this body is sometimes $\frac{1}{30}$th to $\frac{1}{35}$th. The envelope, which consists generally of a brown cellular tissue, is about $\frac{1}{600}$th to $\frac{1}{500}$th thick. The depth of the spermogone is generally as great, at least, as that of the thallus: and it may form, as in *Endocarpon*, a slight prominence on the lower as well as on the upper surface of the thallus, where its depth exceeds that of the latter. The spermogones may either be scattered over the whole surface of the thallus, or only about its margins; or they may be confined to the plicæ or rugæ, with which the thallus is sometimes conspicuously marked. They are usually scattered over the general surface in *S. damæcornis*, *obvoluta*, *carpoloma*, and *gilva*; they are chiefly confined to the margins of the lobes in *S. endochrysa*, *orgymæa*, *glabra*, and *Freycinetii;* and they are scattered on the rugæ or plicæ only, or principally, in *S. pallida*, and *linearis*. But this distribution is by no means invariable; for, in the same species, the spermogones may be distributed sometimes in the one way, sometimes in the other. The spermatia, in all cases, are straight and linear or rod-shaped, with obtuse ends; their length varies from $\frac{1}{6000}$th to $\frac{1}{8000}$th; their breadth, from $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. The sterigmata are, in all cases, articulated and longish, bearing spermatia in great abundance on their sides and apices. They are composed of small, round or cubical cellules, at first having thin walls, which latterly become greatly thickened by deposits on their interior. They vary in length from $\frac{1}{200}$th to $\frac{1}{600}$th, with a breadth of from $\frac{1}{4000}$th to $\frac{1}{8000}$th.

Species 1. *S. pulmonacea*, Ach.,

Which has a very wide geographical range, occurring in Europe, Africa, America, and Australia. *S. linita*, Ach., which occurs in Europe and Asia, is included, and very properly, I think by Nylander, as a variety. The spermogones are normally or generally here punctiform and depressed; but not always, as Nylander and Körber describe them, for I have met with them occasionally, though rarely, papillæform. The body of the spermogone is spherical; the cavity simple; the envelope resembles in structure the cortical layer of the thallus, being composed of very thick-walled cells. The internal tissue is whitish or pale rose-coloured; and, when dry, has a consistence as dense as horn; hence it is divisible by the knife into very thin sections. The body of the organ causes a slight protuberance or papilla on the under surface of the thallus. The horizontal diameter of the spermogone is about $\frac{1}{30}$th to $\frac{1}{35}$th; the thickness of its envelope $\frac{1}{600}$th to $\frac{1}{500}$th. The sterigmata are very irregularly ramose and long, reaching almost to the centre of the spermogonal cavity. The constituent, short, roundish, or cubical cellules have a very narrow cavity from thickening of their walls in process of growth. The breadth of the sterigmata is about $\frac{1}{4000}$th to $\frac{1}{6000}$th. The spermatia are so abundant as to roughen the sterigmata, as it were, with small bristles; their length is usually about $\frac{1}{5000}$th to $\frac{1}{6000}$th. The spermogones of this species probably constitute WALLROTH's variety *stigmatea*, and are also what he describes as a parasitic *Sphœria*, *S. epiblastematica*.

Specimen 1.—Glen Muick, Braemar, Professor DICKIE; no apothecia. The spermogones are old, and contain no free spermatia. They are scattered indiscriminately over the surface of the thallus, and are not confined to the rugæ, as is usually the case. They are frequently maculiform and degenerate.

Specimen 2.—Guttanen Valley, Switzerland; in Herb. Hooker, Kew. The rugæ are dotted over with abundant, minute, brown, papillæform or punctiform spermogones. One specimen from MENZIES (habitat apparently not given), also in Herb. Hooker, has the rugæ studded over with punctiform, brown, immersed spermogones. The thallus has entire, or nearly entire, large rounded lobes; its surface is marked by elevated rugæ and deep sulci; and its colour is deep-olive. It appears to me to be the *S. linita*, Ach.

Specimen 3.—Bootan, India, NUTTALL. The spermogones are few, largish, and very distinct, scattered on the rugæ. Also from Madras, Dr WIGHT; East Indies, Mr SHEPHERD; all in Herb. Hooker, Kew. The rugæ are sharp and well defined, and the spermogones scattered over them are largish, distinct, and brown.

Specimen 4.—North-west America. Spermogones are sometimes here maculiform, that is they are largish, brown spots, rather than mere points. Fort Vancouver, Columbia, SCOULER; both in Herb. Hooker, Kew. Spermogones largish and distinct, brown, round, impressed.

SPECIES 2. *S. sylvatica*, Ach.,

Which occurs in Europe, Africa, and Northern America. I have great doubts as to whether this is really separable, on any good grounds, from *S. fuliginosa*. Though this species is rarely found with apothecia, spermogones sometimes occur of the same character as those of the preceding species. They are usually, however, so minute that they are very apt to be overlooked. The body of the spermogone is of a yellowish colour, which contrasts readily with the white medullary tissue of the thallus, so that one of the best modes of examining or seeing the spermogones is to make a section through the brown punctiform ostioles, and through the thallus. The spermatia are about $\frac{1}{8000}$th long.

SPECIES 3. *S. cinereo-glauca*, Tayl.,

A New Zealand species; in Herb. Hooker, Kew. The spermogones are small, inconspicuous, brown papillæ, scattered here and there over the lobes of the thallus. They resemble young apothecia, with which they are apt to be confounded. But the lacerate-stellate border, gradually enlarging so as to show the disk, and their greater size will distinguish the latter.

SPECIES 4. *S. filicina*, Ach.,

A native of equatorial America, New Zealand, and Java. Its var. *Menziesii*, Hook. fils, occurs in New Zealand, the Antarctic Regions, and Nepal (syn. *Sticta Menziesii*, Tayl., in Dr HOOKER'S "Flora of New Zealand"). In specimens, in Herb. Hooker, Kew, the spermogones are with difficulty discernable. The ostiole is generally depressed in the centre of crater, or cup-shaped cavities of the thallus, or of papillæform elevations thereof. Sometimes the ostiole is black and punctiform, more frequently it is so pale that it is very apt to be overlooked.

SPECIES 5. *S. damæcornis*, Ach.,

Which occurs in Ireland, America, the African Islands, and Australia. This species is most variable, and it includes a number of well-marked or important varieties, of which may be mentioned :—

Var. *linearis*, Nyl., Polynesia.
,, *macrophylla*, Hook., Ireland ; African Islands; Java.
,, *rufa*, Ach., Mexico.
,, *dichotoma*, Del., African Islands; Java.
,, *sinuosa*, Pers., Equatorial America; Philippine Islands.
,, *quercizans*, Ach., America and Central Asia.
,, *Canariensis*, Nyl., Madeira.

Specimen 1.—Feejee Islands; high grounds; on trees, abundant; MILNE, H. M. S. Herald, 1855; in Herb. Hooker, Kew. Both apothecia and spermogones are marginal. The latter are usually brown warts, not very prominent, flattened, often grouped two or three near each other, varying in size. Sometimes, there is merely a brown spot, marked centrally by a depressed ostiole of irregular shape and size.

Specimen 2.—Var. *linearis*, Nyl., Tasmania; Antarctic Expedition, 1839–43, Dr HOOKER. This plant is extremely like *S. pulmonacea*, except that its laciniæ are much more narrow and delicate. The apothecia are marginal, and, as well as the spermogones, are quite those of the species just named. The thallus is furnished below with short brown fibres in rigid tufts, as is frequently the case also in *S. pulmonacea*. The spermogones are abundant, minute, brown depressed points, distinctly visible under the lens, scattered along the margins of the laciniæ, as well as on the rugæ of the thallus. The body of the organ is large, white, hard, and easily enucleated.

Specimen 3.—Var. *macrophylla*. This a bad name for a very variable form. Though in many cases the lobes are broad and round, and the plant bears the same relation to *S. damæcornis* that *S. linita* does to *S. pulmonacea ;* yet in many other cases, and frequently in Irish specimens, the laciniæ are much more narrow than those of *S. pulmonacea*, and it ought to be referred to the var. *linearis*. The spermogones resemble those of *S. pulmonacea*, says TULASNE. So far as regards their external characters, this statement does not at all agree with my own observations. For, while those of *S. pulmonacea*, are generally minute and punctiform, those of *S. damæcornis* are generally largish and papillæform. The spermatia and sterigmata are certainly the same in both; for they are the same, or at least similar, throughout the whole genus *Sticta*. The ostiole is frequently large and round; in the old state of the spermogone it may become an irregular, large stellate fissure, and the thallus may appear studded over with the pseudo-perforations thus produced, precisely as in *Parmelia saxatilis* var. *omphalodes*.

Rocks, Turk Waterfall, Killarney, WILSON; in Herb. Hooker, Kew. (Sub nom. *S. macrocarpa?* var. syn. *S. macrophylla*, Tayl., in MACKAY'S 'Flora Hibernica,' p. 150.) This is certainly not a distinct species; and the specific name of the plant, *S. damæcornis*, to which it belongs as a variety, ought to be restored to our Irish plant. The spermogones are papillæform. In some specimens the lobes are broad and rounded; but in others the segments of the thallus are much narrower, and resemble in their size and form those of *S. pulmonacea*.

Specimen 4.—Var. *macrophylla;* woods of Killarney; TAYLOR, in Herb. Hooker, Kew. TAYLOR remarks on the label, "I have seen specimens with segments still narrower." The colour of the thallus is deep-olive or brown. The papillæform spermogones are with difficulty distinguishable; sometimes they are flattened, and have very pale-brown tips. In age they become large, with stellate-fissured ostioles.

Specimen 5.—Var. *macrophylla*, Killarney Woods; TAYLOR, in Herb. Dr MACKAY, Dublin (author of the "Flora Hibernica"); with apothecia. In describing the apothecia in the "Flora Hibernica," Taylor, apparently inadvertently, includes the spermogones, which he mistakes for young apothecia. The spermogones are large, brown-tipped papillæ, resembling in form and size those of *Ricasolia herbacea* and *R. glomulifera*. Its spermogones should associate this plant with NYLANDER'S genus *Ricasolia;* but, in regard to cyphellæ, it is a true *Sticta*. The spermogones are usually smooth and cone-like, with a round deep-brown ostiole; but frequently also they are flattened, and their apex corrugated round a stellate-fissured ostiole. Their body is a kernel of dense white tissue, and which can be readily enucleated. The tissue becomes gelatinous under moisture. The spermogones are abundant, and are scattered over the whole surface of the thallus. The spermatia are about $\frac{1}{8000}$th long, with a breadth of $\frac{1}{20,000}$th. The sterigmata are long and delicate, from $\frac{1}{200}$th to $\frac{1}{600}$th long, with a breadth of about $\frac{1}{8000}$th, their articulations or component cells being distinct.

Specimen 6.—Var. *macrophylla*, Java, LOBB; in Herb. Hooker, Kew. This seems exactly the Irish plant. The spermogones are scattered chiefly about the margins of the lobes or laciniæ; they are punctiform and flat or depressed, or papillæform—rarely the latter. When papillæform, they resemble the spermogones of *Ricasolia herbacea*, but are smaller. Sometimes they occur in the old state as mere dark maculæ.

Specimen 7.—Var. *dichotoma*, La Pouie, Mauritius; Gardner, in Herb. Hooker, Kew. The spermogones are either scattered generally over the surface of the thallus, or only on the margins of its laciniæ. They are depressed, very pale points, and are very apt to be overlooked.

Specimen 8.—Var. *sinuosa*, Philippine Islands, Cuming; in Herb. Hooker, Kew. The spermogones occur chiefly about the margins of the laciniæ; they are more frequently punctiform than papillæform, brown, and in all cases inconspicuous. The ostioles of the punctiform spermogones are generally depressed in crater or cup-like cavities of the thallus.

Specimen 9.—Var. *quercizans*, Jamaica, Purdie; in Herb. Hooker, Kew. The thallus is brownish; hence the spermogones, which are also brownish, are not easily seen. They are very small papillæ, crowned with brown ostioles of a deeper tint than the papillæ themselves.

Specimen 10.—Var. *Canariensis*, Madeira, Lowe; on the trunks of *Persea Canariensis*, Canary Islands; Herb. Williamson, Dr Leman, both in Herb. Hooker, Kew. The spermogones are scattered chiefly about the ends of the lobes or laciniæ. They resemble those of *Ricasolia herbacea*, being papillæform; the apices of the papillæ are sometimes flattened, seldom depressed.

Specimen 11.—Var. *rufa*, Ecuador, Seemann; in Herb. Hooker, Kew. The spermogones are here scattered chiefly about the periphery of the thallus; they are papillæform, and resemble those of *Ricasolia herbacea*, but are small, and not so prominent.

Species 6. *S. argyracea*, Del.,

Which occurs in America, Java, Cochin-China, Polynesia, and Australia.

Specimen 1.—Pacific Islands, Sinclair; Philippine Islands, Cuming; Martinique, Juan Fernandez, 1830; Madras, Dr Wight; all in Herb. Hooker, Kew. The spermogones are few, scattered, papillæform, resembling those of *Ricasolia herbacea*, but are smaller and less prominent.

Species 7. *S. nitida* Tayl.,

(Syn. *S. flabellata* Mont.)

Specimen 1.—Chili, Lobb; in Herb. Hooker, Kew. This is a narrow-lobed species, somewhat resembling *S. damæcornis*. The spermogones are papillæform or punctiform, scattered chiefly about the ends of the lobes. The papillæform spermogones are frequently flattened on the apex; the punctiform ones are black or brown, sometimes depressed, or surrounded by a thalline ring. In age they may become maculiform. The spermogones may be papillæform about the ends of the lobes, and punctiform, flat, or depressed more centrally. Sometimes they are so abundant as to give the thallus a black or brown-punctate character.

SPECIES 8. *S. Freycinetii*, Del.,

Which occurs in equatorial America, Australia, and the Antarctic Regions.

Specimen 1.—Auckland Islands, Dr HOOKER, in Herb. Hooker, Kew. The spermogones resemble those of *S. orygmæa*; they are mostly punctiform and depressed, though sometimes papillæform. HOOKER apparently describes them as abortive apothecia in his "Flora Antarctica," (Part 25, p. 528, Plate 196, fig. 4.)

Specimen 2.— Var. *fulvocinerea*, MONT. (Syn. *Sticta fulvocinerea*, MONT.) Straits of Magellan, Captain COLLINSON. The spermogones are scattered immediately on or near the margins of the thallus; they are generally papillæform and crowded, with a deep-brown or black ostiole or apex. Sometimes they are punctiform and flat, seldom depressed. The thallus is of a beautiful lemon-yellow colour; hence the spermogones are easily seen.

Specimen 3.— Var. *Gaudichaudii*, DEL. (Syn. *Sticta Gaudichaudii*, DEL.) Australia, BIDWILL; in Herb. Hooker, Kew, as is also No. 2. The spermogones occur on the margins of the lobes, and are papillæform and small, with a pale-brown apex.

SPECIES 9. *S. laciniata*, Ach.

Specimen 1.—Xalapa, Mexico, HARRIS; in Herb. Hooker, Kew. This is a large, handsome species. The spermogones are subpapillæform, sometimes flattened, scattered abundantly about the ends of the lobes.

SPECIES 10. *S. faveolata*, Del.,

A native of equatorial America and Australia.

Specimen 1.—Chili, LOBB; in Herb. Hooker, Kew. The spermogones are minute, depressed brown points, scattered on the rugæ, precisely as in *S. pulmonacea*.

Specimen 2.—Var. *Richardi*, MONT. (sub *Sticta*); which occurs in Chili, Australia, the Auckland Islands, and New Zealand. A specimen from New Zealand, 1853, in Herb. Hooker, Kew, greatly resembles *S. pulmonacea* in its linear laciniæ, and its punctiform spermogones distributed on the thalline rugæ.

SPECIES 11. *S. obvoluta*, Ach.

Specimen 1.—On the trunks and branches of trees in hill woods, Juan Fernandez, 1830; in Herb. Hooker, Kew; a very beautiful species, with marginal large handsome apothecia. The spermogones are the largest I have found in either the genus *Sticta* or *Ricasolia*. They are large papillæ, or cones of the thallus, paler than the surrounding surface; sometimes confluent, and then becoming irregular tubercles. The cones are usually crowned by a brown apex, varying greatly in size, but resembling the disk of an apothecium. The ostiole is sometimes visible in the centre of this brown apical spot. The spermogones are scattered over the whole surface of the thallus, and bear a close resemblance to nascent apothecia. Interspersed among the spermogones are numerous small, round, soredic warts. The spermatia are about $\frac{1}{7000}$th long, rod-shaped, with a breadth of $\frac{1}{20,000}$th; on the usual arthrosterigmata of *Sticta*. In connection with NYLANDER's division into *Sticta* and *Ricasolia*, according as the spermogones are punctiform or papillæform, it is note-worthy here, that the papillæform or mammillar spermogones are larger than in any species of *Ricasolia* I have yet met with!

SPECIES 12. *S. xanthosticta*, Pers.

(Syn. *lutescens*, TAYL.); a species allied to *S. filicina*, which is found in America, the Canary Islands, and Java.

Specimen 1.—Jamaica, PURDIE; in Herb. Hooker, Kew. The spermogones are very minute, brown papillæ, scarcely discernible even under the lens.

SPECIES 13. *S. carpoloma*, Del.

(Syn. *S. impressa*, TAYL.); a species which inhabits equatorial America, Polynesia, and Java. This is a very large and handsome species, having a pale-coloured thallus; hence the spermogones are usually more or less distinct and easily seen.

Specimen 1.—New Zealand, Antarctic Expedition, 1839–43, Dr HOOKER, Kew. The surface of the thallus is smoothish; its under surface fibrillose and pale-coloured; the apothecia marginal. The margins of the thalline lobes or laciniæ are studded over with irregular cushion-like warts, which are soredic, and have no connection either with apothecia or spermogones. The spermogones are either papillæform or punctiform; when the former, they are chiefly scattered about the margins of the lobes; when the latter, they are either distributed over the whole surface of the thallus, or confined to the rugæ, with which it is marked, as in *S. pulmonacea*. When seated on the rugæ, they are frequently disposed in a linear series; they are then usually brown and depressed, resembling the pricks of a needle-point. The thallus is sometimes somewhat raised round the ostiole, to which it gives the appearance of being girt by a ring or border. TAYLOR's name, *impressa*, was probably given in allusion to the punctiform, depressed spermogones so abundantly scattered over the rugæ. The spermatia are rod-shaped, and about $\frac{1}{8000}$th long. The sterigmata consist of short, thick-walled, cubical cellules, precisely as in *S. pulmonacea*.

Specimen 2.—Another specimen from New Zealand (sub nom. *S. impressa*, Tayl.), in the Herbarium, Royal Botanic Garden, Edinburgh, is of enormous size,—at least 1 foot in diameter. The spermogones are punctiform and immersed wholly; they are either seated on the rugæ, or scattered over the general surface of the laciniæ towards their ends.

Specimen 3.—Brazil, in Herb. Hooker, Kew (also sub nom. *S. impressa*, Tayl.). The spermogones are very distinct, punctiform, and depressed, dotting over the here very prominent rugæ. Another specimen in Herb. Hooker (habitat not given), has spermogones irregularly scattered over the whole surface of the thallus, sometimes papillæform, sometimes punctiform; in the latter case usually flat, seldom depressed.

Species 14. *S. orygmæa*, Ach.,

Which occurs in equatorial America, Australia, and the Antarctic Regions.

Specimen 1.—Lord Auckland Islands, Antarctic Expedition 1839–43, Dr Hooker. The spermogones are either papillæform or punctiform; more frequently the latter. In the punctiform state, they resemble those of *S. pulmonacea*, but are larger and more distinct. They are scattered chiefly on the rugæ of the thallus, and are very abundant. The spermatia are rod-shaped and about $\frac{1}{8000}$th long; the arthrosterigmata have the usual characters of the genus *Sticta*. The body of the spermogone is a whitish, dense, hard kernel, easily enucleated, as is generally the case in the spermogones of *Sticta*.

Specimen 2.—Chiloe, Cuming; in Herb. Hooker, Kew. The spermogones are abundant about the edges of the lobes; they are minute black points, generally slightly depressed. Sometimes they are papillæform, or the ostioles have a slight ring of thallus surrounding them.

Species 15. *S. flavicans*, Hook. fils., and Tayl.

I have great doubt as to this being properly a separate species; but I am not prepared to say to what species it is best referrible.

Specimen 1.—Falkland Islands, Antarctic Expedition, 1839–43, Dr Hooker. This is a large and handsome species, with abundant and very distinct spermogones. These organs are usually punctiform and depressed, minute, black or brown round spots. Sometimes they are surrounded by a sub-prominent thalline margin; sometimes they are seated on distinct, thalline papillæ, and the spermogones have then the aspect of those of *Ricasolia herbacea*. From the beautiful yellow colour of the thallus, the spermogones of this species are among the most distinct of those in the genus *Sticta*. The ostiole is generally not perceptible; sometimes it is distinct in the centre of each of the brown or black round spots above referred to, as a round or stellate-fissured perforation.

Specimen 2.—Hermite Island, Cape Horn, Antarctic Expedition, 1839–43, Dr Hooker; no apothecia. The spermogones are usually sub-papillæform, scattered sometimes over the whole surface of the thallus, sometimes over the margins of the lobes only. They are flattened and not prominent, the ostiole is almost always depressed. The body of the spermogone is a hard white kernel, easily enucleated. The spermatia are about $\frac{1}{8000}$th long; the sterigmata are those of *S. pulmonacea*.

Species 16. *S. D'Urvillei*, Del.,

Which occurs in equatorial America, and in New Zealand.

Specimen 1.—Chili, Lobb; in Herb. Hooker, Kew. This plant seems identical with *S. flavicans*, Hook.; and its spermogones are precisely similar.

Species 17. *S. endochrysa*, Del.

Specimen 1.—Andes, Lobb; in Herb. Hooker, Kew. The spermogones are scattered near the periphery of the thallus; they are largish, brown, round spots, flat, or on the apex of slightly elevated thalline papillæ.

Species 18. *S. gilva*, Ach.

Specimen 1.—Juan Fernandez; in Herb. Hooker, Kew. The spermogones are flat, punctiform, brown, scattered over the surface of the lobes of the thallus.

Specimen 2.—Rocks, sea-side, Uitenhage, Cape of Good Hope (sub nom. *S. crocata*, Ach., var. *β. gilva*, Ach.) The spermogones are scattered about the ends of the lobes; they are black or brown minute points, generally flat, sometimes papillæform.

Species 19. *S. aurata*, Ach.,

Which has a wide geographical distribution, being found in India, America, Africa, Asia, Polynesia, and Australia.

Specimen 1.—Coll. Salwey; in Herb. Hooker, Kew. Supposed to be an *English* specimen; but no habitat is given! The thallus bears no apothecia; but old and degenerate spermogones occur as minute, irregular, brown dots scattered abundantly about the periphery of the lobes.

Specimen 2.—On trees, Minas-Geräes, Brazil, 1840; on trees, at an elevation of 7500 feet on the Cordillera, Oaxaca, Mexico; coll. H. Galeotti, 1840; both in Herb. Hooker, Kew. The spermogones are old and degenerate chiefly; they occur as largish black disks or rings; flat, seldom sub-papillæform or depressed; sometimes maculiform.

Specimen 3.—Norfolk Island, Fr. Thompson; in Herb. Hooker, Kew. The thallus is very handsome; about 1 foot in diameter, of a beautiful lake-colour. The spermogones are abundant, large, papillæform, frequently with a deeper coloured ring or macula surrounding them. In another specimen, also in Herb. Hooker, from New Holland, both apothecia and spermogones are abundant.

SPECIES 20. *S. glabra*, Tayl.

I do not regard this as a good species, but I am not prepared to allocate it.

Specimen 1.—Falkland Islands, Antarctic Expedition, 1839–43, Dr HOOKER. In the character of its thallus, as well as of its spermogones, it closely resembles *Ricasolia herbacea.* The latter organs are abundant about the margins of the lobes, as large distinct papillæ, marked on the apex by a round, brown spot which surrounds the ostiole. Sometimes they are grouped in twos or threes, though they are usually scattered singly; but they are seldom or never confluent. The spermatia are rod-shaped, and from $\frac{1}{6000}$th to $\frac{1}{8000}$th long; the sterigmata are composed of short, cubical, thick-walled cellules.

SPECIES 21. *S. pallida*, Hook. fils.

Specimen 1.—On the branches of decayed and live trees; forests, Kaipara, New Zealand, coll. by S. MOSSMAN, 1850, No. 788; in Herb. Royal Botanical Garden, Edinburgh. This species appears to belong to the *S. pulmonacea* group of *Stictas ;* its laciniæ are narrow and sub-linear; the lacunæ deep; the rugæ correspondingly prominent; the spermogones studded over these rugæ, immersed and punctiform.

GENUS II. RICASOLIA, DN., *Nyl.*

The separation of this genus from *Sticta*, I have already pointed out, appears to me to be an exceedingly arbitrary and mischievous one. So far as the spermogones are concerned, most assuredly no distinction can be drawn between the two genera, for I have shown, under *Sticta*, that several species of that genus have papillæform spermogones as large as, nay even sometimes larger than, thoseof any of the *Ricasolias*, while others have papillæform spermogones of the same character as those of *Ricasolia*, though somewhat smaller. I have also shown that it is very common for the same species of *Sticta* to have indiscriminately, papillæform or punctiform spermogones, which latter may further possess flat or depressed ostioles. Precisely the same thing occurs in *Ricasolia.* In *R. corrosa* and *R. Kunthii*, I have found the spermogones either papillæform or punctiform, the latter with depressed or flat ostioles. In *R. dissecta*, the spermogones are usually punctiform and depressed, exactly as in the *S. pulmonacea* group of *Stictas.* Sometimes, in *R. dissecta*, as is frequently the case in the *Stictas*, the ostiole is surrounded by a sort of thalline ring. Here also the spermogones are rarely papillæform. In *R. crenulata*, again, they are usually papillæform, but small; punctiform ones, however, also occasionally occur. Sometimes a ring of thallus round a depressed or flat punctiform ostiole gives the semblance of a papillæ, when this does not really exist. The spermogones of *Ricasolia* may be described in general terms as precisely those of *Sticta*, with the single exception, that they are more generally large and papillæform, resembling nascent apothecia. They are generally so large as to be visible to the naked eye, as in *R. herbacea*. Their diameter in this species is about $\frac{1}{20}$th to $\frac{1}{25}$th; in *R. glomulifera*, $\frac{1}{25}$th to $\frac{1}{30}$th. They are frequently confluent, in which case they become still larger irregular tubercles, with a somewhat depressed apex. Occasionally the spermogones are flat, lurid, or deep-brown maculæ, as in certain forms or varieties of *R. glomulifera*. The ostiole is usually small and round; with age, it becomes frequently stellate-fissured, or it expands into a saucer-shaped cavity, with dark, turgid, irregular edges, when the nucleus or body of the old spermogone falls out. The thallus is sometimes studded over with black, very irregular perforations, where there existed old spermogones, whose nuclei have fallen out. The patent irregular ostiole frequently gives the spermogonal papilla the aspect of a young apothecium, as in *R. herbacea* and *R. glomulifera*. In regard to *site*, the spermogones may be either scattered over the general surface of the thallus, or chiefly on or about the margins of the lobes. They are peripheral in *R. dissecta*, *crenulata*, *Kunthii*, and *coriacea*. Sometimes they occur on large, deformed, wart-like growths of, and from, the thallus, resembling those of *Parmelia saxatilis*, on which *Lecidea Smithii* grows. Occasionally they are met with, seated directly on the margins of the lobes, to which they give a coarsely denticulate character, as in the analogous form of *Parmelia perforata*. Here they are rather barrel-shaped than mammillar or papillæform. The internal tissue, spermatia and sterigmata, are quite those of *Sticta*. The typical species of the genus, *R. herbacea* and *R. glomulifera*, were formerly included among the *Parmelias* by SCHÆRER and other authors, but I long ago pointed out that they really belong to *Sticta*.*

SPECIES 1. *R. herbacea*, DN.,

Which occurs in Europe and America. The spermogones are usually abundant and very distinct; hence this is one of the best species in which to study the spermogones of *Ricasolia*. *Parmelia perlata* is not unfrequently confounded with it; but the character of the spermogones suffices at once to distinguish these two lichens,—those of the *Parmelia* being punctiform, very minute, black, and immersed. The large papillar or mammillar spermogones of *R. herbacea* have the same tint as the thallus, of which they appear to be elevations, with the exception of the ostiole, which is in the centre of a brown areola or spot seated on the apex of the cone. The spermogones are flattened or depressed at the apex; they closely resemble young apothecia; and the only safe way of distinguishing them is by microscopic examination. The internal tissue is white, dense, horny, semi-transparent when moistened, of a grayish or pale rose tint.

* Popular History of British Lichens. London, 1856, pp. 189 and 191.

Specimen 1.—On old trees, Inverary; in Herb. Botanical Society, Edinburgh; coll. by MAUGHAN; apothecia abundant. The spermogones are plentiful, scattered about the periphery of the thallus as regularly formed, very prominent cones or papillæ, readily visible to the naked eye. The ostiole is brown, circular, apical, distinct. The sterigmata are ramose, thick, irregular in outline, formed of short, cubical, or irregularly shaped articulations or cellules, which have very thick walls. With age, they acquire a greenish tint. From among these project a number of long, sterile, ramose, articulated filaments, of the character of those of *Ramalina*; but neither so delicate nor so ramose. The spermatia are longer than is usual in *Sticta*, being about $\frac{1}{5000}$th to $\frac{1}{6000}$th long; they are found in abundance only in the youngest spermogones.

Specimen 2.—On young oak, Cawdor Wood, Nairn; coll. A. CROALL; in Herb. Hooker, Kew. Spermogones are plentiful, but there are no apothecia. Appin; coll. CARMICHAEL; in very large patches, with both apothecia and spermogones; also in Herb. Hooker.

Specimen 3.—Kerry, Ireland; in woods; TAYLOR in Herb. Mackay, Dublin. The spermogones are abundant; the older ones become flattened, and have a stellate-fissured, large, brown ostiole. The spermatia are $\frac{1}{6000}$th to $\frac{1}{7000}$th long, and $\frac{1}{20,000}$th broad; the sterigmata are about $\frac{1}{6000}$th broad.

Specimen 4.—Killarney; in Herb. Royal Botanical Garden, Edinburgh; with apothecia. Spermogones large and abundant.

Specimen 5.—Lachen, Sikkim, Himalaya, alpine region, at 11,000 feet, Dr HOOKER; in Herb. Hooker, Kew; with apothecia. Some of the spermogones are seated directly on the margin of the thallus, forming a kind of teeth, as in the denticulate form of *Parmelia perforata*. Their form is more that of a barrel than of a cone.

Specimen 6.—South Africa, DREGE (sub nom. *Sticta quercizans*, Ach.); Dax, Pyrenees, SPRUCE'S "Lich. Pyrenæi;" in Herb. Hooker, Kew. In both the spermogones are plentiful.

Specimen 7.—LEIGHT. exs. 75 (sub *Sticta*, Delise, "Eng. Bot." 294); Ayrshire. The spermogones are subperipheral, large, and frequently confluent.

Specimen 8.—SCHÆRER exs. 560 (sub *Parmelia lætevirens a. simplex*). On trunks of trees about Vire, PELVET. Spermogones are plentiful. The spermatia are about $\frac{1}{5000}$th long; the sterigmata $\frac{1}{500}$th to $\frac{1}{600}$th long,

SPECIES 2. *R. glomulifera*, DN.,

Which occurs in Europe, America, and Asia.

(Syn. *Sticta amplissima*, KÖRB, 68; *Parmelia*, Ach.) The spermogones are exactly those of the preceding species, but they are scarcely so prominent.

Specimen 1.—On old beech trees, Inverary Woods; in Herb. Botanical Society, Edinburgh; with apothecia and glomeruli. The spermogones are plentiful, but old, containing no free spermatia. They are scattered about the margins of the lobes of the thallus, and closely resemble nascent apothecia, of which the brown, round, saucer-like ostioles somewhat resemble the disks.

Specimen 2.—Minto Craigs, Roxburghshire; Glen Lyon, Breadalbane, coll. by Rev. HUGH M'MILLAN; both in Herb. Royal Botanical Garden, Edinburgh. Both specimens are spermogoniferous; neither have apothecia; and the Glen Lyon specimens have enormous glomeruli. In them the spermogones occur abundantly as lurid or brownish-red round macules, resembling the apothecia of *Arthonia lurida*.

Specimen 3.—SCHÆRER exs. 559 (sub *Parmelia amplissima*, Scop.). Trunks of trees about Vire, PELVET. The specimen has only two or three old spermogones, containing no free spermatia.

Specimen 4.—Col de Lourvie, Pyrenees; "without glomeruli always in this locality," remarks the Rev. CHURCHILL BABINGTON on the label in SPRUCE'S "Lich. Pyrenæi," in Herb. Hooker, Kew. Besides the ordinary form of spermogones, some are distributed on irregular, large, wart-like growths of and from the thallus, resembling those of *Parmelia saxatilis*, on which *Lecidea Smithii* and *L. oxyspora* grow. These growths are subfoliaceous, of a deeper brown than the thallus, and manifestly distinct therefrom, or at least not a normal or usual part thereof. Over these wart-like growths are dotted the ostioles of immersed spermogones, which are brown, round, and rather larger than in the usual form of the spermogones. Under moisture, they swell so as to become small subgelatinous cones. The spermatia are about $\frac{1}{6000}$th long, and $\frac{1}{20,000}$th broad.

SPECIES 3. *R. coriacea*, Tayl.

Specimen 1.—New Zealand; in Herb. Hooker, Kew. The spermogones resemble those of *R. herbacea*; but they are smaller and more abundant. They are crowded about the margins of the lobes, are papillæform, sometimes confluent and tuberculiform, with a brown apex.

SPECIES 4. *R. discolor*, Ach.,

Which inhabits the Isle of Bourbon, Madagascar, and Java.

Specimen 1.—Muckross, Ireland; on trees, 1828; in Herb. Hooker, Kew; named by NYLANDER himself. This appears to me simply our British *R. herbacea*, with a more delicate thallus than usual, but having apothecia and spermogones quite of the usual type. The spermatia are about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad.

SPECIES 5. *R. crenulata*, Hook.

Specimen 1.—On twigs, Juan Fernandez; in Herb. Hooker, Kew. In regard both to its apothecia and spermogones, this species stands near *R. herbacea* and

R. glomulifera. The spermogones are smaller than in these species; they are small papillæ, marked on the apex by a depressed, black, punctiform ostiole. They are scattered about the margins of the lobes. The spermatia are about $\frac{1}{6000}$th long and $\frac{1}{25,000}$th broad; the sterigmata are $\frac{1}{300}$th to $\frac{1}{500}$th long, and $\frac{1}{6000}$th broad.

SPECIES 6. *R. dissecta*, Ach.

Specimen 1.—Casapi, Peru, MATTHEWS; in Herb. Hooker, Kew; in large handsome patches. The spermogones are scattered sparingly about the periphery of the lobes, usually as depressed, round, black points. Though generally flat or depressed, they sometimes become papillæform. Occasionally they are surrounded by a sort of ring of the thallus, well marked. When old, they appear frequently as largish black rings or disks, with a stellate-radiate fissure. The thallus is sometimes studded over with very irregular black perforations, where old spermogones existed, and the bodies or nuclei have fallen out.

SPECIES 7. *R. corrosa*, Ach.,

A native of equatorial America.

Specimen 1.—(Sub nom. *Sticta dissecta*, Ach.); from Mr DICKSON; in Herb. Hooker, Kew. No habitat is given; but it would appear to be from Scotland, as all Mr DICKSON's other collectanea are Scotch! The spermogones are sometimes punctiform, sometimes papillæform: in the former case they are usually depressed, in the latter they possess a distinct, brown, round ostiole. The body of the organ is a large, white, hard kernel, as in all *Stictas* and *Ricasolias*.

SPECIES 8. *R. Kunthii*, Del.

Specimen 1.—Organ Mountains, Brazil; probably coll. by GARDNER; in Herb. Hooker, Kew. The spermogones are very abundantly scattered about the periphery of the thallus. They are usually round brown spots or points, flat, or sometimes depressed; occasionally surrounded by a paler ring of the thallus, which gives them a pseudo-papillate appearance. They are seldom distinctly papillæform.

Specimen 2.—Chinos, Cordillera (Oaxaca), Mexico, at 7000 to 9000 feet of elevation; coll. by H. GALEOTTI, 1840, No. 6895 (sub nom. *Sticta fuliginosa*); in Herb. Hooker, Kew. This specimen is closely allied to, if it is not a mere form or variety of, *R. herbacea*. Its apothecia and spermogones, spores and spermatia, are the same as in that species.

GENUS III. PARMELIA, *Ach.*, *Nyl.*

In this large and comprehensive genus the spermogones are chiefly black, punctiform, wholly immersed in the thallus, and scattered about the periphery of the thallus and on the convexities of the laciniæ, where the thallus is divided into narrow, linear, or sub-linear segments. These black points are the ostioles, which are usually round and very minute, but which are sometimes elongated, even lirellæform, as in some forms of *P. sinuosa*. Sometimes the punctiform ostiole is perched on a pale thalline papilla or wart, as in some forms of *P. tiliacea*. As in most lichens, the ostiole, in the old state, is generally large and gaping, and it then frequently has a prominent ring-like border. The thallus is sometimes studded over with black, large, irregular perforations—frequently lacerate or stellate-fissured—as in *P. stygia*, *P. tristis*, and *P. saxatilis*, var. *omphalodes*. The black punctiform spermogones frequently resemble parasitic *Sphæriæ*, for which they were generally or often mistaken by earlier lichenologists. Seldom are they distinctly papillæform, tuberculiform, or barrel-shaped, as in *P. perforata* var. *denticulata*. In the latter lichen, which is altogether an exceptional and anomalous one, the spermogones are very large barrels, studded on, and forming part of, the margins of the lobes, precisely as in the genus *Platysma*. What is still more curious, they either occur alone, or they are associated on the same specimen with the ordinary black, punctate spermogones of *P. perforata*. Generally, the punctiform ostioles are extremely minute, as in *P. saxatilis*; they are of the same character, but rather larger and more distinct in *P. perlata*, *P. physodes*, *P. tiliacea*, *P. perforata*, and *P. conspersa*. From the fact that the ostiole, or that part of the apex of the spermogone which generally projects or is most visible on the surface of the thallus, is black usually, while the colour of the thallus itself is glaucous or gray, the spermogones of *Parmelia* are generally readily recognised. They are usually scattered, in considerable numbers, outside the region of the apothecia, on the surface of the thallus. In exceptional cases, they are confined to the margins of the laciniæ or lobes, to which they give a more or less denticulate character. On the flattened linear laciniæ of *P. tristis* they are small, and not very prominent; but in var. *denticulata* of *P. perforata* they are very large and conspicuous. Sometimes they are distributed on the flat surface of digitate expansions from the margins of the thallus, as in a form of *P. perforata* from the Organ Mountains, Brazil. Occasionally they are dotted over the exciple of the apothecia, and even on the saucer-like cavities left by the falling out of the disk in degenerate apothecia, as in *P. conspersa*. In number the spermogones are generally considerable, even when merely dotted over the margins of the lobes. But sometimes they are dotted in great profusion over the whole surface of the thallus, as in *P. encausta*, *P. olivacea*, *P. stygia*, and *P. conspersa*. In the last-named species the name might be supposed to have been given in allusion to the great abundance of the spermogones. The walls or envelope of the spermogones are generally thick, and of a brown cellular tissue; they are frequently of the same structure as the epidermic or cortical layer of the thallus. The cavity is usually simple; the internal tissue dense, horny, hygrometric, and pale grayish. In the old state of the spermogone, from the density of the internal tissue and the thickness of the walls, this organ is easily enucleated by a needle. In age, also, the cavity becomes obliterated, and is occupied by a mass or kernel-like nucleus, usually more or less spherical, of a horny consistence, and sometimes slightly coloured. The spermatia are straight, linear, and very delicate, more frequently acicular, with pointed ends, than rod-shaped, with obtuse extremities. NYLANDER describes them as very slightly attenuated in the middle. This I have not specially noticed. Their length varies from $\frac{1}{3000}$th to $\frac{1}{6000}$th, the average being about $\frac{1}{4000}$th; seldom are they so small as $\frac{1}{8000}$th to $\frac{1}{10,000}$th long, as in some forms of *P. Fahlunensis*. Sometimes, as in some forms of *P. tiliacea*, they are double the length when attached that they are when free. In this instance, while still attached to the sterigmata, they measure $\frac{1}{1200}$th to $\frac{1}{2000}$th long, and when thrown off and free, $\frac{1}{2500}$th to $\frac{1}{3000}$th. In such cases it would appear probable that, after becoming free, the spermatia divide into two equal segments. The breadth of the spermatia generally varies from $\frac{1}{20,000}$th to $\frac{1}{30,000}$th, or it is inappreciable. The sterigmata are generally longish, very narrow and delicate, consisting of 2-3, or 5-6 linear elongated cells, which are sometimes articulated, united, or superimposed at very irregular angles. Their length generally varies from $\frac{1}{750}$th to $\frac{1}{1500}$th, their breadth from $\frac{1}{8000}$th to $\frac{1}{10,000}$th. They are sometimes $\frac{1}{500}$th to $\frac{1}{400}$th long in *P. tiliacea*, in which species the sterigmata are among the longest and most handsome I have seen. In many species, associated with the ordinary spermatiferous sterigmata, occur numerous elongated, very ramose, sterile, delicate filaments, resembling those of *Ramalina*,—as in *P. physodes*, *P. stygia*, and *P. sinuosa*. In the latter species they are about $\frac{1}{500}$th long. These anastomosing filaments serve to fill up the cavity of the spermogone. *Pycnides* occasionally occur in *Parmelia*. It may be doubted by some whether they really belong to the species on which they occur. But their occurrence among the undoubted spermogones of the species, all of whose external characters they possess, and the acknowledged existence of pycnides in other lichens, similar to those of many fungi, seem to me strong reasons for regarding them as really pertaining to the lichens, on whose thallus they are found. They are in all respects similar to spermogones, except in regard to their stylospores and sterigmata. I found them chiefly in two Irish specimens, *P. saxatilis* from Connemara, and *P. sinuosa* from Dunkerron. From their abundance and prominence, the genus *Parmelia* is a good one in which to study spermogones.

SPECIES 1. *P. caperata*, Ach.,

Which occurs in Europe, Africa, America, Asia, and Australia.

Specimen 1.—Great stones, near Penzance, Cornwall; in Herb. Hooker, Kew. The thallus is very large and handsome—nearly a foot in diameter. Where the cortical layer is intact, the surface of the thallus is very rugose and warted. But the thallus is nearly altogether devoid of a cortical layer, which has been eroded, exposing the subjacent white, medullary tissue. So much so is this the case, that the plant is scarcely recognisable as *P. caperata.* Apothecia, which are usually rare, are here abundant. The spermogones are punctiform and immersed—black when dry, brown when moistened; they are most irregular as to size and form, often chink-like, sometimes confluent. They are dotted over the rugose or warted portions of the thallus; but they are most conspicuous on the white eroded portions, their brown colour forming a good contrast to the white of the medullary tissue. The body of the organ is spherical, and its cavity simple.

Specimen 2.—Fermanagh, Ireland; Dr SCOTT, 1803; wood, near Camelford, England, 1799; in Herb. Hooker, Kew. The thallus is coarsely warted, the warts or rugosities being studded over with punctiform spermogones, as in No. 1.

Specimen 3.—Tasmania, very common; OLDFIELD; in Herb. Hooker, Kew. The spermogones are more distinct and abundant in this specimen than in any others of this species I have examined. They are distributed chiefly centrally on the thallus, but to a minor extent peripherally, and on specimens not bearing apothecia. The thallus is very rugose, and often consists centrally of a series of large cushion-like warts, which are abundantly studded over with spermogones, resembling parasitic *Sphæriæ.* These spermogones are comparatively large, black, round rings or spots, superficial, flattened, varying in size, sometimes confluent and irregular, never distinctly papillate. In the centre of these rings or spots are the simple, round ostioles. The envelope is of a sooty black colour; the body of the spermogone is easily enucleated. The spermatia are acicular, about $\frac{1}{4000}$th to $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad. KÖRBER very erroneously describes them, as in this species *atomic and globular*, which they certainly never are, according to my observations. The sterigmata usually consist of two, or not more than three, elongated linear cells, articulated at irregular angles; their length is about $\frac{1}{1500}$th. The spermogones, which occur about the more flattened and simple margins of the thallus, are more usually simply punctiform, and wholly immersed; nor are they so crowded as centrally.

SPECIES 2. *P. perlata,* Ach.

Almost a cosmopolite, as well as its well-marked but puzzling variety, *ciliata*, DC., which occurs in Europe, Africa, America, Asia, and Australia. This is a very variable lichen. Many forms of it, especially var. *ciliata*, so strongly resemble *Platysma glaucum* as to be constantly mistaken therefor; others closely resemble forms of *P. sinuosa*, *tiliacea*, and other species. It passes into the next species, *P. perforata*, which I regard, indeed, as a mere variety of *P. perlata.* Its spermogones are generally black, punctiform, immersed, and scattered about the margins of the lobes of the thallus. Its spermatia are acicular and of medium size; its sterigmata are composed of a few linear articulations.

Specimen 1.—Old wall, Caerlaverock Road, Dumfries, August 1856, W. L. L. The edges of the thallus are marked by the presence of a few rudimentary cilia; the surface is fibrillose beneath; there are marginal soredia on some lobes. The spermogones are few, depressed, punctiform; the spermatia about $\frac{1}{4000}$th long; the sterigmata of several cylindrical cells, irregularly articulated.

Specimen 2.—Banks of Crinan Canal, Argyllshire, August 1856, W. L. L. The margins of some of the lobes are sorediiferous, of others black-ciliate. The spermogones are abundantly scattered about the edges of the lobes. The spermatia vary in length from $\frac{1}{6000}$th to $\frac{1}{4000}$th; the sterigmata consist of cylindrical cells, differing in length and breadth. Projecting from among the ordinary spermatiferous sterigmata occur many elongated, articulated, sterile ones, analogous to those of *Ramalina*.

Specimen 3.—Dunkerron, Ireland; coll. by TAYLOR; in Herb. Mackay, Dublin; with apothecia. The margins of the thallus are ciliate. The spermogones are few, and chiefly old, containing no free spermatia.

Specimen 4.—SCHÆRER exs. 360; trunks of trees, Switzerland. Here the spermogones are somewhat exceptional in their characters; they appear to be old and hypertrophied, and contain no free spermatia. They are small, brown, semi-translucent, grain-like bodies, dotted thickly about the edge of one or two lobes.

Specimen 5.—Karin Pass, Kumaon, Himalaya, at an elevation of 7500 feet, Dr HOOKER; in Herb. Hooker, Kew; with apothecia. The plant closely resembles *Platysma glaucum*. The spermogones are as above described. Jamaica, PURDIE (sub nom. *P. perforata*); a very handsome specimen. Spermogones are large and abundant. Teneriffe; rocky parts of Lagura, 1845; BOURGEAU "Pl. Canar." No. 1088 (erroneously labelled *P. conspersa*). The margins of the thallus are ciliate. Teneriffe; common in the woods, 1845. BOURGEAU, "Pl. Canar." No. 1098. The spermogones abound about the margins of the lobes.

Specimen 6.—Canary Islands, ex. Herb. Webbianum; in Herb. Hooker, Kew. This is exactly the plant that is imported, under the name of "Canary Rock Moss," from the Canary Islands into London for the Orchill manufacture. It bears no apothecia; centrally it is frequently sorediiferous or isidiiferous; it sometimes possesses terminal soredia also. In consistence or texture the thallus is leathery and thick; its surface is variously cracked and reticulated. The spermogones are abundant and large.

Specimen 7.—Caribbean Islands, H. SMEATHMAN; Jamaica; both in Herb. British Museum. Neither bear apothecia; the latter has a ciliate margin. Both have abundant spermogones. These, and most of the specimens above enumerated, are referrible to the var. *ciliata* of *P. perlata*; but in none of them is the ciliation of the margin so prominent or so constant as in those which follow.

Specimen 8.—Var. *ciliata*; on trees, Castle Bernard, Cork; coll. CARROLL (sub nom. *P. perforata*). The *P. perforata* of Hook, "Engl. Flora," p. 200; of

Acharius, of Leight. exs. 112, and of E. B. t. 2423, seem to me referrible to *P. perlata*. The confusion between *P. perforata* and *P. perlata* is constant, and the only way to avoid this for the future is, as I certainly do, to regard the former as a mere variety of the latter. Specimens with perforate apothecia are not at all common in the so-called *P. perforata*, and even when they do occur, they are not peculiar to this species, but are found as an accidental condition in various *Parmelias*. The majority of specimens of *P. perforata* I have seen are referrible to var. *ciliata* of *P. perlata*. To the same variety of the same species I am inclined to refer *P. proboscidea*, Tayl., "Fl. Hib.," 143.. This Castle Bernard specimen has spermogones of the usual type of those of *P. perlata*.

Specimen 9.—Var. *ciliata*, SCHÆRER exs. 253 (sub *Cetraria glauca β. fallax*, Ach.); in woods on Mount Gurnigel, Switzerland. The spermogones are old, containing no free spermatia; they are dotted over the margin of the thallus. SCHÆRER has here made the very common mistake of confounding *P. perlata* with *Platysma glaucum*, whose marginal spermogones, as well as spermatia and sterigmata, however, at once distinguish it.

Specimen 10.—Var. *reticulata*, Tayl. (syn. *P. reticulata*, Tayl. "Fl. Hib." 148.) TAYLOR's plant seems to me partly referrible also to *P. sinuosa*. Dunkerron, Ireland; coll. TAYLOR, in Herb. Mackay, and named by TAYLOR himself. The plant is most variable; some of its lobes are broad and rounded, as in *perlata*; others narrow and sub-linear, as in *sinuosa*. The larger lobes are ciliate, precisely as in var. *ciliata* of *P. perlata*; the smaller ones are frequently tipped with soredia as in *sinuosa* and its var. *lævigata*. The reticulations, which give the plant its name, are merely cracks or fissures of a thick, coriaceous, old thallus. The plant bears no apothecia; but its spermogones are sub-marginal, and as described in other forms of *P. perlata*. The same plant occurs also (collected by TAYLOR) in Herb. D. Moore, Glasnevin, Dublin. New Zealand specimens of TAYLOR's *P. reticulata* in Herb. Hooker I refer rather to *P. sinuosa*.

Specimen 11.—Var. *lætiformis*, Fée (sub *Parmelia*), Cuba, ex. Herb. Montagne; in Herb. Hooker, Kew. This is a very curious variety, in which the thallus is very rugose and warted, as in *P. caperata*, chiefly centrally, but the warted condition extending also almost to the margins of the thallus. The apothecia are very abundant and crowded, but all are degenerate; the disk has fallen out, and the saucer-shaped cavity which contained it is of the same colour and substance as the exciple. The exciple is thick and warted; and the apothecia, which vary much in size, resemble so many warts of the most irregular forms. The thallus and apothecia are indiscriminately studded over with black, immersed, punctiform spermogones, as frequently also happens in *P. conspersa*. The spermatia are rod-shaped, $\frac{1}{5000}$th long and $\frac{1}{25,000}$th broad. The sterigmata consist of cylindrical, somewhat irregular cells, articulated at very acute angles; they vary in length from $\frac{1}{750}$th to $\frac{1}{1500}$th, with a breadth of $\frac{1}{10,000}$th.

SPECIES 3. *P. perforata*, Ach.,

Which occurs at the Cape of Good Hope, in America, Polynesia, and Australia. Like the preceding, to which I believe it chiefly belongs, it is a most variable and puzzling plant. It is non-British, but frequent in warm climates; *supposed* British specimens are all referrible to *P. perlata*. The examination of a considerable suite of foreign specimens in the Hookerian Herbarium, named by NYLANDER himself, convinces me that the majority of foreign, equally with British specimens, is referrible to *P. perlata*, and that the perforate state of the apothecia is a most variable and unsatisfactory feature in either *P. perforata* or *P. perlata*. The normal spermogones of *P. perforata* would appear to be essentially those of *P. perlata*, being black, punctiform, immersed, and scattered on the flat surface of the thallus near its periphery. When degenerate, or aged, they sometimes become mere black maculæ. In exceptional cases, the apothecia, as in var. *lœtiformis* of *P. perlata*, are studded over with spermogones. But the most interesting feature in regard to the spermogones is the occurrence, in var. *denticulata*, on the margins of the lobes, of enormous barrel-shaped ones which appear like a fringe or series of coarse black teeth. Sometimes these occur alone, or as the only form of spermogone; at other times, they are associated in the same specimen with the ordinary black punctiform spermogones. It is of much interest here to notice the double form of spermogone; the fact tends to prove that the lichens, as well as the fungi, may have several forms of reproductive organs, and that there is nothing more unnatural in supposing the lichens possessed of spermogones and pycnides—sometimes of more than one form of each—than in allowing that these latter organs are possessed by many fungi, which, fortunately for themselves, have been more fully studied than the lichens!

Specimen 1.—Long Island, North America, May 1856; Dr A. O. BRODIE. The apothecia are very large and abundant; they are flat, cracked, or fissured at their margins, and have a central lacerate-elongate perforation or fissure. This is undoubtedly the *P. perforata* of authors; but the apothecia and spermogones, spores and spermatia, are all those essentially of *P. perlata*. The spermogones are abundant, and, under the lens, distinct; they are scattered about the periphery of the thallus. They are minute, round, black spots, or indistinct papillæ, having their centre pierced by an ostiole, which is generally depressed. The latter is round and patent in the older spermogones; it has sometimes a sub-prominent black margin, or it may be surrounded by a pale thalline margin, not circumscribed, but passing gradually into the ordinary colour of the thallus. Rarely it is seated on a distinct papillar elevation of the thallus. The body of the spermogone is wholly immersed, and consists of a grayish tissue. The spermatia are long delicate needles, about $\frac{1}{2000}$th long, among the largest and most handsome I have seen. The same remark applies to the sterigmata, which are made up of delicate, elongated, cylindrical cells. Intermixed with them are numerous very long branching delicate filaments, as in *Ramalina*, which obscure by their abundance the ordinary sterigmata, and fill up the cavity of the spermogone. In specimens also collected by Dr Brodie, and labelled Waterville, Long Island, April 1856, there are no apothecia, and the spermogones are old. They contain only sterile, elongated, branching filaments as above described, and which, with age, accumulate in the mature spermogone so as to obliterate the spermatiferous sterigmata.

Specimen 2.—Rio Janeiro, 1846–51; from Henry Paul, Edinburgh. A very elegant and beautiful form, in which both the margins of the thallus and of the apothecia are ciliated. The spermogones are as described in No. 1.

Specimen 3.—Mahasa, Simla, North-West Himalaya; temperate region at 8000 feet; coll. by Dr Thomas Thomson; in Herb. Hooker, Kew. The thallus has a ciliate margin, and the spermogones are those of *P. perlata.* Lachen, Sikkim, Himalaya; temperate region at 9000 feet; coll. Dr Hooker; has no apothecia and no ciliate margin of thallus. Monkrum, Khasia; temperate region at 5000 feet; coll. by Drs Hooker and T. Thomson; all in Herb. Hooker, Kew. The spermogones are those of *P. perlata.* Madras, coll. Dr Hunter; also in Herb. Hooker. The margin of the thallus is slightly ciliate; the spermogones are those of *P. perlata.*

Specimen 4.—(Sub nom. *Lichen perforatus*, Jacq.), ex herb. Dickson; in Herb. Menzies, Royal Botanical Garden, Edinburgh. The apothecia are large and perforate; the margin of the thallus is furnished with long marginal cilia; and the spermogones are abundant, and of the character of those of *P. perlata.*

Specimen 5.—Var. *digitata* mihi. Ascent to the Pedra Bonita, Leguca (Brazil), 1836; coll. George Gardner; in Herb. Hooker, Kew. The margins of the thallus are prolonged into curious finger-like lobes or laciniæ, dotted over with black punctiform spermogones, which also cover a large portion of the thallus. The spermogones are largish and distinct. They occur also on a specimen from the branch of a tree in Jurajuba Bay, Rio Garda, 1837 (Gardner), in which the thallus has a rusty-red tint. In a specimen also in Herb. Hooker (with no habitat given), which is referred to *P. perlata* by Nylander, the lobes are frequently divided and prolonged into linear laciniæ, branching and dissected a good deal. These prolongations are evidently the analogues of the digitate ones in Organ Mountain specimens sent home by Gardner. They are almost invariably covered over with black, punctiform, immersed spermogones; they are fringed with long beautiful black fibrils, as are also the margins of the ordinary lobes. The apothecia here are of enormous size.

Specimen 6—Var. *denticulata*, mihi. Singalelah, Sikkim, Himalaya; alpine region at 11,000 feet; coll. Dr Hooker; in Herb. Hooker, Kew. No spermogones of the ordinary kind occur here; but on the margins of the lobes is seated a series of very large black cones, which resemble a fringe of coarse teeth. Some are rather barrel-shaped than papillæform; most of them are broad and short, and all have distinct ostioles. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are about $\frac{1}{1500}$th long, and $\frac{1}{7500}$th broad; they are very delicate, are composed of 5 or 6 delicate cylindrical articulations, and are with difficulty seen amid the dense, intertangled mass of sterile, elongated, anastomosing filaments, which project from among and far beyond them and fill up the cavity of the spermogone. The latter filaments resemble those of *P. saxatilis*, *P. physodes*, and many other *Parmelias;* but they are usually much more abundant, and they branch and anastomose in all directions. The thallus bears apothecia; the under surface and sometimes the margin are sparingly fringed with long black fibres. The spermogones here resemble those of *Platysma*, though the sterigmata, spermatiferous and sterile, differ somewhat. Were it not that in the two following specimens these spermogones are found associated with the ordinary spermogones of *P. perforata* or *P. perlata*, there might be some difficulty in deciding whether this plant belongs to *Platysma* or *Parmelia*. As it is, I have no hesitation in placing it here. The spermogones vary greatly in regard to size and closeness of apposition; hence they form a most irregular fringe or margin.

Specimen 7.—Var. *denticulata*, Munklow, Khasia, India; sub-tropical region, at 4000 feet; coll. Drs HOOKER and THOMAS THOMSON. This appears to be a transition form of great interest, inasmuch as, in addition to the large barrel-shaped marginal spermogones described in No. 6, it possesses black punctiform spermogones of the ordinary kind, dotted about the margins of the lobes. The plant bears apothecia; the margin of the thallus is slightly ciliate, and, but for the barrel-shaped spermogones, the plant has all the appearance of *P. perlata*.

Specimen 8.—Var. *denticulata*, Nepaul; in Herb. Hooker, Kew; a very large and handsome plant. Like No. 7, this possesses both forms of spermogones, the barrel-shaped ones being among the largest and most distinct I have ever met with in lichens. Besides occurring on the margins, however, they are occasionally studded on the flat surface of the lobes, near their margins. The spermatia and sterigmata are precisely as in *P. perlata*.

SPECIES 4. *P. crinita*, Ach.

Specimen 1.—Sicily Island, Ohio, U. S., America, PECK; in Herb. Hooker, Kew. This plant also seems to me referrible to var. *ciliata* of *P. perlata;* its lobes are fringed with beautiful long, delicate, black fibres. The spermogones are abundant, as they are in all extra-European forms of *P. perlata* and its congeners.

SPECIES 5. *P. tiliacea*, Ach.,

Which occurs in Europe, Africa, America, Asia, and Australia. BAYRHOFFER regards this as the type of a hermaphrodite lichen. From observations on this and other lichens, he maintains the doctrine, that spermogones are transformed, in the progress of development, into apothecia. There is certainly nothing in this species to warrant such a conclusion. The site and structure alike of the apothecia and spermogones are different. But BAYRHOFFER's views on this and other departments of physiological lichenology are now generally regarded as speculative in the extreme,—as more ingenious than sound. They will be found freely criticised in the "Flora" for 1851–2, as well as in TULASNE's Mémoire, p. 165, *et seq.* From the pale-gray colour of the thallus, the black punctiform spermogones of this species are generally easily recognised. They are usually grouped, sometimes confluent, studded about the margins of the lobes. The internal tissue is dense, horny, and of a grayish colour, the cavity simple, but obliterated with age, the whole body of the spermogone becoming a nucleus or kernel of a horny tissue. The spermogone, in its mature and old state, particularly the latter, is easily enucleated by the point of a needle. The sterigmata are about $\frac{1}{500}$th to $\frac{1}{400}$th long, and $\frac{1}{8000}$th broad; they consist of five or six delicate linear articulations. The spermatia frequently differ in length, according as they are fixed or free; in the former case they are sometimes $\frac{1}{2000}$th to $\frac{1}{1500}$th. in the latter, $\frac{1}{3000}$th to $\frac{1}{2500}$th long.

According to NYLANDER, *P. carporrhizans*, Tayl., is referrible to *P. tiliacea*. It may be so *pro parte;* but the majority of specimens I have seen are certainly referrible rather to *P. sinuosa*.

Specimen 1.—SCHÆRER exs. 358 (sub nom. *P. quercifolia a. munda*,) on the trunks and branches of trees, Mount Laügenberg, Switzerland. The spermatia and sterigmata of the black punctiform spermogones are among the most beautiful I have seen in the genus *Parmelia*. Some of the attached spermatia are $\frac{1}{1500}$th to $\frac{1}{2000}$th long, with a breadth of $\frac{1}{25,000}$th. Intermixed with the ordinary spermatiferous sterigmata are numerous elongated, sterile, ramose filaments, as in *P. saxatilis*, *P. physodes*, *P. perforata*, and other *Parmelias*. The free spermatia measure $\frac{1}{3000}$th long; some of the spermatiferous sterigmata, with the spermatia attached, about $\frac{1}{500}$th.

Specimen 2.—B. de Bigorre, Pyrenees, SPRUCE's "Lich. Pyrenæi;" in Herb. Hooker, Kew; with plentiful apothecia. The spermogones are generally crowded on the convexities, and about the ends of the lobes, of the thallus, each being perched upon, or rather contained in, a pale cone-like elevation of the thallus. The ostioles are marked by largish black points. The spermatia are needle-shaped, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata consist of five or six linear delicate cells or articulations.

Specimen 3.—Medhari Pass, Kumaon, Himalayas, at an elevation of 8200 feet; ex. Herb. Strachey and Winterbottom; in Herb. Hooker, Kew (sub nom. *P. scortea*, Ach.) The thallus is smoothish; the apothecia abundant. The spermogones are also plentiful, sometimes marked by black points, round or irregular, largish, seated on the summit of pale cone-like elevations of the thallus. Sometimes they are confluent; occasionally the black ostiole is depressed, and seated in the centre of a ring or macula of the thallus.

Specimen 4.—Tasmania, Antarctic Expedition 1839–43, Dr Hooker; in Herb. meo; a small fragment on a twig, associated with *Usnea barbata*. It has no apothecia; but spermogones are abundant about the margins of the thallus, as distinct, black, round, papillar points, sometimes flattened, but never depressed. The spermatia are delicate needles, about $\frac{1}{4000}$th long, seated on the apices and sides of articulated sterigmata, of the character described in No. 2. The cells or articulations, which compose the latter, differ much in length and breadth, though they are generally largish and cylindrical.

Specimen 5.—On trees, Blankenburg, Hartz district, Germany; coll. Hampe, 1846; exs. No. 43. Chinar, Kumaon, Himalayas, at 8700 feet; ex. Herb. Strachey and Winterbottom; apothecia and spermogones abundant. Both organs also occur plentifully in specimens from New Zealand, coll. Colenso; British North America, coll. Drummond; Ohio, U. S., America, coll. Lea (sub nom. *P. galbina*, Ach.) All these specimens are in Herb. Hooker, Kew.

Specimen 6.—(Sub nom. *P. submarginalis*, Ach.) Canada, Carolina, and other parts of North America; in Herb. Hooker, Kew. This is a small form of the thallus, but the apothecia and spermogones alike are essentially those of *P. tiliacea*. The spermogones are black, punctiform, wholly immersed, and scattered about the ends of the lobes on their flat surface.

Species 6. *P. sinuosa*, Ach.

Almost a cosmopolite species. It is a most variable and puzzling species, and so closely resembles *P. perlata*, *P. perforata*, *P. saxatilis*, *P. tiliacea*, and other *Parmelias*, as to be frequently confounded therewith. The apothecia are seldom met with, and the spermogones are generally neither abundant nor very distinct. There are several important varieties more or less well marked, viz.:—

1. Var. *hypothrix*, Nyl., which includes, for the most part, *P. carporrhizans*, Tayl. It occurs both in Europe and in the Canary Islands.

2. Var. *relicina*, Fr., which would appear to be marked chiefly by its yellow colour. This is not, however, a good, because not a constant, distinction. Specimens with a yellow thallus chiefly occur in foreign countries, such as America, Australia, and Java; but I have found them also occasionally in British specimens. Such specimens have generally a tougher thallus than in those of a white or gray

colour, and its surface is generally more or less reticulate or fissured. Hence this var. passes into, and is closely associated with, var. *reticulata*.

3. Var. *reticulata* is *pro parte* *P. reticulata*, Tayl., which also belongs partly to *P. perlata*. It is chiefly a New Zealand species.

4. Var. *rugosa*, the *P. rugosa*, Tayl., "Fl. Hib.," 145, which may sometimes also belong, *pro parte*, to *P. saxatilis*.

5. Var. *lævigata*, Ach. The *P. lævigata*, Tayl., "Fl. Hib.," 148, Eng. Bot., 1852; chiefly an Irish species, but which occurs also in America.

6. Var. *erratica* mihi, a curious erratic form, so far as I am aware as yet peculiar to Melbury Hill, near Shaftesbury. Dorsetshire,

Specimen 1.—On Dunkerron, Ireland; coll. TAYLOR; in Herb. Mackay; with apothecia. The thallus is thick and coriaceous; the ends of the laciniæ frequently bear large soredia, as is commonly the case in foreign specimens; and the colour of the thallus is that of *P. conspersa*. Its colour would refer it to NYLANDER'S var. *relicina* (*Parmelia relicina*, Fr.) Intermixed with the spermogones occur Pycnides, having all the outward aspect, as well as the site, of the spermogones. It admits of a doubt whether these bodies really belong to *P. sinuosa*, as I have not found them in other specimens. But, on the contrary, there are no grounds for supposing that, while the *spermogones* of *P. sinuosa* really belong to that species, the *pycnides* which occur in this individual specimen do not! The pycnides are minute, black, punctiform bodies, wholly immersed, and scattered near the margins of the lobes, on their flat surface. Their envelope is brown. Their stylospores vary much as to size and form; they are mostly spherical or oval, about $\frac{1}{8000}$th in diameter, on very short, simple, linear sterigmata. The spermogones, with which these pycnides are associated, are frequently largish, brown, round bodies, seated on warts of the thallus.

Specimen 2.—Apparently also from Ireland; coll. Miss HUTCHINS, 1810; in Herb. Hooker, Kew; said to be "common on rocks." The spermogones are chiefly old, and sometimes occur as largish, round, flat maculæ.

Specimen 3.—Ballachulish, Argyllshire, 1807; in Herb. Hooker, Kew. The thallus has the greenish-yellow colour of *P. conspersa*, and is therefore referrible to FRIES' *P. relicina*. The spermogones are few and scattered, and resemble outwardly those of *P. conspersa*. Glen Nevis; coll. BORRER, 1810; also in Herb. Hooker; a few young spermogones, containing no free spermatia.

Specimen 4.—Jamaica, Dr WRIGHT. The spermogones are very abundant, dotting over the entire convex surface of the laciniæ, but grouped especially about their extremities. They are generally brown, punctiform, wholly immersed, sometimes with a depressed ostiole, at other times seated on small, ill-marked thalline papillæ, frequently irregular as to form. Mauritius, BOYER; Casapi, Peru, MATTHEWS; Columbia, JAMESON; Quito; old spermogones become large, round, black depressions on the surface of the thallus; Chinar, Kumaon, Himalaya, at 8700 feet, ex Herb. Strachey and Winterbottom. All these specimens are in Herb. Hooker, Kew.

Specimen 5.—Var. *hypothrix*, Nyl. " Lich. Paris." (exs.) The spermogones are very abundant and distinct on the smooth glaucous thallus, about its periphery, as minute, brown, elevated papillæ. The spermatia are delicate needles, about $\frac{1}{5000}$th long, and $\frac{1}{25.000}$th broad; the sterigmata measure about $\frac{1}{1500}$th long, and are very irregular in outline from the acute angles at which the component cells are articulated.

Specimen 6.—Var. *reticulata*, New Zealand, Antarctic Expedition, 1839-43, Dr HOOKER. The thallus is gray, or of a very pale brownish-yellow colour, apparently the result of desiccation; some of the laciniæ haveorediiferous tips, others have black-ciliate margins. The spermogones are old, few, and scattered about the ends of the laciniæ or lobes; they contain no free spermatia. There are no apothecia.

Specimen 7.—Var. *rugosa*, Blackwater River, County Kerry; coll. TAYLOR in Herb. Mackay, and named by TAYLOR himself. The spermogones occur mostly as brown points scattered about the ends of the laciniæ; sometimes they are sub-papillæform; when old and degenerate, or when confluent, they occasionally become maculiform. The ostiole is generally so minute as to be inconspicuous; but occasionally it has a thick, brown, prominent, ring-like margin. The spermatia are needle-shaped, about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata consist of few articulations. Specimens from the same locality in Herb. D. Moore, also collected and named by TAYLOR himself, are identical with specimens in the Herbaria of MACKAY and HOOKER. The young spermogones are generally punctiform, brown, wholly immersed, studded singly, or in small groups, on papillar elevations of the thallus. The older ones are chiefly single, each being the centre of a thalline papilla. The apex of this papilla forms a pale ring round the deep chestnut-coloured ostiole, which is flattened or depressed. Sometimes these old spermogones are so prominent as to appear like *Verrucariæ*, or young apothecia. In the old state of the spermogone, the ostiole is frequently gaping and fissured, and surrounded by a deep-brown ring, as is often the case also in *P. saxatilis*. In a specimen in Herb. Carroll, coll. in County Kerry, in 1842, by D. MOORE, the spermogones are also old, prominent, brown papillæ or rings, with gaping ostioles. The plant has apothecia; the thallus is very white or cream-coloured, smoothish, with frequently proliferous margins. The laciniæ are neither lacunose nor rugose; hence, in this case at least, and perhaps in the majority of cases, the name *rugosa* is a bad and non-characteristic one. Many of the Irish specimens have a greater resemblance, so far as regards their thallus, to *P. saxatilis* than to *P. sinuosa*. A specimen from Dunkerron, Ireland, coll. by TAYLOR, in Herb. Hooker, Kew, has spermogones which, with age, become brown superficial warts, perched on pale thalline papillæ. The apothecia resemble those of *P. saxatilis*.

Specimen 8.—Var. *lævigata*. On Maam, Connemara, Ireland; coll. D. MOORE;

in Herb. Carroll. There are no apothecia; but old degenerate spermogones abound about the ends of the laciniæ. They are brown, immersed, round, ellipsoid or lirellæform, or still more irregular in form; on free spermatia are seen. The colour of the thallus is white. Nova Scotia, 1784, in Herb. Menzies, Royal Botanic Garden, Edinburgh; has both apothecia and spermogones; as has also a specimen from Kollong, Khasia, India, temperate region, at an elevation of 5000 feet; coll. Drs HOOKER and THOS. THOMSON; in Herb. Hooker, Kew.

Specimen 9.—Var. *erratica* mihi, Melbury Hill, near Shaftesbury, Dorsetshire, May 1857; coll. Sir WALTER C. TREVELYAN of Wallington. This is a very curious, erratic, globular form, the thallus having become repeatedly curled inwards on itself, so as to assume the form of a small ball; it was found lying free or unattached on the ground, rolling before the wind on the downs of Melbury Hill. Specimens were submitted by Sir WALTER TREVELYAN to the most distinguished British lichenologists, all of whom were puzzled in regard to its name and place in classification, and each of whom ascribed it to a different species. Sir W. HOOKER referred it to *P. saxatilis*;* the Rev. M. J. BERKELEY and the Rev. CHURCHILL BABINGTON to *P. stellaris*;* the Rev. W. A. LEIGHTON to *P. saxatilis*, of which he constituted it var. *concentrica*;† while I placed it provisionally under *P. cæsia*.‡ This difficulty or dubiety arose from the absence of apothecia. Nor, when I first examined the plant, did I find any spermogones; but in specimens subsequently sent me by Sir WALTER TREVELYAN, I have been successful in finding them in small quantity; and hence am now able to refer the plant to *P. sinuosa*. Many specimens are very like *P. perlata*, and others like *P. saxatilis*. But the examination of a suite of specimens, in very different states, leads me to place it here; constituting it, as it deserves, into a distinct variety, to which I give, in allusion to its peculiar habit, the appellation *erratica*. The thallus is smooth and glaucous; marginal soredia and marginal cilia are occasionally found on some specimens, and on some lobes. The spermogones are few, old, and scattered about the ends of the laciniæ; they contain no free spermatia. Outwardly, they have all the characters of those of *P. sinuosa*. In some specimens the plant is associated with spermogoniferous states of *P. physodes*, and has evidently been detached from the twigs of trees, which would appear to be its normal or usual habitat.

Specimen 10.—Var. *Caracensis* (*Parmelia Caracensis*, Taylor), Caracas, South America; coll. J. LINDEN, 1842, exs. No. 576; also Columbia, JAMESON; both in Herb. Hooker, Kew. The spermogones are scattered about the ends of the laciniæ, the young ones as punctiform, immersed, black bodies, the old ones as small black

* Gardener's Chronicle, Feb. 9, 1856, p. 84, and March 15, 1856, p. 172. Scottish Gardener, No. 3, p. 100, March 1856 (Proceedings of Botanical Society of Edinburgh).

† LEIGHTON's Lich. Britannici exsicc. Fasc. 8, No. 232 (1856).

‡ Popular History of British Lichens, London, 1856, p. 211, *et seq.* Monograph of the Genus *Abrothallus*, in Quarterly Journal of Microscopical Science, January 1857, p. 41.

sub-prominent papillæ. The cavity is simple; the spermatia are about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad, needle-shaped; the sterigmata are $\frac{1}{1000}$th to $\frac{1}{1500}$th long, and consist of a few articulations only. Projecting from among the latter, are numerous elongated, very ramose, and delicate filaments, generally about $\frac{1}{500}$th long, as in *P. saxatilis*, *P. physodes*, *P. perforata*, and other *Parmelias*.

Species 7. *P. mutabilis*, Tayl.

Specimen 1.—On rocks, Uitenhage, Cape of Good Hope; in Herb. Hooker, Kew. This plant is at least partly referrible to *P. conspersa*. The spermogones are brown, punctiform, wholly immersed; grouped in considerable numbers on the convexities and about the ends of the laciniæ. The spermatia are acicular, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata about $\frac{1}{1500}$th to $\frac{1}{2000}$th long, associated with a few elongated, sterile, ramose filaments, as in *P. physodes*, &c.

Species 8. *P. Kamtschadalis*, Ach.

An Asiatic species, some of whose varieties, however, occur also in America. This species is so protean and puzzling that it is necessary to study very carefully all its varied forms. It appears, on the one hand, to pass into *Evernia furfuracea*, and, on the other, into *P. physodes* and *P. perlata*. In the Hookerian Herbarium it is partly included under the genera *Borrera* and *Evernia*, being supposed, apparently, allied to *Evernia furfuracea*, from which, indeed, it is frequently indistinguishable on cursory examination. The peculiarity of the plant is that the thallus is prolonged into linear, digitate processes, more or less irregular in form, which are sometimes convex above, and channelled below, as in *Evernia*, sometimes fistulose (var. *fistulata*, Taylor). These thalline processes appear analogous to those that occur in Organ Mountain specimens of *P. perforata*.

Specimen 1.—Kumaon, India; in Herb. Hooker, Kew. The thalline lobes are frequently margined by long, irregular, narrow processes, which are at first merely channelled below and convex above, but which, from curling in, or involution of the margins, become sub-fistulose and nearly round. The flat processes, especially, sometimes give off from their ends secondary or smaller processes of a similar kind, in groups or tufts. All these processes are studded over with black, punctiform, immersed spermogones, with acicular spermatia, about $\frac{1}{6000}$th long, and sterigmata, consisting of a few articulations, about $\frac{1}{1500}$th long. Specimens also in Herb. Hooker, from Nepaul and the Neilgherry Hills, India (ex. Herb. Montagne), have laciniæ abundantly dotted over with spermogones, resembling those of *P. physodes*, var. *vittata*, Schærer. Some forms of this species are also very like *P. perlata*.

Specimen 2.—On the white oak, California; coll. Deighton, 1857. The apothecia resemble those of *P. physodes*; but they are scattered about the ends of the long linear laciniæ or processes. Some specimens so closely resemble *P. physodes*, in some of its aspects, that they might be referred to that species as a variety. The spermogones are abundant about the ends of the laciniæ or processes; they resemble those of *P. physodes* in internal structure and contents, as well as in outward aspect. The spermatia are acicular, about $\frac{1}{4000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata consist of a few delicate cylindrical articulations, and are associated with long ramifying and anastomosing filaments, as in *P. physodes.* The spermogonal envelope is of a pale-brown cellular tissue.

SPECIES 9. *P. moniliformis*, Bab.

Specimen 1.—New Zealand, Colenso, Nos. 863 and 2685; in Herb. Hooker, Kew. This plant is very closely allied to *P. conspersa*, if it does not belong thereto merely as a variety. Two forms of it here occur. One has linear, simple laciniæ, of a beautiful lemon-yellow, dotted over with punctiform, black, immersed spermogones. The other has lobes much corrugated and warted, convex and deformed; these too are dotted over with spermogones, which have all the external characters of those of *P. conspersa.* These spermogones are frequently confluent, joining each other by black radiating fissures; sometimes they are large and almost papillæform. The spermogones are also studded over the warts, with which the thallus is more or less plentifully covered, and they occasionally occur also on the apothecia, especially the young ones. The spermatia are acicular, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad.

SPECIES 10. *P. colpodes*, Ach.

(Syn. *P. Michauxii*, Auct.)

Specimen 1.—North America; in Herb. Hooker, Kew. This species, like the last, is closely allied to *conspersa*, if it does not belong to it. The spermogones are scattered over the convexities and about the ends of the lobes; they are brown, punctiform, immersed. The ostiole is sometimes easily seen under the lens; it often appears surrounded by a brown ring. The spermatia are acicular, and about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata are about $\frac{1}{1000}$th in length, and are composed of a very few long delicate cylindrical cells, articulated at very irregular and acute angles.

SPECIES 11. *P. physodes*, Ach.

Almost a cosmopolite. This is a most changeable plant, containing a number of marked varieties, to two only of which NYLANDER gives separate names—viz., var. *lugubris*, Pers., and var. *enteromorpha*, Ach., both American species. I also refer to this species, ACHARIUS' *P. encausta.* In all forms of *P. physodes*, spermogones are more or less plentiful; in some to such an extent as to have been chiefly or wholly the source of the names given to its varieties by earlier lichenologists.

Thus SCHÆRER's varieties η. *multipuncta* and δ. *vittata* of his *P. ceratophylla*, as well as the var. *stigmatea* of Wallroth, are mainly or merely spermogoniferous states. The spermogones are usually largish and distinct, scattered about the ends of the laciniæ; they are black, punctiform, and immersed. In the old state the ostioles frequently become large and distinct, generally round, though often stellate-fissured, sometimes surrounded by a turgid brown ring; at other times they are confluent and maculiform. The spermatia are acicular, and about $\frac{1}{4000}$th to $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th to $\frac{1}{30,000}$th broad. The sterigmata are usually composed of a few delicate cylindrical articulations, and measure in length, with the spermatia attached, about $\frac{1}{750}$th to $\frac{1}{1000}$th, their breadth being about $\frac{1}{15,000}$th to $\frac{1}{10,000}$th. Associated with the ordinary spermatiferous sterigmata are elongated, very delicate, branching and anastomosing filaments, which project into and fill the cavity of the spermogone. Their length is frequently about $\frac{1}{400}$th to $\frac{1}{500}$th.

Specimen 1.—Craigie Hill, Perth; on old walls; April 1856, W. L. L. Spermogones are very abundant, in all their stages of development. The older ones have a distinct round black ostiole, surrounded by a prominent ring or border, brown or black. Sometimes, on the darker laciniæ, contiguous ostioles are united by black fissures passing between them; sometimes they become confluent and maculiform. This specimen has abundant apothecia; the young ones sometimes resemble the brown rings which occasionally surround the spermogonal ostiole. There is great variety in regard to the form and size of the laciniæ: sometimes they are short and broad; at other times long and narrow, terminating or not in soredia.

Specimen 2.—Blaeberry Hill, Perth, April 1856, W. L. L.; on the bark of firs and other trees. The thallus has short broad laciniæ. Many of the spermogonal ostioles are depressed; sometimes a chain or group of ostioles is united by a series of black cracks or fissures. The ostiole has also frequently a prominent black border. Corticolous specimens are destitute of apothecia, which, however, occur sparingly on saxicolous ones in this locality.

Specimen 3.—Kinnoull Hill, Perth, March 1856, W. L. L.; on the stumps of dead firs and pines; with apothecia. The spermogones are few; the laciniæ are elongated and sorediiferous, and inflated at the ends.

Specimen 4.—Knock Hill, Crieff, June 1856, W. L. L.; on the bark of firs and pines, especially the Scotch fir (*Pinus sylvestris*). The apothecia are very abundant, more so than in any specimens of this species I have ever collected or seen. The spermogones are also plentiful.

Specimen 5.—Moncreiffe Hill, Perth, on rocks, August 1856; coll. Dr MURRAY LINDSAY; broad-lobed form; no apothecia.

Specimen 6.—In woods, between Dalmahoy and Currie, near Edinburgh, June 1856; coll. Dr MURRAY LINDSAY; on trees; with apothecia. The thallus is of a dark-gray; the laciniæ are narrow, elongated, and sorediiferous. The spermogones are associated with large, flattened, black maculæ, which seem fungoid in their nature.

Specimen 7.—On rocks, Morchone, Braemar, August 1856, W. L. L.; with apothecia. The central as well as peripheral parts of the thallus are studded over with very minute black punctiform spermogones.

Specimen 8.—On blasted Scotch firs (*Pinus sylvestris*), Glen Lui Beg, Braemar, August 1856, W. L. L.; no apothecia. Spermogones are of the usual character.

Specimen 9.—Bridge of Cally, Blairgowrie, August 1856, W. L. L.; on walls; no apothecia. The thallus is eroded in patches, exposing the white medullary layer. Roadside walls, Spittal of Glenshee, Braemar, August 1856, W. L. L.; no apothecia. The spermogones are large; the ostioles patent, with thickish, distinct, black borders, which are ring-like. Frequently the spermogones are confluent and maculiform.

Specimen 10.—Melbury Hill, near Shaftesbury, Dorsetshire, May 1857; coll. Sir WALTER C. TREVELYAN; associated with *P. sinuosa*, var. *erratica*. The spermogones are few and scattered.

Specimen 11.—On a stone fence, near Montrose, Forfarshire, July 1843; coll. A. CROALL; with apothecia. The spermogones are extremely minute, brown, and punctiform, scattered about the ends of laciniæ with large terminal soredia, and inflated or bullose tips. In specimens from Guthrie, Forfarshire, also coll. by CROALL, in Herb. Hooker, Kew, the lobes are broad and simple, but the spermogones are the same.

Specimen 12.—Kildale, Cleveland, Yorkshire, 1855–6; coll. W. MUDD. The thallus is of a darkish hue; the spermogones are very minute and punctiform, giving the laciniæ the appearance of being covered with a series of very minute black perforations.

Specimen 13.—On the white oak of California; coll. DEIGHTON, 1857; with abundant apothecia. The plant resembles SCHÆRER's var. η. *multipuncta*, which, however, he describes as chiefly saxicolous. The laciniæ, or segments of the thallus, differ much in form and size; some are narrow and linear, not terminating, however, in inflated bullæ or soredia; others are flattish, sub-fastigiate at the ends, and somewhat retuse, also like the laciniæ of *P. saxatilis*. The spermogones are minute, punctiform, black. The spermatia are acicular, about $\frac{1}{4000}$th long, borne on the apices and sides of sterigmata, which are composed of two or three delicate, cylindrical articulations only. From among the latter project numbers of the elongated, sterile, very ramose filaments already described as so generally occurring in *P. physodes*.

Specimen 14.—On rocks, Blackpool, near Cork; coll. CARROLL. This is near SCHÆRER's vars. η. *multipuncta* and δ. *vittata*. Though in these spermogoniferous states of *P. physodes*, spermogones are abundant, they are generally old and degenerate, and he who expects always to find in them abundance of spermatia will most assuredly be frequently doomed to disappointment. In specimens on bark from Ardrum, near Cork, also collected by CARROLL, the spermatia are delicate needles about $\frac{1}{6000}$th long, and $\frac{1}{30,000}$th broad; the sterigmata, with spermatia attached, measure $\frac{1}{750}$th to $\frac{1}{1000}$th long, and $\frac{1}{10,000}$th to $\frac{1}{15,000}$th broad. The elongated, ramose, sterile filaments reach a length of $\frac{1}{400}$th to $\frac{1}{500}$th, with a breadth of $\frac{1}{10,000}$th to $\frac{1}{20,000}$th. The envelope is of a pale-brown cellular tissue.

Specimen 15.—SCHÆRER exs. 367 (sub δ. *vittata*); on firs. There are a few old spermogones on the lower specimen in my copy (ed. alt. immut. 1840), scattered on the convexities of the laciniæ near their ends. The ostioles are large, round or oval, with a turgid, black, ring-like border.

Specimen 16.—Van Dieman's Land; coll. CHAS. STUART. The thallus is broad-lobed, very white; the apothecia are seated on bullose erect pedicles, or podetia-like dilatations of the lobes, which resemble those of *Leptogium bullatum.* The spermogones are very abundant, large, and easily seen. Mauritius; both specimens being in Herb. Hooker, Kew.

Specimen 17.—On trees and rocks, forests round Mount Wellington, Van Dieman's Land; coll. MOSSMAN, 1840; in Herb. Royal Botanic Garden, Edinburgh. The laciniæ are large, white, and glossy; the apothecia and spermogones plentiful, and of the ordinary characters.

Specimen 18.—Var. *vittata,* Schær.; West Coast of North America; coll. A. MENZIES, 1787; in Herb. Menzies, Royal Botanic Garden, Edinburgh. The laciniæ are very long, flaccid, narrow, and everniiform. There are no apothecia; and the spermogones are few but large. In a specimen from the same locality, also collected by MENZIES, in Herb. Hooker, Kew, the laciniæ are pendent, and sometimes bullose at their extremities; the spermatia and sterigmata of the spermogones are quite those of our British *P. physodes.*

Specimen 19.—Norway; in Herb. Hooker, Kew; very near SCHÆRER'S *vittata.* Some of the laciniæ are wholly dotted over with old spermogones, in few or none of which are spermatia discoverable.

Specimen 20.—Var. *lugubris,* Pers., Avon Ranges, Australia; coll. MÜLLER, 1854; in Herb. Hooker, Kew; with apothecia. The plant greatly resembles *P. encausta,* the whole surface of the laciniæ being black-punctate with immersed spermogones, as in that species.

Specimen 21.—Var. *enteromorpha,* Ach. (sub *Parmelia enteromorpha,* Ach.); Tasmania, Antarctic Expedition 1839–43, Dr HOOKER. This is a form trailing over shrubs of various kinds, just as it does on heather, &c., in this country. In some specimens apothecia abound, and the same specimens are generally more or less plentifully dotted over with spermogones. They are in all respects those of the type to which this plant manifestly belongs as a variety. They are usually grouped in large numbers; the ostiole is flat or depressed, never papillate. The spermatia are acicular, about $\frac{1}{6000}$th long. Associated with the spermatiferous sterigmata, occur the elongated, branching ones, already so frequently described.

Specimen 22.—Var. *enteromorpha*, Falkland Islands, Antarctic Expedition, 1839–43, Dr HOOKER. The laciniæ are longish and narrow, convex above; concave under surface of a pitchy black colour. The spermogones are as in No. 21.

Specimen 23.—Var. *enteromorpha*, West Coast of North America; coll. A. MENZIES, 1787; in Herb. Menzies, Royal Botanic Garden, Edinburgh. The ends of the laciniæ, which otherwise resemble those described in No. 22, are bullose or inflated; on these bullose extremities the apothecia are seated. The spermogones are abundant, and as in No. 21. In American specimens they sometimes become papillæform, but more usually they are punctiform. Spermogones are also plentiful in specimens from the North-West Coast of America, DOUGLAS; Russian America; the Oregon River, SCOULER; and Monterrey, California, BEECHEY,—all in Herb. Hooker, Kew.

SPECIES 12. *P. encausta*, Ach.,

Which is more or less abundant in various alpine parts of Europe. As I have already stated, I regard it simply as a variety—an alpine spermogoniferous one—of the preceding species. The spermogones are generally much more profusely scattered and easily seen than in *P. physodes;* they are larger, and cover over the whole surface of the laciniæ and thallus. They are wholly immersed, their form subspherical, their cavity simple, their thickish envelope at first grayish, but becoming black. The spermatia, sterigmata, and ramose filaments of the spermogones are precisely as in *P. physodes.* The thallus, however, is much thicker, generally coriaceous; the laciniæ very narrow, and convex on their upper surface.

Specimen 1.—Var. *stygioides;* summit of Cairngorm, Braemar, August 1856, W. L. L. The thallus is centrally of a brown tinge, and pale or whitish only at the periphery. From its great general resemblance to *P. stygia*, with which it is very apt to be confounded, I propose designating this plant, provisionally at least, var. *stygioides.* The spermogones are very distinct on the laciniæ, as small black cones or papillæ. I have gathered similar specimens, but in very small quantity, on Morchone, Braemar; in considerable abundance, however, on the summit of Ben Nevis. The laciniæ are frequently sub-articulated; the spermogones are sometimes large and irregular, with ostioles which are patent and easily seen. Sometimes the segments of the thallus are lobes instead of laciniæ, broadening at their periphery or ends, and dotted over with punctiform spermogones, as in the ordinary form of *P. physodes.* These are evidently transition forms into *P. physodes*, and furnish strong reasons for associating *P. encausta* with *P. physodes.* In Cairngorm specimens, the spermogones are very easily recognised, when the thallus is greenish or pale. In the young state they are papillar; in the old, the ostiole is prominent, large, and roundish, sometimes surrounded by a turgid, black, ring-like border;

at other times they are depressed or flattened. The laciniæ are sometimes profusely covered with black holes or perforations, which are the ostioles in question; this is the source or cause of their frequently pitted character. The spermogonal envelope is of a deep-brown colour, and consists of a tissue made up of small but well-defined roundish cellules. The spermatia are rod-shaped, about $\frac{1}{5000}$th long, borne on the apices and sides of very ramose, delicate, articulated sterigmata. Associated with the latter are numerous elongated branching filaments, with bulging extremities, which project into and fill up the cavity of the spermogone. In the Morchone specimens, which occur on quartz rock and gneiss, the spermogones are mostly old, with large ostioles, which give the thallus the appearance of being jagged all over with large black foramina.

Specimen 2.—Schærer exs. 368 (sub *Parmelia ceratophylla*, *η. multipuncta*); on granitic rocks in the Alps; on the lower specimen in my copy (ed. alt. immut. 1840) the upper one being certainly referrible to *P. saxatilis*, the furfuraceous form of thallus. The spermogones are abundantly scattered over all the laciniæ as minute black papillæ. The spermatia are acicular, about $\frac{1}{4000}$th to $\frac{1}{3000}$th long. The sterigmata consist of articulations, joined at very irregular angles; with the spermatia attached, they measure in length $\frac{1}{1000}$th to $\frac{1}{1200}$th. Körber very erroneously describes the spermatia of *P. encausta* as *ellipsoid*. I have never seen them otherwise than acicular, and as in *P. physodes*.

Specimen 3.—Hepp. exs. 52 (sub *Imbricaria ceratophylla*, var. *candefacta*, Ach.); on granitic rocks, St Moritz, Switzerland. The thallus is very beautifully studded over with the spermogones, which are chiefly old, containing no free spermatia. They occur partly as largish, distinct cones, partly as black perforations, which are the old ostioles. In a specimen in Hepp.'s exs. 40, occurring on moss at St Moritz, associated with *Lecidea disciformis*, var. *muscorum*, the thallus is as plentifully covered with spermogones, which, however, are mostly young; the spermatia and sterigmata are as in No. 2.

Specimen 4.—On rocks, Bructeri, Hartz district, Germany, Hampe exs. No. 2 (sub *P. physodes*, *β. encausta*, Fr.), 1846; tops of the mountains near Kongsvold, Dovrefjeld, Norway, Sommerfeldt, Un. Itin., 1828; Alps of Dalecarlia, Sweden, Dr Swartz, 1809; Riesengebirge, Dr C. Ludwig, 1814; Hartz Mountains, Mohr, 1802; Grimsel, Switzerland, Schærer, 1815;—all in Herb. Hooker, Kew. Also from the Glaciers of Savoy, Smith; in Herb. Menzies, Royal Botanic Garden, Edinburgh. In all these specimens spermogones, having the characters described in No. 2, are abundant.

Species 13. *P. pertusa*, Schærer,

Which occurs in Europe, America, Asia, and Australia, and which is Acharius' *P. diatrypa*. I also refer this plant as a variety to *P. physodes*. It differs in nowise from that species, except in regard to the ends of the laciniæ being occasionally perforated by an irregular hole or fissure. This erosion or perforation is analogous to what occurs in *Umbilicaria erosa*, and other lichens. Either apothecia or thallus may be erose or perforated; but such erosion is accidental—not peculiar to any one species or variety—and does not therefore furnish a good distinctive character. The thecæ and spores of *P. pertusa* are generally larger than those of *P. physodes;* but there are few species in which the thecæ and spores are uniformly of the same size. They usually vary more or less in different specimens of the same species from different localities. The spermogones of *P. pertusa* are identical with those of *P. physodes*, but they are less common and less plentiful.

SPECIES 14. *P. cincinnata*, Ach.

Specimen 1.—Staten Land, Cape Horn; in Herb. Hooker, Kew; also collected by A. MENZIES, 1787, in Herb. Menzies, Royal Botanic Garden, Edinburgh. If this plant is not a form of *P. physodes*, which I am inclined to regard it, it is at least very closely allied. The laciniæ are bullose at their extremities in both sets of specimens; in MENZIES's, occasionally pertuse. In both cases the spermogones are abundantly scattered over the ends of the laciniæ, as black or brown, punctiform, immersed bodies. The spermatia are acicular, about $\frac{1}{4000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata consist of a few delicate cylindrical articulations or cells, as in *P. physodes*.

SPECIES 15. *P. placorodia*, Ach.

Specimen 1.—On the trunks of trees, Troy, U. S., America; in Herb. Hooker, Kew. The plant greatly resembles *P. tiliacea*. The spermogones are scattered generally in round, closely aggregated groups, about the ends of the laciniæ, as black, immersed, punctiform bodies. The spermatia are acicular, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad, on sterigmata about $\frac{1}{1000}$th long, which consist of several articulations, as in *P. tiliacea*.

SPECIES 16. *P. saxatilis*, Ach.,

Which occurs in Europe, Africa, America, and Asia. There is one very well-marked variety, *omphalodes*, Ach., Fr., which occurs in Europe and Asia—the *Parmelia omphalodes* of the earlier lichenologists. It has no claim, however, to rank as a separate species; the gradations between it and the type are easily studied. Its apothecia and spermogones alike are those of *P. saxatilis*. The spermogones are generally very minute, black, punctiform, wholly immersed bodies, scattered over the ends of the laciniæ, always on smooth ones, seldom or never on furfuraceous ones; or, if they occur on the latter, they are so minute and inconspicuous that they are overlooked. The ostiole is flat or depressed, seldom papillæform. Normally it is round, and exceedingly minute; but with age it becomes triangular or stellate-fissured, with turgid, prominent borders or not. The ends of the laciniæ, especially in var. *omphalodes*, are frequently studded over with irregular, stellate-fissured perforations, which are the ostioles of old spermogones. The spermatia are rod-shaped or acicular, about $\frac{1}{4000}$th to $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are about $\frac{1}{750}$th to $\frac{1}{1000}$th long, and consist of three to six delicate, cylindrical articulations, which are sometimes very irregular in form; their breadth is frequently $\frac{1}{10,000}$th to $\frac{1}{15,000}$th. As in *P. physodes* in all its forms and varieties, along with the spermatiferous sterigmata occur numerous elongated, ramose, delicate filaments, that project into and fill up the cavity of the spermogone, which is simple. Occasionally the spermatiferous sterigmata would appear to become elongated and hypertrophied, and to anastomose. In one specimen from Connemara, *pycnides* occur interspersed among the spermogones, of which they have all the external aspect, and from which, outwardly, they cannot be distinguished. The stylospores are very irregular in form,—spherical, oval, or pyriform chiefly,—sometimes curved, about $\frac{1}{6000}$th long, and $\frac{1}{8000}$th broad, on short, simple, linear sterigmata. Pycnides, associated with the ordinary spermogones of the plant, and having almost the same characters as those now described, occur in a specimen of *P. sinuosa*, from Dunkerron (*vide* page 216). It is curious that both the *Parmelias* in which these pycnides occur are *Irish* specimens! Körber appears to me to err greatly where he describes the spermatia of *P. saxatilis* as almost spherical "kugligen spermatien." I have never seen them otherwise than straight and linear, of great tenuity throughout.

Specimen 1.—Form *furfuracea*. It is almost uniformly on this state or form of *P. saxatilis* that spermogones occur; but generally only where the ends of the laciniæ are smooth and free of furfuraceous or isidioid growths. Blaeberry Hill, Perth, April 1856, W. L. L. Most of the laciniæ are broad or lobate, with rounded margins; these laciniæ are found especially at the periphery of the plant. More centrally the laciniæ are narrower, with retuse or truncate ends. It is on the latter, and not the former, that spermogones occur.

Specimen 2.—Birnam Hill, Dunkeld, 1856; with apothecia; W. L. L. Some of the laciniæ are studded over with black stellate-fissured perforations, which are the ostioles of old spermogones. Craig-y-Barns, Dunkeld, April 1856, W. L. L.; with apothecia. The general surface of the plant is furfuraceous; but some of the laciniæ have smooth, glaucous ends, on which occur a few large, degenerate, maculiform spermogones. Craig Vinean, Dunkeld, May 1856, W. L. L. Some of the laciniæ are very narrow, and all are of a bluish-gray colour, and smooth towards the ends. Old wall, Amulree Road, Dunkeld, June 1856, W. L. L.; with apothecia. The laciniæ are narrow, and the punctiform black spermogones are sparingly scattered in groups at their extremities.

Specimen 3.—Hills above Abernethy and Newburgh, May 1856, W. L. L.; with apothecia. Here the spermogones, which have mostly depressed ostioles, are scattered among the isidioid growths which cover the thallus.

Specimen 4.—On roadside walls, Linn of Dee Road, Braemar, August 1856,

W. L. L.; furfuraceous form, with narrow laciniæ. The sterile, elongated, ramose filaments are here abundant in the spermogones; they usually have a distinctly bulging apex, and are frequently distinctly septate, like the paraphyses.

Specimen 5.—Storr Rock, Skye, August 1856, W. L. L.; with apothecia. The spermogones are here very distinct and characteristic; they are of a deep-brown colour, rather than black, however.

Specimen 6.—On roadside walls, between Percy and the Spittal of Glenshee, Perthshire, August 1856, W. L. L. The spermogones are mostly old; in their interior, nothing is to be seen but the ramose, elongated filaments already described, which frequently assume a pale-brown colour at their tips; they are also distinctly septate.

Specimen 7.—On rocks, near Ayton, Cleveland, Yorkshire, 1856, MUDD; furfuraceous form. The spermogones are abundantly scattered among the isidioid growths, which cover the ends of the laciniæ.

Specimen 8.—CROALL's Plants of Braemar, No. 389; on stones, common; July 1855. Furfuraceous form; apothecia plentiful. Dotted over the smooth, shining, light-gray ends of the laciniæ, are numerous punctiform spermogones,—so minute that they can with difficulty be seen even under the lens,—whose ostioles are sometimes slightly depressed, though generally flat.

Specimen 9.—Connemara, Ireland, D. MOORE; in Herb. Carroll; apparently growing on the ground; no apothecia. Spermogones occur only on one specimen; they are mostly degenerate. The ostiole is seldom quite round, generally less or more irregular in outline, and frequently surrounded by a sort of raised, thalline, ring-like border. Intermixed, and scarcely distinguishable from these spermogones except by their slightly greater size, are black punctiform pycnides. The stylospores are very irregular in shape, though mostly spherical, oval, or pyriform, and frequently curved; the sterigmata are short, simple, linear bodies. Pycnides having a similar site and external characters occur associated with the ordinary spermogones in a specimen of *P. sinuosa* from Dunkerron, Ireland. I find no spermogones on specimens from Tasmania, Dr HOOKER; Quebec, SHEPHERD; and B. de Bigorre, Pyrenees, SPRUCE;—all in Herb. Hooker.

Specimen 10.—Var. *sulcata*. The *Parmelia sulcata*, Taylor, "Fl. Hib." 145, seems to me undoubtedly referrible to *P. saxatilis*, and I therefore place it here as a variety, though I do not regard it even as a well-marked variety. It is merely a form of what is called var. *leucochroa* by WALLROTH, SCHÆRER, and others of the earlier lichenologists, a variety distinguished by large lobes, smooth and white, and marked on the upper surface by distinct sulci or lacunæ. It is common in Britain on trees; seldom or never on rocks or stones. Van Dieman's Land, GUNN; in Herb. Hooker, Kew. The spermogones are precisely those of *P. saxatilis*. Here they are few and large, scattered about the ends of the laciniæ—the ostiole being sometimes depressed, sometimes surrounded by a black ring or seated in the centre of a macula, or perhaps papillate. The spermatia are acicular, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are about $\frac{1}{1000}$th to $\frac{1}{1500}$th long, and consist of a few linear articulations.

Specimen 11.—Var. *panniformis*, Schær.; on alpine rocks, Switzerland; in Herb. Hooker, Kew. There are a few scattered spermogones, of the character of those of the type; but they are old, and contain only sterile, branching, delicate filaments.

Specimen 12.—Var. *omphalodes;* hills above Abernethy, 1856, W. L. L.; with apothecia. Some of the spermogones are distinctly papillæform, and large; but they occur chiefly in the old state as ostioles,—triangular or stellate-fissured, large and black, with a turgid black edge,—studded over the ends of the laciniæ. As a general rule, the spermogones are larger in this variety than in the type, and the large gaping ostioles of the old spermogones are particularly conspicuous.

Specimen 13.—Var. *omphalodes;* hills above Loch Freuchie, Amulree, May 1856, W. L. L.; with apothecia. The ends of the dark laciniæ appear as if perforated with a series of black holes, which are sometimes round, more frequently stellate-fissured, even saucer-shaped. These are the ostioles of old spermogones, which are sometimes, moreover, confluent, or are united to each other by black, radiating fissures.

Specimen 14.—Var. *omphalodes;* Birnam Hill, Dunkeld; on mica slate and gneiss; July 1855, W. L. L.; with apothecia. The old ostioles are so abundant here as to give the laciniæ the appearance of having been profusely pricked by needle-points. They are as irregular as those described in No. 13. They sometimes have a black prominent border; are sometimes flat, and at other times depressed. There are also a few young and mature spermogones, containing spermatia and sterigmata of the characters of the type. Craig Vinean, Dunkeld, May 1856, W. L. L. Here also the spermogones are chiefly old, the ostiole being sometimes seated in a papillar elevation of the thallus.

Specimen 15.—Croall's Plants of Braemar, No. 390, common, July 1855. The dark, bronze-coloured laciniæ are covered by a peculiar bluish-gray pruina or bloom, through which the spermogones appear as minute points or papillæ. Clova, Forfarshire, Croall, July 1853; with apothecia. The ends of the smaller laciniæ are jagged over with the depressed, irregular, patent black ostioles of old spermogones.

Specimen 16.—Bunbeg, County Donegal, Professor Dickie, August 1851. The laciniæ are narrow, and many of them are covered with a pruina or bloom of a peculiar bluish-gray tint, as in No. 15; this gives the plant much the aspect of *Physcia pulverulenta*. In respect to colour, this plant is intermediate between the type and var. *omphalodes*. There are no apothecia; but spermogones are plentiful. They are chiefly old, with gaping ostioles, and are distinct under the lens. The spermatia are acicular, about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata measure about $\frac{1}{750}$th to $\frac{1}{1000}$th in length, and $\frac{1}{10,000}$th to $\frac{1}{15,000}$th in breadth; they consist generally of five or six articulations, normally cylindrical, but frequently very irregular in outline. They are, moreover, joined or superimposed at very irregular angles. Sometimes apparently they become elongated, by the superposition of additional articulations or cells, and they anastomose with each other, forming a network, projecting beyond the mass of the sterigmata into the cavity of the spermogone. They continue, however, in this state to bear spermatia, which are developed from the apices of the component articulations. The cavity of the spermogone is further occupied by a network of very delicate, anastomosing filaments, of nearly equal width throughout, very ramose, generally septate, and never bearing spermatia. These are the filaments which so commonly occur in the spermogones of *P. saxatilis*, *P. physodes*, *P. perforata*, and other *Parmelias*, and which are particularly constant in the two species first mentioned.

Specimen 17.—LEIGHTON's exs. 7; Barmouth, Merionethshire; with apothecia. The laciniæ are broad, and exhibit the large gaping ostioles of the old spermogones to great advantage; these ostioles have usually a black, hard border.

Specimen 18.—HEPP. exs. 116; associated with *Umbilicaria hyperborea;* on granitic rocks, St Moritz, Switzerland; no apothecia. Here also the spermogones are chiefly old, the ostioles having a black, raised, ring-like border. The ramose, elongated, sterile filaments abound in the interior of the spermogones.

Specimen 19.—Lachen, Sikkim, Himalaya, alpine region, at an elevation of 13,000 feet; coll. Dr HOOKER; in Herb. Hooker, Kew. The thallus is dark-brown, and of the *omphalodes* type; the spermogones are very abundant and large.

SPECIES 17. *P. Borreri*, Ach.,

Which occurs in Europe, Africa, America, and Asia. I am in doubt as to whether this should be separated as a species from *P. tiliacea*. The apothecia and spermogones are essentially those of the species just named. I cannot help regarding it as a merely sorediiferous form of *P. tiliacea*. This is the result of the examination of a large suite of specimens from every part of the world, contained in the Hookerian Herbarium at Kew, including specimens from Sussex, Ireland, the Pyrenees, Switzerland, Portugal, Teneriffe, South Africa, Chili, Ohio, India, Spitzbergen, and the Arctic Regions. The spermogones are minute, black, punctiform, immersed bodies, generally scattered about the margins of the lobes, but frequently also arranged or distributed more centrally. The ostiole is sometimes depressed, generally flat, but occasionally perched on papillar elevations of the thallus, or surrounded by a ring of the thallus, which gives the spermogones a pseudo-papillar aspect. Sometimes the thallus is very rugose, and much warted over; in such cases, the spermogones are dotted over these thalline warts or rugosities, as in a specimen from Barmouth, coll. SALWEY, in Herb. Hooker, Kew.

Specimen 1.—On trees, Paul, Penzance, Cornwall; coll. Dr BARCLAY MONTGOMERY, Sept. 1856; with apothecia. The thallus is abundantly sorediiferous;

its whole surface more or less mealy. The spermogones are scattered chiefly peripherally; in some the ostiole is depressed, in others it is girt by a slight ring of the thallus, giving it a pseudo-papillate aspect.

Specimen 2.—On the bark of trees, Riverstown, Cork; coll. Carroll. On one specimen there are a few old spermogones, dotted about the margin of the lobes of the thallus; some of them appear seated on a flattened thalline papilla, others are girt by a thalline ring, as in No. 1.

Specimen 3.—Leighton exs. 231 (Eng. Bot. t. 1780); Twycross, Leicestershire; no apothecia. The thallus is abundantly sorediiferous. The spermogones are peripheral in regard to distribution; the spermatia are short and acicular, on articulated, ramose, delicate sterigmata, as in *P. tiliacea*.

Specimen 4.—Schærer exs. 361 (sub *Parmelia dubia*); on trunks of trees and palings, Switzerland. A few spermogones are dotted over the margins of the lobes. but they are old, and contain no free spermatia.

Species 18. *P. conspersa*, Ach.

A cosmopolite. There are two chief forms of the plant: one with narrow, linear convex laciniæ, the var. *stenophylla*, or *minor*, of some authors; and the other, with broad, round lobes, flattened, and resembling occasionally *P. caperata*, usually described as var. *major*. In a very large suite of specimens I have examined, from every part of the world, in the Hookerian Herbarium, Kew, I have rarely found spermogones absent. Moreover, they generally occur in great plenty scattered over the whole surface of the laciniæ, or thallus. So much so is this the case, that the name of the plant may be supposed to have been bestowed in allusion to the great profusion of the spermogones. They are usually minute, black, punctiform, immersed bodies, with an imperceptible ostiole. But, with age, the latter expands and becomes patent, having either a round, triangular, or stellate-fissured shape, as is the case in *P. saxatilis* and *P. physodes*. Hence, the plant is frequently studded over with a profusion of black, lacerate perforations, which are the ostioles of old spermogones. It frequently happens that the apothecia of this species are degenerate or abortive; the disk falls out, and a cup-shaped cavity remains, of the same colour as the exciple and the thallus. The exciple, at the same time, generally becomes corrugated, and the whole organ assumes a coarse, warted appearance. On these apothecia, disk and exciple alike, the spermogones are frequently studded as plentifully as on the thallus, giving them a peculiar black-punctate character. Körber apparently implies that the apothecium becomes barren and degenerate *as a consequence of* the spermogones taking possession of it as a site. But I see no evidence for regarding the phenomenon either as a *propter hoc*, or a *post hoc*. It rather appears to me that, the apothecia being degenerate from other causes, the spermogones are developed upon them. Were we theorizing, on physiological and analogical grounds we might suppose that the spermogones should be first developed, and subsequently the apothecia. But this would not appear to be the case here at least. The cavity of the spermogone is simple; its internal tissue gray. The spermatia are acicular, varying in size usually from $\frac{1}{4000}$th to $\frac{1}{6000}$th, with a breadth of $\frac{1}{25,000}$th. The sterigmata consist of three to six delicate, cylindrical articulations or cells, and measure in length about $\frac{1}{1000}$th to $\frac{1}{1500}$th. Both spermatia and sterigmata resemble those already described as occurring in *P. saxatilis* and *P. physodes*.

Specimen 1.—On old walls about Moffat, Dumfriesshire, August 1851; W. L. L. The apothecia are more abundant and beautiful in Moffat specimens than in any others I ever collected. The spermogones are plentiful on the convexities, and towards the ends, of the laciniæ. The spermatia are about $\frac{1}{6000}$th to $\frac{1}{7000}$th long. The sterigmata are ramose, and composed of a few long, delicate, cylindrical articulations.

Specimen 2.—Var. *minor;* Glen Clova, Forfarshire; coll. CROALL, July 1853; on stones. Here, also, the spermogones are most plentiful about the ends of the laciniæ, as very minute brown or black flat points. Apothecia are less abundant and large than in No. 1.

Specimen 3.—LEIGHT. exs. 79, var. *stenophylla,* Schærer; on stones, Bardon Hill, Leicestershire; a form with narrow, linear, convex laciniæ. On the right-hand specimen in my copy the spermogones are very large and abundant on the convexities of the thalline laciniæ, as prominent, black cones—frequently flattened. The spermatia and sterigmata are as above described.

Specimen 4.—Glenesk, Forfarshire; on old walls, at the foot of the glen; small-lobed form. Quebec, SHEPHERD; both in Herb. Hooker, Kew. The latter has large distinct spermogones. A specimen in the Herbarium of the Botanical Society of Edinburgh, with apothecia—no habitat given—has a thallus black-punctate over its whole surface from the profusion of spermogones. Back River Gully, Tasmania, on rotten wood; coll. by OLDFIELD; in Herb. Hooker; is a large-lobed form, resembling *P. caperata,* with a few large, scattered spermogones.

Specimen 5.—SCHÆRER exs. 379 (sub *P. centrifuga a. conspersa*); on micaceous stones, Switzerland. Spermogones abound, in every stage of their development; sometimes punctiform, sometimes maculiform, always thickly aggregated, frequently with black, stellate-fissured ostioles. The spermatia are acicular, and about $\frac{1}{4000}$th long. The sterigmata, with the spermatia attached, measure about $\frac{1}{1000}$th to $\frac{1}{1500}$th long.

Specimen 6.—HEPP. exs. 37; on the same piece of stone with *Lecidea atro-alba β, vera.* Næg. There are only a few fragments of *P. conspersa,* which are studded over with the apothecia of *Lecidea oxyspora,* Tul. These are round, discoid, largish, black, and immersed; the thecæ are 8-spored, easily found, and strike a blue colour with solutions of iodine. These apothecia cannot be confounded with the spermogones of *P. conspersa;* but the spermogones of *L. oxyspora* might with those of *P. conspersa.* The spermogones of *L. oxyspora*, however, will always be found intermixed with its apothecia, and these generally occur on deformed bullose or wart-like portions of the thallus of *P. conspersa*, somewhat resembling those of *P. saxatilis*, *P. olivacea*, *Platysma glaucum*, and other lichens on which the same *Lecidea* is sometimes parasitic. In this individual specimen I do not find the spermogones of *L. oxyspora*; but they will be found described in my "Monograph of the Genus *Abrothallus*." The spermatia are like those of *P. conspersa*; but the sterigmata differ, in being simple and non-articulated.

Specimen 7.—Var. *leonora* (sub *Parmelia leonora*, Spr.; *P. conspersa*, var. *multifida*, Flot.); near Constantia, Northern Africa, Dr KRAUP; in Herb. Hooker, Kew. The thallus has narrow linear laciniæ, sub-convex above, and distinctly dotted over with the black ostioles of immersed spermogones, which are frequently depressed, frequently surrounded by a black ring, or seated in the centre of a black macula. The spermatia and sterigmata are precisely as in our British *P. conspersa.*

Specimen 8.—*P. Tasmanica*, Tayl., if it is not referrible here as a variety, is a closely allied species. Van Dieman's Land, GUNN; in Herb. Hooker, Kew. In regard to the size of its lobes, it is intermediate between the ordinary forms of *P. conspersa* and *P. caperata*. Its spores are oval and simple, like those of *P. conspersa.* The spermogones are confined to the margins of the lobes; they are black, punctiform, and grouped. The older ones have very irregular, often stellate-fissured ostioles; the spermatia are acicular, about $\frac{1}{4000}$th long; the sterigmata quite as in *P. conspersa*. Some specimens of this supposed species seem to me, also, probably referrible to *P. sinuosa*. The character of the thallus and the site of the spermogones approximate it, in some cases, more to *P. sinuosa* than to *P. conspersa*.

Specimen 9.—*P. cribellata*, Tayl., is also a closely allied species to, if it is not a variety of, *P. conspersa*. West Coast of America; in Herb. Hooker, Kew. The spermogones are punctiform and abundant about the ends of the lobes; they are usually larger and more distinct than those of *P. conspersa*. Frequently they are minute black papillæ, rough on their outer surface. The spermatia and sterigmata are the same, in regard to size and other characters, as those of *P. conspersa*.

SPECIES 19. *P. centrifuga*, Ach.,

Which occurs in the northern parts of both Europe and America. On the Norwegian Alps, I have gathered it in great abundance and great beauty. I do not regard it as a separate species, but refer it, scarcely even as a well-marked variety, to *P. conspersa*.

Specimen 1.—FRANKLIN'S First Journey; in Herb. Hooker, Kew. The thallus is of a lighter yellow than *P. conspersa* usually possesses; the laciniæ are narrow and convex, and dotted over abundantly with spermogones, like those of *P. conspersa.* A morsel collected in FRANKLIN'S First Voyage, also in Herb. Hooker, is marked by NYLANDER as the true *P. centrifuga;* it has neither apothecia nor spermogones, but the thallus is that of *P. conspersa.*

Specimen 2.—Specimens from ACHARIUS, 1805, and from Mr MOHR, Upsal, 1803, in Herb. Hooker, Kew, NYLANDER also labels as the true *centrifuga.* They are quite the Norwegian plant collected by myself; and the apothecia and spermogones alike are those of *P. conspersa.* A specimen from near Edinburgh, in Herb. Menzies, Royal Botanic Garden, Edinburgh, is a large-lobed form of *P. conspersa,* with spermogones sparingly distributed.

SPECIES 20. *P. incurva*, Fr.,

Which occurs in Europe and North America, appears to me to bear the same relation to *P. conspersa* that *P. stygia* does to *P. Fahlunensis.* The laciniæ are narrow, convex—sometimes sub-articulate and dotted over with spermogones, which are essentially those of *P. conspersa.* This plant is the *Lichen incurvus*, Ach.; *Lichen multifidus*, Dicks.; and *P. recurva*, Ach.

Specimen 1.—Mr. ROBSON—from England, probably; BORRER, 1809—from Scotland, probably; and Dr. C. LUDWIG, 1814, Riesengebirge; all in Herb. Hooker, Kew. In all cases the spermogones, as well as the thallus and apothecia, where the latter occur, seem to refer the plant to *P. conspersa.*

SPECIES 21. *P. acetabulum*, Dub.,

A native of Europe, Africa, and North America. It includes, I think, *P. corrugata*, Ach., scarcely as a variety (*Lichen corrugatus*, Smith). In regard to the site and character of its spermogones, it closely resembles *P. tiliacea.* They are scattered about the margins of the lobes as small black papillæ, more or less obtuse or flattened on the summit. They are wholly immersed; in depth they extend through the whole thickness of the thallus; their form is oval, spherical, or irregular. The envelope is horny in consistence, and its structure resembles that of the cortical layer of the thallus; the ostiole is usually so minute as to be imperceptible. The spermatia are acicular—from $\frac{1}{5000}$th to $\frac{1}{8000}$th long, with a breadth of about $\frac{1}{25,000}$th. The sterigmata consist of 3 or 4 cylindrical or irregular articulations, and vary in length from $\frac{1}{600}$th to $\frac{1}{1000}$th. This species is comparatively abundant in certain continental countries—*e.g.* in France; and from the abundance and conspicuous character of its spermogones, it is a good species in which to examine these organs. WALLROTH appears to have been familiar with its spermogones, which he described as his *Sphæria epiblastematica.* MASSALONGHO, according to KÖRBER, has described—very erroneously, as it appears to me—the spermatia of this species as globular or roundish. I have never seen them otherwise than straight and linear.

Specimen 1.—SCHÆRER exs. 547; on the trunks of trees; Switzerland. Spermogones are abundantly studded over the margins of the lobes; they are black or deep-brown punctiform or papillæform bodies—in the latter case, flattened or depressed on the apex. The envelope is of a pale-brown cellular tissue. The spermatia are about $\frac{1}{6000}$th long; the sterigmata, $\frac{1}{600}$th to $\frac{1}{750}$th long. Associated with the ordinary or spermatiferous sterigmata, occur numerous long, branching, delicate filaments, projecting into and occupying the cavity of the spermogone, as in *P. physodes, P. saxatilis*, &c.; they have a breadth of about $\frac{1}{15,000}$th to $\frac{1}{18,000}$th.

Specimen 2.—(Sub *P. corrugata*, Ach.); no habitat given; in Herb. Hooker, Kew. Apothecia are large and plentiful. The spermogones are also plentiful about the margin of the lobes, as brown punctiform bodies, closely aggregated, sometimes sub-confluent—frequently surrounded by a brown ring, or seated in the centre of a roundish macula. The spermatia are about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata are about $\frac{1}{1000}$th long.

SPECIES 22. *P. Hottentotta*, Ach.,

As its name would imply, an African species (syn. *P. reticulata*, Nees; *Sticta Hottentotta*, Ach.; *Omphalodes Hottentotta*, Flot.) The spermogones are frequently very large and distinct, crowded about the periphery of the thallus. NYLANDER refers this plant to the *P. acetabulum* group; but the general aspect of the plant, as well as its apothecia and spermogones, would lead me to place it under *P. saxatilis.*

Specimen 1.—Cape of Good Hope; in Herb. Hooker, Kew. The spermogones, in site, external characters and internal structure, are those of *P. saxatilis.* The spermatia are acicular, about $\frac{1}{5000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are about $\frac{1}{1000}$th long, and consist of a few delicate linear articulations.

SPECIES 23. *P. olivacea*, Ach.,

Which is found in Europe, Africa, America, Asia, and Australia.

Specimen 1.—Var. *exasperata*, Ach. (syn. *Imbricaria aspera*, Mass. Körb. 78.); on birch and other trees, foot of Morchone, Braemar, August 1856, W. L. L. Almost the whole surface of the thallus is isidiiferous, or covered over with very minute cone-shaped or columnar warts—as occurs in *P. saxatilis* or *Evernia furfuracea.* This form of *P. olivacea* bears the same relation to the type that the var. *furfuracea* of *P. saxatilis* does to its type. It is an unnecessary refinement to constitute this into a distinct variety, and still more into a distinct species. The spermogones must be looked for on the smooth ends of the peripheral laciniæ. So difficultly recognizable are they, that it will be necessary to moisten the thallus before they can be seen even under the lens. They will then become apparent, as extremely minute black immersed points. They cannot be confounded with the isidioid warts of the thallus, which contain only gonidia and white medullary tissue. The interior of the spermogone contains much mucilage. The spermatia are rod-shaped, thickish throughout, with obtuse ends—about $\frac{1}{2000}$th to $\frac{1}{3000}$th long. They are thrown off from the ends and sides of very irregular, ramose sterigmata, which consist of several linear, longish articulations—very beautiful and distinct. The cellular tissue, of which the spermogonal envelope is composed, is of a very pale brown. Apothecia are abundant.

Specimen 2.—SCHÆRER exs. 370 (sub *a. corticola a. glabra*); on trees in open places; Switzerland. The spermogones occur, on the right-hand specimen in my copy, as deep olive-coloured or brown punctiform bodies,—wholly immersed,—scattered about the edges of the lobes. The thallus, as in the former case, and indeed in all cases, requires to be moistened before the extremely indistinct spermogones can be seen.

Specimen 3.—SCHÆRER exs. 372 (sub *β. saxicola, a. glabra*); on stones in alpine localities; Switzerland. The spermogones are here scattered over the surface of the thallus as minute black or brown bodies, sometimes punctiform, sometimes papillæform. The spermatia are about $\frac{1}{5000}$th to $\frac{1}{6000}$th long, rod-shaped, studded on the apices and sides of articulated sterigmata.

Specimen 4.—Var. *aquiloides* mihi. From Miss HUTCHINS, 1810; no habitat given, but probably from Ireland; in Herb. Hooker, Kew; and also, from the same lady, in Herb. Carroll. The whole plant so closely resembles in general aspect *Physcia aquila*, that I propose designating it as var. *aquiloides*. It is generally only distinguishable by its apothecia and spores, which are those of *P. olivacea*, simple, oval, and colourless; those of *P. aquila* being brown and 1-septate. The laciniæ are pale, narrow, and convex, studded over with minute papillæform spermogones, resembling those of *P. aquila*, chiefly old, and containing no free spermatia.

SPECIES 24. *P. stygia*, Ach.,

A native of Europe and Northern America.

Specimen 1.—Summit of Ben Nevis, August 1856, W. L. L. The plant is abundant in this locality, bearing fine apothecia. The laciniæ are narrow, convex, and pitchy-black; they are covered over with black minute papillæ or perforations, the latter having generally a sub-prominent black edge. These papillæ mark young spermogones with imperceptible ostioles; the perforations are the patent ostioles of old spermogones, generally very indistinct on the dark-coloured thallus. The peripheral laciniæ are sometimes pale; in which event the plant has a close resemblance to var. *stygioides* of *P. encausta*, as it occurs on the summit of Cairngorm.

Specimen 2.—Summit of Morchone, Braemar, August 1856, W. L. L.; with apothecia. The spermogones are scattered abundantly over the convexities, and towards the tips of the laciniæ, as minute black papillæ. The older spermogones are marked by large, gaping ostioles, usually more or less round in outline, having black, turgid, ring-like borders. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, seated on the apices and sides of very irregular, delicate sterigmata, the articulations of which are short, roundish cells. Associated with the sterigmata are numerous elongated branching filaments, also articulated or septate, which project into and occupy the cavity of the spermogone, as in *P. physodes*, *P. saxatilis*, &c.

Specimen 3.—SCHÆRER exs. 255 (sub *Cetraria stygia*, *a. latior*); with apothecia; on stones in the higher Alps, Switzerland. The laciniæ are studded over with minute perforations, which are the ostioles of old spermogones, containing no free spermatia.

SPECIES 25. *P. Fahlunensis*, Ach.,

A native of the alpine or frigid portions of Europe, America, and Asia. In this and the following species the spermogones are marginal,—forming a sort of denticulate fringe, as in *Platysma*.

Specimen 1.—Summit of Cairngorm, August 1856, W. L. L. The spermogones abundantly fringe the crisped, curled margins of the flat, linear, pitchy-black laciniæ, as deep-brown, minute, round warts. They resemble the spermogones of *Platysma ciliare*, but are generally not so closely aggregated. The spermatia are very minute, ellipsoid, about $\frac{1}{10,000}$th long, immersed in an abundant mucilage. The sterigmata are articulated, but very delicate and indistinct.

Specimen 2.—On rocks, Carlowrie, 1843; coll. GARDINER, of Dundee; in Herb. Royal Botanic Garden, Edinburgh. There are no apothecia; but the spermogones are very abundant and distinct. They are barrel-shaped and black, fringing the margins of the laciniæ like teeth, and precisely resembling the spermogones of *P. ciliare*. They are seated also frequently on the flat surface of the laciniæ, near their ends, growing upwards at right angles to the thalline surface.

Specimen 3.—SCHÆRER exs. 373 (sub *a. vulgaris*, *a. major*), and 374 (sub *a. vulgaris*, *b. minor*); on micaceous rocks in the Alps. The spermogones are precisely as in Nos. 1 and 2; the spermatia are rod-shaped and minute, and the sterigmata shortish and of a few articulations.

SPECIES 26. *P. tristis*, Web.,

A native of Europe and North America. As in the preceding species, the spermogones occur only on the margins of the flat, linear, erect laciniæ. In the young state, they are inconspicuous small black cones or warts; in the old state, they are much more easily recognised by the large, gaping ostioles with turgid, black borders. The oldest spermogones are usually found lowest down on the thalline laciniæ; hence the spermogones about the tips are generally papillæform, young, and full of free spermatia, while those about the base are perforate, empty, and contain no spermatia at all. The spermatia are rod-shaped, and about $\frac{1}{5000}$th to $\frac{1}{6000}$th long.

Specimen 1.—Hills above Loch Freuchie, Amulree, Perthshire, May 1856, W. L. L. The spermogones are abundant as small irregular warts, fringing the margins of the sub-compressed laciniæ. They are generally of a deeper black colour than the laciniæ, and have a more or less distinct and patent ostiole. They vary much in size; sometimes they are confluent, and then become very irregular. They are generally arranged in a linear series along the edge of the laciniæ, but sometimes they are clustered thickly about their ends. In some cases the apex of a lacinia consists of an irregular fusiform bulging or swelling, pierced by a number of minute perforations, irregularly distributed, and of a deeper black than the swellings in question, or than the general surface of the thallus. These perforations are the ostioles of confluent and compound spermogones, and closely resemble what occurs normally and regularly in *Neuropogon melaxanthus* and *Alectoria Taylori*.

Specimen 2.—Summit of Morchone, Braemar, August 1856, W. L. L. The spermogones are as described in No. 1. The spermatia are rod-shaped, about $\frac{1}{6500}$th long, borne on the apices of sub-simple linear sterigmata, which are ramose at the base. They are frequently sub-digitate, apparently given off as finger-like processes or elongations from basal tubes or cells. They are almost always very delicate and indistinct.

Specimen 3.—Hills east of Sligachan, Skye, August 1856, W. L. L. The spermogones are sparingly distributed; they are chiefly old, and are marked by large, gaping ostioles.

Specimen 4.—High Mountains, County Kerry; coll. TAYLOR; in Herb. Hooker, Kew. There are spermogones, resembling those above described, but no apothecia.

Specimen 5.—SCHÆRER exs. 256 (sub *Cetraria*); on stones in the higher Alps; with apothecia. The spermogones are mostly old, containing no free spermatia; they are black tubercles, scattered along the edges of the flattened linear laciniæ, to which they give a minutely denticulate character. Most of them are perforated by a large, gaping ostiole.

GENUS IV. PHYSCIA, *Fr.*, *Nyl.*

I do not think that *Physcia* should be separated from *Parmelia*, save as a section or sub-division. Its spermogones are essentially the same, though there are several points of difference as well as resemblance. Their site is usually the same—they are more or less immersed—the spermatia are straight and linear, borne on articulated sterigmata. In *Physcia*, however, the spermogones are usually larger and more conspicuous than in *Parmelia*; their colour is sometimes orange-red or yellow, as well as brown or black; the spermatia are mostly smaller, and the sterigmata longer and composed of more numerous and shorter articulations. In *Physcia*, the spermogones are more frequently papillæform, or tuberculiform, than in *Parmelia*. Sometimes they are very large and prominent, particularly when they become confluent, and assume the form of irregular tubercles, as in *P. ciliaris*. The diameter of the spermogone in this species is $\frac{1}{25}$th; while in *P. parietina* it is about ten times less. The spermogones are largish, distinct, black cones in *P. stellaris* and other species with a grayish or whitish thallus. In other cases, they are brown. Sometimes they are covered with a white pruina, as in *P. pulverulenta*. In *P. parietina*, *flavicans*, *chrysophthalma*, *flammea*, *villosa*, and other species, they are orange-coloured cones or warts, which become very conspicuous and beautiful where the plant has a grayish or whitish thallus, as in *P. villosa*. In this species, also, they may be so large as to be visible to the naked eye. The ostiole is usually very minute and round. Sometimes it becomes stellate-fissured with age, as in *P. pulverulenta*. Frequently, also, in the old state of the spermogone, it assumes the form of a large roundish perforation, with more or less distinct, turgid margins, as in *P. aquila*. If the body of the spermogone fall out in age, as is occasionally the case, the ostiole may expand still more, and become saucer-shaped, or like cyphellæ, as in the same species. The diameter of the simple, round, imperceptible ostiole is frequently about $\frac{1}{600}$th to $\frac{1}{800}$th, as in *P. parietina*. The spermogonal envelope is formed of roundish or cubical cellules, more frequently brown than any other colour. The cavity of the spermogone is generally simple; but in several species, and particularly in the case of compound or confluent spermogones, it is divided into sinuosities or compartments, as in *P. ciliaris* and *P. villosa*. The spermatia are generally shorter than those of *Parmelia*; they are usually rod-shaped or acicular, sometimes sub-ellipsoid. They vary in length from $\frac{1}{3000}$th to $\frac{1}{10,000}$th, a large number being from $\frac{1}{4000}$th to $\frac{1}{8000}$th long. Their average breadth is $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. The sterigmata seldom consist of only two or three articulations, as in *Parmelia*, nor are these articulations often long linear cells. They are more usually longish, ramose or simple, composed of more than five or six short, roundish or cubical cellules. These cellules have originally thin walls, which, however, become thickened by deposits in their interior. The arthro-sterigmata of *Physcia*, therefore, somewhat resemble those of *Sticta* and *Collema*. Their length varies from $\frac{1}{300}$th to $\frac{1}{1000}$th generally.

SPECIES 1. *P. ciliaris*, DC.,

A native of Europe, Africa, and North America. This species is of much historical importance and interest to the lichenologist, inasmuch as in it spermogones were first discovered and described by ITZIGSOHN, in Germany. It is, moreover, a common lichen, and a species abounding in large, well-marked spermogones, visible usually to the naked eye. They are obtuse, very prominent warts or tubercles, scattered on the convexities of the laciniæ; they are isolated or confluent—in the latter case becoming very irregular in form. Their colour is usually brown; that of the thallus varies between olive and gray. The spermogones are generally most conspicuous on the gray thallus, from the contrast of their deep olive-brown colour. The apex of the spermogone is usually brown, sometimes blackish, the ostiole being minute and very indistinctly marked. Sometimes it is elongated or chink-like. The apices of confluent spermogones are generallystudded over with minute black or brown roundish ostioles. The interior tissue is grayish, and of a horny denseness; it is hence easily sectioned in thin laminæ. The sterigmata are longish, and composed of short, roundish cellules; they are the "Männliche Prosphysen" of the speculative Bayrhoffer. So abundant and so constant are the spermogones sometimes, as to give a character to the plant; hence spermogoniferous states have been described as varieties by the earlier authors. Such is the var. *melanostigma* of Acharius.

Although it is only a few years ago since Itzigsohn pointed out the existence of what are now called "spermatia," yet the spermogones above described have long been familiar to lichenologists. So long ago as 1741, Dillenius* drew attention to the brown tubercles occurring on the thallus of *P. ciliaris;* and Hedwig,† in 1784, saw in the same bodies one of the forms of his supposed masculine organs of reproduction in lichens. Acharius regarded the same organs as secondary or accessory apothecia,—of inferior importance to the normal or usual ones,—which he called *Cephalodia*, and which he described as filled with *gongyli.* Nor did Itzigsohn, so lately as 1850, correctly appreciate the character of the spermogones of *P. ciliaris*, or of their contents. He described the spermogones as *antheridia*, and the spermatia as *spermatozoids*, similar to those of *Marchantia* and *Polytrichum*, possessing true animalcular movements. From these spermatozoids, however, the spermatia of *P. ciliaris* differ entirely in regard to their genesis. The important bearing of Itzigsohn's observations, whether his theories were correct or not, was at once seen by other Continental botanists, who forthwith proceeded to repeat his experiments. Some observers corroborated Itzigsohn's theories as well as his facts; while others, more cautious, less biassed, and less impulsive or sanguine in their temperament perhaps, saw the spermatia, but took a different view as to their nature and analogies. It is unnecessary to detail the results of the observations of different German botanists, who contributed voluminously on the subject to the "Botanische Zeitung," in 1850 and 1851.‡ Suffice it to notice the most important result of Itzigsohn's observation on *P. ciliaris*,—apparently a most simple one,—which was, that the subject was followed up in France by Tulasne to a previously unknown extent. He made an

* Historia Muscorum, p. 150, Tab. 20, f. 45, BC.

† Theoria Generationis et Fructificationis Plant. Crypt., p. 120. Pl. 30 and 31.

‡ *Vide* vol. viii., pp. 393–94, May 17, 1850; pp. 917–19, December 27, 1850. Vol. ix., pp. 153–4, February 21, 1851, and p. 913.

elaborate series of investigations, to ascertain whether all lichens did not possess similar organs; and the result was one of the most valuable contributions ever made to the natural history of the lichens,—one which is the basis of all our recent and improved information on their minute structure.* The years 1850 and 1852, the dates of the publications respectively of ITZIGSOHN and TULASNE, may be thus said to constitute an important era or epoch in the history of lichenology. The labours of the German and French lichenologists, during the years 1848–52, have certainly given a powerful and much-wanted impetus to lichenology.

Specimen 1.—On old ash trees, roadside, Balthayock, near Perth, June 1856, W. L. L. The spermogones are old, containing no free spermatia; they are mostly confluent, very irregular and quite distinct to the naked eye. So abundant are they, that they give a coarsely warted character to the whole thallus. In none of the spermogones, whether isolated or confluent, is there a distinct ostiole.

Specimen 2.—On trees, old Castle of Melgund, Forfarshire; coll. A. CROALL, 1853. Here also the spermogones are old; they are of a deeper brown colour than the thallus, and are irregular large warts, frequently confluent, scattered about the ends of the laciniæ. The ostiole is seldom recognisable when young; when old, it sometimes becomes a narrow elongated fissure.

Specimen 3.—A specimen in Herb. Botanical Society, Edinburgh (no habitat given), has young and mature spermogones, containing spermatia. The spermogones are very abundant as brown papillæ rather than warts. The ostiole is seldom round, generally elongated or stellate-fissured. The spermogones are generally grouped, frequently confluent; they are distinct on account of the pale grayish-brown colour of the thallus. This is one of the best specimens I have ever met with of the spermogones of *P. ciliaris*. The spermatia are rod-shaped, about $\frac{1}{6500}$th long.

SPECIES 2. *P. leucomela*, Mich.,

A beautiful species, growing in Europe, Africa, Asia, America, and Australia. The spermogones are essentially those of the last species in site and structure; but they are usually smaller and more regular, and, from the whitish colour of the thallus, and their own brown or blackish colour, they are usually much more easily recognised than in *P. ciliaris*.

Specimen 1.—On rocks by the sea, near Ballycotton, County Cork; coll. CARROLL. There are a few old spermogones, closely resembling those of *P. ciliaris*; they are largish brown tubercles or papillæ, scattered about the ends of the laciniæ, and very distinct from the contrast of their deep-brown colour with the almost pure white of the thallus. The cavity is sinuous, as in *P. ciliaris*.

* Mémoire pour servir, &c., *ol. citat.*

The spermatia are rod-shaped, and about $\frac{1}{7000}$th long, with a breadth of $\frac{1}{25,000}$th seated on articulated indistinct sterigmata.

Specimen 2.—Torquay, 1812; in Herb. Hooker, Kew. In this, as in all English specimens I have seen, the laciniæ are short, stout, and broadish; the spermogones are rare, and the apothecia never found.

Specimen 3.—Var. *contracta*, Nyl. (Syn. *P. echinata*, Tayl.); in Herb. Hooker, Kew. Here also the lobes are short and broad. The spermogones are abundant as brown warts or papillæ, about the ends, and on the convexities, of the grayish or whitish lobes. Most of the foreign specimens of *P. leucomela*, in Herb. Hooker, are referrible to NYLANDER's var. *angustifolia*, M. and Flot., which he describes as occurring only in equatorial America, St Helena, and the East Indies.

SPECIES 3. *P. speciosa*, Fr.,

Which occurs in Europe, Africa, America, Asia, Polynesia, and Australia. This plant may be considered, in regard to its general aspect, as intermediate between *P. leucomela* and *P. stellaris*, though it more closely resembles the latter than the former. Its spermogones are for the most part those of the latter,—of which, indeed, I am inclined to consider *P. speciosa* a variety.

Specimen 1.—SCHLEICHER's exs. No. 47, 1815; on the trunk of *Prunus avium*, Nepaul. The spermogones are those of *P. stellaris*. They are black, prominent papillæ, seated on the convexities, and about the ends, of the laciniæ, sometimes isolated, sometimes in closely aggregated groups. A specimen from Caracas, BIRSCHELL, is precisely the Irish form of the plant as sent me by Mr CARROLL. There are no apothecia; but spermogones are abundant. Mauritius specimens have the spermogones brown, very small and inconspicuous, wholly immersed. In those from Jamaica, Dr WRIGHT, the laciniæ are large and cream-coloured, and the spermogones bluish-black, and distinct from the contrast of their colour with that of the thallus. In those from Madras, the laciniæ or lobes are large, waxy, and pale, and the spermogones few, large, and black. All the above specimens are in Herb. Hooker, Kew.

Specimen 2.—(Sub *P. diadenata*, Tayl.); Madras, Calcutta, Singapore, Nepaul, Jamaica; all in Herb. Hooker, Kew. This is a very handsome form of the plant, peculiar to hot climates. The spermogones occupy precisely the position they do in *P. stellaris*. A few are grouped together about the ends of the laciniæ, as small, brown papillæ.

SPECIES 4. *P. Domingensis*, Mont. non. Ach.,

Which occurs in America, Asia, and Polynesia. It seems to me also a mere form of *P. stellaris*; their spermogenes are quite the same.

Specimen 1.—Cuba, ex. Herb. Mont.; in Herb. Hooker, Kew. The spermogones are grouped on the convexities of the laciniæ; they are usually brown, punctiform, and immersed. Sometimes they are confluent, and then they become irregular in form. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata consist of a few delicate, cylindrical articulations, and measure about $\frac{1}{3000}$th long only.

SPECIES 5. *P. stellaris*, Fr.,

A native of Europe, America, Africa, Asia, and Australia. There are several varieties, of which the most common and important is var. *tenella*, Schærer, which is *pro parte* at least the *Borrera tenella* of the earlier authors. From the frequency with which the spermogones occur, and from their distinctness,—their colour being black or deep brown, while that of the thallus is gray or whitish—*P. stellaris* is one of the best species in which to study the spermogones of *Physcia*. Usually only the black, papillar ostioles are visible on the surface of the thallus, in the medullary tissue of which the body of the spermogone is immersed. Hence those black ostioles frequently resemble parasitic *Sphœriæ*. The walls or envelope of the spermogone are at first gray, but subsequently become black. The diameter of the spermogone in the large-lobed form of the plant,—*P. aipolia* of authors,—is about $\frac{1}{130}$th. The cavity is pluricellular and sinuous, as in *P. ciliaris*.

Specimen 1.—On ash trees, Muirhall, Perth, W. L. L.; associated with *P. pulverulenta*, which it often very closely resembles. The spermogones and spores, however, especially the former, to a certain extent distinguish *P. stellaris*; for the spores differ from those of *P. pulverulenta* chiefly in size. The spermogones of *P. stellaris* are always small, black or brown cones or papillæ, with imperceptible ostioles; while those of *P. pulverulenta* are largish cæsio-pruinose, thalline papillæ or tubercles, opening by stellate-fissured ostioles.

Specimen 2.—Kyles of Bute, on trees, 1852, W. L. L. This is a broad-lobed form. The spermogones are grouped in considerable numbers as small, punctiform, immersed bodies.

Specimen 3.—On ash trees, roadside, near Pitrodie, Carse of Gowrie, June 1856, W. L. L. The spermogones are smooth, prominent, black cones or warts, with imperceptible ostioles, scattered sparingly about the ends of the laciniæ. On ash trees, roadside, near Glencarse, Carse of Gowrie,, May 1856, W. L. L. They vary greatly in size; but all are black, papillar, and distinct, the thallus being of a very pale grayish tint. In other narrow-lobed forms from the same locality, the spermogones are very prominent as brown, minute, round warts grouped on the convexities of the thallus. The spermatia are about $\frac{1}{8000}$th long; the sterigmata are very delicate, composed of short roundish cellules or articulations.

Specimen 4.—On trees, Glen Nevis, August 1856. Here the spermogones are mostly degenerate. They are, moreover, sparingly scattered, inconspicuous and small, being more mere black points than well-developed warts. Spermogones also abound in specimens collected on ash and other trees, at Annat Cottage, Carse of Gowrie, 1855, W. L. L.

Specimen 5.—On trees, Morchone, Braemar, August 1856, W. L. L. This is the broad-lobed form—the *P. aipolia* of older authors. The spermogones are minute, black papillæ; their envelope light brown; the spermatia from $\frac{1}{6500}$th to $\frac{1}{8000}$th long, and the sterigmata short and distinct. On roadside walls, between the Spittal of Glenshee and Braemar, August 1856, W. L. L. The spermogones are few; the spermatia about $\frac{1}{4000}$th long; the sterigmata very distinct, irregular, composed of elongated, cylindrical, thick-walled cells, varying, however, considerably in size.

Specimen 6.—On trees, Kinmundy, Aberdeen, Professor DICKIE. The disk of the apothecium is brown, instead of black, and the apothecia have consequently the appearance of those of *Lecanora subfusca.* The spermogones are abundant as black papillæ or cones. The spermatia are rod-shaped, about $\frac{1}{8000}$th long, and $\frac{1}{25,000}$th broad, on sterigmata which measure $\frac{1}{1500}$th to $\frac{1}{1000}$th long, and which are composed of short, roundish or oblong irregular cells.

Specimen 7.—On basalt, near the Giant's Causeway, County Antrim; Dr MOORE, in Herb. Carroll; no apothecia. The spermogones are plentiful; the spermatia about $\frac{1}{10,000}$th long, and $\frac{1}{25,000}$th broad.

Specimen 8.—SCHÆRER exs. 350 (sub *a. aipolia*); on the bark of trees about Belp. The spermogones are of the papillar type, as is usual in the broad-lobed form of the plant.

Specimen 9.—HEPP. exs. 473; associated with *Lecidea exilis;* a form passing into var. *tenella.* The spermogones are distinct black cones, scattered in groups over the broadish laciniæ.

Specimen 10.—Var. *tenella*, Sch.; a variety characterised chiefly by the presence of marginal and terminal cilia, varying in length. The laciniæ are generally narrow; convex above, occasionally almost sub-fistulose, with frequently bullose or sorediiferous extremities. With var. *tenella*, it appears to me that SCHÆRER's var. *hispida* should also be associated; at least, I know of no valid reason for dissociating them. In this variety, which has usually a very pale thallus, the spermogones are more abundant and distinct than in the ordinary type of the plant. Walls on the hills above Innerleithen, August 1855, W. L. L.; with apothecia. The centre of the thallus is abundantly sorediiferous. The spermogones are plentiful, and very distinct as prominent, elevated, roundish deep blackish-brown or black warts, in many of which the ostiole may be seen as a minute, round, or slightly irregular pore or foramen. The spermatia are rod-shaped, about $\frac{1}{8000}$th long; the sterigmata very slender. Similar spermogones occur in specimens growing on walls at the Grange, Edinburgh, 1851, W. L. L.

Specimen 11.—Var, *tenella;* Blaeberry Hill, Perth; on trees and stones, plentiful; April 1856, W. L. L. The spermogones are plentiful on specimens destitute of apothecia; the ostiole is frequently distinct, usually triangular or stellate. On an old wall, Rossie Moor, Forfarshire; coll. CROALL. Specimens bear both apothecia and spermogones.

Specimen 12.—Var. *tenella;* on walls, Penmanshiel, Berwickshire, 1856; coll. JAMES HARDY; no apothecia. The spermogones are sometimes isolated, sometimes grouped. The latter chiefly occur about the centre of the thallus. Some of them are very large, prominent, black warts, flattened above, and with a distinct ostiole.

Specimen 13.—Var. *tenella;* Morchone, Braemar; on trees, August 1856, W. L. L. This is a dark olive-green form, closely resembling *P. obscura*. The margins of the laciniæ bear few cilia. On the same trees occurs the broad-lobed form of *P. stellaris*. The spermogones are few and scattered.

Specimen 14.—Var *tenella;* on the trunks of trees, under Dunscombe's Wood, Cork; coll. CARROLL; associated with *P. obscura*. The spermogones are distinct, as black or brown papillæ. The spermatia are about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata measure $\frac{1}{1500}$th to $\frac{1}{1000}$th in length. The var. *tenella* is common in Ireland, according to TAYLOR in Herb. Mackay. Spermogones are plentiful in specimens from Carrigaloe, Cork; coll. CARROLL; on the bark of trees.

Specimen 15.—Var. *tenella;* Bieldside, Aberdeen, Professor DICKIE; one of the very common transition forms between the *aipolia* and the *tenella* varieties, the marginal fibres or cilia being neither many nor prominent. The spermogones are plentiful and prominent as brownish papillæ or tubercles, varying much in size. The envelope is, as in all cases in *P. stellaris*, brown; the spermatia $\frac{1}{9000}$th long, and $\frac{1}{25,000}$th broad; and the sterigmata about $\frac{1}{1500}$th to $\frac{1}{1000}$th long.

Specimen 16.—Var *tenella*, SCHÆRER exs. 349 (sub *Parmelia pulchella γ. semipinnata*); on palings about Belp, Switzerland. The spermogones are prominent black cones or tubercles sparingly scattered. Exs. 351 (sub *β. ambigua*); on young ash trees about Belp.; on the right-hand specimen in my copy (ed. alt. immut. 1840). The spermogones are here smaller, but are still distinct. The spermatia are $\frac{1}{9000}$th long, and the sterigmata $\frac{1}{1500}$th to $\frac{1}{1200}$th. Exs. 352 (sub *δ. tenella*), on the trunks of trees about Belp. The spermatia are very minute, about $\frac{1}{12,000}$th long, and $\frac{1}{25,000}$th broad, sub-ellipsoid, and in myriads. The sterigmata are longish, the articulations being numerous and short. HEPP. exs. 15, associated with *Lecidea chalybeia;* on old willows and poplars. The spermatia and sterigmata are those of the type.

Specimen 17.—Var. *adglutinata* mihi; on trees, roadside, Caerlaverock Road, Dumfries, August 1856, W. L. L. This is a peculiar form from the thallus being rather crustaceous than of the usual foliaceous type. It is very closely adherent to the bark on which the plant grows; unless at the periphery here and there, there is little or no trace of laciniæ, the thallus consisting of a series of white crustaceous warts. The whole plant has a close resemblance to some forms of *Lecanora sophodes* or *L. atra*. The spermogones also resemble externally those of the *Lecanoras* just named. They are minute black points, scattered on the warts aforesaid, and among the apothecia. The spermatia are about $\frac{1}{8000}$th long; the sterigmata very irregular, sub-ramose, thickish, composed of short broadish articulations. The sterigmata are very closely aggregated, and hence indistinct *en masse*.

Specimen 18.—Var. *albinea*, Ach. (Syn. *Parmelia erosa*, Borr.); Falmouth and Cornwall, Miss WARREN. The spermogones are distinct, black, sub-prominent papillæ, generally isolated; the spermatia are $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad, and the sterigmata about $\frac{1}{2000}$th long, consisting of a very few longish, cylindrical, and generally irregular articulations. British North America, RICHARDSON; Rocky Mountains, DRUMMOND: on the trunks of trees, Troy, U. S.; on *Gleditschia*, Ohio, U. S., LEA: Swan River, Australia, JAS. DRUMMOND; on stone walls, Boston, U. S., F. BOOTT. All these specimens are in Herb. Hooker, Kew, and all possess both apothecia and spermogones.

SPECIES 6. *P. astroidea*, Fr.,

Which occurs in Europe and America. This, as well as the following species, seem to me mere varieties of *P. stellaris*; this is characterized by the very soderiiferous surface of the thallus. The spermogones are externally similar to those of *P. stellaris;* but the spermatia are usually larger, and the sterigmata composed of much longer, delicate, linear cells or articulations. The spermatia, in one specimen, in Herb Botanical Society of Edinburgh,—the habitat not being given,—are $\frac{1}{4000}$th long. The plant is associated with var. *tenella* of *P. stellaris.*

SPECIES 7. *P. cæsia*, Fr.,

A native alike of Northern America and of Europe. It is chiefly saxicolous, characterized by plentiful, roundish, gray soredia on the very narrow convex laciniæ. Its spermogones are essentially those of *P. stellaris*; they would appear to have been described by SPRENGEL as *Endocarpon athallum*.

Specimen 1.—On boulders and walls, roadside between Sligachan and Portree, Skye, August 1856, W. L. L. The plant is associated with var. *tenella* of *P. stellaris;* and, indeed, *P. cæsia*, *P. stellaris*, and *P. astroidea*, graduate into each other, and are certainly, in my opinion, referrible to a common type. The spermatia are very small, about $\frac{1}{8000}$th to $\frac{1}{10,000}$th long; the sterigmata very delicate, irregular, and composed of short, roundish articulations.

Specimen 2.—SCHÆRER exs. 348, (sub. *Parmelia pulchella*, *β dubia*); on palings about Belp. There are no apothecia; the spermogones are, in all respects, those of *P. stellaris*.

SPECIES 8. *P. confluens*, Fr.,[1]

A foreign species, growing in equatorial America, Africa, and Asia.

Specimen 1.—New Orleans; on bark, DRUMMOND; in Herb. Hooker, Kew (sub nom. *Lecanora atra*). The apothecia closely resemble those of *L. atra;* but the thallus is that of *P. stellaris*. The spermogones are also those of the latter species; they are here brown and punctiform, rather than papillæform however.

SPECIES 9. *P. obscura*, Fr.,

Occurring in Europe, Asia, Africa, and Australia. This species, in regard to both its thallus and spermogones, is intermediate between *P. stellaris* and *P. pulverulenta;* and it is frequently mistaken for one or other of these species. The spermogones, however, are rather those of *P. pulverulenta* than of *P. stellaris*. They are small warts or tubercles, generally of the colour of the thallus, scattered sometimes about the centre, sometimes about the periphery, of the thallus. The internal tissue is whitish; the cavity is divided into sinuous compartments, as in *P. ciliaris*. The sterigmata are longish, and composed of numerous short thick-walled cellules or articulations. The spermatia have always appeared to me rod-shaped or ellipsoid; TULASNE describes them as almost ovoid, and KÖRBER as "eirundlich," They are in all cases very minute,—their average length being $\frac{1}{8000}$th to $\frac{1}{10,000}$th.

Specimen 1.—On the trunks of trees under Dunscombe's Wood, Cork; coll. CARROLL. The ends of the laciniæ are frequently converted into irregular wart-like bullosities, over which are studded black or brown punctiform immersed bodies, somewhat irregular in shape, which have quite the aspect of spermogones. They are really, however, lecidine apothecia, containing 8-spored thecæ, about $\frac{1}{500}$th long and $\frac{1}{1500}$th broad. The spores are simple, ellipsoid, $\frac{1}{1500}$th long, and $\frac{1}{6000}$th broad, pale-brown or yellow, full of oil globules of every size, which oil globules also abound in the thecal protoplasm. For this parasite, I propose, provisionally only, the name *Lecidea obscuroides*. The apothecia, which are at first round and immersed, ultimately become more superficial and saucer-shaped.

On specimens of var. *leprosa* (HEPP. exs. 65), [a form in which the thallus is almost absent, or is leprose, from Morchone, Braemar (on trees),] there is a parasitic *Sphæria*, which also closely resembles spermogones. It occurs as small black points on the leprose thallus, external to the apothecia.

Specimen 2.—LEIGHTON exs. 49; on old bark, near Shrewsbury, associated with *P. pulverulenta*; bears apothecia. There are only two spermogones in the specimens in my copy. The spermatia are $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad, sub-ellipsoid or rod-shaped.

Specimen 3.—Near Melgund Castle, Forfarshire; coll. A. CROALL, 1854; with apothecia and spermogones: old wall near Rescobie, Forfarshire, July 1853; coll. CROALL (sub nom. *Parmelia cycloselis*, Ach.), with apothecia. The spermogones are scattered about the ends of the laciniæ as small, prominent, obtuse, deep-brown warts, in some of which there is a distinct ostiole.

Specimen 4.—HEPP. exs. 183, associated with *Lecanora subfusca;* on the bark of old poplars and other trees. The spermogones are distinct, brown tubercles, scattered about the ends of the narrow white-pruinose laciniæ. Some of the sterigmata have a brownish colour; they are composed of short broad articulations.

Specimen 5.—SCHÆRER, exs. 353 (sub *a. chloantha*); on the trunks of trees about Berne. The spermogones are small, distinct, deep olive-coloured papillæ, sparingly scattered—generally isolated—near the ends of the narrow laciniæ. The spermatia are rod-shaped, about $\frac{1}{6000}$th long; the sterigmata are composed of a few short articulations. Exs. 354 (sub γ *orbicularis*); on tiles and rafters about Belp. The spermogones are as just described; the spermatia are sub-ellipsoid, about $\frac{1}{10,000}$th long. Exs. 609 (sub var. *nigricans*); on poplars about Bienne. The spermogones are abundant as deep olive-brown, prominent, roundish tubercles, sparingly scattered about the margins of the lobes. The spermatia are about $\frac{1}{10,000}$th long; the sterigmata are very delicate, narrow, about $\frac{1}{1000}$th to $\frac{1}{1500}$th long, and composed of three or four, seldom more, articulations.

Specimen 6.—Var. *firmula*, Nyl. (Syn. *Physcia firmula*, Nyl.) NYLANDER places *P. firmula* under *P. obscura*; but I am inclined to refer it rather to *P. speciosa*. A specimen of *P. speciosa* from Lachen, Sikkim, Himalaya (alpine region, at 13,000 feet, with apothecia, in Herb. Hooker, Kew), NYLANDER labels "Transiens in *Ph. firmulam*, Nyl.," which would imply that he regards the latter as, at least, very near *P. speciosa*. But in his "Enumeration générale des Lichens," p. 106, he places *P. speciosa* beside *P. leucomela*, and *P. obscura* beside *P. pulverulenta*. Chongtam, Sikkim, Himalaya; temperate region, at 6000 feet. The thallus is whitish and waxy, with marginal black fibres; the lobes are short, thick, sub-erect. The sterile lobes are studded over with large spermogones, usually one or two, not more than two or three, occurring about the end of each lacinia. They are large brown cones, generally flattened; their body is a large hard white kernel, immersed in the medullary tissue of the thallus. The spermatia are $\frac{1}{8000}$th long, and $\frac{1}{23,000}$th broad; the spermatia are very indistinct. Dr HOOKER, in his Herbarium, refers the plant to *P. speciosa*.

SPECIES 10. *P. pulverulenta*, Fr.,

Is a familiar and widely spread species, occurring in Europe, Africa, and Northern America. Its spermogones closely resemble those of the preceding species; but they are usually larger and more prominent. They are cones or tubercles, the former generally when single, the latter when compound and formed of several confluent spermogones. They are frequently, like the thallus, dusted over with a fine white pruina or powder. Sometimes they are so abundant, according to KÖRBER, as to give the whole thallus an isidioid character. The ostiole is often stellate-fissured, and comparatively conspicuous, especially in the old state of the spermogone. The internal tissue is white, solid or dense, being hence easily divided into thin sections. The cavity is divided into numerous sinuous compartments, as in *P. ciliaris* and *P. obscura*. The length of the spermatia is usually about $\frac{1}{4000}$th to $\frac{1}{6000}$th.

Specimen 1.—On ash, Muirhall, Perth, W. L. L.; associated with *P. stellaris*, with which it is frequently very apt to be confounded. In regard to the differential diagnosis of these two species, I may refer to what I have already said under *P. stellaris*. Old Scone Road, Perth, April 1855, W. L. L.; associated with *P. obscura*, with which, also, this species is apt to be confounded. The spermogones are very abundant as obscure, irregular cones or warts, of the same colour as the thallus; the apex deeper brown; the ostiole seldom distinct when round, but more conspicuous when stellate-fissured. They are generally grouped, sometimes confluent—two or three spermogones uniting to constitute one spermogonal wart. They are thus very different from the spermogones of *P. stellaris;* which spermogones serve to distinguish—where other marks fail—*P. pulverulenta* from *P. stellaris*.

Specimen 2.—On trees, Glen Nevis, August 1856, W. L. L.; associated here, also, with *P. stellaris*, and sometimes scarcely distinguishable therefrom. The spermogones are brown, sub-confluent, or closely grouped prominent tubercles, seated on the convexities, and about the extremities, of the laciniæ. The spermatia are about $\frac{1}{6000}$th long; the sterigmata are very delicate and irregular, consisting of shortish articulations.

Specimen 3.—Carrigaloe, Cork Harbour; coll. CARROLL. The spermogones are pale-brown, largish, white-pruinose papillæ, opening by stellate-fissured ostioles. The spermatia are $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad. On a wall, Sidlaw Hills, 1844, GARDINER; in Herb. Hooker, Kew; a good typical specimen. The spermogones and spermatia are as just described.

Specimen 4.—SCHÆRER exs. 356 (sub *a. allochroa, a. corticola*); on the trunks and branches of trees about Belp. The spermogones are pale-brown, indistinct papillæ, slightly prominent, semi-immersed. The spermatia are about $\frac{1}{6000}$th long, and very abundant; the sterigmata are very irregularly articulated.

SPECIES 11. *P. muscigena*, Ach.,

Which occurs in Europe and North America, seems to me only a muscicolous form of the preceding. The spores are of the same form and size as in *P. pulverulenta*; the spermogones have the same structure, though they are usually smaller papillæ, of a darker brown colour—naked, or not so frequently pruinose.

Specimen 1.—Guldbrandsdal, Norway, SOMMERFELDT, Un. Itin. 1828; also Switzerland; in Herb. Hooker, Kew. Both apothecia and spermogones occur. I have gathered this plant abundantly at various points on the Dovrefjeldt range of mountains in Norway.

SPECIES 12. *P. aquila*, Fr.

Specimen 1.—LEIGHTON exs. 144 (E. B. 982; MOUG. and NEST. 1049); Torquay, Devonshire. The spermogones closely resemble those of *Parmelia stygia;* they are plentiful as small brown tubercles, occurring about the ends of the laciniæ.

When mature, they are generally seen each to be pierced by a minute ostiole, which, with age, becomes very patent and large. When moistened, the spermogones become semi-translucent. The envelope is deep-brown. The spermatia are minute, rod-shaped, seated on the apices and sides of articulated sterigmata, whose component cellules have very thick walls.

Specimen 2.—On granite, coast of Cork; coll. CARROLL; with apothecia. The spermogones are here also plentiful as small brown papillæ, grouped generally in twos or threes, sometimes confluent, and then very irregular in form. The older ones are marked by their large irregular gaping ostioles, which give the laciniæ the appearance of being studded over with a series of perforations. The spermatia are rod-shaped, about $\frac{1}{9000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata consist of a few shortish linear articulations.

Specimen 3.—SCHÆRER exs. 565; on maritime rocks, coasts of the Atlantic; PELVET. There are a few young or mature papillæform spermogones; but the majority are old, with large irregular ostioles. The latter, in many cases, from falling out of the body of the spermogone, have become saucer-shaped or cyphelloid—the base of the cavity being deep-brown, and the edge very irregular. These cyphelloid ostioles are generally visible to the naked eye. The spermatia are about $\frac{1}{8000}$th long; the sterigmata $\frac{1}{800}$th to $\frac{1}{1000}$th long.

SPECIES 13. *P. parietina*, L.,

A beautiful and familiar plant, having a very wide geographical range, as it occurs in Europe, Africa, Asia, Northern America, Chili, Polynesia, and Australia. In this, and the species which follow, the spermogones are cones or warts of a yellow or reddish colour; but internally, their structure is that of the spermogones of the *Physciæ* already described. *P. parietina* is the type of a section of *Physcia* with a Parmeliiform thallus of a yellowish colour—a section which includes *P. candelaria*, *P. flammea*, and *P. chrysophthalma*. The spermogones of *P. parietina* are minute cones or tubercles, scattered about the periphery of the thallus, outside the region occupied by the apothecia. They are of an orange-red colour, deeper than that of the apothecia, and are generally more or less easily seen under the lens. They are usually in groups of two or three, seldom aggregated in large numbers. Their diameter is about $\frac{1}{250}$th; that of their ostiole, which is usually minute, round, and imperceptible, from about $\frac{1}{850}$th. The body of the spermogone is a spherical mass of a hard, dense, whitish tissue, immersed in the medullary substance of the thallus. The envelope is composed of delicate, cubical cellules, resembling those which make up the cortical layer of the thallus. The sterigmata are ramose and very irregular; they consist of numerous short, roundish, or cubical cellules, originally having thin walls, which, however, in progress of growth, become almost solid, from thickening deposits on their interior. The spermatia are rod-shaped or sub-ellipsoid, and about $\frac{1}{8000}$th to $\frac{1}{10,000}$th long.

Specimen 1.—Kinnoull Hill, Perth, March 1856, W. L. L.; with abundant apothecia. The thallus has a grayish or very pale greenish colour, apparently due to a deficiency of chlorophylle, from growing in damp, dark situations. Hence the orange-coloured cone-like spermogones are very apparent; they are also very abundant; and not being pierced by distinct ostioles, they cannot be confounded with the nascent apothecia, which, besides their different form (always showing the rudimentary disk and exciple), have uniformly a much paler colour. The spermogonal envelope is composed of beautiful hexagonal cellular tissue, the cells being full of yellow colouring matter; this tissue is similar to that of the cortical layer of the thallus. The spermatia are sub-ellipsoid, and about $\frac{1}{10,000}$th long; the sterigmata are delicate, indistinct, and very closely aggregated into a compact tissue.

Specimen 2.—On walls, Grange, Edinburgh, 1852, W. L. L. The spermogones are small, sometimes indistinct, cones or papillæ, of a deeper orange than the thallus, having no perceptible ostioles. They are distinguishable from the young apothecia by their rounded apex and their darker colour.

Specimen 3.—Leighton exs. 10 (E. B. 194); Berwick, near Shrewsbury, Shropshire. The spermatia are innumerable, and indistinct from their minute size. Exs. 11, sub. var. *sub-stellata*, Fr. (E. B., 1794); also from Berwick, near Shrewsbury. The thallus bears no apothecia, and only a few spermogones. Hepp. exs. 54 (sub. var. *polycarpa*, Sch.) This is a dwarf form, with abundant, crowded apothecia, common on fruit-trees; its spermogones are those of the type.

Specimen 4.—Schærer exs. 380 (sub *α. vulgaris*); on wood and stones in open places, Switzerland. The spermogones are small, distinct, orange-red papillæ, without distinct ostioles; the whitish hard kernel, which constitutes the body of the spermogone, can be readily enucleated. The spermatia are sub-ellipsoid, and about $\frac{1}{10,000}$th long; the arthrosterigmata are about $\frac{1}{750}$th to $\frac{1}{1000}$th long.

Specimen 5.—Var. *laciniosa*, Sch., a form marked by small laciniæ, much dissected or subdivided. Schærer's exs. 381 (sub *δ. laciniosa*, Duf.); on old trees in hilly and alpine districts, Switzerland. The spermogones have the usual site; but they are of a very bright red, almost vermilion, colour; they are few, and sparingly scattered. Exs. 383 (sub *ξ. fulva*); on palings, about Samaden. This plant seems referrible to var. *laciniosa*. Along with the ordinary spermatia and sterigmata of the type, there occurs in the same specimen, and apparently in the same spermogone, occasionally, abundance of curved, linear, or filiform spermatia, about $\frac{1}{2000}$th long. I have not met with them elsewhere in this species, and am therefore disposed to regard them as accidental, and not properly belonging thereto. Exs. 549 (sub. var. *lychnea*, Fr.); on trunks of trees in open places. The spermogones are few, scattered; the sterigmata are very delicate and indistinct; the spermatia are about $\frac{1}{10,000}$th to $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad—almost atomic in regard to size.

Species 14. *P. candelaria*, Ach.,

Which occurs in Europe and North America. It closely resembles var. *laciniosa* of *P. parietina*, but is distinguished from that species by its thecæ having 20 to 30 spores, instead of eight. It seldom occurs bearing apothecia, and its spermogones are not very common or abundant. Externally, they are those of *P. parietina;* but, in regard to their contents, they differ considerably in the specimens I have examined. Körber says, " Spermogonien unbekannt." This species is the var. *candelaria* of *P. parietina* of older lichenologists; and some modern writers have constituted it not only into a separate species, but into a separate genus under the name of *Candelaria vulgaris* (Massalongho, *fide* Körb. 120).

Specimen 1.—Schærer exs. 382 (sub *Parmelia parietina*, ε. *candelaris*); on trees and stones, Switzerland. The external appearance and site of the spermogones are the same as in *P. parietina;* but the spermatia and sterigmata differ remarkably. The spermatia are atomic in size, ellipsoid or oval, in myriads, resembling *en masse* a quantity of fish-roe. The sterigmata are simple linear cells, branching below as in *Lichina*, *Ramalina*, and other lichens, having single sterigmata measuring with the spermatia attached about $\frac{1}{2400}$th long. The spermogonal envelope is pale or colourless, never brown. Some of the spermogones are comparatively large and wart-like, closely resembling nascent apothecia; the ostiole, as in *P. parietina*, is usually indistinct.

Species 15. *P. flammea*, Ach.

There has been some difficulty as to the position of this plant. It is the *Dufourea flammea* of older authors. Nylander places it as a distinct species beside *P. parietina;* while Laurent makes it a mere var. of *P. parietina.* In the latter view I concur. It is a very beautiful plant, with podetia-like ramules or segments, broadish, rounded, hollow, and with extremely thin papyraceous walls. Its colour and general aspect are those of *P. parietina*, and its spermogones are quite those of that species.

Specimen 1.—Cape of Good Hope; also Uitenhage, on trees; Cape Diege, Africa; —all in Herb. Hooker, Kew. The spermogones are scattered on the outside of the fistulose segments of the thallus, especially about the tips. They are small orange tubercles, deeper in colour than the thallus. The spermatia are sub-ellipsoid, about $\frac{1}{10,000}$th to $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad; the arthrosterigmata are about $\frac{1}{500}$th to $\frac{1}{370}$th long, and $\frac{1}{8000}$th broad.

Species 16. *P. chrysophthalma*, DC.,

A beautiful, small species, which grows in Europe, Africa, America, Polynesia, and Australia. The spermogones are essentially those of *P. parietina*, but they are frequently larger and more distinct.

Specimen 1.—Schærer exs. 389 (sub. *Parmelia*); on fruit-trees, Switzerland; Schimper. The spermogones are small orange-red tubercles, scattered about the ends of the laciniæ; the spermatia and sterigmata are those of *P. parietina.*

Specimen 2.—Long Island, North America, May 1856; coll. Dr A. O. Brodie; with plentiful apothecia. A few spermogones are distributed in groups about the ends of the laciniæ, as inconspicuous, small, rounded, orange-coloured tubercles. They are chiefly old, containing no free spermatia; there are numerous sterile, elongated, hypertrophied sterigmata, which fill up the spermogonal cavity.

Specimen 3.—St Catharine's (Brazil), TWEEDIE; also var. *farnenis*, Ach., Nyl., from North America; in Herb. Hooker, Kew. In the latter variety, the spermogones are generally very distinct, large, deep orange-red tubercles, occurring in the axils of the branches or segments of the thallus, which are linear or filiform as in *P. flavicans*, and of a very light colour.

SPECIES 17. *P. flavicans*, DC.,

A beautiful Everniiform species, growing in Western Europe, Africa, Asia, America, and Australia.

Specimen 1.—Var. *crocea*, Ach., which occurs in the West Indies and Chili (sub. *Cornicularia crocea*, Ach.); from Dr ACHARIUS himself, 1809; in Herb. Hooker, Kew; no habitat given. In addition to the value belonging to the specimen from its being an authentic one from Dr ACHARIUS himself, it is interesting as bearing spermogones, which are not very common in this species. They are small papillæ or warts, of the same colour as the thallus, scattered along the sides of the thicker segments of the thallus, nearer the base than the apex. The ostiole is of a deep orange-red, much darker than the colour of the thallus, frequently depressed; in which event the papillæform spermogone assumes an urceolate character. The spermatia are rod-shaped, about $\frac{1}{10,000}$th long, and $\frac{1}{25,000}$th broad; on longish arthrosterigmata like those of *P. parietina*. But another kind of sterigmata also occurs; they are simple, linear, branching at the base as in *Ramalina* and *Lichina*, about $\frac{1}{1500}$th to $\frac{1}{1000}$th long; the spermatia, given off from the apices only, of these sterigmata are acicular, $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad. These two kinds of sterigmata occur in different spermogones; but on the same plant or specimen. There is no reason to believe that the one is a rudimentary form of the other; for their structure and appearance differ *ab initio*.

Specimen 2.—Var. *exilis*, Mich., which occurs in equatorial America and Chili. New Orleans, DRUMMOND; in Herb. Hooker, Kew. The thallus is frequently of a very pale gray colour; it is studded over with small orange tubercles, which are spermogones.

SPECIES 18. *P. villosa*, Dub.,

A beautiful species, occurring in Spain and Portugal, Africa and Peru, and a variety of which I have also found occurs sparingly in Ireland. From the pale-gray colour of the thallus, and the large size of the orange spermogones, the latter organs are particularly conspicuous in this species.

Specimen 1.—Portugal, Trans-Tagus Districts, on sea-coasts; coll. WELWITZSCH, No. 110; in Herb. Hooker, Kew; very fine specimens. The spermogones are abundant as very prominent and large orange-coloured tubercles, somewhat irregular in form, scattered sparingly on the pale segments of the thallus. The spermatia are rod-shaped or sub-ellipsoid, $\frac{1}{9000}$th long, and $\frac{1}{20,000}$th broad, on arthrosterigmata, resembling those of *P. parietina*.

Specimen 2.—Var. *Dickieana*, mihi*—a plant sent me last summer by Professor DICKIE of Belfast—appears referrible to *P. villosa* as a variety. It was gathered "either on calcareous rocks in the Deer Park, or on the wall which surrounds it. The locality is on the north side of Belfast Bay, and about three quarters of a mile from the Bay" (in litt., 5th May 1858). It has not hitherto been known as a British plant. It is a dwarf, entangled form; the upper surface of the thallus is scarcely villose; the laciniæ are grayish above, paler below and scarcely channelled or lacunose; their margins are copiously fringed with short, irregular, white fibres. The apothecia are conspicuous, having a large saffron-coloured disk. The spermogones are very large and distinct as orange tubercles, seated near the ends of the laciniæ, rounded, isolated, of similar colour to the apothecia. The spermogonal cavity is divided into sinuous compartments, as in *P. ciliaris*. The spermatia are rod-shaped, about $\frac{1}{10,000}$th to $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad, seated on the apices and sides of long articulated sterigmata, resembling those of *P. parietina*.

SPECIES 19. *P. intricata*, Schær.,

Which, like the preceding, is essentially a Spanish and Portuguese species, occurring also in England and in Africa. Its thallus somewhat resembles that of the preceding species: but the disk of the apothecium is black, instead of orange. This is the old *Evernia intricata*, Fries., the *Borrera Atlantica*, Ach., and *Lichen Atlanticus*, E. B. 1715, which grows sparingly on the south coast of England.

Specimen 1.—Lancerotta, on old trunks of *Opuntia fico-indica;* Teguire, 1846; coll. BOURGEAU, No. 610;—both in Herb. Hooker, Kew. The spermogones are abundant, but they require to be carefully looked for with the lens, when the thallus is moistened. They are small brown points, scattered over the convexities of the laciniæ, or crowning a series of very inconspicuous small warts. The spermatia are rod-shaped, about $\frac{1}{9000}$th long, and $\frac{1}{20,000}$th broad, on arthrosterigmata such as are found in *P. villosa* and *P. parietina*.

* Since this Memoir was originally presented to the Royal Society, I have had two communications from Professor Dickie on the subject of the *name* of this plant. In his first (dated 25th March 1859), he says, "Twelve months ago I sent a *Borrera*, supposed by me to be a variety of *Atlantica*. I have now good reason to believe that it is *new*. Should you, therefore, publish anything on British species including it, I should wish it to stand as *B. Hibernica*, Dickie MSS." In his second letter (dated 3d June 1859), he remarks, "The supposed *P. villora*, Dub., has been submitted to Nylander, who pronounces it a monstrosity of *P. chrysophthalma*. I have compared the fruit in both, and find them identical, so we must bow to the high authority of Nylander." In giving these criticisms, however, which I do in justice to Professors Dickie and Nylander, I see no reason for in any way modifying or altering my opinion regarding the place in classification or name of the plant in question—as above given.

FAMILY XIII. Pyxineæ.

GENUS I. Pyxine, *Fr.*

This genus, which Nylander places between the families *Umbilicariæ* and *Lecanoreæ*, has a Parmeliiform thallus, but lecidine apothecia. The whole plant frequently resembles, on the one hand, *Parmelia stellaris*, and on the other, *Lecidea canescens*. For the latter plant, especially, it is often mistaken: several specimens from Madras, Dr Wight, in Herb. Hooker, Kew, are labelled *L. canescens*. Its spermogones externally resemble those of many *Parmeliæ* and *Physciæ*, as well as some *Lecideæ*—such as *L. canescens*. The plant occurs in all equatorial countries, and in Chili.

Species 1. *P. cocöes*, Ach.

Specimen 1.—Demerara, W. H. Campbell (sub nom. *Lecidea cocöes,* Ach.); Madras, Dr Wight;—both in Herb. Hooker, Kew. The plant has sometimes greatly the aspect of *Parmelia stellaris;* but the apothecia are always lecidine, the exciple and disk being of the same colour, which is black. The spermogones are generally scattered about the ends of the laciniæ, as brown points, seated on the apices of pale, thalline papillæ. Sometimes they are not confined to the periphery of the thallus, but are plentifully distributed over the whole thalline surface, and among the apothecia. The body of the spermogone is always immersed in the medullary tissue of the thallus. The spermatia are usually linear, straight, or very slightly curved, with rounded or obtuse ends, about $\frac{1}{6000}$th long, and $\frac{1}{20,000}$th broad. The sterigmata closely resemble those of *Ramalina;* they are narrowly linear, very delicate, branching at the base, about $\frac{1}{2000}$th to $\frac{1}{1500}$th long, and of equal thickness with the spermatia, which are given off from the apices only, as terminal cells or articulations.

FAMILY XIV. Lecanoreæ.

The genera *Psoroma*, *Pannaria*, *Coccocarpia*, *Squamaria*, and *Placodium* are intermediate between *Parmelia* and *Lecanora*, as regards, particularly, their thallus. In some, the Parmelioid character predominates, in others the Lecanorine. They cannot be properly excluded from the foliaceous class of lichens.

GENUS I. Psoroma, *Fr., p.p. Nyl.*

This genus is closely allied to *Pannaria* and *Coccocarpia*, and its spermogones also resemble those of these genera. The most familiar species of the genus, and the only British one, is *P. hypnorum*, Fr., which grows equally in America and Europe. It has short, rod-shaped spermatia, on arthrosterigmata like those of *Pannaria* and *Coccocarpia*.

GENUS II. Pannaria, *Del., Nyl.*

The spermogones of this genus are essentially those described under *Cocco-*

carpia, which should not, I think, be separated as a genus from *Pannaria*. They are largish warts or papillæ, scattered about the periphery of the thallus, flattened on the apex, generally brown or black, reddish in *P. muscorum*. The spermogones sometimes, in old age, become black internally. The sterigmata are articulated as in *Physcia*; the component cellules being numerous, short, roundish or cubical, and with walls thickened by internal deposits. They occasionally, in old age, and especially about their base, acquire a blackish tint, as in *P. triptophylla*. The spermatia are rod-shaped, varying in length from $\frac{1}{4000}$th to $\frac{1}{8000}$th.

Species 1. *P. pannosa*, Del.,

Is common in *all* tropical countries, and also occurs in the Sandwich Islands.

Specimen 1.—Low Island, Beechey. The spermogones are abundant as small papillæ, scattered here and there in the direction of the radiations of the laciniæ, between the centre region occupied by the apothecia and the margin of the thallus. The apex is marked by a brown, roundish or elongated ostiole. Philippine Islands, Cuming; both in Herb. Hooker, Kew. The spermogones are scattered about the periphery of the thallus, as brown papillæ, sometimes seated on slight elevations of the thallus.

Species 2. *P. rubiginosa*, Del.,

Which occurs in America as well as in Europe.

Specimen 1.—Leighton exs. 234 (sub. *Parmelia*, E. B. 983); Keswick, Cumberland. The spermogones are similar to those of *Coccocarpia plumbea*, both externally as to appearance and site, and internally as to structure or contents. The whole plant is closely allied to *C. plumbea*. Indeed, I am inclined to refer both to a common type; and I look upon Nylander's arrangement, which separates them, as a most artificial and unnatural one.

Species 3. *P. triptophylla*, Ach., Fr.,

Like the preceding, occurs both in America and Europe.

Specimen 1.—Schærer exs. 159 (sub. *Lecidea microphylla a. Schraderi*); on the trunks of trees in alpine woods, Switzerland. The spermogones are small, round, black, roe-like bodies, grouped closely together. The envelope is composed of cellules having an indigo-blue colour; the spermogonal cavity is simple. The spermatia are rod-shaped, about $\frac{1}{8000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata appeared to me simple, linear, short filaments, sometimes branching very slightly below. This is exceptional—the sterigmata of *Pannaria* being, as I have already mentioned, normally articulated.

Species 4. *P. muscorum*, Ach., Del.

Specimen 1.—Schærer exs. 482 (sub. *Parmelia carnosa*); on granite rocks in the Alps. The spermogones are largish, distinct, flattened, reddish-brown warts, scattered on the thalline laciniæ. The spermatia are rod-shaped, about $\frac{1}{4000}$th long, and $\frac{1}{20,000}$th broad. The arthrosterigmata resemble those of *Sticta* or *Collema*—the cellules or articulations being short, broadish, and thick-walled.

GENUS III. COCCOCARPIA, *Pers.*, *Nyl.*

The spermogones of this genus resemble those of *Ricasolia* somewhat, being largish superficial papillæ or tubercles, having rod-shaped spermatia on arthrosterigmata. They are generally seated about the periphery of the thallus, outside the region occupied by the apothecia. Sometimes they are arranged longitudinally, or in the line of radii passing from the centre to the circumference of the thallus; sometimes in arcs parallel to the zones which mark distinctly the development of the thallus. They are generally of the colour of the thallus, the ostiole being usually brown or black. In *C. molybdæa*, they are pale yellow, with a brown ostiole. They are frequently confluent, becoming then very irregular in form. The ostiole is seldom round, and this only in the young or mature state. Subsequently it becomes generally elongated or chink-like, and more or less irregular in outline. The body of the spermogone forms a dense, hard, whitish or yellowish kernel, immersed in the medullary tissue of the thallus. The envelope is generally of a pale-brown or brownish-yellow cellular tissue. The sterigmata are ramose, longish,—$\frac{1}{600}$th to $\frac{1}{750}$th in length in *C. plumbea*,—with a breadth of $\frac{1}{6000}$th, composed of short roundish or cubical thick-walled cellules. In the old spermogones, the sterigmata frequently acquire a brown colour, especially below, and they sometimes become aggregated into a compact tissue, which fills the cavity of the spermogone. This tissue, in some cases in *C. plumbea*, may even become black. The diameter of the cavity of the spermogone in *C. plumbea* is $\frac{1}{75}$th to $\frac{1}{80}$th; the spermatia are rod-shaped, and about $\frac{1}{6000}$th to $\frac{1}{7000}$th long, with a breadth of $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. NYLANDER's distinction between *Coccocarpia* and *Pannaria* seems to me a very insufficient and unsatisfactory one:—"Nimis arcta est affinitas inter Coccocarpias et Panarias," he himself admits. "In *Coccocarpiis* thallus ad formam radiato-sub-monophyllinam tendens (sæpe concentrice versus ambitum rugulosam) et apotheciis constanter biatorinis levem offert differentiam a *Pannariis*."*

SPECIES 1. *C. plumbea*, Lightf.,

Which occurs in North Africa, as well as in Europe; a familiar British species. The spermogones are sometimes inconspicuous from being of the same colour with the thallus; the ostiole, however, is generally of a deep brown, sometimes black, colour. They are large, flattened tubercles—frequently elongated in the direction of the radiations of the thallus—often confluent and very irregular in form. The cavity is simple. In old spermogones, the sterigmata frequently assume a brown colour, and become agglutinated into a compact tissue.

* Enumération Générale des Lichens, p. 109. 1858.

Specimen 1.—On trees between Tarbert and Arrochar, Loch Lomond, Aug. 1855, W. L. L. There are no apothecia; but spermogones abound in every stage of their development. They are large papillæ, with ostioles of a deep leaden-gray or blackish colour. The papilla generally becomes elongated, and the ostiole enlarges until a black disk-like or saucer-shaped cavity is exposed. The spermogones are scattered most plentifully about the centre of the thallus, few occurring about its periphery. Some are seated on the plicæ of the thallus, which run from the centre to the circumference; others are distributed parallel to the periphery of the thallus. There are also spermogoniferous specimens in Don's Herbarium (now possessed by Mr M'Nab, Royal Botanic Garden, Edinburgh); no habitat given. The spermogones are chiefly young, with elongated chink-like ostioles. They closely resemble the spermogones of *Ricasolia herbacea* and *R. glomulifera*.

Specimen 2.—Leighton exs. 233 (sub. *Parmelia*, E. B. 353); Keswick, Cumberland; with abundance of apothecia. The spermogones are small tubercles, of the colour of the thallus, with very irregular ostioles.

Specimen 3.—Var. *myriocarpa;* on trees, Killarney, Ireland, common; coll. Carroll. This is merely a form in which the apothecia are small, and confluent in irregular masses. With it may probably properly be associated Schærer's γ. *cyanoloma* (Enum. p. 36), which has "apotheciis in maculas fusco-atras congestis." The spermogones are imbedded in large tubercles or papillæ of the thallus, each marked by a brown apex or ostiole; they are scattered abundantly external to the region of the apothecia. The envelope is of a very pale brownish-yellow. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad; the sterigmata are from $\frac{1}{600}$th to $\frac{1}{750}$th long, and $\frac{1}{6000}$th broad.

Species 2. *C. molybdæa*, Pers.,

A species which occurs in all tropical countries, closely allied to the preceding.

Specimen 1.—St Vincent, on barks; Canaries, ex Herb. Welwitzsch; Surinam, ex Herb. Miguel;—all in Herb. Hooker, Kew (Syn. *Solorina maculata*, Tayl.; *Lecidea parmelioides*, Hook.) The spermogones are abundantly scattered all over the thallus; they are pale yellow warts, with brown tips, superficial, prominent, becoming darker in colour and less conspicuous. In one specimen, with the thallus of a leaden hue, closely resembling that of *C. plumbea*, the spermogones are small, distinct, prominent black or brown papillæ, grouped in considerable numbers. The body of the spermogone is a hard yellow kernel, sunk in the medullary tissue of the thallus. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad, on arthrosterigmata like those of *C. plumbea*.

Specimen 2.—Assam; Philippine Islands, Cuming; in Herb. Hooker, Kew. Some specimens have large, handsome, pale lobes. The spermogones are few, scattered, very distinct and large, resembling, except as to size, those of *Ricasolia herbacea*.

GENUS IV. Squamaria, *DC.*

This genus is closely allied to the following one—*Placodium;* but there are some prominent differences in regard to the character of the spermogones,—particularly in regard to the spermatia and sterigmata. In reference to its spermogones, *Placodium* stands much nearer *Physcia* than *Squamaria* does. The spermogones of *Squamaria* are mostly immersed, and are marked by an inconspicuous punctiform ostiole, which is frequently of the same colour as the thallus. The ostiole is sometimes black, bluish, or brownish—generally minute and round—occasionally stellate-fissured. Seldom are the spermogones tubercles or papillæ; seldom are they conspicuous or large. In *S. aleurites,* they are punctiform; in *S. gelida,* they are perched on pale thalline papillæ. They are usually scattered about the periphery of the thallus—sometimes distributed chiefly about its centre. Sometimes, in *S. chrysoleuca,* they are studded on the apices of isidioid growths of the thallus; and in *S. concolor,* they are scattered over the apothecia. The greatest diameter of the body of the spermogone varies from $\frac{1}{70}$th to $\frac{1}{150}$th; in *S. saxicola* it is $\frac{1}{130}$th. The cavity is usually simple; in *S. crassa* it is divided into sinuous compartments, as in *Physcia ciliaris.* The spermatia are, as a general rule, long, filiform, and curved or twisted, among the most beautiful and largest that occur in lichens. Their length varies from $\frac{1}{600}$th to $\frac{1}{1000}$th, many being about $\frac{1}{700}$th long; their breadth varies from $\frac{1}{25,000}$th to $\frac{1}{50,000}$th, and is frequently inappreciable. In *S. aleurites,* I have found short rod-shaped spermatia, about $\frac{1}{7000}$th long; this, however, is the only instance in which I have ever met with them other than filiform and curved. In this species, too, the sterigmata are of an exceptional character, being articulated, consisting of a few linear, delicate cells, and resembling those of many *Parmeliæ.* They are usually simple, linear, elongated, branching or not at the base, and resembling those of *Lecanora subfusca.* The spermatia, sterigmata, and spermogones of *Squamaria* are much more closely allied to those of *Lecanora* than to those of *Physcia*—quite the reverse being the case in regard to *Placodium.* The length of the sterigmata varies from $\frac{1}{1500}$th to $\frac{1}{3000}$th; their breadth from $\frac{1}{10,000}$th to $\frac{1}{15,000}$th.

Species 1. *S. crassa,* DC.,

Which occurs equally in Africa and Europe. Its spermogones in French specimens, according to Tulasne—for I have not myself met with them—are minute tubercles scattered over the thallus, generally of a pale-brown colour, sometimes flesh-coloured, occasionally violet. The apex is more frequently marked by a fissured ostiole than by a round imperceptible pore. In the old state, the ostiole expands so as to assume a discoid character, its borders being very irregular and lacerate. The greatest or transverse diameter of the spermogone varies from $\frac{1}{75}$th to $\frac{1}{110}$th. Its body is wholly or nearly immersed in the thallus; it is sometimes girt by the gonidic layer of the thallus; at other times it is plunged immediately in, and surrounded by, the white medullary tissue. The cortical envelope is not of a deeper tint than the rest of the tissue of the spermogone. The cavity is irregular, and is divided into numerous sinuses or anfractuosities which are marked externally by bulgings of the walls of the spermogone. The sterigmata are simple, resembling those of *Lecanora subfusca.* The spermatia are very delicate, filiform, and much curved; their length is about $\frac{1}{650}$th to $\frac{1}{800}$th, with a breadth of $\frac{1}{25,000}$th.

SPECIES 2. *S. chrysoleuca*, Sm.,

A beautiful species, which grows in Europe, North America, and the Himalayas.

Specimen 1.—SCHÆRER exs. 345 (sub *Parmelia rubina a. chrysoleuca*); on micaceous rocks, in the Southern Alps. On the right-hand specimen in my copy (original ed. 1840), there are a few old spermogones, containing no free spermatia; they are punctiform, seated on the tips of small, isidioid warts, and are marked by inconspicuous ostioles. On the left-hand specimen, mature and young spermogones are scattered over the surface of lobes bearing no apothecia. They are wholly immersed, and are marked by round black, or bluish-black, ostioles. They closely resemble the spermogones of the preceding species. The spermatia are long, filiform, and curved or twisted, about $\frac{1}{1500}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are simple, linear, elongated, measuring, with the spermatia attached, $\frac{1}{750}$th.

SPECIES 3. *S. saxicola*, Ach.,

A cosmopolite. The thallus frequently consists of an aggregation of small, irregular, dark-gray scales. On these the spermogones are scattered as small black points, without appreciable prominence. The body of the spermogone is spherical, with a diameter of about $\frac{1}{130}$th, of a brownish-violet colour externally, as well as internally. The cavity is simple; the sterigmata are also simple, narrowly linear, almost solid from thickening deposits on their interior; their length is about $\frac{1}{1700}$th to $\frac{1}{3000}$th; their breadth scarcely $\frac{1}{13,000}$th. The spermatia are filiform and curved, about $\frac{1}{1000}$th to $\frac{1}{1300}$th long.

Specimen 1.—SCHÆRER exs. 332 (sub *Parmelia muralis a. ochroleuca*); on limestone, Switzerland. The spermogones are small black papillæ, seated on separate, sterile scales of the thallus, chiefly at the corners thereof, as in *Lecanora cinerea* and many *Lecideæ.* The spermatia are sub-ellipsoid, $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad, seated on the apices and sides of arthrosterigmata. The spermatia and sterigmata show that this plant certainly does not belong to our *S. saxicola*, however much it may outwardly resemble it.

SPECIES 4. *S. concolor*, Ram.

The black warts on the apothecia, of which SCHÆRER speaks, are spermogones. The spermatia are among the most slender, longest, and most beautiful known among lichens. Their length is $\frac{1}{620}$th; theirbreadth from $\frac{1}{25,000}$th to $\frac{1}{50,000}$th.

SPECIES 5. *S. gelida*, L.,

Which occurs in Europe, America, and New Zealand. In Scotland, it is common in Skye, and also along the banks of the Caledonian Canal.

Specimen 1.—New Zealand, COLENSO; in Herb. Hooker, Kew; on water-worn pebbles, precisely as on the banks of our Caledonian Canal. The spermogones are very beautiful and distinct. The convexities of the laciniæ, about their centre, are elevated into a series of aggregated, pale papillæ, each having a broadish base, surmounted by a second or separate cone, of a brownish-yellow colour, pierced or not by a very minute ostiole. The interior of the upper cone is found to consist of a large brownish-yellow hygrometric kernel, very like the body of the spermogone of *Pertusaria communis*, and becoming similarly gelatinous under moisture. The spermatia are so extremely delicate as to be almost invisible; they are among the most beautiful I have seen. They are vermiform threads, about $\frac{1}{1500}$th long, and $\frac{1}{30,000}$th broad. The sterigmata are linear, simple, branching slightly at the base, about $\frac{1}{3000}$th to $\frac{1}{1500}$th long.

SPECIES 6. *S. ambigua*, Wulf.,

Which occurs in Europe, Asia, and North America.

Specimen 1.—Madras; on the bark of trees; in Herb. Hooker, Kew. The plant seldom or never bears apothecia in this country. In this specimen, both apothecia and spermogones occur. The latter are minute, brown, immersed, punctiform bodies, resembling in external aspect the spermogones of *Parmelia saxatilis*.

SPECIES 7. *S. aleurites*, Ach.,

Which also grows in North America, as well as in Europe.

Specimen 1.— Franklin's First Voyage, in Herb. Hooker, Kew (sub nom. *Parmelia ambigua*). This species closely resembles the preceding, with which it is constantly associated, and for which it is constantly mistaken. The spermogones are punctiform, minute, brown or black immersed bodies, outwardly resembling those of *Parmelia saxatilis*.

Specimen 2.—Valley of Guttanen, Switzerland; in Herb. Hooker, Kew. The spermogones are numerous and very distinct. The spermatia are rod-shaped and straight, about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad; apparently seated on the apices and sides of short articulated sterigmata, about $\frac{1}{2000}$th long, and which resemble those of *Parmelia conspersa*.

Specimen 3.—On old fir-trees, at Aviemore, 1807; in Herb. Hooker, Kew. The thallus is very like that of *Physcia stellaris*; but the spermogones and the spores equally distinguish the two plants.

GENUS V. Placodium, *DC.*

This genus is intermediate in character between *Parmelia* or *Physcia*, and *Lecanora;* but its spermogones are those of the two former genera. The spermogones are usually papillæ or tubercles, of various size and variously coloured, scattered about the periphery of the sub-foliaceous thallus, and on the convexities of the laciniæ, just as in *Physcia*. They are isolated or grouped, more or less irregular in form frequently, especially when confluent, often flattened on the apex. Sometimes they are scattered on separate sterile areolæ, as is the case with the spermogones of many *Lecanoræ* and *Lecideæ*. They are then punctiform and immersed, with a raised, light, thalline border, as in *P. chalybæum* and *P. alphoplacum*. The spermogones are, in a form of *P. circinatum*, pseudo-lecidine in appearance, and as large as apothecia. They are the largest spermogones, without exception, with which I am acquainted. They are large whitish or buff-coloured disks, destitute of an exciple, having frequently a ragged or notched edge. They are generally semi-immersed in the limestone on which the plant grows. The internal structure and contents are those of the ordinary form of spermogone in this species. The colour of the spermogone is also whitish in *P. chalybæum*, in which the ostiole is of a pale-gray. In species with a reddish or yellowish thallus, just as in *Physcia*, the colour of the spermogone is orange-red or orange-yellow. This is the case in *P. muscorum*, *P. callopismum*, *P. elegans*, and other species. The colour is sometimes brownish or blackish; in *P. candicans* it is bluish. The ostiole is usually very minute and indistinct; sometimes it is fissured irregularly. The greatest diameter of the body of the spermogone, in *P. murorum*, is $\frac{1}{50}$th. The tissue of its body is hard, dense, whitish and hygrometric; its cavity is generally simple. The spermatia are short, linear, straight or rod-shaped, with truncate ends, sometimes oblong or ellipsoid. Their length varies from $\frac{1}{5000}$th to $\frac{1}{13,000}$th, a large number measuring about $\frac{1}{6000}$th to $\frac{1}{8000}$th long. In many species they are almost atomic in size. Their breadth varies from $\frac{1}{20,000}$th to $\frac{1}{30,000}$th. The sterigmata are normally, and as a general rule, articulated,—the component cellules or articulations being short, roundish or cubical, as in many *Physciæ*. They are longish, varying from $\frac{1}{750}$th to $\frac{1}{1500}$th, many of them being about $\frac{1}{1000}$th long, with a breadth of about $\frac{1}{10,000}$th. In some species, as *P. circinatum* and *P. fulgens*, elongated, ramose, sterile, hypertrophied filaments, not unfrequently occur, growing from among the spermatiferous sterigmata, and filling the cavity of the spermogone. In exceptional cases, as in forms of *P. circinatum* and *P. alphoplacum*, I have met with sub-simple sterigmata, which, however, is altogether an exceptional phenomenon in this genus. The sterigmata become, in progress of growth, almost solid, from thickening deposits in the interior of their individual component cells.

SPECIES 1. *P. candicans*, Dub.

This may be considered the type of a section of the genus, characterised by a whitish or grayish thallus.

Specimen 1.—LEIGHTON exs. 218 (sub *Lecidea rimosa*). (Syn. It is certainly not E. B. 1736, as LEIGHTON quotes, but E. B. 1778.) On quartzose rock, Great Orme's Head, Caernarvonshire. The spermogones are distinct, as minute bluish or black points, sparingly scattered towards the periphery of the thallus. They are flattened or cone-like, wholly immersed, or nearly so. The spermatia are very short, rod-shaped bodies, bristling over the apices and sides of arthrosterigmata.

SPECIES 2. *P. circinatum*, Pers.,

A comparatively widely-spread species, occurring in Europe, Africa, and Asia.

Specimen 1.—Dereham Church, England, 1810; in Herb. Hooker, Kew (sub nom. *Lichen candicans*, Dicks.; *Parmelia epigœa*, Ach.) The spermogones are plentifully scattered among the apothecia. They are seated on the warts of which the thallus is in a great measure composed. They are brown papillæ, which burst through the thallus, and become irregular, flattish bodies, resembling deformed apothecia. The ostiole is seldom round and inconspicuous; it is, especially in the old state, more or less patent and stellate-fissured. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad, seated on sterigmata about $\frac{1}{1500}$th long, which are composed of only two or three linear irregular cellules or articulations.

Specimen 2.—Clare Hall Bridge, Cambridge, Rev. H. DAVIES; also from same locality, coll. JAMES DALTON, 1803,—both in Herb. Hooker, Kew. That portion of the thallus external to the region occupied by the apothecia is copiously covered with spermogones; they are seated on thalline warts, and are brown, irregular, papillæform, sub-immersed bodies.

Specimen 3.—Var. *variabile*, Pers.; HEPP. exs. 74 (sub. *Placodium variabile*); on old walls. The spermogones are pale, flat, brown, roundish spots, studded over the periphery of the whitish thallus. They closely resemble the spermogones of *Lecanora subfusca*, whose apothecia those of this variety of *P. circinatum* also resemble in outward aspect. The spermatia are oblong or sub-ellipsoid, almost atomic as to size. *P. circinatum* has frequently, intermixed with the ordinary or spermatiferous sterigmata, elongated, sterile, ramose filaments, like those which occur in many of the *Parmeliœ*. NYLANDER has likewise noticed this fact; but he alludes to it as an abnormal and occasional condition only. I see no reason for regarding the occurrence of these hypertrophied sterile sterigmata in this species as exceptional, while they are regarded as normal in *Ramalina* and *Parmelia*. Indeed, I would lay down as a proposition, that there is a tendency in all spermogones whatever to the development of an elongated, hypertrophied, and sterile condition of the sterigmata. This is mostly seen in old spermogones, the sterigmata in which often become so hypertrophied and so aggregated as to fill the whole spermogonal cavity with a dense coloured tissue. But the phenomenon also is of frequent occurrence in mature spermogones; and the abnormal or exceptional condition, I should say, is the absence, not presence, of these peculiar filaments.

Specimen 4.—Var. *ecrustaceum* (sub *Placodium Agardhianum;* syn. *Lecanora Agardhiana*, Ach. SCHÆRER exs. 617; on limestone, in the Jura and Alps); HEPP. exs. 407. The apothecia are black, flattish, or sub-convex bodies, with an indistinct, thin, evanescent border. Accompanying or intermixed with these, are bodies of the same size, flat or sub-convex, without any distinct exciple, having frequently a ragged or notched edge. They are of a whitish or buff colour, have quite the aspect of apothecia, are white-pruinose, like the apothecia and spermogones of *Lecidea abietina*, and are generally semi-immersed in the limestone on which the plant grows. They are really spermogones, though outwardly very unlike these organs in their ordinary forms; and they are the largest bodies of the kind with which I am acquainted. The spermatia are ellipsoid or linear-oblong, about $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad. The sterigmata are longish, delicate, articulated, about $\frac{1}{750}$th to $\frac{1}{1000}$th long, and $\frac{1}{10,000}$th broad. The spermogones are not only white-pruinose on their surface, but are whitish and mealy throughout. The apothecia are occasionally also white-pruinose externally, and they are then distinguishable from the spermogones only by microscopical examination. The spermogones, however, are always lecidine, the apothecia lecanorine; but this distinction may not at once strike the eye.

SPECIES 3. *P. chalybæum*, Duf., Næg.

In his "Prodromus Lichenographiæ Galliæ et Algeriæ," 1857, p. 81, NYLANDER arranges this species with the *Lecanoras* having simple sterigmata. This does not at all accord with my observations; the sterigmata in all specimens examined by me, as is also the case in all the species of *Placodium*, were articulated. His removal of this species to the genus *Placodium*, in his "Enum. Générale des Lichens," 1858, p. 111, may, however, be regarded as a confession of error.

Specimen 1.—HEPP. exs. 204; on calcareous rocks. The spermogones are plentifully scattered over the whitish or grayish areolæ; they are punctiform, immersed, grayish or blackish; with a raised, lighter, broken thalline margin. The spermatia are rod-shaped, atomic in size, on arthrosterigmata.

Specimen 2.—SCHÆRER exs. 566 (sub *Lecanora chalybæa*); on calcareous stones about Montpellier, and in the Eastern Pyrenees. The spermogones are whitish small tubercles, with a pale-gray ostiole of the same colour as the thallus, not easily recognised even under the lens. They somewhat resemble the spermogones of *Lecidea fusco-atra*, both in site and in external appearance. The spermatia are very abundant, rod-shaped or ellipsoid, $\frac{1}{12,000}$th long.

Species 4. *P. alphoplacum*, Wahl.,

Which occurs in North America, as well as in Europe.

Specimen 1.—Schærer exs. 330 (sub *Parmelia radiosa β. inflata*); on granitic alpine rocks; with apothecia. The spermogones are marked by their small, brown ostioles, which crown the separate, sterile warts of the thallus. The spermatia are short, rod-shaped, about $\frac{1}{5000}$th to $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad. The sterigmata are apparently sub-simple, linear, branching below, measuring with the attached spermatia $\frac{1}{1000}$th to $\frac{1}{1200}$th long. The existence of simple sterigmata in *Placodium* is quite exceptional,—arthrosterigmata almost universally occurring.

Species 5. *P. teicholytum*, DC.

This is the type of a section of *Placodium* characterised by the possession of a yellowish thallus (Syn. *Parmelia erythrocarpia*, Fr.; *Lecidea*, Schær.; *Blastenia erythrocarpia*, Pers., Körb. 183; *Lichen cæsio-rufus*, Sin., E. B. 1040). This species, I think, should certainly be merged in *Lecanora ferruginea*, or, as I should arrange it, *Lecidea ferruginea*. The spermogones are scattered among the apothecia as blackish, punctiform, depressed bodies, sometimes slightly papillæform. The form of the spermogonal cavity is oblong; it is narrow and simple. The spermogonal envelope is black, and this distinguishes the spermogone—on section—from the surrounding white medullary tissue. The spermatia are ellipsoid or ovoid, about $\frac{1}{8000}$th long, on arthrosterigmata resembling those of *P. murorum*.

Species 6. *P. fulgens*, DC.,

A handsome species, which occurs both in Africa and Europe. The spermogones are large, distinct, orange-red tubercles, which are apt to be mistaken for, or confounded with, the nascent apothecia. The internal tissue is whitish-yellow; the cavity is simple, but it is ultimately obliterated by convergent hypertrophied sterigmata. The sterigmata are ramose, and consist of small cubical cellules, which become almost solid from thickening deposits in their interior. The spermatia are not above $\frac{1}{10,000}$th to $\frac{1}{13,000}$th long, and are in immense numbers.

Specimen 1.—Hepp. exs. 194; on sandy ground, on the banks of the Rhine, in the neighbourhood of Tardisbrücke, near Chur. The spermogones are abundant as large, prominent, deep orange-red tubercles or cones, scattered towards the periphery of the thallus. They are most easily seen when moistened. The spermatia are sub-ellipsoid, atomic in size, seated on the apices and sides of arthrosterigmata which resemble those of *Physcia parietina*.

Species 7. *P. aureum*, Schær.,

A beautiful native of the Alps and Pyrenees.

Specimen 1.—Schærer exs. 165 (sub *Lecidea*); in the fissures of calcareous rocks among the Alps. The spermogones are largish tubercles, seated at the corners of the squamules, and about the periphery of the thallus, sometimes also scattered among the apothecia. They are usually flattened on the top, are of a paler or lighter colour than the thallus, and have orange-red ostioles. The spermatia and sterigmata are those of the preceding species.

SPECIES 8. *P. scorigenum*, Mont. (sub *Evernia*).

Specimen 1.—Canary Islands, Dr LEMAN; in Herb. Hooker, Kew. The spermogones are seated on the convexities of the laciniæ as orange papillæ or tubercles, which are much lighter in colour than the disks of the apothecia. The spermatia are rod-shaped, and about $\frac{1}{6000}$th long; the arthrosterigmata are those of the two preceding species. This plant comes very close to *Physcia villosa*, both in regard to its spermogones and apothecia; so close, indeed, that, were a trivial difference in the character of the thallus overlooked, it might almost be included.

SPECIES 9. *P. elegans*, DC.,

One of the most widely-spread species of *Placodium*, occurring in Europe, America, Asia, and Abyssinia. It is also one of the most beautiful species.

Specimen 1.—Var. *miniatum*, SCHÆRER exs. 338 (sub *Parmelia elegans a. miniata*); on sunny stones among the Alps. The spermogones resemble in site and external appearance, as well as internal structure, those of the following species. They are small orange-red tubercles, scattered about the ends of the laciniæ. The spermatia are sub-ellipsoid or rod-shaped, atomic as to size, seated on very indistinct arthrosterigmata.

SPECIES 10. *P. murorum*, DC.,

A cosmopolite, familiar and beautiful species. Its spermogones, in regard to site, outward appearance, and internal structure, closely resemble those of *Physcia parietina*. They are small papillæ or warts, scattered about the periphery of the thallus, isolated or grouped two or three together. Their colour is somewhat deeper than that of the thallus. They sometimes resemble nascent apothecia. The ostiole is usually minute, round, and imperceptible; occasionally it has a thick margin, and sometimes it is fissured. The greatest diameter of the spermogone is $\frac{1}{50}$th. The internal tissue is hard, dense, whitish, opaline. The form of the body of the spermogone is oblong and irregular; the cavity is divided into many sinuosities. The gonidic layer of the thallus sometimes girds the immersed body of the spermogone, which is more usually directly plunged in the white medullary thalline tissue. The sterigmata are ramose, and are composed of almost solid, cubical cellules. The spermatia are rod-shaped, and vary in length from $\frac{1}{6000}$th to $\frac{1}{12,000}$th.

Specimen 1.—LEIGHTON exs. 113 (sub *Parmelia*); on mortar, ruins of Tong

Priory, Shropshire. The spermogones are small orange tubercles, scattered about the periphery of the thallus.

Specimen 2.—Var. *lobulatum*, Flk.; on limestone, Blackrock, near Cork; coll. CARROLL; associated with var. *fuscella*, Ach. of *Verrucaria nigrescens*, Pers. The spermogones are somewhat abundant and distinct as minute, sub-irregular, deep orange-red papillæ, scattered over the convexities of the laciniæ, and about the periphery of the thallus. They are usually more or less isolated. Both the thallus and apothecia have an orange-yellow colour; and hence the spermogones, from their brilliant red tinge, are sufficiently conspicuous, especially under moisture. The spermatia are rod-shaped, very abundant, about $\frac{1}{12,000}$th long, and $\frac{1}{25,000}$th broad, on arthrosterigmata which measure $\frac{1}{750}$th long, and $\frac{1}{9000}$th broad. *P. callopismum* has similar spermogones. There is no sufficient distinction between *P. murorum* and *P. callopismum*, unless that the apothecia in the latter are generally more of a red colour than those of the former. I refer the latter to the former as a mere variety.*

FAMILY XV. COLLEMACEÆ.

SECTION I. LICHINA *Tribe.*

GENUS I. EPHEBE, *Fr.*, *Born.*

The structure of the spermogones of this genus will be sufficiently illustrated by that of the spermogones of *E. pubescens*, its best-known species.

SPECIES 1. *E. pubescens*, Fr.,†

Which occurs both in Northern America and in Europe (Syn. *Cornicularia*, Ach.; *Stigonema atro-virens*, Agardh.) The filiform segments of the thallus, near their tips, exhibit two forms of swellings of their substance. The one is spherical or ovoid, and largish; the other is fusiform, elongated, and much smaller. The first-mentioned swelling contains the endocarpous apothecium, the last-mentioned the spermogone. But these two forms of swelling, or in other words, apothecia and spermogones, never occur on the same segment of the thallus, nor even on the same tuft of the plant. Apothecia are found on one tuft or specimen; spermogones on another. But both organs have the same relative position on the segments of the thallus. The spermogonal ostioles or pores are extremely minute and inconspicuous. The envelope is formed of the same kind of cells as those which enter into the structure of the exciple or perithecium of the apothecia; they are of a bluish-green colour. The sterigmata are very delicate linear cells, branching slightly below, resembling those of *Ramalina*. The spermatia are oblong, with

* The other genera of the *Lecanorei* will be found included in my Memoir on the Spermogones and Pycnides of *Crustaceous* Lichens. *Vide* foot-note, p. 280.

† A good account of the minute structure of its spermogones will be found in BORNET's "Recherches sur la Structure de *l'Ephebe pubescens*, Fr." Annales des Sciences Naturelles, 3d Ser. Botanique, vol. xviii., 1852, p. 161.

truncate ends, given off as terminal cells or articulations from the apices of the sterigmata.

Specimen 1.—Mr HARRIMAN,—probably from some of the northern counties of England, though no habitat is given; in Herb. Hooker, Kew. The spermogones are abundant as small, but, under the lens, distinct, spherical swellings of, or tubercles attached to, the filaments or segments of the thallus; they are of a brown colour, while the thalline filaments are of a deep bottle-green. The spermatia are sub-ellipsoid, about $\frac{1}{6000}$th to $\frac{1}{7000}$th long, and $\frac{1}{20,000}$th broad, given off from the tips of delicate, linear, simple sterigmata, about $\frac{1}{1500}$th to $\frac{1}{1000}$th long, and of equal breadth with the spermatia. Some of the sterigmata, especially in old spermogones, become elongated and hypertrophied, projecting into the free cavity of the spermogone as in *Ramalina*, and in many *Parmeliæ*. NYLANDER has seen the same phenomenon, but he describes it as an abnormal condition. On this subject, I would only refer to what I have already said under the head of *Placodium circinatum* (p. 263). *Ephebe pubescens* is sometimes confounded with *Parmelia lanata*, to which it certainly bears a considerable resemblance. This mistake has occurred in Herb. Menzies, Royal Botanic Garden, Edinburgh (*pro parte*). The character of the apothecia, the stronger segments of the thallus, and the different spermogones, will at once, however, serve to distinguish the two plants.

GENUS II. LICHINA, *Ag.*

The spermogones of *Lichina*, to a certain extent, resemble those of *Ephebe;* but they are greatly larger. They are seated in spherical or ovoid dilatations of the ramuscles or segments of the thallus. Where they are placed below the apothecia, as in *L. pygmæa*, they appear mere dilatations of the thalline ramuscle as in *Ephebe;* where they are terminal, as in *L. confinis*, they appear large barrel or tub shaped bodies, resembling the spermogones of *Cladonia*, except in that they are much larger. In the latter species, also, they are sometimes seated directly on the apothecia, as also happens occasionally in *Cladonia rangiferina;* in such circumstances they are barrel-shaped, more so than when they form horn-like terminations to the thalline ramuscles. The ostiole is usually very minute and inconspicuous. The cavity is generally divided into sinuous compartments. The spermatia are ovoid or ellipsoid, about $\frac{1}{7000}$th to $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad, seated on the ends of linear, simple sterigmata, about $\frac{1}{1000}$th to $\frac{1}{1500}$th long, subramose at the base as in *Ramalina*. The presence of these spermogones is a strong reason, among many others, for dissociating this genus from the *Algæ*, and placing it permanently among the *Lichens*.

SPECIES 1. *L. pygmæa*, Ag.

The spermogones, in specimens which I have examined, are terminal, occupying the same relative position as the apothecia. They are spherical, large, prominent bodies, seated like horns on the ends of the thalline ramuscles. NYLANDER likewise describes the spermogones as terminal; but TULASNE describes and figures them as seated immediately below the apothecia, and on the same ramuscles therewith. The cavity of the spermogone is divided into compartments, which are very tortuous and narrow. The spermatia are oblong, and imbedded in abundant mucilage.

Specimen 1.—LEIGHTON exs. 260; Torquay, Devonshire. The plant appears to be spermogoniferous only: no apothecia are found; but the very plentiful spermogones closely resemble apothecia. They are seated at the angles of the fastigiate extremities of the thalline segments as very large and prominent spherical bodies of the same colour as the thallus. The ostiole is very minute and imperceptible. The spermogonal wall or envelope consists of large, oblong cells, of an olive-brown colour, closely aggregated into a compact cellular tissue. By placing the ends of any of the thalline segments, bearing spermogones, between glass slides in water, and applying pressure, under the microscope, the spermatia may be seen issuing from the spermogonal ostioles in myriads. They are ellipsoid or oval corpuscles, about $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad, or almost atomic as to size, and are given off from the ends of simple, linear sterigmata, about $\frac{1}{1500}$th long, and branching below.

SPECIES 2. *L. confinis*, Ag.

According to TULASNE, the spermogones of this species are either terminal, occupying the position I have described those of the preceding species to occupy, or they are seated immediately on the apothecia. They are smaller than those of *L. pygmæa.* The position on the apothecia may be supposed in this and other cases to favour the supposition that the contents of the spermogones exercise a direct, and probably a fertilizing, influence on the contents of the apothecia. But it must be remembered that this site is not a very usual one among the lichens. The spermatia are about $\frac{1}{7000}$th long, and $\frac{1}{10,000}$th broad, on sterigmata which measure about $\frac{1}{1000}$th to $\frac{1}{1500}$th long, and are linear and simple as in *L. pygmæa.*

SECTION II. COLLEMA *Tribe.*

GENUS I. SYNALISSA, *DR.*

This genus has the external aspect of *Collema*, both in regard to its thallus and spermogones. But the spermatia are developed from the apices only of very delicate, linear, simple sterigmata, which resemble those of *Ramalina.* The spermatia are among the smallest known, being about $\frac{1}{25,000}$th long in *S. micrococca;* they are usually rod-shaped or ellipsoid.

SPECIES 1. *S. symphorea*, DC.,

(Syn. *S. lichenophila*, DR.,) which occurs equally in Africa and Europe. This plant appears to include *Collema synalissum*, Ach. L. U. 640; *Synalissa Acharii*, Trevis, Hepp. exs. 89; *Collema stygium*, var. *incisum*, Schær. Enum. 260. According to NYLANDER, this species is diœcious,—the spermogones and apothecia occurring on separate plants. The spermatia are oblong, or oblong-ellipsoid, about $\frac{1}{8000}$th long, and $\frac{1}{25,000}$th broad, given off as terminal cells or articulations from the tips of very delicate, linear, simple sterigmata, precisely like those of *Ramalina*.

Specimen 1.—Sand-hills, Dunfanaghy, County Donegal, Ireland; Prof. DICKIE, 1858. About the name and nature of this plant, I am extremely diffident and doubtful. It occurs in very small patches, and only a few fragments were sent to me for examination. The apothecia are endocarpous, and constitute spherical bulgings at the ends of the laciniæ; they somewhat resemble those of *Lichina pygmæa*. The spores are ellipsoid,—1–3 septate,—normally the latter. The spermogones appear also to be terminal, small, spherical bodies,—resembling outwardly, except as to size, the apothecia,—round which they are clustered. The spermatia are sub-ellipsoid, and very small. The sterigmata are not distinctly seen. In *S. micrococca*, a French species, the spermatia are atomic as to size, being about $\frac{1}{25,000}$th long, and a little less in breadth, according to NYLANDER.

GENUS II. OMPHALARIA, *DR.* and *Mont.*

This genus closely resembles *Collema* in its thallus and in its spermogones,—in the latter, both as regards their site, appearance, and contents.

SPECIES 1. *O. pulvinata*, Schær.,

Which appears to include *Collema stygium*, var. *pulvinatum*, Schær. exs. 435.

Specimen 1.—Associated with *Pannaria triptophylla*, var. *nigra*; on limestone rocks about Yeadon, Yorkshire; coll. Dr CARRINGTON. Of this plant I am not at all sure. I have examined only a small fragment, and that not bearing apothecia. The spermogones are abundant on the tops of the turgid warts, which form, or occur on, the margins of the lobes. They are pale, brownish-yellow, immerseddisks, disti nct when moistened from the contrast of their colour with the dark bottle-green of the thallus. The spermatia are rod-shaped and small, and the sterigmata articulated, just as in *Collema*.

GENUS III. COLLEMA, *Ach.*

The spermogones of this genus are always immersed in the tissue of the thallus, and more or less inconspicuous, unless the thallus is moistened. In this case, they become frequently very distinct, from the contrast of their pale, brownish, or brownish-yellow colour, with the dark-green of the thallus. They are distinctly circumscribed, round, hard disks, when distributed on the flat surface of the thallus; when marginal,—seated on the crisped and sub-erect margins of the lobes,—they are usually tubercles or warts, resembling frequently knobs or buttons. In the latter case, they give the margins of the thallus a denticulate or warted character. Sometimes, though rarely, they are found both on the sub-erect margins and on the flat surface of the thallus near the margin, as in some forms of *C. melænum*. From their pale-yellowish or buff colour, and discoid form, they frequently resemble seeds imbedded in the thallus. Sometimes they are of a greenish tint, having acquired some of the colouring matter of the thallus. The size of the spermogones is pretty uniform; in *C. plicatile*, the breadth is $\frac{1}{150}$th to $\frac{1}{160}$th. The envelope is of a brownish or yellowish cellular tissue. The ostiole is generally brown, minute, and round,—central,—of a deeper colour than the rest of the organ. Sometimes it becomes, in the old state, patent and conspicuous. The spermogone is not easily enucleated, from its adhesion to the surrounding tissue of the thallus, especially when the latter is moistened and gelatinous. It is generally necessary, for the examination of the spermogones of *Collema* under the microscope, with a pair of very fine-pointed scissors to cut away a portion of the margin of the lobe, with one or more spermogones included, making the incision, if possible, through a spermogone. On subjecting such a section to pressure between glass slides, in a drop of water under the microscope, the emission of myriads of spermatia may be easily seen. These spermatia are in all cases short, rod-shaped, and with obtuse ends; they vary in length from $\frac{1}{4000}$th to $\frac{1}{12,000}$th, —the majority being about $\frac{1}{6000}$th to $\frac{1}{8000}$th long, with a breadth of $\frac{1}{20,000}$th to $\frac{1}{25,000}$th. The sterigmata, in all specimens examined by me, are articulated,—sometimes ramose,—about $\frac{1}{500}$th to $\frac{1}{600}$th long, composed of short, roundish, or cubical cells, with thinnish walls compared with the component articulations of the arthro-sterigmata of *Sticta*.

SPECIES 1. *C. auriculatum*, Hoffm.

Specimen 1.—SCHÆRER exs. 432 (sub *Parmelia granosa a. vulgaris*; on stones among moss, Switzerland. There are two specimens, neither of them bearing apothecia; on the right-hand specimen in my copy (original ed., 1842), spermogones occur. In external form, situation, and structure, they closely resemble those of *Leptogium saturninum*.

SPECIES 2. *C. flaccidum*, Ach.,

A widely-spread and familiar species, occurring in Europe, Asia, Northern America, and New Zealand. The fact of a variety *pyrenodes* being mentioned by FLOTOW shows that the spermogones of this species have not escaped the attention of the older lichenologists. He evidently alludes to the spermogones as his " Pseudo-peritheciis minutissimis, fusco-atris, vertice poro pertusis."

Specimen 1.—On Aghalie Bridge, Lagan Canal, Ireland; D. MOORE; in Herb. Carroll; with apothecia. The spermogones are small, brownish-yellow disks, immersed in the substance of the thallus, and scattered about the margins of its lobes, on their flat surface. They are conspicuous when moistened, amid the dark-green thallus.

Specimen 2.—Malham, Yorkshire; Dr CARRINGTON, 1857. The spermogones are brown disks or warts,—distinctly perforate or ostiolate on the apex,—scattered over the surface of the lobes among the apothecia, and resembling nascent apothecia.

Specimen 3.—Var. *furvum*, Stroove Head, County Donegal; Prof. DICKIE, 1852. This is a form with a furvous or granulate thallus; it includes *Collema rupestre*, Schærer exs. 412, and is probably also what NYLANDER describes as *C. furvum*. The spermogones are dotted about the margins of the lobes, on their flat surface. They are very minute, pale, brownish-yellow disks,—distinct when the thallus is moistened,—imbedded amid the dark-green tissue of the thallus. The spermatia are about $\frac{1}{12,000}$th long, and $\frac{1}{20,000}$th broad, rod-shaped, seated on the apices and sides of long arthrosterigmata.

SPECIES 3. *C. furvum*, Ach.,

Which occurs alike in Northern America and in Europe. This I regard simply as a variety of the preceding, characterised by the possession of a granulate and rough thallus.

Specimen 1.—SCHÆRER exs. 414 (sub *Parmelia rupestris β. furva, c. fuliginea*); on stones and the trunks of trees, Switzerland. The spermogones closely resemble those of *Leptogium tremelloides*. They are round disks, of a yellowish or light-brown colour, with a deeper brown, central, punctiform ostiole. They are usually indistinct amid the deep-green thallus, unless when the thallus is moistened, and held up between the eye and the light. They are studded about the edges of the lobes, on their flat surface.

Specimen 2.—SCHÆRER exs. 499 (sub *Parmelia nigrescens β. conglomeratum*); on the trunks of various trees in the milder parts of Switzerland,—in my copy (original ed. 1843). The spermogones are as described in No. 1; they are much less distinct than in *Leptogium tremelloides*, on account of the very dark-green colour of the thallus, and its furfuraceous surface. The spermatia are rod-shaped, about $\frac{1}{10,000}$th long, on arthrosterigmata about $\frac{1}{1500}$th to $\frac{1}{600}$th long.

SPECIES 4. *C. melænum*, Ach.,

Also occurring, like the last, in Northern America and Europe, and including, as a variety, *C. cristatum*, Schær. Among its synonyms are *Collema marginalis*, Hook.; *Parmelia multifida β. marginalis*, Schær. En. 255, exs. 420; *Collema*, Körb. 409; *Lichen jacobæfolius*, Bernhardi; and *Lichen marginalis*, E. B. The spermogones are immersed and discoid, as in the species already described. They may sometimes be mistaken for, or confounded with, a small parasitic *Sphæria*, whose perithecia are similarly immersed. It is possible that WALL-

ROTH's *Thrombium bacillare*, and SCOPOLI's Pseudo-perithecia of *Collema multifidum* referred either to the *Sphæria* in question, or to the ordinary spermogones of the species.

Specimen 1.—Clapham, Yorkshire; coll. Dr DEIGHTON, 1855; a beautiful large specimen, with abundant apothecia. The spermogones are abundant on the edges of the plicate sub-erect lobes as distinct brownish-red warts, easily distinguished when moistened, on account of the contrast of their colour with that of the dark blackish-green of the thallus.

Specimen 2.—Malham, Yorkshire; coll. Dr CARRINGTON; with apothecia. The spermogones are marginal, small, brownish-yellow tubercles, very distinct when moistened. The spermatia are rod-shaped and very small; the arthrosterigmata are short, broadish, and very irregular.

Specimen 3.—Deer Park, Belfast; Prof. DICKIE, 1851. The spermogones are very abundant roundish warts, of a pale brownish-yellow colour, distinct when moistened. They are chiefly marginal, but are also scattered over the flat surface of the lobes, towards their periphery.

Specimen 4.—Ben Bulben, County Sligo; Prof. DICKIE, 1851. The spermogones are marginal, pale, brownish-yellow knobs or tubercles, but not very distinct even when moistened, as they partake somewhat of the deep dull-green colour of the thallus. The spermatia are rod-shaped, about $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad, seated on longish arthrosterigmata.

Specimen 5.—Appin, CARMICHAEL; in Herb. Hooker, Kew. The spermogones are marginal, pale, brownish-yellow or buff-coloured round disks, quite resembling small seeds, their colour contrasting well with the dark-green of the thallus. They are still more abundant and beautiful in specimens from Ireland, Sir THOMAS GAGE (sub nom. *C. crispum*), and from Choos, Pyrenees (sub nom. *C. marginale*, var. Ach.), without apothecia.

Specimen 6.—SCHÆRER exs. 420 (sub *Parmelia multifida* δ. *marginalis*); on sunny calcareous rocks, Switzerland. Spermogones occur on the left-hand specimen in my copy (original ed., 1842). They are plentiful on the edges of the lobes, to which they give a buttoned or toothed character. They are small brown tubercles, roundish or flattened, many of them having a distinct, deepish-brown ostiole. The spermatia are rod-shaped, about $\frac{1}{6000}$th long; the arthrosterigmata are pale-yellowish, thick, and irregular in outline.

Specimen 7.—Var. *cristatum*, Schærer exs. 417 (sub *Parmelia multifida* β. *cristata*); on calcareous rocks, Switzerland. The spermogones are marginal, grouped, small, distinct, roundish brown tubercles; there is no very perceptible ostiole. The spermatia are rod-shaped, about $\frac{1}{6000}$th long; the arthrosterigmata are very irregular in outline, and about $\frac{1}{425}$th to $\frac{1}{500}$th long.

Specimen 8.—Var. *jacobæfolium* (Syn. *Lichen jacobæfolius*, Bernhardi); with laciniæ narrow and much cut or dissected. A specimen from Dr ACHARIUS, 1809, in Herb. Hooker, Kew, has the curled edges of the laciniæ studded over with very distinct, pale, brownish-yellow tubercle-like spermogones.

SPECIES 5. *C. plicatile*, Ach.,

Which occurs in Northern America and Europe. I am inclined to refer this species to *C. pulposum*.

Specimen 1.—HEPP. exs. 86; on the banks of the Lake of Zurich, Switzerland; with apothecia. The spermogones are reddish tubercles, seated on the margins of the lobes. Exs. 215 (sub *C. turgidum*, Ach.); on calcareous rocks, Switzerland. In the upper specimen, the spermogones are marginal, distinct tubercles, brownish-red, and with a perceptible ostiole. In the lower specimen, they are whitish or paleish-brown externally, yellow within. The spermatia of this species are rod-shaped, $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad.

SPECIES 6. *C. pulposum*, Ach.,

A widely-spread species, growing in Europe, Africa, Asia, and Northern America. Its spermogones are immersed disks or tubercles, brownish-yellow externally, whitish within. The ostiole, which is, in the young state of the spermogone, very minute, round, and inconspicuous, enlarges sometimes with age, until it forms a large irregular perforation or cavity. The edge of the thallus as well as the exciple of the apothecia are sometimes studded over with very conspicuous, ragged, deep perforations, which are the ostioles of old spermogones.

Specimen 1.—(Sub *C. chalazanum*, Ach.); in Herb. Hooker, Kew; no habitat given,—but apparently from Dr ACHARIUS. The turgid margins of the thalline lobes as well as the exciple of the apothecium are studded over with abundant spermogones, which are brownish-yellow or tawny-coloured round wartlets, conspicuous amid the deep leek-green tissue of the thallus. They bear on their apex a deep-brown papilla, which marks the ostiole; the former is frequently irregular in form. The papillæform ostiole expands with age into a large irregular perforation. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, and $\frac{1}{25,000}$th broad; another specimen, also in Herb. Hooker (sub nom. *C. crispum*, Nyl.), has the edge of the lobes profusely dotted over with spermogones.

Specimen 2.—Lisclash, Fermoy, Ireland; coll. T. CHANDLER; in Herb. Carroll. The spermogones are seated on the top of tumid marginal warts; they are, as usual, of a pale, brownish-yellow colour. The spermatia are rod-shaped, $\frac{1}{10,000}$th long, and $\frac{1}{25,000}$th broad. In specimens from Malham, Yorkshire, coll. Dr CARRINGTON, the spermogones are also seated on the tops of turgid marginal warts.

Specimen 3.—Var. *tenax*, LEIGHTON exs. 105 (sub *Collema limosum*, Ach.); Twycross, Leicestershire (E. B. Suppl. 2704, f. 1.) The spermogones are marginal, brownish-yellow, distinct, circumscribed from the surrounding green of the thallus.

Specimen 4.—Var. *tenax*, Hepp. exs. 87 (sub *Collema multiflorum*); on moss, at the foot of old trunks of willows, Switzerland. The spermogones are tubercles of the same colour as the thallus, scattered upon the edges of the lobes. The envelope is of a deepish-brown cellular tissue. The spermatia are in myriads, rod-shaped, almost atomic as to size.

Specimen 5.—Var. *turgidum*, Schærer exs. 433 (sub *Parmelia turgida*); on siliceous and calcareous stones, in sunny places, Switzerland. The spermogones are marginal, resembling young apothecia. I am also inclined to place here SCHÆRER's exs. 434 (sub *Parmelia stygia β. orbicularis*), on calcareous rocks, at the Lake of Bienne. In this plant, also, the spermogones are marginal, and intermixed with the apothecia; they are dull-brown, small tubercles. The spermatia are rather longer than those in most of the species of *Collema* I have already described.

Specimen 6.—County Wicklow, Ireland, 1845; among moss; coll. MOORE, in Herb. Carroll. The spermogones are abundant on the margins of the lobes as small, pale-brown disks, distinct when moistened amid the dark leek-green of the thallus. The spermatia are $\frac{1}{8000}$th long, and $\frac{1}{25,000}$th broad, rod-shaped; the arthrosterigmata are longish, and about $\frac{1}{8000}$th broad.

SPECIES 7. *C. crispum*, Ach.

This appears to me to belong to the preceding species; its spermogones and spermatia are the same. The spermogones, though usually of a brownish-yellow tint, are sometimes concolorous with the thallus.

Specimen 1.—LEIGHTON exs. 106 (sub *C. cristatum*, Ach., E. B. 834); near Shrewsbury, Shropshire. The spermogones are as described in *C. pulposum*. In a specimen in Herb. Hooker, Kew, the thallus is a mass of isidioid pulvinuli, many of them tipped with pale, brownish-yellow, discoid spermogones.

SPECIES 8. *C. cheileum*, Ach.,

Which occurs in Africa and Europe. This appears to include *C. crispum*, Schærer exs. 425, and *C. plicatile*, Moug. and Nestler, 456. The thallus frequently bears a close resemblance to that of *C. melænum*.

Specimen 1.—On sand-hills, Dunfanaghy, County Donegal; Professor DICKIE, 1858. The spermogones are pale, brownish-yellow, round tubercles, fringing the margins of the dark-green, sub-erect lobes. In another specimen from the same locality, they are scattered on the flat surface of the lobes, near their margin; they are distinct amid the dark-olive tissue of the thallus. The spermatia are rod-shaped, about $\frac{1}{8000}$th long, and $\frac{1}{20,000}$th broad.

Specimen 2.—On limestone, near Fermoy, Ireland; coll. T. CHANDLER; in Herb. Carroll. The lobes are erect—their margins thin, wavy, and crisped or denticulate from the presence of spermogones, which are small brownish-yellow buttons or disks. The spermatia are about $\frac{1}{9000}$th long, and $\frac{1}{20,000}$th broad, rod-shaped, on longish arthrosterigmata. Similar spermogones occur, giving a denticulate character to the margins of the curled lobes, in specimens from Glencairn Deer Park, coll. D. MOORE, in Herb. Carroll. In specimens from near Galway, on limestone rocks, coll. D. MOORE, in Herb. Carroll, and Black Rock, Cork, on limestone, coll. CARROLL, the spermogones are more or less closely aggregated.

SPECIES 9. *C. microphyllum*, Ach.

Specimen 1.—SCHÆRER exs. 411 (sub *Parmelia nigrescens* ϵ. *microphylla*, Sch.); on the trunks of trees, Switzerland; with apothecia. The spermogones are small light-brown or yellowish tubercles, scattered near the edges of the lobes, on their flat surface. They somewhat resemble those of *Leptogium tremelloides*. The spermatia are rod-shaped, $\frac{1}{4000}$th to $\frac{1}{6000}$th long.

SPECIES 10. *C. nigrescens*, Ach.,

A widely-spread species, which occurs in Europe, Asia, America, Polynesia, and New Zealand.

Specimen 1.—HEPP. exs. 216 (sub *Synechoblastus vespertilio*, Lightf. Syn. *Collema nigrescens a. vespertilio*, Schær. exs. 410; Moug. and Nestler, 164, p.p. and 453; Leight. exs. 104); on the bark of old fruit-trees. In the right-hand specimen in my copy, spermogones occur. They are wholly immersed, and are externally of the same colour as the thallus, except the ostiole, which is of a pale-brown colour and round. The ostioles pierce the apices of the thalline papillæ, which are seated external to the region occupied by the apothecia. The spermatia are rod-shaped, about $\frac{1}{6000}$th to $\frac{1}{5000}$th long, seated on ramose, irregular arthrosterigmata.

SPECIES 11. *C. multipartitum*, Sm.

This European species seems closely allied to NYLANDER'S *C. laciniatum*, from Alabama.

Specimen 1.—Dunkerron; coll. TAYLOR; in Herb. Hooker, Kew. The specimen is bad, and in small detached fragments; the apothecia are young. The spermogones are abundant, scattered over the margins of the laciniæ; seated on large, pale warts; sometimes confluent, and always more or less irregular.

SPECIES 12. *Collema ? epiphyllum*, Leight.

Specimen 1.—LEIGHTON exs. 103; on laurel and other leaves, Gopsall, Leicestershire. There are here two distinct plants. The one occurs in small round scales, gelatinous when moistened, becoming, in progress of growth, palmate and divided irregularly. This plant has quite the aspect of *Collema* externally, but has not its structure internally. Neither has it distinct apothecia, thecæ, spores, nor spermatia. The other plant is a granular, blackish mass, occurring in round patches of varying size. It possesses *Pycnides*, but neither apothecia nor spermogones. These Pycnides are quite superficial, removeable by the slightest touch; they are minute black perithecia, resembling, on the one hand, the perithecia of many *Sphæriæ*, and, on the other, the spermogones of many *Verrucariæ* and *Graphideæ*. They are probably referrible to some Fungus, whose primary fruit does not occur in the specimens examined by me. The stylospores are plentiful, ellipsoid, pale-yellow, simple, about $\frac{1}{6000}$th long, and $\frac{1}{8000}$th broad. The sterigmata are very short, linear and simple. The envelope is of a deep brown. Both plants are altogether anomalous in their characters; and until I have further opportunities of examining them, I do not know where most appropriately to place them.

GENUS IV. Leptogium, *Fr.*

As a general rule, in regard to site, external appearance, and internal structure or contents, the spermogones of this genus are precisely those of *Collema*. Nor am I aware of any very valid reason for dissociating *Leptogium* from *Collema*, as is done by Nylander and other modern authors. From the thallus in *Leptogium* being frequently more delicate and diaphanous than in *Collema*, and often of a beautiful pale-blue, or bluish-green colour, it is generally easier to see and examine the spermogones in the former than in the latter genus. This is especially the case in *Leptogium tremelloides* and its congeners, which possess the most beautiful and easily studied spermogones in the whole family of the Collemata. The spermogones of *Leptogium* are always immersed, flattened disks, resembling double convex lenses, of a pale brownish-yellow colour, with a central, round, very minute, brownish ostiole. The ostiole, though usually in the mature and young state of the spermogone punctiform, becomes comparatively large and patent in *L. saturninum*, in which it sometimes gives to the spermogone the aspect of a young apothecium. The spermogones of *Leptogium* are more frequently seated on the flat surface of the lobes, near their margin, less often seated on the margins themselves, than in *Collema*. In *L. subtile*, they are marginal, giving a denticulate character to the edges of the lobes, as in many *Collemas*. In *L. fragile* and *L. phyllocarpum*, they occur both on the margins and on the flat surfaces of the lobes, near their margins. Some forms of the beautiful *L. tremelloides* have distinctly denticulate lobes, from the presence of marginal spermogones, though generally, in this species, these organs are scattered over the flat surface of the lobes, near their periphery or margins. In *L. tremelloides*, the marginal spermogones are sometimes distinct largish cones, with a brown apical ostiole. The plant then resembles somewhat variety *denticulata* of *Parmelia perforata*. In this form of *L. tremelloides*, the body of the spermogone sometimes falls out in age, leaving small cup-like cavities, which give to the margin of the thallus a notched and very irregular character. The spermatia and sterigmata in *Leptogium* are precisely those described as belonging to *Collema*.

SPECIES 1. *L. fragile*, Tayl.

Specimen 1.—On limestone, probably from Dunkerron, Ireland; coll. TAYLOR himself; in Herb. Carroll (Syn. *Collema fragile*, Tayl., "Fl. Hib." 109; Schær. Enum. 259). The plant is allied to *L. cretaceum*, but its thallus is much larger. TAYLOR remarks, "Marginal lobes rough with wrinkles and granules;" and again, "their upper surface rough with granules, concolorous with the thallus, clustered, of different sizes, globular, yet flattened at the top." The granules described so minutely by TAYLOR are the spermogones of the plant. These organs are scattered abundantly over the flat surface of the lobes of the thallus, towards its periphery, sometimes extending nearly to the centre of the thallus. They never fringe the margins of the lobes. They are pale, brownish-yellow, discoid, immersed bodies, precisely resembling those of the majority of the *Collemas*. They are very conspicuous when moistened, under the lens. The spermatia are rod-shaped, about $\frac{1}{10,000}$th long, and $\frac{1}{20,000}$th broad, on arthrosterigmata having the characters of those of *Collema*.

SPECIES 2. *L. subtile*, Nyl.,

Which includes, as a variety, *L. diaphanum*, Ach.

Specimen 1.—Var. *diaphanum*, Philippine Islands, CUMING; in Herb. Hooker, Kew (sub. nom. *Collema erythrophthalma*, Tayl.) The margins of the extremely delicate thalline lobes are fringed with very minute, pale, brownish-yellow spermogonal warts, which constitute a series of teeth or denticulations, resembling those met with in South American forms of *L. tremelloides*.

SPECIES 3. *L. tremelloides*, Fr.,

A cosmopolite and very beautiful species, which includes, as varieties, the *L. azureum*, *L. marianum*, and *L. marginellum* of authors.

Specimen 1.—On trees, Muckross Woods, Killarney, Ireland; coll. CARROLL; with apothecia. This is one of the best species of *Leptogium* in which to study its spermogones. In this specimen, however, they are well seen only when moistened. They are abundant, resembling grains of mustard-seed, studded along the edges of the lobes; their colour is of a pale brownish-yellow, which contrasts strongly with the dark leaden-gray of the thallus. Each spermogone is pierced centrally by a very minute pore or ostiole. The spermatia are rod-shaped, about $\frac{1}{12,000}$th long, and $\frac{1}{25,000}$th broad.

Specimen 2.—Graham's Town, Cape of Good Hope; in Herb. Hooker, Kew. The spermogones are scattered outside the region of the apothecia, on the flat surface of the thallus, not on its margins. They are aggregated or grouped in considerable numbers as small, regular, roundish or flattened warts or papillæ, concolorous with the thallus. The body of the organ is semi-immersed only, and consists of a hard, whitish kernel; the ostiole is minute, punctiform, and brown. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, and $\frac{1}{25,000}$th broad; the arthrosterigmata are about $\frac{1}{370}$th long.

Specimen 3.—Schooley's Mountains, North America, June 1856; coll. Dr A. O. BRODIE. The spermogones are easily mistaken for young apothecia; they form small, slightly elevated, flattened tubercles on the surface of the thallus, about its periphery. They somewhat resemble grains of sago; are very distinct, from the contrast of their pale colour with the dark-green of the thallus; and are roundish and hard, having an obscure, minute ostiole. The spermatia are rod-shaped, about $\frac{1}{7000}$th long, on arthrosterigmata resembling those of *Collema*.

Specimen 4.—SCHÆRER exs. 260, associated with *Nephromium tomentosum*, var. *helveticum*, Black Forest, Switzerland; coll. HOCHSTETTER. The spermogones are plentiful about the margins of the lobes of the thallus. They are distinctly circumscribed, palish-yellow or whitish disks, round, flattened, with a distinct brown punctiform ostiole.

Specimen 5.—South America, HUMBOLDT; in Herb. Hooker, Kew (sub nom. *Collema olivaceum*, Hook.) The thallus is very delicate, diaphanous, and of an olive-green colour; the lobes are large and rounded. The margins are beautifully denticulate, being fringed with spermogones, which look like so many minute teeth. These organs are small but well-formed cones, each marked with a brown, punctiform, apical ostiole. The cones are distinctly circumscribed; the base of the buff-coloured spermogone not passing into, but being clearly distinguishable from, the deep leek-green colour of the thallus. The body of the spermogone sometimes falls out, and then small cups or cavities are left, which give to the margins of the thallus an irregularly notched character. The spermatia are rod-shaped, about $\frac{1}{8000}$th long, and $\frac{1}{20,000}$th broad; the arthrosterigmata are about $\frac{1}{300}$th long.

SPECIES 4. *L. phyllocarpum*, Pers.,

Which is common in tropical countries.

Specimen 1.—On bark, St Vincent, West Indies; in Herb. Hooker, Kew. The margins of the lobes are studded over with distinct, small, brownish-yellow spermogones, of the character of the marginal spermogones of *Collema*. Similar spermogones occur plentifully in specimens from Surinam, ex. Herb. Miguel; also in Herb. Hooker (sub nom. *L. marginellum*, Mont.)

SPECIES 5. *L. saturninum*, Ach.

Specimen 1.—SCHÆRER exs. 423 (sub *Parmelia myochroa a. saturnina*); on the trunks of trees in the warmer parts of Switzerland. The spermogones are quite those of *L. tremelloides*, except that they are less distinct on account of the deeper colour of the thallus. They occur on the right-hand specimen in my copy (original ed., 1842). They abound on the margins of the lobes as pale disks, immersed, with a more or less distinct brown punctiform ostiole. The latter sometimes expands, with age, to such an extent as to give the spermogone the appearance of a young apothecium. The spermatia are rod-shaped, about $\frac{1}{6000}$th long, on arthrosterigmata about $\frac{1}{600}$th to $\frac{1}{500}$th long. The spermogones and spermatia of *L. Hildenbrandii*, Garov., are similar to those just described.

GENUS V. Obryzum, *Wallr., Tul.*

This genus is represented by its single species, *O. corniculatum*, Wallr. It possesses angiocarpous apothecia, which are so small that they are very apt to be overlooked, unless very carefully sought for. The spermogones are also very small and inconspicuous; they are scattered about the ends of the lobes, and generally resemble those described under *Collema*. Their diameter is about $\frac{1}{200}$th. The plant closely resembles *Leptogium palmatum;* but its angiocarpus apothecia distinguish it.

[The Author has embodied his Researches on the Spermogones and Pycnides of *Crustaceous* Lichens in a separate Memoir, similar in length to the foregoing Memoir, and illustrated by an equal number of drawings. This Memoir on Crustaceous Lichens will include one or two genera, such as *Endocarpon* and *Normandina*, which have not strictly a *crustaceous* thallus, but which, nevertheless, it would be inconvenient and unscientific to consider apart from their ally,—the extensive and important genus *Verrucaria*. It will also include the *Calicei* (genera *Sphinctrina*, *Calicium*, and *Coniocybe*), which are usually associated in classification with the *Spærophorei*, but which have a horizontal crustaceous thallus, on which the spermogones are seated, or in which they are contained or immersed.]

EXPLANATION OF PLATES*

ILLUSTRATIVE OF DR LAUDER LINDSAY'S MEMOIR ON THE SPERMOGONES AND PYCNIDES OF LICHENS.

PLATE IV.

Illustrative of the genera USNEA, Hoffm.; NEUROPOGON, Nees *and* Flot.; ALECTORIA, Ach., Nyl.; *and* CHLOREA, Nyl.

Fig. 1. *Usnea barbata*, Fr., var. *plicata*, Fr., from California; showing the long pendulous ramules covered over with spermogonal warts.

Fig. 2. Spermogones from the same specimen, more highly magnified.

Fig. 3. *U. barbata*, Fr., from Tasmania; showing spermogonal warts covering the cilia, which radiate from the margins of the apothecium.

Fig. 4. *U. barbata*, Fr., var. *hirta*, Fr., from Rio Janeiro. Portion of thallus profusely covered with small spermogonal warts, most of which have black-punctate ostioles.

Fig. 5. Spermogonal warts from the same specimen, more highly magnified.

Fig. 6. *U. barbata*, Fr. Section of a spermogone, showing the ostiole *a*; the multiple or compound cavity *b*, dividing into numerous anfractuosities, or compartments with sinuous walls; *c*, the gonidic layer of the thallus; *d*, the white medullary tissue, composed of delicate branching tubes; *e*, the cortical layer of the thallus, consisting of closely aggregated irregular cells.

Fig. 7. *U. barbata*, Fr. Sterigmata *a*, and spermatia *b*. Elongated, branching, delicate filaments, which project from among the spermatiferous sterigmata, *c* (in right-hand figure).

Fig. 8. Sterigmata and spermatia of the same species, from a Tasmanian specimen. The letters *a*, *b*, have the same reference as in fig. 7.

Fig. 9. *Neuropogon melaxanthus*, Ach. *a*, The black fusiform tips of the ramuscles, the seat of the compound or confluent spermogones.

Fig. 10. Portion of one of the spermogoniferous ramuscles more highly magnified.

Fig. 11. Sterigmata and spermatia of *N. melaxanthus*; specimen from Hermite Island, Cape Horn: *a*, sterigmata; *b*, spermatia.

Fig. 12. *Alectoria Taylori*, Hook., from Kerguelen's Land: *a*, apothecium; *b*, *Lecidea alectoriæ* mihi, dotted over the under surface of the apothecium, and over the surface of the thallus.

Fig. 13. *A. Taylori*, showing the tips of the ramuscles, black and warted from the presence of the spermogones *b*; *a*, an apothecium, young; *c*, apothecia immersed, punctiform, and black, of *Lecidea alectoriæ* mihi.

* The microscopical analyses were chiefly made with the combination of powers of Nachet's microscope (Petit modèle of 1851), which magnify 380 diameters.

The following is the scale of $\frac{1}{1000}$th of an inch, to which the *sterigmata, spermatia*, and *stylospores* are drawn:—

$\frac{1}{1000}$ |———————|

The fragments of thallus bearing spermogones or pycnides are mostly magnified more or less, in order that these organs may be the more easily recognised. The sections of spermogones, which are mostly diagrammatic, are also variously magnified.

Fig. 14. Portion of tip of one of the ramuscles—spermogoniferous—more highly magnified.

Fig. 15. Section of the compound spermogones of *A. Taylori*: *a*, ostioles; *b*, cavity of spermogone.

Fig. 16. Sterigmata *a* and spermatia *b* of same species.

Fig. 17. *Alectoria jubata*, Ach.; Schærer's "Lich. Helvet. exsic.," Nos. 392 and 496, showing the *pycnides* at the angles of the ramules.

Fig. 18. Sterigmata and stylospores of same species: *a*, sterigmata or basidia; *b*, stylospores, still fixed or adherent to the sterigmata; *c*, free stylospores, apparently devoid of contents; *d*, free stylospores, with nucleiform contents.

Fig. 19. *A. lata*, Tayl., Nyl., from Mexico. Sterigmata *a* and spermatia *b*.

Fig. 20. *Chlorea vulpina*, Nyl., from Germany, showing the black punctiform spermogones at *a*.

Fig. 21. Portion of the same thallus more highly magnified, showing the spermogones more distinctly.

Fig. 22. *Chlorea vulpina* growing on the *Wellingtonea gigantea* of California: *a*, punctiform spermogones; *b*, *Phacopsis vulpina*, Tul., parasitic on its thallus.

Fig. 23. Portion of the thallus of *C. vulpina*, highly magnified, showing the small barrel-like or wart-shaped spermogones *a*.

Fig. 24. Section of a spermogone of *C. vulpina*: *a*, ostiole; *b*, cavity; *c*, walls, consisting of sterigmata; *d*, gonidic layer of thallus; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 25. *C. vulpina*; Schærer exs., 390.
Fig. 26. *C. vulpina*; Rocky Mountains.
Fig. 27. *C. vulpina*; Germany.
} Sterigmata *a*; spermatia *b*; basal cellular tissue *c*.

Plate V.

Illustrative of the genera Evernia, Ach., Nyl.; Ramalina, Ach., Fr.; *and* Thamnolia, Ach., Schær.

Fig. 1. *Evernia furfuracea*, Mann.; Schærer exs., 387. Portion of extremity of thalline segments: *a*, minute punctiform spermogones; *b*, brown tips of ramuscles, resembling spermogones of *Cladonia*; *c*, furfuraceous or isidioid warts of thallus.

Fig. 2. *E. furfuracea*; Ingleborough, Yorkshire: *a*, punctiform immersed spermogones; *b*, brown tips of ramuscles, resembling the spermogones of *Cladonia*.

Fig. 3. *E. furfuracea*; Schærer exs., 387. Sterigmata *a*; spermatia *b*; sterile elongated filaments of spermogone *c*; basal cellular tissue *d*.

Fig. 4. *E. furfuracea*; Orizaba, Mexico. Sterigmata *a* and spermatia *b*.

Fig. 5. *E. Richardsoni*, Hook. Portion of thallus magnified, showing the marginal spermogones, resembling those of *Cetraria Islandica*: *a*, seated on marginal processes; *b*, immediately marginal.

Fig. 6. *Ramalina calicaris*, Fr., var. *fraxinea*, Fr. (= *ampliata* of authors), Hepp. exs., 167: *a*, apothecia; *b*, wart-like spermogones.

Fig. 7. Portion of the thallus more highly magnified, showing the very irregular spermogones, and their pale ostioles *a*.

Fig. 8. Section of the thallus of same species, showing spermogones *a* in different stages of development; *b*, ostioles.

Fig. 9. *R. calicaris*, var. *fraxinea*. Sterigmata *a*, spermatia *b*, and network of elongated branching filaments *c*, which fill the spermogonal cavity: basal cellular tissue *d*.

Fig. 10. *R. calicaris*, var. *fraxinea*. Section of a spermogone: *a*, ostiole; *b*, cavity divided into several compartments, with sinuous walls; *c*, inner wall of spermogone, consisting of sterigmata; *d*, gonidic layer of thallus; *e*, medullary tissue; *f*, cortical layer of thallus.

Fig. 11. *R. calicaris*, var. *fraxinea*, Schærer exs., 554. Sterigmata *a* and spermatia *b*.

Fig. 12. *R. ceruchis*, Ach.; Chili. Sterigmata *a* and spermatia *b*.

Fig. 13. *Ramalina scopulorum*, Ach.; Leighton exs., 2. Portion of thallus, showing *a*, apothecium; *b*, irregular wart-like spermogones, mostly with black-punctate ostioles.

Fig. 14. *R. scopulorum*, Schærer exs., 554. Sterigmata *a* and spermatia *b*.

Fig. 15. *R. polymorpha*, Ach.; Leighton exs., 73. Thallus very much warted with confluent spermogones *a*.

Fig. 16. *R. terebrata*, Tayl. Flat thalline segments covered with irregular spermogonal warts.

Fig. 17. Portion of thallus more highly magnified to show the irregular spermogonal warts, and their pale ostioles *b*.

Fig. 18. Sterigmata *a*, spermatia *b*, sterile branching filaments *c*, which occupy the cavity of the spermogone in the same species; basal cellular tissue *d*.

Fig. 19. *Thamnolia vermicularis*, Schær., Falkland Islands, dotted over with the parasitic *Lecidea vermicularia* mihi *a*.

Fig. 20. *T. vermicularis*, Schærer exs., 86; bearing large, distinct, wart-like spermogones *aa*.

Fig. 21. Some of the same spermogones more highly magnified, showing the very pale, inconspicuous, stellate-fissured ostiole *a*.

Fig. 22. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, inner wall formed of articulated sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical tissue of thallus.

Fig. 23. Sterigmata *a* and spermatia *b* from same specimen (Schær. exs., 86).

Fig. 24. Section through the thallus of *T. vermicularis*, showing the immersed apothecia of *Lecidea vermicularia*: *a*, with a convex surface; *b*, with a flat or sub-depressed surface; *c*, young, not yet bursting through the cortical layer of thallus.

Fig. 25. Spores of *Lecidea vermicularia*; Falkland Islands.

Plate VI.

Illustrative of the genera Roccella, Bauh.; Dactylina, Nyl.; Dufourea, Ach., Nyl.; Acroscyphus, Lév., Tul.; Stereocaulon, Schreb.; *and* Sphærophoron, Pers.

Fig. 1. *Roccella fuciformis*, Ach., dotted over with black, punctiform, immersed spermogones.

Fig. 2. Portion of the thallus more highly magnified, showing some of the spermogones to be papillæform; the black ostiole seated on the apex of a thalline papilla.

Fig. 3. *R. fuciformis*, Ach.; Schærer exs., 553. Portion of the thallus magnified, showing the confluent ostioles, seated on the apices of large, irregular, thalline papillæ.

Fig. 4. *R. fuciformis*, Ach.; west coast of Africa; used in the manufacture of Orchil by Messrs Robinson, Huddersfield. Portion of thallus magnified, showing the punctiform spermogones scattered alike over the apothecia *a* and thallus.

Fig. 5. Section through the spermogones of *R. fuciformis*, showing their papillæform character, and the frequently depressed ostiole *a*.

Fig. 6. Sterigmata and spermatia of *R. fuciformis*, Ach.; Africa.

Fig. 7. *R. tinctoria*, Ach. Thickest Lima "Orchella Weed." Portion of thallus, showing difform apothecia *a*, and punctiform or sub-papillæform spermogones *b*.

Fig. 8. Section through same spermogones, showing the depressed form of ostiole *a*.

Fig. 9. Portion of thallus of same species magnified, showing the papillæform spermogones *a*.

Fig. 10. Portion of thallus of same species magnified, showing a difform apothecium *a*, and confluent ostioles seated on large irregular thalline papillæ *b*.

Fig. 11. Two spermogones of same species more highly magnified, showing the confluent ostioles *a*.

Fig. 12. Sterigmata and spermatia of the same species. Figs. 8–12 are taken from Lima specimens of commercial Orchella Weed.

Fig. 13. Sterigmata and spermatia from other specimens of *R. tinctoria*, Ach.

Fig. 14. Free, curved, or twisted spermatia of the same species.

Fig. 15. *Roccella Montagnei*, Bél.; Angola, Africa. Portion of thallus magnified, showing *a*, the ordinary punctiform immersed spermogones; *b*, large lecidine superficial spermogones; and *c*, cavities left by the falling out of the old lecidine spermogones.

Fig. 16. Portion of the same thallus more highly magnified, showing the same punctiform or subpapillæform spermogones *a*, and lecidine ones *b*.

Fig. 17. Sterigmata and spermatia of same lichen. Some of the sterigmata *a* become degenerate and elongated with age. The cavity of the spermogone is occupied by a network of delicate ramose filaments *b*, resembling those of *Ramalina*.

Fig. 18. *R. intricata*, Mont., from Coquimbo. Sterigmata and spermatia.

Fig. 19. *R. mollusca*, Ach. (olim *Dufourea*), from Cape of Good Hope. Portion of thallus magnified, showing an apothecium *a*, and punctiform or papillæform spermogones *b*.

Fig. 20. Sterigmata and spermatia of same species.

Fig. 21. *Dufourea madreporiformis*, Ach., from Switzerland. Portion of thallus magnified, showing the punctiform spermogones *b*.

Fig. 22. Sterigmata and spermatia of same species.

Fig. 23. *Dactylina arctica*, Hook., collected during Franklin's first voyage to the Polar regions. Sterigmata and spermatia.

Fig. 24. *Acroscyphus sphærophoroides*, Lév., from Sikkim, Himalayas Portion of end of one of the thalline ramuscles, showing the spermogone (and its ostiole) *a*, resembling that of *Sphærophoron coralloides*, Pers.

Fig. 25. Section of one of the spermogones of same plant. The letters have the same references as in fig. 30.

Fig. 26. Sterigmata and spermatia of same plant.

Fig. 27. *Stereocaulon ramulosum*, Sw., from Tasmania. Portion of the ultimate segments of the thallus, showing the roundish or wart-like spermogones *a*.

Fig. 28. Some of the same spermogones, more highly magnified to show the stellate-fissured, indigo-blue-coloured ostiole *a*.

Fig. 29. Section through one of the same spermogones: *a*, ostiole; *b*, body of the spermogone.

Fig. 30. Section, much more highly magnified, through one of the same spermogones: *a*, ostiole; *b*, cavity, divided into numerous sinuous compartments; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 31. Sterigmata and spermatia of same lichen.

Fig. 32. Two fragments of the same lichen, showing the spermogones *b*, forming a sort of collar round the apothecia *a*.

Fig. 33. *S. denudatum*, Flk., from Antrim, Ireland. End of a thalline ramuscle magnified, showing the crowded wart-shaped spermogones *a*.

Fig. 34. Spermatia of the same plant, partly straight, partly curved.

Fig. 35. *S. alpinum*, Laur.; Ben Nevis. End of a thalline ramuscle, showing the crowded wart-like spermogones *a*.

Fig. 36. *S. paschale*, Fr., from near Bonhard, Perth. End of a thalline ramuscle, magnified to show the terminal wart-like spermogones *a*.

Fig. 37. Some of the same spermogones more highly magnified, showing the stellate-fissured ostiole *a*.

Figs. 38 and 39. Sterigmata and spermatia from specimens of *S. paschale*, from Bonhard.

Fig. 40. *S. Argus*, Tayl., from Campbell's Island. Portion of end of one of the thalline ramuscles, showing an apothecium *a*, and a collar of wart-like spermogones *b*.

Fig. 41. Portion of ends of thalline ramuscles of same plant magnified, showing terminal spermogones *a*, the segments bearing no apothecium.

Fig. 42. Sterigmata and spermatia of same plant.

Fig. 43. *Sphærophoron compressum*, Ach., var. *australe*, Laur., from New Zealand. Portion of undersurface of thallus magnified, showing the round ring-like ostioles of the spermogones *a*.

Fig. 44. *Sphærophoron compressum*, Ach., var. *australe*, Laur., from New Zealand. Specimen resembling *S. coralloides*, Pers., in its terminal spermogones *a*.

Fig. 45. *S. compressum*, Ach., from the Auckland Islands. Portion of end of one of thalline segments, magnified to show the apothecia *a*, and the grouped spermogones *b*.

Fig. 46. Portion of a ramuscle, bearing spermogones *a*, still more highly magnified.

Fig. 47. *S. compressum*, Ach., from Tasmania. Sterigmata and spermatia, with the network of elongated ramose filaments, which occupy the cavity of the spermogone *a*.

Fig. 48. *S. coralloides*, Pers., from Cleveland, Yorkshire, showing abundance of terminal papillæform brown spermogones *a*.

Fig. 49. Tip of one of the spermogoniferous ramuscles more highly magnified, showing the ostiole *a*.

Fig. 50. Section of one of the spermogones. The letters have the same references as in fig. 30.

Fig. 51. Sterigmata and spermatia of same species.

Fig. 52. *S. fragile*, Pers., from Craig-y-Barns, Dunkeld. Portion of the thallus, showing the same terminal spermogones *a* as in *S. coralloides*, Pers.

Fig. 53. *S. tenerum*, Laur., from Hermite Island, Cape Horn. Portion of thallus magnified, showing the grouped spermogones *a*.

Plate VII.

Illustrative of the genus Cladonia, Hoffm.

Fig. 1. *Cladonia deformis*, Hoffm., from Ben Nevis. Portion of a podetium, showing the barrel-shaped spermogones *a*.

Fig. 2. The same spermogones isolated and much more highly magnified: *a*, ostiole.

Fig. 3. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, inner wall of spermogone consisting of sterigmata; *d*, gonidia; *e*, medullary tissue; *f*, cortical layer of thallus.

Fig. 4. *C. deformis*, Schærer exs., 49. Podetium, showing *pycnides b*, black, punctiform, immersed.

Fig. 5. *C. bellidiflora*, Schær.; Ben Nevis. Portion of a podetium, showing brown barrel-shaped spermogones *a*.

Fig. 6. One of the thalline folioles, with its spermogone more highly magnified: *a*, ostiole; *b*, body of spermogone.

Fig. 7. *C. bellidiflora*, Ben Nevis: *a*, apothecium; *b*, terminal spermogones resembling those of *C. rangiferina*.

Fig. 8. *C. bellidiflora*, Schærer exs., 39. Spermogones *a*, on a scyphus *b*.

Fig. 9. Three of the same spermogones highly magnified: *a*, ostiole; *b*, body of spermogone; *c*, thalline papilla.

Fig. 10. A barrel-shaped spermogone, also highly magnified: *a*, ostiole; *b*, body.

Fig. 11. *C. uncialis*, Hoffm.; Schærer exs., 82. End of a podetium, showing the terminal horn-like spermogones *a*.

Fig. 12. Variously-shaped spermogones of the same species magnified: *a*, ostiole; *b*, body.

Fig. 13. Terminal spermogones *a*, on podetia resembling those of *C. rangiferina*.

Fig. 14. *C. uncialis*, deformed from being the seat of *Lecidea cladoniaria* mihi, whose *pycnides*, *b*—black, punctiform, immersed—resemble spermogones: *a*, spermogones of *C. uncialis*.

Fig. 15. Section of deformed bullose portions of thallus of *C. uncialis*, from Birnam Hill, Dunkeld, showing the immersed *pycnides* of *Lecidea cladoniaria* mihi: *a*, old; *b*, young.

Fig. 16. Sterigmata *a*, and stylospores *b*, of above *pycnides*: *c*, free stylospores, some of them with oily contents.

Fig. 17. *C. aggregata*, Sw., Eschw. Portion of thallus, showing the terminal barrel-like spermogones at *a*.

Fig. 18. Portion of thallus, containing on same podetium apothecia *a*, and spermogones *b*.

Fig. 19. Two of the barrel-shaped spermogones greatly magnified; *a*, ostiole; *b*, body.

Fig. 20. *Cladonia aggregata;* New Zealand. Sterigmata *a*, spermatia *b*, elongated sterile filaments *c*.

Fig. 21. Section of a spermogone: the letters have the same reference as in fig. 3.

Fig. 22. *C. retipora*, Ach., Flk.; Tasmania. Portion of the cancellated thallus, showing the terminal horn-like spermogones at *a*.

Fig. 23. Spermogones of the same, highly magnified: *a*, ostiole; *b*, body.

Fig. 24. *C. rangiferina*, Hoffm.; Blaeberry Hill, Perth. Portion of the thallus, showing the terminal spermogones at *a*. Here they are *erect*.

Fig. 25. Portion of thallus, showing spermogones *a*, on the *nodding* apices of the ultimate ramuscles.

Fig. 26. Spermogones highly magnified: *a*, ostioles; *b*, body.

Fig. 27. *C. rangiferina*, from Tasmania. Terminal spermogones *a*, very minute, and whole thallus very delicate and attenuated.

Fig. 28. *C. rangiferina;* Long Island, U.S., America. Sterigmata *a*, spermatia *b*; sterile, elongated, branching filaments *c*, which occupy the cavity of the spermogone.

Fig. 29. *C. rangiferina;* Tasmania. Sterigmata *a*, spermatia *b*, and elongated branching filaments *c*.

Fig. 30. *C. rangiferina;* Long Island, U.S., America. Spermogones *a*, seated on the apothecium *b*.

Fig. 31. Portion of thallus bulging and warted at *c*, the warts resembling spermogones; *a* and *b* refer as in fig. 30.

Fig. 32. *C. amaurocrœa*, Flk., var. *capitellata*, Bab.; New Zealand. Portion of thallus, showing *a*, terminal spermogones, and *b*, lateral spermogones; in both cases barrel-shaped and large.

Fig. 33. Spermogones isolated and highly magnified: *a*, ostiole; *b*, body of spermogone.

Fig. 34. Sterigmata *a*, and spermatia *b c*, of same species—*c* fixed, and *b* free spermatia.

Fig. 35. *C. macilenta*, Hoffm.; Schærer exs., 337. Showing the barrel-shaped spermogones *a*, fringing the margin of a scyphus.

Fig. 36. Sterigmata *a*, and spermatia *b*, of same species.

Fig. 37. One of the spermogones highly magnified: *a*, ostiole; *b*, body.

Fig. 38. *C. macilenta;* var. *cornuta;* Schærer exs., 337. Spermogones *a*, on margins of narrow scyphi, borne on the ends of long slender podetia.

Fig. 39. *C. macilenta*, var. *polydactyla*, Flk.; Schærer exs., 454. Spermogones *a*, wart-like or barrel-shaped, fringing a scyphus.

Fig. 40. *C. macilenta;* Schærer exs., 36. Spermogone terminal and isolated, on end of a long, delicate, linear podetium: *a*, ostiole; *b*, body.

Fig. 41. *C. macilenta;* Schærer exs., 337. Sterigmata *a*, and spermatia *b c* [*b* fixed, *c* free].

Plate VIII.

Illustrative of the genus Cladonia, Hoffm.

Fig. 1. *Cladonia alcicornis*, Flk., from Craigie Hill, Perth; magnified: *a*, horizontal foliaceous thallus, bearing on its surface sessile, barrel-shaped spermogones *b*; *c*, a podetium, having the margin of its scyphi fringed with abortive spermogones.

Fig. 2. One of the same spermogones isolated, showing the largish regular ostiole *a*.

Fig. 3. *C. alcicornis*, Flk.; Leighton exs., 15. Under surface of horizontal thallus, dotted over with papillæform and punctiform pycnides *a*.

Fig. 4. Sterigmata *a*, and spermatia *b c*, of *C. alcicornis;* Schær. exs., 455; *b* fixed, *c* free spermatia.

Fig. 5. Spermogones, *a*, fringing margin of scyphi of same plant; Leighton exs., 15.

Fig. 6. *C. gracilis*, Fr., var. *cervicornis*, Ach., from Morchone, Braemar: *a*, horizontal foliaceous thallus; *b*, a podetium, terminating in a scyphus fringed with barrel-shaped spermogones *c*.

Fig. 7. One of the same spermogones isolated and more highly magnified, showing ostiole *a*.

Fig. 8. *Cladonia gracilis*, Fr., var. *cervicornis*, Ach., from Muckish Mountain, Ireland. A deformed podetium, studded over with abortive or degenerate spermogones *a*.

Fig. 9. *C. gracilis*, Fr.; Schærer exs., 66: scyphus bearing *a*, apothecia, and *b*, barrel-shaped marginal spermogones.

Fig. 10. One of latter more highly magnified: *a*, ostiole; *b*, body.

Fig. 11. *C. gracilis*, Fr., from Tasmania. A barrel-shaped spermogone *a*, forming the apex of a long, slender, tapering podetium *b*.

Fig. 12. *C. gracilis*, Fr.; Schærer exs., 641. Scyphi, showing marginal tooth-like spermogones *a*; *b* [in lower figure] an apothecium; *c* [in upper figure] a secondary sterile podetium.

Fig. 13. One of the same spermogones more highly magnified: *a*, ostiole; *b*, body.

Fig. 14. *C. gracilis*, Fr.; Falkland Islands. Degenerate and old sterigmata, becoming elongated and sub-ramose.

Fig. 15. *C. gracilis*, Fr.; Schærer exs., 67. Sterigmata also old and degenerate, becoming elongated and ramose; their ramifications forming a network of filaments, which occupy cavity of old spermogone.

Fig. 16. *C. pyxidata*, Fr.; Schærer exs., 53. A scyphus fringed with marginal barrel shaped spermogones *a*.

Fig. 17. Two of the same more highly magnified: *a*, ostiole; *b*, body.

Fig. 18. *C. pyxidata*, Fr.; Schær. exs., 268. A scyphus bearing *a*, apothecia; and *b*, marginal spermogones.

Fig. 19. Same plant. A barrel-shaped spermogone terminal on a slender tapering podetium: *a*, ostiole.

Fig. 20. *C. pyxidata*, Fr.; Schærer exs., 58. A scyphus fringed with large marginal spermogones *a*.

Fig. 21. The same species; Long Island, North America. A scyphus, bearing marginal spermogones *a*, and secondary tapering sterile podetia *b*.

Fig. 22. *C. pyxidata*, Fr.; Sligachan, Skye. Surface, as well as margins, of scyphus, studded over with spermogones *a*.

Fig. 23. Two of the same spermogones more highly magnified: *a*, ostiole; *b*, body.

Fig. 24. *C. pyxidata*, Fr.; Dumfries. A scyphus bearing large marginal spermogones *a*.

Fig. 25. Sterigmata *a*, and spermatia *b*, of the same plant.

Fig. 26. *C. fimbriata*, Fr.; Schærer exs., 589. A scyphus bearing large marginal spermogones *a*.

Fig. 27. *C. fimbriata*, Fr.; Schærer exs., 640. Sterigmata *a*, and spermatia *b c* [*b* fixed, *c* free].

Fig. 28. *C. fimbriata*, Fr.; Derry, Ireland. Scyphus bearing an apothecium *a*, and spermogones *b*, both on its surface and margins.

Fig. 29. Sterigmata *a*, and spermatia *b*, of the same plant.

Fig. 30. *C. degenerans*, Flk.; Schærer exs., 274. Scyphus bearing marginal large spermogones *a*.

Fig. 31. *C. cenotea*, Schær. Scyphus bearing marginal spermogones *a*.

Fig. 32. *C. Papillaria*, Hoffm.; Schærer exs., 511. Irregular deformed podetia, studded over with horn-like or barrel-shaped spermogones *a*.

Fig. 33. *C. Papillaria*, Hoffm.; Schærer exs., 512. Mature podetium, bearing confluent apothecia *b*; young podetia *c*; brown lecidine spermogones seated on the horizontal granulose thallus *a*.

Fig. 34. *C. Papillaria*, Hoffm.; Schær. exs., 511 and 512. Sterigmata *a*, and spermatia *b c* [*b* fixed, *c* free]. In the right-hand figure the sterigmata are old and degenerate, becoming elongated and ramose.

Fig. 35. *C. furcata*, Schær., var. *racemosa*, Schær. Portion of thallus, showing the terminal barrel-shaped spermogones *a*.

Fig. 36. One of the same spermogones more highly magnified: *a*, the largish regular ostiole; *b*, body.

Fig. 37. *Cladonia furcata*, Schær., var. *racemosa*, Schær.; Dumfries. Sterigmata *a*, and spermatia *b c* [*b* fixed, *c* free].

Fig. 38. Sterigmata *a*, and spermatia *b c* [*b* fixed, *c* free], from other specimens of the same plant. In the left-hand figure the sterigmata are old and degenerate *d*, bearing no spermatia.

Fig. 39. *C. squamosa*, Hoffm.; Glen Callater, Braemar. Portion of thallus, showing terminal spermogones at *a*, and sessile ones scattered indiscriminately over the podetium at *b*.

Fig. 40. *C. squamosa*, Hoffm.; Schær. exs., 74. A scyphus, bearing marginal large barrel-shaped spermogones *a*, and secondary scyphi, which are fringed with small, tooth-like, abortive spermogones *b*.

Fig. 41. The same plant; Schær. exs., 73. Portion of the end of a podetium, showing an apothecium *a*, and terminal barrel-shaped spermogones *b*.

Fig. 42. *C. squamosa*, Hoffm., var. *cæspititia*, Ach. Portion of thallus, bearing an apothecium *a*, and several sessile barrel-shaped spermogones *b*.

Fig. 43. One of the same spermogones more highly magnified: *a*, ostiole; *b*, body.

Plate IX.

Illustrative of the genera Umbilicaria, Hoffm.; Peltigera, Hoffm.; Nephromium, Nyl.; Solorina, Ach.; Cetraria, Ach., Nyl.; *and* Platysma, Hoffm., Nyl.

Fig. 1. *Umbilicaria hyperborea*, Hoffm., var. *convoluta* mihi; Brandon Mountain, Ireland. Portion of thallus, showing *a*, apothecia; *b*, spermogones, perched on the summit of the thalline convolutions or papillæ.

Fig. 2. Section through thallus showing the said convolutions *a*, and spermogones *b*.

Fig. 3. Two of the thalline papillæ *b*, with spermogones *a* on their apices; *c*, ostiole.

Fig. 4. Section of a spermogone: *a*, ostiole; *b*, cavity; *c*, inner wall of spermogone, consisting of sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical tissue of thallus.

Fig. 5. *U. hyperborea*, var. *convoluta* mihi. Sterigmata *a*, and spermatia *b*.

Fig. 6. *U. polyphylla*, Hoffm.; Braemar. Polyphyllous thallus, showing the minute papillæform black spermogones *a*.

Fig. 7. Section of the thallus, showing the immersed spermogones *a*.

Fig. 8. *U. cylindrica*, L., Fr.; Muckish Mountain, Ireland. Showing the minute black punctiform spermogones *a*.

Fig. 9. *U. cylindrica*; Ben Lawers. Showing largish papillæform spermogones *a*.

Fig. 10. The same; showing *a*, an apothecium, and *b*, wart-like spermogones, with large black ostioles.

Fig. 11. *U. cylindrica*; Braemar. Portion of thallus, showing largish punctiform ostioles *a* of spermogones, each ostiole forming the centre of a black spot or areola.

Fig. 12. *U. cylindrica*; Braemar. Ostioles *a*, with their surrounding areolæ *b*, isolated and greatly magnified.

Fig. 13. Section of thallus, showing immersed spermogones *a*. At *b* the spermogones have fallen out, and have left saucer-like cavities.

Fig. 14. *U. cylindrica*; Ben Lawers. Section of thallus, showing spermogones *b*, with stellate-fissured large ostioles *a*; *c*, fibrillæ or fixuræ of under surface of thallus.

Fig. 15. Section through thallus, in another specimen of same species, showing the papillæform spermogones *a*.

Fig. 16. Section through thallus, in another specimen, also showing sub-papillæform spermogones *a*.

Fig. 17. Section through thallus, in another specimen, showing spermogones with depressed ostioles *a*.

Fig. 18. *U. proboscidea*, DC.; Lochnagar. Monophyllous thallus, showing sub-papillæform spermogones *b*; *a*, umbilicus or point of adhesion.

Fig. 19. Section through thallus, showing papillæform spermogones *a*.

Fig. 20. *U. polyrrhiza*, L.; Lochnagar. Monophyllous thallus, showing papillæform spermogones *a*.

Fig. 21. Section through thallus, showing the immersed spermogones *a*.

Fig. 22. *Umbilicaria erosa*, Hoffm. Monophyllous thallus, showing the minute, black, papillæform spermogones *a*.

Fig. 23. Section through thallus, showing the immersed spermogones *a*.

Fig. 24. *U. hirsuta*, DC.; Hepp. exs., 117. Portion of thallus, showing *a*, apothecia; *b*, papillæform spermogones; *c*, marginal cilia of thallus; *d*, cavities with irregular edges, left by the falling out of the apothecia.

Fig. 25. Section through thallus, showing *a*, an apothecium; *b*, immersed spermogones.

Fig. 26. *U. papulosa*, Ach.; Schooley's Mountains, North America. Specimen showing *a*, apothecia; *b*, spermogones,—very minute, black, punctiform, frequently seated on the pustules of the thallus.

Fig. 27. Section through thallus, showing *a*, an apothecium; *b*, immersed spermogones.

Fig. 28. *Neprhomium tomentosum*, Hoffm.; Schær. exs., 259. Portion of margin of thallus, showing marginal spermogones: *a*, papillæform; *b*, wart-like; *c*, young.

Fig. 29. Section of one of the same spermogones: *a*, ostiole; *b*, body of spermogone.

Fig. 30. Portion of margin of thallus of another specimen of the same plant (Schær. exs., 259), showing the spermogones *a*, seated on the ends of digitate processes.

Fig. 31. *N. tomentosum*, Hoffm.; Sikkim, Himalaya. Large barrel-shaped spermogones *b*, perched on the apices of digitate processes *c*, of margin of thallus: *a*, ostiole.

Fig. 32. Two of the same spermogones more highly magnified: *a*, ostiole.

Fig. 33. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 34. Sterigmata and spermatia of same plant.

Fig. 35. *Solorina saccata*, Ach., bearing on its surface *Sphæria urceolata*, *a*; Hepp. exs., 475.

Fig. 36. *Cetraria Islandica*, Ach. Portion of thallus, showing the marginal cilia *a*, which bear the spermogones.

Fig. 37. Portion of same thallus magnified, showing the same cilia and the barrel-shaped spermogones *a* at their tips.

Fig. 38. The same spermogones still more highly magnified: *a*, ostiole.

Fig. 39. Portion of thallus of another specimen of the same plant, showing abortive marginal cilia *a*.

Fig. 40. Sterigmata and spermatia from different specimens of *C. Islandica*.

Fig. 41. *C. aculeata*, Fr.; spermogones highly magnified: *a*, ostiole.

Fig. 42. *Platysma nivale*, L.; Leight. exs., 43. Portion of thallus, showing the black, wart-like, marginal spermogones *a*.

Fig. 43. Portion of same thallus magnified, to show the same spermogones: *a*, ostiole.

Fig. 44. Section of one of the same spermogones. The letters have the same references as in fig. 33.

Fig. 45. Sterigmata and spermatia from different specimens of *P. nivale*, L.

Fig. 46. *P. sepincolum*, Hoffm.; Cleveland, Yorkshire. Thallus showing brown papillæform spermogones *a*.

Fig. 47. Some of the same spermogones magnified: *a*, ostiole.

Fig. 48. Sterigmata and spermatia of same lichen.

Fig. 49. *P. cucullatum*, Hoffm.; Schær. exs., 18. Portion of thallus, showing the black, wart-like, marginal spermogones *a*.

Fig. 50. Sterigmata and spermatia of same plant.

Fig. 51. *P. juniperinum*, L.; Schær. exs., 20. Thallus showing the black, wart-like, marginal spermogones *a*.

Fig. 52. Sterigmata and spermatia of same species.

Plate X.

Illustrative of the genera Platysma, Hoffm., Nyl.; Ricasolia, DN., Nyl.; *and* Sticta, Ach.

Fig. 1. *Platysma ciliare*, Ach.; Schooley's Mountains, North America. Showing the marginal denticulate spermogones *a*.

Fig. 2. Portion of edge of thallus magnified, showing the barrel-shaped spermogones: *a*, ostiole.

Fig. 3. Sterigmata *a* and spermatia *b* of same species.

Fig. 4. *P. lacunosum*, Ach., var. *β atlanticum*; Tuckerman exs., 6. Portion of thallus, showing the marginal button-shaped spermogones *a*.

Fig. 5. Portion of edge of thallus, magnified to show the marginal spermogones *a*.

Fig. 6. *Ricasolia herbacea*, DN., Inverary. Portion of thallus, showing *a*, apothecia; and *b*, papillæform or mammillæform spermogones.

Fig. 7. Two of the spermogones more highly magnified, showing *a*, a simple ostiole; and *b*, a stellate-fissured ostiole.

Fig. 8. Section of thallus, showing *a*, an apothecium; *b*, mammillar spermogones.

Fig. 9. *R. herbacea*, from Sikkim, Himalayas. Portion of thallus, showing marginal tooth-like spermogones *a*, as well as the ordinary mammillæform ones *b*.

Fig. 10. Two of the same marginal spermogones more highly magnified: *a*, ostiole.

Fig. 11. *R. herbacea*. Sterigmata *a* and spermatia *b*.

Fig. 12. *R. glomulifera*, DN.; Inverary. Portion of thallus, showing *a*, apothecia; *b*, mammillæform spermogones; and *c*, a "glomerulus."

Fig. 13. *Sticta glabra*, Tayl.; Falkland Islands. Portion of thallus, showing *a*, apothecia; and *b*, papillæform spermogones.

Fig. 14. Sections through thallus, showing the spermogones in different phases of development: *a*, body of spermogone; *b*, papillæform ostiole.

Fig. 15. *S. linearis*, Tayl.; Tasmania. Portion of thallus, showing *a*, apothecia; and *b*, brown punctiform immersed spermogones, scattered chiefly on the rugæ.

Fig. 16. *S. damæcornis*, Ach., var. *macrophylla*, Hook.; Killarney. Portion of thallus, showing *a*, apothecia; and *b*, mammillæform spermogones.

Fig. 17. Two of the same spermogones, isolated and magnified to show *a*, a simple ostiole—young; and *b*, a stellate-fissured ostiole—old.

Fig. 18. Section of one of the same spermogones.

Fig. 19. Sterigmata *a* and spermatia *b* of the same lichen.

Fig. 20. *S. flavicans*, Tayl.; Falkland Islands. Portion of thallus, showing the sub-marginal papillæform spermogones *a*, and the bright-yellow medullary tissue appearing in a fissure of the cortical layer of the thallus at *b*.

Fig. 21. Portion of another specimen of same plant, showing both papillæform *a* and punctiform *b* spermogones; the latter occurring chiefly on the rugæ of the thallus.

Fig. 22. Section of thallus, showing both papillæform *a* and punctiform *b* spermogones.

Fig. 23. *S. orygmæa*, Ach.; Auckland Islands. Portion of thallus, showing *a*, apothecia; and *b*, sub-papillæform spermogones, seated both on the rugæ and about the margins of the thallus.

Figs. 24 and 25. Sections of thallus, showing *a*, an apothecium; and *b*, spermogones.

Fig. 26. *S. carpoloma*, Del. (= *S. impressa*, Tayl.); New Zealand. Portion of thallus, showing *a*, apothecia; and *b*, minute brown punctiform immersed spermogones, mostly seated on the rugæ.

Fig. 27. Section of thallus, showing the same spermogones *a*.

Fig. 28. *S. filicina*, Ach., var. *Menziesii*, Hook. fils.; New Zealand. Section through thallus, showing the spermogones *a* seated in cavities *b* of thalline papillæ.

Fig. 29. *S. pulmonacea*, Ach.; Glen Muick, Braemar. Portion of thallus, showing the brown, minute, punctiform, immersed spermogones *a*.

Plate XI.

Illustrative of the genus Parmelia, Ach., Nyl.

Fig. 1. *Parmelia tiliacea*, Ach.; Tasmania. Portion of thallus, showing *a*, apothecia; *b*, papillæform spermogones; and *c*, punctiform spermogones.

Fig. 2. Section of thallus, showing both papillæform and punctiform spermogones with depressed ostioles: *a*, mature; *b*, young.

Fig. 3. *P. tiliacea;* Schærer exs., 358. Sterigmata and spermatia: *a*, sterigmata, composed of a few irregular articulations; *b*, spermatia—*attached*, acicular—double the length of those at *c*, which are *free; d*, network of ramose, delicate filaments, which grow from among the sterigmata into the cavity of the spermogone; *e*, basal tissue from which the sterigmata spring.

Fig. 4. *P. perforata*, Ach.; Rio Janeiro. Portion of thallus, showing *a*, apothecia, perforate in the centre, and with a ciliated border; *b*, punctiform, black, immersed spermogones.

Fig. 5. *P. perforata;* North America. Sterigmata and spermatia: *a*, sterigmata, composed of a few delicate articulations; *b*, spermatia—free—acicular; *c*, network of ramose filaments, which occupy the cavity of the spermogone; *d*, basal tissue, which forms the outer wall of the spermogone.

Fig. 6. *P. perforata*, Ach., var. *denticulata* mihi; Nepal. Portion of edge of thallus, showing the large barrel-shaped marginal spermogones: *a*, ostiole; *b*, body of the spermogone.

Fig. 7. One of the same spermogones more highly magnified: *a*, ostiole; *b*, body of spermogone; c, margin of thallus.

Fig. 8. *P. perlata*, Ach., var. *ciliata*, DC.; Crinan Canal, Argyleshire. Portion of thallus, showing papillæform spermogones at *a*, and punctiform ones at *b*.

Fig. 9. Section of thallus, showing both these forms of spermogones: *a*, papillæform; *b*, punctiform, with sub-depressed ostiole.

Fig. 10. Sterigmata and spermatia from same specimen: *a*, sterigmata, composed of several irregular articulations or cellules; *b*, free acicular spermatia; *c*, network of anastomosing filaments, which occupy cavity of spermogone; *d*, basal tissue, which forms outer wall of spermogone.

Fig. 11. *P. perlata;* Schærer exs., 360. Portion of thallus, showing spermogones *a*, which are brownish, semi-pellucid, resembling sago grains.

Fig. 12. *P. perlata* (= *P. læteformis*, Fée); Cuba. Sterigmata *a*, spermatia *b*, and basal cellular tissue *c*.

Fig. 13. *P. caperata*, Ach.; Tasmania. Portion of thallus, showing papillæform or wart-like spermogones at *a*, and punctiform ones at *b*.

Fig. 14. Sterigmata and spermatia from same specimen. Letters have same references as in fig. 12.

Fig. 15. *P. Borreri*, Ach.; Penzance, Cornwall. Portion of thallus, showing *a*, apothecia; and *b*, punctiform, black, immersed spermogones.

Fig. 16. *P. acetabulum*, Dub.; Schærer exs., 547. Portion of thallus, showing *a*, apothecia; *b*, papillæform spermogones; *c*, punctiform ones.

Fig. 17. Section of thallus, showing the same spermogones, both papillæform *a*, and punctiform *b c*.

Fig. 18. *P. acetabulum;* Schærer exs., 547. Sterigmata and spermatia: *a*, sterigmata, composed of several irregular cells or articulations; *b*, spermatia attached to apices of individual articulations of the sterigmata; *c*, network of anastomosing filaments, which occupy the cavity of the spermogone; *d*, basal tissue.

Fig. 19. *P. acetabulum* (= *P. corrugata*, Ach.); France. Sterigmata and spermatia. Letters have same references as in fig. 12.

Plate XII.

Illustrative of the genus Parmelia, Ach., Nyl.

Fig. 1. *Parmelia physodes*, Ach.; Knock Hill, Crieff. Portion of thallus bearing apothecia *a*, and punctiform, black, immersed spermogones *b*.

Fig. 2. *Parmelia physodes*, Ach.; Cleveland, Yorkshire. Portion of a thalline lacinia, showing parasitic fungi *a*, associated with the punctiform spermogones of *P. physodes*; and *b*, marginal soredia.

Fig. 3. *P. physodes*, Ach.; Schær. exs., 367. Portion of thallus, showing brown, semi-pellucid, lecidine spermogones *a*, and marginal or terminal soredia *b*.

Fig. 4. *P. physodes*, Ach.; Moncreiffe Hill, Perth; bearing on its thallus the parasitic *Lecidea Smithii*, Tul. *a*; *b*, terminal soredia; *c*, cavities left by the falling out of the apothecia of *L. Smithii*; *d*, punctiform or papillæform pycnides of *L. Smithii*.

Fig. 5. Section through the above thallus, showing the relative position and size of the apothecia *a*, and pycnides *b*, of *L. Smithii*.

Fig. 6. Spores of *Lecidea Smithii*, Tul.

Fig. 7. *P. physodes*, Ach.; Ardrum, Cork. Sterigmata and spermatia, as well as the network (*a*) of ramose filaments, which occupy the spermogonal cavity.

Fig. 8 *a*. *P. physodes*, Ach., var. *enteromorpha*, Ach.; Tasmania. Portion of thallus bearing an apothecium *a*, and punctiform spermogones *b*, on broad bullose laciniæ. 8 *b* shows another specimen of the same plant, with narrow segments, bearing at their ends the same punctiform spermogones *c*.

Fig. 9. *P. physodes*, Ach., var. *enteromorpha*, Ach.; Falkland Islands. Sterigmata, spermatia, and ramose spermogonal filaments.

Fig. 10. *P. Kamtschadalis*, Ach.; California. Portion of thallus, bearing apothecia *a*, and punctiform spermogones *b*.

Fig. 11. Sterigmata, spermatia, and ramose spermogonal filaments of the same plant.

Fig. 12. *P. encausta*, Ach.; Hepp. exs., 40. Portion of thallus, showing the very abundant punctiform spermogones *a*.

Fig. 13. *P. encausta*, from Morchone, Braemar. Thallus showing *a*, papillæform spermogones; *b*, an apothecium.

Fig. 14. Section through the same spermogones, showing the depressed urceolate ostiole *a*.

Fig. 15. Magnified section of one of the same spermogones: *a*, ostiole; *b*, cavity occupied by a network of ramose filaments; *c*, sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 16. Sterigmata, spermatia, and ramose spermogonal filaments of *P. encausta*, from Morchone.

Fig. 17. *P. saxatilis*, Ach. Portion of thallus, showing the punctiform, black, immersed spermogones *a*.

Fig. 18. *P. saxatilis*, Ach.; Storr Rock, Skye. Portion of thallus, showing the abundant brown punctiform spermogones *a*.

Fig. 19. Sterigmata and spermatia of *P. saxatilis*, Ach., from Bunbeg, Ireland: *a*, network of anastomosing filaments, which occupy spermogonal cavity.

Fig. 20. *P. saxatilis*, Ach., var. *sulcata*, Tayl.; Derry, Ireland. Portion of thallus, showing spermogones and pycnides, intermixed and outwardly indistinguishable from each other, *a*.

Fig. 21. *P. saxatilis*, Ach., var. *sulcata*, Tayl.; Connemara: *a*, stylospores; *b*, spermatia.

Fig. 22. *P. saxatilis*, Ach., var. *omphalodes*, Ach.; Donegal, Ireland. Portions of thallus magnified, showing the stellate-fissured ostioles (*a*) of the immersed spermogones.

Fig. 23. *P. saxatilis*, var. *omphalodes*; Birnam Hill, Dunkeld. Portion of thallus, showing largish papillæform spermogones *a*.

Fig. 24. *P. saxatilis*, var. *omphalodes*; Loch Freuchie, Amulree. Portion of thallus magnified, showing the papillæform spermogones, with stellate-fissured ostioles *a*.

Fig. 25. Sections of the same spermogones: *a*, papillæform; *b*, the urceolate cavities left after the falling out of the bodies of old spermogones.

Fig. 26. *P. sinuosa*, Ach., var. *hypothrix*, Nyl. (= *P. carporrhizans*, Tayl.); Nyl., "Lich. Paris." Portion of thallus, showing *a*, apothecia; *b*, papillæform spermogones; *c*, punctiform spermogones.

Fig. 27. *Parmelia sinuosa*, var. *hypothrix*, Nyl. L. P. Sterigmata and spermatia.

Fig. 28. *P. sinuosa*, Ach., var. *erratica* mihi; Melbury Hill, Dorsetshire: *a*, oldish spermogones with stellate-fissured ostioles; *b*, youngish spermogones.

Fig. 29. *P. sinuosa*, Ach., var. *lævigata*, Tayl.; Connemara, Ireland. Portion of thallus, showing *a*, punctiform spermogones; *b*, terminal soredia.

Fig. 30. *P. sinuosa*, Ach., var. *Caracensis*, Tayl.; Caracas. Sterigmata and spermatia: *a*, network of anastomosing delicate filaments, which occupy cavity of spermogone.

Fig. 31. *P. conspersa*, Ach. Portion of thallus, showing *a*, apothecia, the exciple being studded over with punctiform spermogones; *b*, the punctiform spermogones, frequently with a stellate-fissured ostiole in old state.

Fig. 32. *P. conspersa*, Ach., minor form; Leight. exs., 79. Narrow laciniæ quite covered with punctiform spermogones *a*.

Fig. 33. *P. conspersa*, Ach., major form; Schær. exs., 379. Portion of thallus, showing *a*, papillæform, and *b*, punctiform spermogones.

Fig. 34. *P. conspersa*, Ach., major form; Schær. exs., 379. Sterigmata and spermatia.

Fig. 35. *P. conspersa*, Ach., bearing on its thallus the parasitic *Lecidea oxyspora*, Tul.; Hepp. exs., 37: *a*, apothecia; and *b*, spermogones and pycnides, intermixed, of *L. oxyspora*, Tul.

Fig. 36. Section showing the relative position and size of the same apothecia, spermogones, and pycnides: *a*, apothecia; *bc*, spermogones; *d*, a pycnide.

Fig. 37. *P. conspersa*, Ach. Sterigmata and spermatia.

Fig. 38. The same, from Schær. exs., 379.

Fig. 39. *P. Tasmanica*, Tayl.; Tasmania. Portion of thallus, showing *a*, apothecia; and *b*, spermogones, punctiform or papillæform.

Fig. 40. Sterigmata and spermatia of the same lichen.

Fig. 41. *P. colpodes*, Ach. (=*P. Michauxii*, Ach.); North America. Sterigmata and spermatia.

Fig. 42. *P. mutabilis*, Tayl.; Uitenhage, South Africa. Sterigmata, spermatia, and ramose filaments of spermogone.

Plate XIII.

Illustrative of the genera Parmelia, Ach., Nyl.; *and* Physcia, Fr., Nyl.

Fig. 1. *Parmelia tristis*, Web.; Morchone, Braemar. Portion of thallus, showing an apothecium *a*, and marginal wart-like spermogones *b*.

Fig. 2. Section of the same spermogones: *a*, papillæform, with a depressed ostiole; *b*, simply papillæform, young; *c*, urceolate cavity left by falling out of an old spermogone; *d*, flattened, with depressed ostiole.

Fig. 3. Sterigmata and spermatia of same plant.

Fig. 4. *P. Fahlunensis*, Ach.; Cairngorm, Braemar. Portion of thallus, showing the marginal wart-like spermogones *a*.

Fig. 5. Some of the same spermogones magnified: *a*, simple or regular ostiole; *b*, stellate-fissured ostiole.

Fig. 6. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 7. Sterigmata and spermatia of same plant.

Fig. 8. *P. stygia*, Ach.; Ben Nevis. Portion of thallus, bearing *b*, an apothecium; *a*, papillæform spermogones. At *c* the spermogones are old, and exhibit largish irregular gaping ostioles.

Fig. 9. Section of the same spermogones: *a*, papillæform; *c*, with depressed ostiole; *b*, cavities left by falling out of old spermogones.

Fig. 10. *P. olivacea*, Ach., var. *exasperata*, Ach.; on trees, Morchone, Braemar. Portion of thallus, showing *a*, apothecia; *b*, very minute punctiform spermogones, seen only when the thallus is moistened.

Fig. 11. Section of the same spermogones, showing the depressed form of ostiole *a*.

Fig. 12. Sterigmata and spermatia of same plant.

Fig. 13. *Physcia villosa*, Dub., var. *Dickiana* mihi, Belfast. Portion of thallus, showing apothecia *a*, and beautiful large orange-coloured spermogones *b*.

Fig. 14. Section of same plant, showing the relation of the apothecium *a* to the spermogones *b*. The apothecium is dotted over with the small black perithecia of a parasitic fungus.

Fig. 15. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, sterigmata; *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Fig. 16. Sterigmata and spermatia of same plant.

Fig. 17. *P. leucomela*, Mich.; Cork. Portion of thallus, bearing black papillæform spermogones *a*.

Fig. 18. Sterigmata and spermatia of same plant.

Fig. 19. *P. ciliaris*, DC.; Balthayock, by Perth. Portion of thallus, showing *a*, large, irregular, wart-like spermogones, frequently confluent, and with stellate-fissured ostioles; *b*, brown papillæform spermogones; and *c*, punctiform spermogones, as in Schær. exs., 388.

Fig. 20. One of the large papillæform spermogones magnified: *a*, ostiole.

Fig. 21. Sections of the same spermogones.

Fig. 22. *P. stellaris*, Fr., var. *tenella*, Schær.; Penmanshiel, Berwickshire. Portion of thallus, bearing *a*, apothecia; and *b*, papillæform spermogones.

Fig. 23. *P. stellaris*, Fr., var. *tenella*, Sch. Sterigmata and spermatia from different specimens—Schær. exs., 348; exs., 349; and exs., 352.

Fig. 24. *P. stellaris*, Fr. (= *Parmelia aipolia*, Auctt.) Portion of thallus, showing numerous papillæform spermogones *a*.

Fig. 25. Another specimen of the same plant, having brown, instead of black, papillæform spermogones *a*.

Fig. 26. Some of the same spermogones magnified: *a*, ostiole.

Fig. 27. *P. stellaris*, Fr.; Schær. exs., 350. Portion of thallus, showing spermogones grouped on wart-like prominences of thallus *a*.

Fig. 28. *Parmelia stellaris*, Fr. (= *Parmelia aipolia*, Auctt.) Sterigmata and spermatia.

Fig. 29. *P. stellaris*, Fr., var. *albinea*, Ach. (= *Parmelia erosa*, Borr.); Falmouth. Sterigmata and spermatia.

Fig. 30. *P. cæsia*, Fr.; Skye. Portion of thallus, showing papillæform spermogones *a*, and terminal soredia *b*.

Fig. 31. Sterigmata and spermatia of same plant.

Fig. 32. *P. obscura*, Fr.; Rescobie, Forfarshire. Portion of thallus, showing the minute, brown, papillæform spermogones *a*.

Fig. 33. Some of the same spermogones magnified: *a*, ostiole.

Fig. 34. Sections of the same spermogones.

Fig. 35. *P. obscura*, Fr. Sterigmata and spermatia.

Fig. 36. *P. obscura*, Fr.; Cork; bearing on its thallus the parasitic *Lecidea obscuroides* mihi *a*.

Fig. 37. Sections of the apothecia of L. *obscuroides*, showing them in different stages of development: *a*, mature; *b*, *c*, young.

Fig. 38. Theca and spores of the same *Lecidea*.

Plate XIV.

Illustrative of the genera Physcia, Fr., Nyl.; Pannaria, Del., Nyl.; *and* Coccocarpia, Pers., Nyl.

Fig. 1. *Physcia parietina*, L., var. *polycarpa*, Ehrh.; Hepp. exs., 54. Portion of thallus, showing the numerous crowded apothecia *a*, and the papillæform spermogones *b*.

Fig. 2. *P. parietina*, L., var. *laciniosa*, Schær.; Schær. exs., 383: *a*, orange-coloured papillæform spermogones.

Fig. 3. Section of one of the same spermogones: *a*, ostiole; *b*, cavity; *c*, sterigmata; *d*, gonidia; *e*, medullary tissue; *f*, cortical layer of thallus, the component cells full of beautiful yellow colouring matter.

Fig. 4. Sterigmata and spermatia of same lichen.

Fig. 5. *Physcia candelaria*, Ach.; Schær. exs., 382. Portion of thallus, showing orange-coloured papillæform spermogones *a*.

Fig. 6. Sterigmata and spermatia of same plant.

Fig. 7. *P. flammea*, Ach.; Cape of Good Hope. Portion of thallus, showing its orange-coloured papillæform spermogones *a*.

Fig. 8. *P. chrysophthalma*, DC.; Long Island, North America. Portion of thallus, showing an apothecium *a*, and orange-coloured wart-like spermogones *b*.

Fig. 9. Some of the same spermogones magnified: *a*, ostiole.

Fig. 10. Sections of the same spermogones.

Fig. 11. *P. pulverulenta*, Fr.; Scone, Perth. Portion of thallus, showing *a*, simple papillæform spermogones; *b*, largish, wart-like, frequently confluent ones; *c*, apothecia.

Fig. 12. Some of the same spermogones magnified: *a*, simple, papillæform; *b*, wart-like.

Fig. 13. Apices of some of the wart-shaped spermogones, magnified to show the stellate-fissured ostioles *a*.

Fig. 14. Sections of the same spermogones: *a*, simple, papillæform; *b*, wart-shaped and confluent.

Fig. 15. *P. pulverulenta*, Fr. Sterigmata and spermatia from different specimens.

Fig. 16. *P. aquila*, Fr.; Cork. Portion of thallus, showing *a*, papillæform young spermogones; *b*, the largish gaping ostioles of old spermogones; *c*, apothecia.

Fig. 17. Sterigmata and spermatia of different specimens of same plant.

Fig. 18. *P. stellaris*, Fr., var. *adglutinata* mihi; Dumfries. Portion of thallus, showing *a*, apothecia; *b*, papillæform spermogones perched on thalline warts.

Fig. 19. Sterigmata and spermatia of same plant.

Fig. 20. *P. flavicans*, DC. (= *Cornicularia crocea*, Ach.) Sterigmata and spermatia.

Fig. 21. *Pyxine cocöes*, Ach.; Demerara. Sterigmata and spermatia.

Fig. 22. *Coccocarpia plumbea*, Lightf.; Tarbert, Loch Lomond. Portion of thallus, showing *a*, apothecia; *b*, confluent spermogones; *c*, isolated, papillæform spermogones.

Fig. 23. Some of the same spermogones magnified: *a*, isolated; *b*, confluent, showing the irregular ostioles *c*.

Fig. 24. Sections of the same spermogones: *a*, isolated; *b*, confluent.

Fig. 25. Sterigmata and spermatia of same species.

Fig. 26. *Pannaria muscorum*, Ach.; Schær. exs., 482. Thallus, bearing apothecia *a*, and papillæform spermogones *b*.

Fig. 27. Portion of a lacinia of same plant, magnified to show the reddish papillæform spermogones *a*.

Fig. 28. Sections of the same spermogones.

Figs. 29 and 30. Sterigmata and spermatia of the same plant.

Fig. 31. *P. rubiginosa*, Del.; Leighton exs., 234. Thallus, bearing apothecia *a*, and papillæform spermogones *b*.

Fig. 32. *P. triptophylla*, Ach.; Schær. exs., 159. Two confluent thalli, bearing apothecia *a*, and black, roe-like spermogones *b*.

Fig. 33. Sections of the same spermogones.

Fig. 34. Spermatia of the same plant.

Fig. 35. Section of one of the spermogones of same plant: *a*, ostiole; *b*, cavity; *c*, sterigmata *d*, gonidia; *e*, medullary tissue of thallus; *f*, cortical layer of thallus.

Plate XV.

Illustrative of the genera Placodium, DC., Nyl.; Squamaria, DC.; Ephebe, Fr., Born.; Lichina, Ag.; Collema, Ach.; *and* Leptogium, Fr.

Fig. 1. *Placodium murorum*, DC.; Cork. Portion of thallus, showing apothecia *a*, and orange-coloured papillæform spermogones *b*.

Fig. 2. Sterigmata and spermatia of same species.

Fig. 3. *P. circinatum*, Pers., var. *variabile*, Pers.; Hepp. exs., 74. Thallus, bearing apothecia *a*, and brown, pellucid, punctiform spermogones *b*.

Fig. 4. Section of the same spermogones.

Fig. 5. *P. circinatum*, Pers.; Dereham Church. Sterigmata and spermatia.

Fig. 6. Spermogones of same specimen: *a*, simple; *b*, confluent,—in both cases irregularly stellate-fissured and pseudo-lecidine in aspect.

Fig. 7. *P. alphoplacum*, Wahlb.; Schær. exs., 330. Portion of plant, bearing apothecia *a*, and punctiform or papillæform spermogones *b*, perched on thalline warts.

Fig. 8. *P. fulgens*, DC.; Hepp. exs., 194. Thallus, bearing apothecia *a*, and papillæform orange-red spermogones *b*.

Fig. 9. *P. chalybæum*, Duf.; Hepp. exs., 204. Portion of thallus, showing apothecia *a*, and punctiform spermogones *b*.

Fig. 10. Section of the same spermogones.

Fig. 11. One of the thalline areolæ, magnified to show the punctiform, immersed spermogones *a*.

Fig. 12. Sterigmata and spermatia of same plant.

Fig. 13. *P. candicans*, Dub.; Leighton exs., 218. Portion of thallus, showing *a*, punctiform spermogones; and *b*, apothecia.

Fig. 14. Section of the same spermogones.

Fig. 15. *Squamaria chrysoleuca*, Sm.; Schær. exs., 345. Thallus, bearing *a*, apothecia; and *b*, punctiform or papillæform spermogones, seated at *b*, on thalline warts; at *c*, about the subfoliaceous margins of the thallus.

Fig. 16. Section of the same spermogones: *a*, papillæform; *b*, flattened, with depressed ostiole.

Fig. 17. Sterigmata and spermatia of same species.

Fig. 18. *S. gelida*, L.; New Zealand. Section of a spermogone: *a*, ostiole; *b*, body of spermogone; *c*, thalline wart on which spermogone is seated.

Fig. 19. Sterigmata and spermatia of same species.

Fig. 20. *Placodium circinatum*, Pers., var. *ecrustaceum*, Nyl.; Hepp. exs., 407. Portion of plant, showing *a*, apothecia; *b*, pseudo-lecidine large spermogones.

Fig. 21. Section of the same apothecia *a*, and spermogones *b*.

Fig. 22. Sterigmata and spermatia of the same plant.

Fig. 23. *Squamaria ambigua*, Wulf. Portion of thallus, showing minute, punctiform, immersed spermogones *a*, and terminal soredia *b*.

Fig. 24. *Placodium aureum*; Schær exs., 165. Thallus, bearing apothecia *a*, and papillæform spermogones *b*.

Fig. 25. Some of same spermogones magnified: *a*, orange-red ostioles.

Fig. 26. Section of same spermogones.

Fig. 27. *P. elegans*, DC.; Schær. exs., 338. Thallus, bearing apothecia *a*, and papillæform spermogones *b*.

Fig. 28. One of the laciniæ of same plant, magnified to show the same spermogones *a*.

Fig. 29. Section of same spermogones.

Fig. 30. *Ephebe pubescens*, Fr.; ex herb. Harriman. Sterigmata and spermatia.

Fig. 31. *Lichina pygmæa*, Ag.; Leighton exs., 260. Portion of thallus, showing different forms of spermogones *a* and *b*.

Fig. 32. Portion of thallus of same plant, more highly magnified to show the spermogones *a* (closely resembling apothecia).

Fig. 33. Section of portion of a spermogone : *a*, cellular envelope ; *b*, sterigmata ; *c*, cavity of spermogone full of free spermatia.

Fig. 34. Sterigmata and spermatia of same species.

Fig. 35. *L. confinis*, Ag. Apothecia (*a*) highly magnified, showing the spermogones *b*, seated on their surface ; *c*, ostiole of apothecia ; *d*, ostiole of spermogones.

Fig. 36. *Collema pulposum*, Ach. Portion of thallus, showing an apothecium *a*, and marginal spermogones *b*.

Fig. 37. *C. melænum*, Ach. (= *C. jacobæfolium*, Auctt.) Thallus, showing an apothecium *a*, and spermogones which are marginal at *b*, and sub-marginal at *c*.

Fig. 38. *C. melænum*, Ach. Portion of margin of thallus slightly magnified, showing the marginal (*a*) and sub-marginal (*b*) spermogones.

Fig. 39. One of the discoid marginal spermogones of the same species : *a*, margin of thallus ; *b*, body of spermogone ; *c*, ostiole.

Fig. 40. *C. nigrescens*, Ach. Portion of thallus, showing *a*, apothecia ; *b*, papillæform spermogones.

Fig. 41. Section through an apothecium (*a*) and spermogones (*b*) of *C. nigrescens*, Ach.

Fig. 42. *C. flaccidum*, Ach. ; Aghalie Bridge, Ireland. Portion of thallus, showing apothecia *a*, and sub-marginal spermogones *b*.

Fig. 43. *Leptogium tremelloides*, Fr. ; Killarney, Ireland. Portion of thallus, showing *a*, apothecia ; *b*, marginal and sub-marginal spermogones.

Fig. 44. *L. tremelloides*, Fr. ; South America. Portion of margin of thallus, magnified to show the denticulate spermogones *a* ; *b*, ostiole.

Fig. 45. Sterigmata and spermatia of same species.

INDEX OF FAMILIES AND GENERA.

(*Synonyms and the Names of Fungi are in Italics.*)

INDEX OF SPECIES.

(Synonyms and the Names of Fungi are in Italics.)

USNEA. *Hffm.* NEUROPOGON. *Nees & Flot.* ALECTORIA. *Ach. pr. p. Nyl.* CHLOREA. *Nyl.*

W. H. Tutten ... sculp

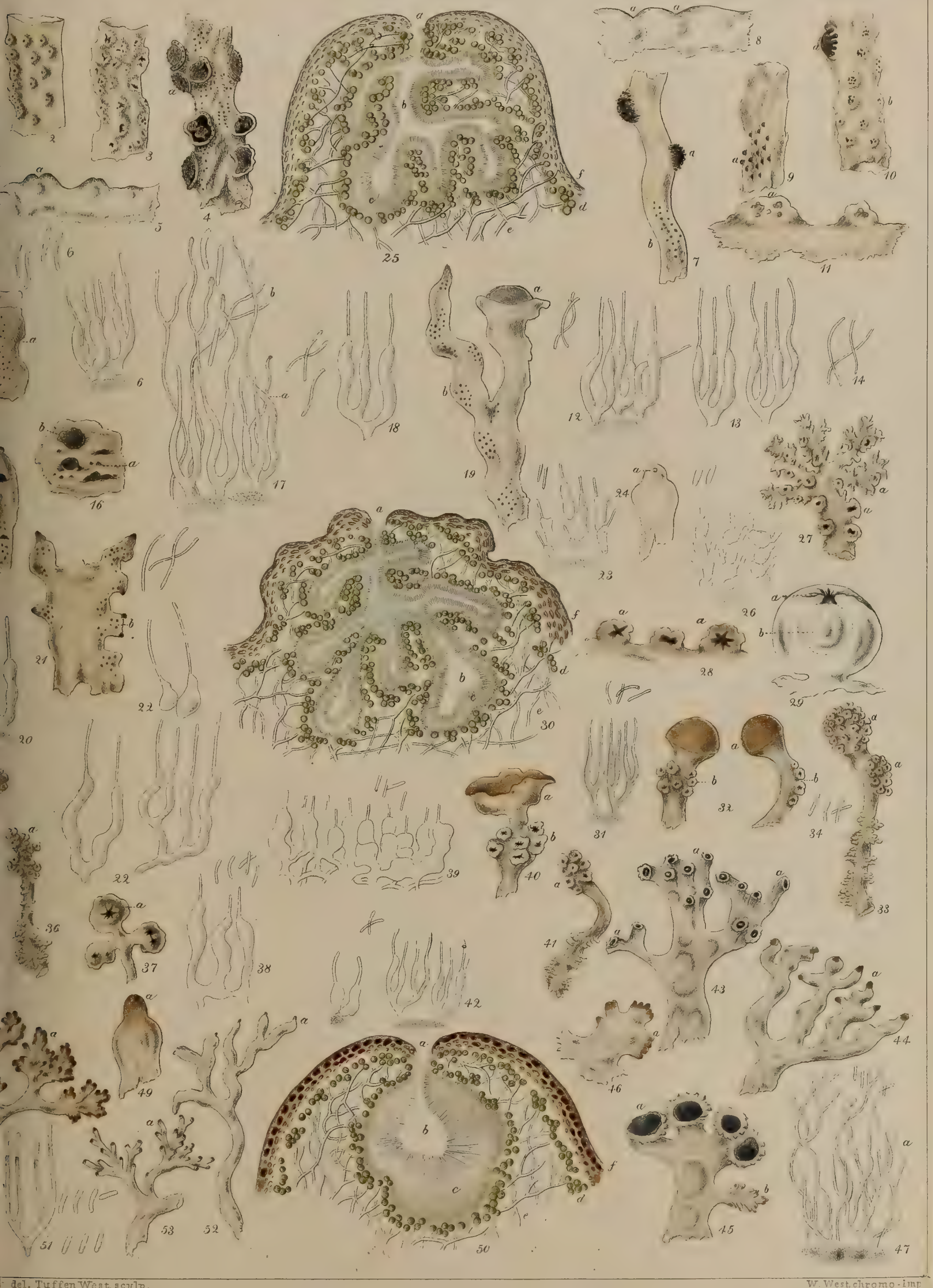
W. West, chromo-imp.

-EVERNIA. Ach. Nyl. RAMALINA. Ach. Fr. THAMNOLIA. Ach. Schær

Tuffen West sculp.

…LLA. *Bauh.* DACTYLINA *Nyl.* DUFOUREA *Ach. Nyl.* ACROSCYPHUS *Lév. Tul.* STEREOCAULON *Schreb.* SPHÆROPHORON *Pers.*

Trans. Roy. Soc. Edin. Vol 22. Pl VI.



…del. Tuffen West, sculp. W. West, chromo-imp.

Trans Roy Soc Edin Vol.22.Pl VII

Tuffen West, sculp

W. West, chromo-imp

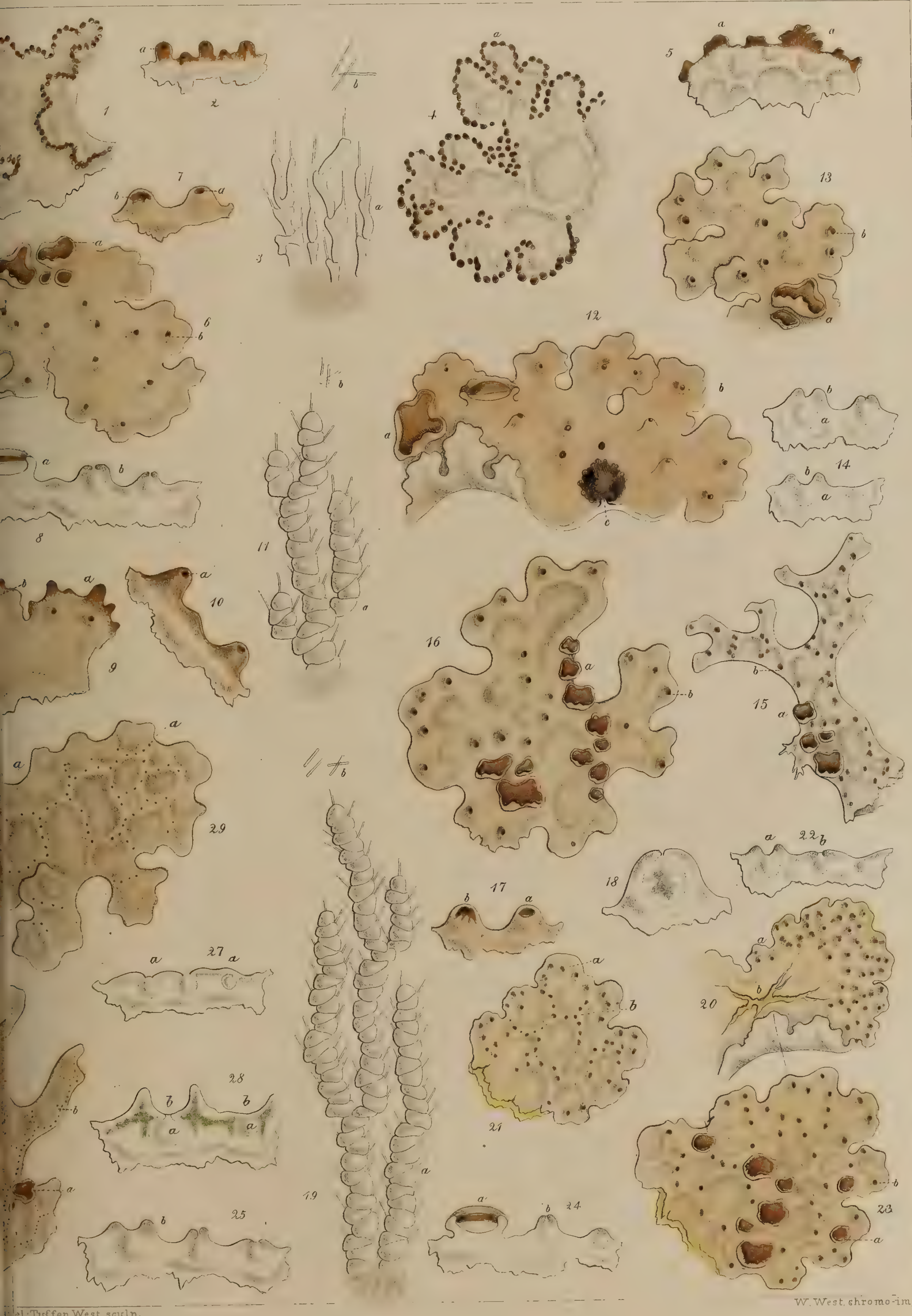
say, del. Tuffen West, sculp.

W.West, chromo imp

Tuffen West sculp.

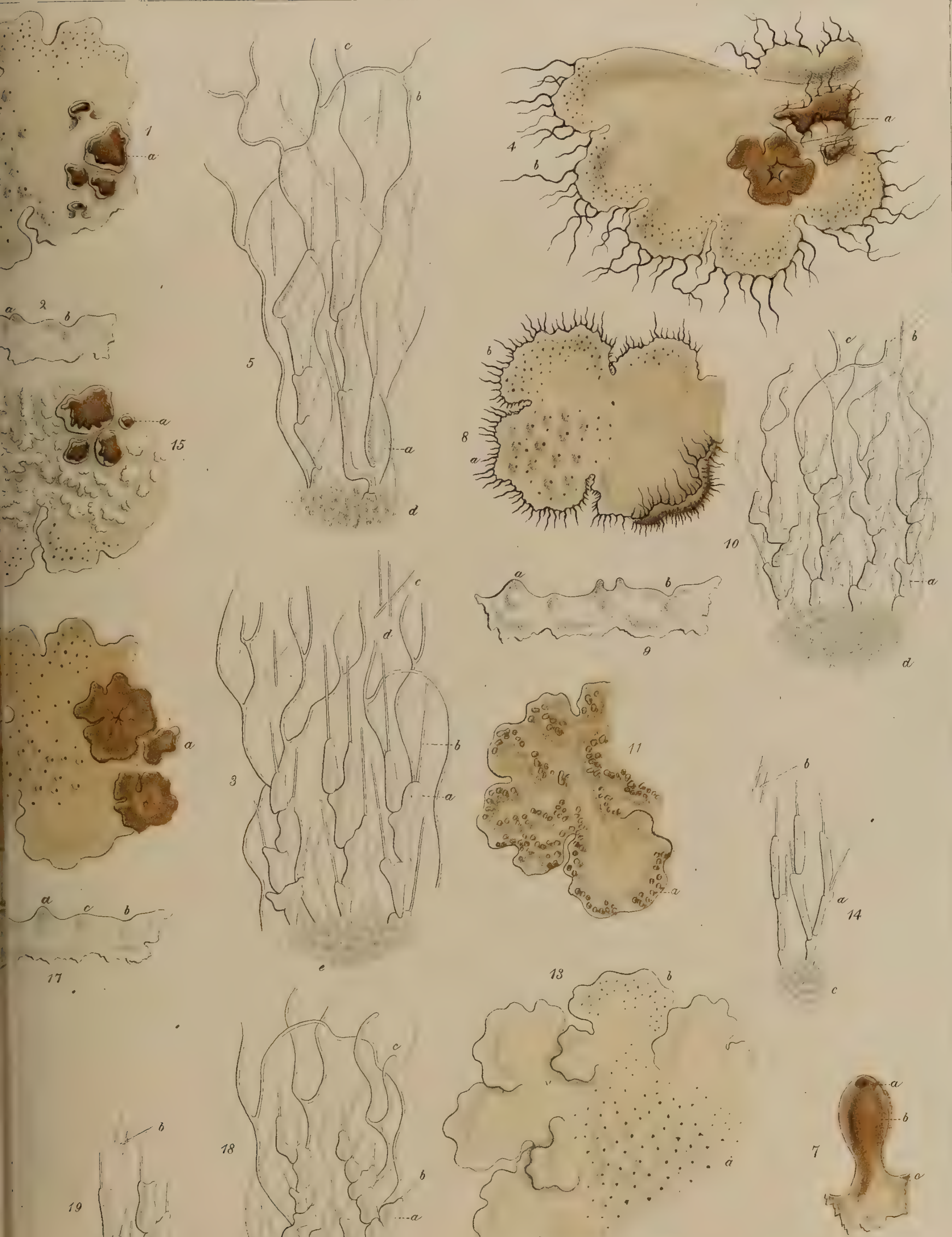
W. West chromo. imp.

PLATYSMA. Hffm. Nyl. RICASOLIA. DN. Nyl. STICTA. Ach.



...el: Tuffen West, sculp.

W. West, chromo-imp



...ffen West, sculp. W. West, chromo-imp.

del. Tuffen West. sculp. W. West. chromo-imp.

PHYSCIA. Fr. Nyl. PANNARIA. Del. Nyl. COCCOCARPIA. Pers. Nyl.

del. Tuffen West sculp

W. West, chromo-imp

ODIUM DC.Nyl. SQUAMARIA. DC. EPHEBE: Fr.Born. LICHINA. Ag. COLLEMA. Ach. LEPTOGIUM. Fr.

Trans. Roy. Soc. Edin. Vol 22. Pl. XV.

del Tuffen West sculp.

W. West, chromo-imp.

ERRATA.

Page 392, line 11, *for* fasciculata *read* fasciculatum.
... ,, 22, *for* cylindraceus *read* cylindraceum.
... ,, Add to the list *Loxonema sulculosa.*
... 393, line 20, *for* longispina *read* longispinus.
... ,, 22, *for* duplicicosta *read* duplicicostatus.
... ,, 24, *for* Aviculu rugosa *read* Aviculopecten rugosus.
... ,, 28, *delete* Orthis filiaria.
... ,, 19, *for* Athyris gibera *read* Atrypa gibbera, but it should be conjoined with Orthis resupinata.

IX.—*Description of the Plant which produces the Ordeal Bean of Calabar.* By John Hutton Balfour, A.M., M.D., F.R.SS. L. & E., Professor of Medicine and Botany in the University of Edinburgh. (With two Plates, XVI. and XVII.)

(Read 16th January 1860.)

It has been long known that in various parts of Africa, the natives are in the habit of subjecting to the ordeal of poison parties who are suspected of crimes. On the east coast, we meet with *Tanghinia venenata*, yielding the Tanghin poison-nut of Madagascar; and on the west coast, seeds and barks of different kinds have been employed as ordeals,—the sources of which, however, have not been hitherto fully ascertained.

Dr Kirk, naturalist to the Livingstone Expedition, states, that the Manganja tribe, in the south-east of Africa, believe in a God, and in medicine, or the ordeal which he directs as the means of discovering crime. If the ordeal causes vomiting, it shows innocence; if it acts by the bowels, crime, and the person is put to death. But the doctors have a good knowledge of which to give, for there are different plants used.

In the district of Old Calabar a bean is used for an ordeal poison, to which the name of Eséré is given. It possesses extraordinary energy, and the attention of the missionaries of the United Presbyterian Church of Scotland in that quarter was directed to this poison several years ago. The Rev. H. M. Waddell, one of these missionaries (now in Edinburgh), brought some of the beans to this country; and of late, numerous specimens of them have been sent or brought to Edinburgh by other missionaries. As they possessed considerable interest in a toxicological point of view, they naturally attracted the attention of medical jurists.

The effects and mode of action of the ordeal bean were examined in 1855 by Dr Christison (*Edinburgh Monthly Journal of Medical Science*, March 1855). The information obtained by him as to its effects on the negroes in Africa from observers there, merely went to show that the bean did not cause any serious injury if it was vomited not long after being taken; but that, if retained, it invariably caused death, sometimes within an hour, and apparently occasioning insensibility and slight convulsions. On careful inquiry, however, he found that the real phenomena, and the kind of action exerted on the body, are quite different.

From an incidental observation made on himself, in consequence of an overdose having been accidentally swallowed, it appears that the ordeal bean causes giddiness, a sense of not unpleasant weariness and heaviness in the limbs, then great languor and tumultuous irregularity of the pulse and heart, extreme weak-ness and faintness, great abridgment of the power of volition over the voluntary muscles, very slight twitches of the muscles of the chest, but no diminution of sensibility, and no disorder of the mental functions. The articulation becomes sluggish; but it is not imperfect, if the words be pronounced deliberately and with attention. As these effects wear off sleep supervenes, and it lasts for a few hours; after which there is languor of the muscles, and inaptitude for exertion, passing off before next day. The effects now described were the result of taking twelve grains carefully chewed, while the stomach was empty. As the stomach was cleared out by an emetic so soon as the giddiness and weariness of the limbs were felt decidedly, it is not improbable that even that small dose, amounting to a fourth part of one bean, might prove speedily fatal.

The mode of action seemed to be by paralyzing the heart on the one hand, and on the other by suspending the influence of volition over the muscles, but without affecting sensation. This conclusion was confirmed by a few experiments on the lower animals, showing that an emulsion of the seed introduced into the cellular tissue under the skin occasions sudden feebleness, slight muscular twitches, muscular paralysis, and death in a few minutes by arrestment of the heart; which is accordingly found immediately afterwards to be paralysed, and filled in its left cavities with florid blood. Sensibility was manifested so long as advancing paralysis did not take away the power of expression.

Dr Sharpey has since communicated to Dr Christison some experiments made at his request on the frog with an alcoholic extract of the seed. This extract was found by Dr Christison, by experiment on quadrupeds, to concentrate in itself the activity of the seed, and to be consequently a poison of intense energy. Dr Sharpey ascertained by experiments on the frog, that it paralyses the action of the lymph-hearts, does not impair circulation in the vessels, appears to suspend the influence of volition over the muscles, does not affect the direct excitability of the muscular fibre, and apparently also leaves the muscles excitable by stimuli conveyed along the nerves, other than volition, at least by electricity.

Dr Christison attempted to detach the active proximate principle from the alcoholic extract; but the quantity of material was insufficient to enable him to do more than ascertain, that an alkaloidal principle was not separable by some of the simple processes of proximate analysis used in similar circumstances.

The beans are said in Africa to lose their poisonous qualities after being roasted or boiled; but this is extremely doubtful. In the cooked condition, however, they are (according to Mr Waddell) sometimes administered medicinally, without producing poisoning. The difference of apparent effect is often remarkable. Mr Hewan, medical missionary of Calabar, states, that in one case which came under his own notice, a woman who was accused of injuring her child by witchcraft, came in from a distance, strong in innocence, and demanded to have the ordeal administered. She ate twenty-four beans and did not die. Next day, another woman, encouraged by her escape, underwent the ordeal, and she ate twenty-two beans, and died. There was no vomiting in either case. The difference of effect might be owing either to an actual difference in the beans administered in the two cases, or to their mode of preparation. The fetish-man who administers the poison can manage this beforehand, according as he wishes the party to live or die. The natives themselves do not seem to have much faith in the bean as an ordeal, rather looking upon a summons to undergo the test as a sentence of death, and, if in their power, making their escape and going into exile.

The Rev. Zerub Baillie, another missionary, now in this country, who studied medicine partially at our school, writes to me in the following terms:—" I have several times been called upon to visit people under the influence of this poison. The symptoms, so far as I have observed them, are as follow:—The patient, when fairly under the influence, presents a peculiarly stupid, drunken look, the face is flushed and swollen, the eyes protruding, the mouth externally has somewhat the appearance of a person under salivation. At first there is a considerable flow of saliva, which eventually becomes frothy; the pulse is moderately full; the limbs gradually become powerless; the person walks very like an individual under the influence of strong drink; the muscles of the tongue, as well as the other muscles of the body, soon appear to get into a state of paralysis; the breathing becomes laborious, and the patient gradually sinks. I have used with good effect both the stomach-pump and emetics. I may state, that the bean is generally administered in supposed cases of witchcraft. The accused parties, whether male or female, are tried very much in the same way as witches were dealt with in Scotland, in former times. The judges are the chiefs of the town. Each chief puts down an Eséré on the ground, and the accused party takes them up one by one, chews, and swallows them. Sometimes as many as twenty or thirty are thus taken. If he vomits, he is innocent; if he dies, guilty. On questioning my boy from Calabar, he tells me that in cases where they wish the accused party to die, they rub the Eséré over with the gall of the leopard before administering it."

It is a common custom in Old Calabar to sacrifice human lives on the death of a king. In 1847, when King Eyamba died, the horrid practice was carried on. The ordeal of poison by the Eséré bean, commonly called "chop nut," was also, as usual, put in execution to discover who, by the *ifod* or native witchcraft, had killed the deceased man. It was thus employed as a judicial proceeding for the detection of crime, according to native ideas; and although the missionaries tried then, and at other times, to enlighten the minds of the natives on the subject, and had enlisted the succeeding King Eyo in their views, still the chiefs generally, could not be persuaded to abandon the use of the Eséré. The following account is given in a missionary journal:—" In the early part of 1852, Archibong, Duke of Duke Town, died. His mother, a great lady, and highly connected and influential, sought to comfort herself for the death of her son by the death of as many as she could lay hands on. Four distant connections of his were charged by her before a high official, brother of the late King Eyamba, and they had to purge themselves by the poison ordeal from the imputation of having caused his death by witchcraft. They all died. Some of his wives were also put to death that day in the same way. The next day, a host of armed slaves came from the Qua-river plantations, and filled the town, determined, they said, to find out who had killed Archibong. Supported by these, the bloody-minded woman had many more put to death, charging them with practising witchcraft against her son, and making them chop nut. The process was publicly carried on in the open town-place, and in presence of the chief men. The efforts of the missionaries to arrest the work of destruction were in vain. Duke Efraim, who was next in authority to the deceased, was full of wrath that they should presume to interfere by a single word in the matter, and the murders went on, till above twenty free people were known to have died by the poison ordeal."

The beans which Mr Waddell brought to Scotland germinated in the Botanic Garden, as well as in Professor Syme's garden at Milbank; but although the plants grew vigorously, and produced twining stems and leaves, they never flowered. The twigs and foliage were quite identical with native specimens which I have lately received from Africa. Some of our plants were much injured by the red spider. Attempts were made by the missionaries to get native specimens of the flowering stems of the plant, but they were for a long time unsuccessful; at length, however, the Rev. W. C. Thomson succeeded. Writing to Mr Andrew Murray from Ikoneto, Old Calabar, on 29th August 1859, Mr Thomson says—"I am happy to be at length able to send you samples of the flower of the Eséré or ordeal bean. You may perhaps wonder why none have been sent home long ere this; the explanation being not so much remissness on our part, as rather fortunate ignorance on that of the natives. Very few of them (none that I have ever met with) know anything of the plant at all, however well acquainted they may all be with the actual bean. Among the first things I did on returning from Britain last year was to offer a reward to be shown a veritable living plant. Many tried for the reward. Various most different leaves were brought to me as those of the Eséré; nor was it till the ripe fruit was seen that success was obtained, and a fine plant pointed out to me, with numerous pods still attached. From this plant we have since got the flowers also. For want of spirits, I have had to preserve those I am sending in a solution of common salt, which I trust will keep them in an examinable condition; otherwise, I must trust to your seeing those Mr Baillie is taking with him from the same source, but preserved in spirits."

Unfortunately, the specimens sent by Mr Thomson have not reached Mr Murray, but those brought by my friend and former pupil Mr Baillie have been given to me for examination. By means of them, I have been able to make out fully the characters of the plant. After doing so, I was favoured with the use of a letter from Mr THOMSON to Mr MURRAY, in which he gives the characters he had noticed in the living plant. These are remarkably well detailed, and point out Mr THOMSON as a very good botanical observer, and one who is likely to add to our information relative to the Flora of Africa. It is pleasing to observe that all the missionaries at Old Calabar have a taste for natural science. They have already contributed many valuable zoological and botanical species. May they long be spared to carry on their noble evangelizing efforts and their natural history pursuits.

The ordeal bean has been found to belong to the natural order *Leguminosæ*, the sub-order *Papilionaceæ*, and the tribe *Phaseoleæ*, and it appears to constitute a new and distinct genus. It is curious to find, that among the papilionaceous plants, which yield our edible beans, peas, and pulse of various kinds, there should occur many poisonous genera and species. Among them may be noticed *Coronilla varia;* the seeds and bark of *Laburnum;* seeds of *Lathyrus Cicera*, and of *Lathyrus Aphaca,;* the root of *Phaseolus multiflorus*, or the scarlet runner, and of *Phaseolus radiatus*; the bark of the root of *Piscidia erythrina*, or Jamaica dogwood; the branches and leaves of *Tephrosia toxicaria* (the two latter plants being employed as fish-poisons); *Gompholobium uncinatum*, which is said to have poisoned sheep in the Swan River Colony; and the plant now under consideration. The Calabar bean-plant seems to be closely allied to *Phaseolus*, and it has also many characters in common with *Vigna*, *Dolichos*, and *Lablab*, all of which genera belong to the tribe *Euphaseoleæ* of BENTHAM. The legumes which were given to me by Mr BAILLIE and by Mr HEWAN have an apparent resemblance to those of *Mucuna*. This induced Mr MURRAY, in a communication to the Botanical Society, to refer the plant to this genus, under the name of *Mucuna venenosum*. Mr MURRAY was confirmed in his opinion by the character of the seeds. He had not seen the flowers.

The character by which the plant seems to be specially characterised is the stigma, which has a remarkable crescentic or hooded appendage (Plate XVI., figs. 6 and 7). On this account I have proposed to call the genus *Physostigma*, from φυσάειν, to inflate, and στιγμα, applied to the upper part of the style. It will be placed close to *Phaseolus*, from which it differs in the stigma, and in the long grooved hilum of the seed. In the last character it approaches *Mucuna*. The spirally twisted carina and style of *Phaseolus* does not occur in *Physostigma*. To the species I have given the name of *venenosum*, in allusion to its poisonous qualities. I transmitted specimens of the flower to my friend and former pupil Dr THOMAS ANDERSON, of her Majesty's Indian Service, who is now engaged in examining the Indian *Acanthaceæ* in the Hookerian Herbarium at Kew. He kindly examined the specimens, and compared them with the allied plants in the herbarium. He informs me,—“ I have dissected the flower, and compared it with numerous drawings and descriptions of *Phaseolus* and *Lablab*, both of which genera I knew well in India. The flowers of your plant are, as you remark, quite phaseoloid; but then the seed is different from any known seed of that genus. The seed, with its elongated sulcated hilum, is very close to that of *Mucuna*, but the characters of the flower and pod remove it from that genus. Were the carina and pistil not so completely *Phaseolus*, it would otherwise, and especially in its nodose inflorescence, come near to *Lablab*. As it is, I cannot see how one can help making a new genus of it.”

The flowers were subsequently shown by Dr ANDERSON to Mr BENTHAM, who is the chief authority in regard to *Leguminosæ;* and in a subsequent letter Dr ANDERSON says:—“ Mr BENTHAM desires me to tell you that the plant is very near *Canavalia* in the long hilum and the calyx, and very near *Phaseolus* in the flower generally, except in the stigma.” The following is the description of the genus. The characters are illustrated by excellent drawings (Plates XVI. and XVII.), made, with his usual botanical accuracy, by Dr GREVILLE, from specimens and careful dissections supplied by me:—

Nat. order, *Leguminosæ;* Sub-order, *Papilionaceæ;* Tribe, *Euphaseoleæ.*

PHYSOSTIGMA VENENOSUM; Ordeal Bean of Calabar.

GEN. CHAR.—Calyx campanulatus, apice quadrifidus, laciniis brevibus, lacinia suprema bifida. Corolla crescentiformis, papilionacea; vexillum recurvum, apice bilobatum, basi angustatum, margine utroque auriculatum, membranâ inflexâ auctum, medio longitudinaliter bicallosum; alæ obovato-oblongæ, liberæ, supra carinam conniventes, versus basin appendiculatæ, curvæ; carina vexillum æquans, apice rostratum, rostro multum incurvo. Stamina decem, diadelpha, filamento vexillari libero, supra basin appendiculato. Discus vaginifer. Ovarium stipitatum, 2–3-ovulatum. Stylus cum carina tortus, infra stigma subtus barbatus; stigma obtusum, cucullo cavo oblique tectum. Legumen dehiscens, oligospermum, elliptico-oblongum, subcompressum, extus rugosum, endocarpium intus telâ laxâ cellulari tectum, isthmis cellulosis inter semina. Semina strophiolata, hemisphærico-oblonga hilo late-sulcato semicincta.

Herbæ suffruticosæ volubiles in Africa occidentali tropica crescentes: foliis pinnatim-trifoliolatis, stipellatis, floribus nodoso-racemosis, purpureis.

P. venenosum.—The only species of the genus as yet known.

A large twining plant, turning from right to left.

Root spreading, with numerous fibrils, often having small succulent white tubers attached. *Stem* about two inches in diameter at its thickest part, sometimes attaining a length of fifty feet, cylindrical, of a brown-gray colour, roughish; younger branches of a dark-green colour, thickened at the nodes; branches twisting on themselves and round those in their vicinity; wood of the stem very porous, giving out, when cut, a pretty free stream of limpid fluid, which is slightly astringent and acrid; woody bundles arranged in wedges; bark giving out a reddish, gummy exudation, which becomes very dark on drying.* *Leaves* alternate, petiolate, stipulate, pinnately-trifoliate; leaflets ovate, acuminate, each having a struma, which serves as a short petiolule, and two small, thickened, acute, and somewhat falcate stipels; lateral leaflets oblique at the base. *Venation* reticulated, curved-veined, with a prominent midrib and two less distinct lateral ribs. *Petioles* about three inches in length, rounded on the lower side, grooved on the upper, having a pulvinus, with two minute triangular stipules, which are reflexed at the margins. *Inflorescence* axillary on pendulous multifloral racemes; rachis of raceme zigzag and knotty; knots rounded, irregular on the surface like minute tubers, bearing the pedicellate flowers. *Pedicels* about a quarter of an inch in length, two or three arising from the same nodosity, from which they separate by disarticulation; flowers articulated to the pedicels; at the upper part of the pedicel, close to the flower, are two callosities representing bractlets, and sometimes a sort of thickened ring. Flowers about an inch in length, half an inch across. *Calyx* campanulate, four-cleft at its apex, the upper division being notched, and its segments ciliated; the calyx is thus composed of five united sepals, and it assumes a somewhat bilabiate appearance. *Corolla* papilionaceous, beautifully veined, of a pale pink colour, with a purplish tinge (Thomson), when preserved in spirits assuming a pale yellowish hue, curved in a crescentic manner. *Vexillum* external, large, completely covering the other parts of the flower in æstivation; bilobate at the apex, which is completely recurved, narrowed at the base, with two small projections on each side of the very short claw which is furrowed, and has two longitudinal callosities in the middle; basal portion of limb of vexillum having rounded lobes, which are turned inwards so as nearly to meet. *Alæ* large, more deeply coloured than the other parts of the flower, reaching to the edges of the vexillum in bud, obovato-oblong, curved, narrowed into a curved hook-like claw, with a projection above it, edges slightly incurved. *Carina* as broad as the alæ, and much longer than them, equal in length to the vexillum, broad below, prolonged upwards into a narrow sort of rostrum, which ends in a blunt apex, and is curved upwards and backwards, so as to form between two-thirds and three-fourths of a circle; petals of keel ovate-oblong, with triangular acuminate processes projecting from above their base on the inside, and with very narrow claws. *Stamens* ten, diadelphous, nine united by their filaments for about two-thirds of their length, vexillary free stamen an inch and a quarter long, with an appendage to the filament immediately above its base; staminal sheath swollen below, filaments long, not thickening upwards; anthers two-lobed, dehiscing longitudinally. *Disk* at the base of the ovary thickened, with a sheath extending upwards over the gynophore. *Pistil* more than one and

* For an account of the stem, wood, and bark, I am indebted to notes furnished by the Rev. W. C. Thomson of Old Calabar.

a half inch long; ovary stipitate, rough on the surface, not hairy; style curved, smooth except below the stigma, where the concavity is covered with a continuous line of hairs, which give a marked barbate appearance; stigma blunt, covered by a remarkable ventricular sac or hood, which extends along the upper part of the convexity of the style.* *Ovules* two or three attached to the ventral suture by a broad process, crescentic in form, with a convex placental edge, and a long hilum. *Legume* in the young state green, and somewhat falciform, afterwards becoming dark-brown and straight; sutures slightly prominent, ventral one grooved, interior lined with white loose pith-like cellular tissue, in which the ovules are embedded, and by which they are separated from each other. Full grown legume about seven inches in length, elliptico-oblong, with an apicilar curved point, stipitate (stalk about an inch in length), dehiscent, outer integument (epicarp) separating from the inner, dark-brown, rugose, marked with anastomosing fibres, which run partly in a transverse direction, and partly along the edge of the pods. Inner covering (endocarp) of legume pale-coloured and roughish externally; ventral suture furrowed. *Seeds*, two or three, about an inch long, three quarters of an inch broad, each weighing from 40 to 50 grains, separated from each other by a woolly cellular substance; hilum dark, sulcate, with brown elevations on either side, extending along the whole convex placental edge of the seed; other edge nearly straight; cotyledons pale, hypogeal.

* Mr Thomson, in a letter to Mr Murray, describes this process in the recent flower as "resembling an admiral's hat set in a jaunty manner."

DESCRIPTION OF THE PLATES.

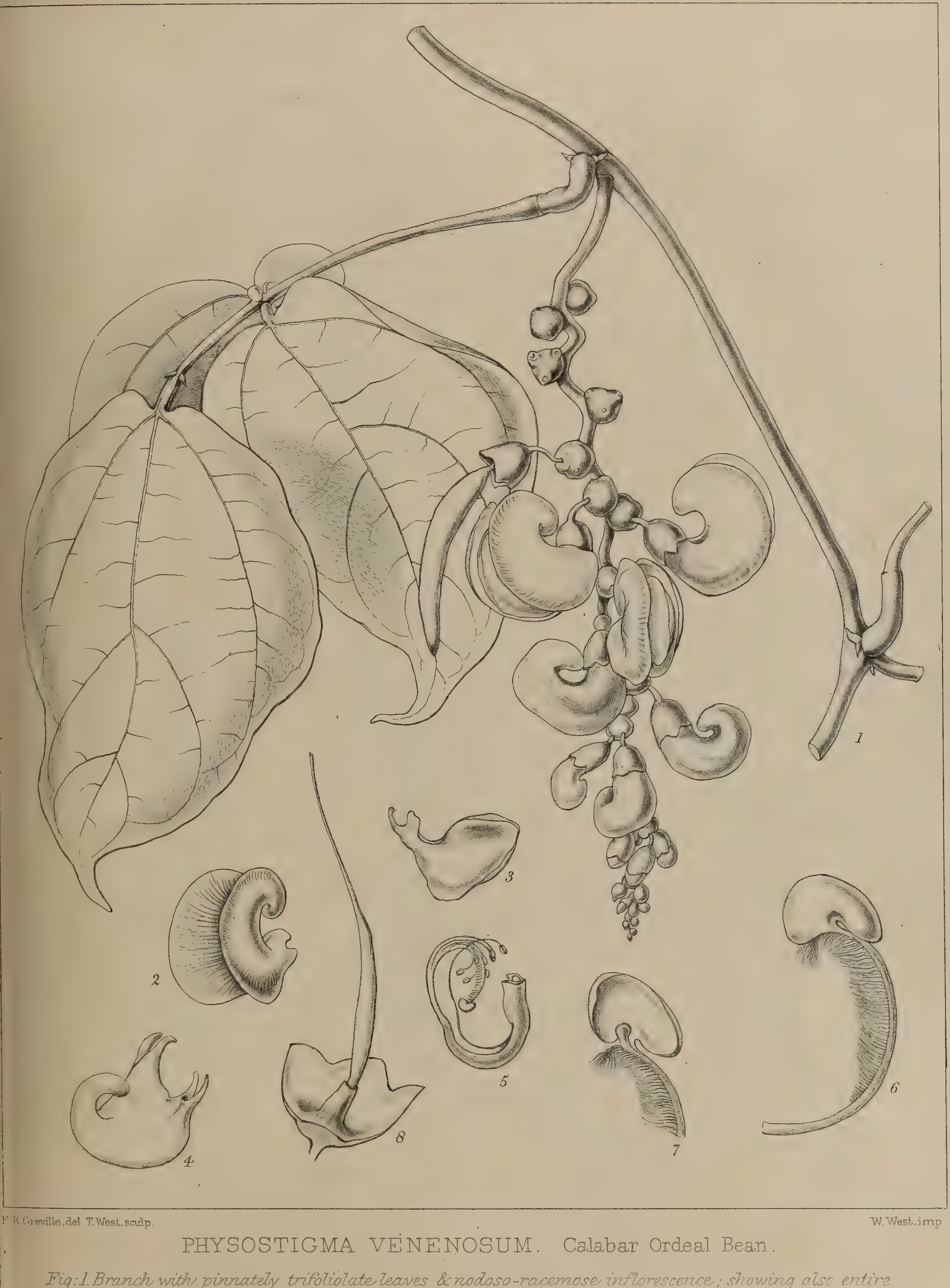
Plate XVI.

Physostigma venenosum, Calabar Ordeal Bean.

Fig. 1. Branch with pinnately-trifoliolate leaves, and nodoso-racemose infloresence, showing also entire flowers with persistent calyx and young legume. Fig. 2. Vexillum separated. Fig. 3. Alæ. Fig. 4. Carina. Fig. 5. Diadelphous stamens. Fig. 6. Upper part of style, bearded, and with cucullate stigma. Fig. 7. Upper part of bearded style, with stigmatic hood laid open. Fig. 8. Calyx and young legume. Figs. 6, 7, 8, magnified.

Plate XVII.

Fig. 1. Young legume of *Physostigma venenosum*, with three ovules. Fig. 2. Full grown legumes of ditto. Fig. 3. Seed of Ordeal Bean seen laterally. Fig. 4. The same, showing the sulcate and extended hilum on the convex edge. All the figures natural size.

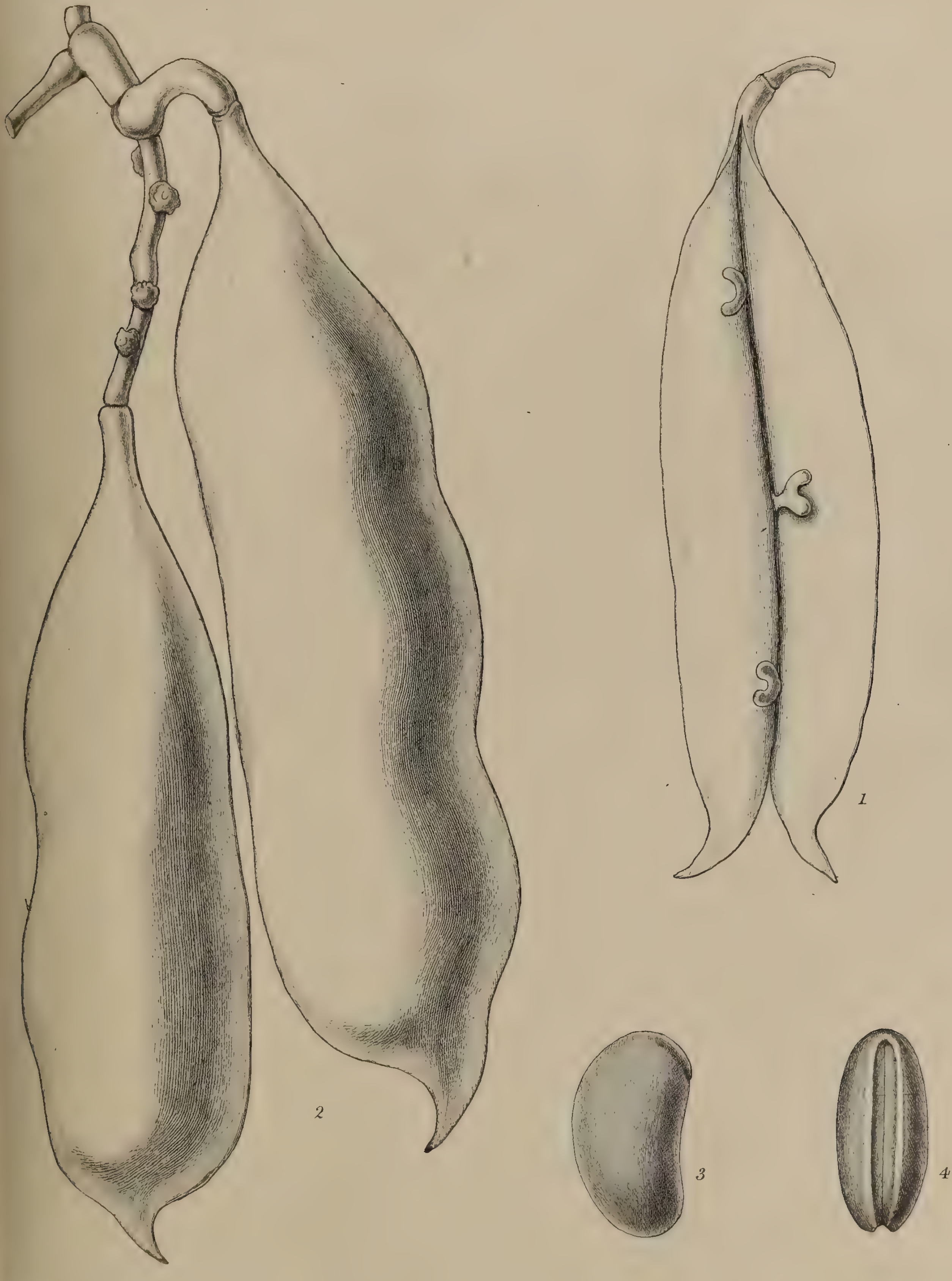


F. K. Greville, del. T. West, sculp.

W. West, imp.

PHYSOSTIGMA VENENOSUM. Calabar Ordeal Bean.

Fig: 1. Branch with pinnately trifoliolate leaves & nodoso-racemose inflorescence; showing also entire flowers, persistent calyx & young pod. Fig: 2. Vexillum separated. Fig: 3. Ala. Fig: 4. Carina. Fig: 5. Diadelphous stamens. Fig: 6. Upper part of style bearded, & with cucullate stigma. Fig: 7. Upper part of bearded style, with stigmatic hood laid open. Fig: 8. Calyx & young legume. Figs 6. 7 & 8. magnif.



...ville del. T. West, sculp. W. West, imp.

Fig: 1. Young pod of Physostigma venenosum, with three ovules. Fig: 2. Full grown pods of Do.
Fig: 3. Seed or Ordeal Bean seen laterally. Fig: 4. The same showing the sulcate and extended hilum on the convex edge. All the figures natural size.

X.—*On an Unusual Drought in the Lake District in* 1859. By John Davy, M.D., F.R.S. Lond. & Edin., &c.

(Read 17th April 1860.)

In a former communication to the Royal Society of Edinburgh, I gave an account of an unusual fall of rain in the Lake District in the month of January last year. That occurrence was followed by its opposite in May, June, and July; not for a long period, not since 1826, has the district suffered more from want of water than in those months.

This drought is best shown by the following table, in which will be found the rain-fall for the several months of the year at five different places, only a few miles remote from each other. The table will also show the remarkable contrast as to excess and deficiency of rain during the period. It may be premised, that at Ambleside, where the drought appears to have been felt as much as anywhere, the ordinary fall of rain for the months in question is about three times as great; thus for May (our driest month of the twelve), taking the average of the preceding eleven years, it is 2·37 inches, for June 4·22 inches, for July 5·27 inches, making a total of 12·36 inches, against 4·54 inches of the months of drought.

Table I.

Months.	Kendal.		Lesketh How, Ambleside.		Keswick.		High Close, above Grasmere.		Seathwaite, Borrowdale.
	Inches.	Rainy Days.	Inches.	Rainy Days.	Inches.	Rainy Days.	Inches.	Rainy Days.	Inches.
January, . .	6·514	17	14·82	19	11·168	21	10·95	19	23·40
February, .	4·022	18	7·29	22	5·214	20	6·29	21	15·80
March, . .	5·617	20	10·32	23	9·512	21	8·78	23	20·84
April, . .	3·900	12	5·44	12	4·868	13	5·27	16	12·71
May, . . .	0·123	1	0·55	4	0·206	2	0·23	5	1·04
June, . . .	2·024	12	1·91	13	2·446	9	2·81	14	5·95
July, . . .	1·757	8	2·08	10	2·866	7	2·55	9	3·33
August, . .	5·224	10	5·45	12	5·467	12	6·55	15	13·38
September, .	7·343	21	11·36	20	9·346	20	11·16	22	15·32
October, . .	2·760	12	6·89	14	3·834	10	4·99	14	8·27
November, .	5·075	17	10·08	16	6·595	13	8·61	17	13·55
December, .	3·931	13	7·93	16	5·451	15	6·59	16	13·70
	43·290	161	84·12	181	66·883	163	75·08	191	147·29

For the Table which follows I am indebted to Mr SAMUEL MARSHALL of Kendal, a gentleman of whose accuracy as an observer I have before made mention. The results it contains, expressive of the meteorological qualities of most importance, are applicable, with certain allowances, to the Lake District generally, and more especially as regards atmospheric temperature, and the prevailing winds.

TABLE II.

Months.	Barometer.			Thermometer.			Thermometer on Grass.		Mason's Hygrometer.		Quantity of Rain in Inches.	Number of Rainy Days.	Prevalent Winds.	Ozone.
	Maximum.	Minimum.	Mean.	Max.	Min.	Mean.	Solar Radⁿ.	Terrest. Radⁿ.	Dry Bulb.	Wet Bulb.				
January, . .	30·398	29·097	29·853	52°	28°	40·468°	46·6°	33·7°	40·4°	39·1°	6·514	17	S.W.	1·7
February, .	30·483	29·048	29·712	52	27½	40·946	53·7	34·3	40·5	39	4·022	18	S.W.	4·1
March, . .	30·201	28·894	29·701	59½	24	44·113	63·1	39·5	43·7	41·8	5·617	20	S.W.	4·3
April, . .	30·085	29·454	29·694	68½	24	43·416	82·3	34·6	45·6	41·3	3·900	12	S.W.	4·2
May, . . .	30·251	29·660	29·922	79	29	54·532	10·4	35	60	54	0·123	1	N.E.	3·4
June, . . .	30·099	29·578	29·854	80	39	59·216	97·3	46·8	62·3	56·3	2·024	12	N.E.	3·2
July, . . .	30·265	29·739	30·021	86	41	63·468	104·4	49·8	66·2	60·1	1·757	8	S.W.	2·5
August, . .	30·258	29·219	29·837	83	39	61·089	93·4	47·8	62·7	58·1	5·224	10	S.W.	2·4
September, .	30·139	29·279	29·677	66	35	53·733	83·6	42·4	54·4	52·1	7·343	21	S.W.	3·0
October, . .	29·965	28·936	29·566	71	19	48·113	69·3	39·8	47·6	45·8	2·760	12	N.E.	2·0
November. .	30·566	28·502	29·769	53½	22	39·541	52·3	30·1	37·4	36·1	5·075	17	N.E.	2·1
December, .	30·459	28·756	29·552	54	11	33·008	31·3	30·5	38·4	23·6	3·931	13	S.E.	3·2
Annual Means, &c.	30·264	29·180	29·763	67	28	48 470	73·4	38·7	49·9	45·6	48·290	161	S.W.	3·0

The following Table (No. III.) is given for the purpose of showing the great inequality of the fall of rain in different parts of the United Kingdom. For the observations from which it is framed, I am chiefly indebted to correspondents.

Comparing these Tables, it would appear, that whilst one portion of the country was suffering from deficiency of rain, other parts of it had rain in excess, and both in a remarkable degree; for instance, London and the Lake District. It would appear, also, that over the country generally, even where for three months a drought prevailed, the yearly fall of rain exceeded the average. At Seathwaite, in the upper part of Borrowdale, according to the observer there, Mr JOHN DIXON, the excess, in that spot, so remarkable for its rain, exceeded that of the average of the last fourteen years by 17 inches.

Recurring to the drought as experienced in the Lake District,—a district, from the nature of its declivities and the quality of its soil, peculiarly apt to suffer

TABLE III.

Months.	Penzance.	Burcher, near Kington, Herefordshire.	London.	Cambridge.	Wakefield.	Caton, about four miles east of Lancaster.			Edinburgh.	Glasgow.	Stornoway Castle, Isle of Lewis.
						Caton Farm, near Normanton, Yorkshire.		Arncliff, head of Wharfdale.			
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
January, . .	3·18	1·16	0·794	0·310*	0·709	0·72	4·095	8·76	1·86	5·300	5·43
February, . .	2 ·3	1·51	1·232	1·117	1·460	1·48	2·751	5·91	1·19	5·327	3·61
March, . . .	2·74	2·38	1·331	1·259	2·485	2·36	4·709	11·06	2·54	5·160	6·16
April, . . .	3·10	2·47	2·528	1·379	3·766	4·35	3·208	5·30	2·78	4·437	3·12
May, . . .	1·04	1·12	2·214	1·284	0·784	0·37	0·222	0·34	0·17	0·582	0·55
June, . . .	0·59	3·65	2·896	1·243	3·345	3·47	1·764	4·24	2·04	1·953	2·21
July, . . .	1·00	2·61	2·929	2·305	5·558	3·25	1·854	3·55	3·08	2·538	3·46
August, . . .	3·40	3·53	2·652	1·638	3·957	4·20	3·742	4·66	0·67	2·858	3·46
September, . .	4·42	3·98	4·039	2·103	3·434	3·88	5·558	9·97	1·35	4·867	4·76
October, . . .	5·34	3·73	2·496	3·746*	2·777	3·19	2·603	5·36	3·04	6·062	2·64
November, . .	3·62	4·33	2·930	0·864	2·053	3·02	3·494	9·17	2·48	3·243	3·08
December, . .	8·28	4·49	2·248	0·070	2·879	2·71	4·332	5·98	1·44	2·415	4·06
	39·01	34·96	28·289	17·818*	33·207	33·50	38·330	74·30	22·64	44·742	42·53

* It is stated that the rain-gauge was out of order during part of January and part of November, and that, to make up the deficiency, about 5 inches, it is estimated, should be added, making a total of about 23 inches for the year.

from any deficiency of rain,—its effects were witnessed not only in a failure of most of the springs and a want of water distressingly felt by the inhabitants, but also on vegetation; those plants requiring moisture, suffering; those benefited by warmth and dryness—the comparative few—flourishing. The crop of small fruits, such as the gooseberry, currant, strawberry, was unusually scanty and poor; that of mushrooms, and of other fungi,* was unusually abundant. The same in regard to flowers; the lavender flowered in fine profusion; roses the contrary, and with a very small growth of wood. The drought took effect severely on the grasses; the hay-grass, the great crop of this pastoral district, was only about one-third an average one. Animals, I need hardly remark, were not exempt from its influence; some insects were unusually abundant and troublesome; others the opposite. During the dry months, our valley was almost deserted by the swallows.

* The common mushroom, *Agaricus campestris*, was so abundant, that in the Lancaster market it was sold at a penny a quart, about four or five times cheaper than usual: it was met with, too, in places where, it is said, it had never before been found. Of wild flowering plants, the common harebell, *Campanula rotundifolia*, was unusually plentiful, and in many spots where I had never seen it before.

The weather which followed this drought was also abnormal. Snow accompanied with frost fell in October;* and this before many of the trees had acquired their autumnal tints. Moreover, the winter months, up indeed to the present time, have been remarkable for uncommon vicissitudes of temperature, for frequent snow-storms—the snow lying much longer than ordinary—and for severe gales, some of these almost hurricanes, accompanied with sudden and great fluctuations of the barometer.

LESKETH HOW, AMBLESIDE, *March* 22, 1860.

Postscript.

The loss of stock amongst the farmers in the Lake District, the consequence of the drought and the inclement winter which followed it up to the present time has been great, and it has continued increasing. In the *Kendal Mercury* of the 7th April there is an account of it, so descriptive, and, as I believe, truthful, that I am induced to transcribe it. It is headed, "Dreadful mortality amongst the mountain sheep in Westmoreland." "In our last week's impression" (it proceeds), "we noticed the snow-storm that fell on the hills and valleys in Westmoreland, on Saturday morning the 25th ult., and that a vast number of sheep, not only on the hills, but on the low grounds, were buried beneath the snow, and that in consequence of a large quantity of rain falling along and at intervals during the storm, the worst fears were entertained for the

* Mr SAMUEL MARSHALL, in his summary of Meteorological observations for this month, remarks, "On the morning of the 21st October we had the first frost this season, and on the following one the first snow, and the next a heavier fall still. The thermometer has not been below the freezing point since the 9th May till the 21st October, or more than five months." A very unusual degree of cold, about the same time, was observed elsewhere. Mr LOWE in a note of the 23d of October, from Highfield House Observatory, headed "Great Cold," published in the *Evening Mail*, says, "It is scarcely three weeks since I had to announce a degree of heat greater than had been known to have occurred in October (viz., 77°·5), and now the same has to be said with regard to the intense cold of the past two nights. Yesterday the *minimum* temperature was 23°·5, and this morning it fell to 22°·4; previously 24°·6 was the greatest cold that had been registered here." It was curious to observe the aspect of plants at this time;—the foliage of many trees, such as the sycamore and the ash, their leaves still green, were shrivelled and curled by the frost, so that their under surface was conspicuous, whilst the roses, the China variety still in flower, were weighed down by snow. The effect of the severity of the winter as to cold was not less strongly marked on vegetation than the summer drought; some of the hardier plants were killed, for instance the Russian violet, which during the preceding winter had flowered uninterruptedly; and yet, even the shallower lakes, such as Rydal Mere, were frozen over, so as to allow of skating, only for two or three days, and this only once, so rapid were the changes of temperature from a low degree, as 12° to 15° and 20° to 34°–40°; it was rarely higher. And, as the mildness of last winter was shown by a forward vegetation, so the severity of the last and the protracted low temperature have been indicated by the opposite this year; now, on the 21st of March, the flower-buds of the *Ribes sanguineum* have only just begun to unfold, and not a leaf-bud of the sweetbrier has yet opened.

safety of the sheep; and we are sorry to say that those fears have been realised to an alarming extent. The snow was nearly all washed from the grounds by the rains which fell during the succeeding week, and then the shepherds began to have some idea of the destruction amongst their flocks, and it was truly fearful. On Saturday last, one skinner in Kendal received no less than 250 skins from the neighbourhood of Shap, and other skinners in this town had an almost fabulous number. Cartloads of skins were also forwarded on Saturday to Penrith, and other towns and villages in the neighbourhood of the hills; and they still, nearly daily, keep arriving here from the fells. On Wednesday last, 100 skins arrived from one farm, and it was some time before the owner could dispose of them, as the skinners had so large a number still unpulled that were rotting and becoming putrid in their skinneries. The sheep, whose skins are now brought in, have not all perished in the snow-storm, but they were so weak and emaciated from the long winter, and hunger, and cold, that they reeled about, and then tottered, fell, and died by scores together. It is said that one-half of the sheep in the parish of Bampton have perished, and that Mr T. Mounsey, in that parish, has lost 500, and Mr T. Abbott, of Thornthwaite Hall, near Shap, counts up his loss to more than 1200 head. Indeed, the loss has been fearful all along the Lake Mountains, and the range of hills extending from Coniston Old Man to Stainmore. From Coniston, Hawkshead, Ambleside, Troutbeck, Kentmere, Longsleddale, Selside, Shap, Bampton, Crosby, Ravensworth, Ravenstonedale, Kirby Stephen, Garsdale, Hawes, Wensleydale, and Dent, the loss has been great, and the flocks are very weak and sickly, and large numbers are daily dying. Never, in the memory of the oldest shepherd on the hills of Westmoreland, can be remembered so fearful a mortality amongst the mountain sheep, and great fears are entertained that it has not yet reached its highest pitch." These fears, I regret to add, are too likely to be realised; on this 9th of April there has been another fall of snow, succeeding a fall of rain of 1·15 inch in the twenty-four hours; this morning, not only were the hills covered with snow, but even the lower dales. Since April last year, that month included, I find recorded here thirteen falls of snow, in some instances mixed with sleet and rain, the whole equal to, that is, yielding when thawed, 6·9 inches of water. Now, supposing it to have been all snow, as it probably was on the higher fells, the total depth of snow there, if accumulated, would be little short of 83 inches.* It is remarkable that from the 23d of October, when snow first fell, up to the present time, some of the higher hills have not been free from snow.

Incidents, catastrophes, such as have been described above, in connection with

* Of course, according to the quality of the snow, the proportion of water it will yield when thawed must vary; in one instance, when the depth of snow was 6·5 inches, the water from it measured ·54 inch; in another instance, when its depth was 4·5 inches, the water it yielded was ·47 inch. The snow was collected in the funnel of the rain-gauge; its depth was tried where it had not drifted.

adverse seasons, and resulting in scarcity of food and an excessive mortality, seem specially deserving of attention, being equally applicable to the human race—*e.g.*, our army in the Crimea, during the first winter, under the same circumstances—and to brute animals, and may help to account for the extinction of races or species.

LESKETH HOW, AMBLESIDE, *April* 9, 1860.

XI.—*Upon the Thyroid Glands in the Cetacea, with Observations on the Relations of the Thymus to the Thyroid in these and certain other Mammals.* By William Turner, M.B. (Lond.), Senior Demonstrator of Anatomy, University of Edinburgh.

(Read 2d April 1860.)

In the writings of comparative anatomists, considerable difference of opinion is expressed respecting the position and relations of the thyroid gland in the Cetacea, and some authorities even have asserted that it does not exist in these Mammalia.

John Hunter states* that he has examined several porpoises, balænæ, and other cetacea, yet "could not observe anything like a thyroid gland."

Meckel † believed that he found, in a fœtal porpoise (*D. phocœna*), eight inches long, a thyroid gland. He describes it as half an inch broad, two lines thick and high, and of equal depth and thickness both on the middle and sides of the air-tube, in the same position as that in which the gland is found in other mammals. From this examination, however, of so young a fœtus, he does not feel disposed to affirm that, contrary to the opinion of Hunter, it exists in full grown cetacea. In a subsequent paper ‡ he mentions incidentally, that in the dolphins the gland is formed of two quite separate lobes. Cuvier § states that he has found the gland very distinct in many dolphins and porpoises. In these animals it was divided into two parts, and suspended from the trachea opposite the upper border of the sternum, and some distance from the larynx. Carus || describes the gland in the dolphin and porpoise as consisting of two parts, entirely separate from each other. It is difficult to say, however, from the text, whether he is giving the result of his own observations, or simply adopting those of Cuvier. Dr Martyn ¶ repeats the statement that the cetacea do not possess a thyroid, and he ascribes the supposed absence of the voice in these animals to the want of this glandular structure.

As I have had, during the last three years, opportunities of dissecting three porpoises, and as I have found in them appearances differing from those which I have quoted from the above authorities, I am induced to offer the following description of my observations. The animals were specimens of the common

* On the Structure and Economy of Whales. Philosophical Transactions, 1787.

† Abhandlungen aus der Menschlichen und Vergleichenden Anatomie und Physiologie. Halle, 1806.

‡ Beyträge zur Vergleichenden Anatomie, 1811.

§ Anatomie Comparée, vol. viii.

|| Traité Elementaire d'Anatomie Comparée, vol. ii.

¶ Proceedings of the Royal Society of London, 1857.

porpoise (*Phocœna communis*), one was a fœtus, twelve inches long; another was a well-grown male, three feet ten inches long; the third being a full grown male, between five and six feet in length.

On removing in each of these animals the large sterno-hyoid and smaller sterno-thyroid muscles, a distinct and well-defined glandular mass was seen lying on the anterior and lateral surfaces of the trachea at its upper end, and extending slightly upwards on each side over the outer surface of the cricoid cartilage. Its position thus closely corresponded with that of the thyroid gland in other mammalia. Instead, however, of being divided into two distinct lateral lobes, as described by Cuvier and Carus, the gland consisted of a single uniform mass, which in the adult animal was two inches long, extending across the middle line, and closely fitting both to the front and sides of the trachea. The median portion of the gland can hardly be described as an intervening isthmus, for in its supero-inferior diameter it equalled that of the lateral portion. This, in the adult animal, was three-fourths of an inch, in the fœtus, one-fourth.

In the full grown specimen (which was examined in the fresh state, the other specimens having been for some time in spirits), the gland presented a dark purple tint, and a soft and somewhat succulent aspect. At the upper end of each lateral portion, but separated from it by a slight interval, a glandular mass about the size of a small nut was found, apparently an accessory thyroid. In this respect the gland corresponded in its arrangement to one which is occasionally found in the human subject.

In the smaller adult porpoise, in the interval between the two crico-thyroid muscles, and almost concealed by the plates of the cricoid cartilage, a small glandular mass was situated. It had the same colour as the thyroid; but presented more evident indications of being divided into distinct lobes. It was in contact by its deep surface with the crico-thyroid membrane. It must, I think, be regarded as an isolated portion of the thymus.

In the fœtal porpoise, a long and slender glandular process extended from the inferior margin of the median part of the thyroid, downwards along the anterior surface of the trachea, and behind the heart and pericardium, into the posterior mediastinum. This must also be looked upon as a part of the thymus.

Both in the fœtal and smaller adult porpoise, the thymus gland was exceedingly well developed. As the thymus closely corresponds in its structure to the thyroid, and as the relations of the two glands are extremely interesting in a developmental point of view, I purpose, in the next place, describing the general disposition and arrangement of the thymus in these animals.

This gland was exposed by cutting through the sterno-hyoid and thyroid muscles, and by turning on one side the upper end of the sternum. It was composed of two large lateral lobes, separated from each other by a thin layer of cellular tissue. These lobes, of a conical form, were situated for the most part behind the first bone of the sternum, and immediately in front of the upper end of the pericardium. Their apices projected above the sternum into the lower part of the neck, lying in front of the trachea, and extending upwards almost as far as the lower margin of the median portion of the thyroid gland, from which they were separated by the innominate vein. From each of these lobes a long process of

Fig. 1.

The Thyroid and Thymus Glands of the well-grown male porpoise. About one-third the natural size. The relation of these glands to the wind-pipe, the pericardium, and to each other, is represented.

glandular tissue extended deeply between the structures situated at the root of the neck. That from the right lobe passed in front of the trachea, being in close contact with the anterior surface of that tube, to the left side, where it became connected to the deep process from the left lateral lobe. This transverse communicating portion extended behind the arch of the aorta, so that this vessel, with its ascending carotid branches, was situated between the deeper and more superficial parts of the gland. Connected with the upper margin of the deep process from each lateral lobe was an elongated portion, which extended upwards on each side of the neck as far as the thyroid cartilage, being in close relation with the carotid vessels. These ascending prolongations of the thymus were thus brought into intimate relation with the lateral portions of the thyroid, so that at first it appeared as if they formed a common glandular mass with them. On a closer examination, it was found that they were not continuous, but intimately connected together by a little cellular tissue, on dividing which, the two glands could be separated from each other, without effecting any injury to their proper structure.

On referring to that part of Mr Simon's essay,* which treats of the com-

* Physiological Essay on the Thymus Gland, 1845.

parative anatomy of the thymus, I find that he gives an account of a dissection of this gland, which he made in a fœtal dolphin. He describes in this cetacean a pericardiac portion of the gland, from which long ascending processes proceed, which extend upwards in close contiguity with the vertebræ, as high as the level of the upper part of the trachea, and then bending inwards in front of that tube, so as to join in the middle line. The figure which he appends, illustrating this description, closely corresponds with the appearances I have seen both in the fœtal porpoise and in the smaller well-grown animal. I cannot, however, agree with Mr Simon in considering this median tracheal portion as forming a part of the thymus. I am disposed to regard it as the thyroid, and as such I have described it in the former part of this paper. My reasons for doing so are the following:—It is situated exactly in the position of the thyroid gland; it possesses a perfect continuity of gland-structure from side to side, so that it does not present the same subdivision into lobes which is characteristic of the thymus; its capsule is much more adherent than that of the thymus, and it can be separated from the ascending processes of the pericardiac portion of the thymus by carefully removing the thin layer of cellular tissue which connects it with them. Moreover, there is no other structure, either on the front or sides of the trachea and larynx, which can be looked upon as constituting a thyroid gland in these mammalia, if this is not regarded as such.*

The persistence of the thymus gland in an animal so well grown as this porpoise is a fact of considerable interest, especially if we take into consideration its large size. That it was in a condition perfectly capable of performing its functions, and not merely a collection of fat-cells, as is generally the case where the gland in the human subject apparently persists for some years after birth, I was enabled to prove by a microscopic examination. On submitting a portion of the gland to a magnifying power of 200 diameters, I found it to consist of lobularly arranged masses of small closely-packed corpuscles, about the size of, and a little larger than, the red corpuscles of the human blood, presenting, in fact, a structure exactly similar to that with which we are familiar in the fœtal gland. We are furnished by this illustration with additional evidence of the fact, so especially insisted on by Haugsted and Simon, that the thymus gland is not merely a fœtal structure, but that it plays an important part in the animal economy for some time after birth. As I had an opportunity of comparing it at the same time with the gland in the fœtal porpoise, there could be no doubt that it had grown considerably after birth, and apparently in a ratio closely corresponding with that of the growth of the animal.

* Since this paper was read to the Society, I have dissected the neck of a fœtal Dolphin, probably the young of a bottle-nose (D. Tursio). This dissection confirms the opinion I had arrived at and stated in the text, viz., that the glandular structure in front of the upper part of the trachea in the genus Delphinus is the thyroid, and not merely a part of the thymus.

The close connection which I have now shown to exist between the thymus and thyroid glands in these porpoises, strongly indicates that they most probably have originated in a common structure. This view of the common origin of these glands was prominently announced by Professor GOODSIR, in a paper in the Philosophical Transactions,* published many years ago. His investigations were conducted on the embryoes of sheep. He describes these glands as, together with the supra-renal bodies, developed from the remains of the blastodermic membrane extending along each side of the spine, from the Wolffian bodies to the base of the cranium,—a separation taking place between them in the process of development.

The porpoise is not, however, the only mammal in which, in the non-fœtal state, a connection may be seen to exist between the thymus and thyroid bodies.

In a fine specimen of an adult male Hartebeest (*Bubalus caama*), in which I dissected some time ago these glands, I found the lateral lobes of the thyroid entirely separated from each other, and lying on the sides of the upper end of the trachea. Connected with the lower part of each of these lobes was a long slender process of gland substance, which descended along the sides and front of the trachea, until it reached the fourteenth ring, when the processes from each side became connected together. At this spot they united with another slender process of a similar structure, which descended from the sides of the larynx. The common gland-mass, formed by the union of these processes, now passed down the front of the trachea, and beneath the sternum, into the anterior mediastinum, undergoing, immediately above the sternum, a considerable augmentation in size. That portion of the structure which was situated at the upper part of the trachea received its supply of blood from the arteries which supplied the thyroid gland. On examining this glandular substance microscopically, I found it to correspond in structure with the thymus gland, for it was essentially composed of numerous small circular corpuscles. Its structure and position warrant us in regarding it as a persistent thymus, and its close relation to the thyroid points to the conclusion that it has been developed along with it.

Fig. 2.

View of one lateral lobe of the Thyroid and of the slender processes of the Thymus of the Hartebeest, about one-third natural size.

In a dissection which I recently made of the thymus and thyroid in the Nylghau (*Antilope picta*), I obtained several very interesting facts connected with these glands. The animal which I examined was presented to the Anatomical Museum of the

* On the Supra-renal, Thymus, and Thyroid bodies, 1846.

University by the Marquis of BREADALBANE. It was a very large example of an adult male, its proportions exceeding in every direction those given by Dr WILLIAM HUNTER, in his description of the Nylghau.* The thyroid gland was exposed in the usual way. It was found to consist of two entirely distinct lateral halves. Each half was seated quite at the posterior part of the side of the air-tube, the upper end being in relation with the outer surface of the cricoid cartilage, the lower end reaching to the side of the fourth tracheal ring. The two lobes were thus separated from each other by the entire width of the trachea. The lobes, wide at their upper ends, gradually became narrower as they extended down the side of the trachea, until they terminated below in an almost pointed extremity. Branches from the great artery of the neck passed both to the upper and lower ends of each lobe. On the anterior surface of the trachea, as well as on the crico-thyroid membrane, in the interval between the lobes of the thyroid, scattered lobules of glandular tissue of a slightly reddish tint were seen. These were not connected with the thyroid, but were lying in the cellular tissue between its lobes. Extending for some distance down the front of the trachea, scattered lobules of a similar glandular substance were found, separated from each other by varying intervals. About thirteen inches above the sternum the gland-lobules became much more closely connected together, and formed two long lines of glandular tissue which extended downwards on the front of the trachea. Immediately above the sternum they became wider, and, in this manner, passed beneath that bone for a short distance, lying in front of the great blood-vessels. Small arteries derived from the carotid trunk passed to this long line of gland-substance. This gland, from its position, was evidently the thymus, the lobules of which, closely aggregated together below, were separated from each other by varying intervals at the upper part of the trachea, some even extending as high as the crico-thyroid membrane. It was thus brought into close relation to, although not actually in contact with, the thyroid.

A microscopic examination satisfied me that it was the thymus,—the great bulk of the gland being composed of collections of small colourless corpuscles, about the size of, or a little larger than, the red corpuscles of human blood, arranged in a distinctly lobular manner. In some parts of the gland were scattered about highly refracting globular particles of varying size, probably fat. They presented a more granular aspect than is usual with oil-globules. Lying here and there in the connective tissue between the lobules of the gland were numerous crystals, sometimes aggregated together in irregular masses, at others arranged in lines, and in some cases scattered about in an indefinite manner. These crystals were all of a prismatic shape, many of them distinctly three-sided, presenting a close resemblance to the crystals of the ammoniaco-magnesian phosphate occasionally

* Philosophical Transactions, 1771.

met with as a urinary deposit. They were soluble in acetic acid without effervescence. The existence of crystals scattered freely about in the cellular tissue of the animal body is, so far as my observation extends, a fact of very unusual occurrence. From the position and microscopic character of this gland, there could be no doubt that it was the thymus.

The evidence that we have now obtained, both by the dissection of this Nylghau and the Hartebeest, shows us, that in these Antilopidæ the thymus is a permanent gland; for there could be no question but that both these animals had reached the adult period of life, and even acquired a considerable age,—their large size, and the worn appearance of the teeth, rendered this sufficiently manifest. So far, then, as regards these animals, the thymus must be looked upon as possessing a more enduring function than has hitherto been ascribed to it in the economy, —not disappearing, or altogether degenerating, in the early period of extra-uterine life, but persisting, even in the adult animal, probably throughout its entire existence.

In conclusion, I may state that I have seen in the human subject indications of a close connection between the thymus and thyroid glands. I have notes of an examination which I made of a child between two and three months old, in which long ascending processes passed upwards from the lobes of the thymus, in front of, and to the sides of, the trachea, as high as the lateral lobes of the thyroid gland, with which they were closely connected by cellular tissue. Each of these ascending processes received a branch from the inferior thyroid artery. This case furnishes us with an example of the thymus receiving a considerable portion of its vascular supply from the artery of the thyroid. The converse of this, viz., the thyroid obtaining a large share of blood from the artery of the thymus, may also occasionally be seen. In a subject in the dissecting-room, I observed the internal mammary artery, which may be regarded as the great thymic trunk, give off a large branch, which ascended, on the right side of the trachea, to the right lateral lobe of the thyroid gland.

XII.—*On the Climate of Edinburgh for Fifty-six years, from* 1795 *to* 1850, *deduced principally from Mr Adie's Observations; with an Account of other and Earlier Registers.* By JAMES D. FORBES, D.C.L., F.R.S., Sec. R.S. Ed., Professor of Natural Philosophy in the University of Edinburgh. (With two Plates, XVIII. and XIX.

(Read 5th March 1860.)

1. The late Mr ALEXANDER ADIE, optician, and Fellow of the Royal Society of Edinburgh,* was so generally known to be a zealous and careful observer of meteorological instruments, that an attempt to combine the results deducible from his labours carried on (though with one long break) over more than forty years, cannot be otherwise than interesting.

2. The plan of superintending the careful reduction of the thermometrical part of Mr ADIE's registers occurred to me a long time ago, but circumstances prevented the execution of it until two or three years since, when, through the kindness of Mr ADIE and his family, the whole of the manuscript observations, commencing with 1795, were put into my hands, and the Council of the Royal Society of Edinburgh provided sufficient funds for the employment of computers for reducing them.

3. The work has proceeded with frequent interruptions, but is at length complete. Before I proceed to detail the particulars of the reductions and their results, I will give a short account of the earlier observations on the climate of Edinburgh which I have been able to trace, some of which perhaps have hitherto escaped notice.

SECT. 1. *On the Earlier Recorded Observations on the Climate of Edinburgh.*

4. I have been fortunate enough to discover an old printed Register of Meteorological Observations at Edinburgh, extending from June 1731 to May 1736. It is contained in five successive volumes of "Medical Essays and Observations published by a Society in Edinburgh," which reached a third edition in 1748, and it is the one from which I quote.

5. This register appears to have been made with remarkable care, ndd most likely by one observer, and in the same locality, for the above-mentioned period, and probably longer, as I judge from the mention of it in MARTINE's Essays.†

* Some account of Mr ADIE's personal history and labours will be found in the Vice-President's Address for the Session 1859–60 (Proceedings of the Royal Society of Edinburgh, vol. iv. pp. 225–27.)

† Essays and Observations on the Construction and Graduation of Thermometers by GEORGE MARTINE, M.D., 2d edit. 1772, p. 48.

The Observatory was situated in the town of Edinburgh, about 270 feet above the sea.* The thermometer was sheltered by a case well perforated with holes to admit the air.† It was filled with alcohol, and graduated, not, as now, into degrees, but into inches and tenths. But the reference to Fahrenheit's scale becomes easy, since we are told (p. 7), that "the freezing point is at 8 inches 2 tenths; and the heat of a man in health raises the spirits to 22 inches 2 tenths." The former point of course corresponds to 32° Fahr.; the latter was found by Dr MARTINE to be 97° Fahr. by actual experiment on the person who graduated the Edinburgh thermometer.‡ Hence it is easy to form a table for reducing the "Edinburgh Scale" to Fahrenheit's; but it may be sufficient to adopt a reduction which is to be found already made at page xiv. of the preliminary matter to the third volume of "Essays of the Philosophical Society in Edinburgh," published in 1771. The observations there tabulated are evidently identical with the observations already described, although these are not there directly referred to. It would also appear that blood-heat was reckoned at 96° instead of 97°, as I find by comparing the numbers in the "Medical Essays" with those of the Philosophical Society. If we assume (as is reasonable) MARTINE to be correct, the numbers in the foregoing tables ought to be slightly raised; but for the mean annual temperature the difference would be less than a quarter of a degree.

6. I regret that it is not in my power to throw any light on the name of the person by whom these records were made; but he was in all probability a medical man.

7. I ought to add that the barometer, hygrometer, wind, weather, and amount of rain, are all carefully entered. The observations were almost invariably made twice a-day, the first nearly always at 9 A.M., the second at an hour (usually between two and six) which varied with the season of the year.

8. Confining our attention to the thermometrical observations, they require a correction for the varying hour at which the afternoon observations were made at different seasons of the year. Taking a sort of average, I have applied the following tabular corrections to the reduced observations as given in the "Essays of the Philosophical Society" above referred to. The second line contains the reductions for the observations made in 1764–70, which will be immediately referred to:—

Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1732–35, ...	−0·3	−0·5	−1·0	−2·1	−1·7	−1·3	−1·9	−1·1	−1·8	−0·8	−0·5	−0·2
1764–70, ...	+0·9	+1·3	+1·8	+2·2	+1·4	+1·1	+1·1	+1·1	+1·5	+1·0	+1·0	+0·5

9. The *earlier* of these series of observations, it is to be observed, was adapted to the *Julian, or old style.* These tabular corrections are taken from M. DOVE'S reductions of the Leith hourly observations.§

* Medical Essays, i. p. 6.—Most likely in the neighbourhood of the present Royal Exchange.
† Ibid. p. 8. ‡ MARTINE'S Essays, p. 48. § British Association Reports for 1847.

10. The next observations we find recorded are in the same volume (the third) of the "Essays of the Philosophical Society in Edinburgh" from which I have already quoted. They embrace the years 1764 to 1770 inclusive, and consist of two sets, one made at Hawkhill, situated between Edinburgh and Leith, at 103 feet above the sea, the other at Edinburgh itself. If we assume that the latter set was made in the same locality as the observations of 1732–36, the height above the Hawkhill Observatory would be 167 feet. Both sets were made uniformly at the hour of 8 A.M., and a correction has been applied to the monthly means to reduce them to the average, to the extent indicated in Art. 8. The Hawkhill observations were continued at least until 1776 by Mr MACGOWAN, and the results are contained in the first volume of the "Edinburgh Transactions," page 333. They are also included in this Table, with the same correction for the hour of observation (8 A.M.)

EDINBURGH (*reduced*).

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1732	34·4	41·5	41·0	41·8	48·6	57·7	56·1	54·2	48·5	44·4	36·5	35·9	45·0
1733	38·1	39·3	38·8	45·4	50·9	58·1	59·3	53·7	48·5	43·5	43·4	43·2	46·8
1734	34·4	42·0	44·2	48·2	48·1	56·3	57·1	54·2	47·6	40·8	36·5	35·9	45·4
1735	36·3	35·1	38·8	43·6	48·1	54·9	57·5	56·5	47·6	43·1	42·0	38·2	45·1
1764	34·6	35·4	40·3	45·0	53·5	55·9	60·0	57·5	51·9	46·6	40·2	36·7	46·5
1765	40·9	34·5	40·9	45·7	49·4	53·3	57·5	56·6	54·1	47·0	41·2	37·6	46·5
1766	38·1	31·1	38·7	46·1	46·3	55·7	59·3	59·5	46·9	46·4	43·7	37·9	45·8
1767	31·2	41·3	39·2	42·6	47·1	52·9	55·7	57·8	55·2	45·5	42·5	37·6	45·7
1768	33·2	37·8	38·6	46·2	50·0	54·2	57·9	57·5	50·8	42·6	38·8	37·5	45·4
1769	33·8	35·2	40·6	45·2	49·0	53·2	59·0	55·4	53·3	45·2	39·2	37·8	45·6
1770	37·1	38·8	34·4	40·6	46·1	52·4	55·7	57·2	53·6	44·0	37·3	34·9	44·3
										Mean of 11 years,			45·64

HAWKHILL (*reduced*).

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
1764	36·6	38·6	40·0	46·3	54·3	57·5	61·4	59·0	52·6	47·3	39·2	36·2	47·4
1765	40·1	33·5	41·3	46·8	54·0	55·6	60·1	58·1	53·3	48·0	37·9	35·7	47·0
1766	35·0	35·1	39·4	48·1	47·9	55·9	60·6	60·9	53·2	47·4	43·8	37·8	47·1
1767	32·0	41·7	40·2	47·1	50·8	55·0	58·1	61·2	56·2	46·5	43·8	39·4	47·7
1768	33·5	38·8	41·5	49·0	54·6	56·4	60·0	60·1	52·6	47·8	40·9	39·2	47·9
1769	35·6	37·2	42·9	47·8	52·5	56·3	61·8	57·7	55·5	46·5	40·9	40·5	47·9
1770	39·5	41·6	37·1	43·8	50·0	55·2	58·6	59·6	56·7	46·6	39·1	37·7	47·1
1771	34·1	37·9	37·7	43·9	51·8	56·8	59·6	57·7	53·2	47·8	42·9	41·8	47·1
1772	32·4	32·2	38·8	45·1	50·5	58·3	59·8	58·5	53·0	49·8	42·7	40·1	46·8
1773	39·5	36·4	43·9	47·8	50·0	56·3	58·8	59·4	52·8	47·0	39·2	36·9	47·3
1774	30·0	37·5	38·9	45·3	48·0	56·2	58·5	58·3	53·2	49·3	39·1	37·8	46·0
1775	38·7	40·4	41·8	49·0	54·1	57·7	60·2	58·7	54·8	46·3	39·0	39·1	48·3
1776	30·1	37·0	42·7	48·1	50·7	56·6	60·5	57·8	53·3	48·0	42·0	38·3	47·1
										Mean of 13 years,			47·28

11. The two sets of observations are each consistent among themselves; but the average difference of the two series, amounting to 1°·6 in excess for the mean temperature of Hawkhill above Edinburgh, is greater than the difference of level and exposure would seem to warrant. Even after applying a correction of +0°·25 to the Edinburgh observations, deduced from MARTINE's estimate of blood heat (Art. 5), these averages appear to be too low, whilst those of the Hawkhill observations agree well with the modern ones contained in the sequel of this paper.*

12. Professor PLAYFAIR appears to have commenced in 1794 a register in Windmill Street (near George Square), Edinburgh, 265 feet above the level of the sea. The results are published in the Edinburgh Transactions, Vols. IV. and V., from 1794 to 1799 both inclusive. The hours of observation were nearly 8, 2, and 10 (not 8, 12, and 10, as stated by M. DOVE†), the middle observation being chosen so as to fall nearly at the moment of highest temperature.

Mean Annual Temperature of Edinburgh.

Years.	Playfair, 8^h, 2^h, and 10^h.	Adie, 8^h and 8^h.	Difference.
	°	°	°
1794	50·32	...	...
1795	47·75	45·67	−2·08
1796	48·10	46·46	−1·64
1797	48·04	46·33	−1·71
1798	49·28	47·59	−1·69
1799	46·13	44·44	−1·69

The difference is striking, and nearly constant. Sir D. BREWSTER attributes it to the radiation of heat from neighbouring houses at the midday observation.‡ At all events, Professor PLAYFAIR's observations seem to be in error.

13. The only farther contribution I have to make to the older series of observations is to mention that in Mr ADIE's earliest Register Book, mentioned below, I find a memorandum that the mean temperature of the year 1787 was 46°·44; of 1788, 46°·191; and of 1789, 46°·573; but the authority is not given.

SECT. 2. *On Mr Adie's Thermometrical Observations generally, and their Reduction.*

14. The observations of Mr ADIE on the temperature of Edinburgh have hitherto been known by their periodical publication for some years, commencing with 1824, in Sir D. BREWSTER's "Edinburgh Journal of Science," from whence they have been quoted by M. DOVE in his various writings.

* Farther references to Mr MACGOWAN's observations will be found in the "London Philosophical Transactions" for 1775, and in the Edinburgh Transactions, vol. iv. p. 214; but I have not been able to discover any continuation of the observations later than 1776.

† Not unnaturally, since in the Tables themselves the word "noon" is used to denote the midday observation. Compare p. 214 of the paper in vol. iv. of the Transactions.

‡ Edin. Trans. ix. p. 209.

15. The original observations were far more extensive. Stimulated probably by Professor PLAYFAIR's example and advice, Mr ADIE commenced what appears to have been a very careful register of the thermometer, barometer, wind, and rain, on the 1st January 1795. After continuing this register with great punctuality for more than ten years, it came abruptly to a close about the middle of 1805. It seems certain that Mr ADIE then discontinued it, not from any want of interest in the subject, but because he considered that he had amassed sufficient materials for ascertaining the peculiarities of the climate of Edinburgh. For he reduced these ten years' observations with care, and not only so, but projected the whole in neat curves now in the possession of his family. These observations were made in Merchant Court, a locality now apparently extinct, but which was close to Merchant Street, near George IV. Bridge, in the old town of Edinburgh. Its elevation above the sea was, according to Mr JAMES JARDINE,* 230 feet. The distance from Windmill Street, the locality of Professor PLAYFAIR's observations, was inconsiderable. The observations were made at 8 A.M. and 8 P.M.

16. Nearly fifteen years elapsed from 1805 without observations being made. I shall afterwards state the source whence I have attempted to supply this blank.

17. In 1821 Mr ADIE resumed his observations at his villa of Canaan Cottage, in a sheltered valley about a mile and a quarter south from his former locality. Its elevation was 260 feet above the sea.† The observations of the common thermometer and barometer were made at 10 A.M. and 10 P.M. instead of eight o'clock, as formerly. From 1822 the observations included the maximum and minimum temperature.

18. These observations were continued until 1850 inclusive, by Mr Adie or some member of his family. But it is important to observe, that from the middle of May 1831 to the middle of May 1838, the locality was removed to No. 9 Regent Terrace, on the Calton Hill, in the new town of Edinburgh, 246 feet above the sea, about five furlongs N.E. from his first station in Merchant Court, but in a far opener and more airy situation. In 1838 the old residence at Canaan Cottage was resumed.

19. Thus we have consecutive observations from 1795 to 1804 both inclusive; and again consecutive observations from 1821 to 1850 both inclusive, at two localities distinct from the former. The changes of locality and exposure are no doubt unfavourable to the perfect comparability of these observations. Nevertheless the considerable continuity of the observations in each locality enables me to affirm, after comparing the mean results, that the change of position (the

* See Sir D. BREWSTER's Memoir on the Mean Temperature of the Globe (Edin. Trans. vol. ix. pp. 209, 210), where also the mean temperature is deduced from Mr JARDINE's observations on the springs of the Pentland Hills to be 47°·1.

† Edinburgh Journal of Science, vol. i. In later volumes it is stated at 300 feet, but this is certainly too high. By the Ordnance Survey Map it would appear to be about 280 feet.

height above the sea not having materially varied) has very slightly, if at all, affected the indications of the thermometer.

20. The observations are recorded in seven quarto paper books, all apparently original. My attention has been almost entirely confined to the *thermometrical* observations, though I have also used the monthly totals of the rain-fall which were first collected by Mr JOHN ADIE.

21. My first business was to obtain the mean temperature of each day of the forty years' observations. This was done with great care by Mr GRASSICK, clerk in Messrs ADIE and SON's establishment. For the ten and a half years, 1795–1805, the mean of the eight o'clock morning and evening observations of the thermometer was taken and entered in vertical columns under each day of the year.

22. Beginning with 1822, the mean of the maximum and minimum temperature is taken to represent the mean of the day; for 1821 *only* the mean of the 10 A.M. and 10 P.M. observations was used. I have not attempted any correction for the more accurate estimation of the mean temperature than is given by these several times of observation. They are known all to coincide closely with the mean in the long-run. The degree of coincidence of the mean of the 10 A.M. and 10 P.M. observations with the mean of the maxima and minima may be appreciated by an examination of Mr ADIE's printed registers in the Edinburgh Journal of Science. As a *general* rule, I am averse to the application of corrections to particular meteorological data, depending upon averages merely, because they fail to reproduce the very peculiarities of which we may be in search. In deducing probable results for the climate at one place from that at a neighbouring locality, the possible error arising from such corrections must be submitted to. But in most other cases I prefer using, when admissible, those observations in their pure and simple form which give most nearly the mean temperature of the day (omitting any others) to applying to individual results any considerable correction or factor derived from long averages merely. Such corrections may, if wished, be easily applied to the *final average* of a long course of observations, to which alone they are strictly applicable.

23. The sums and means of each column (Art. 21) of daily mean temperature were taken for four periods of ten years each, into which the whole of Mr ADIE's observations were divided; viz., for the periods 1795–1804, 1821–30, 1831–40, 1841–50. The total averages were then taken.

24. In like manner, the monthly averages for each year were taken, and the whole combined in the usual way. The mean temperature of the month, for each period of ten years, was first taken by the mean of the averages for each day of the month (or means of the vertical columns), and again, by the mean of averages of the months for each year separately.

25. Another check on the accuracy of the computer was obtained by the circumstance that Mr ADIE had already, in by far the majority of instances, taken the means himself. Mr GRASSICK's calculations were made independently of these

determinations, and where any discrepancy appeared, the cause was carefully sought out.

26. Farther, the accuracy of the copy from the original registers, and of each part of the calculations, was tested in a great many instances (taken at random) by Mr BALFOUR STEWART (now of Kew Observatory), in whose exactness I have the utmost confidence. Although some errors were thus detected, they were not sufficiently numerous or important to shake my confidence in the care with which the reductions had been made, but rather indeed confirmed it.

27. I ought to add, that the observations were all made with instruments manufactured by Mr ADIE himself, and certainly equal in accuracy to any then constructed. I have not been able to ascertain when or how often the thermometers were renewed. We must therefore rely on their general exactness, without attempting a correction for index error.

28. The thermometers were commonly read to whole degrees merely. Consequently, in taking the mean temperature of the day from two observations, we have not usually to do with any fractions differing from 0°·5. To save room, I have adopted, in the MS. calculations, a plan which may be usefully employed in all such cases. I have written such a temperature as 52·5 thus, 52˙, and have allowed for these half degrees in making the summations. Where *quarter degrees* occurred, the nearest *whole* degree was written, and this little error is evidently self-compensatory in the long-run.

SECT. 3. *On the Annual and Monthly Mean Temperatures of Edinburgh for Fifty-six years.*

29. A peculiar interest attaches to long-continued series of thermometrical observations in one locality. When made by one observer, and with comparable instruments, the interest is greatly heightened. We then see clearly the great extent of what M. DOVE calls the "Non-periodic fluctuations" of temperature, and the great length of time required to attain any certainty, even as to the precise mean temperature of a place, still more the peculiarities of the inflection of the diurnal and annual curves of temperature.

30. A slight inspection of M. DOVE's large collection of monthly average temperatures,* will show in how few instances anything like fifty years of continuous thermometrical observations can be depended on. The interesting deductions by M. QUETELET from his own perfectly comparable observations at Brussels for only twenty years, show how much may be done to reduce the apparently lawless changes of climate to order, by the judicious combination of long averages.† I have kept M. QUETELET's reductions in view, in the course of those which follow.

* See his Memoirs in the Berlin Transactions. In the Index to these which I have made and printed in the Edinburgh Transactions, vol. xxii. p. 75, I have indicated by an asterisk the stations where the observations have been most continuous.

† Mem. de l'Acad. de Bruxelles, tom. xxviii. Paper read June 1853.

31. The unfortunate blank in Mr ADIE's observations from 1805 to 1820 inclusive, detracted considerably from their interest, and I used every effort to discover some other register which might be used to supply the defect. None from the immediate neighbourhood of Edinburgh, however, appeared. But my attention was directed by M. DOVE's summaries to a register of twenty years' continuance, kept at Dunfermline by the Rev. Mr FERGUS, which extended over the missing years, and which farther indicated a climate remarkably agreeing with that of Edinburgh, not only in the annual mean, but in the partition of temperature throughout the seasons.

32. The town of Dunfermline lies thirteen miles in a right line to the N.W. of Edinburgh. It is little more than three miles distant from the estuary of the Forth, and about 300 feet above its level. I shall detail in a short paper on the climate of Dunfermline, following the present one, the fortunate circumstances which put me in possession of Mr FERGUS's original registers, extending over a period nearly equal to those of Mr ADIE.

33. In order to reduce the Dunfermline temperatures to those of Edinburgh, I selected the ten years 1821–30, during which observations were made contemporaneously at both places; and taking the monthly means, and averaging the differences for each month of the year, I obtained the following numbers for the reduction of the Dunfermline monthly mean temperatures at 9 A.M., to those of Edinburgh (mean of maxima and minima):—

January, . . .	−0°·61	July, ...	+0°·32
February, . . .	+0·19	August, . . .	+0·67
March, ...	+1·46	September, . . .	+1·20
April, ...	+1·08	October, . . .	+0·71
May, ...	+0·66	November, . . .	+0·11
June, ...	0·00	December, . . .	−0·29

If these corrections be projected, an annual curve passes very fairly through them, indicating two maxima in March and September, and two minima in June and December.

34. The corrections derived from the table above were employed to reduce the Dunfermline observations of the years 1805–20 (deficient in Mr ADIE's series) to Edinburgh. It is to be observed, that these corrections are irrespective of the error of either thermometer, and merely reduce the readings of the one to those of the other. I have distinguished the derived observations in the following table by the letter D. While I neither claim for them the original worth and precision of Mr ADIE's observations, nor rely too much on the universal application of the reductions from one locality to another, I believe that they will be found to indicate in a trustworthy manner the specific characters of those seasons which would otherwise have been defective in the series.

TABLE I.—Mean Monthly Temperature at Edinburgh for 56 Years.

N.B.—The numbers followed by D are deduced from the Dunfermline Observations.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Annual Means.
	°	°	°	°	°	°	°	°	°	°	°	°	°
1795,	30·03	30·43	37·26	44·20	48·88	52·30	57·32	59·19	56·98	50·24	37·80	43·40	45·67
1796,	44·11	40·03	38·27	48·43	48·17	55·35	56·67	59·17	54·30	43·75	38·26	31·03	46·46
1797,	39·58	42·26	38·93	43·68	50·62	53·08	58·88	57·04	51·03	43·58	38·50	38·74	46·33
1798,	37·09	37·50	39·35	48·13	53·40	61·36	59·79	58·70	53·45	47·41	39·13	35·72	47·59
1799,	36·20	34·87	36·82	39·65	47·3*	54·18	57·05	55·43	52·63	44·51	40·30	34·30	44·44
1800,	34·53	34·69	36·79	45·00	49·06	54·48	60·72	59·31	53·68	46·32	38·70	35·12	45·70
1801,	37·77	38·21	39·90	43·95	50·61	56·58	56·95	60·21	55·75	48·61	39·01	32·53	46·67
1802,	37·12	36·57	40·66	45·90	48·45	55·83	55·93	59·72	54·73	49·14	41·10	37·16	46·86
1803,	35·19	36·82	41·05	46·20	49·89	55·26	62·74	58·32	51·06	46·66	38·48	37·91	46·63
1804,	39·77	35·22	37·17	41·82	53·98	59·26	58·87	57·93	57·10	49·26	41·65	35·68	47·31
1805,	37·08	37·10	42·53	46·08	48·00	54·60	60·4 D	60·32	56·5 D	46·5 D	43·5 D	36·3 D	47·41 D
1806,	35·0 D	37·8 D	41·6 D	45·9 D	52·7 D	57·8 D	58·7 D	58·9 D	55·1 D	50·4 D	44·5 D	40·7 D	48·26 D
1807,	37·1 D	36·8 D	36·8 D	44·6 D	50·0 D	54·9 D	61·9 D	59·5 D	48·5 D	49·0 D	34·1 D	36·7 D	45·82 D
1808,	35·8 D	36·2 D	40·8 D	42·4 D	53·6 D	57·9 D	62·8 D	59·6 D	54·0 D	43·8 D	40·0 D	36·1 D	46·91 D
1809,	31·1 D	38·9 D	43·4 D	41·3 D	53·4 D	54·7 D	57·7 D	56·8 D	54·1 D	52·3 D	41·0 D	36·8 D	46·80 D
1810,	37·1 D	36·1 D	37·9 D	45·1 D	46·6 D	57·1 D	56·8 D	58·3 D	55·2 D	49·7 D	39·5 D	35·8 D	46·26 D
1811,	34·1 D	37·5 D	43·7 D	45·4 D	51·2 D	54·2 D	58·2 D	55·8 D	53·9 D	50·8 D	42·9 D	36·2 D	47·00 D
1812,	35·5 D	39·5 D	37·1 D	40·5 D	49·1 D	54·4 D	55·6 D	56·1 D	53·9 D	47·3 D	39·6 D	35·3 D	45·32 D
1813,	35·9 D	40·0 D	44·2 D	43·9 D	48·3 D	55·7 D	58·0 D	56·9 D	53·8 D	44·7 D	38·8 D	37·6 D	46·48 D
1814,	27·7 D	35·8 D	39·4 D	48·3 D	48·6 D	52·6 D	58·4 D	56·8 D	54·5 D	45·6 D	39·1 D	35·7 D	45·21 D
1815,	33·4 D	41·1 D	43·0 D	46·0 D	50·9 D	55·1 D	57·6 D	57·0 D	53·5 D	47·9 D	37·2 D	34·1 D	46·40 D
1816,	35·2 D	35·3 D	38·2 D	41·0 D	49·4 D	53·4 D	54·8 D	54·5 D	51·3 D	46·6 D	38·5 D	35·4 D	44·46 D
1817,	38·0 D	39·5 D	39·7 D	44·7 D	45·9 D	54·1 D	56·3 D	54·1 D	53·8 D	42·6 D	44·2 D	35·4 D	45·69 D
1818,	36·9 D	36·5 D	38·2 D	40·7 D	50·0 D	59·0 D	59·7 D	56·2 D	52·9 D	52·4 D	46·9 D	39·7 D	47·42 D
1819,	37·6 D	36·6 D	42·2 D	45·1 D	49·3 D	54·0 D	57·9 D	61·7 D	53·5 D	46·1 D	37·3 D	34·0 D	46·27 D
1820,	31·6 D	40·0 D	40·7 D	46·8 D	50·2 D	54·0 D	57·3 D	55·9 D	51·8 D	44·3 D	42·1 D	38·7 D	46·11 D
1821,	38·29	39·21	41·40	47·58	46·50	52·15	56·87	57·55	56·46	49·89	42·60	40·80	47·44
1822,	39·05	40·58	43·74	45·53	52·45	59·22	58·05	57·00	50·31	47·79	44·05	36·11	47·82
1823,	31·06	34·41	40·52	42·40	51·34	53·27	56·40	55·58	51·92	44·85	44·56	37·32	45·30
1824,	39·89	39·03	39·64	45·22	50·08	56·65	59·89	57·22	54·56	45·76	40·73	38·42	47·26
1825,	39·09	38·96	41·19	46·58	50·72	56·70	61·40	60·06	56·91	50·14	38·51	37·97	48·19
1826,	33·19	41·75	41·84	46·76	51·79	61·28	61·98	60·98	54·63	49·92	38·75	41·06	48·66
1827,	35·42	33·98	40·06	45·05	50·77	56·15	58·45	55·24	54·98	50·13	42·80	42·24	47·11
1828,	39·45	40·09	42·87	45·23	51·22	56·86	57·63	56·98	54·51	48·47	44·88	43·34	48·46
1829,	32·08	38·77	39·68	41·90	51·64	56·35	56·55	54·05	50·30	45·93	39·53	35·97	45·23
1830,	34·32	36·03	44·21	46·63	49·74	51·98	57·72	52·68	52·15	48·51	42·35	35·45	45·98
1831,	34·69	38·68	42·29	45·01	48·80	50·30	59·39	60·10	55·28	52·97	40·38	41·85	47·48
1832,	39·13	40·55	41·82	45·80	48·68	55·88	57·71	57·36	54·05	49·74	41·43	40·55	47·72
1833,	34·69	39·52	38·87	44·41	55·82	55·55	58·87	54·55	52·96	48·93	41·76	40·30	47·19
1834,	41·42	40·50	42·89	45·05	52·26	56·88	59·26	58·37	54·02	48·85	43·18	42·22	48·74
1835,	37·88	39·62	40·56	44·63	48·96	54·31	57·55	59·09	52·21	45·63	42·40	38·80	46·80
1836,	38·09	37·15	39·64	42·78	50·87	55·93	56·00	54·93	49·55	45·08	39·76	38·93	45·73
1837,	34·97	38·88	34·78	38·93	47·98	56·00	59·61	55·59	51·70	49·22	40·07	40·97	45·72
1838,	30·63	29·82	39·13	41·14	46·04	54·53	59·15	56·87	53·53	47·39	37·93	40·53	44·72
1839,	35·50	37·85	38·24	43·50	49·13	55·75	58·63	56·56	53·41	47·37	42·31	38·08	46·36
1840,	39·23	37·47	41·13	48·36	48·32	55·11	55·93	59·14	51·40	46·29	41·65	36·58	46·72
1841,	33·43	37·87	46·48	45·35	52·03	53·86	56·35	57·30	54·41	44·56	38·98	38·92	46·63
1842,	34·98	40·02	42·51	46·00	51·68	57·08	56·25	59·93	55·10	45·42	40·93	45·59	47·96
1843,	39·42	34·28	42·32	45·63	47·13	52·20	58·78	57·90	57·10	44·89	44·13	47·70	47·62
1844,	41·16	35·77	41·40	49·66	48·82	55·05	56·89	55·55	53·15	47·08	43·26	32·98	46·73
1845,	36·56	35·21	36·80	45·11	48·13	56·81	55·09	55·82	54·25	49·37	43·38	38·77	46·27
1846,	42·06	44·85	42·68	44·73	53·18	61·60	59·43	59·90	59·30	48·19	44·85	34·39	49·60
1847,	35·95	35·84	42·03	43·35	50·59	55·86	61·77	57·56	51·48	48·95	45·56	39·72	47·39
1848,	33·64	40·07	41·56	44·06	55·48	54·93	59·18	54·06	53·75	46·61	40·23	40·45	47·00
1849,	37·09	42·41	42·58	42·71	51·03	52·91	56·75	57·01	52·41	44·85	41·78	36·64	46·51
1850,	31·50	41·75	42·37	46·36	48·29	58·45	59·11	56·82	52·36	47·49†	41·17†	38·57†	47·02
Mean of the whole,	36·15	37·90	40·55	44·65	50·18	55·55	58·28	57·41	53·66	47·50	41·00	37·98	46·75
Mean of the Edinburgh Observations only,	36·64	37·92	40·58	44·84	50·26	55·65	58·29	57·49	53·72	47·49	41·17	38·57	46·88

* Interpolated.

† Supplied from the Means.

35. With a view to trace more intelligibly the specific characters of the different seasons, and in the hope of perhaps distinguishing in them something of a periodic or recurring character, I had the whole of these monthly temperatures projected in the form of fifty-six annual curves of temperature. The result, however, does not seem at present to warrant the labour and expense of reducing and engraving them. Looking, however, in a general way at these curves, or at the numbers in the preceding table, we note three leading characteristics of any year. I. The mean temperature of the year, or the position of the line of abscissæ of the curve for that year. II. The annual range due to season. III. The earliness or lateness of the season, or the period of culmination of the curve for the year.* We shall consider these elements of climate more particularly.

36. I. *Mean Temperature of the Year.*—The mean of the whole period, deduced from nearly 35,000 observations, is 46°·75, or if we exclude the Dunfermline observations, 46°·88.†

The highest annual mean was that of 1846, amounting to, . . .	49°·60
The lowest was that of 1799, ...	44·44
The range,	5·16

The higher limit was nearly touched in 1826 and 1834; the lower limit in 1816 and 1838.‡ The following table contains the order of the years, taken with respect to mean temperature, beginning with the highest:—

TABLE II.—The Seasons arranged according to the Mean Temperature, beginning with the Highest.

1.	1846	8.	1822	15.	1805	22.	{1811	29.	1840	36.	1815	43.	1830	50.	1812
2.	1834	9.	1832	16.	1847	23.	{1848	30.	1801	37.	1839	44.	1807	51.	1823
3.	1826	10.	1843	17.	1804	24.	1808	31.	{1803	38.	1797	45.	1836	52.	1829
4.	1828	11.	1798	18.	1824	25.	1802	32.	{1841	39.	{1819	46.	1837	53.	1814
5.	1806	12.	1831	19.	1833	26.	{1809	33.	1849	40.	{1845	47.	1800	54.	1838
6.	1825	13.	1821	20.	1827	27.	{1835	34.	1813	41.	1810	48.	1817	55.	1816
7.	1842	14.	1818	21.	1850	28.	1844	35.	1796	42.	1820	49.	1795	56.	1799

* In the usual approximate expression for the annual curve of temperature represented by the curve of sines, where t is the temperature of any day of the year, x the time reckoned from the commencement of the year, then, $t = A + B \sin (x + u_1)$. The three constants, A, B, and u_1, refer to the three particulars specified in the text. The equation to the annual curve will be more fully considered farther on (in § 6).

† It will be seen how nearly this coincides with Mr Jardine's deductions from the temperature of springs, viz., 47°·08. (Art. 15, *note*).

‡ The mean temperature of Greenwich for seventy-nine years (1771–1849) is estimated by Mr Glaisher at 48°·29, or only 1°·54 above that of Edinburgh. The fluctuation of the mean annual temperature at Greenwich was 6°·2, or within the period of the Edinburgh observations (1795–1850) 5°·6. (Phil. Trans., 1850.)

37. II. *The Annual Range*, as roughly represented by the difference of the hottest and coldest months, varied from 30°·7 in 1814 to 17°·9 in 1836. The mean is 24°·1.* The importance of this element in estimating the character of any year with respect to temperature, is well illustrated by comparing the years 1826 and 1828, which stand third and fourth on the list of mean annual temperature; but whereas the former was the hottest summer recollected in Scotland, the last was remarkably the reverse, the annual mean being kept up by the mildness of both the preceding and following winter. Table III. contains the years arranged according to the amount of the Annual Range, where it will be seen that 1826 stands *fourth* in order, and 1828 *fifty-fifth.*

TABLE III.—The Seasons arranged according to the Difference of Hottest and Coldest Months, beginning with the Greatest Difference.†

1.	1814	8.	1801	15.	1847	22.	1837	29.	1811}	36.	1818	43.	1813	50.	1849
2.	1838	9.	1850	16.	1820	23.	1843	30.	1804	37.	1802	44.	1845	51.	1816
3.	1795	10.	1803	17.	1798	24.	{1827	31.	1844	38.	1839	45.	1824	52.	1821
4.	1826	11.	1846	18.	1848	25.	1829	32.	1806	39.	1822	46.	1835	53.	1834
5.	1796	12.	1808	19.	1831	26.	1815	33.	1841	40.	1799	47.	1817	54.	1832
6.	1807	13.	1809	20.	1823	27.	1833	34.	1825	41.	1840	48.	1812	55.	1828
7.	1819	14.	1800	21.	1842	28.	{1805	35.	1830	42.	1810	49.	1797	56.	1836

38. It may be interesting to classify the years in the order of the mean temperature of the *hottest month*, distinguishing which month that is, as in the following Table:—

TABLE IV.—Containing the Mean Temperature of the Hottest Month in each Year.

1808	62°·8	July	1824	59°·89	July
1803	62·74	July	1802	59·72	August
1826	61.98	July	1818	59·7	July
1807	61·9	July	1837	59·61	July
1847	61·77	July	{1804	59·26	June
1819	61·7	August	{1834	59·26	July
1846	61·60	June	1822	59·22	June
1825	61·40	July	1795	59·19	August
1798	61·36	June	1848	59·18	July
1800	60·72	July	1796	59·17	August
1805	60·4	July	1838	59·15	July
1801	60·21	August	1840	59·14	August
1831	60·10	August	1850	59·11	July
1842	59·93	August	1835	59·09	August

* According to Mr Glaisher, the mean difference of the hottest and coldest months at Greenwich for 79 years (1771–1849) is 28°·5, varying from 37°·1 to 21°·3. The climate of Greenwich is therefore more extreme than that of Edinburgh. The mean temperature of January is nearly a degree higher at Edinburgh than at Greenwich.

† In this Table the months in all cases belonged to the same Calendar Year.

TABLE IV. (*continued.*)

1806	58°·9	August	1821	57°·55	August
1797	58·88	July	{ 1820	57·3	July
1833	58·87	July	{ 1841	57·30	August
1843	58·78	July	1799	57·05	July
1839	58·63	July	1849	57·01	August
1827	58·45	July	1844	56·89	July
1814	58·4	July	1845	56·81	June
1810	58·3	August	1829	56·55	July
1811	58·2	July	1823	56·40	July
1813	58·0	July	1817	56·3	July
1830	57·72	July	1812	56·1	August
1832	57·71	July	1836	56·00	July
1809	57·7	July	1816	54·8	July
1828	57·63	July			
1815	57·6	July	Mean of the whole, 58°·91		

From whence it appears, that in 56 years June was five times the hottest month, July thirty-six times, and August fifteen times.*

39. If we make a similar comparison for the coldest month of the year, we shall find it to range over no less than five calendar months from November to March. In the following Table it is to be observed, that when November or December is set down as the coldest month, it means that it was colder than the immediately *succeeding* January, February, or March. [In Tables III. and IX. the monthly ranges are those strictly included within the year.]

TABLE V.—Containing the Mean Temperature of the Coldest Months of each Winter.

1814	27°·7	January	1843	34°·28	February
1838	29·82	February	1799–1800	34·30	December
1795	30·03	January	1830	34·32	January
1796–7	31·03	December	1846–7	34·39	December
1823	31·06	January	{ 1831	34·69	January
1809	31·1	January	{ 1833	34·69	January
1850	31·50	January	1837	34·78	March
1820	31·6	January	1799	34·87	February
1829	32·08	January	1842	34·98	January
1801–2	32·53	December	1806	35·0	January
1844–5	32·98	December	1800–1	35·12	December
1826	33·19	January	1803	35·19	January
1815	33·4	January	1804	35·22	February
1841	33·43	January	1812–13	35·3	December
1848	33·64	January	{ 1816–17	35·4	December
1827	33·98	February	{ 1817–18	35·4	December
{ 1807–8	34·1	November	{ 1812	35·5	January
{ 1811	34·1	January	{ 1839	35·50	January
{ 1815–6	34.1	December	1804–5	35·68	December

* Reducing Mr Glaisher's numbers for Greenwich in proportion to the number of years, they would give—June 3½, July 33, August 17½, September 2. The maximum occurs, therefore, later at Greenwich that at Edinburgh.

Table V. (*continued.*)

1844	35·77	February	1795–6	37·80	November
1810	36·1	February	1835	37·88	January
1819	36·6	February	1821	38·29	January
1807	36·8	Feb. and March	1824–5	38·42	December
{ 1798	37·09	January	1845–6	38·77	December
{ 1849	37·09	January	1822	39·05	January
1836	37·15	February	1832	39·13	January
1823–4	37·32	December	1828	39·45	January
1840	37·47	February	1833–4	40·30	December

40. Thus it appears that out of fifty-six winters, the lowest monthly mean temperature occurred twenty-seven times in January, fifteen times in December, ten and a half times* in February, twice in November (in 1795 and 1807), and one and a half times in March (in 1807 and 1837).†

41. III. *The Epoch of Highest Temperature* mainly determines the earliness or lateness of the season. It is well known that in these latitudes the mean epochs of greatest heat and cold are, on a long average of years, nearly six months apart.‡ But in any given year, the fluctuations of temperature in winter are so irregular, as to make it very difficult to define the inferior culmination of the curve of temperature. I employ, therefore, the position of the maximum, as deciding the character of the season with respect to earliness or lateness. This has been approximately determined by a very simple process of approximation, which I used in my paper on the Temperature of the Earth at Different Depths.§ The rule is as follows:—"Calling A the excess of the mean temperature of the hottest month above the *preceding* month, B the excess of the mean temperature of the hottest above the *following* month; Then $15 \times \frac{A-B}{A+B}$ is the number of days $\pm$ that the hottest day of the year {follows / precedes} the 15th day of the hottest month."

42. The results of this (merely approximate) estimate will be given in a future table (see Table IX. col. 5, below). In the meantime, the following is the classification of the seasons, as early or late. The earliest date was June 22d in 1845, the latest August 14th in 1795.

* When the temperature of February and March was the same, as in 1807, then one-half is the proportion for each.

† Mr Glaisher's numbers for Greenwich would give for a like number of years, January 30, December 15, February 10, March 1, November 0.

‡ See Quetelet on the Climate of Brussels, and § 6 of the present paper.

§ Edin. Trans., vol. xvi. p. 216.

TABLE VI.—The Seasons arranged as Early or Late by the date of Summer Maximum.

1.	1845*	8.	1818	15.	1817	22.	1808	29.	1797	36.	1815	43.	1849	50.	1796
2.	1846*	9.	1850	16.	1824	23.	1799	30.	1807	37.	1816	44.	1831	51.	1810
3.	1798	10.	1826	17.	1828	24.	1803	31.	1834	38.	1823	45.	1812	52.	1821
4.	1822	11.	1827	18.	1830	25.	1811	32.	1809	39.	1832	46.	1835	53.	1801
5.	1804	12.	1833	19.	1839	26.	1813	33.	1814	40.	1843	47.	1841	54.	1802
6.	1836	13.	1837	20.	1844	27.	1838	34.	1825	41.	1805	48.	1819	55.	1842
7.	1829	14.	1848	21.	1847	28.	1820	35.	1800	42.	1806	49.	1840	56.	1795

Sect. 4. *On the Annual and Monthly Fall of Rain at Edinburgh for Thirty-eight years.*

43. Mr Adie appears always to have paid great attention to the amount of rain.

44. The rain-gauge used by him was a metal funnel, about 6½ feet above the ground, with a glass tube connected with it, and a stop-cock, by means of which the depth of rain was at once indicated.†

45. The following Table contains the monthly results for thirty-eight complete years, and part of two others. I have been unable to find a comparable register for the years omitted; but even had one existed for a neighbouring locality, the seemingly capricious variations of this element of climate would make it hazardous to attempt any arbitrary reduction from one spot to another:—

* In these two years, and also in 1810, there is some ambiguity owing to a double maximum occurring in June and August. In 1845 and 1846, at least, the effective maxima must be held to have occurred in July.

† Mr Alexander J. Adie has favoured me with the following information about his father's rain-gauges:—"*Linlithgow, 14th March* 1859.—My belief is, that there were but two gauges used in all the time the register was kept, and that the one still standing in the garden at Canaan Cottage was the only one used after that at Merchant Court was broken up. The second gauge is about 6½ feet above the ground, and of the ordinary form of the funnel mouth, with the glass tube and scale at the side. Falls of snow were taken by pushing down a cylinder through the snow in an open place, melting it, and measuring the depth of water for the fall had it been in rain."

TABLE VII.—MONTHLY FALL OF RAIN AT EDINBURGH.

Year.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.	In.
1795	2·81	3·87	1·37	3·01	1·20	3·92	2·42	3·62	1·12	4·87	4·58	3·81	36·60
1796	3·28	1·40	·43	1·09	1·43	1·03	2·77	·45	2·21	1·19	1·31	1·06	17·65
1797	1·32	·67	1·20	1·47	1·96	2·18	5·19	4·50	2·99	3·24	1·20	1·26	27·18
1798	1·80	·55	1·52	1·56	1·62	2·53	2·10	2·99	2·28	2·15	2·07	1·41	22·58
1799	·89	1·57	·47	2·15	3·27	·87	2·60	5·66	4·02	1·99	1·79	1·23	26·51
1800	3·26	·49	1·34	2·05	2·50	·53	·40	1·26	2·53	3·33	·98	2·91	21·58
1801	1·75	1·44	·82	·60	1·99	·20	5·25	·88	2·66	1·59	1·06	2·17	20·41
1802	·71	1·87	·69	·73	·86	2·21	4·19	2·13	2·37	2·43	2·09	1·02	21·30
1803	·80	1·56	·74	1·16	1·13	1·35	·86	2·00	1·82	1·00	2·26	1·13	15·81
1804	3·72	·57	2·58	2·04	1·58	1·32	1·86	3·91	·74	2·37	1·92	1·96	24·57
1805	·65	1·58	......	·64	1·01	1·38	......	2·83	......	......	......	......	......
1822	1·23	2·50	3·57	1·41	1·80	1·36	4·53	2·36	1·27	2·39	2·12	1·60	26·14
1823	2·23	3·85	·66	1·68	2·35	1·	4·25	3·87	1·82	3·10	1·07	4·38	30·26
1824	·87	1·70	1·34	·57	·63	2·01	1·58	1·50	1·62	4·73	4·38	3·88	24·81
1825	1·31	·69	·43	1·41	3·25	2·05	·15	1·89	2·85	2·19	3·91	1·99	22·12
1826	·55	1·77	1·33	1·52	1·25	·30	2·31	1·83	1·01	1·38	·76	1·26	15·27
1827	3·33	1·58	4·84	2·74	1·28	1·62	2·27	4·89	1·15	4·97	1·02	2·90	32·59
1828	1·70	·98	1·18	1·42	1·85	·81	4·57	3·43	2·31	·86	3·94	2·18	25·23
1829	2·49	1·61	·32	3·35	·77	2·03	4·48	6·80	1·77	2·53	2·48	1·33	29·96
1830	·95	1·21	1·78	2·28	1·96	2·54	6·57	6·69	3·63	·16	3·13	2·35	33·25
1831	·66	3·88	1·97	1·54	·69	1·41	2·44	4·03	1·55	2·15	2·95	1·26	24·53
1832	·61	1·42	1·29	1·21	1·35	2·89	1·14	3·64	·92	5·53	·95	2·28	23·23
1833	·57	2·53	1·43	1·34	·79	3·48	1·53	1·16	2·37	1·13	·71	3·84	20·88
1834	3·28	·86	1·65	·44	·51	1·45	3·20	1·18	4·50	1·23	1·22	1·52	21·04
1835	1·08	2·48	2·28	·79	2·04	1·02	1·37	1·99	5·43	2·09	2·76	1·89	25·22
1836	4·06	1·62	3·79	1·54	·56	2·50	6·53	2·45	2·81	1·66	3·05	2·46	33·03
1837	1·23	2·14	1·28	1·61	1·53	2·86	4·54	4·13	1·73	2·02	2·03	1·67	26·77
1838	2·47	1·21	2·76	1·78	2·90	5·16	2·45	2·97	4·00	1·55	3·06	·73	31·04
1839	1·76	1·45	1·47	·33	·47	3·91	3·51	1·77	3·09	2·38	1·65	1·66	23·45
1840	3·72	1·58	·43	·19	3·97	2·75	3·46	1·99	2·39	2·01	2·33	·68	25·50
1841	1·23	1·64	·60	1·14	1·14	1·56	3·87	3·64	2·63	4·53	2·28	1·96	26·22
1842	1·01	1·11	3·44	·15	1·45	·97	1·53	1·36	1·45	·98	1·63	1·79	16·87
1843	1·69	1·38	·99	1·87	2·99	2·26	3·59	1·40	·89	4·20	2·20	·34	23·80
1844	1·23	1·72	2·42	·40	·15	2·71	2·39	2·11	2·70	·82	3·92	·37	20·94
1845	1·77	·61	1·67	·40	2·24	3·08	1·72	3·48	1·77	6·14	1·70	2·04	26·62
1846	2·64	1·60	·97	2·88	1·27	3·59	4·17	5·01	3·35	3·60	1·74	·72	31·54
1847	·51	·79	·13	1·25	4·77	1·79	1·37	·91	1·25	3·48	1·64	4·88	22·77
1848	1·26	5·21	2·80	1·06	·60	6·04	1·36	2·00	1·45	4·56	2·42	1·84	30·60
1849	2·84	·97	1·05	1·64	1·66	2·45	2·58	2·31	2·02	1·74	1·50	1·45	22·21
1850	1·62	2·84	·14	·88	3·14	1·18	1·63	2·20	1·83	......	......	......	......
Means,	1·77	1·71	1·51	1·38	1·69	2·10	2·89	2·83	2·26	2·58	2·15	1·92	25·00*
	TOTAL, 24·79.												

* For 38 *complete* years.

46. The average rain-fall at Edinburgh is therefore exactly 25 inches, ranging from 36·60 in 1795 to 15·27 in 1826. The order of the seasons from Wet to Dry is shown in the following Table for the years which are complete:—

TABLE VIII.—The Seasons arranged from Wet to Dry.

1.	1795	8.	1823	15.	1822	22.	1843	29.	1800	36.	1842	The years are from 1795–1804, and from 1822–1849 inclusive.
2.	1830	9.	1829	16.	1840	23.	1839	30.	1802	37.	1803	
3.	1836	10.	1797	17.	1828	24.	1832	31.	1834	38.	1826	
4.	1827	11.	1837	18.	1835	25.	1847	32.	1844	...	...	
5.	1846	12.	1845	19.	1824	26.	1798	33.	1833	...	...	
6.	1838	13.	1799	20.	1804	27.	1849	34.	1801	...	...	
7.	1848	14.	1841	21.	1831	28.	1825	35.	1796	...	...	

47. The means of the columns of Table VII. show the following averages of rain-fall according to the season:—

Winter.	Inch.	Inch.	Spring.	Inch.	Inch.	Summer.	Inch.	Inch.	Autumn.	Inch.	Inch.
Dec.	1·92	5·40, or 21·8 per cent.	Mar.	1·51	4·58, or 18·4 per cent.	June,	2·10	7·82, or 31·6 per cent.	Sept.	2·26	6·99, or 28·2 per cent.*
Jan.	1·77		April,	1·38		July,	2·89		Oct.	2·58	
Feb.	1·71		May,	1·69		Aug.	2·83		Nov.	2·15	

48. It thus appears that at Edinburgh spring is decidedly the driest, and summer decidedly the wettest, quarter of the year. If we project the monthly results, we obtain a pretty regular curve, showing a minimum about the middle of April, and a maximum about the end of July, but October has a slight maximum of its own. Of individual rainfalls, Mr Adie noted, on the 18th November 1795, 2·89 inches within 24 hours; on the 30th July 1797, 2·63 inches; and on the 18th August 1797, 2·56 inches, nearly the whole of which fell within 6 hours from 2 to 8 p.m.

Sect. 5. *General Remarks on the Succession of the Seasons for the period* 1796–1850 *and their Extremes.*

49. The following Table contains a concise view of the succession of the seasons from 1795 to 1850. It is difficult to trace any periodic recurrence of good and bad seasons, although it is very plain that they happen for the most part in groups of usually from seven to ten or twelve years' duration.† This is well seen by the third column of Table IX., showing the annual deviations of the

* The sum total at all seasons is 24·79 inches, which is slightly below the average of 38 *complete* years given above. This arises from the partial observations of 1805 and 1850 (which are below the average) being included in the monthly means.

† There is a slight appearance (from Table IX. column 2) of alternate ten-year periods below and above the mean, commencing in 1793 or 1794, and terminating in 1852 or 1853,—

The maxima would be 1809, 1829, 1849.
The minima would be 1799, 1819, 1839.

mean temperature from the average of fifty-six years. The succeeding columns show, *First*, the range of the monthly means within one and the same year. *Secondly*, the approximate date of the maximum temperature of summer, deduced from the monthly means, on which some remarks have already been made in Art. 41. *Thirdly*, the highest and lowest *mean temperature of any day* in each year, with the dates (the Dunfermline observations not included). *Fourthly*, the *extreme* temperatures occurring in any year, with the dates (confined to the period for which self-registering instruments were used). The highest individual temperature noted in the twenty-eight years 1822–1850, was 87°, on the 24th and 26th June 1826, and on the 17th June 1839; and the lowest, 5°, occurred on the 31st January 1845 and the 29th January 1848.

50. It will easily be seen that the second, fourth, and fifth columns afford the means of supplying the approximate constants for the curve of each year denoted by A, B, and u_1, in the note to Art. 35, and in § 6, below. It might be wished that these constants were compared in several moderately distant localities (for example over Europe), to see how far the characteristic features of any season may be held to extend. By this means it might even be possible, after ascertaining the proportional constants for each season, to infer the characters of the climate of any locality from a few years' observation only. Even were this method applicable to so limited an area as that of Great Britain, it might be of great use in generalizing meteorological results.

TABLE IX.—Showing the General and Extreme Characters of each Season.

Year.	Mean Temp.	Deviation from the Mean.	Diff. Hottest and Coldest Months.	Calculated Time of greatest Heat.†	Highest Mean Daily Temp.	Date.	Lowest Mean Temp.	Date.	Difference or Range.	Extreme Heat.	Date.	Extreme Cold.	Date.	Extreme Range.
	°	°	°		°		°		°	°		°		°
1795	45·67	−1·08	29·16	Aug. 14	68·5	Aug. 12 …	16·5	Jan. 29 …	52·	…	…	…	…	…
1796	46·46	−0·29	28·14	Aug. 10	68·	June 30 …	18·5	Dec. 24 …	49·5	…	…	…	…	…
1797	46·33	−0·42	20·38	July 22	67·5	July 14 …	24·	Nov. 29 …	43·5	…	…	…	…	…
1798	47·59	+0·84	25·64	June 25	69·	June 28 …	21·5	Dec. 28 …	47·5	…	…	…	…	…
1799	44·44	−2·31	22·75	July 19	67·	June 21, 22	20·	Dec. 31 …	47·	…	…	…	…	…
1800	45·70	−1·05	26·19	July 24	70·	July 24 …	23·	Dec. 30 …	47·	…	…	…	…	…
1801	46·67	−0·08	27·68	Aug. 13	69·	Aug. 19 …	25·	Dec. 19 …	44·	…	…	…	…	…
1802	46·86	+0·09	23·15	Aug. 13	67·	Aug. 17 …	24·5	Jan. 1, 6, 7	42·5	…	…	…	…	…
1803	46·63	−0·12	27·55	July 19	77·	July 18 …	19·5	Jan. 13 …	57·5	…	…	…	…	…
1804	47·31	+0·56	24·04	June 28	66·	Sept. 14 …	21·	Feb. 7, D^{c} 31	45·	…	…	…	…	…
1805	47·41	+0·66	24·1	July 30	…	…	…	…	…	…	…	…	…	…
1806	48·26	+1·51	23·9	Aug. 1	…	…	…	…	…	…	…	…	…	…
1807	45·82	−0·93	27·8	July 22	…	…	…	…	…	…	…	…	…	…
1808	46·91	+0·16	27·0	July 18	…	…	…	…	…	…	…	…	…	…
1809	46·80	+0·05	26·6	July 23	…	…	…	…	…	…	…	…	…	…
1810	46·26	−0·49	22·5	Aug. 10	…	…	…	…	…	…	…	…	…	…
1811	47·00	+0·25	24·1	July 19	…	…	…	…	…	…	…	…	…	…
1812	45·32	−1·43	20·8	Aug. 6	…	…	…	…	…	…	…	…	…	…
1813	46·48	−0·27	22·1	July 20	…	…	…	…	…	…	…	…	…	…
1814	45·21	−1·54	30·7	July 23	…	…	…	…	…	…	…	…	…	…
1815	46·40	−0·35	24·2	July 24	…	…	…	…	…	…	…	…	…	…
1816	44·46	−2·29	19·6	July 25	…	…	…	…	…	…	…	…	…	…
1817	45·69	−1·06	20·9	July 15	…	…	…	…	…	…	…	…	…	…
1818	47·42	+0·67	23·2	July 5	…	…	…	…	…	…	…	…	…	…
1819	46·27	−0·48	27·7	Aug. 9	…	…	…	…	…	…	…	…	…	…
1820	46·11	−0·64	25·7	July 21	…	…	…	…	…	…	…	…	…	…
1821	47·44	+0·69	19·26	Aug. 11	67·5	July 19 …	17·	Jan. 3 …	50·5	…	…	…	…	…
1822	47·82	+1·07	23·11	June 26	65·5	June 5 …	25·	Dec. 28, 29	40·5	80	June 13 …	18	Dec. 28 …	62
1823	45·30	−1·45	25·34	July 25	66·	Aug. 11 …	19·	Feb. 5 …	47·	75	Aug. 11 …	11	Feb. 5 …	64
1824	47·26	+0·51	21·47	July 16	72·	Sept. 2 …	22·5	Dec. 5 …	49·5	85	Sept. 2 …	16	Dec. 5 …	69
1825	48·19	+1·44	23·43	July 23	70·5	July 14 …	27·	Jan. 5, F^{b} 4	43·5	83	July 30, 31	19	Nov. 10 …	64
1826	48·66	+1·91	28·79	July 12	74·	June 28 …	18·	Jan. 16 …	56·	87	June 24, 26	10	Jan. 16 …	77
1827	47·11	+0·36	24·47	July 12	63·5	J^{y} 16, S^{t} 16	19·	Jan. 3 …	44·5	77	July 16 …	14	Jan. 3 …	63
1828	48·46	+1·71	18·18	July 16	66·	June 27 …	23·	Jan. 11 …	43·	76	Aug. 27 …	15	Jan. 11 …	61
1829	45·23	−1·52	24·47	July 3	65·	Aug. 8 …	22·5	Jan. 22 …	42·5	75	July 13 …	15	Jan. 22, 25	60
1830	45·98	−0·77	23·40	July 16	68·	July 26 …	22·	Dec. 24 …	46·	81	July 28 …	15	Dec. 25, 26	66
1831	47·48	+0·73	25·41	Aug. 3	67·	July 29, 31	26·	Feb. 4 …	41·	76	July 31 …	19	Feb. 4 …	57
1832	47·72	+0·97	18·58	July 25	65·	Aug. 10 …	29·5	Jan. 3, 27	35·5	75	Aug. 10 …	24	Jan. 27 …	51
1833	47·19	+0·44	24·18	July 13	67·5	July 28 …	27·	Jan. 15 …	40·5	75	July 17, 29	23	Jan. 16 …	52
1834	48·74	+1·99	18·76	July 22	68·5	Aug. 12 …	31·	F^{b} 21, N^{v} 24	37·5	77	Aug. 12 …	20	Mar. 24 …	57
1835	46·80	+0·05	21·21	Aug. 6	66·5	Aug. 11 …	28·	Jan. 20 …	38·5	77	Aug. 4, 10	22	Jan. 21 …	55
1836	45·73	−1·02	17·91	July 2	65·	June 15 …	28·	Dec. 26 …	37·	76	June 15 …	24	Jan. 19 …	52
1837	45·72	−1·03	24·64	July 14	64·	July 6 …	23·	Jan. 11 …	41·	73	July 10 …	16	Jan. 12 …	57
1838	44·72	−2·03	29·33	July 20	68·5	July 12 …	18·	Jan. 21 …	50·5	84	Sept. 9 …	13	Feb. 13 …	71
1839	46·36	−0·39	23·13	July 17	66·5	June 17 …	24·	Feb. 21 …	42·5	87	June 17 …	13	Jan. 30 …	74
1840	46·72	−0·03	22·56	Aug. 9	67·5	Aug. 21 …	27·5	Dec. 24 …	40·	78	Aug. 9 …	21	J^{n} 30, F^{b} 27	57
1841	46·63	−0·12	23·87	Aug. 7	67·	Aug. 20 …	21·5	Jan. 9 …	45·5	79	June 10 …	8	Jan. 9 …	71
1842	47·96	+1·21	24·95	Aug. 13	68· ?	Aug. 13 ? …	26·5	Jan. 16 …	41·5	79	July 23 …	18	Jan. 16, 17	61
1843	47·62	+0·87	24·50	July 26	67·	July 14 …	24·	Feb. 15 …	43·	77	July 14 …	16	Feb. 15, 17	61
1844	46·73	−0·02	23·91	July 17	66·	July 22, 25	24·5	Feb. 21 …	41·5	77	Sept. 1 …	13	Feb. 27 …	64
1845	46·27	−0·48	21·60	June 22‡	69·	June 12 …	18·	Jan. 31 …	51·	79	June 12, 13	5	Jan. 31 …	74
1846	49·60	+2·85	27·21	June 24‡	71·5	June 5 …	25·5	Dec. 25 …	46·	84	June 5 …	16	Dec. 18 …	68
1847	47·39	+0·64	25·93	July 17	75·5	July 12 …	25·5	F^{b} 8, 9, D^{c} 31	50·	83	July 14 …	17	Feb. 8, 9	66
1848	47·00	+0·25	25·54	July 14	68·5	July 13 …	17·5	Jan. 29 …	51·	82	July 13 …	5	Jan. 29 …	77
1849	46·51	−0·24	20·37	Aug. 2	65·5?	July 10 ? …	20·	Jan. 2 …	45·5?	78	June 5 …	19	Jan. 4, 6 …	59
1850	47·02*	+0·27	27·61?	July 7	68·5	June 24 …	19·5	Jan. 17 …	49·	78	July 23 …	12	Jan. 18 …	66
Mean,	46·75	…	24·08		68·0	July 19·5	22·8	Jan. 11·9	45·2					

* Three months of 1850 are supplied from the general average of those months.

† Calculated by Formula of Art. 41.

‡ See Note to Table VI.

51. Table X. shows the succession of the seasons in a somewhat different form; the seasons being indicated as *Hot or Cold, Extreme or not, Summer Hot or Cold, Early or Late, Rainy or Dry.* The numbers affixed to any year, denote its Rank in those respects amongst all the years for which the observations were made. They are in fact the numbers in the Tables II., III., IV., VI., and VIII., arranged chronologically instead of quantitatively. The seventh column refers to the Price of Grain, which is considered in the concluding section of the present paper.

TABLE X.—Showing the Relative Characters of Fifty-six Successive Seasons in Chronological Order.

	Hot or Cold.	Summer, Hot or Cold.	Extreme or not.	Early or Late.	Rainy or Dry.	Oats, Cheap or Dear.		Hot or Cold.	Summer, Hot or Cold.	Extreme or not.	Early or Late.	Rainy or Dry.	Oats, Cheap or Dear.
1795	49	22	3	56	1	36	1823	51	52	20	38	8	38·5
1796	35	24	5	50	35	10	1824	18	15	45	16	19	28
1797	38	30	49	29	10	3	1825	6	8	34	33	28	32
1798	11	9	17	3	26	5	1826	3	3	4	10·5	38	48
1799	56	47	40	24	13	52	1827	20	34	24·5	10·5	4	24
1800	47	10	14	35·5	29	55	1828	4	42	55	17	17	34
1801	30	12	8	54	34	23	1829	52	51	24·5	7	9	21·5
1802	25	16	37	54	30	17	1830	43	39	35	18	2	38·5
1803	31·5*	2	10	24	37	26	1831	12	13	19	44	21	26
1804	17	19·5	30	5	20	34	1832	9	40	54	38	24	6
1805	15	11	28·5	41	...	...	1833	19	31	27	12	33	3
1806	5	29	32	42	...	38·5	1834	2	19·5	53	31	31	14
1807	44	4	6	30	...	51	1835	26·5	28	46	45·5	18	14
1808	24	1	12	22	...	47	1836	45	56	56	6	3	41
1809	26·5	41	13	33	...	53	1837	46	18	22	13·5	11	18
1810	41	36	42	51	...	29	1838	54	25	8	26·5	6	42
1811	22·5	37	28·5	24	...	45	1839	37	33	38	19	23	34
1812	50	54	48	45·5	...	54	1840	29	26	41	48·5	16	11·5
1813	34	38	43	26·5	...	43	1841	31·5	45·5	33	47	14	11·5
1814	53	35	1	33	...	31	1842	7	14	21	54	36	8
1815	36	43	26	35·5	...	7	1843	10	32	23	40	22	19
1816	55	56	51	38	...	49	1844	28	49	31	20	32	21·5
1817	48	53	47	15	...	45	1845	39·5	50	44	1†	12	38·5
1818	14	17	36	8	...	45	1846	1	7	11	2†	5	50
1819	39·5	6	7	48·5	...	26	1847	16	5	15	21	25	30
1820	42	45·5	16	28	...	20	1848	22·5	23	18	13·5	7	9
1821	13	44	52	52	...	16	1849	33	48	50	43	27	1
1822	8	21	39	4	15	14	1850	21	27	9	9	...	3

* When in this and the following columns two years are designated by the same number (whether whole or fractional), it indicates that they were *equally* hot, or extreme, or rainy (as the case may be), and the mean of the numbers is assigned to them which they would have had if there had been an inequality.

† These positions are not the true ones, for the reason assigned in the Note to Table VI. In both years, however, the actual highest temperature, both in the extremes and in the mean of the day and of the month, occurred in June.

SECTION 6. *On the Form of the Annual Curve of Temperature at Edinburgh, and on its Accidental Fluctuations.*

52. The method usually employed to represent the annual curve of temperature, is to take the mean temperature of the twelve separate months (each month being represented in extent by 30° or one-twelfth of an entire circumference), and to express them by a series of the form—

$$y_n = A + B \sin(30° \times n + u_1), + C \sin(30° \times 2n + u_2) + D (30° \times 3n + u_3), + \&c.$$

Where y_n is the temperature of any month whose number is n (reckoning January=0, February=1, &c.) Eliminating the constants (by the method given, for example, in DOVE's *Repertorium*, vol. ii. p. 275, or "Encyclopædia Britannica" (8th Edition), Art. *Meteorology*, p. 665, we obtain the following numerical formula:—

$$y_n = 46°{\cdot}88 - 10°{\cdot}83 \sin(30n + 83° 28') + 0°{\cdot}963 (60n + 52° 8'), + \&c.$$

(the fourth term is negligible, its greatest value being only 0°·104).

53. A comparison of this calculation with the observations collected in Table I. gives the following results:—

TABLE XI.

Month.	Temperature. Observed.	Temperature. Calculated.	Excess of Calculation.	Month.	Temperature. Observed.	Temperature. Calculated.	Excess of Calculation.
January,.....	36°·64	36°·88	+0°·24	July,.........	58°·29	58°·40	+0°·11
February,....	37·92	37·84	−0·08	August,......	57·49	57·70	+0·21
March,.......	40·58	40·53	−0·05	September,..	53·72	53·46	−0·26
April,........	44·84	44·89	+0·05	October,......	47·49	47·35	−0·14
May,.........	50·26	50·30	+0·04	November,...	41·17	41·68	+0·51
June,.........	55·65	55·45	−0·20	December,...	38·57	38·05	−0·52

54. Consequently, the mean temperatures *of the months* are satisfactorily represented by the formula. It is evident, however, that the annual curve drawn through the mean temperatures of the months will lie somewhat too low during the hotter part of the year, and too high in winter; in other words, the inflection of the curve will be too small. This arises from the fact that the *mean elevation* of a given number of points, which all coincide with the arc of a curve, will necessarily fall *within* the concavity of the curve, and the true curve will be external to the curve of the means, especially if the period embraced in the means be so considerable as thirty days.

55. The correction for this (which, I think, has not usually been made) is easily found, with sufficient approximation, as shown in the subjoined note.*

* Let A B C D be four points in the *true* annual curve which is sought, and which is assumed to be symmetrical on either side. It will be sufficient for a first approximation to assume that these points, so far as they are considered at one time, are situated in a parabolic arc, formed by daily temperatures horizontally equidistant from one another. The mean temperature of the month BC (for example) will lie at β, and not at b in the parabolic arc. In like manner α and γ are the tabular averages for the preceding and following months. We want to find the quantity $\beta\, b$, by

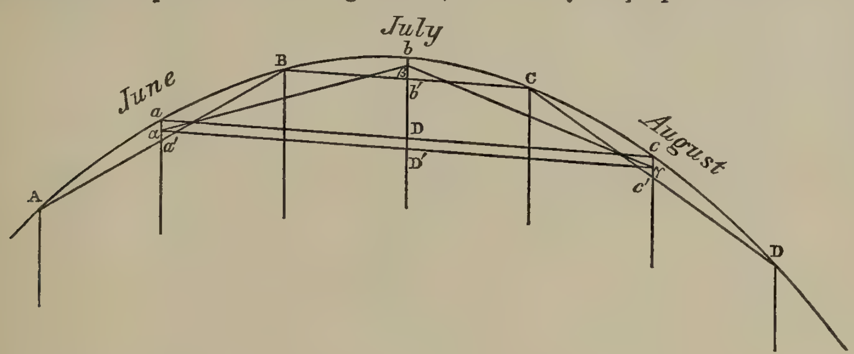
56. The greatest value of this correction of the numbers in the preceding table, in order to obtain the curve of daily mean temperature, is about 0°·15. As it will only be sensible in the second term of the equation of the annual curve, and as it tends to increase its co-efficient, this latter, instead of 10°·83, becomes 10°·98; and if we farther modify the angular constants of Art. 52, so as to adapt them to the beginning of the year as an origin, instead of the middle of January, the formula becomes (x being the distance of any day of the year from the beginning, in angular measure)—

$$y=46°·88-10°·98 \sin (x+68° 28')+0°·96 \sin (2x+22°).$$

57. If we consider the two first terms only of this formula, the hottest day will be the 23d July; if all three terms, it will be the 27th July. The coldest day in the former case would be the 22d January, or in the latter, the 17th January. The effect of the third term is therefore to shorten the period of declining temperature by about six days, and to increase the period of rise by the same quantity. The days corresponding to the mean temperature of the year shown by the geometric curve are the 28th April and the 18th October. The temperature is therefore above the mean for 173 days, and below it for 182 days.

58. We next proceed to compare this equation with the annual curve in detail, as derived from Mr ADIE's forty years' observations.

which the monthly mean is to be increased, in order to make it coincide with the temperature of the middle day of the month. β is the centre of gravity of the daily temperatures lying in the arc BC. Considering these daily temperatures as equally heavy points distributed uniformly with respect to a double ordinate BC parallel to the tangent at b, we have by the properties of the centre of gravity



$\beta b=\dfrac{\int p \cdot \frac{y^2}{2a}\, dy}{\int p \cdot dy}$; where the equation to the parabola is $y^2=2ax$, and where the weight of an individual observation is p. Hence we have $\beta b=\dfrac{y^2}{6a}=\dfrac{x}{3}$, where x is the abscissa $b\,b'$ intercepted by the chord or double ordinate BC. In like manner $\alpha a=\frac{1}{3}aa'$ and $\gamma c=\frac{1}{3}cc'$. But a, c, the points representing the middle of the preceding and following months, are 60 days apart, while B and C are only 30 days apart. Therefore bD$=4bb'$ and $\beta b=\frac{1}{12}b$D, which is equal (neglecting small quantities) to very nearly $\frac{1}{12}\beta$D'. So that the required correction is found by *increasing* the co-ordinate of temperature expressed by the periodic part of the equation in the text (+ or − as the case may be) at the middle day of each month by $\frac{1}{12}$ *of the difference between the mean temperature of the month and the average of the temperatures of the preceding and following months.*

TABLE XII.—Showing the Mean Temperature for every Day of the Year at Edinburgh, derived from Forty Years' Observations; also for each of Four Decennial Periods; also the Fluctuation in the Mean Temperature of each Day in Forty Years.

JANUARY.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1805, ...	34·0	34·9	36·4	39·2	38·5	37·0	36·0	35·7	36·5	35·2	34·7	35·2	37·4	37·1	37·2	39·8	39·6	39·1	39·7	39·7	38·4	37·9	38·0	37·4	36·7	38·2	36·0	36·3	35·7	37·8	35·0
1821—1830, ...	36·1	34·4	33·1	35·2	33·7	35·8	36·7	35·9	35·5	36·1	34·2	35·3	35·9	35·6	32·7	34·0	34·2	38·1	37·3	36·9	38·8	35·3	35·1	36·3	36·2	37·0	36·8	37·9	39·0	41·1	40·9
1831—1840, ...	37·5	37·6	38·6	38·4	37·4	36·6	36·4	36·9	36·1	34·4	35·0	35·8	37·3	36·4	34·6	35·5	35·7	37·3	36·8	36·2	36·0	37·5	39·7	39·1	37·9	36·7	36·1	36·3	34·6	34·1	35·5
1841—1850, ...	36·6	33·9	35·7	36·9	37·2	36·0	35·5	35·3	33·5	35·3	35·3	35·4	34·7	35·0	34·0	35·1	35·1	37·0	38·3	35·4	36·1	37·3	39·6	39·7	39·7	40·3	38·7	39·2	36·9	37·7	36·2
Mean, ...	36·10	35·24	35·99	37·46	36·72	36·37	36·17	35·96	35·42	35·26	34·80	35·46	36·36	36·06	37·15	36·14	36·15	37·91	38·05	37·05	37·34	37·01	38·12	38·15	37·64	38·07	36·92	37·45	36·57	37·69	36·94
Highest M. T. in 40 yrs.,	46·0	44·5	46·0	47·5	47·0	48·0	47·5	50·0	50·0	49·5	47·5	48·0	49·0	52·0	47·0	49·0	50·5	49·0	49·5	50·0	50·5	49·0	48·5	49·5	49·0	49·0	48·0	50·0	48·5	50·5	51·0
Lowest, ...	26·0	20·0	17·0	23·0	23·0	26·5	25·0	24·0	21·5	26·0	23·0	24·5	19·5	20·0	19·0	18·0	19·5	22·0	22·0	18·5	18·0	18·5	21·5	23·5	24·0	22·5	25·5	24·5	16·5	24·0	18·0
Fluctuation, ...	20·0	24·5	29·0	24·5	24·0	21·5	22·5	26·0	28·5	23·5	24·5	23·5	29·5	32·0	28·0	31·0	31·0	27·0	27·5	31·5	32·5	30·5	27·0	26·0	25·0	26·5	22·5	25·5	32·0	26·5	33·0

FEBRUARY.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	...	...
1795—1805, ...	36·4	37·7	36·7	35·2	35·1	34·1	33·5	37·6	38·9	39·0	37·0	35·2	34·6	35·3	35·4	35·3	34·0	35·0	37·9	38·0	37·9	39·9	39·7	39·3	38·1	37·6	37·6	35·8	33·8	...	...
1821—1830, ...	39·8	37·8	36·8	36·3	35·8	38·2	40·4	39·4	39·0	39·1	38·4	39·7	38·8	37·9	36·4	37·4	37·5	33·9	35·2	36·8	37·5	38·3	37·3	39·9	40·4	40·3	41·0	39·3	46·0	...	...
1831—1840, ...	35·8	36·0	37·0	37·3	39·3	38·9	40·0	40·5	40·5	39·5	39·5	39·2	38·0	39·6	40·1	40·8	38·9	39·3	36·9	36·1	33·4	36·4	38·1	37·4	36·3	35·0	36·2	37·2	37·6	...	...
1841—1850, ...	36·8	37·4	39·3	38·7	38·5	35·1	34·8	35·4	35·6	36·7	39·1	38·9	39·3	41·2	41·0	39·7	40·9	41·2	41·4	40·8	39·5	40·7	40·3	39·2	37·8	38·3	38·0	40·9	40·0	...	...
Mean, ...	37·22	37·25	37·49	36·89	37·20	36·59	37·21	38·24	38·52	38·61	38·54	38·30	37·67	38·54	38·26	38·31	37·86	37·39	37·90	37·97	37·10	38·85	38·87	38·97	38·16	37·81	38·24	38·30	39·37	...	...
Highest M. T. in 40 yrs.,	52·5	50·0	51·0	50·5	51·0	50·0	49·0	47·0	49·0	51·5	49·5	48·0	48·0	49·5	49·5	50·5	47·5	48·5	54·0	47·5	48·0	50·0	53·5	53·0	52·5	52·5	52·5	55·0	51·5	...	...
Lowest, ...	22·0	26·0	25·0	24·0	19·0	23·0	21·0	23·5	25·5	28·5	25·5	23·5	19·5	19·0	24·0	24·5	24·0	25·0	26·0	28·0	24·0	25·0	27·0	32·0	30·0	29·0	27·5	21·0	31·0	...	...
Fluctuation, ...	30·5	24·0	26·0	26·5	32·0	27·0	28·0	23·5	23·5	23·0	24·0	24·5	28·5	30·5	25·5	26·0	23·5	23·5	28·0	19·5	24·0	25·0	26·5	21·0	22·5	23·5	25·0	34·0	20·5	...	...

MARCH.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1805, ...	37·1	36·3	37·6	36·8	35·8	35·7	35·9	38·9	38·8	37·9	37·5	37·1	38·9	38·7	38·2	38·9	39·8	38·8	38·3	38·0	39·2	40·3	40·0	41·9	42·3	42·1	42·0	41·3	40·5	39·7	43·2
1821—1830, ...	41·0	39·4	40·2	38·9	37·2	37·3	39·1	39·8	42·3	42·6	42·4	42·7	41·4	41·0	40·6	40·9	41·9	42·7	44·6	44·8	44·0	41·4	41·5	41·3	41·1	41·3	44·5	43·7	43·2	41·3	40·1
1831—1840, ...	38·4	39·7	40·4	41·1	39·8	38·6	37·9	37·5	38·9	39·9	40·2	39·4	40·6	40·7	40·4	40·0	39·0	40·5	41·6	42·0	42·2	40·4	39·4	36·5	38·1	37·9	42·2	40·9	40·3	40·8	41·9
1841—1850, ...	39·7	41·3	41·6	38·6	40·5	41·9	42·9	41·4	41·2	41·5	41·2	41·8	41·6	43·0	45·6	42·7	42·8	43·6	41·4	40·6	41·4	44·1	42·8	42·9	42·4	42·1	41·9	42·4	42·1	42·0	44·5
Mean, ...	39·09	39·19	39·97	38·86	38·36	38·41	38·96	39·42	40·34	40·47	40·34	40·29	40·65	40·87	41·24	40·66	40·92	41·41	41·49	41·37	41·72	41·60	40·94	40·65	41·00	40·87	42·67	42·09	41·52	40·95	42·46
Highest M. T. in 40 yrs.,	51·0	50·0	51·0	52·5	47·0	48·5	50·5	51·0	53·5	62·0	49·0	51·0	53·0	52·0	56·0	53·5	53·0	55·0	52·5	52·0	51·0	50·5	51·0	51·5	53·0	54·0	52·0	51·0	57·5	48·5	52·0
Lowest, ...	26·0	26·0	31·0	29·0	27·5	28·0	25·5	27·0	28·0	31·0	31·0	28·0	28·5	28·5	29·0	25·0	32·5	32·5	29·0	30·0	32·5	33·0	31·5	31·0	32·0	30·5	30·5	30·5	29·5	29·0	30·5
Fluctuation, ...	25·0	24·0	20·0	23·5	19·5	20·5	25·0	24·0	25·5	31·0	18·0	23·0	24·5	23·5	27·0	28·5	20·5	22·5	23·5	22·0	18·5	17·5	19·5	20·5	21·0	23·5	21·5	20·5	28·0	19·5	21·5

APRIL.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	..
1795—1805, ...	42·9	43·2	41·3	41·9	40·9	41·7	43·9	44·4	43·6	43·7	43·0	43·4	44·5	46·7	47·3	45·9	45·8	45·9	45·8	45·1	45·3	46·0	45·7	45·1	46·2	47·2	47·5	46·7	45·7	47·7	...
1821—1830, ...	40·7	42·1	42·4	43·0	44·4	45·1	45·7	45·9	45·0	42·3	43·1	44·7	44·9	46·1	45·9	46·5	45·3	43·7	45·0	47·3	45·8	45·9	44·4	43·5	44·7	46·8	46·5	50·2	51·1	50·1	...
1831—1840, ...	40·8	42·0	40·1	42·1	44·3	43·4	42·5	41·7	42·1	43·1	42·0	44·4	43·7	44·2	45·2	42·8	42·4	42·3	43·9	44·9	44·8	46·4	46·2	45·4	46·4	47·2	46·9	46·4	45·0	45·5	...
1841—1850, ...	45·5	45·1	45·8	43·0	44·5	43·6	44·6	44·7	43·0	44·3	42·3	43·1	43·5	44·4	44·4	46·0	45·4	47·9	47·7	45·4	45·3	44·8	45·0	46·2	46·4	46·9	46·4	46·1	48·2	49·0	..
Mean, ...	42·50	43·14	42·42	42·51	43·54	43·47	44·20	44·19	43·45	43·36	42·60	43·92	44·20	45·40	45·71	45·32	44·76	44·97	45·62	45·71	45·30	45·80	45·35	45·07	45·95	47·04	46·85	47·35	47·51	48·09	...
Highest M. T. in 40 yrs.,	51·0	52·0	54·5	53·0	52·0	52·0	53·0	53·5	57·0	59·0	57·5	56·0	52·5	54·0	56·0	53·0	52·0	53·5	55·5	57·0	56·5	57·0	58·0	57·5	56·5	56·0	57·0	58·5	59·0	58·5	...
Lowest, ...	31·5	26·5	31·5	31·0	30·5	33·5	34·5	34·5	34·5	34·0	33·5	30·0	35·5	36·0	37·5	33·5	28·5	33·0	36·5	34·5	33·0	34·0	34·0	33·0	37·0	39·0	37·0	38·0	37·5	38·5	...
Fluctuation, ...	19·5	25·5	23·0	22·0	21·5	18·5	18·5	19·0	22·5	25·0	24·0	26·0	17·0	18·0	18·5	19·5	23·5	20·5	19·0	22·5	23·5	23·0	24·0	24·5	19·5	17·0	20·0	20·5	21·5	20·0	...

MAY.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1805, ...	48·2	46·6	45·9	47·5	48·5	47·0	47·4	47·9	47·1	47·7	46·9	46·2	45·4	46·7	47·0	49·3	48·8	50·8	51·1	53·1	54·1	55·3	54·6	55·4	54·5	53·5	53·6	53·0	53·4	50·7	52·4
1821—1830, ...	50·1	50·0	48·5	49·0	50·3	49·7	49·6	50·0	48·3	48·5	48·2	48·2	49·4	48·9	51·2	51·3	52·6	51·9	50·7	49·6	50·5	50·4	52·3	51·1	51·6	50·3	52·2	51·9	52·5	54·9	55·0
1831—1840, ...	45·9	46·9	47·8	48·2	48·1	47·2	47·8	48·8	48·1	46·4	48·9	49·4	47·2	45·7	46·9	50·9	51·8	51·0	49·8	50·5	50·5	50·5	51·5	52·3	51·0	54·4	53·0	53·1	53·7	53·5	54·3
1841—1850, ...	49·7	48·1	49·4	47·5	47·6	47·6	49·2	47·8	47·2	49·0	49·7	49·9	52·6	51·9	51·2	51·3	49·6	49·2	49·4	50·6	50·7	51·8	51·6	53·9	52·6	52·4	53·1	52·1	53·5	54·6	54·0
Mean, ...	48·50	47·91	47·91	48·06	48·65	47·91	48·52	48·65	47·71	47·92	48·45	48·45	48·66	48·32	49·10	50·74	50·71	50·75	50·27	50·99	51·50	52·01	52·52	53·20	52·45	52·67	53·01	52·54	53·29	53·45	53·92
Highest M. T. in 40 yrs.,	58·5	57·0	57·0	57·5	60·5	61·0	62·0	59·0	59·0	56·0	57·0	59·5	64·5	59·0	59·0	61·0	63·0	60·0	61·5	60·5	59·5	64·0	63·0	65·5	63·5	67·0	67·0	65·5	61·5	61·0	65·0
Lowest, ...	37·0	39·5	39·5	40·5	39·0	36·0	38·5	40·5	39·0	40·5	40·5	43·0	41·0	36·5	36·5	39·5	39·0	39·0	40·5	40·5	42·0	43·5	43·0	44·0	42·0	42·5	44·5	43·0	40·5	35·0	45·5
Fluctuation, ...	21·5	17·5	17·5	17·0	21·5	25·0	23·5	18·5	20·0	15·5	16·5	16·5	23·5	22·5	22·5	21·5	24·0	21·0	21·0	20·0	17·5	20·5	20·0	21·5	21·5	24·5	22·5	22·5	21·0	26·0	19·5

JUNE.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	...
1795—1805, ...	52·6	54·1	53·1	53·7	54·7	55·9	55·5	55·7	53·3	52·7	54·2	54·6	55·1	55·2	55·4	56·7	56·6	56·0	55·9	55·4	56·4	55·5	56·6	57·2	57·3	56·4	57·5	57·9	59·0	59·0	...
1821—1830, ...	55·9	54·8	54·4	54·0	52·3	51·7	56·0	54·9	56·0	55·4	57·2	59·2	58·7	57·4	54·6	54·8	55·5	56·3	53·2	55·9	54·1	55·2	57·2	57·6	57·7	57·9	57·3	59·0	59·5	57·4	...
1831—1840, ...	51·7	53·4	52·2	52·4	52·4	52·7	52·6	53·9	54·3	55·8	56·3	53·8	55·1	55·0	57·9	58·7	59·3	56·3	56·2	56·6	56·8	54·6	55·2	55·0	55·2	55·0	55·9	55·2	55·6	55·8	...
1841—1850, ...	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	...
Highest M. T. in 40 yrs.,	63·0	63·5	64·0	68·5	71·5	70·5	64·0	63·5	65·0	64·0	65·0	69·5	68·0	65·5	65·5	68·5	66·5	66·0	66·0	65·5	67·0	67·5	65·5	68·5	68·0	68·0	66·0	74·0	73·5	69·0	...

1795—1804,	57·1	58·0	56·7	57·3	57·4	58·4	58·4	57·4	57·4	57·0	58·2	58·2	58·4	60·4	58·3	59·9	59·3	59·5	58·2	59·1	59·7	60·1	58·7	58·8	57·8	58·8	59·2	58·9	58·0	58·3	59·7
1821—1830,	56·4	56·9	56·9	58·0	58·6	56·4	56·8	57·4	57·7	56·5	58·6	57·1	59·4	59·2	59·4	59·5	59·4	60·1	60·1	59·6	57·6	60·3	58·9	58·3	59·5	57·7	59·5	60·0	59·5	58·7	58·6
1831—1840,	58·1	57·1	58·2	59·1	61·0	59·3	57·5	58·9	57·7	59·8	58·5	59·0	57·9	57·0	57·9	58·1	57·9	56·8	56·7	56·8	56·3	55·1	56·7	57·7	58·4	59·1	59·7	61·1	58·6	58·6	59·0
1841—1850,	56·7	56·6	57·4	58·3	56·1	56·8	56·7	57·3	55·9	59·3	58·0	60·6	60·3	59·4	58·9	58·3	57·7	57·3	58·3	56·1	57·8	57·9	58·7	55·5	58·3	59·1	59·1	59·3	57·7	56·9	58·8
MEAN,	57·12	57·17	57·30	58·20	58·31	57·75	57·36	57·79	57·19	58·19	58·35	58·74	59·02	59·04	58·62	58·99	58·60	58·44	58·35	57·90	57·86	58·39	58·26	57·60	58·50	58·72	59·41	59·84	58·45	58·15	59·04
Highest M. T. in 40 yrs.,	67·0	65·5	66·0	69·0	69·5	68·0	65·0	69·0	64·5	65·5	69·5	75·5	68·5	70·5	65·5	68·5	72·0	77·0	67·5	65·5	65·5	66·5	67·5	70·0	67·5	68·0	68·0	68·0	68·0	68·5	70·5
Lowest,	50·5	48·5	50·0	53·0	50·5	51·0	51·0	52·0	51·0	50·5	50·0	50·5	50·5	51·5	50·5	49·5	48·0	49·0	51·5	51·5	53·0	51·5	51·0	51·5	51·5	51·5	53·0	54·0	50·5	51·0	51·5
Fluctuation,	16·5	17·0	16·0	16·0	19·0	17·0	14·0	17·0	13·5	15·0	19·5	25·0	18·0	19·0	15·0	19·0	24·0	28·0	16·0	14·0	12·5	15·0	16·5	18·5	16·0	16·5	15·0	14·0	17·5	17·5	19·0

AUGUST.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1805,	60·1	59·3	58·0	58·0	58·0	59·2	59·3	60·2	59·7	59·7	59·7	59·9	59·4	58·9	59·2	59·4	60·4	59·7	60·0	57·6	57·8	57·7	58·2	57·5	57·0	56·8	56·9	57·7	58·7	57·7	55·2
1821—1830,	56·8	58·9	58·5	57·9	57·5	56·3	58·2	58·9	58·2	56·5	57·6	56·0	55·0	55·9	56·2	53·5	55·6	57·1	58·0	56·9	56·3	54·6	57·6	57·5	55·8	55·4	55·9	55·2	56·5	56·9	56·9
1831—1840,	57·8	57·3	57·2	58·9	58·0	58·6	59·2	59·4	58·4	60·0	60·1	59·6	57·7	56·8	57·9	58·1	57·0	58·3	57·8	58·1	57·4	55·6	56·8	55·1	55·0	55·3	55·9	54·6	53·8	54·5	54·1
1841—1850,	58·9	57·8	56·7	57·2	56·8	58·6	57·5	58·1	57·5	56·5	56·9	58·0	58·9	57·0	56·7	56·5	56·6	57·6	56·7	57·6	56·0	54·8	55·2	54·7	58·0	56·6	57·2	56·4	58·4	57·1	57·6
MEAN,	58·42	58·35	57·64	58·02	57·62	58·20	58·56	59·20	58·46	58·19	58·57	58·39	57·76	57·16	57·52	56·90	57·44	58·19	58·15	57·56	56·91	55·69	56·96	56·22	56·49	56·07	56·49	55·99	56·85	56·57	55·95
Highest M. T. in 40 yrs.,	65·5	68·0	67·0	64·0	64·5	64·5	65·5	67·5	68·5	66·5	66·5	68·5	67·0	66·0	66·0	63·5	67·0	70·5	70·5	68·0	67·5	65·0	64·5	63·0	64·5	63·0	64·5	63·0	66·5	64·5	66·5
Lowest,	50·0	51·5	52·0	51·5	51·0	50·5	53·0	52·5	51·0	52·0	51·0	50·0	46·5	46·5	47·0	48·0	49·0	49·0	48·0	48·0	48·5	49·0	48·0	50·0	51·0	50·0	46·5	46·0	47·5	49·0	47·5
Fluctuation,	15·5	16·5	15·0	12·5	13·5	14·0	12·5	15·0	17·5	14·5	15·5	18·5	20·5	19·5	19·0	15·5	18·0	21·5	22·5	20·0	19·0	16·0	16·5	13·0	13·5	13·0	18·0	17·0	19·0	15·5	19·0

SEPTEMBER.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	...
1795—1804,	56·2	56·4	56·2	55·4	55·6	56·1	55·4	55·3	55·3	55·9	54·4	52·5	55·1	56·4	57·2	56·8	55·8	55·5	54·3	52·8	51·4	51·4	50·3	50·1	51·2	52·3	51·0	52·4	52·3	51·3	...
1821—1830,	56·3	58·1	56·6	56·7	54·6	54·1	54·3	54·2	54·2	54·2	56·3	54·6	53·2	52·2	53·0	55·6	56·2	54·0	53·6	50·5	52·4	52·1	50·7	52·6	53·1	52·8	52·3	50·2	49·3	51·4	...
1831—1840,	54·4	53·4	52·9	53·9	54·5	54·8	54·9	53·0	54·3	52·5	51·6	52·0	51·8	51·7	52·8	53·1	52·9	51·8	52·3	52·8	52·4	51·8	52·6	53·3	52·2	52·8	53·2	51·4	51·6	50·7	...
1841—1850,	57·0	59·8	53·4	54·6	54·2	55·2	55·7	55·3	55·9	55·8	55·9	55·5	56·5	55·9	55·3	57·2	55·5	52·6	52·6	52·6	52·6	51·2	54·4	54·0	53·1	51·9	52·1	51·4	49·2	50·4	...
MEAN,	56·00	56·95	55·56	55·19	54·74	55·07	55·09	54·47	54·94	54·61	54·57	53·67	54·16	54·07	54·60	55·69	55·12	53·50	53·22	52·19	52·22	51·62	52·02	52·52	52·45	52·47	52·19	51·36	50·65	50·99	...
Highest M. T. in 40 yrs.,	65·0	72·0	67·5	65·0	64·5	65·5	66·5	63·0	62·5	64·0	66·0	66·0	64·5	66·0	65·0	64·0	63·0	62·5	63·0	61·0	62·5	60·5	63·5	62·0	64·5	62·0	61·0	61·5	61·0	62·0	...
Lowest,	48·0	48·0	47·0	47·0	47·0	47·5	45·0	47·5	47·0	46·5	45·5	40·5	42·5	44·0	45·5	45·0	43·5	43·5	47·0	44·5	42·0	39·5	42·5	43·5	43·0	42·0	40·0	39·0	35·5	44·5	...
Fluctuation,	17·0	24·0	20·5	18·0	17·5	18·0	21·5	15·5	15·5	17·5	20·5	25·5	22·0	22·0	19·5	19·0	19·5	19·0	16·0	16·5	20·5	21·0	21·0	18·5	21·5	20·0	21·0	22·5	25·5	17·5	...

OCTOBER.

	1.	2.	3.	4.	5.	6	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1804,	50·6	52·1	51·5	51·2	49·0	48·1	49·5	48·7	47·0	46·0	45·7	45·1	46·0	48·6	48·5	47·1	46·3	46·6	46·8	47·7	47·4	45·4	44·0	45·1	45·8	44·0	43·2	43·4	44·0	45·6	44·7
1821—1830,	51·1	49·3	52·8	52·3	50·9	51·6	50·9	49·2	47·8	49·2	48·6	48·2	47·3	46·3	45·7	48·5	46·8	44·6	47·8	49·3	48·0	47·8	47·7	49·4	49·1	46·1	47·4	45·2	43·8	44·3	44·6
1831—1840,	51·6	51·2	51·3	49·9	49·8	49·1	50·3	50·1	49·9	50·2	50·4	47·6	47·7	48·2	49·1	49·1	50·4	48·8	47·7	48·7	48·6	49·4	47·2	45·9	44·4	45·0	45·9	43·0	43·0	44·4	43·8
1841—1849,	51·5	50·9	48·6	48·1	49·5	49·6	49·6	48·5	49·8	49·4	49·9	47·1	46·1	47·9	46·3	45·0	46·5	45·9	46·1	45·1	41·8	44·4	46·3	43·7	42·8	41·6	43·6	44·6	44·5	45·1	45·9
MEAN,	51·22	50·91	51·07	50·41	49·82	49·61	50·12	49·15	48·62	48·74	48·67	47·04	46.82	47·77	47·41	47·47	47·51	46·50	47·12	47·72	46·50	46·76	46·32	46·04	45·54	44·20	45·05	44·09	43·85	44·86	44·76
Highest M. T. in 40 yrs.,	60·0	59·0	60·0	61·5	60·0	60·5	62·0	58·0	55·5	60·5	60·0	58·5	58·5	62·0	56·0	58·0	57·0	59·5	60·5	56·5	56·5	56·0	61·0	58·5	56·0	54·0	53·5	54·5	52·5	55·5	54·0
Lowest,	43·0	41·0	39·5	41·0	38·5	38·0	40·0	38·0	39·0	39·0	38·5	38·0	35·0	39·5	33·5	35·0	35·5	34·0	35·0	34·5	35·0	37·0	38·0	34·0	38·5	35·5	32·0	31·5	30·0	30·5	29·5
Fluctuation,	17·0	18·0	20·5	20·5	21·5	22·5	22·0	20·0	16·5	21·5	21·5	20·5	23·5	22·5	22·5	23·0	21·5	25·5	25·5	22·0	21·5	19·0	23·0	24·5	17·5	18·5	21·5	23·0	22·5	25·0	24·5

NOVEMBER.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	...
1795—1804,	44·4	44·3	41·0	40·0	40·6	41·8	43·1	40·6	39·9	39·4	40·3	40·7	40·8	41·5	40·3	40·1	40·7	38·9	37·5	37·4	37·1	37·8	36·8	36·6	35·2	36·4	36·5	35·2	36·9	36·3	...
1821—1830,	44·8	45·8	45·8	42·3	43·0	42·3	41·9	40·2	41·1	41·8	42·8	42·3	44·6	43·7	41·6	40·3	41·9	38·8	39·9	42·7	44·0	40·4	41·1	41·1	39·8	41·7	39·7	41·3	40·9	38·6	...
1831—1840,	44·8	44·6	43·1	41·2	42·3	39·4	40·4	41·5	41·4	42·9	42·5	41·8	40·8	39·3	39·5	40·5	40·1	39·6	40·9	39·8	40·5	42·3	42·6	41·7	39·0	38·4	37·9	38·8	40·8	43·4	...
1841—1849,	46·5	44·6	43·6	43·4	42·5	45·8	44·8	46·1	45·1	45·0	43·1	41·5	41·5	40·6	40·9	42·6	43·8	42·1	43·1	43·3	42·4	40·8	38·9	39·2	39·4	41·3	42·4	40·5	41·6	39·6	...
MEAN,	45·14	44·86	43·41	41·74	42·14	42·35	42·59	42·12	41·90	42·30	42·19	41·57	41·96	41·29	40·59	40·90	41·66	39·85	40·36	40·84	41·01	40·35	39·89	39·67	38·40	39·46	39·12	39·00	40·10	39·52	...
Highest M. T. in 40 yrs.,	53·5	53·0	51·0	52·5	55·0	52·5	51·5	54·5	51·0	54·0	54·5	54·5	53·0	52·0	56·0	50·0	53·0	51·0	50·0	51·0	54·5	51·0	53·0	52·5	52·0	51·5	53·0	51·0	52·0	50·5	...
Lowest,	32·5	36·5	29·5	32·0	32·5	34·0	32·0	33·5	30·0	27·0	32·0	30·5	34·5	32·0	31·0	31·5	29·5	30·0	27·5	26·0	31·0	30·0	25·5	28·5	29·5	28·5	27·5	26·0	24·0	25·5	...
Fluctuation,	21·0	16·5	21·5	20·5	22·5	18·5	19·5	21·0	21·0	27·0	22·5	24·0	18·5	20·0	25·0	18·5	23·5	21·0	22·5	25·0	23·5	21·0	28·5	24·0	22·5	23·0	25·5	25·0	28·0	25·0	...

DECEMBER.

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14.	15.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.
1795—1804,	37·5	36·9	35·0	33·4	35·9	36·3	37·2	35·5	37·0	37·4	36·7	36·3	36·6	35·8	37·3	38·2	37·2	37·3	37·7	36·1	36·4	37·3	36·0	34·9	34·4	35·4	35·3	35·1	34·9	35·6	33·6
1821—1830,	37·0	37·6	37·7	38·8	37·6	38·8	41·0	40·9	41·0	40·7	42·2	41·9	41·6	40·3	42·5	41·6	41·5	40·7	39·1	38·1	38·4	38·0	35·8	38·0	38·9	35·5	35·5	35·1	35·2	36·9	36·3
1831—1840,	42·4	41·3	42·1	43·7	41·0	40·8	41·1	40·4	41·8	39·6	39·7	39·8	40·6	39·6	38·7	40·9	40·9	39·1	40·0	39·2	40·2	40·0	38·7	38·9	39·1	37·3	36·4	36·1	37·9	39·4	38·8
1841—1849,	41·6	42·0	42·1	40·3	39·3	38·7	39·4	40·0	41·1	42·7	41·5	40·7	40·0	41·4	42·1	41·5	38·8	38·8	39·1	39·0	37·3	38·4	35·3	36·1	38·4	39·6	37·1	35·8	38·8	39·9	38·4
MEAN,	39·66	39·45	39·25	39·10	38·47	38·67	39·71	39·22	40·24	40·12	40·05	39·70	39·72	39·30	40·16	40·55	39·62	39·00	38·99	38·12	38·09	38·46	36·46	37·00	37·72	36·96	36·12	35·54	36·72	37·95	36·77
Highest M. T. in 40 yrs.,	49·0	52·0	52·0	51·0	51·0	54·0	48·0	49·5	51·5	55·0	52·5	50·5	53·5	53·5	53·5	51·5	45·0	50·0	50·0	48·5	50·5	52·5	46·5	50·0	51·0	52·5	48·0	47·5	49·5	50·0	53·0
Lowest,	26·5	31·0	28·5	26·0	22·5	23·0	28·5	24·0	28·5	28·5	27·5	29·0	26·0	26·5	28·5	28·0	28·5	27·5	25·0	29·0	23·5	23·0	19·0	18·5	19·0	22·5	23·5	21·5	25·0	24·5	20·0
Fluctuation,	22·5	21·0	23·5	25·0	28·5	31·0	19·5	29·5	23·0	26·5	25·0	21·5	27·5	27·0	25·0	23·5	16·5	22·5	25·0	19·5	27·5	29·5	27·5	31·5	32·0	30·0	24·5	26·0	24·5	25·5	33·0

59. The preceding table (pp. 348–49) contains the synopsis of the whole thermometric observations described in Section 2, arranged under each day of the year, and divided into four decennial periods. From these partial results, the great length of period required to determine the mean temperature of any given day may be estimated. I have farther added the extremes of the observed mean temperature of the day during forty years, and the difference of these, which I call the "fluctuation." This uncertainty as to the mean temperature of a given day amounts occasionally in winter and spring to 30° Fahr. or more.

60. The mean daily temperatures in the preceding Table are projected on a large scale in Plate XVIII. Notwithstanding the casual sinuosities of the curve of temperature from day to day, the interpolating curve derived from the formula obtained in Art. 56 evidently represents the course of temperature with general exactness, and the temperature of a given day may be estimated from it with far more accuracy than by the observed mean of that day only, even if derived from forty years' observations.

61. Nevertheless, it is interesting and important to ascertain whether there are not *partial inflections* of the annual curve, subject to recur, and which cannot be satisfactorily represented by the usual periodic series. These are fitly termed by M. QUETELET "periodic anomalies." *

62. With this object in view, as well as to facilitate a comparison of the Edinburgh temperatures with observations made elsewhere, I caused the *five-day means* to be taken from one end of the year to the other (derived from the collective observations of 40 years), in the same way that was done by the earlier meteorologists, and more lately by M. DOVE, who has published a considerable collection of such results.† By this process the sinuosities of the larger curve are very much reduced, and anything like a systematic deviation from symmetry is more clearly shown.

63. The results are contained in the following table, and are represented in Plate XIX.

* Memoire, &c., p. 4.

† DOVE, Fünftägige Mittel, &c. Folio, Berlin: and in the Tables of the Prussian Statistical Bureau. Folio, 1858.

TABLE XIII.—SHOWING THE FIVE-DAY MEANS OF TEMPERATURE FOR FORTY YEARS, AS OBSERVED AND AS COMPUTED FROM THE FORMULA; ALSO THE FLUCTUATION OF DAILY TEMPERATURE IN FORTY YEARS, AND THE MEAN DAILY RANGE (TWENTY-NINE YEARS' AVERAGE).

	Temperature.		Diff.	Daily Fluctuation in 40 Years.	Mean Daily Range.		Temperature.		Diff.	Daily Fluctuation in 40 Years.	Mean Daily Range.
	Calculated.	Observed.					Calculated.	Observed.			
Jan. 1–5	36°·92	36°·30	−0°·62	24°·4	9°·4	July 5–9	58°·00	57°·68	−0°·32	16°·1	16°·9
6–10	36·76	35·84	− ·92	24·4	9·5	10–14	58·30	58·67	+ ·37	19·3	16·5
11–15	36·74	35·97	− ·77	27·5	9·4	15–19	58·54	58·60	+ ·06	20·4	16·1
16–20	36·72	37·06	+ ·34	29·6	9·6	20–24	58·71	58·00	− ·71	15·3	15·8
21–25	36·78	37·65	+ ·87	28·2	10·3	25–29	58·78	58·98	+ ·20	15·8	17·0
26–30	36·82	37·34	+ ·52	26·6	10·5	30–3	58·69	58·32	− ·37	16·7	16·5
31–4	37·06	37·16	+ ·10	28·0	10·6	Aug. 4–8	58·52	58·32	− ·20	13·5	16·5
Feb. 5–9	37·27	37·55	+ ·28	26·8	10·6	9–13	58·24	58·27	+ ·03	17·3	16·5
10–14	37·54	38·33	+ ·79	26·1	11·1	14–18	57·81	57·44	− ·37	18·7	15·7
15–19	37·80	37·94	+ ·14	25·3	11·2	19–23	57·37	57·05	− ·32	18·8	15·7
20–24	38·21	38·35	+ ·14	23·2	10·8	24–28	56·80	56·25	− ·55	14·9	16·0
25–1	38·60	38·32	− ·28	26·0	11·3	29–2	56·12	56·46	+ ·34	18·9	16·1
Mar. 2–6	39·08	38·96	− ·12	21·5	12·5	Sept. 3–7	55·36	55·13	− ·23	19·1	15·4
7–11	39·53	39·91	+ ·38	24·7	13·9	8–12	54·54	54·45	− ·09	18·9	16·0
12–16	40·11	40·74	+ ·63	25·3	13·3	13–17	53·62	54·73	+1·11	20·4	15·7
17–21	40·66	41·38	+ ·72	21·4	14·0	18–22	52·71	52·55	−0·16	18·6	15·1
22–26	41·35	41·01	− ·34	21·0	13·7	23–27	51·72	52·33	+ ·61	20·4	14·2
27–31	42·03	41·94	− ·09	22·2	14·3	28–2	50·70	51·03	+ ·33	20·1	14·9
April 1–5	42·75	42·82	+ ·07	22·3	14·6	Oct. 3–7	49·57	50·21	+ ·64	21·4	13·5
6–10	43·44	43·73	+ ·29	20·7	14·9	8–12	48·61	48·44	− ·17	20·0	12·6
11–15	44·30	44·37	+ ·07	20·7	15·7	13–17	47·55	47·40	− ·15	22·6	13·1
16–20	45·08	45·28	+ ·20	21·0	16·1	18–22	46·53	46·92	+ ·39	22·7	13·1
21–25	46·01	45·49	− ·52	22·9	15·5	23–27	45·44	45·43	− ·01	21·0	12·0
26–30	46·92	47·37	+ ·45	19·8	16·3	28–1	44·54	44·54	·00	23·2	12·2
May 1–5	47·79	48·21	+ ·42	19·0	17·1	Nov. 2–6	43·55	42·90	− ·65	19·9	11·1
6–10	48·70	48·14	− ·56	20·5	16·5	7–11	42·69	42·22	− ·47	22·2	10·6
11–15	49·64	48·60	−1·04	20·3	17·6	12–16	41·79	41·26	− ·53	21·2	10·9
16–20	50·55	50·69	+0·14	21·5	17·5	17–21	41·05	40·74	− ·31	23·1	11·2
21–25	51·49	52·34	+ ·85	20·2	16·7	22–26	40·35	39·55	− ·80	23·8	10·6
26–30	52·38	52·99	+ ·61	23·3	17·5	27–1	39·64	39·48	− ·16	25·2	10·0
31–4	53·27	54·03	+ ·76	20·1	18·0	Dec. 2–6	39·01	38·99	− ·02	25·8	9·8
June 5–9	54·08	54·41	+ ·33	22·9	17·5	7–11	38·53	39·87	+1·34	24·7	9·7
10–14	54·93	55·68	+ ·75	21·5	17·9	12–16	38·00	39·89	+1·89	24·9	9·9
15–19	55·64	56·00	+ ·36	19·5	17·9	17–21	37·69	38·76	+1·07	22·2	9·7
20–24	56·36	56·39	+ ·03	18·8	17·7	22–26	37·32	37·32	0·00	30·1	9·7
25–29	56.96	56·81	− ·15	21·7	17·7	27–31	37·11	36·62	− ·49	26·7	9·7
30–4	57·50	57·39	− ·11	17·0	17·6						

64. In this Table I have included the five-day means of the "fluctuation" of temperature for forty years for a given day, deduced as above; also the "mean

daily range," deduced from the average of all the daily extremes for twenty-nine years (1822–1850), during which self-registering thermometers were in use.* I shall make a few observations under each of these heads.

(1.) *On the inflections, or "periodic anomalies" of the annual curve, compared with the standard or computed values.*

65. Of these the most marked, indicated by the Curve and the Table last referred to, is an excess of temperature above the calculated or normal amount in the latter part of January and earlier part of February. This is a well-known and long recognised anomaly. In most European instances it affects materially the mean temperature of February, which is very commonly far too high, when contrasted with the general sweep of the annual curve. At Brussels, for example, M. Quetelet finds an excess in the temperature of February above the general curve of at least 1°·5 Fahr. The same peculiarity may be noticed in the annual curves of London, Prague, St Petersburg, Vienna, and many other places, including even the Great St Bernard. If it is nearly insensible in the monthly means of Table XI. p. 346, this apparently arises from the anomaly occurring rather sooner at Edinburgh than in most other places, and therefore affecting the temperature of January fully as much as that of February.

66. In connection with this anomaly, I may observe that it is apparently connected with an anomalous depression of the thermometer in the early part of January, of which it may be said to be the reaction. Although we have seen (Art. 57), that in the equalized curve of temperature the minimum is attained on the 17th January (and if two terms of the equation alone were used, it would be on the 22d), the average coldest day is very decidedly earlier in the month. This is well shown in both the detailed curve and the curve of five-day means. The 11th January is the average coldest day (Table IX.), and it is also the central point of an abnormal depression of temperature. The same thing is well marked in M. Quetelet's curves, which coincide almost to a day with the preceding results.†

67. Of the other periodic inequalities of the annual curve we cannot speak with much confidence. Even after forty years' observations, the casual fluctuations of daily temperature are far from being eliminated; and for a period of ten, or even twenty years, very great uncertainty still remains, as may easily be concluded from a comparison of the numbers under each day in Table XII. for the four decennial periods. Perhaps the general depression of temperature in the month of November, which is also traceable in the curves of Greenwich and Brussels, may be considered as a true periodic anomaly, at least in this part of the world.

* The reductions of the daily range have been less scrupulously verified than most of the other computations contained in this paper, but any residual errors are hardly likely to affect sensibly the mean results.

† Since writing the above, I notice that M. Quetelet, at page 39 of his Memoir, expresses himself as to this anomaly in almost the same terms that I have used.

A sort of reaction appears in a comparatively limited yet marked excess of temperature, during the middle fortnight of December. This excess is clearly indicated in every one of the four decennial periods. About the 12th May there is also a brief depression of temperature, which, so far, appears to confirm the existence of the three cold days (11th, 12th, and 13th May) mentioned by Humboldt,* which likewise seem to be indicated at Greenwich; but these deductions are of a description not much to be relied on, and, after all, they most likely depend on causes more or less local.

(2 *and* 3). *On the "fluctuation" of daily mean temperature, and on the diurnal range.*

68. If we project, in the form of a curve, the fluctuation of the daily mean temperature for forty years included in Mr Adie's observations (as shown in column 5 of Table XIII.), we find a very remarkable variation with the season of the year. There appears to be the least casual fluctuation about the end of July, when it amounts to about 16° or 17°, and the maximum occurs nearly six months later, or about the middle of January, when it may be reckoned at between 28° and 29°. These periods coincide, it will be observed, nearly with the hottest and coldest seasons. It may be accidental, but I cannot help remarking, that for some days together these values of "fluctuation" range remarkably low, and then for another short period as uniformly high. An example of this may be noticed in Table XII. for the latter part of December.

69. The other element, the diurnal range, or mean daily difference of maximum and minimum readings for twenty-nine years, gives us a curve of a nearly opposite form to the preceding, and much more regular. The minimum range of 9°·5 occurs in the end of December or beginning of January; the maximum of nearly 18° between the middle and end of June.

Sect. 7. *Remarks on the Price of Corn during Fifty-six years, as compared with Meteorological Data.*

70. It will be recollected that Sir William Herschel, when investigating the connection of the solar spots with terrestrial temperature, employed (though not without some reserve, and only in the absence of better data) the price of wheat as an indication of the heat or cold of different years.

71. I thought it might be worth while to test roughly the applicability of such a scale of climate; and I even considered that it might be practicable to express the relation of the abundance of corn to the meteorological elements which might be expected chiefly to influence it. These expectations signally failed. But I think it may be instructive to record the failure, at a time when agriculturists are directing their attention to meteorology.

* Cosmos, vol. i. note 86.

72. I decided to use the price of oats in the Edinburgh market as the fairest test of the state of the harvest, being at once the most abundant crop, and the one least likely to be affected by foreign importations and by fiscal enactments. In this view I was confirmed by two eminent agricultural authorities.

73. To Mr Charles Lawson I am indebted for a table of the average price of oats of first and second quality, in the Edinburgh market for each year from 1795 to 1850 inclusive (with the exception of the year 1805). The following Table contains the prices of the first quality, in chronological order, and the differences + or – (neglecting fractions of a penny) from the mean of the whole, which is 18s. 11d. per boll of six bushels:—

TABLE XIV.—Showing the Price of Oats (First Quality) in the Edinburgh Market, per Boll of Six Bushels, from 1795 to 1850 inclusive.

		Difference from Mean.			Difference from Mean.			Difference from Mean.
	s. d.	s. d.		s. d.	s. d.		s. d.	s. d.
1795	19 6	+ 0· 7	1814	18 3	– 0· 8	1833	13 6	– 5· 5
1796	14 4	– 4· 7	1815	14 3	– 3· 8	1834	15 0	– 3·11
1797	13 6	– 5· 5	1816	25 11	+ 7· 0	1835	15 0	– 3·11
1798	14 0	– 4·11	1817	23 0	+ 4· 1	1836	20 9	+ 1·10
1799	29 4	+10· 5	1818	23 0	+ 4· 1	1837	15 7½	– 3· 4
1800	33 2	+14· 3	1819	17 6	– 1· 5	1838	21 0	+ 2· 1
1801	16 6	– 2· 5	1820	16 0	– 2·11	1839	18 6	– 0· 5
1802	15 6	– 3· 5	1821	15 4	– 3· 7	1840	14 7½	– 4· 4
1803	17 6	– 1· 5	1822	15 0	– 3·11	1841	14 7½	– 4· 4
1804	18 6	– 0· 5	1823	20 0	+ 1· 1	1842	14 3	– 4· 8
1805	...	...	1824	17 10	– 1· 1	1843	15 9	– 3· 2
1806	20 0	+ 1· 1	1825	18 4	– 0· 7	1844	16 3	– 2· 8
1807	27 0	+ 8· 1	1826	25 9	+ 6·10	1845	20 0	+ 1· 1
1808	24 0	+ 5· 1	1827	17 0	– 1·11	1846	26 3	+ 7· 4
1809	29 9	+10·10	1828	18 6	– 0· 5	1847	18 1½	– 0·10
1810	18 0	– 0·11	1829	16 3	– 2· 8	1848	14 3	– 4· 8
1811	23 0	+ 4· 1	1830	20 0	+ 1· 1	1849	12 3	– 6· 8
1812	31 6	+12· 7	1831	17 6	– 1· 5	1850	13 6	– 5· 5
1813	21 6	+ 2· 7	1832	14 1½	– 4·10			
						Average,	18 11	

74. The next Table shows the seasons arranged according to the dearness of oats, or the reverse.

TABLE XV.—Containing the Seasons arranged according to the Price of Oats, beginning with the Cheapest.

1.	1849	9.	1848	17.	1802	25.	1803	33.	1804	41.	1836	49.	1816
2.	1797	10.	1796	18.	1837	26.	1819	34.	1828	42.	1838	50.	1846
3.	1833	11.	1840	19.	1843	27.	1831	35.	1839	43.	1813	51.	1807
4.	1850	12.	1841	20.	1820	28.	1824	36.	1795	44.	1811	52.	1799
5.	1798	13.	1822	21.	1829	29.	1810	37.	1806	45.	1817	53.	1809
6.	1832	14.	1834	22.	1844	30.	1847	38.	1823	46.	1818	54.	1812
7.	1815	15.	1835	23.	1801	31.	1814	39.	1830	47.	1808	55.	1800
8.	1842	16.	1821	24.	1827	32.	1825	40.	1845	48.	1826	...	...

75. If this Table be compared with similar ones of the different meteorological data in the earlier part of this paper, the complete discordance from all or any of these will be perceived. It is true that the cold years of 1799, 1800, and 1812, certainly coincide with periods of dear corn; but, on the other hand, we find them in close proximity with 1826 and 1846, the two hottest summers of the record. On the other hand, the cheapest years of the whole, 1849 and 1797, will be seen from Table X. to have been cold, late, and rainy. I have in that Table included the character of the season as one of cheapness or of scarcity, in anticipation of this comparison.

76. It might be suggested that the abundance, or the contrary, of the crop of any year might be expected rather to influence the prices of the next than of that season; but this supposition does not seem to reconcile the anomaly. Thus, the cold years 1797 and 1849 were not only cheap years, but were succeeded by cheap years; and the hot summers of 1826 and 1846 produced not only high prices, but were succeeded by years of only average prices.

77. With a view to test impartially the possible connection between prices and these elements of climate, I assumed that it might be possible to represent the price of oats in any year by a linear function of the following variables—viz., the mean temperature of the year, the temperature of the hottest month, and the fall of rain. I accordingly wrote out (without selection) those data for the following years of those for which I possessed complete records—viz., the three dearest, the three cheapest, the three years having the highest mean temperature, the three having the lowest mean, the three having the hottest summer months, and the three wettest years. I took the mean of the three years of the same description, and thus obtained six equations of a linear form, each containing three factors as multipliers of the meteorological elements, which factors were to be determined. It will show the extreme anomaly of the results that the mean of the three years of most rain showed a price of oats rather *below* the average, that the three hottest years were *above* the average. The six equations being solved separately

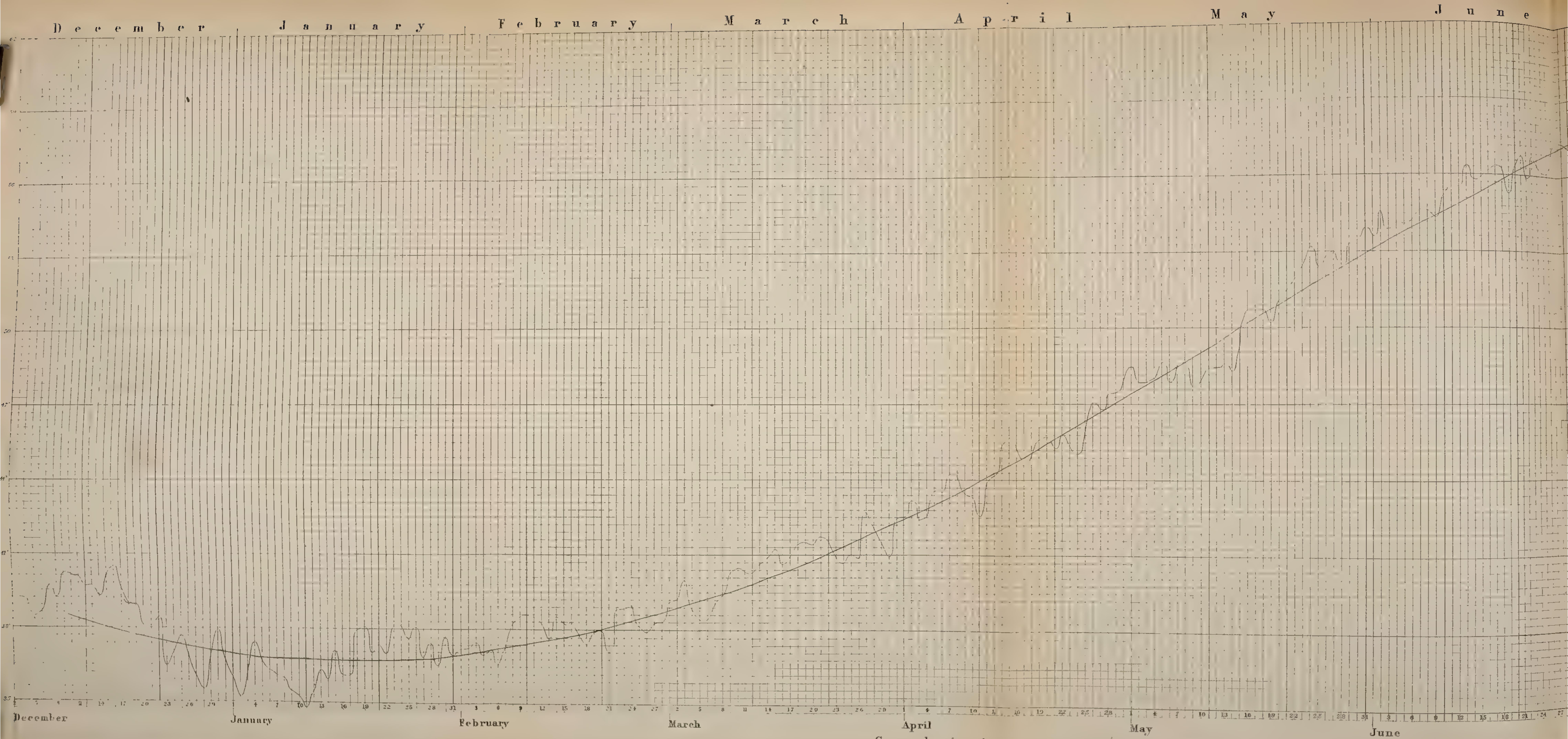
in two groups of three, each give constant factors of the meteorological elements so extravagantly wide of one another as not to be worth reporting.

78. It may of course be said that the meteorological data affecting the harvest are mainly confined to one critical period of the year. It is also true that *extremes*, whether of heat or cold, drought or wet, are not favourable to abundant harvests.* Making all allowances, however, the results are exceedingly anomalous, and seem to show that the price of corn cannot be used to afford the slightest clue to the temperature or meteorological character of a given season.

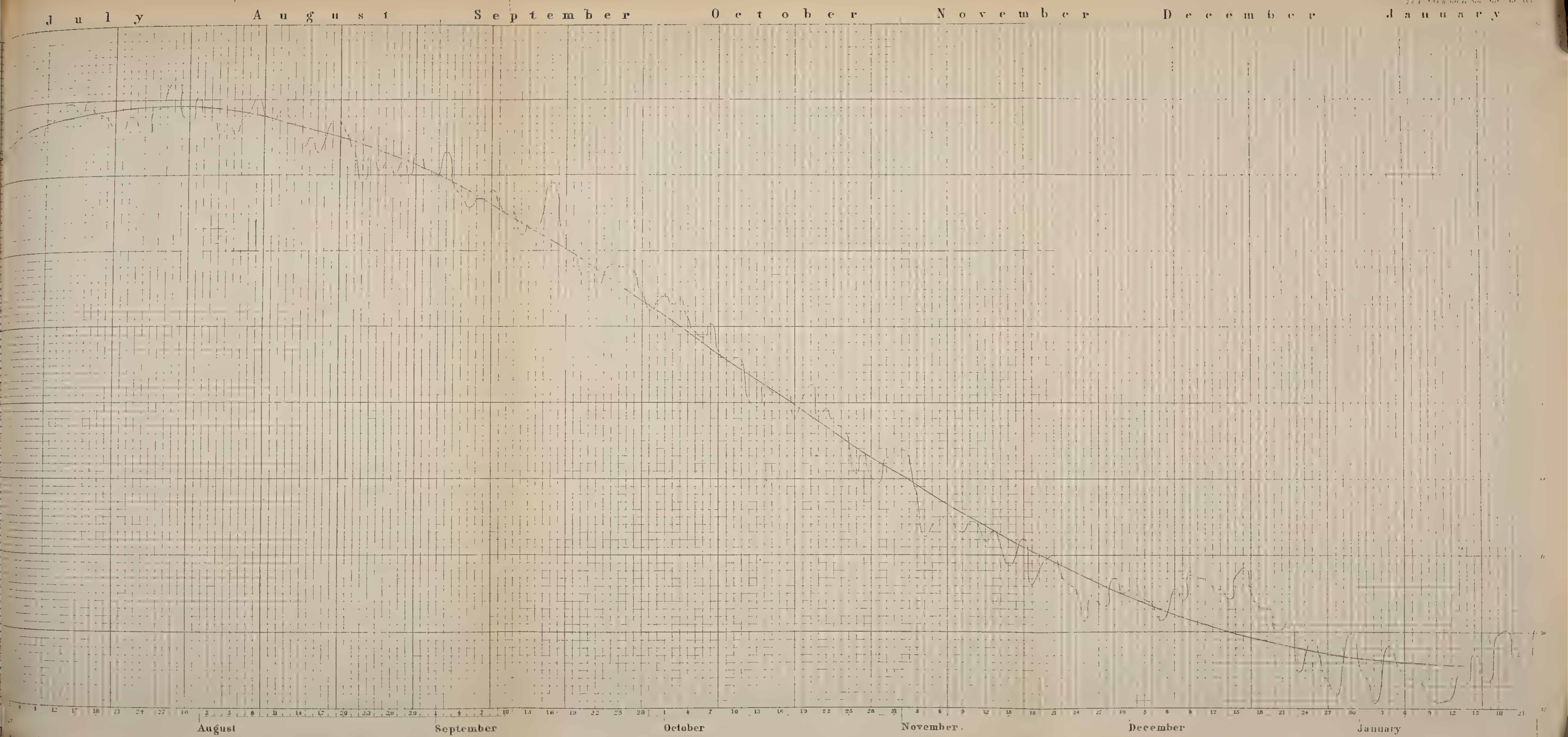
Postscript.

I have already acknowledged the assistance which I have derived from Mr Grassick, and especially from Mr Balfour Stewart, in the preparation of this paper. I have farther to add, that I am indebted to Mr Stewart for the projection of the curves of Plates XVIII. and XIX., and to Mr Robert Cram for the calculation of several of the Tables.

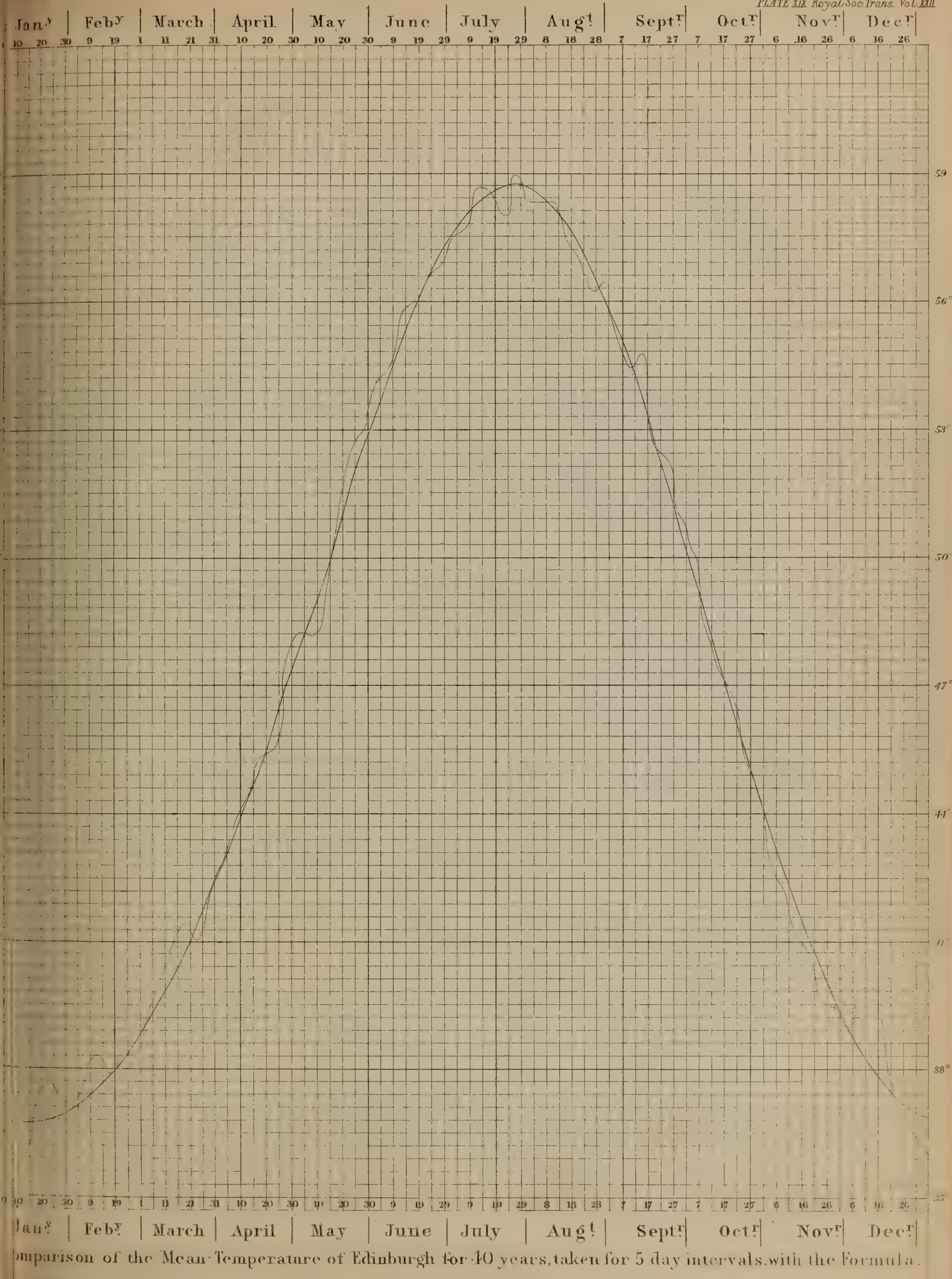
* The same remark is made in page 39 of Mr Jenyns' "Observations on Meteorology," a very carefully compiled work. It might be possible to include this view of the case by considering the prices to vary with the *square* of the departures of the meteorological elements from a certain amount most favourable to cultivation, but I find no encouragement to make a fresh calculation on this more complex system.



Curve showing the Course of the mean daily Temperature at Edinburgh for 40 years deduced from M^r. Ad



ervations & compared with the Formula $y = 46^\circ 88' - 10^\circ 98 \text{ Sine } (x + 68^\circ 28') + 0^\circ{\cdot}96 \text{ Sine } (2x + 22^\circ)$



...mparison of the Mean Temperature of Edinburgh for 40 years, taken for 5 day intervals, with the Formula.

W. & A. K. Johnston, Edinburgh.

XIII.—*Account of a Thermometrical Register kept at Dunfermline by the Rev. Henry Fergus, from* 1799 *till* 1837, *with the principal Results.* By JAMES D. FORBES, D.C.L., F.R.S., Sec. R.S. Ed., Professor of Natural Philosophy in the University of Edinburgh.

(Read 6th March 1860.)

1. When I found that the interesting meteorological register of Mr ADIE, which is well fitted to throw light upon the climate of Edinburgh, and of Scotland generally, was deficient of the important period of nearly sixteen years, from 1805 to 1820, I set on foot inquiries as to the existence of any other register of the thermometer which might approximately supply the defect. After some unsuccessful attempts, my attention was directed by Professor DOVE's useful temperature tables to a register of the thermometer kept by the Rev. Mr FERGUS of Dunfermline, of which the monthly means, from 1805 to 1824, are given in the "Edinburgh Philosophical Journal," vol. xiii. Though the distance of Dunfermline from Edinburgh is thirteen miles in a right line, and though it occupies the opposite slope of the valley of the Forth, not far from the Ochil Hills, yet a slight comparison of the observations showed a very remarkable coincidence in its climate with that of Edinburgh, not only as regards the mean annual temperature, but also in the distribution of temperature throughout the year. I therefore made an effort to obtain the original register from which the results published in the "Edinburgh Philosophical Journal" were derived; and through the kindness, in the first instance, of Mr DAVID LAING of the Signet Library, I was brought into communication with the Rev. JOHN FERGUS of Bower, near Wick, in Caithness, son of the Dunfermline observer, who most kindly placed in my hands his father's original register of the barometer, thermometer, and weather at Dunfermline, extending from 1799 to the time of his death in 1837, all made with one instrument, and at the same hour daily (9 A.M.), with very remarkable regularity.

2. During this long period of time but one thermometer was used, and it is still entire, and now in my possession.

3. From November 1802 until August 1837 the thermometer appears to have been constantly kept in the same exposure, which was rather a peculiar one, and which has been minutely described to me by the Rev. JOHN FERGUS. It was placed on the outside of an ordinary glazed window, in a staircase leading to an attic, with a north exposure. This window was above 3½ feet wide, but, in order to avoid the window-tax, it was contracted externally by brickwork, so as to leave

in the centre of the lower part an unglazed opening 9 inches square, which admitted air freely to the interval between the brick wall and the window. The thermometer was suspended in this interval, into which the snow often drifted.

4. The effect of this peculiarity of exposure would probably be to modify the extremes both of heat and cold, but (especially for observations taken at 9 A.M.) it was not likely to affect materially the *mean* results.

5. The observations from May 1799 to November 1802, when the thermometer was moved into this position, seem (to judge by their results) to have been made probably *within* the house, and therefore I have not retained them in the following paper. Till August 1829 the observations were invariably made by Mr FERGUS, senior, when the failure of his eyesight devolved them (I believe) upon some member of his family; but they were still continued in all respects in the same manner until the commencement of September 1837, when the instrument was removed to a different situation in the town of Dunfermline, where it was rather exposed to reflected heat; and in 1842 it was transferred to a different part of the country. Two years later it was removed to Edinburgh, where I found it in April 1857, in the custody of Mrs FERGUS, widow of the original observer who had begun to use it nearly 60 years before. That lady confirmed the history of the observations, and the fact of its being one and the same instrument which was used from the first. She kindly placed it at my disposal for the purpose of comparison.* I found it to be a spirit of wine thermometer by KNIE, a very well known Edinburgh maker of the last century. The colour of the spirit was unimpaired (a circumstance very rare in modern thermometers), and the scale was of ivory clearly divided. Unfortunately the tube was fixed to the scale with thread in an insecure manner, so as to leave some uncertainty as to the precise reading. On a comparison with a standard thermometer, *corrections to the scale readings* of KNIE's thermometer were obtained within the limits of the monthly temperatures, and, by the aid of an interpolating curve, the following *approximate* corrections ascertained, which were then applied to the monthly averages calculated anew from Mr FERGUS' MS. volume :—

Corrections to Scale Readings of the Dunfermline Thermometer.

At temp. 32°	−0°·5	At temp. 50°	+0°·6
40	−0·3	55	+0·9
45	+0·1	60	+0·9

* This lady died at an advanced age in the interval between the writing of this paper and its being read.

6. The monthly average temperatures to 1830 are contained in the following Table :—

TABLE XVI.—DUNFERMLINE OBSERVATIONS CORRECTED FOR INDEX ERROR.

A.D.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1803	35°·4	35°·8	39°·6	45°·3	48°·9	54°·3	63°·5	58°·0	52°·7	47°·6	38°·0	35°·7
1804	38·0	34·9	37·8	41·4	54·1	59·3	60·8	57·8	55·8	48·4	40·2	34·3
1805	35·7	35·6	41·3	45·8	48·7	55·5	61·1	59·4	56·2	46·0	43·4	36·2
1806	35·1	37·2	39·8	44·9	52·9	58·7	59·3	59·1	54·7	50·3	44·5	39·8
1807	37·3	36·1	34·8	43·5	49·8	55·7	62·4	59·7	47·7	48·8	33·5	36·5
1808	35·9	35·5	39·0	41·1	53·6	58·8	63·3	59·8	53·5	43·1	39·6	35·9
1809	31·2	38·3	41·7	39·9	53·4	55·5	58·3	57·0	53·6	52·3	40·6	36·7
1810	37·3	35·4	35·9	44·0	46·1	58·0	57·4	58·5	54·8	49·5	39·1	35·6
1811	34·2	36·9	42·1	44·4	51·1	55·0	58·8	55·9	53·4	50·7	42·7	36·0
1812	35·6	39·0	35·1	39·1	48·9	55·2	56·1	56·1	53·4	46·9	39·2	35·1
1813	36·0	39·5	42·6	42·7	48·0	56·5	58·6	57·1	53·3	44·1	38·3	37·5
1814	27·7	35·1	37.5	47·6	48·3	53·3	59·0	57·0	54·1	45·0	38·6	35·5
1815	33·5	40·6	41·3	45·0	50·8	55·9	58·2	57·2	53·0	47·6	36·7	33·9
1816	35·3	34·6	36·2	39·6	49·2	54·2	55·3	54·6	50·7	46·1	38·0	35·2
1817	38·2	39 0	37·8	43·6	45·4	54·9	56·8	54·2	53·3	41·6	44·1	35·2
1818	37·0	35·8	36·2	39·3	49·7	59·9	60·2	56·3	52·4	52·4	47·1	39·7
1819	37 8	35·9	40·4	44·0	49·1	54·8	58·5	61·9	53·0	45·6	36·8	33·8
1820	31·7	39·5	38·9	45·9	50·0	54·8	57·9	56·0	51·2	43·6	41·9	38·6
1821	37·2	39·3	39·5	44·8	46·7	53·5	57·2	57·5	53·9	48·4	42·3	39·6
1822	39·3	40·0	41·3	46·0	51·8	59·7	58 6	57·1	50·6	47·5	44·2	37·2
1823	33·5	33·7	38·6	42·6	51·0	54·0	56·3	55·2	52·2	45·2	45·5	37·2
1824	39·7	38·8	38·2	44·8	50·2	55·7	58.9	56·5	53·3	45·4	39·7	37·6
1825	38·2	39·0	40·1	44·6	49·2	56·6	60·9	59·2	56·3	48·8	37·3	38·4
1826	34·0	41·4	39·9	45·3	51·9	62·6	63·0	59·6	53·6	49·1	38·5	40·4
1827	34·9	33·1	37·7	44·2	50·2	56·8	59·7	56·3	55·3	50·3	42·1	42·3
1828	39·1	39·3	41·4	43·8	51·4	58·0	58·7	58·0	54·5	47·9	44·4	43·5
1829	33·0	37·3	38·0	40·7	51·4	57·9	58·0	54·6	49·9	46·6	39·5	37·1
1830	34·8	35·5	42·8	45·9	51·6	54·1	59·1	55·2	52·2	49·2	43·0	35·1
Means,	35·59	37·22	39·12	43·56	50·12	56·40	59·14	57·31	53 16	47·43	40·67	37·13

Mean Temperature of the year, 46°·40.

I do not consider these results to be of a high scientific character, but yet to be so carefully and continuously made as to be well worthy of preservation. I think, also, that the history I have given of the recovery of every particular respecting the observer and the observations, through the testimony of an eye-witness, together with the recovery of the original register and of the original instrument, is a circumstance worthy of note, as an encouragement to trace such data to the best procurable authority.

7. In order to render the observations fit for the purpose for which I had

sought them out—namely, to supplement the deficient years of Mr ADIE's series, I availed myself of the ten years 1821–30, which were common to both series, and by finding the differences of the *uncorrected* Dunfermline temperatures from those of Edinburgh, I used them to deduce for Edinburgh the temperatures of the years 1805–20. This I have more fully explained in my paper on the Climate of Edinburgh.

XIV.—*Description of Asafœtida Plants* (Narthex Asafœtida, Falconer) *which have recently borne Flowers and Fruit in the Royal Botanic Garden of Edinburgh.* By J. H. Balfour, A.M., M.D., F.R.SS. L. and E. (With two Plates, XX. and XXI.)

(Read 30th April 1860.)

By means of my correspondents abroad, and more particularly through the kind offices of Dr Christison, I have been enabled from time to time to cultivate in the Botanic Garden some of the rarer plants of the Materia Medica. Several of these, such as the Jalap plant, the Quassia, and the *Aconitum ferox*, have been already described and figured by me. The present is an interesting addition, and at the suggestion of Dr Christison I have brought it under the notice of the Royal Society.

Since the time of Kæmpfer, who visited Persia in 1687, Asafœtida has been known to be the produce of an umbelliferous plant. The name is derived from *Asa*, the Persian word for a staff or cane, with the addition of a Latin word indicating its odour. Some suppose that *Asa* is a corruption of the word *Laser* or *Lasar*, used by Pliny to indicate the plant. Several plants have been supposed to yield this article of Materia Medica, and it is probable that it is furnished by at least two distinct species of *Ferula* :—1. *Ferula Asafœtida* of Linnæus, or *Narthex Asafœtida* of Falconer; and 2. *Ferula persica* of Willdenow. Both these plants have been cultivated in this country for some time. Two roots of the latter plant were sent to Edinburgh in 1778, by Dr Guthrie of St Petersburg, as the true Asafœtida plant. They had been collected by Pallas, on the mountains of the province of Ghilan, on the southern border of the Caspian, in the north-west of Persia. Both roots were planted by Dr John Hope, Professor of Botany, in the open ground of the Edinburgh Botanic Garden. One of them died, but the other bore flowers and fruit. A drawing was made of the plant by Mr Fife, which was published in the 75th volume of the "Philosophical Transactions of the Royal Society of London," along with a description of the plant by Dr Hope. *Ferula persica* is figured in "Curtis's Botanical Magazine," plate 2096. The plant has flowered and fruited frequently in Britain. The former species, or the *F. Asafœtida* of Linnæus, had never done so in any part of Europe till the year 1858, when two specimens flowered in the Botanic Garden here. This species was found by Kæmpfer, growing in the province of Laristan towards the Persian Gulf, not far from Gambroon, and near the territory and town of Disguun; and he also states that the plant grows on the eastern confines of Persia, in the province of Khorassan near Herat. Kæmpfer speaks of it as "Umbellifera Levistico affinis, foliis instar Pæonia ramosis; caule pleno, maximo; semine foliaceo, nudo, solitario, Brancæ ursinæ [Angelicæ] vel Pastinacæ simili; radice asam fœtidam fundente." Since KÆMPFER's time it has been found in various parts of Persia by European travellers. Sir WILLIAM HOOKER, in speaking of the vexed question as to the origin of the various Asafœtidas, says:*—"Referring to our herbarium, we find various plants (varieties, genera, or species), all yielding the Asafœtida of commerce, or an entirely similar gum-resin:—1. Dr FALCONER's *Narthex Asafœtida* (leaves, fruit, and root) from Tibet. 2. A very similar one, collected by Drs FALCONER and THOMSON, in the southern damp valleys of the same mountain (and elsewhere in Kashmire) in whose northern dry valleys FALCONER obtained his Narthex; also, by Dr THOMSON in Piti (Tibet). 3. A flowering specimen gathered in Turkistan by Dr LORD (19th April 1838), and given to Dr FALCONER. 4. Leaves and roots of a quite similar plant sent by Dr STOCKS from Doobund in Beloochistan, as the Asafœtida of commerce. 5. Another similar plant from the banks of the Zenderad, in the Baktiyari mountains of Persia, collected by the late W. LOFTUS (June 7, 1852), of which excellent specimens are in the British Museum. 6. The *Scorodosma fœtidum* of Bunge (characterised generally by the absence of vittæ), collected by M. BORSCZHOW in sandy places on the steppes east of the Caspian, where it attains a height of 9 feet. Of this plant we know the fruit, root, and stems, but not the leaves. BORSCZHOW believes it to be the Khorassan plant of KÆMPFER, and of which fruits are in the British Museum. 7. Imperfect specimens of an oriental umbellifer from Aucher-Eloi and others, which may belong to some of the above."

Among the plants in the Edinburgh Botanic Garden, there is one raised from seeds sent by Mr LOFTUS which resembles the Narthex much in its leaves, but which has not produced flowers. It was received under the name of *Dorema Asafœtida*. The leaves of this plant, in the young state, have no fœtid odour when bruised.

In 1838 Dr FALCONER saw the Narthex growing in a valley to the north of Kashmire, and afterwards cultivated it in the Saharunpoor Botanic Garden. Sir JOHN M'NEILL in 1839, sent home seeds of an Asafœtida plant from Herat. These seeds were given to Dr GRAHAM by Dr CHRISTISON. The Astore seeds were sent by Dr FALCONER himself to the Botanic Garden. All these seeds were sown, and there was some difficulty in saying which of them germinated. The late Mr M'NAB thought that the plants were raised from FALCONER's seeds. The latter says that from an examination of an umbelliferous fruit in the Roylean Herbarium (now at Liverpool), labelled as being the seeds of the wild Asafœtida plant, collected and transmitted by Sir JOHN M'NEILL from Persia, he is disposed to think that it is quite different from Narthex and Ferula, and belongs to another tribe in the order. Through Dr CHRISTISON's kindness, I have obtained specimens of the fruits sent to him by Sir JOHN M'NEILL, as well as those sent by Dr FALCONER

* Botanical Magazine, Description of Table 5168.

(all of which are in the Materia Medica Museum of the University), and on examination I am disposed, with Dr Falconer, to look upon the former as distinct from the latter. The fruits of the plants in the Botanic Garden agree completely with those sent by Dr Falconer, and differ somewhat from those sent by Sir John M'Neill.

In 1840 another locality was found for this Asafœtida plant, by the expedition of Lieutenant Wood to the sources of the Oxus. This is situated in Syghan near the western termination, and on the northern slope of the Hindoo Koosh range of mountains, about twenty miles north of Bameean. Burnes, in his "Travels into Bokhara," vol. ii. p. 243, says:—" At an elevation of 7000 feet, on Hindoo Koosh, we found the Asafœtida plant flourishing in great luxuriance. It grows to the height of eight or ten feet, when it withers and decays. The milk which exudes is first white, and then turns yellow and hardens, in which state it is put into hair bags and exported. In the fresh state it has an abominable smell, yet our fellow-travellers greedily devoured it."

The seeds sent to the Edinburgh Botanic Garden were carefully reared by the late Mr William M'Nab, the superintendent. In 1842 these seeds germinated, but the shoots merely appeared above ground, and then seemed to die. Mr M'Nab, however, did not give them up for lost. He would not allow the earth under the frame to be dug up, and determined to give them another year's trial. Accordingly, next summer new shoots appeared, and from them the stock of plants in the garden has been derived. Ever since that time the plants have sent up a vigorous crown of leaves in early spring, but these have withered by midsummer, and without any symptoms of flowering. The crown of the root, however, continued to increase annually, and in some of the specimens it attained a diameter of four inches or more. Year after year the flowering of the plants was looked for; but this event did not take place till 1858, when two plants which had been transplanted in the spring of 1857 showed, very early in spring, evidence of pushing up a flowering axis. Dr Falconer, who saw the plants some years before, thought that the delay in flowering might be caused by the too luxuriant growth of the roots, and he suggested that the process might be accelerated by cutting the roots. It is probable that the warm summer of 1857 tended to mature the plants and increase their vigour. The flowering plants did not, as in previous years, produce large radical leaves. The shoots sent up by them consisted entirely of an axis covered by large yellowish-green membranous sheaths, which speedily reached a height of from one to two feet. Flowering branches then began to show themselves in the axils of these sheaths, which are enlarged petioles or pericladia embracing the stems and covering the flower-buds. In the lower part of the axis, the sheaths produced at their extremity pæony-like leaves, much smaller than the ordinary stem leaves. The size of the leaf-laminæ diminished in proceeding upwards; and finally, leafless sheaths were produced, which became reduced in size, and ultimately disappeared as the terminal umbels were reached. Mr M'Nab furnishes the following particulars:—The plant which flowered in 1858 had been growing vigorously for many years. It had been transplanted on 10th March 1857, and had been protected with glass during winter. On 15th February 1858 it first showed symptoms of flowering, by shooting up a large round ball of a greenish-yellow colour, with a few short leaves rising from it. On the 19th of March the plant had assumed a peculiar club-shaped appearance, twenty-one inches high, and fifteen inches in circumference at the top. This appearance is well seen in some of the photographs taken by my friend Mr W. Walker, Fellow of the Royal College of Surgeons of Edinburgh. About the 22d of March the sheaths began to unfold themselves, and expose dense clusters of flowers; and at this stage the daily growths became very conspicuous. When it reached the height of about two feet, it was freely exposed to the air, but protected from wind,—and for some time without injury, though the temperature of the night was almost regularly under that of freezing.

The following are the measurements made:—

From 8 A.M. of the	22d March	to 8 A.M. of the	23d,	growth	4	inches.
Do.	23d	do.	do.	24th	do.	4½ do.
Do.	24th	do.	do.	25th	do.	4½ do.
Do.	25th	do.	do.	26th	do.	3½ do.
Do.	26th	do.	do.	27th	do.	2½ do.
Do.	27th	do.	do.	28th	do.	1½ do.
Do.	28th	do.	do.	29th	do.	5½ do.
Do.	29th	do.	do.	30th	do.	6½ do.
Do.	30th	do.	do.	31st	do.	2½ do.

The upward growth was less marked after this, and at the same time the lateral branches (twenty-nine in number) increased much in length. On 7th April 1858 the plant was 5 feet 7 inches in height, and the branches 36 inches in diameter of spread. The plant attained the height of upwards of 10 feet, and produced abundance of flowering umbels, when it was destroyed by a sudden severe frost on 13th April,—the temperature falling to 22° Fahr. in the night.

An opportunity had been afforded, however, of taking photographs of the plant in its different stages of growth, but unfortunately the fruit was not developed so as to allow of its characters being recorded.

In 1859 other Asafœtida plants produced flowers, and one specimen in particular, which had been planted for five years in the open air, in front of the Orchid House, grew most vigorously. It showed symptoms of flowering at the end of February, long before any of the non-flowering specimens had produced leaves. The flowering axis shot up, as in the former case, from the underground stem, without developing the usual large radical leaves. In order to secure the plant against frost a glazed wooden frame, about 8 feet high, was erected around it, and a connection was established with the adjoining stove, so that a moderate heat might have been supplied in the event of intense frost occurring during night.

This, however, was not necessary. The plant was thus protected from the effects both of very high winds and of cold. On the 13th April, or in about forty-five days, it had attained the height of 7 feet 8 inches. From the 2d to 13th April, the total growth was 30 inches. The first anther was observed fully developed at 11 A.M. on 7th April, and in the course of that day the anthers expanded by hundreds. The plant produced about forty-five compound umbels, some of which were 5 to 6 inches across. The plant progressed well and yielded a large quantity of fruit, which has been partly distributed to botanic gardens in various parts of the country, and has also been sent, by request, to M. DECAISNE, of the Jardin des Plantes in Paris; to M. PLANCHON and M. CHARLES MARTINS, at Montpellier; to Dr REGEL, St Petersburg; and to M. VAN HOUTTE at Ghent. The seeds of this plant germinated freely in the Edinburgh garden in the spring of 1860.

The Asafœtida plant belongs to the Natural Order Umbelliferæ, Section Peucedaneæ, and to the Class Pentandria, order Digynia of LINNÆUS. The plant was referred by LINNÆUS to his Genus *Ferula*, but Dr FALCONER thinks that the character of the vittæ, combined with the obsolete limb of the calyx, and the absence of any involucre are sufficient to constitute a new genus, which he has named *Narthex*, from the word νάρθηξ, applied by DIOSCORIDES to a species of *Ferula* (Dioscord. lib. iii. cap. 75). HOOKER and BENNETT, however, consider the characters of the vittæ of little value, when unaccompanied with others of importance. The former says,—"The number and length of the vittæ vary extremely in the specimens examined. The habit of the species is entirely the same with that of various Ferulas, which themselves vary greatly in habit and vittæ. We may add, that the individual species or varieties further differ in the smoothness or pubescence of their leaflets, their entire or serrated margins, in the shape of the mericarps, and in the position of the smaller umbels of male flowers, which are often extra-axillary. Plants growing in arid climates (and, like the Narthex, on the borders of moist ones) are eminently variable, both as to sensible properties, form of organs, and habit; and we suspect that the discrepancies between the specimens and descriptions of several of the plants yielding Asafœtida may be attributed to climate."*

The following are the generic characters,†—*Calycis* margo obsoletus, vel 5-denticulatus. *Petala* oblonga, apice unica inflexa. *Stylopodium*, plicato-urceolatum. *Styli*, reflexi. *Fructus*, a dorso plano-compressus, margine dilatato. *Mericarpia*, jugis primariis 5, 3 intermediis filiformibus, 2 lateralibus obsoletioribus margini contiguis immersis. *Vittæ*, in valleculis dorsalibus plerumque solitariæ (lateralibus nunc 1½—2½ vittatis); commissuralibus 0—6, variis. *Semen*, complanatum. Genus inter Peucedaneas, fructûs vittis magnis, commissuralibusque inæqualibus, et involucro utroque nullo distinctum.

* HOOKER, *loc. cit.*

† FALCONER, in Linn. Trans. xx. 285.

Narthex Asafœtida.—Herba gigantea Tibetica; radice crassa, fibris intertextis rigidis coronata; caule robusto, ramoso; foliis bipinnatis, laciniis lineari-oblongis obtusis, integris vel sinuatis, decurrentibus, glabris vel pubescentibus; petiolis latis, amplis, vaginantibus, ventricosis, interdum aphyllis; umbellis compositis; involucris nullis; floribus flavis, interdum unisexualibus vel sterilibus. It is probably *Asafœtida Disgunensis*, or Hingiseh of KÆMPFER, Amoen. Exot. p. 535. *Ferula Asafœtida*, LINN., Mat. Med. p. 79; D.C. Prod. iv. 173; LINDL., Fl. Med. p. 45.

The plant grows in sunny spots among stones, in the valley of Astore or Hussorah, near the Indus, beyond Kashmire. FALCONER gathered it in fruit near Boosthon, on 21st September 1838. By the Dardohs or Daradri it is called Sip or Süp, and the young shoots are employed as a culinary vegetable.

The following description is taken from the plants which were grown in the Botanic Garden,—Herbaceous plants attaining a height of between 9 and 10 feet, and giving out a strong alliaceous odour when any part is bruised. Flowering stem erect, terete, striated, about a foot in circumference at the base, giving off flowering branches bearing compound umbels. After the plant flowers and fruits it dies, but the period of flowering is often long delayed. In the case of the plants in the Botanic Garden it was postponed for sixteen years. It is therefore a monocarpic plant, with the period of flowering indefinite. The cotyledons are linear, from 2 to 2½ inches in length. The roots are large and thickened, fusiform, dark-coloured externally, and white within, about a foot and a half in length, and about a foot in circumference at their thickest part, exhaling a very strong and enduring asafœtida smell. Some of them were laid for a few weeks in a room last year, and, although removed five or six months ago, the odour still remains. The crown of the roots is covered with a mass of fibrous matter. During the first year of growth, the root attains the thickness of the thumb. It continues to increase annually, and sometimes attains the thickness of a man's calf, or even his thigh. The radical leaves, which are the only ones produced on non-flowering specimens, are about 18 inches in length, but in flowering specimens they are smaller; they are bipinnately cut, and have a pæony-like appearance; the segments are linear, ligulate, and obtuse, entire or sinuately lobed. The lower leaves in the fruiting plant had compound laminæ 13 or 14 inches long, borne on evident rounded petioles, which, at the base, had short sheaths, nearly surrounding the whole stem; the lowest four leaves did not bear umbels in their axil; all the rest did. In proceeding upwards on the flowering stem, the laminæ diminished in size, while the sheathing part of the petiole or the pericladium increased—the laminæ becoming 3½ or 4 inches long, the sheaths 7 to 9 inches in length by 8 in breadth. In the upper part of the axis the sheathing petiole represents the whole leaf; and the sheaths near the top are reduced to abortive membranous scales, about 1 inch in length, and finally disappear, when the umbels at the summit are reached. The large sheathing inflated petioles gave a peculiar character to the plants.

The petioles divided in a trifurcate manner. From the axils of the petioles compound umbels were produced. The largest flowering branch was 19 inches long, and the others varied from 6 to 12 inches. The umbels had neither involucre nor involucel. The rays of the general umbels varied in length from 2 to $2\frac{1}{2}$ inches, and in number from thirty to fifty. Besides the fructiferous umbels, there were others below them which appeared first in a globular form, and the flowers of which were unisexual, usually male, and sterile. The peduncles bearing these barren umbels were very long, and they sometimes exhibited small bractlets at their base. Similar bractlets were seen occasionally on the other peduncles. The limb of the calyx was obsolete—a mere rim with five slight projections or denticular points; petals yellowish, somewhat ovate, entire, one of them with the point inflexed. In the barren flowers, the petals were oblique and unequal, and acute at the apex. Stylopode urceolate and plicate, with a sinuous margin. Styles filiform, at length recurved and deflexed. Fruit, with single vittæ in the dorsal valleculæ; occasionally in the lateral valleculæ the vittæ were more than one, and divided.

The Asafœtida plant grows in a very dry climate. Besides the gum-resin, Falconer states that the fruit of Narthex is imported into India from Persia and Affghanistan under the name of Anjoodan, being extensively employed by the native physicians of India. Anjoodan or Andsjudaan and Halteet are the terms applied to the seed of Heengseh or Hingiseh by Avicenna, and used by the Indo-Persians and Arabic writers generally in describing the Asafœtida plant.

The gum-resins procured from umbelliferous plants were in high repute in ancient times, and they are noticed by ancient authors. One of these is Galbanum, the Chelbenah of Scripture, used for compounding various ointments; another, Opoponax, the produce of a plant called Πάνακες Ἡράκλειον, by Dioscorides; a third, is Sagapenum, described by the same author as being furnished by a species of *Ferula;* a fourth is Ammoniacum, yielded by a plant called Agasyllis; and a fifth is the gum-resin, now under consideration.* There was also a gum-resin, called by the Greeks ὀπὸς κυρηναϊκὸς, or Cyrenaic juice, which appears to have been the produce of an umbellifer called *Thapsia Sylvium.* Pliny, in referring to this says, "Laserpitium, quod Græci Σιλφιον vocant, in Cyrenaica provincia repertum; cujus succum vocant Laser."† There appears, however, to have been another Laser; for Pliny says, "Diuque jam non aliud ad nos invehitur Laser, quam quod in Perside aut Media et Armenia nascitur large, sed multo infra Cyrenaicum." This Laser of Persia is by some supposed to be the Asafœtida. Avicenna, in his "Canon Medicinæ," says, that there are two species of Asa or Laser, "quarum una est fœtida, et alia est odorifera non fortem habens odorem."‡

* Dioscorides lib. iii. c. 94, 95, 97, 98.

† Plin. Nat. Hist. xix. c. 15.

‡ Avicenna, lib. ii. tract 2, c. 53.

Asafœtida is got by incision, cuts, and slices, taken from the top of the root of Narthex. The stem yields also a milky juice, which, when allowed to flow, concretes into clear tears, having a very strong fœtid and enduring odour. The whole plant, especially when bruised, exhales a strong garlic odour. The smell of the flowers, when expanded, is of a sweetish honey-like nature, resembling that of *Galium verum*. The ripe fruits have the asafœtida odour when bruised, and retain it at least for eighteen years. Nevertheless, the cotyledons and early leaves of the growing young plant are not fœtid, although they contain a milky juice. The young root has a bitterish taste.

DESCRIPTION OF THE PLATES.

Plate XX.

Narthex Asafœtida, Falconer.

Fig. 1. Plant of *Narthex Asafœtida* much reduced in size, showing ventricose sheathing petioles or pericladia, bearing pinnately-divided laminæ, and giving origin to numerous compound umbels. Fig. 2. Perfect flower, with adherent calyx, having an obsolete 5-lobed or 5-toothed limb, five oblong yellow petals, one of them having an inflexed point, five stamens, an epigynous disk, and two styles slightly recurved. Fig. 3. Sterile male flower, having five stamens and a rudiment of the pistil, with unequal and somewhat ovate yellow petals. Fig. 4. Ovary, with epigynous limb of calyx, which exhibits five denticular points; disk, and two recurved and deflexed styles. Fig. 5. Young germinating Asafœtida Plant, with two linear cotyledons and primordial leaf.

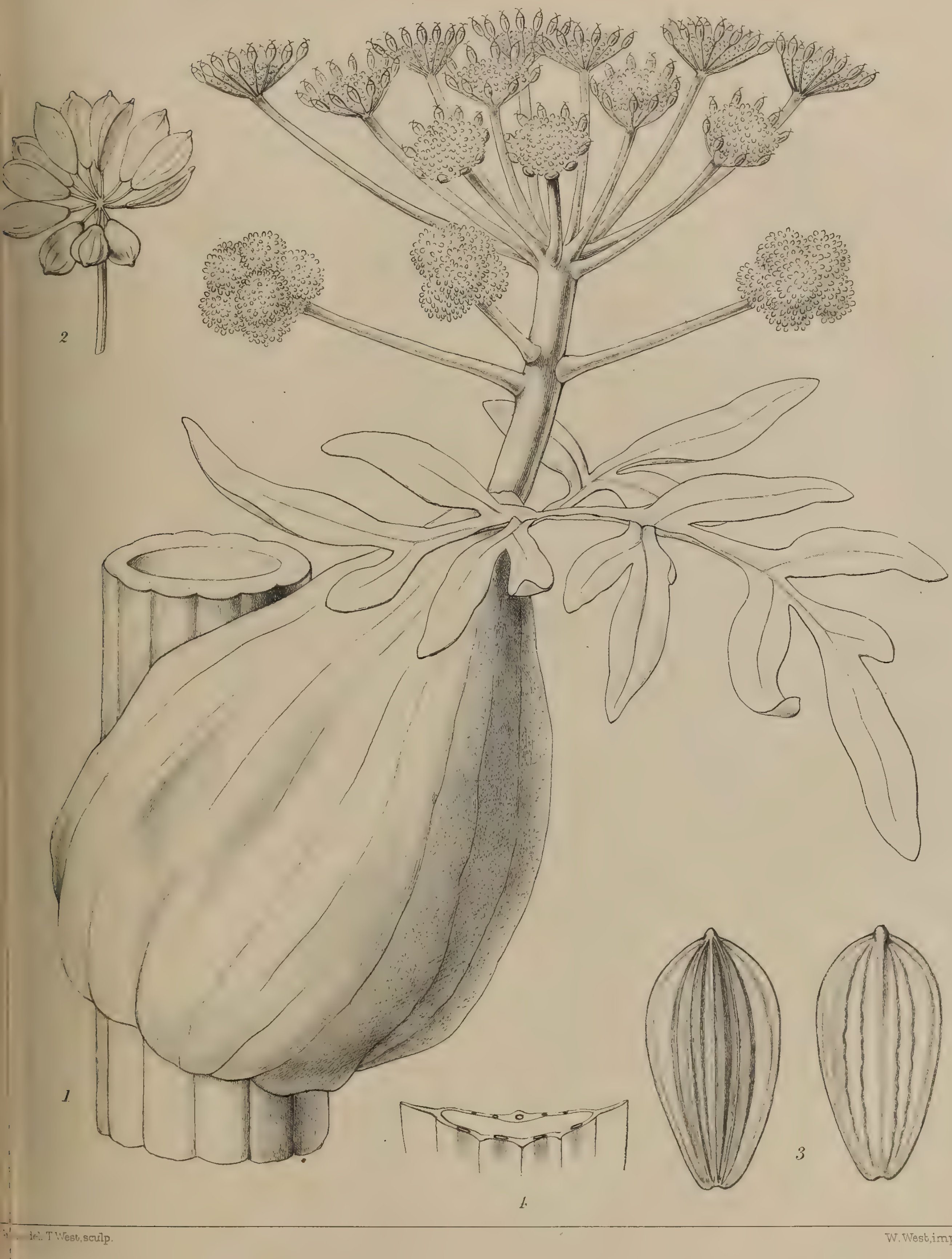
Plate XXI.

Fig. 1. Portion of hollow stem of *Narthex Asafœtida*, bearing an amplexicaul inflated petiole or pericladium which is terminated by a pinnately-divided lamina, and gives origin to a peduncle with a large fertile compound umbel, and three smaller rounded unisexual or sterile ones. Fig. 2. Cluster of Cremocarps or Diachænia. Fig. 3. Mericarps magnified, showing dorsal and commissural surface. The margins are winged, and the juga are represented, with the valleculæ and vittæ. Fig. 4. Transverse section of a mericarp, showing winged margins, valleculæ, vittæ, juga, and albumen.

W. West, imp.

NARTHEX ASAFOETIDA. *Falc.*

ig: 1. Plant of Narthex Asafoetida much reduced in size, showing sheathing pericladia, leaves and nbels. Fig: 2. Perfect flower, showing adherent calyx, oblong petals, one having an inflexed point, stamens, epigynous disk, and 2 styles slightly recurved. Fig: 3. Male flower with rudiment of the [illegible]. Fig: 4. Ovary with denticulate epigynous limb of calyx, & 2 recurved and deflexed styles.



del. T West, sculp. W. West, imp.

Fig: 1. Portion of stem of Narthex Asafoetida, bearing an amplexicaul inflated petiole or pericladium which is terminated by a divided lamina; and also bearing a peduncle with a fertile compound umbel, and 3 smaller rounded unisexual or sterile ones. Fig: 2. Cluster of fruit or cremocarps. Fig: 3. Fruit or cremocarps magnified, showing winged margin & juga with valleculæ & vittæ. Fig: 4 Transverse section of mericarp showing winged margins, valleculæ, vittæ, juga & albumen.

XV.—*On the Constitution of Oil of Cajeput.* By Maximilian Schmidl, Assistant to Professor Anderson in the Laboratory of Glasgow College.

(Read 17th April 1860.)

The constitution and properties of the essential oils attracted considerable attention during the earlier period of the investigations in organic chemistry, and several of them have contributed in no small degree to the development of the general doctrines of that department of the science. A majority of these substances, however, may be said to be still almost unknown, all the information we possess regarding them being restricted to a single analysis, made on what was obviously a mixture, or to a few observations of a general and often indefinite character. The complex nature of many essential oils, and the want of experience and easy processes for the separation of their constituents, have hitherto deterred chemists from attempting their minute examination, but the progress of the science has increased our knowledge of the methods of investigating these substances, and renders it important that their true constitution and position in the chemical system be definitely fixed. With this object I have taken up the investigation of Oil of Cajeput; our information regarding which is confined to a single analysis made by Blanchet and Sell, some five and twenty years ago.

Oil of Cajeput is prepared in the East Indies, by distilling along with water the leaves of *Melaleuca Leucadendron;* it was formerly used to a great extent as an external and even internal medicine, but has now become more or less obsolete, and is seldom met with in a pure or unchanged state, except in the hands of wholesale druggists. As introduced into Europe, it possesses a light-green colour resembling a dilute solution of chloride of chromium, which is caused by a resinous colouring matter dissolved in it, but in so small a proportion, that I have hitherto failed to obtain it in sufficient quantity and pure enough for elementary analysis. I suspected, in common with other observers, that this coloration might be due to a salt of copper; but although I always detected this metal in the crude oil, by treating it with nitric acid, when, after its total destruction, the blue nitrate of copper was left behind, or by the still simpler process of passing sulphuretted hydrogen through the oil, when a black precipitate of sulphuret of copper was immediately formed; I nevertheless satisfied myself that it possessed a green colour of its own; since, after the removal of the sulphuret of copper, it exhibited the same appearance, and, on distillation, the latter fractions which passed over had a decided green colour, which could not be due to any salt of copper, as none of its compounds volatilise at the temperature at which these fractions distilled; nor could I then by any reagent or operation detect the presence of copper, as I did in the crude oil.

The fact, however, that copper almost invariably is found in the crude commercial article, can only be accounted for, either by the use of a copper head in the distilling apparatus of the Indians, or by intentional adulteration employed in order to preserve the green colour of the oil, which it otherwise, as I have convinced myself, loses when in process of time oxidation takes place, in consequence of which a reddish brown colour is produced, which is said to make the article, for medicinal purposes, less saleable.

The Specific Gravity of the Crude Oil at 10° C.=0·926.—It does not solidify at – 25° C.; its taste is pungent and aromatic; its smell only pleasant when diluted, but very disagreeable when concentrated; it is soluble in all proportions in alcohol and ether. When submitted to distillation, it becomes turbid at 120° C., and acquires a yellowish brown colour; at 175° C., it commences to distil over, and before the thermometer indicates 178°, nearly two-thirds of the oil have passed over, the fluid collected being limpid and perfectly colourless; from 178° to 250° C. the mercury rises gradually, without showing any distinct boiling points. The fluid passing over between this long interval changes gradually from a pale yellowish colour into darker shades, approaching always more and more to green, until at last the fraction between 240° to 250° C. becomes of a dark untransparent green colour.

At 265° C. the retort is almost dry, retaining some metallic copper mixed with carbonaceous and resinous matter, which, when treated with ether, imparts to this reagent a green colour, and on evaporation of the latter a green resin is left behind, which is soluble in the rectified fraction (boiling at 175° C.), and thereby able to restore the coloured appearance of the original oil.

Whether the fractions beyond 178° C. be special and pre-existing constituents of the crude oil, or mere products of decomposition, and therefore of changeable character, I am as yet not able to state, since the results of operations performed with them are either contradictory as to this effect, or not yet sufficient to countenance the one or the other of these opinions; but still, in the course of time, and in a second paper, I hope I will be able to give some satisfactory accounts about them.

Most of my operations are therefore confined to the first large fraction, boiling at 175° to 178° C.; in particular cases, however, which I shall endeavour to specify, the crude oil has been employed.

I. Bihydrate of Cajputene, $C_{20} H_{16} + 2HO$.

I commenced my experiments by agitating the rectified fraction with bisulphate of soda, by means of which I satisfied myself of the absence of aldehydes and other bodies, capable of combining with that substance. And as, from the fixed boiling point, there could be no doubt that this fraction consisted only of one substance, I at once proceeded to its elementary analysis, after having had it rectified four times, and well dried over chloride of calcium. The following are the detailed results:—

(*a*) 2·60 grains of substance gave	. . .	7·42 CG_2	2·79 HO.
(*b*) 3·29 " "	. . .	9·22 CO_2	3·48 HO.

	A.	B.	Theory.
Carbon, ...	77·83	77·86	77·92
Hydrogen, ...	11·92	11·91	11·68
Oxygen, ...	10·25	10·23	10·40
	100·00	100·00	100·00

These results agree with those of Messrs BLANCHET and SELL,* who found Oil of Cajeput to consist of 77·92 carbon, 11·69 hydrogen, and 10·39 oxygen, to which they applied the name of Hydrate of Dadyl.

In order, therefore, to fix its rational formula, I then proceeded to determine its vapour density, of which the following are the details:—

Temperature of air, . . .	14° C.
Temperature of vapour, . . .	85° C.
Excess of weight of balloon, . .	0·580 grm.
Capacity of balloon, . . .	200·00 C.C.
Residual air, ...	...
Density of vapour	5·43

The formula $C_{20}\ H_{16}$ 2HO requires—

20 volumes of carbon, ...	$20 \times 0·831 = 16·620$
18 " hydrogen, ...	$36 \times 0·0693 = 2·490$
2 " oxygen, ...	$2 \times 1·050 = 2·100$
	21·21

21·21 : 4 = 5·30 theoretical result.

From the close agreement of the experiment with the theory, I could not hesitate to represent Oil of Cajeput by the formula $C_{20}\ H_{18}\ O_2$; and, induced by reactions of the substance, to be mentioned hereafter, I assigned to it the name of Bihydrate of Cajputene,† thereby indicating its resemblance with Oil of Turpentine, in comparison with which it possesses (besides $C_{20}\ H_{16}$) two additional equivalents of water.

Physical and Chemical Qualities and Reactions of Bihydrate of Cajputene.

The specific gravity of this substance at 17° C. is = 0·903; it boils constantly at 175° C., and is soluble in all proportions in oil of turpentine, alcohol, and ether.

* Annalen der Pharmacie, vii. 162.

† In order to avoid long words I write Cajputene and not Cajeputene, thus rendering the "j" half mute like "i."

When exposed in a moist state for a considerable time to atmospheric air, it changes into a reddish fluid, showing at last a pretty strong acid reaction to litmus paper.

In contact with an aqueous solution of potash a soluble salt is formed, the acid of which is precipitated by hydrochloric or sulphuric acid as a resinous substance.

When dropped into melted potash, a compound is formed which is soluble in water and decomposed by a strong inorganic acid; the precipitate being also a resin.

When treated at high temperature with sodium, a crystalline mass is produced, which is soluble in water and alcohol, and consists of soda and an organic substance; the latter being likewise separable by strong acids (organic and inorganic), as a resin of a very agreeable smell.

If the vapours of the oil be passed through a combustion tube filled with soda-lime and maintained at a red heat, an oily product is formed, which is obtained in a receiver suitably connected with the tube. This product possesses a peculiar smell, entirely different from that of the original substance, and a bright yellow colour; the soda-lime itself is thoroughly blackened with charcoal, and on the addition of an acid, it evolves copiously carbonic acid, thereby indicating that some decomposition must have taken place in the oil when passing through the tube; the analyses of the changed product will follow afterwards.

Bihydrate of cajputene does not seem to be changed when digested with peroxide of lead.

If the oil be distilled over permanganate or bichromate of potash in the presence of dilute sulphuric acid, a thick resinous fluid is produced.

Fuming nitric acid acts very violently on the oil, red fumes of nitrous acid being evolved even in the cold, and an abundance of oxalic acid being formed. Commercial nitric acid produces the same effect at boiling temperature; at ordinary temperature, however, it acts slowly, converting the oil into a thick red fluid.

Fuming sulphuric acid entirely changes the molecular condition of the oil, even if the latter be kept during the operation immersed in ice, a thick brown fluid being formed, which boils beyond 360° C.

Commercial sulphuric acid acts at low temperature very slowly on the oil, so, that after four or five hours little or no change is observed if the acid be removed and the oil well washed; but if the temperature be allowed to rise, either by artificially employed heat, or by continued unchecked chemical action, sulphurous acid is given off, blackening of the oil commences, and may even go on to total destruction of the substance. This can be avoided by caution, and then a sulpho-compound will be formed, which gives with baryta a soluble salt.

Dilute sulphuric acid acts most curiously on the oil, since, in the opposite manner to the fuming and commercial acid, it not only does not deprive the oil of its two equivalents of water, but causes the formation of a crystalline substance which possesses four equivalents of water in addition to the two original ones.

Anhydrous phosphoric acid deprives the oil of its two equivalents of water, when heated along with it.

Chloride of zinc, under similar circumstances, does not act so energetically, the two equivalents of water having been found to have been only partly removed from the oil after the application of that reagent.

Commercial hydrochloric acid, if left in contact for some weeks with the crude oil, produces a crystalline compound. Gaseous hydrochloric acid produces, under particular circumstances to be mentioned below, two kinds of crystalline compounds.

Chlorine, when passed through the oil, raises its temperature to a considerable height, producing, however, no visible change in it.

Iodine dissolves in the oil, and, under precautions which will be further described, different crystalline compounds may be formed.

Bromine acts very briskly, and produces under similar circumstances, like iodine, crystalline compounds.

Before leaving the Bihydrate of Cajputene, I will briefly note the results of the analyses performed with that secondary product, which was obtained when the first large fraction had been passed through red-hot soda-lime.

Fraction 180° to 185° C.

(*a*) 2·49 grains of substance gave, ...	7·29 CO_2	4·25 HO.
(*b*) 4·15 „ „ . . .	12·18 CO_2	4·51 HO.

	A.	B.
Carbon, ...	79·76	80·03
Hydrogen, ...	12·20	12·07
Oxygen, ...	8·04	7·90
	100·00	100·00

The increase of carbon and hydrogen shown by these analyses on the one hand, and the presence of a large amount of charry matter and carbonic acid in the employed soda-lime on the other, indicate sufficiently that by that operation some change or another must have taken place in the oil; but as I have not yet entered upon any investigation of this product, further than the above analyses, I refrain from giving any other opinion about it, except that the above results would best correspond with the empirical formula $C_{26}\ H_{24}\ O_{20}$, the percentages of which are—

79·59	C.
12·44	H.
7·97	O.
100·00	

Since I succeeded in obtaining a crystalline iodine compound, and a hydrate of this secondary product, I hope to be able to give some further and more satisfactory results about it in a subsequent paper.

II. Monohydrate of Cajputene.—$C_{20}H_{16}+HO$.*

The crude oil is raised to its boiling point in a deep open vessel, and when commercial sulphuric acid is continuously dropped into it, violent ebullition—which after a short time is accompanied by a peculiar crackling sound—takes place. As soon as this is observed the flame is lowered, and the acid very cautiously added, until almost suddenly the fluid assumes a dark colour, which goes on in one moment from the surface throughout its whole depth. Should this be overlooked, and the acid indiscriminately added, the process goes on further than desired, sulphurous acid is formed, both equivalents of water removed, and the products become very complicated. At the moment, therefore, when the darkening of the substance just commences, the vessel must be removed from above the flame and allowed to cool. The upper oily fluid is then separated from the acid, well washed and distilled. Amongst the fractions obtained thereby, I chose that which passed over at 170° to 175° C., as having been the largest; and after several rectifications, I proceeded to ascertain its composition, and to determine the density of its vapour, of which the following are the details:—

(*a*) 3·75 grains of substance gave,	11·38 CO_2	4·00 HO.
(*b*) 3·45 „ „	10·47 CO_2	3·59 HO.
(*c*) 2·04 „ „	6·18 CO_2	2·180 HO.

	a	*b*	*c*	Theory.
Carbon,	82·73	82·79	82·62	82·75
Hydrogen,	11·85	11·59	11·87	11·72
Oxygen,	5·42	5·62	5·51	5·53
	100·00	100·00	100·00	100·00

Vapour Density.

(1.)	(2.)	(3.)
Temperature of air, 18° C.	Temperature of air, 10° C.	Temperature of air, 20° C.
Temperature of vapour, 220° C.	Temperature of vapour, 210° C.	Temperature of vapour, 200° C.
Excess of weight, 0·404 grm.	Excess, 0·405 grm.	Excess, 0·520 grm.
Capacity, 159·5 CC.	Capacity, 158·4 CC.	Capacity, 214 CC.
Residual air	Residual air, 2 CC.	Residual air, 14. CC.
		Barometer, 750 M.M.
D=5·19.	D=5·26.	D=5·27.

* Since April last, the time when the present paper was read before the Royal Society, I undertook, at the suggestion of several professional friends, to prepare anew the substances under consideration. The results arrived at now, by repeated combustions and determinations of its vapour density, showing nowhere a difference of much more than one-tenth, if compared respectively with one another, or with those obtained previously, leave really little or no doubt at all about the purity and chemical unity of the substance—however novel, singular, and exceptional it may seem, that the vapour of a body containing one atom of oxygen should condense to four volumes. However, as the substance is easily prepared, the experiment should be repeated by others, and not only with Oil of Cajeput, but with all the bihydrates of the turpentine-radical. Like experiments with bodies of ana-

The formula, C_{29} H_{17} O, requires—

20 volumes of carbon	$= 20 \times 0·831$	$= 16·620$
17 „ hydrogen	$= 34 \times 0·0693$	$= 2·356$
1 „ oxygen	$= 1 \times 1·108$	$= 1·108$
		20·090

20·09 : 4 = 5·02.

III.—Cajputene, Isocajputene, Paracajputene—C_{20}, H_{16}.

The rectified oil is allowed to cohobate over anhydrous phosphoric acid for about half an hour; on entire distilling, an oil passes over, which by repeated rectification separates into three principal fractions of distinct and steady boiling points.

Cajputene is one and the first of these fractions; it passes over at 160° to 165° C. It is perfectly colourless, and possesses a very pleasant smell, resembling that of hyacinths; it is insoluble in alcohol, soluble in ether and oil of turpentine; its specific gravity at 15° C. = 0·850.

The following are the details of its analysis:—

(*a*) 3·20 grains of substance gave 10·36 CO_2 3·43 HO.
(*b*) 3·90 „ „ 12·63 CO_2 4·10 HO.

	a	*b*	Theory
Carbon,	88·29	88·34	88·24
Hydrogen,	11·91	11·78	11·76
	100·20	100·12	100·00

Vapour Density.

Temperature of air,	16° C.
Temperature of vapour,	204° C.
Excess of balloon,	0·399 grm.
Capacity of balloon,	165 CC.
Residual air,	7 CC.

D=4·717.

The formula requires ·465.

Reactions.

If Cajputene is exposed to a current of gaseous hydrochloric acid, a beautiful violet fluid is produced; but no crystalline compound is deposited, even if the oil be maintained during the operation at –10° C, and preserved afterwards for any length of time. A mixture of commercial nitric and sulphuric acid acts very vio-

logous composition will probably increase the number of similar instances. Further remarks as to its reactions, physical qualities, secondary products, and its relation to the Bihydrate of Cajputene, compared with which it might prove to be an analogous ether, I will endeavour to give in a subsequent paper.

lently on Cajputene, producing a yellow brittle resin. Bromine, also, acts very briskly in contact with it, producing a dark viscid oil. Iodine behaves indifferently at ordinary temperature towards it; but at a raised temperature hydrogen is copiously evolved, and a black fluid produced. Cajputene resists the influence of atmospheric air, retaining its peculiar smell and colourless appearance even after a very long exposure to this generally powerful agent.

Isocajputene is the second fraction, separated from that oily product obtained by the action of anhydrous phosphoric acid; it passes over at 176° C. to 178°; its specific gravity at 16° C. is = 0·857; it is insoluble in alcohol, and mixes in all proportions with ether and with oil of turpentine; its smell is different from and less agreeable than that of Cajputene, and when exposed to atmospheric air it soon acquires a yellow colour, and a more pungent aromatic smell.

The same body may be procured by continued action, at a raised temperature, of commercial sulphuric acid upon the Bihydrate of Cajputene, especially if the oil be distilled along with the acid.

The following are the details of the analyses performed :—

(1.) *Product got by the Action of Phosphoric Acid.*

(*a*) 2·24 grains of substance gave 7·24 CO_2 2·35 HO.
(*b*) 2·70 " " 8·72 CO_2 2·84 HO.

	a	*b*	Theory.
Carbon, . . .	88·16	88·18	88·24
Hydrogen, . . .	11·64	11·68	11·76
	99·80	99·86	100·00

(2.) *Product got by the Action of Sulphuric Acid,*

(*a*) 4·20 grains of substance gave 13·56 CO_2 4·50 HO.
(*b*) 2·93 " " 9·48 CO_2 3·12 HO.

	a	*b*
Carbon, . . .	88·05	88·23
Hydrogen, . . .	11·90	11·83
	99·95	100·06

Vapour density of (1.) = 4·82; of (2.) = 4·52; theory = 4·65.

Nitro-sulphuric acid, gaseous hydrochloric acid, bromine, and iodine react in the same way on Isocajputene as on Cajputene. Commercial and even dilute sulphuric acid, dilute nitric, and dilute hydrochloric acid, all of which behave indifferently towards Cajputene, react upon Isocajputene, producing by mere contact, in a very short time, dark viscid fluids.

Paracajputene, $C_{40} H_{32}$, is the last fraction of those isomeric hydrocarbons produced by the action of anhydrous phosphoric acid; it distils at 310° to 316° C.; is very viscous, and of lemon-yellow colour, but if looked at in certain directions, it shows a beautiful deep blue fluorescence. It is insoluble in alcohol and oil of turpentine, but soluble in ether, and when exposed to atmospheric air, it rapidly oxidises, acquiring a red colour and resinous consistence.

Analyses.

(*a*) 4·19 grains of substance gave 13·57 CO_2 4·55 HO.
(*b*) 3·15 " " 10·19 CO_2 3·42 HO.

	a	*b*
Carbon	88·33	88·28
Hydrogen	12·06	12·06
	100·39	100·34

Vapour Density.

Temperature of air,	16° C.
Temperature of vapour,	320° C.
Excess of weight of balloon,	0·599 grm.
Capacity of balloon,	198 CC.
Residual air,	22 CC.

$$D = 599 + \left(\frac{198 \times 0{\cdot}0001224}{176 \times 0{\cdot}000605}\right) = \frac{84135}{10168} = 7{\cdot}96.$$

The theory requires double the quantity of what is required for the formula $C_{20} H_{16} = 4{\cdot}65 \times 2 = 9{\cdot}30$. The great difference between the experimental and theoretical results can only be accounted for by the high boiling point of the substance, and its great tendency to decompose at that temperature.

Reactions.

Gaseous hydrochloric acid produces a dark violet fluid, which does not deposit any crystalline compound, even if the operation be performed at –10° C. Nitro-sulphuric acid does not act so violently as on the two foregoing fractions.

IV. Hexhydrate of Cajputene, $C_{20} H_{16} + 6$ HO.

Two parts of dilute sulphuric acid are added to one of the crude Oil of Cajeput; the mixture is then well shaken for several days, until the watery layer acquires a yellowish colour; thereby the presence of organic matter in the latter is indicated. After that the mixture is left to itself, when, usually from about the tenth day and upwards, crystalline tufts, adhering to the sides of the vessel, are found.

These crystals are sparingly soluble in cold, but readily in boiling alcohol; they fuse at 120° C., and solidify again at 85° C. When submitted to dry distillation, the oily fluid which passes over solidifies again in the colder parts of the receiver; but from the limited amount of substance then at my disposal, I could not ascertain if this product of sublimation was of the same or of altered composition.

The following are the detailed results of the analyses performed with the substance after previous recrystallisation out of alcohol:—

(*a*) 2·65 grains of substance gave		6·17 CO_2	2·86 HO.
(*b*) 2·61	„ „	6·04 CO_2	2·61 HO.
(*c*) 2·98	„ „	6·90 CO_2	3·21 HO.

	a	*b*	*c*	Theory.
Carbon,	63·39	63·11	63·11	63·15
Hydrogen,	11·99	11·96	11·92	11·57
Oxygen,	24·62	24·93	24·97	25·28
	100·00	100·00	100·00	100·00

Crystals of the same composition I found deposited in a secondary fraction of the crude oil, which on distillation passed over at 210°–230° C., and was left for a very long time moist and exposed to the action of atmospheric air. When the crude oil is mixed with dilute nitric acid and alcohol in the same proportions as are used when a similar compound is contended for in oil of turpentine, no crystals are found before at least seven or eight months; after the lapse of this time, however, such appear and are seen suspended in the oil, which meanwhile changes into a heavy black fluid. The quantity which I got by this method was so small, that I was not able to carry out any operations with it in order to satisfy myself if its composition and qualities really were the same with, or different from, the above-mentioned Hexhydrate of Cajputene; but as I am again preparing the same substance just now, I hope to give some account of it in a second paper. There also I intend to describe other crystalline compounds which I just recently obtained, by the action of dilute nitric acid upon the total crude oil, upon the rectified fraction, boiling at 175° C., upon the second fraction, boiling from 178°–200° C., and upon the last green fraction, boiling from 200°–255° C. By the comparison of these crystalline substances I may perhaps become enabled to state something more satisfactory about the nature of those secondary fractions of the crude oil.

V. Hydrochloro Compounds of Cajputene.—*Bihydrochlorate of Cajputene*, $C_{20} H_{16} + 2 HCl$.

If gaseous hydrochloric acid be passed through the rectified oil, which is maintained at low temperature, a violet fluid is produced, which, after 10–15 minutes, suddenly solidifies into a crystalline mass, so that the orifice of the delivery-tube becomes obstructed, thereby preventing the further application of the gaseous acid. This crystalline compound, however, I was unable to analyse, since no sooner was it removed from the vessel where prepared than it deliquesced, even when pressed between bloating paper, which by means of artificial cold had been maintained at ′−25° C.; the fluid, also, resulting from that deliquescend substance, gave off constantly fumes of hydrochloric acid, and on distillation it decomposed entirely, showing no constant boiling point. If, however, immediately after the application of gaseous hydrochloric acid, that crystalline mass be thrown into a vessel containing water or alcohol, beautiful long prisms are formed after a few days, which contain no chlorine, and seem to be of the same composition as the Hexhydrate of Cajputene.

If the oil be mixed with a third of its volume of alcohol, or if, in place of alcohol, strong aqueous hydrochloric acid be taken, and gaseous hydrochloric acid then passed through either of the mixtures, a crystalline compound is formed which is of steady constitution, and different in all its physical and chemical qualities from the one formed without the presence of alcohol or aqueous hydrochloric acid.

The following are the detailed results of its elementary analyses :—

(*a*) 0·266 grm. of substance gave 0·562 CO_2 0·214 HO.
(*b*) 0·268 „ „ 05·65 CO_2 0·216 HO.
(*c*) 0·145 „ „ 0·205 AgCl.

	a	*b*	*c*	Theory.
Carbon,	57·61	57·54		57·41
Hydrogen,	8·93	8·95		8·61
Chlorine,	.	.	34·49	33·98
				100·00

Bihydrochlorate of Cajputene melts at 55° C., and solidifies again at about 30° C.; when submitted to dry distillation, it gives off fumes of hydrochloric acid at 60° C., and splits into several fractions, one of which is of constant boiling point and steady chemical composition, which will be mentioned afterwards. When boiled with an alcoholic or aqueous solution of potash it undergoes no change, unless a high temperature be maintained for a long time by cohobation, when one equivalent of hydrochloric acid is removed. It is sparingly soluble in cold, but readily soluble in boiling alcohol and in ether; it possesses no taste or smell whatever, and differs in that and in most of its other physical and chemical qualities from the isomeric compound in oil of turpentine, called the artificial camphor; out of alcohol it crystallizes in beautiful radiating tufts.

VI. Monohydrochlorate of Cajputene, $C_{20} H_{16} + HCl$.

When the Bihydrochlorate of Cajputene is submitted to distillation, amongst several other fractions, one passes over which has been mentioned before as possessing a constant boiling point. This fraction distils at 160°, and its analyses gave the following results :—

(*a*) 0·330 grm. of substance gave 0·848 CO_2 0·295 HO.
(*b*) 0·257 „ „ 0·654 CO_2 0·233 HO.
(*c*) 0·172 „ „ 0·143 chloride of silver.

	a	*b*	*c*	Theory.
Carbon, .	70·00	69·40		69·76
Hydrogen, .	9·93	10·07		9·88
Chlorine, .	.	.	20·53	20·36
				100·00

A product of similar composition is obtained when the Bihydrochlorate of Cajputene is treated for several days at high temperature with an aqueous or alcoholic solution of potash; the smell of this substance, however, is so entirely different from that of the other monohydrochlorate (reminding of pelargonic ether), that some further investigation may probably lead to more striking chemical as well as physical differences between these two isomeric substances.

VII. Bichloride of Cajputene, $C_{20} H_{16} + 2Cl$.

The large rectified fraction of Oil of Cajeput is mixed with some very dilute nitric acid, and then exposed to a stream of gaseous hydrochloric acid, when, after a few minutes, violent evolution of yellow and red fumes, consisting of chlorine and nitrous acid, takes place. The gaseous hydrochloric acid is allowed to pass so long till the oily fluid in the vessel has entirely sunk to the bottom, having then the watery layer (reversely to the beginning of the operation) above itself.

If the vessel be, after the operation, kept at a low temperature, a crystalline compound may be formed, which, however, I was only once fortunate enough to obtain, but in so small a quantity that I could not make more than one analysis of it, by means of which, however, I convinced myself of the presence of chlorine in that substance. In ordinary cases, therefore, I had to content myself with a limpid brown fluid, which, in consequence of the adhering nitric and nitrous acid, I redistilled over a strong solution of potash; and thus prepared I submitted it to its elementary analyses, of which the following are the detailed results:—

(*a*) 2·87 grains of substance gave		6·05 CO_2	2·09 HO.
(*b*) 3·61	,, ,,	7·60 CO_2	2·63 HO.
(*c*) 2·91	,, ,,	4·10 chloride of silver.	
(*d*) 4·84	,, ,,	3·97 ,,	

	a	*b*	*c*	*d*	Theory.
Carbon,	57·49	57·41			57·98
Hydrogen,	8·09	8·09			7·72
Chlorine,			34·57	34·21	34·30
					100·00

As this substance could not be distilled by itself without decomposition unless in vacuo, I was not able to take its vapour density. It possesses an extremely fine and agreeable smell, and may be kept for any length of time without undergoing any decomposition. When boiled with nitrate of silver, a peculiar detonation takes place, and chloride of silver is formed.

Before leaving the compounds which are produced by the action of hydrochloric acid, I must observe that only recently I got another crystalline compound which had been formed by the mere contact of the crude oil with commercial hydrochloric acid, which, however, I have not yet analysed, and must therefore preserve for a following paper.

BROMO COMPOUNDS.

VIII. TETRABROMIDE OF CAJPUTENE, $C_{20}H_{16}+4$ Br.

When the rectified oil is shaken with bromine water, a red resin is formed, out of which a solid substance crystallizes in small white prisms. This crystalline compound, however, is unmanageable, in consequence of the readiness with which it deliquesces and decomposes. When dry bromine is dropped into the oil a very brisk action takes place, and the sides of the vessel become covered with yellow needles, but which immediately disappear again; if bromine be added so long till almost no reaction is observed in the fluid, a dark, thick, and viscous oil is produced, which, after the lapse of several weeks, deposits a granular substance. As soon as this is observed, alcohol is added to the whole mixture, and boiled along with it. By this operation the granular substance is extracted, and a heavy oil left behind. On the cooling of the alcohol a soft crystalline substance is deposited, of a fatty lustre, resembling very much cholesterine when crystallizing out of the same menstruum. The following are the details of its analyses:—

(*a*) 2·60 grains of substance gave 2·51 CO_2 0·994 HO.
(*b*) 3·21 „ „ 3·05 CO_2 1·20 HO.
(*c*) 3·27 „ „ 5·38 bromide of silver.

	a	*b*		Theory.
Carbon,	26·32	25·97		26·31
Hydrogen,	4·24	4·15		3·52
Bromine,			70·03;	70·17
				100·00

This substance is soluble in ether and boiling alcohol; it melts at 60° C., and solidifies again at 32° C. When submitted to dry distillation, the fluid which passes over crystallizes again in the cooler parts of the retort; whether this product is changed or not I have not yet ascertained. When boiled with a solution of caustic potash, the tetrabromide seems to remain unaltered.

Another crystallized bromine compound has been obtained by the action of phosphorus, dissolved in bisulphide of carbon, on the oil dissolved along with bromine in the same menstruum; the substance, however, at my disposal was so limited in quantity as to preclude the possibility of a satisfactory analysis.

IODINE COMPOUNDS.

XI. Hydriodate of Hydrate of Cajputene, $C_{20}\ H_{16} + HO + HI$.

If iodine be added in small quantities to the crude or rectified oil, no reaction seems to take place; if, however, the fluid be heated, such is observed, as the oil, under the evolution of fumes of hydriodic acid, changes into a black heavy fluid; but in order to get a crystalline compound, no artificial heat in this way is allowed to be applied, as by its application the action of the iodine goes too far, resulting in a viscous substance, out of which nothing can be made. After the addition of the iodine the fluid must be stirred rather constantly, and the heat thus produced by the friction of the rod, as well as the mechanical distribution of the iodine, favour the action between the two substances, so that after a few minutes the temperature of the fluid rises from 10° to 40° C. When this is observed, no more iodine is to be added, and the whole vessel is immersed in cold water, when, after a very short time, a black crystalline compound is deposited in the bottom of it. After the oily fluid is filtered off, the solid substance is pressed between bloating paper, and, when nearly dry, dissolved in alcohol or ether, out of which it crystallizes in prisms of beautiful yellow-green metallic lustre.

The following are the results of some of the analyses performed with it:—

(*a*)	3·63 grains of substance gave	5·71 CO_2	2·30 HO.
(*b*)	3·26 „ „	5·18 CO_2	1·97 HO.
(*c*)	2·69 „ „	4·28 CO_2	1·69 HO.
(*d*)	5·55 „ „	4·78 iodide of silver.	

	a	*b*	*c*	*d*	Theory.
Carbon,	42·91	43·33	43·21	. . .	43·95
Hydrogen,	7·01	6·71	6·98	. . .	6·59
Oxygen,	. . .	. . .	. . .	. . .	2·94
Iodine,	. . .	. . .	. . .	46·51	46·52
					100·00

This compound is very soluble in alcohol and ether, insoluble in water, in contact with which it does not become decomposed. It is, however, a very unstable substance, as it easily deliquesces in the course of time, and when melted, which it does at 80° C., it is not recrystallizable. In contact with a cold solution of potash it soon assumes a fluid condition, losing some of its iodine, which at a raised temperature it gives off entirely.

X. Hydriodate of Cajputene, $C_{20}\ H_{16} + HI$.

A solution of phosphorus in bisulphide of carbon is added to a solution of iodine and oil of Cajeput in the same menstruum. As soon as this is done, a very brisk reaction takes place; the vessel becomes so hot that it cannot be touched by the bare hand of the operator; red oxide of phosphorus is formed and precipitated; the oily fluid acquires a reddish colour, and gives off fumes which, by the prevalence of the volatile oil, I could not exactly recognise, nor was I, by the peculiarity of the operation, able to receive them under a pneumatic trough. The reaction, however, may be represented by the following simple equation:—

$$3\,(C_{20}\,H_{16}) + 6H + 60 + 3PI =$$
$$3\,(C_{20}\,H_{16} + HI) + H3P + PO + PO5;$$

according to which gaseous phosphoretted hydrogen, oxide of phosphorus, and phosphoric acid would be formed; the last two of which I always found present in the fluid out of which the Hydriodate of Cajputene, in the course of ten or twelve days, crystallized. These crystals are deposited in cells like those of beehives, and possess a black metallic lustre. The following are the detailed results of the analyses:—

(*a*) 4·39 grains of substance gave 7·29 CO_2 2·48 HO.
(*b*) 3·01 „ „ 5·01 CO_2 1·72 HO.
(*c*) 5·54 „ „ 5·02 iodide of silver.

	a	*b*	*c*	Theory.
Carbon,	45·29	45·36		45·45
Hydrogen,	6·31	6·35		6·43
Iodine,			48·85 I	48·12
				100·00

Hydriodate of Cajputene is soluble in alcohol and ether, and more stable than the preceding iodo-compound, as it remains for any length of time, and even if boiled with a solution of potash, unchanged.

Secondary products of this and the other iodo-compound I intend to describe in a following paper, which I will endeavour to finish as soon as possible.

Finally, I consider it my duty to express my sincerest thanks to Professor Dr Thomas Anderson, who so generously and forbearingly supported me with all kinds of mental and material aid previous to and during the time of this investigation.

XVI.—*Notes on the Mountain Limestone and Lower Carboniferous Rocks of the Fifeshire Coast from Burntisland to St Andrews.* By the Rev. Thomas Brown, Edinburgh.

(Read 17th April 1860.)

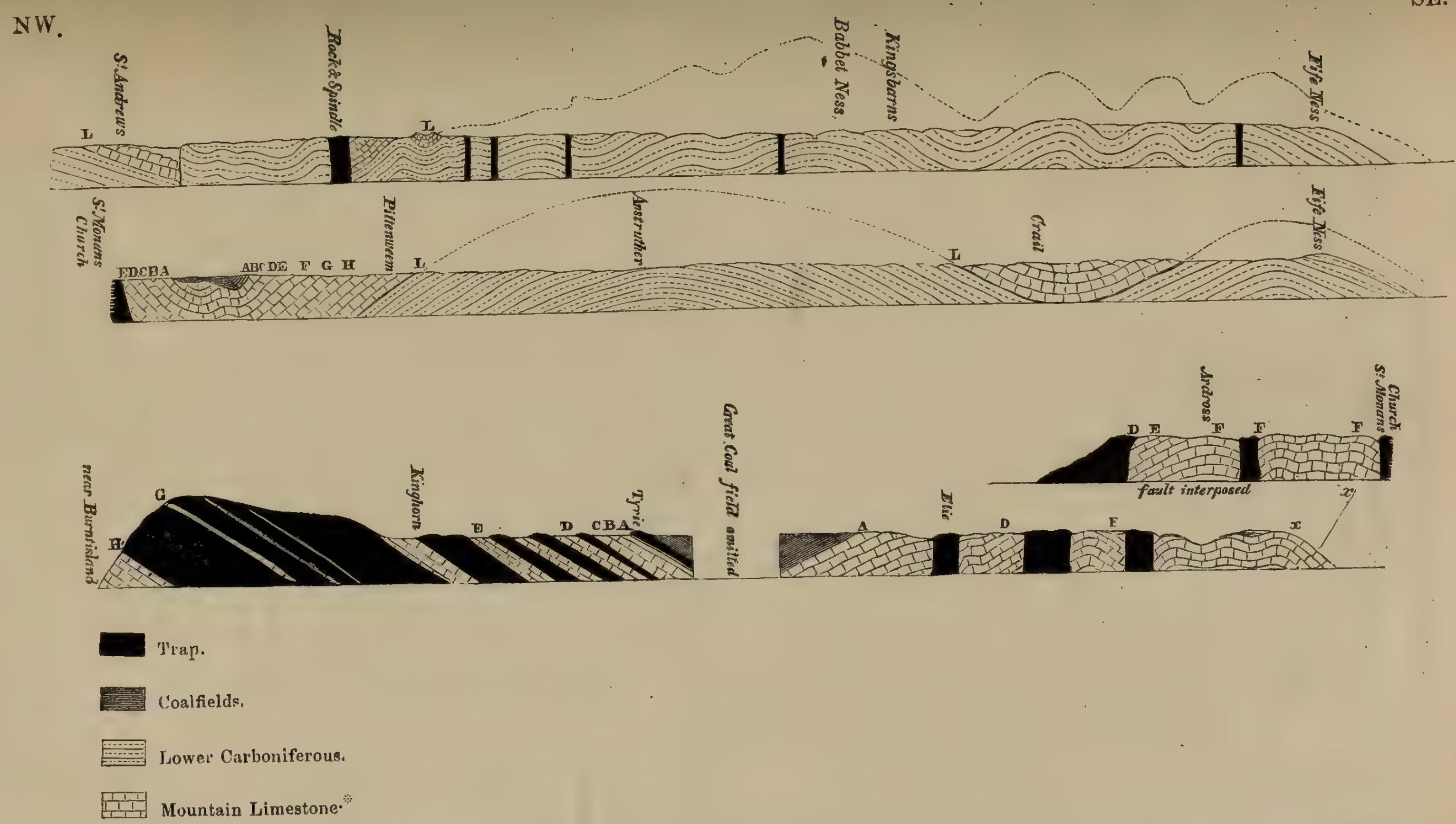
Introduction.

In this paper I shall first refer to the circumstances under which the following observations were made.

I had gone in the autumn of 1856 for a few weeks to Elie on the Fife coast, and was induced, as a means of relaxation and exercise in the open air, to pay some attention to the geology of the neighbourhood, resuming for a brief interval what was once a favourite pursuit. About a mile to the east of the village, I found a stratum well deserving attention—a thin bed of limestone—dipping inland a little beyond the cliff on which stands the ruined Castle of Ardross. The fossil shells which it contained were of unusual form, and beautifully preserved; there were fish remains of two or three species, and a small group of crustaceans still more remarkable. Among the fish I thought I could detect the large scales of an Irish species—the *Holoptychius Portlockii*—and among the crustaceans there were the valves of Dithyrocaris, a genus particularly characteristic of the Irish beds. At once the question arose whether these fossils might not serve as links connecting this Ardross bed with the Irish series. The point was of the more importance, that our leading geologists had been differing widely as to the true position of our Scottish coal strata in the geological scale. The lamented Professor Edward Forbes had assigned them a place comparatively high, while Sir Roderick Murchison, with surer judgment, had taken the opposite view and put them beneath the Newcastle coal-field. If any light could be thrown on this question, it might prove of some interest to the Scottish geologist. My first object, then, was to ascertain the level on which the Ardross limestone lay among our own strata; but this proved at first a question of unexpected difficulty. The coast near Ardross is cut up by trap in the most singular way, and the sedimentary strata are fractured and isolated into patches, in one of which the bed in question is situated. Looking into our local authorities, I found Mr MACLAREN gave no assistance, Dr ANDERSON was silent, and even Mr LANDALE, in his valuable Essay, was still more discouraging. East and west there is no lack of detail in his account of the coast; but precisely here for some distance on either side of Ardross he gives up the case as hopeless, the trap having reduced the whole to "a heap of ruins." A rapid glance at the rocks convinced me that matters were not so bad as this. At all, events the attempt to reduce these beds to order promised to give pleasant occupation for three or four idle weeks. Selecting, accordingly, a fixed point, I began at first, quite mechanically, noting each bed as it came, —its composition, thickness, dip, strike, and gathering such fossils as might serve to identify it—the results being laid down each evening in detailed sections. It ended, indeed, in my making (besides the sections) a ground plan of the coast from Elie to St Monans. And very singular it was to see how, under this treatment, the beds fell into their places, and the supposed heap of ruins became an orderly series. Through faults, convolutions, and outbursts of trap, the strata could be distinctly followed westward into the coal-basin at Earlsferry, and eastward into that of St Monans.

The position of the Ardross bed being thus determined, other questions arose. The limestone strata of Burntisland have long been a fixed point well known to geologists. Where was the level of the Ardross bed as compared with these Burntisland strata, and generally, how would the western side of the basin correspond with what I had found on the east? This led me to examine the shore from Invertiel to Burntisland, and nothing could be clearer than the general resemblance. Beds with which I had made myself familiar came up in regular order. The thick white limestone of St Monans, for example, distinguished for its abundance of Zaphrentes and similar corals, was there in position, covered by the same fossils still larger and more abundant. Going on as far as Burntisland, I found the relative position of the strata to be as shown in the section.

Another question referred to the underlying series of rocks. On the shore to the east of St Monans, I had seen the Ardross bed overlying that great mass of strata which Mr MACLAREN has termed the calciferous sandstones. What was the character and relations of this lower group? This investigation I found one of extreme interest. It led me first as far as Anstruther; then past Crail on to Fife Ness, and then to where the rocks are lost in the sand a little to the north of St Andrews. It has occupied my autumn leisure for several years—in some cases, however, only a few days being at my disposal. I beg to offer to the Society a notice of such facts as I have observed on the following points, viz.:—



* It consists chiefly of shales and sandstone, with a few beds of limestone, but is marked thus in the section to express the opinion (here advocated) that the mass is the equivalent of the Mountain Limestone of England—lower portion. The dotted line marks the supposed level which (if the strata had been continuous) would have been occupied by the bed L—the base line of the Mountain Limestone.

Note.—In order to bring the section within proper limits, it has been divided into two parts, but they should be viewed as continuous. For part of the distance between Elie and St Monans a double line of section is given to represent the rocks on both sides of the fault. The inward termination of the line x x, which marks the course of a stratum across the end of the fault, should have pointed more to the west. The remarkable contortions in the cliffs to the east of St Andrews, and those near Newark Castle, should have been more strongly represented than they are in the section.

I. The General Course of the Strata.

The section passes along near high-water mark, the strata being supposed to be cut at right angles so as to show their real thickness only, not the space they occupy on the shore. From Fife Ness to St Andrews they are laid down in reverse, as if the spectator were looking seaward, and this is done to bring the corresponding portions of the two shores into comparison.

From Burntisland to Inverteil the great feature is the immense development of trap beds, amidst which the sedimentary strata lie conformably. The limestones G and H,* with other beds as far as Kinghorn, are estuarine, and then come the six upper marine limestones, all dipping beneath the great coal-fields.

Rising at Elie harbour in reverse order the beds are with some difficulty to be made out covered as they are at some points by sand or obscured by trap, at others as in Woodhaven almost removed by quarrying, and complicated throughout by the thirty-fathom fault, yet with patient attention the position of the whole series can be well enough traced. The fault cuts the Earlsferry coal-field in two, passes along-shore in front of Elie, goes, according to Mr Landale, through the "Taft," may be seen west of Ardross skirting *low-water* mark till it touches the bend of the coast west of Newark, where it seems to vanish.† Outside this line the beds are thrown up and carried (the field geologist well knows how) in the direction of their dip far out of the bearing of the same beds as they lie in-shore. The middle portion of the coast between Elie and St Monans, consisting of the lower beds, is estuarine. Approaching Newark, these strata become remarkably contorted, dipping into little basins, but rising at each movement into higher beds, till the six marine bands of limestone finally fold over and plunge beneath the coal-field at St Monans. Rising again to the east all trap is left behind, and the sequence of the whole beds is singularly clear as they lie exposed along the shore like the mighty pages of nature's book. Passing through the same estuarine beds the strata beyond Pittenweem rise into bold cliffs, remarkable for the depth of the shales which they display, and at that point occurs the limestone L, so important in the classification of the whole series. Eastward among the fine rocks of the Billow Ness lie the thin limestone bands of the lower series, and the shales charged with numerous vegetable remains, continuing down till the anticlinal axis is reached at the harbour of Anstruther. From Anstruther to Crail the same rocks are repeated—the depth of the whole series, however, being apparently greater and—the sandstones especially—more powerfully developed. A red colour

* Owing to the small size of the section, as given in this paper, it has been impossible to represent the separate beds of limestone, or the sub-divisions of the upper group. For the same reason it has been found difficult to give the angle of dip with anything like minute accuracy. Some of the lesser bendings of the strata are omitted—only the general results could be given.

† This point is marked in the section by the letter *x*.

from iron tinges some of the limestones, and especially the bed L, which at Pittenweem is dark gray. At Roome beyond Crail the synclinal axis is reached: the beds again show a descending series till they fold over an anticlinal close to Fife Ness. That point forms a splendid display of powerful yellow sandstone, dipping with gentle slope towards the ocean whose stormy waves it has flung back for ages.

Away to the north, and on as far as St Andrews, my examination of the coast was more rapid. In the section as it approaches Crail, and goes north of Fife Ness, I do not attempt to show the effect of the faults, but the general features of the strata will be found given with sufficient accuracy. Passing Balcomie, the lower series of rocks is well displayed; but especially from Cambo Point, on beyond Kingsbarns and down to the lowest beds at Babbet Ness, all is singularly complete and clear. At the latter point, the lowest strata of the whole coast from Burntisland to St Andrews are reached, lying considerably beneath the level of Anstruther. Passing Pitmilly Burn, the section exhibits the various bendings of these strata, till the limestone L is found on the shore near the Rock and Spindle. On to St Andrews the foldings seen in the cliffs form a striking feature of the coast, till at the Witch Lake, with its deep shale beds, the limestone L again comes into view.

The general aspect of the coast thus described will best be understood by a glance at the accompanying section. Omitting the minor foldings of the strata there are, east of the Ochills and on to Fife Ness, four great anticlinals, with their accompanying basins on either shore. The first of these basins on the coast of the Firth (not shown in this section) reaches from Alloa and Dunfermline to Aberdour. It corresponds to that on the east, in which St Andrews is situated, and whose southern margin touches the Babbet Ness. The second stretches from Aberdour to a point beyond Elie, where the axis, though obscure, is really present; and so on to Fife Ness, every anticlinal and basin on the west has its corresponding feature on the east, though not always in the same relative proportions. One marked difference, however, will be observed. Along the German Ocean the beds have been lifted to a far higher level, as is shown by the dotted line which represents the supposed level of the bed L. High above the ground on the eastern side, it is often from one to two thousand feet beneath it on the shores of the Firth.

II. The Trap Rocks.

These I did not attempt to study, but one or two points may be mentioned which came under my notice.

First, A large portion of these traps can have had nothing to do with the elevation of the other strata. On the one hand, they are so interstratified that on looking to the details one can hardly resist the inference that they were contemporaneously formed; and on the other, they have themselves been acted on much as the other rocks by the forces of elevation. A glance at the section from Pettycur to Inverteil will show how the beds of trap and the other strata have been lifted together to the same angle of dip. Another example is still more instructive. Not far from Queensferry there is, to the east of St David's, a mass of tufaceous trap, and south of St Andrews there is a mass of sedimentary strata both contorted in a similar way. They lie in the same position on the southern rise of the great basin—which leans against the axis of Aberdour on the one shore, and Babbet Ness on the other. The force which caused these convolutions must thus have acted over a wide stretch of country, and the traps and the sedimentary strata must have yielded alike to its power.

Second, There are trap rocks evidently intrusive, and of subsequent formation, containing as they do fragments of the other strata. Every Edinburgh geologist knows well the Basalts, Tufas, and Amygdaloids of the coast from Pettycur to Inverteil. In the Huttonian and Wernerian controversy this western series was the stronghold of the Wernerians. It seems strange that their adversaries did not claim the Elie side, where the intrusive traps may be studied to singular advantage.* Perhaps the most common appearance resembles that at Edinburgh Castle—the sedimentary strata at the point of contact being fractured and bent downwards; but there is this difference, that the phenomena can be studied not in section, as at the Castle, but amid the bared rocks of the coast they are laid open as on a ground plan.

Whether these intrusive traps had anything to do with the elevation of the other strata seems extremely doubtful. For the most part they appear to penetrate the mass much as a musket bullet does a pane of glass, fracturing the portions in immediate contact, but leaving the general plane of the beds unchanged. A single example near Kinghorn is the only instance of what seems elevation resulting from the intrusion of trap. That some deep-seated force of elevation has acted over the district is indeed obvious. Starting at Fife Ness, we can trace the long, rolling undulations of the strata, as if lifted over the crests and sinking into the troughs of some gigantic sea. How vast the elevation must have been at first, and how immense the denuding agencies by which all was subsequently planed down to its present level, may be seen from the dotted line showing the supposed level of the bed L, itself very far below the coal-fields. I have seen, however, no

* It is not intended in this or the following statements to advance any theory as to the formation of these rocks, the term intrusive being merely used to indicate that the previously formed sedimentary strata must have been consolidated and fractured before these traps could have come into their present position. While on the west the two kinds of rock lie for the most part conformably interstratified, it seemed deserving of notice that on the east side of the basin, when they come into contact, there are in most cases clear traces of convulsion. A geologist holding extreme Huttonian or extreme Wernerian opinions might easily enough find on these shores not a few facts in support of his favourite views on either side, but there are still considerable difficulties in the way of any theory which shall explain and harmonise *all* the phenomena.

clear evidence to connect these intrusive traps with the deep-seated forces which produced such vast results. The question would require much closer attention than it was in my power to give; but everything seemed to support the views so ably propounded by Professor ROGERS in the Transactions of this Society.

Before entering on the sedimentary strata, it is right to state that the object of this paper is restricted properly to a single point. The petralogy of these coasts —the mineral structure of their rock-masses—I do not refer to, except incidentally. For the present, my remarks are confined to one point, a consideration of the fossils in connection with the different levels at which they occur, and the light which is thus cast on the different groups of strata in their geological relations.

III. MOUNTAIN LIMESTONE.

In regard to the classification of the rocks of this district, I have been led to deviate to a considerable extent from the views commonly held. If about 1400 feet be taken from the lower series—the calciferous sandstones of Mr MACLAREN—and added to that upper marine zone, usually termed the Mountain Limestone, then a well-defined base line is obtained for the upper division, and the two groups may be distinguished by satisfactory characters. To the whole of the upper division, I would extend the term Mountain Limestone; and to the underlying group the term Lower Carboniferous. The reasons for this arrangement I shall afterwards state. Assuming it in the meantime, the Mountain Limestone will present the three following portions, viz.:—

1. *The Six Upper* Limestones*, A *to* F.

Immediately underlying the coal-fields on the Fife coast, we find these beds with shales and sandstones intercalated. The whole body of strata is set down by Mr GEIKIE as from 150 to 200 feet thick in the Lothians; and by Mr PAGE as 200 feet thick in Fife. If the lowest bed F be included, I am disposed to put the estimate considerably higher. The Ardross limestone, to which I referred at the outset of this paper, is the bed F, the lowest of these six beds.

It is the abundance of their fossils which render these six limestones so important. As it is often difficult to know how far such lists as the following may be depended on, I may mention that all the fossils here named were collected by myself, the beds and the localities being carefully noted. With the exception of one or two of the commoner species, they will all be submitted along with this paper. The determination of fossil species is often a point of much difficulty, especially where no collection exists to which reference can be made; and I may therefore mention, that the lamented Dr FLEMING and Dr SCOULER of Glasgow, two of our highest authorities, did me the favour to examine part of my collec-

* The term *upper* is used only relatively. They form the highest portion of the strata to which this paper refers, underlying the coal-fields.

tion, and that I have submitted the whole to Mr Salter, Palæontologist to the Government Survey, whose assistance has been of special importance, not only from his great eminence in that science, but from his familiarity with the fossils of England and Ireland. The system of nomenclature in his hands being uniform, we can employ the species here named with confidence as points of comparison with distant formations. A considerable proportion of the following list are new to Scotland. Two or three of the names are given on the authority of Dr Fleming; the rest on that of Mr Salter.

Fossils.

Corals.—The following seem the most common species:—

Chaetetes tumidus.
Aulophyllum fungites.
Lithostrotion junceum.
L. fasciculata.
Zaphrentis species.

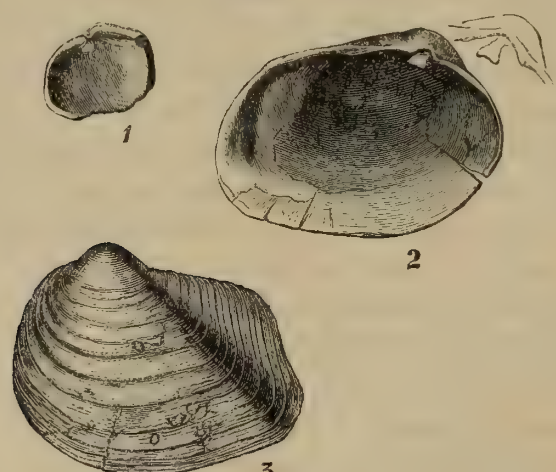
To these may be added (from the Bryozoa), the *Fenestella plebeia*, which is plentiful in all the strata.

Shells.—From the bed F at Ardross, I obtained the following, viz.:—

1. Lingula mytiloides.
2. Productus semi-reticulatus.
3. Pecten Sowerbii.
4. Edmondia unioniformis.
5. Schizodus sulcatus.
6. Nucula gibbosa.
7. Nucula attenuata.
8. Macrocheilus ovalis.
9. Bellerophon Urii.
10. Bellerophon decussatus.
11. Nautilus subsulcatus.
12. Orthoceras cylindraceus.

Along with these there were other species belonging to the following genera not yet determined, *Orthoceras*, *Schizodus*, *Arca*, *Modiola*, *Loxonema* and *Goniotites*. Of the whole perhaps the shells most characteristic of the bed are a strong handsome *Schizodus*, and a thin stiletto-like *Orthoceras*, whose long, taper form does not seem as yet to have been figured or described.

Fig. 1.



1. Right Valve. 2. Left Valve. 3. Outside of Left Valve.

Of the *Schizodus*, figures are here given from characteristic drawings furnished by Mr Salter.

Dr FLEMING, to whom I formerly submitted this shell, considered it to be the *Anatina attenuata* of M'COY, but held that it had been erroneously referred to that genus. He possessed numerous specimens from a bed near Colinton, where it occurs in such abundance as to suggest the idea of its having been gregarious; but the specimens from Fife were in better preservation, and he intended to have them laid open and submit them to a careful examination, in order to determine the generic character. Circumstances prevented this, but it has now been made clear by Mr SALTER. The species seems to have belonged properly to the Lower Carboniferous group, rather than to the Mountain Limestone. It is common enough, indeed, in the bed F, to be characteristic of the stratum; but when met with in the lower rocks, it shows itself in a far different way, and in far greater abundance. This is seen not only at Colinton, but in a very remarkable bed south-east of Kingsbarns, where, in countless masses, it covers the surface of the rock in a state of preservation singularly fresh and beautiful. On passing up into the Mountain Limestone it occurs rather in a straggling condition, and in comparatively scanty numbers.

Passing to the five overlying beds, besides most of the shells just enumerated, we find the following:—

1. Athyris ambigua.
2. Athyris Royssii.
3. Chonetes Hardrensis.
4. Chonetes variolata.
5. Discina nitida.
6. Leptaena crenistria.
7. Productus giganteus.
8. Productus punctatus.
9. Orthis Michelini.
10. Orthis filiaria.
11. Orthis resupinata.
12. Athyris gibera.
13. Productus longispina.
14. Rhynconella pleurodon.
15. Spirifer duplicicosta.
16. Spirifer trigonalis.
17. Avicula rugosa.
18. Aviculopecten interstrialis.
19. Mytilus triangularis.
20. Nucula tumida.
21. Euomphalus carbonarius.
22. Orthoceras annulare.

Along with these there occur species of *Schizodus*, *Aviculopecten*, *Modiola*, and *Turbo*, not determined. There is also one species of *Sanguinolites*, which Mr SALTER pronounces to be new.

Crustaceans.—The bed B east of St Monan's has yielded various specimens of a species of trilobite—the *Griffithides mucronatus;* and in the bed E, near Kinghorn, I found a plate of the *Eurypterus Hibberti.*

It is the bed F at Ardross, however, which has proved most productive of these remains. They are of two kinds. *First,* Those belonging to the genus Dithyrocaris, chiefly detached valves; one specimen, however, showing distinctly the tail spines, and another the jaws. Mr SALTER, whose authority stands so high in regard to this class of fossils, has decided that the specimens belong to two species both hitherto undescribed.

The other crustaceans are of a form nearly allied to the shrimp, and closely resemble the species of Gampsonyx, described by VON MEYER, from the coal formation of Saarbruck in Lorraine. The shelly covering seems to have been peculiarly thin and tender, for though the limestone is singularly favourable for their preservation, yet there is a difficulty in making out the form with sufficient distinctness for scientific description. Its resemblance to the shrimps of our shores is obvious, however, at a glance, and like them it seems to have been social in its habits; for at the only spot in which it occurred a whole swarm was laid open at once, and very remarkable it was to see these tiny forms of crustacean life lying close to each other in every imaginable attitude on the surface of the rock. For the following remarks and figure, singularly true to nature, I am indebted to Mr SALTER:—

Fig. 2.

Uronectes (Gampsonyx of Jordan) socialis, n. sp.

"There can be little doubt this is of the same genus as the curious *Gampsonyx fimbriatus* of Jordan, figured so well by VON MEYER in his "Palæontographica" for 1854, Vol. VI. t. t. That species was found in the coal of Saarbruck and Salzbach, and it was regarded by VON MEYER as belonging to the Amphipod group, the only example yet known of a true Malacostracous crustacean below the New Red Sandstone. Our specimens, though crushed, show much fewer segments than the German fossil, and it is no doubt desirable to compare specimens of both. I am not clear about any appendages to the head, which appears (if that be not due to pressure) to be elongated. Seven body-rings and a minute telson are all that can be made out. But the tail appendages are very like those of a shrimp, and the body-rings not dissimilar."*

A single remark of a general kind I may be permitted to offer. One of the most delightful passages in PALEY's "Natural Theology" is his description of the shrimp, and the proof of the goodness of God in communicating such manifest enjoyment of life to these lower orders of being, diffusing such happiness among myriads of His creatures. When we look back into the old creations of geology with their predaceous races, covered with bony armature, and furnished with instruments of destruction so formidable, we are ready to feel as if the world must have been a scene only of darkness and terror; yet the light of God's love must have shone then as now, and perhaps the little crustacean here before us may give some indication of this truth. If PALEY can stand on our modern shores, and, amidst the social instincts of its shrimps, can point to the fulness of their enjoyment as a proof of the goodness of God, I know not why, in the little Gampsonyx of these primeval rocks, evidently not less social in its instincts, we may not read the same lesson, and feel that then of old, as now, the world which He had made bore witness that "God is love."

Fish.—These remains deserve particular attention. At Ardross I detected small

* Mr SALTER, MSS.

scales of some species of Palæoniscus, and one good specimen of an Amblypterus, which seems to be the *A. striatus*. There were teeth and scales also of a Holoptychius; some of the latter more than an inch in diameter, and their resemblance to the figures of the *H. Portlockii*, published in the Report of the Irish Survey, seemed to be complete. If the fish remains at Ardross are thus not devoid of interest, those on the west side of the basin near Kinghorn are still more important. It was in connection with these that I obtained one of the most striking proofs of the identity of the corresponding beds on the two sides of the basin. Beginning at Inverteil, or rather at Tyrie, I had traced the strata backwards and downwards through every link of the series, to that level on which the fish occur on the east. The limestone bed was there, its corals and shells agreed, but at first there seemed no trace of fish. The point was important, the opportunity for search was good, for the beds lay open, intercalated between two sheets of trap. Beginning at the top, and resolved that nothing should escape, I had nearly gone over the whole, when, about three inches above the lowest trap, I caught the glitter of a ganoid scale, and laying open the spot, a very slight effort disclosed a whole array of fish remains—spines, plates, teeth, scales, &c., in singular abundance. I was reminded of the famous bone-bed at Ludlow, described as resembling a mass of broken beetles. This was obviously a similar formation of the carboniferous system. About an inch in thickness, imbedded among shale with a few shells, and charged with its abundant fish remains, all disjointed, but in beautiful preservation, I could trace it, running at its own level for fifty yards, till lost at low-water mark in its course seawards. All the fish I had found at Ardross were there, with additional species; but there was one new and most noticeable feature, the abundance of Cestraciont teeth—the crushing teeth of ancient sharks. Would it not be possible to find these fossils also on the eastern side of the basin? Returning to Ardross, I sought for them in the bed F, but in vain. In the bed E, I also failed in finding them; but at last the limestone D, and especially a bed of underlying shale, yielded a considerable number of specimens. The links of connection between these beds, separated at a distance of some twenty miles, were thus made clear, and it was also established that fish remains were diffused through the lower half of these six marine limestones.

The disjointed state of the remains from the fish-bed renders it difficult to identify the species. There are head-plates and scales of *Rhizodus Hibberti*. There is a well-preserved jaw undetermined, and scales of Amblypterus. Besides these there is a spine of Ctenacanthus, which Sir P. Egerton considers as hitherto undescribed, and among the teeth there are several fine specimens belonging to the genus Cochliodus, also marked by him as new to science.* More than by all these, however, my attention was attracted by some plates belonging to the great

* It was through the kindness of Sir R. Murchison that the specimens were submitted to Sir P. Egerton, our highest authority in fossil Ichthyology.

class of tuberculated fish. I extremely regret that from the softness of the shale it has been impossible to preserve them in anything like their original completeness. When first laid open they seemed unequivocal plates of some species of Pterichthys. When submitted in their present state to Sir P. Egerton he has marked them as "very doubtful—probably not Pterichthys." Enough, however, still remains to show that they must have belonged to the great class of tuberculated fish. At Mr Salter's request, I have agreed to place these specimens in the new museum here. Should they prove to have belonged to any genus allied to Pterichthys, the discovery would be one of considerable importance. The range of that great family would no longer be confined to the Devonian formation, and this point might have an important bearing on questions connected with systematic geology. Already, in England and elsewhere, these tuberculated fish have been found up to the highest beds of the Devonian system; but should their discovery at Kinghorn be confirmed, they must be held to have existed through the long period of the Lower Carboniferous group, and to have passed far up into the Mountain Limestone. It would be well, meantime, if the attention of our local geologists were directed to this bone-bed. A thorough search by those who could command the necessary time would yield results of considerable interest. Before leaving these fish remains, it is right to call attention to their position as belonging to the six upper marine limestones. In the corresponding marine formation of Yorkshire, the fish remains are few or none; and in the same marine band, as found in the Lothians, Mr Geikie mentions that fish remains are also absent. It will be remembered that the ganoid fish now living are found only in fresh water, and it might have been argued that their ancient congeners were also fresh-water fish. This idea might have found support from the absence of their remains from the deep marine formation of Yorkshire, and the marine beds of the Mountain Limestone in the Lothians. The Fife beds, however, at once place the whole matter in another light. At Ardross we have the remains of Rhizodus and Amblypterus intermingled with the Cephalopods and Brachiopods of the ancient seas. At Kinghorn the bone-bed gives us the remains of the whole family of carboniferous Ganoids, side by side with those of Cestraciont Sharks, and Brachiopods like the Lingula, all evidently marine.

One other fossil deserves notice—the *Serpulites carbonarius*, which is confined, so far as I observed, to the two lower beds E and F. Immediately to the west of Newark Castle, the bed F yields these remains in great abundance, and fine condition, in many cases filled with carbonate of lime.

2. *The Estuarine Strata between F and L.*

Underneath the six limestones we find a series of rocks of considerable depth, apparently 1400* feet. That they are fresh water or estuarine, is shown by the

* Since presenting this paper to the Society, I have gone over these beds to the east of St Monans

sudden disappearance of the crinoids, corals, and other marine fossils so abundant in the overlying beds. The *Cypris scoto-burdigalensis* is also found in layers so distinct, and entering so largely into the composition of the rocks, as fairly to indicate fresh water conditions. One marking feature also is the abundance of *Sphenopteris affinis*, unknown in the overlying limestones, but all along between Elie and St Monans, and farther east down as far as the bed L, it is the prevailing fossil in this the Estuarine part of the series.

The well-known Limestones of Burntisland, with their numerous fish remains, lie on this level. It is, however, to the east of St Monans and on beyond Pittenween that the series can be studied to best advantage. The very point in the descending order can be fixed where the Sphenopteris begins, and its rapid increase traced downwards through the strata. Two singular beds of limestone, obviously on the same level with those marked G and H at Pettycur, on the west, well deserve attention. They are yellow or pale-buff in colour, distinctly brecciated, often siliceous and cherty, and so much harder in structure than the sandstone, that they may be traced on the shore west of Pittenweem harbour, standing boldly up in marked outline and running seawards like tall slanting walls. In colour and structure they are quite different from the six overlying limestones. On the west side there is a bed at Pettycur marked G, which may be traced running inland through the railway cutting and sweeping round till it reappears behind the Binn, which shows at certain points much of the same colour and some tendency to the same brecciated structure, but from the absence of siliceous matter it is comparatively soft.

West of Newark there is in the coal-shale a bed with nodules of clay ironstone, containing coprolites, from which I extracted two complete specimens of fish—a species of Palæoniscus. Near the same point, close to an out-burst of intrusive trap, is a layer containing good specimens of carboniferous wood in a state of charcoal, some of the fragments being very distinct.

To this part of the series also belongs a shale-bed beyond Crail (close to the farm-servants' houses at Kilminning) containing fish remains, among which I could detect the scales of Megalichthys and Eurynotus. It was there I obtained the jaw of a small species of fish belonging to the family of Pycnodonts, with five rows of tesselated teeth. Of this family, so common in the secondary strata, only one previous example is mentioned by Professor OWEN as having been found in the palæozoic rocks, a small jaw described as occurring in the coal-field at Leeds. That found at Kilminning was upwards of 1000 feet below our Scottish coal-fields, and is probably therefore of a still older date.

in order to ascertain the thickness of the mass of strata measured in a line perpendicular to the plane of the beds. Taking the direct distance from F to L at right angles to the general strike, and taking the average dip from a series of measurements, the result is that this mass of estuarine beds is about 1400 feet in thickness. Such measurements are of course only approximate.

3. *Limestone L. Line of lower Encrinites.*

Underlying these estuarine beds we have already referred to a thin stratum of marine limestone, seen in the cliffs of Pittenween. At various points along the coast it again occurs as shown in the section. Its fossils are numerous, and obviously, even at first sight, similar to those of beds A to F. The following kinds have been noticed :—

Crinoids.—In speaking of the upper limestones, I should have remarked that these fossils (the Crinoids) are found everywhere in great profusion in the form of detached vertebræ or fragments of stems. The bed E, west of Ardross, seems to have been a singular storehouse of these remains. Washed out by the sea, they used to lie scattered in thousands along the shore, and under the local name of Croupies were familiar as playthings to all the children of Elie. The deposit seems now to be in a great measure exhausted, and those formerly washed out are buried by the sand.

The Crinoids of this lower bed L are smaller and apparently of different species. There is among my specimens one Rhodocrinus and one Poteriocrinus, the latter showing the head, and being therefore of considerable interest. It has often been matter of surprise why the remains of Encrinites in our limestones should consist entirely of disjointed stems. "What can have become of the *heads* of all our Scottish Encrinites?" a leading naturalist once asked me, adding, that of the thousands of specimens he had seen he could find nothing but the vertebræ. The bold conjecture has, I believe, sometimes been hazarded, that our Scottish Encrinites either never had heads at all or had them of some softer substance than their English brethren, so as not to admit of preservation. This somewhat whimsical idea might perhaps have been met by asking in reply whether there were any analogy to support it; whether other Scottish productions were usually more destitute of head or more soft-headed than those of the south? But there is really no need for pushing the argument. Specimens enough will be forthcoming. Among those here produced is the small head of a Poteriocrinus taken from the bed L, the base of the Mountain Limestone, a little to the south of the Rock and Spindle.

Corals.—Of these I observed four species, two of which are undetermined. The *Chœtetes tumidus* is common, and still more so the *Fenestella plebeia.*

Shells.—Of species not observed in the upper limestones I found the following, viz. :—

1. Spirifer octoplicatus.
2. Aviculopecten arenosa.
3. Sanguinolites tricostatus.
4. Chemnitzia gracilis.

Of species already found in the beds above, there were

1. Productus semi-reticulatus.
2. Edmondia unioniformis.
3. Nucula attenuata.
4. Nucula gibbosa.
5. Bellerophon decussatus.
6. Bellerophon Urii.

Of these, the most characteristic shell at Pittenweem is the Productus; and at Crail, the Edmondia and the Bellerophons, which are abundant and large.

These three portions—the upper limestones, the estuarine beds, and the line of lower Encrinites—have now been described, and their fossils, when viewed together, form an assemblage which all will at once recognise as belonging to the Mountain Limestone. To this point I shall afterwards advert. Meantime, no one can go over the ground without feeling how singularly rich these deposits are in the remains of ancient life. Justice has perhaps hardly been done as yet in this respect to our Scottish rocks. Among the Crustaceans and fish we have seen that there are not a few additions to be made to our extinct Fauna. Of the forty named species of shells recorded in this paper, only twelve are found in Professor NICOL's list of Scottish fossils, and the specimens I have mentioned as unnamed species will probably furnish still farther additions. It should be remembered that I made no special effort to collect fossils, visited no quarries, asked no assistance, took only what came in my way. The naturalist, who should, with time at his disposal, take up this work would find his researches richly rewarded.

IV.—LOWER CARBONIFEROUS.

Along these shores there occurs a great body of strata underlying L, the line of lower Encrinites.

A distinguishing feature, which at once strikes the observer, is the great prevalence of shell-beds—limestones composed of a single species of bi-valve resembling Unio, and now placed in the genus Myalina or Anthracosia. It were much to be desired that these obscure families were dealt with by some competent naturalist, and their distinctions satisfactorily made out. Meantime, we must be content to refer to them as undetermined species of Myalina. One circumstance connected with these beds is, that they increase as we go eastwards, both in number and size. Thus, taking the axis at Anstruther, I found not more than two shell-beds to the west, only one of which is of importance, viz., that lying among the strata in front of the town. To the east of the axis there are up to bed L at least three shell-bands. The lowest sweeps round from Anstruther, running inland at Kilrenny, where it is comparatively thick. Two others were detected lying at distant intervals in the series above. Near Fife Ness these shell-bands are more fully developed, but it is towards Kingsbarns that they come out in all their force as limestones, four or five feet thick, consisting of consolidated shells piled above each other in countless myriads. They have been compared to banks of mussels, and held to indicate a shallow sea, if not estuarine conditions. There is a difficulty, however, in their extent, reaching from St Andrews far beyond Dunbar, and from Anstruther to Kingsbarns, getting ever the more fully developed. It is to be observed also that those portions of the shore, where there are on other grounds the greatest indications of estuarine conditions (as from Anstruther to Pittenweem), are exactly those in which the shell-beds are least prevalent. One is struck further also with the immense extent to which the ocean of that early time must have been pervaded by this form of life, its waters swarming with myriads of these bi-valves. It can hardly have been a shallow sea, across the bottom of which there stretched continuously layers of dead shells four or five feet in thickness, more especially when we observe that just in proportion as the accompanying beds abound in evidences of marine conditions, these bands of Myalina are the more fully developed.

Among these lower rocks may be noticed the occurrence near Caiplie of what is termed in the neighbourhood the petrified forest, a thick bed of sandstone with twelve or fifteen trunks of trees, some of them prostrate, but most showing their stumps projecting through the rock. As the bed dips at about fifteen degrees to the east, and the trees lie slanting at about seventy-five degrees west, they are nearly perpendicular to the plane of the bed, showing that they must have been growing on the spot when enveloped in the sand. Unlike those of Craigleith there is no real petrifaction; they are simply casts of the inside of the stem from which the bark has subsequently fallen away, but which show obscurely the flutings and other marks peculiar to the genus Sigillaria.

Another circumstance of great importance to the understanding of this lower series is, that at various levels it shows beds with unequivocal marine fossils. Thus there is a stratum with many specimens of Natica in the Billow Ness, and across near Caiplie it is again found with the same pretty little shell still better preserved. Again, in the axis of the anti-clinal, near Fife Ness, there occur, along with some fish remains, species of Orthoceras, Chemnitzia, and Natica, the two last very beautifully preserved. South-east of Cambo is a bed charged with shells, distinctly marine, and on the other side what appears to be the same stratum, more fully developed. A species of Schizodus especially, as formerly stated, is found in great profusion. In the neighbourhood of Caiplie also there is a shale-bed with specimens of Lingula, on a different level from that in which the Natica prevails.

Shells.—Two species may be mentioned, both carboniferous, but different from those already referred to:

Murchisonia trilineata, from near Cambo.
Lingula marginata, near Caiplie.

Along with these occurred *Orthoceras cylindraceus*, and *Aviculopecten arenosa*. These all comparatively lie deep in the series.

One of the most interesting discoveries which I met with in this lower series is a thin stratum of reddish limestone, charged in great abundance with a little Annelid, a species of Spirorbis or Serpula. It is allied to the *Spirorbis* (*Microconchus*) *carbonarius*, but larger in size, and, instead of being folded on itself like the coil of an Ammonite, is remarkably twisted in a serpentine form.

A clear idea of it will be obtained from the following figures and specific character, with remarks, for which I am indebted to Mr SALTER :—

Fig. 3.

"*Spirorbis* (*Serpula*) *helicteres*, n. sp."

"S. ¼ uncialis, laxe spiratus; anfractibus, 4—5; quorum, 2—3 compactis, reliquis longe vagis,—omnibus compressis. Superficies rugosa, lineis incrementi rugisque irregularibus aspera, nec striata. Apertura ovata, margini haud incrassato."

"This striking fossil occurs in distinct beds, grouped hundreds together, yet without ostensible attachment to any other object than its own species. The helix formed by the compressed whorls is a very open one, and often drawn out to more than a quarter of an inch long; the first whorl or two only being discoid. The surface is roughened by lines and ridges of growth, but has no distinct striæ either longitudinal or transverse.

"*S. Archimedis* of DE KONINCK (animaux foss de Belge PC. G. f. 6), a fossil from the Carboniferous Limestone of Visè, is only slightly compressed. It is much more closely coiled, the whorls touching each other, and has close set striæ and larger plaits in the direction of the lines of growth."*

Another feature to be noticed is the marked abundance of Cyclopteris. This is especially seen among the rocks from Pittenweem eastward. Both plants occur in both portions of the series, but above the bed L Sphenopteris is the prevailing form; below L it is Cyclopteris.

V. RESULTS.—THE TWO GROUPS.

Mr MACLAREN's classification, in his able work on the "Geology of Fife and the Lothians," has been in substance adhered to by subsequent writers. Underlying the coal-field there is first a zone of encrinal limestone, comparatively thin,

* Mr SALTER, MSS. Our fossil is imbedded in the stone, which is to a large extent made up of it; but the weathered surface often shows the fossil very beautifully, the white snake-like form charged with carbonate of lime being well relieved by the dark red of the limestone. The bed occurs among the rocks of the shore near Fife Ness, a short way to the north-west of Balcomie Sands.

Beneath this there is a large mass of strata, the calciferous sandstones of his nomenclature,—the lower carboniferous of subsequent authors. When I began these observations on the Fifeshire coast, I held to this received view, and put the strata into two groups. Down to the bed F all was marine, and marked by me as the Mountain Limestone; below F came the estuarine beds,—the lower carboniferous.

What first shook my confidence in this classification was the discovery of the marine bed L, or rather the results obtained, after a full examination of its fossils. Lying 1400 feet down among these estuarine strata, it exhibited not only the same fauna with the upper six limestones, but that fauna amply developed. Why should it not go into the same group with these upper beds?

Next came the question, whether the difference of character between Estuarine and Marine could form a safe ground for distinguishing the groups,—it might or it might not be convenient as a local arrangement, but if the groups were so formed, would the classification be of any value on a wider area when brought into comparison with the strata of other districts?

But what proved most decisive, was an examination of the great mass of strata underlying L. Studying these lower beds on to Fife Ness and northwards, it became evident that they had a character of their own by which they might be defined and recognised,—that L was really the lowest point or base line of an upper group, and that the two were separated by characters more to be depended on than the difference between a fresh-water and marine formation.

The only difficulty in assigning the bed L to the upper group is the fact that the mass of strata intercalated between F and L are Estuarine, while these two beds are Marine, but there should really be no hesitation in setting aside this character as a ground of distinction. Every epoch has its fresh-water and salt-water beds contemporaneously formed. Just as at this moment deposits are going on simultaneously in our fresh-water lakes like Loch Lomond, in our estuaries, as among the upper reaches of our Firth, as well as in the open sea, all representing the same point of time, so the fact that a mass of strata is estuarine does not in the least disconnect it with the *period* of the two limestone bands between which it is intercalated. It must be grouped along with them, so that the whole mass of the nine limestone bands from A to L, with their accompanying strata, must be associated together.

Now there cannot be any ground even for hesitation as to what portion of the geological scale this group belongs to. The fossils which we have enumerated not only as a whole, must be referred to the Mountain Limestone, but contain a large proportion of the species held to be decisive as characterising that formation. Take a list of shells like *Productus giganteus*, *P. semi-recticulatus*, *P. longispinus*, *Athyris ambigua*, *A. Royssii*, *Rhynconella pleurodon*, *Edmondia unioniformis*, *Bellerophon Urii*, *B. decussatus*,—let these and others similar not only be found, but be the prevailing forms in a group of rocks, and any one accustomed to deal with such questions will hold the conclusion irresistible—*that* group is simply the Mountain Limestone. This is one of the best marked and most thoroughly understood portions in the whole series of ancient rocks. Powerfully developed in Yorkshire, it passes south by Bristol into Devonshire and Wales, crosses over into Ireland, where, north and south, the level of the great Scaur Limestone has been well recognised. Spreading over the kingdom, this belt of Mountain Limestone lies everywhere on the same geological horizon, and what we have here on the Fifeshire coast overlying the bed L is simply a powerful mass of strata forming a prolongation of the same great series. The limit of the group upwards I have not examined.

The question, therefore, which suggested itself on the shore at Ardross, on first looking at the limestone bed with its fossils, has been satisfactorily solved. Its place is somewhere about 1400 feet above the base of that great series which is recognised over the kingdom as the Mountain Limestone proper.

And now, in regard to the inferior group—the Lower Carboniferous—Mr GEIKIE recognising the insufficiency of the difference between the fresh-water and marine character of beds as a ground of distinction between the groups, has proposed to regard the whole carboniferous series beneath our coal-fields as the representative merely of the marine Mountain Limestone of Yorkshire.* There seems, however, reason to believe that the lower portion belongs to that antecedent period which ushered in the Mountain Limestone proper. Should this be confirmed, it will give special importance to our Scottish rocks, as casting valuable light on the obscure introductory stage of the carboniferous era. The difference of this group from the other is no doubt only one of degree, for both are carboniferous and belong to the same formation; but referring back to the details of our general description in the preceding section, the following points may be noted as distinctive of the lower series, viz.:—

1. The prevalence of Myalina beds throughout the strata below L.

2. The comparative abundance of *Sphenopteris affinis* above L, and of Cyclopteris below it. Both plants occur in both series, but their comparative abundance is markedly different.

3. The most important point is that the carboniferous fauna of the Mountain Limestone is seen only in an incipient state.

This was not for want of sea-room in which to show itself. There was room for Pectens, Modiolæ, and Schizodi, just as in the limestones above and what is not less conclusive, there was room for Gasteropods like Murchisonia, Chemnitzia, Natica, and Cephalopods, like Orthoceras. But where are the Corals, the Encrinites, the immense development of Brachiopods, all those great characteristic forms of life that make the Mountain Limestone fauna what it is. If they occur

* See his interesting work "The Story of a Boulder," p. 195.

at all it must be scantily, and we seem warranted in holding that the rocks below L exhibit that great fauna only in its feeble beginnings. Thus the bed L, marking the point where it fairly took possession of the ancient seas, forms the true base-line of the upper group.

It may confirm these views to observe that an underlying series of strata of the same kind has been found in other parts of the kingdom. In Yorkshire nothing carboniferous is seen below the Mountain Limestone, but these lower beds have been traced at Bristol, in South Wales, and still more fully in Ireland. The Calp. series in the north and the Comhoola grits in the south, with their accompanying strata, are described as occurring in a position beneath the Mountain Limestone, closely analogous to that of our lower series. In these different districts the group, while agreeing in its general features, varies according to the locality. These varying aspects should be carefully studied and compared, and when the results are fully wrought out, the effect will be to unfold many a deeply interesting page in the opening history of the great carboniferous era. It is from Fife Ness on to St Andrews that the beds are most fully developed with us, and the few details which I have endeavoured to record, will, I trust, be sufficient to show the interesting nature of the field, and the value of those results which are yet to be brought to light.

XVII.—*On the Reduction of Observations of Underground Temperature; with Application to Professor Forbes' Edinburgh Observations, and the continued Calton Hill Series.* By Professor William Thomson.

(Read 30th April 1860.)

I.—*Analysis of Periodic Variations.*

1. Every purely periodical function is, as is well known, expressible by means of a series of constant coefficients multiplying sines and cosines of the independent variable with a constant factor and its multiples. This important truth was arrived at by an admirable piece of mathematical analysis, called for by Daniel Bernouilli, partially given by La Grange, and perfected by Fourier.

2. To simplify my references to the mathematical propositions of this theory, I shall commence by laying down the following definitions:—

Def. 1. A simple harmonic function is a function which varies as the sine or cosine of the independent variable, or of an angle varying in simple proportion with the independent variable. The harmonic curve is the well known name applied to the graphic representation, on the ordinary Cartesian system, of what I am now defining as a simple harmonic function. It is the form of a string vibrating in such a manner as to give the simplest and smoothest possible character of sound; and, in this case, the displacement of each particle of the string is a harmonic function of the time, besides being a harmonic function of the distance of its position of equilibrium from either end of the string. The sound in this case may be called a perfect unison.

Def. 2. The argument of a simple harmonic function is the angle to the sine or cosine of which it is proportional.

Cor. The argument of a harmonic function is equal to the independent variable multiplied by a constant factor, with a constant added; that is to say, it may be any linear function of the independent variable.

Def. 3. When time is the independent variable, the epoch is the interval which elapses from the era of reckoning till the function first acquires a maximum value. The augmentation of argument corresponding to that interval will be called "the epoch in angular measure," or simply "the epoch" when no ambiguity can exist as to what is meant.

Def. 4. The period of a simple harmonic function is the augmentation which the independent variable must receive to increase the argument by a circumference.

Cor. If c denote the coefficient of the independent variable in the argument, the period is equal to $\frac{2\pi}{c}$. Thus, if T denote the period, ε the epoch in angular measure, and t the independent variable, the argument proper for a cosine is

$$\frac{2\pi t}{\mathrm{T}} - \varepsilon,$$

and the argument for a sine

$$\frac{2\pi t}{\mathrm{T}} - \varepsilon + \frac{\pi}{2}.$$

3. *Composition and Resolution of Simple Harmonic Functions of one Period.*

Prop. The sum of any two simple harmonic functions of one period is equal to one simple harmonic function whose amplitude is the diagonal of a parallelogram described upon lines drawn from one point to lengths equal to the amplitudes of the given functions, at angles measured from a fixed line of reference equal to their epochs, and whose epoch is the inclination of the same diagonal to the same line of reference.

Cor. 1. If A, A′ be the amplitudes of two simple harmonic functions of equal period, and ε, ε' their epochs; that is to say, if $\mathrm{A}\cos(mt-\varepsilon)$, $\mathrm{A}'\cos(mt-\varepsilon')$ be two simple harmonic functions; the one simple harmonic function equal to their sum has for its amplitude and its epoch the following values respectively:—

(amplitude) $\{(\mathrm{A}\cos\varepsilon+\mathrm{A}'\cos\varepsilon')^2+(\mathrm{A}\sin\varepsilon+\mathrm{A}'\sin\varepsilon')^2\}^{\frac{1}{2}}$; or $\{\mathrm{A}^2+2\mathrm{AA}'\cos(\varepsilon'-\varepsilon)+\mathrm{A}'^2\}^{\frac{1}{2}}$

(epoch) $$\tan^{-1}\frac{\mathrm{A}\sin\varepsilon+\mathrm{A}'\sin\varepsilon'}{\mathrm{A}\cos\varepsilon+\mathrm{A}'\cos\varepsilon'}.$$

Cor. 2. Any number of simple harmonic functions, of equal period, added together, are equivalent to a single harmonic function of which amplitude and epoch are derived from the amplitude and epochs of the given functions, in the same manner as the magnitude and inclination to a fixed line of reference, of the resultant of any number of forces in one plane, are derived from the magnitudes and the inclinations to the same line of reference of the given forces.

Cor. 3. The physical principle of the superposition of sounds being admitted, any number of simple unisons of one period co-existing, produce one simple unison of the same period, of which the intensity (measured by the square of the amplitude) and the epoch are determined in the manner just specified.

Cor. 4. The sum of any number of simple harmonic functions of one period vanishes for every argument, if it vanishes for any two arguments not differing by a semi-circumference, or by some multiple of a semi-circumference.

Cor. 5. The co-existence of perfect unisons may constitute perfect silence.

Cor. 6. A simple harmonic function of any epoch may be resolved into the sum of two whose epochs are respectively zero and a quarter period, and whose amplitudes are respectively equal to the value of the given function for the arguments zero and a quarter period respectively.

4. *Complex Harmonic Functions.*—Harmonic functions of different periods added, can never produce a simple harmonic function. If their periods are commensurable their sum may be called a complex harmonic function.

Cor. A complex harmonic function is the proper expression for a perfect harmony in music.

5. *Expressibility of Arbitrary Functions by Trigonometrical series.*

Prop. A complex harmonic function, with a constant term added, is the proper expression, in mathematical language, for any arbitrary periodic function.

6. *Investigation of the Trigonometrical Series expressing an Arbitrary Function.*—Any arbitrary periodic function whatever being given, the amplitudes and epochs of the terms of a complex harmonic function, which shall be equal to it for every value of the independent variable, may be investigated by the "method of indeterminate coefficients," applied to determine an infinite number of coefficients from an infinite number of equations of condition, by the assistance of the integral calculus, as follows:—

Let $F(t)$ denote the function, and T its period. We must suppose the value of $F(t)$ known for every value of t, from $t=o$ to $t=T$. Let M_0 denote the constant term, and let M_1, M_2, M_3, &c., denote the amplitudes, and ϵ_1, ϵ_2, ϵ_3, &c., the epochs of the successive terms of the complex harmonic functions by which it is to be expressed; that is to say, let these constants be such that

$$F(t)=M_0+M_1\cos\left(\frac{2\pi t}{T}-\epsilon_1\right)+M_2\cos\left(\frac{4\pi t}{T}-\epsilon_2\right)+M_3\cos\left(\frac{6\pi t}{T}-\epsilon_3\right)+\&c.$$

Then, expanding each cosine by the ordinary formula, and assuming

$$M_1\cos\epsilon_1=A_1,\ M_2\cos\epsilon_2=A_2,\ \&c.$$

$$M_1\sin\epsilon_1=B_1,\ M_2\sin\epsilon_2=B_2,\ \&c.$$

we have

$$F(t)=A_0+A_1\cos\frac{2\pi t}{T}+A_2\cos\frac{4\pi}{T}+A_3\cos\frac{6\pi t}{T}+\&c.$$

$$+B_1\sin\frac{2\pi t}{T}+B_2\sin\frac{4\pi t}{T}+B_3\sin\frac{6\pi t}{T}+\&c.$$

Multiplying each member by $\cos\frac{2i\pi t}{T}dt$ where i denotes o or any integer, and integrating from $t=o$ to $t=T$, we have,—

$$\int_o^T F(t)\cos\frac{2i\pi t}{T}dt=A_i\int_o^T\left(\cos\frac{2i\pi t}{T}\right)^2 dt;$$

$$=A_i\times\tfrac{1}{2}T,\text{ when } i \text{ is any integer;}$$

or

$$=A_0\times T,\text{ when } i=0.$$

Hence

$$A_0=\frac{1}{T}\int_o^T F(t)\,dt$$

$$A_i=\frac{2}{T}\int_o^T F(t)\cos\frac{2i\pi t}{T}\,dt;$$

and similarly we find
$$B_i=\frac{2}{T}\int_o^T F(t)\sin\frac{2i\pi t}{T}\,dt:—$$

equations by which the coefficients in the double series of sines and cosines are expressed in terms of the values of the function supposed known from $t=o$ to $t=T$. The amplitudes and epochs of the single harmonic terms of the chief period and its submultiples are calculated from them, according to the following formula:—

$$\text{Tan}\ \epsilon_i=\frac{B_i}{A_i};\ M_i=(A_i^2+B_i^2)^{\frac{1}{2}}$$

(or for logarithmic calculation, $M_i=A_i\sec\epsilon_i$).

The preceding investigation is sufficient as a solution of the problem,—to find a complex harmonic function expressing a given arbitrary periodic function, when once we are assured that the problem is possible; and when we have this assurance, it proves that the resolution is *determinate;* that is to say, that no other complex harmonic function than the one we have found can satisfy the conditions. For a thorough and most interesting analysis of the subject, supplying all that is wanting to complete the investigation, and giving admirable views of the problem from all sides, the reader is referred to FOURIER'S delightful treatise. A concise and perfect synthetical investigation of the harmonic expression of an arbitrary periodic function is to be found in POISSON'S "Theorie Mathématique de la Chaleur," chap. vii.

II.—*Periodic Variations of Terrestrial Temperature.*

7. If the whole surface of the earth were at each instant of uniform temperature, and if this temperature were made to vary as a perfectly periodic function of the time, the temperature at any internal point must ultimately come to vary also as a periodic function of the time, with the same period, whatever may have been the initial distribution of temperature throughout the whole. FOURIER'S principles show how the periodic variation of internal temperature is to be conceived as following, with diminished amplitude and retarded phase, from the varying temperature at the surface supposed given: and by his formulæ the precise law according to which the amplitude would diminish and the phase would be retarded, for points more and more remote from the surface, if the figure were truly spherical and the substance homogeneous, is determined.

8. The largest application of this theory to the earth as a whole is to the ana-

lysis of imaginable secular changes of temperature, with at least thousands of millions of years for a period. In such an application, it would be necessary to take into account the spherical figure of the earth as a whole. Periodic variations at the surface with any period less than a million* of years will, at points below the surface, give rise to variations of temperature not appreciably influenced by the general curvature, and sensibly agreeing with what would be produced if the surface were an infinite plane, except in so far as they are modified by superficial irregularities. Hence FOURIER's formulæ for an infinite solid, bounded on one side by an infinite plane, of which the temperature is made to vary arbitrarily, contain the proper analysis for diurnal or annual variations of terrestrial temperature, unless a theory of the effect of inequalities of surface (upon which no investigator has yet ventured) is aimed at.

9. The effect of diurnal variations of temperature becomes insensible at so small a distance below the surface, that in most localities irregularities of soil and drainage must prevent any very satisfactory theoretical treatment of their inward progression and extinction from being carried out. At depths exceeding three feet below the surface, all periodic effects of daily variations of temperature become insensible in most soils, and the observable changes are those due to a daily average, varying from day to day. If now the annual variation of temperature were truly periodic, a complex harmonic function could be determined to represent for all time the temperature at three feet or any greater depth. But in reality the annual variation is very far from recurring in a perfectly periodic manner, since there are both great differences in the annual average temperatures, and never-ceasing irregularities in the progress of the variation within each year. A full theory of the consequent variations of temperature propagated downwards, must include the consideration of non-periodic changes; but the most convenient first step is that which I propose to take in the present communication, in which the average annual variations for groups of years will be discussed according to the laws to which periodic variations are subject.

10. The method which FOURIER has given for treating this and other similar problems is founded on the principle of the independent superposition of thermal conductions. This principle holds rigorously in nature, except in so far as the

* A periodic variation of external temperature of one million years' period would give variations of temperature within the earth sensible to one thousand times greater depths than a similar variation of one year's period. Now the ordinary annual variation is reduced to $\frac{1}{20}$ of its superficial amount at a depth of 25 French feet, and is scarcely sensible at a depth of 50 French feet (being there reduced, in such rock as that of Calton Hill, to $\frac{1}{400}$). Hence, at a depth of 50,000 French feet, or about ten English miles, a variation having one million years for its period would be reduced to $\frac{1}{400}$. If the period were ten thousand million years, the variation would similarly be reduced to $\frac{1}{400}$ at 1000 miles' depth, and would be to some appreciable extent affected by the spherical figure of the whole earth, although to only a very small extent, since there would be comparatively but very little change of temperature (less than $\frac{1}{20}$ of the superficial amount) beyond the first layer of 500 miles' thickness.

conductivity or the specific heat of the conducting substance may vary with the changes of temperature to which it is subjected; and it may be accepted with very great confidence in the case with which we are now concerned, as it is not at all probable that either the conductivity or the specific heat of the rock or soil can vary at all sensibly under the influence of the greatest changes of temperature experienced in their natural circumstances; and, indeed, the only cause we can conceive as giving rise to sensible change in these physical qualities is the unequal percolation of water, which we may safely assume to be confined in ordinary localities to depths of less than three feet below the surface. The particular mode of treatment which I propose to apply to the present subject consists in expressing the temperature at any depth as a complex harmonic function of the time, and considering each term of this function separately, according to FOURIER's formulæ for the case of a simple harmonic variation of temperature, propagated inwards from the surface. The laws expressed by these formulæ may be stated in general terms as follows.

11. *Fourier's Solution stated.**—If the temperature at any point of an infinite plane, in a solid extending infinitely in all directions, be subjected to a simple harmonic variation, the temperature throughout the solid on each side of this plane will follow everywhere according to the simple harmonic law, with epochs retarded equally, and with amplitudes diminished in a constant proportion for equal augmentations of distance. The retardation of epoch expressed in circular measure (arc divided by radius) is equal to the diminution of the Napierian logarithm of the amplitude; and the amount of each per unit of distance is equal to $\sqrt{\frac{\pi c}{\mathrm{T}k}}$, if c denote the capacity for heat of a unit bulk of the substance, and k its conductivity.†

12. Hence, if the complex harmonic functions expressing the varying temperature at two different depths be determined, and each term of the first be compared with the corresponding term of the second, the value of $\sqrt{\frac{\pi c}{\mathrm{T}k}}$ may be determined either by dividing the difference of the Napierian logarithms of the amplitudes or the difference of the epochs by the distance between the points. The comparison of each term in the one series with the corresponding term in the other series gives us, therefore, two determinations of the value of $\sqrt{\frac{\pi c}{k}}$, which should agree perfectly, if (1) the data were perfectly accurate, if (2) the isothermal surfaces throughout were parallel planes, and if (3) the specific heat and conductivity of the soil were everywhere and always constant.

* For the mathematical demonstration of this solution, see Note appended to Professor EVERETT's paper, which follows the present article in the Transactions.

† That is to say, the quantity of heat conducted per unit of time across a unit area of a plate of unit thickness, with its two surfaces permanently maintained at temperatures differing by unity.

As these conditions are not strictly fulfilled in any natural application, the first thing to be done in working out the theory is to test how far the different determinations agree, and to judge accordingly of the applicability of the theory in the circumstances. If the test thus afforded prove satisfactory, the value of the conductivity in absolute measure may be deduced from the result with the aid of a separate experimental determination of the specific heat.

13. The method thus described differs from that followed by Professor FORBES in substituting the separate consideration of separate terms of the complex harmonic function for the examination of the whole variation unanalysed, which he conducted according to the plan laid down by POISSON.

This plan consists in using the formulæ for a simple harmonic variation, as approximately applicable to the actual variation. At great depths the amplitudes of the second and higher terms of the complex harmonic function become so much reduced as not sensibly to influence the variation, which is consequently there expressed with sufficient accuracy by a single harmonic term of yearly period; but at even the greatest depths for which continuous observations have actually been made, the second (or semi-annual) term has a very sensible influence, and the third and fourth terms are by no means without effect on the variations at three feet and six feet from the surface. A close agreement with theory is therefore not to be expected, until the method of analysis which I now propose is applied. It may be added, that in the theoretical reductions hitherto made, either by Professor FORBES or others, the amplitudes of the variations for the different depths have alone been compared, and the very interesting conclusion of theory, as to the relation between the absolute amount of retardation of phase and the diminution of amplitude for any increase of depth, has remained untested.

14. In Professor FORBES's paper,* the very difficult operations which he had performed for effecting the construction and the sinking of the thermometers, and the determination of the corrections to be applied to obtain the true temperatures of the earth at the different depths from the readings of the scales graduated on their stems protruding above the surface, are fully described. The results of five years' observations—1837 to 1842—are given, along with most interesting graphical representations and illustrations. A process of graphic interpolation, for estimating the temperatures at times intermediate between those of observations, is applied for the purpose of obtaining data from which the complex harmonic functions expressing the temperatures actually observed for the different depths are determined. I am thus indebted to Professor FORBES for the mode of procedure (described below) which I have myself followed in expressing the variations of temperature during the succeeding thirteen years for the Calton Hill

* Account of Some Experiments on the Temperature of the Earth at Different Depths and in Different Soils near Edinburgh; *Transactions* R.S.E., Vol. XVI. Part II. Edinburgh, 1846.

station (where alone the observations were continued). The only variation from his process which I have made is, that instead of taking twelve points of division for the yearly period I have taken thirty-two, with a view to obtaining a more perfect representation of all the features of the observed variations, and a more exact average for the principal terms, especially the annual and the semi-annual terms of the complex harmonic function expressing them.

15. *Application of the General Theory to Five Years' Observations*—1837 *to* 1842—*at* Professor FORBES's *three Thermometric Stations.*—The first application which I made of the analytical theory explained above, was to the harmonic terms which Professor FORBES had found for expressing the average annual progressions of temperature during the five years' term of observations at the three stations. These terms (which I have recalculated to get their values true to a greater number of significant figures), with alterations of notation which I have found convenient for the analytical expressions, are as follows:—

Three Feet below Surface.

Observatory, . .	$45{\cdot}49 + 7{\cdot}39 \cos 2\pi(t - {\cdot}63) + 0{\cdot}362 \cos 2\pi(2t - {\cdot}669)$
Experimental Gardens,	$46{\cdot}13 + 9{\cdot}00 \cos 2\pi(t - {\cdot}616) + 0{\cdot}737 \cos 2\pi(2t - {\cdot}183)$
Craigleith, . . .	$45{\cdot}88 + 8{\cdot}16 \cos 2\pi(t - {\cdot}617) + 0{\cdot}284 \cos 2\pi(2t - {\cdot}154)$

Six Feet below Surface.

Observatory, . .	$45{\cdot}86 + 5{\cdot}06 \cos 2\pi(t - {\cdot}686) + 0{\cdot}433 \cos 2\pi(2t - {\cdot}731)$
Experimental Gardens,	$46{\cdot}42 + 6{\cdot}66 \cos 2\pi(t - {\cdot}665) + 0{\cdot}501 \cos 2\pi(2t - {\cdot}182)$
Craigleith, . . .	$45{\cdot}92 + 6{\cdot}16 \cos 2\pi(t - {\cdot}649) + 0{\cdot}368 \cos 2\pi(2t - {\cdot}305)$

Twelve Feet below Surface.

Observatory, . .	$46{\cdot}36 + 2{\cdot}44 \cos 2\pi(t - {\cdot}799) + 0{\cdot}075 \cos 2\pi(2t - {\cdot}833)$
Experimental Garden, .	$46{\cdot}76 + 3{\cdot}38 \cos 2\pi(t - {\cdot}782) + 0{\cdot}230 \cos 2\pi(2t - {\cdot}390)$
Craigleith, . . .	$45{\cdot}92 + 4{\cdot}22 \cos 2\pi(t - {\cdot}713) + 0{\cdot}067 \cos 2\pi(2t - {\cdot}819)$

Twenty-four Feet below Surface.

Observatory, . .	$46{\cdot}87 + 0{\cdot}655 \cos 2\pi(t - 1{\cdot}013)$
Experimental Garden, .	$47{\cdot}09 + 0{\cdot}920 \cos 2\pi(t - {\cdot}986)$
Craigleith, . . .	$46{\cdot}07 + 1{\cdot}940 \cos 2\pi(t - {\cdot}849)$

The semi-annual terms in these equations present so great irregularities (those for the Calton Hill station, for instance, showing a greater amplitude at 6 feet deep than at 3 feet), that no satisfactory result can be obtained by including them in the theoretical discussion on which we are now about to enter. We shall see later, however, that when an average for the whole period of eighteen years for the Calton Hill station is taken, the semi-annual terms are, for the 3 feet and 6 feet depths, in fair agreement with theory; and for the two greater depths are as small as is necessary for the verification of the theory, and so small as to be much influenced by errors of observation and of reduction, or of "corrections" for temperature of the thermometer tubes. For the present, we attend exclusively to the annual terms. The amplitudes and epochs of these terms, extracted from the preceding equations, are shown in the following table:—

TABLE III.—ANNUAL HARMONIC VARIATIONS OF TEMPERATURE.

Depths below surface in French feet.	Calton Hill.			Experimental Garden.			Craigleith Quarry.		
	Amplitudes in degrees Fahr.	Epochs of Maximum. In Degs. and Mins.	Epochs of Maximum. In Months and Days.	Amplitudes in degrees Fahr.	Epochs of Maximum. In Degs. and Mins.	Epochs of Maximum. In Months and Days.	Amplitudes in degrees Fahr.	Epochs of Maximum. In Degs. and Mins.	Epochs of Maximum. In Months and Days.
Feet. 3	° 7·386	° 226 52′	Aug. 19	° 9·063	° 221 40′	Aug. 13	° 8·069	° 222 0′	Aug. 14
6	5·063	247 5′	Sept. 8	6·661	239 20′	31	6·148	233 43′	26
12	2·455	287 30′	Oct. 19	3·408	281 27′	Oct. 13	4·216	256 42′	Sept. 17
24	0·655	365 6′	Jan. 6	0·920	355 0′	Dec. 27	1·836	305 46′	Nov. 7

By taking the differences of the Napierian logarithms of the amplitudes, and the differences of epochs reduced to circular measure (arc divided by radius), thus shown for the different depths, and dividing each by the corresponding difference of depths, we find the following numbers.

TABLE IV.—RATES OF LOGARITHMIC DIMINUTION IN AMPLITUDE, AND OF RETARDATION IN EPOCH, OF ANNUAL HARMONIC VARIATIONS DOWNWARDS.

Depths below surface in French feet.	Calton Hill.		Experimental Garden.		Craigleith Quarry.	
	Rate of Diminution of Napierian Logarithm of Amplitude per foot of Descent.	Rate of Retardation of Epoch in Circular Measure, per foot of Descent.	Rate of Diminution of Napierian Logarithm of Amplitude per foot of Descent.	Rate of Retardation of Epoch in Circular Measure, per foot of Descent.	Rate of Diminution of Napierian Logarithm of Amplitude per foot of Descent.	Rate of Retardation of Epoch in Circular Measure, per foot of Descent.
3 to 6 feet.	·1259	·1176	·1004	·1163	·09372	·06399
6 to 12	·1206	·1176	·1130	·1193	·06304	·06690
12 to 24	·1101	·1129	·1084	·1062	·06476	·06690
3 to 24	·1154	·1149	·1082	·1114	·06841	·06648

16. All the numbers here shown for each station would be equal, if the conditions of uniformity supposed in the theoretical solution were fulfilled. The discrepancies are, with the exception of one of the numbers for Craigleith Quarry, on the whole small—smaller, indeed, than might be expected, when the very notable deviations of the true circumstances from the theoretical conditions are considered. The mean results over the 21 feet, shown in the last line, present very remarkable agreements: the numbers derived from amplitudes being identical with that derived from epochs for the Calton Hill station; while the differences between the corresponding numbers for the two other stations are in each case only about 3 per cent. Taking that one number for the first station, and the mean of the slightly differing numbers derived from amplitudes and from epochs respectively, for the second and third, we have undoubtedly very accurate determinations of the value of $\sqrt{\frac{\pi c}{k}}$ for the three stations, which are as follows:—

Calton Hill Trap Rock.	Experimental Garden Sand.	Craigleith Quarry Sandstone.
$\sqrt{\frac{\pi c}{k}} = \cdot 1154$	$\sqrt{\frac{\pi c}{k}} = \cdot 1098$	$\sqrt{\frac{\pi c}{k}} = \cdot 06744$

A continuation of the observations at Calton Hill not only leads, as we shall see, to almost identical results, both by diminution of amplitude and by retardation, on the whole 21 feet, but also reproduces some of the features of discrepance presented by the progress of the variation through the intermediate depths; and therefore confirms the general accuracy of the preceding results, for all the stations, so far as it might be questioned because of only five years' observations having been available. Further consideration of these results, and deduction of the conductivities of the different portions of the earth's crust involved, is deferred until after we have taken into account the farther data for Calton Hill, to the reduction of which we now proceed.

17. *Application to Thirteen Years' Observations* (1842–1854) *at the Thermometric Station, Calton Hill.*—The observations on thermometers fixed by Professor Forbes at the different depths in the rock of Calton Hill, have been regularly continued weekly till the present time by the staff of the Royal Edinburgh Observatory, and regularly corrected to reduce to true temperatures of the bulbs, on the same system as before. Tables of these corrected observations, for the twelve years 1842 to 1854 inclusive, having been supplied to me through the kindness of Professor Piazzi Smyth, I have had the first five terms of the harmonic expression for each year determined in the following manner:*—In the first place, the observations were laid down graphically, and an interpolating curve drawn through the points, according to the method of Professor Forbes. The four curves thus obtained represent the history of the varying temperature at the four different depths respectively, as completely and accurately as it can be inferred from the weekly observations. The space corresponding to each year was then divided into 32 equal parts (the first point of division being taken at the beginning of the year), and the corresponding temperatures were taken from the curve. The co-efficients of the double harmonic series (cosines and sines) for each year were calculated from these data, with the aid of the forms given by Mr Archibald Smith, and published by the Board of Admiralty, for deducing the harmonic expression of the error of a ship's compass from observations on the 32 points. The general form of the harmonic expression being written thus—

$$V = A_0 + A_1 \cos 2\pi t + B_1 \sin 2\pi t + A_2 \cos 4\pi t + B_2 \sin 4\pi t + \&c.,$$

where V denotes the varying temperature to be expressed, and t the time, in terms of a year as unit. The following table shows the results which were obtained, with the exception of the values of A_0:—

* The operations here described, involving, as may be conceived, no small amount of labour, were performed by Mr D. M'Farlane, my laboratory assistant, and Mr J. D. Everett, now Professor of Mathematics and Natural Philosophy in King's College, Windsor, N.S.

TABLE V.

Year.	Feet.	A_1.	B_1.	A_2.	B_2.	A_3.	B_3.	A_4.	B_4.
1842	3	−6·19	−5·00	+ ·01	+ ·25	+ ·60	+ ·06	+ ·23	− ·71
	6	−2·85	−4·80	− ·15	+ ·03	+ ·10	+ ·10	+ ·12	− ·26
	12	+ ·34	−2·73	− ·12	− ·13	− ·08	− ·04	+ ·01	− ·04
	24	+ ·68	− ·14	·00	− ·07	− ·02	− ·04	− ·01	− ·02
1843	3	−4·75	−5·11	+ ·17	+ ·91	+1·23	+ ·30	+ ·79	− ·17
	6	−1·63	−4·38	− ·20	+ ·61	+ ·45	+ ·42	+ ·32	+ ·30
	12	+ ·83	−2·04	− ·18	− ·08	− ·05	+ ·17	− ·03	+ ·10
	24	+ ·62	+ ·12	·00	− ·02	− ·01	− ·01	·00	·00
1844	3	−5·29	−4·53	− ·05	+ ·70	+ ·74	+ ·71	+ ·08	+ ·49
	6	−2·11	−4·09	+ ·22	+ ·50	+ ·20	+ ·50	− ·06	+ ·20
	12	+ ·52	−2·15	+ ·18	+ ·05	+ ·11	+ ·13	− ·05	− ·01
	24	+ ·59	− ·02	− ·03	− ·02	·00	− ·03	− ·01	− ·02
1845	3	−5·17	−5·01	− ·17	+ ·56	+ ·67	+ ·29	− ·28	+ ·02
	6	−2·02	−4·38	+ ·07	+ ·30	·00	+ ·18	− ·04	− ·08
	12	+ ·63	−2·15	+ ·12	+ ·06	− ·01	− ·03	·00	+ ·02
	24	+ ·65	+ ·13	+ ·04	·00	+ ·01	+ ·02	+ ·01	+ ·02
1846	3	−5·65	−5·17	+ ·03	+1·05	− ·86	+ ·64	+ ·00	− ·49
	6	−2·37	−4·64	− ·38	+ ·44	− ·63	− ·39	− ·11	− ·22
	12	+ ·47	−2·70	− ·30	− ·17	− ·14	− ·45	·00	− ·07
	24	+ ·64	− ·22	− ·02	− ·17	+ ·03	− ·11	− ·03	− ·06
1847	3	−5·36	−5·31	+ ·69	+ ·24	− ·18	− ·81	− ·02	− ·14
	6	−2·08	−4·58	+ ·18	+ ·32	+ ·11	− ·39	− ·05	− ·04
	12	+ ·70	−2·37	− ·03	+ ·17	+ ·12	+ ·14	+ ·03	+ ·02
	24	+ ·66	+ ·16	− ·01	+ ·04	+ ·01	+ ·03	+ ·01	+ ·03
1848	3	−5·83	−4·46	+ ·33	+ ·27	+ ·29	+ ·35	+ ·45	− ·30
	6	−2·32	−4·16	+ ·13	+ ·27	+ ·02	+ ·23	+ ·28	+ ·09
	12	+ ·56	−2·15	+ ·04	+ ·16	− ·01	+ ·09	+ ·04	+ ·11
	24	+ ·66	+ ·10	− ·01	+ ·03	·00	+ ·02	− ·01	+ ·01
1849	3	−4·56	−4·44	+ ·05	+1·14	− ·66	− ·10	− ·48	− ·69
	6	−1·85	−3·97	− ·20	+ ·45	− ·28	− ·15	+ ·01	− ·25
	12	+ ·49	−2·06	− ·23	+ ·04	+ ·04	− ·06	+ ·09	− ·05
	24	+ ·57	+ ·03	·00	− ·02	+ ·01	+ ·02	·00	+ ·01
1850	3	−5·40	−4·50	− ·12	+ ·70	− ·54	− ·82	− ·15	− ·42
	6	−2·43	−4·15	− ·22	+ ·31	+ ·03	− ·47	+ ·11	− ·17
	12	+ ·17	−2·27	− ·15	− ·04	− ·10	− ·05	+ ·04	+ ·01
	24	+ ·61	− ·04	+ ·01	− ·03	+ ·01	·00	− ·01	− ·01
1851	3	−4·18	−4·53	+ ·12	+ ·96	− ·09	+ ·31	+ ·22	+ ·18
	6	−1·65	−3·92	− ·19	+ ·53	− ·18	+ ·07	− ·03	+ ·14
	12	+ ·61	−1·99	− ·22	+ ·01	− ·04	− ·06	− ·05	− ·02
	24	+ ·56	+ ·02	+ ·01	− ·05	·00	− ·01	− ·14	− ·01
1852	3	−4·92	−4·80	+ ·20	+1·32	+ ·64	− ·24	− ·46	+ ·31
	6	−1·87	−4·25	− ·23	+ ·71	+ ·15	+ ·10	− ·31	− ·02
	12	+ ·54	−2·24	− ·26	+ ·05	+ ·01	+ ·09	− ·01	− ·07
	24	+ ·61	− ·03	− ·12	− ·07	− ·01	− ·04	·00	− ·02
1853	3	−5·08	−5·43	+ ·83	+ ·30	+ ·11	+ ·27	+ ·18	+ ·19
	6	−1·92	−4·57	+ ·38	+ ·41	− ·05	+ ·17	+ ·06	+ ·13
	12	+ ·76	−3·15	− ·01	+ ·21	− ·01	·00	− ·01	+ ·03
	24	+ ·62	+ ·18	− ·39	+ ·03	·00	+ ·10	+ ·01	+ ·03
1854	3	−5·69	−4·56	− ·61	+ ·53	·00	− ·15	+ ·15	− ·20
	6	−2·48	−4·27	− ·50	− ·01	·00	− ·13	+ ·08	− ·03
	12	+ ·42	−2·31	− ·12	− ·21	+ ·02	− ·03	+ ·02	+ ·01
	24	+ ·63	− ·03	+ ·02	− ·02	·00	− ·01	− ·01	− ·01
verage for 13 years— 1842 to '54.	3	−5·236	−4·835	+ ·114	+ ·687	+ ·150	+ ·0778	+ ·05462	− ·14846
	6	−2·122	−4·320	− ·0838	+ ·375	− ·00615	+ ·0185	+ ·02923	− ·01615
	12	+ ·5415	−2·332	− ·0985	+ ·00923	− ·01846	− ·00778	+ ·006154	+ ·003078
	24	+ ·6231	− ·0200	− ·0385	− ·0285	− ·00231	− ·00462	− ·01462	− ·003846

The values which were found for A_0 should represent the annual mean temperatures. They differ slightly from the annual means shown in the Royal Observatory Report, which, derived as they are from a direct summation of all the weekly observations, must be more accurate. The variations, and the final average values of these annual means, present topics for investigation of the highest interest and importance, as I have remarked elsewhere (see British Association's Report, section A, Glasgow, 1855); but as they do not belong to the special subject of the present paper, their consideration must be deferred to a future occasion.

18. *Theoretical Discussion.*—The mean value of the coefficients in the last line of the table, being obtained from so considerable a number of years, can be but very little influenced by irregularities from year to year, and must therefore correspond to harmonic functions for the different depths, which would express truly periodic variations of internal temperature consequent upon a continued periodical variation of temperature at the surface.

19. According to the principle of the superposition of thermal conductions, the difference between this continuous harmonic function of five terms for any one of the depths, and the actual temperature there at the corresponding time of each year, would be the real temperature consequent upon a certain real variation of superficial temperature. Hence the coefficients shown in the preceding table afford the data, first by their mean values, to test the theory explained above for simple harmonic variations, and to estimate the conductivity of the soil or rock, as I propose now to do; and secondly, as I may attempt on a future occasion, to express analytically the residual variations which depend on the inequalities of climate from year to year, and to apply the mathematical theory of conduction to the nonperiodic variations of internal temperature so expressed.

20. Let us, accordingly, now consider the complex harmonic functions corresponding to the mean coefficients of the preceding table, and, in the first place, let us reduce the double harmonic series in each case to series in each of which a single term represents the resultant simple harmonic variation of the period to which it corresponds, in the manner shown by the proposition and formulæ of § 3 above.

21. On looking to the annual and semi-annual terms of the series so found, we see that their amplitudes diminish, and their epochs of maximum augment, with considerable regularity, from the less to the greater depths. The following table shows, for the annual terms, the logarithmic rate of diminution of the amplitudes, and the rate of retardation of the epoch between the points of observation in order of depth:—

TABLE VI.—Average of Thirteen Years, 1842 to 1854; Trap Rock of Calton Hill.

Depths below surface, in French feet.	Diminution of Napierian logarithm of amplitude per French foot of descent.	Retardation of epoch in circular measure, per French foot of descent.
3 to 6 feet	·1310	·1233
6 to 12 "	·1163	·1140
12 to 24 "	·1121	·1145
3 to 24 feet	·1160	·1156

22. The numbers here shown would all be the same, if the conditions of uniformity supposed in the theoretical solution were fulfilled. Although, as in the previous comparisons, the agreement is on the whole better than might have been expected, there are certainly greater differences than can be attributed to errors of observation. Thus, the means of the numbers in the two columns are for the three different intervals of depth in order as follows:—

	Mean deductions from amplitude and epoch.
3 to 6 feet,	·127
6 to 12 "	·115
12 to 24 "	·113

—numbers which seem to indicate an essential tendency to diminish at the greater depths. This tendency is shown very decidedly in each column separately; and it is also shown in each of the corresponding columns, in tables given above, of results derived from Professor Forbes' own series of a period of five years.

23. There can be no doubt but that this discrepance is not attributable to errors of observation, and it must therefore be owing to deviation in the natural circumstances from those assumed for the foundation of the mathematical formulæ. In reality, none of the conditions assumed in Fourier's solution is rigorously fulfilled in the natural problem; and it becomes a most interesting subject for investigation to discover to what particular violation or violations of these conditions the remarkable and systematic difference discovered between the deductions from the formula and the results of observation is due. In the first place, the formula is strictly applicable only to periodic variations, and the natural variations of temperature are very far from being precisely periodic; but if we take the average annual variation through a sufficiently great number of years, it may be fairly presumed that irregularities from year to year will be eliminated; and that the discrepance we have now to explain does not depend on residual inequalities of this kind seems certain, from the fact that it exists in the average

of Professor Forbes' first five years' series no less decidedly than in that of the period of thirteen years following.

24. For the true explanation we must therefore look either to inequalities (formal or physical) in the surface at the locality, or to inequalities of physical character of the rock below. It may be remarked, in the first place, that if the rates of diminution of logarithmic amplitude and of retardation of epoch, while less, as they both are, at the greater depths, remained exactly equal to one another, the conductivity must obviously be greater, and the specific heat less in the same proportion inversely, at the greater depths. For in that case, all that would be necessary to reconcile the results of observation with FOURIER's formula, would be to alter the scale of measurement of depths so as to give a nominally constant rate of diminution of the logarithmic amplitude and of the retardation of epoch; and the physical explanation would be, that thicker strata at the greater depths, and thinner strata at the less depths (all of equal horizontal area), have all equal conducting powers and equal thermal capacities.*

25. Now, in reality, a portion, but only a portion, of the discrepance may be done away with in this manner; for while the logarithmic amplitudes and the epochs each experience a somewhat diminished rate of variation per French foot of descent at the greater depths, this diminution is much greater for the former than for the latter; so that although the mean rates per foot on the whole 21 feet are as nearly as possible equal for the two, being ·1160 for the logarithmic amplitudes, and ·1156 for the epoch), the rate of variation of the logarithmic amplitude exceeds that of the epoch by about 6 per cent., on the average of the stratum 3 to 6 feet; and falls short of it by somewhat more than 2 per cent., in the lower stratum, 12 to 24 feet. To find how much of the discrepance is to be explained by the variation of conductivity and specific heat in inverse proportion to one another at the different depths, we may take the mean of the rates of variation of logarithmic amplitude and of epoch at each depth, and alter the scale of longitudinal reckoning downwards, so as to reduce the numerical measures of these rates to equality. This, however, we shall not do in either the five years' or the thirteen years' term, which we have hitherto considered separately, but for a harmonic annual variation representing the average of the whole eighteen years 1837 to 1854.

* The "conducting power" of a solid plate is an expression of great convenience, which I define as the quantity of heat which it conducts per unit of time, when its two surfaces are permanently maintained at temperatures differing by unity. In terms of this definition, the specific conductivity of a substance may be defined as the conducting power per unit area of a plate of unit thickness. The conducting power of a plate is calculated by multiplying the number which measures the specific conductivity of its substance by its area, and dividing by its thickness.

The *thermal capacity of a body* may be defined as the quantity of heat required to raise its mass by a unit (or one degree) of temperature. The specific heat of a substance is the thermal capacity of a unit quantity of it, which may be either a unit of weight or a unit of bulk.

26. By taking, for each depth, the coefficients A_1, B_1 (not explicitly shown above), derived from the first five years' average, and multiplying by 5; taking similarly the coefficients A_1, B_1, for the succeeding thirteen years' average, and multiplying by 13; adding each of the former products to the corresponding one of the latter, and dividing by 18; we obtain, as the proper average for the whole eighteen years, the values shown in the following table, in the columns headed A_1, B_1. The amplitudes and epochs shown in the next columns are deduced from these by the formulæ $\sqrt{(A_1^2+B_1^2)}$ and $\tan^{-1}\frac{B_1}{A_1}$ respectively,—

TABLE VII.—ANNUAL HARMONIC VARIATION OF TEMPERATURE IN CALTON HILL, FROM 1837 TO 1844 INCLUSIVE.

Depths.	A_1 In degrees Fahr.	B_1 In degrees Fahr.	Amplitudes in degrees Fahr.	Epochs in degrees and minutes.
3 feet	−5°·184	−4°·989	7°·1949	223° 54′
6 feet	−2·080	−4·416	4·8812	244 47
12 feet	+ ·5961	−2·3345	2·4094	284 19
24 feet	+ ·6311	+ ·0306	·6319	362 47

From these, as before, for ten terms of five years and of thirteen years separately, we deduce the following:—

TABLE VIII.—AVERAGE OF EIGHTEEN YEARS, 1837 TO 1844; TRAP ROCK OF CALTON HILL.

Depths below surface, in French feet.	Diminution of Logarithmic Amplitude per French foot of Descent.	Retardation of Epoch in Circular Measure, per French foot of Descent.
3 to 6 feet.	·1286	·1215
6 to 12 „	·1177	·1150
12 to 24 „	·1115	·1141
3 to 24 feet.	·1157	·1154

27. Hence, we have as final means, of effects on logarithmic amplitudes and on epochs, for the average annual variation on the whole period of eighteen years, —

1. From depth 3 feet to 6 feet, ... ·1250
2. „ 6 „ 12 „ . . . . ·1163
3. „ 12 „ 24 „ . . . . ·1128

If now, in accordance with the proposed plan, we measure depths, not in constant units of length, but in terms of thicknesses corresponding to equal conducting powers and thermal capacities, and if we continue to designate the thickness of the first stratum by its number 3 of French feet, our reckoning for the positions of the different thermometers will stand as follows:—

TABLE IX.

Thermometers numbered downwards.	Depths in true French feet, below No. 1.	Depths in Terms of Conductive Equivalents.
I.	0	0
II.	3	3
III.	9	$3+\frac{\cdot 1163}{\cdot 1250}\times 6=8\cdot 58$
IV.	21	$8\cdot 58+\frac{\cdot 1128}{\cdot 1250}\times 12=19\cdot 41$

According to this way of reckoning depths, we have the following rates of variation of the logarithmic amplitudes, and of the epochs separately, reduced from the previously stated means for the whole period of eighteen years:—

TABLE X.

Portions of Rock.	Rates of Diminution of Logarithmic Amplitude per French foot, and Conductive Equivalents.	Rate of Retardation of Epoch per French foot, and Conductive Equivalents.
Between Thermometers Nos. I. and II.	·1286	·1215
„ „ II. and III.	·1265	·1236
„ „ III. and IV.	·1236	·1264
Between Thermometers Nos. I. and IV.	·1252	·1248

28. Comparing this Table with the preceding Table VIII., we see that the discrepancies are very much diminished; and we cannot doubt but that the conductive power of the rock is less in the lower parts of the rock, and that the amount of the variation is approximately represented by Table IX. We have, however, in Table X. still too great discrepancies to allow us to consider variation in the value of kc, as the only appreciable deviation from FOURIER's conditions of uniformity.

29. In endeavouring to find whether these residual discrepancies are owing to

variations of k and c not in inverse proportion one to the other, I have taken FOURIER's equation

$$c\frac{dv}{dt}=k\frac{d^2v}{dx^2}+\frac{dk}{dx}\frac{dv}{dx},$$

where v denotes the temperature at time t, and at a distance x from an isothermal plane of reference (a horizontal plane through thermometer No. I., for instance); k the conductivity, varying with x; and c the capacity for heat of a unit of volume, which may also vary with x. In this equation I have taken

$$v=a\varepsilon^{-\mathrm{P}}\cos\left(\frac{2\pi t}{\mathrm{T}}-\mathrm{Q}\right),$$

where P and Q are functions of x, assumed so as to express as nearly as may be the logarithmic amplitudes, and the epochs, deduced from observation. I have thus obtained two equations of condition, from which I have determined k and c, as functions of x. The problem of finding what must be the conductivity and the specific heat at different depths below the surface, in order that, with all the other conditions of uniformity perfectly fulfilled, the annual harmonic variation may be exactly that which we have found on the average of the eighteen years' term at Calton Hill, is thus solved. The result is, however, far from satisfactory. The small variations in the values of P and Q which we have found in the representation of the observed temperatures, require very large and seemingly unnatural variations in the values of k and c.

30. I can only infer that the residual discrepancies from FOURIER's formula shown in Table X. are not with any probability attributable to variations of conductivity and specific heat in the rock, and conclude that they are to be explained by irregularities, physical and formal, in the surface. It is possible, indeed, that thermometric errors may have considerable influence, since there is necessarily some uncertainty in the corrections estimated for the temperatures of the different portions of the columns of liquid above the bulbs; and before putting much confidence in the discrepancies we have found, as true expressions of the deviations in the natural circumstances from FOURIER's conditions, a careful estimate of the probable or possible amount of error in the observed temperatures should be made. That even with perfect *data* of observation, as great discrepancies should still be found in final reductions such as we have made, need not be unexpected when we consider the nature of the locality, which is described by Professor FORBES in the following terms:—

The position chosen for placing the thermometer was below the surface "in the Observatory enclosure on the Calton Hill, at a height of 350 feet above the sea. The rock is a porphyritic trap, with a somewhat earthy basis, dull and tough fracture. *The exact position is a few yards east of the little transit house. There are also other buildings in the neighbourhood.* The ground rises slightly to the east, and *falls abruptly to the west at a distance of fifteen yards.* The immediate surface is flat, *partly covered with grass, partly with gravel.*"*

I have marked by italics those passages which describe circumstances such as it appears to me might account for the discrepancies in question.

31. *Application to Semi-annual Harmonic Terms.*—The harmonic expressions given above (§ 15) for the average periodic variations for the three stations of Professor FORBES' original series of five years' observations, contain semi-annual terms, which are obviously not in accordance with theory. The retardations of epochs and the diminutions of amplitudes are, on the whole, too irregular to be reconcileable by any supposition as to the conductivities and specific heat of the soils and rocks involved, or as to the possible effects of irregularity of surface; and in two of the three stations, the amplitude of the semi-annual term is actually greater as found for the six feet deep than for the three feet deep thermometer, which is clearly an impossible result. The careful manner in which the observations have been made and corrected, seems to preclude the supposition that these discrepancies, especially for the three feet and six feet thermometers, for which the amplitudes of the semi-annual terms are from ·28° to ·74° (corresponding to variations of double those amounts, or from ·56° to 1°·48), can be attributed to errors in the *data.* It must be concluded, therefore, that the semi-annual terms of those expressions do not represent any truly periodic elements of variation, and that they rather depend on irregularities of temperature in the individual years of the term of observation. Hence, until methods for investigating the conduction inwards of non-periodic variations of temperature are applied, we cannot consider that the special features of the progress of temperature during the five years' period at the three stations, from which our apparent semi-annual terms have been derived, have been theoretically analysed. But, as we have seen, every irregularity depending on individual years is perfectly eliminated when the average annual variation over a sufficiently great number of years is taken. Hence it becomes interesting to examine particularly the semi-annual terms for the eighteen years' average of the Calton Hill thermometers, which we now proceed to do.

32. Calculating as above (§ 26), for the coefficients A_1, B_1, the average values of A_2 and B_2, from Professor FORBES' results for his first five years' term, and from the averages for the next thirteen years shown in Table V. above, we find the values of A_2 and B_2 shown in the following table. The amplitudes and epochs are deduced as usual by the formulæ $\sqrt{\left(A_2^2 + B_2^2\right)}$ and $\tan^{-1}\frac{B_2}{A_2}$. These reductions I only make for the three feet deep and the six feet deep thermometers, since, for the two others, as may be judged by looking at the thirteen years' average, shown in the former table, the amounts of the semi-annual varia-

* Professor FORBES on the Temperature of the Earth, *Trans.* R.S.E., 1846, p. 194.

tion do not exceed the probable errors in the data of observation sufficiently to allow us to draw any reliable conclusions from their apparent values.

TABLE XI.—AVERAGE SEMI-ANNUAL HARMONIC TERM, FROM EIGHTEEN YEARS' OBSERVATIONS AT CALTON HILL.

Depths below surface, in French feet.	A_2 In degrees Fahr.	B_2 In degrees Fahr.	Amplitudes In degrees Fahr.	Epochs in degrees and minutes.
3 feet.	°1518	°·5842	°·604	°·75 26′
6 feet.	·0461	·3911	·394	·96 43,

The ratio of diminution of the amplitude here is $\frac{\cdot 604}{\cdot 394}$ or 1·53, of which the Napierian logarithm is ·426. Dividing this by 3, we find

$$\cdot 142$$

as the rate of diminution of the logarithmic amplitude per French foot of descent.

The retardation of epoch shown is 21° 17′; and therefore the retardation per French foot of descent is 7° 6′, or, in circular measure,

$$\cdot 1239.$$

If the data were perfect for a periodical variation, and the conditions of uniformity supposed in FOURIER's solution were fulfilled, these two numbers would agree, and each would be equal to $\sqrt{\frac{2\pi k}{c}}$. Hence, dividing them each by $\sqrt{2}$, we find

Apparent values of $\sqrt{\frac{\pi c}{k}}$

·100 (by amplitudes)
·877 (by epochs).

The true value of $\sqrt{\frac{\pi c}{k}}$ must, as we have seen, be ·116, to a very close degree of approximation.

33. When we consider the character of the reduction we have made, and remember that the data were such as to give no semblance of a theoretical agreement when the first five years' term of observations was taken separately, we may be well satisfied with the approach to agreement presented by these results, depending as they do on only eighteen years in all, and we may expect that, when the average is of a still larger term of observation, the discrepancies will be much diminished. In the mean time, we may regard the semi-annual term we have found for the three feet deep thermometer as representing a true feature of the yearly vicissitude; and it will be surely interesting to find whether it is a constant feature for the locality of Edinburgh, to be reproduced on averages of subsequent terms of observation.

34. It may be remarked, that the nearer to the equator is the locality, the

greater relatively will be the semi-annual term; that within the tropics the semi-annual term may predominate, except at the great depths; and that at the equator the tendency is for the annual term to disappear altogether, and to leave a semi-annual term as the first in a harmonic expression of the yearly vicissitude of temperature. The facilities which underground observation affords for the analysis of periodic variations of temperature, when the method of reduction which I have adopted is followed, will, it is to be hoped, induce those who have made similar observations in other localities to apply the same kind of analysis to their results; and it is much to be desired, that the system of observing temperatures at two if not more depths below the surface may be generally adopted at all meteorological stations, as it will be a most valuable means for investigating the harmonic composition of the annual vicissitudes.

III.—*Deduction of Conductivities.*

35. Notwithstanding the difficulty we have seen must attend any attempt to investigate all the circumstances which must be understood in order to reconcile perfectly the observed results with theory, the general agreement which we have found is quite sufficient to allow us to form a very close estimate of the ratio of the conductivity of the rock to its specific heat per unit of bulk. Thus, according to the means deduced from the whole period of eighteen years' observation, the average rate of variation of the logarithmic amplitude of the annual term through the whole space of twenty-one feet is ·1157, and of the epoch of the same term, ·1154. The mean of these, or ·1156, can differ but very little from the true average value of $\sqrt{\frac{\pi c}{k}}$ for the portion of rock between the extreme thermometers.

36. Dividing π by the square of the reciprocal of this number, we find 235·1 as the value of $\frac{k}{c}$, or, as we may call it, the conductivity of the rock in terms of the thermal capacity of a cubic foot of its own substance. In other words, we infer that all the heat conducted in a year (the unit of time) across each square foot of a plate one French foot thick, with its two sides maintained constantly at temperatures differing by 1°, would, if applied to raise the temperature of portions of the rock itself, produce a rise of 1° in 235 cubic feet. As it is difficult (although by no means impossible) to imagine circumstances in which the heat, regularly conducted through a stratum maintained, with its two sides, at perfectly constant temperatures, could be applied to *raise* the temperatures of other portions of the same substance, we may vary the statement of the preceding result, and obtain the following completely realisable illustration.

37. Let a large plate of the rock, everywhere one French foot thick, have every part of one of its sides (which, to avoid circumlocution, we shall call its lower side) maintained at one constant temperature, and let portions of homo-

geneous substance, at a temperature 1° lower, be continually placed in contact with the upper surface, and removed to be replaced by other homogeneous portions at the same lower temperature, as soon as the temperature of the matter actually thus applied rises in temperature by $\frac{1}{1000}$ of a degree. If this process is continued for a year, the whole quantity of the refrigerating matter thus used to carry away the heat conducted through the stratum must amount to 235,000 cubic feet for each square foot of area, which will be at the rate of ·00745 of a cubic foot per second. We may therefore imagine the process as effected by applying an extra stratum ·00745 of a foot thick every second of time. This extra stratum, after lying in contact for one second, will have risen in temperature by $\frac{1}{1000}$ of a degree. By means of the information contained in this apparently unpractical statement, many interesting problems may be practically solved, as I hope to show in a subsequent communication.

38. The value of $\sqrt{\frac{\pi c}{k}}$, derived from the whole eighteen-years period of observation (·1156), differs so little from that (·1154) found previously (§ 16) from Professor FORBES's observations and reductions of the first five of the years, that we may feel much confidence in the accuracy of the values ·1098 and ·06744, which, from his five years' data alone, we found (§ 16) for the corresponding constant with reference to the sand at the Experimental Garden and the sandstone of Craigleith Quarry. From them, calculating as above (§ 36), we find 260·5 and 690·7 as the values of $\frac{k}{c}$ for the terrestrial substances of these localities respectively; results of which the meaning is illustrated by the statements of §§ 36 and 37.

39. To deduce the conductivities of the strata, in terms of uniform thermal units, Professor FORBES had the "specific heats" of the substances determined experimentally by M. REGNAULT. The results, multiplied by the specific gravities, gave for the thermal capacities of portions of the three substances, in terms of that of an equal bulk of water, the values ·5283, ·3006, and ·4623 respectively. Now, these must be the values of c, if the thermal unit in which k is measured is the thermal capacity of a French cubic foot of water. Multiplying the values of $\frac{k}{c}$ found above by these values of c, we find for k the following values:—

Trap-rock of Calton Hill.	Sand of Experimental Gardens.	Sandstone of Craigleith.
124·2	78·31	319·3

The values found by Professor FORBES were—

111·2	82·6	298·3

Although many comparisons have been made between the conducting powers of different substances, scarcely any data as to thermal conductivity in absolute measure have been hitherto published, except these of Professor FORBES, and probably none approaching to their accuracy. The slightly different numbers to which we have been led by the preceding investigation are no doubt still more accurate.

40. To reduce these results to any other scale of linear measurement, we must clearly alter them in the inverse ratio of the square of the absolute lengths chosen for the units.* The length of a French foot being 1·06575 of the British standard foot, we must therefore multiply the preceding numbers by 1·13581, to reduce them to convenient terms.

41. We may, lastly, express them in terms of the most common unit, which is the quantity of heat required to raise the temperature of a grain of water by 1°; and to do this we have only to multiply each of them by 7000 × 62·447, being the weight of a cubic foot in grains.

42. The following table contains a summary of our results as to conductivity expressed in several different ways, one or other of which will generally be found convenient:—

TABLE XII.—THERMAL CONDUCTIVITIES OF EDINBURGH STRATA, IN BRITISH ABSOLUTE UNITS [UNIT OF LENGTH, THE ENGLISH FOOT].

Description of Terrestrial Substance.	Conductivities in Terms of Thermal Capacity of Unit Bulk of Substance $\left(\frac{k}{c}\right)$.			Conductivities in Terms of Thermal Capacity of Unit Bulk of Water (k).			Conductivities in Terms of Thermal Capacity of One Grain of Water.
	Per Ann.	Per 24^h.	Per Second.	Per Ann.	Per 24_h.	Per Second.	Per Second.
Trap-rock of Calton Hill,	267·0	·7310	·000008461	141·1	·3863	·000004471	1·9544
Sand of Experimental Garden,	295·9	·8100	·000009375	88·9	·2435	·000002818	1·2319
Sandstone of Craigleith Quarry,	784·5	2·1478	·00002486	362·7	·9929	·00001149	5·0225

43. The statements (§§ 36 and 37) by which the signification of $\frac{k}{c}$ has been defined and illustrated, require only to have *cubic feet of water* substituted for

* Because the absolute amount of heat flowing through the plate across equal areas will be inversely as the thickness of the plate; and the effect of equal quantities of heat in raising the temperature of equal areas of the water will be inversely as the depth of the water. The same thing may be perhaps more easily seen by referring to the elementary definition of thermal conductivity (footnote to § 11, above). The absolute quantity of heat conducted across unit area of a plate of unit thickness, with its two sides maintained at temperatures differing by always the same amount, will be directly as the areas, and inversely as the thickness, and therefore simply as the absolute length chosen for unity. But the thermal unit in which these quantities are measured, being the capacity of a unit bulk of water, is directly as the cube of the unit length, and therefore the numbers expressing the quantities of heat compared will be inversely as the cubes of the lengths chosen for unity, and directly as these simple lengths: that is to say, finally, they will be inversely as the squares of these lengths.

cubic feet of rock, in their calorimetric specifications, to be applicable similarly to define and illustrate the meaning of the conductivity denoted by k. The fluidity of the water allows a modified and somewhat simpler explanation, equivalent to that of § 36, to be now given, as follows:—

44. If a long rectangular plate of rock, one foot thick, in a position slightly inclined to the horizontal, have water one foot deep flowing over it in a direction parallel to its length, and if the lower surface of the plate be everywhere kept 1° higher in temperature than the upper, the water must flow at the rate of k times the length of the plate per unit of time, in order that the heat conducted through the plate may raise it just 1° in temperature in its flow over the whole length. [It must be understood here, that the plate becomes warmer, on the whole, under the lower parts of the stream of water, its upper surface being everywhere at the same temperature as the water in contact with it, while its lower surface is, by hypothesis, at a temperature 1° higher.] If, for instance, the plate be of Calton Hill trap-rock, the water must, according to the result we have found, flow at the rate of 141·1 times its length in a year, or of ·3863 of its length in twenty-four hours, to be raised just 1° in temperature in flowing over it. Thus water, one French foot deep, flowing over a plane bed of such rock at the rate of ·3863 of a mile in twenty-four hours, will, in flowing one mile, have its temperature raised 1° by heat conducted through the plate. The rates required to fulfil similar conditions for the sand of the Experimental Gardens and the sandstone of Craigleith Quarry are similarly found to be ·2435 of the length and ·9929 of the length, in twenty-four hours.

XVIII.—*On a Method of Reducing Observations of Underground Temperature, with its Application to the Monthly Mean Temperatures of Underground Thermometers, at the Royal Edinburgh Observatory.* By Joseph D. Everett, M.A., Professor of Mathematics, &c., in King's College, Windsor, N.S., and late Secretary to the Meteorological Society of Scotland.

(Read 30th April 1860.)

A few years since I was engaged in the performance of some calculations under the direction of Professor W. Thomson of Glasgow, having reference to the observations of underground temperature made at the Royal Edinburgh Observatory. In this paper I propose to describe a modification of Professor Thomson's method, which, while retaining a sufficient degree of accuracy, will be simple enough for general adoption. The objects proposed are—

1*st*, To express the variations of temperature at a given depth in terms of the time of year.

2*d*, To deduce the conducting power of the soil.

In the calculations performed for Professor Thomson, the temperatures at 32 equal intervals in each year were required as the basis of calculations; and as the observations had been made only once a-week, it was requisite to interpolate, either by graphical projection (which was the method employed) or in some other way.

A Report of the Royal Edinburgh Observatory having recently passed through my hands, containing the mean temperature of each of the underground thermometers for each month of each year during a period of seventeen years, I have adapted Professor Thomson's method to a computation from 12 (instead of 32) points in the year, and have applied the method thus modified to the means on the seventeen years' observations. The present paper embodies the results, which will be found to agree pretty closely with those obtained by the more elaborate method. The monthly mean temperatures printed in the Observatory Report, on the averages of which, for the seventeen years, the following results are based, are simply the arithmetical means of the weekly readings taken in each calendar month.

For the sake of making the paper intelligible, it will be necessary to premise a few principles which are common to both methods.

The form of expression to which the temperature of each thermometer is to be reduced, is

$$v=A_0+P_1 \sin\left(2\pi\frac{t}{T}+E_1\right)+P_2 \sin\left(4\pi\frac{t}{T}+E_2\right)+\&c. \quad . \quad . \quad (1.)$$

the general term being $$P_n \sin\left(2n\pi\frac{t}{T}+E_n\right)$$

Where v is the temperature at the line t from the epoch of reckoning, T is the periodic time (a year), π is the ratio of the circumference of a circle to the diameter, and A_0, P_1, P_2, E_1, E_2, &c. are constants, whose value must be found from the temperatures observed.

It is evident from the form of the expression that A_0 is the mean temperature of the whole year, and that the maximum and minimum values of any subsequent term $P_n \sin\left(2n\pi\frac{t}{T}+E_n\right)$ are $+P_n$ and $-P_n$ respectively. As the range of value through which any term passes depends only on the coefficient P_n, this coefficient is styled the *amplitude* of the term, being in fact equal to half the range.

The epochs of maxima and minima will be very different for different terms. The term involving P_1 has one maximum and one minimum in the year. The term involving P_2 has two maxima and two minima, and generally the term in P_n has n maxima and n minima in the year, its values going through their entire cycle in the $\frac{1}{n}$th part of a year. The term in P_1 is therefore called the annual term, and the term in P_2 the half-yearly term.

The maximum and minimum values of a term will occur earlier or later in the year, according to the value of the constant E_n, any diminution in the value of E_n being the same thing as a retardation of the maxima and minima. Such retardation is called *retardation of phase.* It is the diminution of amplitude and retardation of phase between the terms for thermometers at different depths, that afford the means of deducing the conducting power of the soil.

In order to find from the observed temperatures the values of the constants in expression (1), we must make use of the equivalent expression—

$$v=A_0+\left(A_1 \cos 2\pi\frac{t}{T}+B_1 \sin 2\pi\frac{t}{T}\right)+\left(A_2 \cos 4\pi\frac{t}{T}+B_2 \sin 4\pi\frac{t}{T}\right)+\&c.$$

the general term being $$\left(A_n \cos 2n\pi\frac{t}{T}+B_n \sin 2n\pi\frac{t}{T}\right) \quad . \quad . \quad (2.);$$

and then by applying the equations of transformation

$$\sqrt{A_n^2+B_n^2}=P_n\ ,\ \frac{A_n}{B_n}=\tan E_n \quad . \quad . \quad . \quad . \quad . \quad (3.)$$

we shall obtain the values of the constants in expression (1).

In the calculations performed for Professor THOMSON, the expressions were carried as far as the terms depending on A_4 and B_4. I have carried them only as far as A_2 and B_2, the convergence of the terms being so rapid that a good approximation to the value of the whole series is thus obtained. For deducing the conducting power of the soil even this is more than is required, the values of any single term (except A_0) for the different thermometers being all that theory requires, and the values of A_1 and B_1, inasmuch as they admit of more accurate determination than the coefficients of following terms, can be most advantageously used for making this deduction.

The process for finding the values of A_0, A_1, B_1, &c., is different according to the number of points in the year that are taken. To find analytically the process for 12 points in the year, let

v_0 denote the temperature at the epoch of commencement;

v_1 " " $\frac{1}{12}$ of the year later;

v_2 " " $\frac{2}{12}$ " "

&c. &c.,

and let the sines of 0°, 30°, 60°, and 90°, be denoted by S_0, S_1, S_2, S_3 respectively; we have then the following values of v for the 12 points in the year:—

I.	II.
$v_0=A_0+A_1 S_3+A_2 S_3+B_1 S_0+B_2 S_0$	$v_6=A_0-A_1 S_3+A_2 S_3-B_1 S_0+B_2 S_0$
$v_1=A_0+A_1 S_2+A_2 S_1+B_1 S_1+B_2 S_2$	$v_7=A_0-A_1 S_2+A_2 S_1-B_1 S_1+B_2 S_2$
$v_2=A_0+A_1 S_1-A_2 S_1+B_1 S_2+B_2 S_2$	$v_8=A_0-A_1 S_1-A_2 S_1-B_1 S_2+B_2 S_2$
$v_3=A_0+A_1 S_0-A_2 S_3+B_1 S_3-B_2 S_0$	$v_9=A_0-A_1 S_0-A_2 S_3-B_1 S_3+B_2 S_0$
$v_4=A_0-A_1 S_1-A_2 S_1+B_1 S_2-B_2 S_2$	$v_{10}=A_0+A_1 S_1-A_2 S_1-B_1 S_2-B_2 S_2$
$v_5=A_0-A_1 S_2+A_2 S_1+B_1 S_1-B_2 S_2$	$v_{11}=A_0+A_1 S_2+A_2 S_1-B_1 S_1-B_2 S_2$

Subtracting the quantities in column II. from those in column I. we find

III.	IV.
$v_0-v_6=2 A_1 S_3+2 B_1 S_0$	
$v_1-v_7=2 A_1 S_2+2 B_1 S_1$	$v_5-v_{11}=-2 A_1 S_2+2 B_1 S_1$
$v_2-v_8=2 A_1 S_1+2 B_1 S_2$	$v_4-v_{10}=-2 A_1 S_1+2 B_1 S_2$
$v_3-v_9=-2 A_1 S_0+2 B_1 S_3$	

Subtracting the quantities in column IV. from those opposite to them respectively in column III. (remembering that $S_0=0$, and $S_3=1$), we obtain the remainders—

$2 A_1$ $4 A_1 S_2$ $4 A_1 S_1$ $2 B_1$

If these be multiplied respectively by the factors,

1 S_2 S_1 0

the products are

$2 A_1$ $4 A_1 (S_2)^2$ $4 A_1 (S_1)^2$ 0

and the sum of these four products (since $(S_1)^2+(S_2)^2=1$) is 6 A_1. Hence the value of A_1 can be found.

Again, adding the quantities which stand opposite to each other in columns III. and IV. we have the sums

$$2\,A_1 \qquad 4\,B_1\,S_1 \qquad 4\,B_1\,S_2 \qquad 2\,B_1\,;$$

and if we multiply these respectively by the factors,

$$0 \qquad S_1 \qquad S_2 \qquad 1$$

we obtain the products,

$$0 \qquad 4\,B_1\,(S_1)^2 \qquad 4\,B_1\,(S_2)^2 \qquad 2\,B_1$$

The sum of these products is 6 B_1; hence B_1 can be found.

Adding the terms opposite each other in columns I. and II. we find

V.	VI.
$v_0+v_6=2\,A_0+2\,A_2\,S_3+2\,B_2\,S_0$	$v_3+v_9=2\,A_0-2\,A_2\,S_3-2\,B_2\,S_0$
$v_1+v_7=2\,A_0+2\,A_2\,S_1+2\,B_2\,S_2$	$v_4+v_{10}=2\,A_0-2\,A_2\,S_1-2\,B_2\,S_2$
$v_2+v_8=2\,A_0-2\,A_2\,S_1+2\,B_2\,S_2$	$v_5+v_{11}=2\,A_0+2\,A_2\,S_1-2\,B_2\,S_2$

The sum of all the terms in V. and VI. is 12 A_0, which is in fact the sum of the 12 values of v.

Subtracting the quantities in VI. from those opposite to them in V., we have the remainders,—

$$4\,A_2 \qquad 4\,A_2\,S_1+4\,B_2\,S_2 \qquad -4\,A_2\,S_1+4\,B_2\,S_2.$$

Multiply these remainders respectively by

$$1 \qquad S_1 \qquad -S_1$$

and omitting the two terms $4\,B_2\,S_1\,S_2$ and $-4\,B_2\,S_1\,S_2$, which destroy one another, we have the products—

$$4\,A_2 \qquad 4\,A_2\,(S_1)^2 \qquad 4\,A_2\,(S_1)^2$$

whose sum (since $S_1=\frac{1}{2}$) is 6 A_2. Hence A_2 can be found.

Again, if the above remainders be multiplied respectively by

$$0 \qquad S_2 \qquad S_2$$

the products (omitting terms which destroy each other) are

$$0 \qquad 4\,B_2\,(S_2)^2 \qquad 4\,B_2\,(S_2)^2$$

and since $S_2=\frac{\sqrt{3}}{2}$, the sum of these products is 6 B_2. Hence B_2 can be found.

The application of the process above indicated to the determination of A_1 B_1 A_2 B_2 for the 3 feet thermometer is subjoined.

I. Temperatures of first 6 months.	II. Temperatures of last 6 months.	III. I. – II.	IV. Last two Nos. in III. reversed.	III. – IV.	Multipliers.	Products.	III. + IV.	Multipliers.	Products.
40·57	52·70	–12·13		–12·13	1	–12·13	–12·13	0	– 0·00
39·64	53·82	–14·18	+7·24	–21·42	S_2	–18·55	– 6·94	S_1	– 3·47
40·31	52·75	–12·44	+0·35	–12·79	S_1	– 6·39	–1209	S_2	–10·47
42·45	49·15	– 6·70		– 6·70	0	·00	– 6·70	1	– 6·70
45·87	45·52	+ 0·35			6)	–37·07		6)	–20·64
49·86	42·62	+ 7·24			$A_1=$	– 6·18		$B_1=$	– 3·44

V. First Half of (I.+II.)	VI. Last Half of (I.+II.)	V. – VI.	Multipliers.	Products.	V. – VI. again.	Multipliers.	Products.
93·27	91·60	+1·67	1	+1·67	1·67	0	·00
93·46	91·39	+2·07	S_1	+1·035	+2·07	S_2 }	+2·295
93·06	92·48	+0·58	$-S_1$	–0·290	+0·58	S_2 }	
			6)	+2·415		6)	+2·295
			$A_2=$	+ ·4025		$B_2=$	+ ·3825

A_0 = mean of all the numbers in I. and II. = 46·27.

There are in all four thermometers, their bulbs being sunk to depths of 3, 6, 12, and 24 French feet respectively below the surface of the ground. The means of their readings, in degrees Fahrenheit, for each calendar month, on the average of the seventeen years 1838–1854, are as under:—

Depth of Thermometer.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
3 feet	40·57	39·64	40·31	42·45	45·87	49·86	52·70	53·82	52·75	49·15	45·52	42·62
6 feet	43·59	42·35	42·00	42·79	44·65	47·23	49·71	51·31	51·54	50·11	47·81	45·48
12 feet	46·84	45·82	45·06	44·68	44·88	45·63	46·84	48·07	48·96	49·27	49·02	47·94
24 feet	47·77	47·63	47·39	47·08	46·79	46·59	46·55	46·69	46·97	47·31	47·61	47·79

The values of A_0, A_1, B_1, A_2, B_2, obtained in the manner above indicated, are—

	A_0	A_1	B_1	A_2	B_2
For the 3 feet thermometer,	46·27	−6·18	−3·44	+·4025	+·3825
... 6 feet ...	46·55	−3·10	−3·65	+·120	+·293
... 12 feet ...	46·92	+0·03	−2·31	−·0833	+·0635
... 24 feet ...	47·18	+0·615	−0·118	−·0167	−·0144

And the values of P_1, P_2, E_1, E_2, obtained from these by the formulæ of transformation (3), are—

	P_1	P_2	E_1	E_2
For the 3 feet thermometer,	7·07	·56	240° 54′	46° 27½′
... 6 feet ...	4·79	·32	220° 20′	22° 16′
... 12 feet ...	2·31	·10	179° 15′	− 52° 41′
... 24 feet ...	·63	·02	100° 52′	−130° 46′

With the view of testing how nearly the formulæ give the true temperature of each month, I have calculated the temperature of each thermometer for each month both by formula (1) and formula (2), the results in the two cases being identical; and the following table exhibits their differences from the actual temperatures. The numbers in the first line are the actual temperatures; those in the second line are obtained by putting t successively equal to 0, $\frac{1}{12}$ T, $\frac{2}{12}$ T, &c. in expressions (1) and (2); and those in the third line are the corrections necessary for reducing the calculated to the actual temperatures. For the sake of exhibiting the variations of temperature more clearly, the temperatures have in each case been diminished by the mean of the year, so that temperatures below the mean bear the negative sign.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
3 feet Ther.												
Actual,	−5·70	−6·63	−5·96	−3·82	−0·40	+3·59	+6·43	+7·55	+6·48	+2·88	−0·75	−3·65
By formula,	−5·78	−6·54	−5·94	−3·84	−0·42	+3·50	+6·58	+7·60	+6·20	+3·04	−0·64	−3·76
Difference,	+ ·08	− ·09	− ·02	+ ·02	+ ·02	+ ·09	− ·15	− ·05	+ ·28	− ·16	− ·11	+ ·11
6 feet Ther.												
Actual,	−2·96	−4·20	−4·55	−3·76	−1·90	+0·68	+3·16	+4·76	+4·99	+3·56	+1·26	−1·07
By formula,	−2·98	−4·20	−4·52	−3·77	−1·93	+0·67	+3·22	+4·82	+4·91	+3·53	+1·30	−1·05
Difference,	+ ·02	·00	− ·03	+ ·01	+ ·03	+ ·01	− ·06	− ·06	+ ·08	+ ·03	− ·04	− ·02
12 feet Ther.												
Actual,	−0·08	−1·10	−1·86	−2·24	−2·04	−1·29	−0·08	+1·15	+2·04	+2·35	+2·10	+1·02
By formula,	−0·05	−1·12	−1·89	−2·23	−2·03	−1·28	−0·11	+1·14	+2·08	+2·39	+2·00	+1·08
Difference,	− ·03	+ ·02	+ ·03	− ·01	− ·01	− ·01	+ ·03	+ ·01	− ·04	− ·04	+ ·10	− ·06
24 feet Ther.												
Actual,	+ ·59	+ ·45	+ ·21	− ·10	− ·39	− ·59	− ·63	− ·49	− ·21	+ ·13	+ ·43	+ ·61
By formula,	+ ·60	+ ·45	+ ·20	− ·10	− ·39	− ·59	− ·63	− ·49	− ·21	+ ·13	+ ·43	+ ·60
Difference,	− ·01	·00	+ ·01	·00	·00	·00	·00	·00	·00	·00	·00	+ ·01

If we had neglected the term involving P_2 (the half-yearly term), and taken only the term involving P_1 (the annual term), we should have obtained the results entered in the first line of the following table. The numbers in the second line are the corrections necessary for reducing these results to the actual temperatures.

	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Results,	−6·18	−7·07	−6·07	−3·44	+0·11	+3·63	+6·18	+7·07	+6·07	+3·44	−0·11	−3·63
Corrections,	+ ·48	+ ·44	+ ·11	− ·38	− ·51	− ·04	·25	+ ·48	+ ·41	− ·56	− ·64	− ·02
Results,	−3·10	−4·51	−4·71	−3·65	−1·61	+0·86	+3·10	+4·51	+4·71	+3·65	+1·61	−0·86
Corrections,	+ ·14	+ ·31	+ ·16	− ·11	− ·29	− ·18	+ ·06	+ ·25	+ ·28	− ·09	− ·35	− ·21
Results,	+0·03	−1·13	−1·98	−2·31	−2·02	−1·18	−0·03	+1·13	+1·99	+2·31	+2·02	+1·18
Corrections,	− ·11	+ ·03	+ ·12	+ ·07	− ·02	− ·11	− ·05	+ ·02	+ ·05	+ ·04	+ ·08	− ·16
Results,	+ ·62	+ ·47	+ ·20	− ·12	− ·41	− ·59	− ·62	− ·47	− ·21	+ ·12	+ ·41	+ ·59
Corrections,	− ·03	− ·02	+ ·01	+ ·02	+ ·02	·00	− ·01	− ·02	·00	+ ·01	+ ·02	+ ·02

The processes hitherto described are applicable not only to underground temperatures, but also to open-air temperatures, and, in fact, to any element that varies in a regular manner.

It remains to show how the results which we have obtained can be applied for determining the conductivity of the soil. The mode of procedure will be exactly the same as that adopted in the calculations for Professor THOMSON.

The conducting power of the soil may be inferred either from the diminution in the values of P_1 and P_2 as we descend in the soil, or from the diminution of E_1 and E_2. In other words, it may be inferred either from diminution of amplitude, or from retardation of phase.

Let x denote the difference in depth of any two of the thermometers; let $\Delta \,.\, E_n$ denote the retardation of phase, or the excess of the value of E_n, for the upper of the two thermometers above its value for the lower, E_n being expressed not in degrees and minutes, but in circular measure; and let $\Delta \,.\, \log_e P_n$ denote the diminution of the Napierian logarithm of the amplitude, or the excess of $\log_e P_n$ for the upper thermometer above $\log_e P_n$ for the lower; the ratio of k, the conductivity of the soil, to c, the capacity of the soil, for heat, may then be determined by either of the equations

$$\frac{\Delta \,.\, E_n}{x} = \sqrt{\frac{n\pi c}{Tk}} \qquad \frac{\Delta \,.\, \log_e P_n}{x} = \sqrt{\frac{n\pi c}{Tk}} \quad . \quad . \quad . \quad . \qquad (4)$$

The manner in which these equations are deduced from the differential equation for the flow of heat through the soil,

$$\frac{dv}{dt} = \frac{k}{c} \cdot \frac{d^2v}{dx^2},$$

will be stated in a note at the end of this paper. At present we proceed to apply the equations to the numerical results above obtained.

The values of E_1 and E_2 in circular measure, and of $\log_e P_1$ and $\log_e P_2$, are as under:—

	$\text{Log}_e\ P_1$	$\text{Log}_e\ P_2$	E_1 in circular measure.	E_2 in circular measure.
3 feet thermometer	1·95	− ·59	4·20	+ ·81
6 feet "	1·56	−1·15	3·85	+ ·39
12 feet "	·84	−2·25	3·15	− ·92
24 feet "	− ·47	−3·81	1·76	−2·28

By comparing the thermometers two and two in every possible combination, the following results are obtained:—

For the Annual Term.

Thermometers compared.	ΔE_1	x	$\sqrt{\frac{\pi c}{Tk}}$	$\Delta \log_e P_1$	x	$\sqrt{\frac{\pi c}{Tk}}$
3 feet and 6 feet.	·35	3	·117	.39	3	·130
3 feet and 12 feet.	1·05	9	·117	1·11	9	·123
3 feet and 24 feet.	2·44	21	·116	2·42	21	·115
6 feet and 12 feet.	·70	6	·117	·72	6	·120
6 feet and 24 feet.	2·09	18	·116	2·03	18	·113
12 feet and 24 feet.	1·39	12	·116	1·31	12	·109
Means, ...			·1165	. . .		·1183

For the Half-yearly Term.

Thermometers compared.	ΔE_2	x	$\sqrt{\frac{2\pi c}{Tk}}$	$\Delta \log_e P_2$	x	$\sqrt{\frac{2\pi c}{Tk}}$
3 feet and 6 feet.	·42	3	·140	·56	3	·187
3 feet and 12 feet.	1·73	9	·192	1·66	9	·184
3 feet and 24 feet.	3·09	21	·147	3·22	21	·153
6 feet and 12 feet.	1·31	6	·218	1·10	6	·183
6 feet and 24 feet.	2·67	18	·148	2·66	18	·148
12 feet and 24 feet.	1·36	12	·113	1·56	12	·130
Means, ...			·160	. . .		·164
Quotients by $\sqrt{2}$, . . .			·113	. . .		·116

The results deduced from the annual term agree the best among themselves, and are the most reliable; the coefficients P_2 of the half-yearly term being very small, and varying considerably from year to year. Notwithstanding, the mean values ·113, ·116 of $\sqrt{\frac{\pi c}{Tk}}$, deduced from the half-yearly term, agree very well with the values ·1165, ·1183 from the annual term. Professor Thomson's results from the temperatures of the thirteen years 1842–1854 were:—

	By Phase.	By Amplitude.
For the annual term, . . .	·1156	·1160
For the half-yearly term, . .	·08861	·11133

—these numbers being the values of the function $\sqrt{\frac{\pi c}{Tk}}$ obtained from the coefficients in the same manner as above. The agreement as regards the annual term is very remarkable, extending, as it does, both in the determination from phase and in that from amplitude to the fourth decimal place.

Note on the Equations

$$\frac{\Delta \,.\, \mathrm{E}}{x}=\sqrt{\frac{n\pi c}{\mathrm{T}k}}=\frac{\Delta \,.\, \log_e \mathrm{P}_n}{x}.$$

The differential equation for the conduction of heat through the soil, the surface being supposed horizontal and the soil uniform, is

$$\frac{dv}{dt}=\frac{k}{c}\cdot\frac{d^2v}{dx^2}.$$

This equation is satisfied if we assume

$$v=\mathrm{P}e^{-x\sqrt{\frac{n\pi c}{\mathrm{T}k}}}\sin\left(2n\pi\frac{t}{\mathrm{T}}+\mathrm{E}_n-x\sqrt{\frac{n\pi c}{\mathrm{T}k}}\right)$$

—e being the base of Napierian logarithms, and P any constant.

To show that this integral satisfies the differential equation, put

$$\sqrt{\frac{n\pi c}{\mathrm{T}k}}=\alpha,\quad \frac{2n\pi t}{\mathrm{T}}+\mathrm{E}-\beta.$$

The equation then becomes

$$v=\mathrm{P}e^{-\alpha x}\sin(\beta-\alpha x).$$

Whence

$$\frac{dv}{dt}=\frac{d\beta}{dt}\,.\,\mathrm{P}e^{-\alpha x}\cos(\beta-\alpha x)=\frac{2n\pi}{\mathrm{T}}\,.\,\mathrm{P}e^{-\alpha x}\cos(\beta-\alpha x)$$

$$\frac{dv}{dx}=-\mathrm{P}\alpha e^{-\alpha x}\left\{\sin(\beta-\alpha x)+\cos(\beta-\alpha x)\right\}$$

$$\frac{d^2v}{dx^2}=\mathrm{P}\alpha^2e^{-\alpha x}\left\{\sin(\beta-\alpha x)+\cos(\beta-\alpha x)+\cos(\beta-\alpha x)-\sin(\beta-\alpha x)\right\}$$

$$=2\,\mathrm{P}\alpha^2e^{-\alpha x}\cos(\beta-\alpha x).$$

Hence

$$\frac{dv}{dt}=\frac{n\pi}{\mathrm{T}}\cdot\frac{1}{\alpha^2}\cdot\frac{d^2v}{dx^2};\text{ but }\frac{1}{\alpha^2}=\frac{\mathrm{T}k}{n\pi c}.$$

Whence

$$\frac{dv}{dt}=\frac{k}{c}\cdot\frac{d^2v}{dx^2},$$ or the differential equation is satisfied.

It will be equally satisfied if, instead of a single term, we have a series of terms of the same form as that above assigned to v, and if we likewise prefix a constant A_0. Hence we have the general equation

$$v = A_0 + P_1 e^{-x\sqrt{\frac{\pi c}{\mathrm{T}k}}} \sin\left(2\pi\frac{t}{\mathrm{T}} + E_1 - x\sqrt{\frac{\pi c}{\mathrm{T}k}}\right) + P_2 e^{-x\sqrt{\frac{2\pi c}{\mathrm{T}k}}} \sin\left(4\pi\frac{t}{\mathrm{T}} E_2 - x\sqrt{\frac{2\pi c}{\mathrm{T}k}}\right) + \&c.$$

the general term being

$$P_n e^{-x\sqrt{\frac{n\pi}{\mathrm{T}k}}} \sin\left(2n\pi\frac{t}{\mathrm{T}} + E_n - x\sqrt{\frac{n\pi c}{\mathrm{T}k}}\right).$$

In this equation x denotes the distance below any assumed horizontal plane. Let the plane pass through the bulb of one of the thermometers; then the general term will become for this thermometer

$$P^n \sin\left(2n\pi\frac{t}{\mathrm{T}} + E^n\right);$$

while for a thermometer lower by x feet it is

$$P\, e^{-x\sqrt{\frac{n\pi}{\mathrm{T}k}}} \sin\left(2n\pi\frac{t}{\mathrm{T}} + E_n - x\sqrt{\frac{n\pi c}{\mathrm{T}k}}\right).$$

Hence it appears that in descending through x feet the amplitude P_n is diminished in the ratio of $e^{-x\sqrt{\frac{n\pi c}{\mathrm{T}k}}}$ to 1, while the quantity E_n is diminished by the amount $x\sqrt{\frac{n\pi c}{\mathrm{T}k}}$. Whence the equations

$$\frac{\Delta\,.\,\log_e P}{x} = \frac{\Delta\,E}{x} = \sqrt{\frac{n\pi c}{\mathrm{T}k}}.$$

XIX.—*On a Mode of Taking the Density of Vapour of Volatile Liquids, at Temperatures below the Boiling Point.* By Dr Lyon Playfair, C.B., F.R.S., and J. A. Wanklyn, F.R.S.E.

(Read 7th January 1861.)

The interest awakened by Gay-Lussac's great discovery of the simplicity in the relation of the volumes of gases has greatly increased in recent times, when chemists have discovered that, in a large number of instances at least, the formula of a body, as deduced physically from its vapour density, exactly coincides with that deducible from chemical considerations of its reactions, and from the nature of the products arising in consequence of them.

The processes at present used for determining the vapour densities of bodies, are those of Gay-Lussac and Dumas.

Although the operations by which both these processes are carried out are well known to chemists, it will save considerable repetition in description if we give a short account of them at the outset, and will enable the modifications in practice which we make of both processes to be more readily appreciated.

Gay-Lussac's process consists in measuring the volume of vapour produced by a known weight of liquid under circumstances which enable us to compare the former with an equal volume of air at normal temperatures and pressure. A graduated tube is filled with mercury, and inverted in a mercurial trough. A known weight of the volatile body is introduced into the tube, and the whole apparatus is transferred to a bath, which is heated 20° to 40° C. above the boiling point of the enclosed volatile liquid. By this arrangement, readings of the volume occupied by the vapour can conveniently be made, at different temperatures. The pressure to which the vapour is subject is obtained by adding the barometric pressure to that of the column of water or oil contained in the bath, and deducting from the sum of these pressures the pressure of the column of mercury contained in the graduated tube. Some minute but necessary corrections require to be applied; the barometric column, and that in the graduated tube, must be reduced to 0° C., and an allowance be made for the expansion of the graduated tube.

Dumas' method for taking vapour densities is the converse of Guy-Lussac's, and consists in determining the weight of a given volume of vapour at a known temperature and pressure.

It is practised as follows:—A flask with the neck contracted and drawn to a point is weighed in dry air, charged with a portion of volatile liquid, heated to a suitable temperature, so as to convert the liquid wholly into vapour; and then, after noting the barometer, is sealed with the blowpipe flame. On cooling, it is weighed, the temperature of the balance case and the barometric pressure being noted. The difference between the two weighings, added to the weight of the air displaced by the sealed flask, gives the weight of the vapour in the flask when it was sealed. The volume of the vapour at the time of sealing was equal to the capacity of the flask, its temperature was that of the bath, and the pressure to which it was subject was that indicated by the barometer. It only remains to ascertain the capacity of the flask, in order to compare equal volumes of air and of the vapour. For this purpose the flask is filled with water or mercury, and the capacity determined by weight or measurement of these liquids. The weight of the volume of air can now easily be determined by reference to tables constructed for this purpose. After applying the corrections previously described under GAY-LUSSAC's process, we can readily fix the vapour density of the liquid, as we have all the elements for the ratio of the weights of equal volumes of the air and vapour at the same temperature and pressure. Both the processes of GAY-LUSSAC and DUMAS require for their successful execution, that the vapour densities should be taken at 30° to 40° C. above the boiling point of the body operated upon. This restriction of their application at once excludes the numerous class of substances which will not bear this elevation of temperature without decomposition. Before we describe the methods which we employ to determine the vapour densities of liquids at temperatures below their boiling points, it is necessary to discuss the difficulties inherent in the processes already described, and which compel the operation to be performed at the highest practicable temperatures.

Vapours do not expand equally, for equal increments of heat at temperatures close to their point of condensation, and even at temperatures considerably elevated above this. A vapour only a few degrees above its temperature of condensation, has a tendency to condense on the surface of solids plunged into it, and on the sides of the vessel containing it. Even among the permanent gases, such as carbonic acid, protoxide of nitrogen, and sulphurous acid, there is a higher coefficient of expansion between 0° and 100° C. than there is for air, although at these temperatures, and at ordinary pressures, they are still several atmospheres removed from condensation (REGNAULT).* At the same time, be it observed, that these gases are among those of the permanent gases, which are most easily liquefied; and this fact has led to the belief, that vapours also have their coefficient of expansion abnormally high, as they approach temperatures at which they pass into the liquid state. In fact, it is a matter of common observation, that the vapour density of a body taken near the boiling point is frequently higher than it should be by theory.

* REGNAULT, Annales de Chim. et Phys. (1842), 3^{me} séries, v. p. 80.

The cause of the increased coefficient of expansion at temperatures approaching those of condensation appears to be, that the atoms of gases, under these conditions, approach each other too nearly, so as to come under the influence of cohesion.* If this cause be the true explanation, the tendency of the atoms of vapours to cohere at low temperatures may be combatted in two ways—either by diminishing the pressures to which they are subjected, or by separating the atoms by mixture with another gas of a more permanent character.

Various experiments on vapours have been made at diminished pressures. REGNAULT† has examined the vapour of water under these conditions, and BINEAU has determined the vapour densities of acetic and formic acids at pressures much below that of the barometric column. Indeed, GAY-LUSSAC's method of taking vapour densities is, to a certain extent, one of estimating them at diminished pressures, as there is generally a considerable column of mercury within the apparatus to be deducted from the column of mercury in the barometer. The practical objection to the correction of the error by diminishing the pressure is, that slight diminutions of it seem to exercise little effect in counteracting the effect due to the cohesion of the particles of gas on approaching to the condition of liquefaction, whilst the working at extremely low pressures is surrounded with great experimental difficulties.

The second remedy to which we have alluded, viz. the separation of the particles of the vapour by a considerable excess of a permanent gas, having in itself a normal coefficient of expansion, such as hydrogen or air, appeared to be one which promised good results, and has chiefly engaged our attention—especially so, because it offered a means by which both the difficulties to which we have alluded might be overcome—viz., the danger of incipient condensation on the surface of the containing vessels, and the danger of contraction by the action of cohesion when the particles of gas approach each other too closely. The first danger can be wholly avoided by always having an excess of gas, so that it does not become saturated with the vapour under examination. The second danger is also greatly reduced by the admixture of the gas; for we shall show, by experimental evidence, that, although the coefficient of expansion of a vapour taken under ordinary circumstances is higher than that of air, it undergoes an alteration when the vapour is mixed with hydrogen gas—this alteration making it, if not identical, at least approach closely to that of air and other non-condensible gases.

Before we proceed to describe the peculiar apparatus which we use in determining the vapour densities of bodies which are either decomposed at their boiling points, or which it may be desirable to examine at lower temperatures,

* The researches of REGNAULT (Annales de Chim. et Phys., v.), showing that at diminished pressure gases have very nearly the same expansion-coefficient, whilst at increased pressure considerable divergency is observable, lends experimental support to the hypothesis we have adopted.

† REGNAULT, Annales de Chim. et Phys., xv. p. 146. 3me série (1845).

with a view to questions of chemical constitution, it may be desirable to show that a vapour partially saturating a gas deposits itself like a gas, although the temperature is lower than that requisite for its condensation if alone and under ordinary barometric pressure.

The researches of REGNAULT on aqueous vapours, undertaken with a view to meteorological inquiries, have shown that the vapour of water at a temperature even so low as 0° C. behaves as if it were a true gas. Its ratio of expansion closely approximates to that of air; its vapour density, when mixed with air, is ·622, or the theoretical numbers. The evidence in this case is satisfactory, that aqueous vapour, held as such in air, follows the laws which regulate uncondensible gases; but the mode in which the results were obtained is quite special, and applicable only to water itself.* The tension of water at low temperatures having been determined, REGNAULT caused a measured volume of air, saturated with moisture at a known temperature, to pass through a weighed tube containing sulphuric acid. The increase in weight of the drying-tube gives the amount of aqueous vapour present; and as the quantity of moist air and the tension of water were known, the data were sufficient to calculate the volume of the aqueous vapour which occasioned the increment in weight.

By employing permanent gases to take up volatile liquids, we have examined whether other vapours comport themselves like gases, as aqueous vapour does. Our experiments embrace alcohol and ether: the former we have employed in a slightly moist state, and also absolutely anhydrous.

For this inquiry we have found a slight modification of GAY-LUSSAC's process to be most convenient. A carefully dried graduated tube is filled with warm mercury, and inverted in the mercurial trough. Next, dry hydrogen is introduced. The gas is then measured, adopting the precautions which are requisite in measurements for a gas analysis. The liquid to be operated upon, of which a weighed portion is contained in a small glass bulb, is subsequently passed up to the hydrogen contained in the graduated tube. The tube, with its contents, is then lifted out of the mercurial trough by means of a small iron cup, and transferred to the bath in which it is to be heated, and which contains some mercury, occupying about an inch of its interior. An adjustment of the graduated tube having been made, water is poured into the bath, and heat applied, until the boiling-point of the liquid under examination has been passed. After all the liquid contained in the bulb has evaporated, the bath is allowed to cool very slowly, being stirred up constantly, so as to keep its temperature uniform throughout. Before each observation, great care was taken to ensure uniformity of temperature.

The following minute corrections were made:—

1. A correction for meniscus equal to 0·3 cubic centimeter.

* REGNAULT, Ann. de Ch. et Phys., 3me séries, p. 158.

2. A correction for expansion of the glass tube, which amounts to from ·4 cubic centimeter to 0·1 cubic centimeter.

Both the barometric column and the mercurial column contained in the graduated tube were reduced to zero, according to tables given for that purpose in BUNSEN's "Geometry." The water column occupying the bath was measured in millimeters, corrected for temperature, and reduced to mercurial measure.

A. SERIES OF EXPERIMENTS WITH SLIGHTLY MOIST ALCOHOL.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cub. Cent. corrected at 0° C. and 760 m. m. Pressure.
Dry Hydrogen, ...	68·18	7° C.	600	52·482
Dry Hydrogen and Alcohol Vapour—Observation 1,	130·94	101°	732·9	92·189
Dry Hydrogen and Alcohol Vapour—Obs. 2, . .	126·04	84°	724·6	91·916
Dry Hydrogen and Alcohol Vapour—Obs. 3, . .	124·28	77·5°	720·9	91·840
Dry Hydrogen and Alcohol Vapour—Obs. 4, . .	122·68	70·5	717·9	92·117
Dry Hydrogen and Alcohol Vapour—Obs. 5, . . .	120·02	61°	712	91·922

The numbers contained in the last column are obtained from those in the other columns, by applying MARRIOTTE's law, and using the coefficient ·00366 for the expansion of 1° C. Inspection will show that the pressures are nearly alike in the five observations made of hydrogen, mixed with alcohol vapour, whilst the temperatures vary 40° C.

Since the numbers in the last column are almost identical, it follows that the coefficient of expansion adopted in their calculation is correct.

The alcohol in this instance was supposed to have been dry, but subsequent examination showed that a small quantity of water had escaped the action of the dehydrating agents. The vapour density of this moist alcohol may be found by the following calculation. We will take Observation 1:—

	Cubic cent.
Vol. of hydrogen + alcohol vapour	= 92·189
Vol. of hydrogen	= 52·482
	39·707

The weight of the alcohol which was introduced was ·0775 grm.
Therefore, 39·707 cub. cent. of alcohol vapour weigh ·0775 grm.
39·707 cubic cent. of air weigh ·05137 grm.

$\frac{\cdot 0775}{\cdot 05137} = 1\cdot 508$, the vapour density of the moist alcohol.

If the other observations be calculated, the numbers will be found to differ very little from that obtained from the first; indeed Observation 3d, which departs furthest from Observation 1st, gives for the vapour density the quantity 1·522.

The same sample of moist alcohol was made the subject of an experiment, in which its vapour density was determined in the usual way, without the employment of a permanent gas:—

Weight of Alcohol taken = ·0792 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cubic Cent. corrected at 0° C. and 760 m. m.
Observation 1, ...	63·48	95°	636·8	39·468
Observation 2, ...	61·35	83°	631·5	39·10

From which is deduced:—

Temperature.	Vapour density.
95°	1·551
83°	1·565

In the first described experiment, where hydrogen was present, we found the vapour density of the alcohol to lie between 1·508 and 1·522. It would appear, therefore, that the presence of hydrogen lowers the vapour density of alcohol vapour; the lowering cannot be due to difference of pressure, for in the experiment where the higher vapour density was obtained, the pressure was about 630 millimeters, whilst in the other experiment it was about 730.

B. Experiments with perfectly Anhydrous Alcohol.

Weight of the Alcohol taken = ·0889 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cubic Cent. corrected at 0° C. and 760 Millimeters.
Vol. of Dry Hydrogen, . .	43·16	7°	572·07	31·676
Hydrogen and Alcohol Vapour—Observation 1, . .	110·84	99°	710·6	76·073
Hydrogen and Alcohol Vapour—Obs. 2, ...	107·16	83·5°	699·7	75·565
Hydrogen and Alcohol Vapour—Obs. 3, ...	102·74	68°	695·1	75·238

A correction of 0·4 cub. cent. for air contained in the alcohol bulb has to be made. This quantity must be subtracted from the volume of alcohol vapour.

The vapour densities, as deduced from the three observations, are as follows:—

	Vapour Density.
Observation 1 at 99° . .	1·562
„ 2 at 83·5° . .	1·580
„ 3 at 68° . .	1·592

The same sample of anhydrous alcohol gave without hydrogen :—

Weight of the Alcohol taken = ·0991.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cubic Cent. corrected at 0° C. and 760 Millimeters.
Vol. of Alcohol Vapour—Observation 1, . .	75·42	100·5°	661·9	48·024
Vol. of Alcohol Vapour—Obs. 2, . . .	72·80	86·5°	658·8	47·931

Correction for air contained in the bulb = 0·1 c.c.

	Vapour Density.
Observation 1 at 100·5° . .	1·599
„ 2 at 86·5° . .	1·602

Here, again, we notice the same peculiarity as in the former experiments with the specimens of moist alcohol, viz., the vapour densities taken with hydrogen are rather lower than those taken without it. We shall recur to this circumstance afterwards.

The theoretical vapour density of alcohol calculated from the sp. gr. of hydrogen is $\frac{46}{2} \times \cdot 0691 = 1\cdot 5893$, a number which agrees with our experiment.

In several elementary works on organic chemistry, in Regnault's "Manual" for example, the following vapour densities for alcohol at different temperatures are given :—

Temperature.	Vapour Density.
88° C.	1·725
98°	1·649
110°	1·610
125°	1·603
150°	1·604
175°	1·607
200°	1·602

Our observation does not confirm the decrease of ·08 in density between 88° C. and 98° C. Between 86·5° and 100·5°, we have an decrease of ·003 only.

C. EXPERIMENTS WITH ETHER WHICH HAD BEEN PURIFIED AND DRIED WITH GREAT CARE.

Weight of Ether taken = ·0808 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cubic Cent. corrected at 0° C. and 760 Millimeters.
Vol. of Dry Hydrogen, . .	55·09	6·5°	557·4	39·465
Hydrogen and Ether Vapour—Obs. 1, ...	94·0	69·5°	653·8	64·466
Hydrogen and Ether Vapour—Obs. 2, ...	82·97	20·8°	631·8	64·094

	Temperature.	Vapour Density.
Observation 1 at .	69·5° . .	2·499
„ 2 at .	20·8° . .	2·539

Experiment without Hydrogen.

Weight of Ether taken = ·1702 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cubic Cent. corrected at 0° C. and 760 Millimeters.
Ether Vapour—Obs. 1, . .	80·49	94°	659·7	51·985
Ether Vapour—Obs. 2, . .	72·38	52°	640·3	51·232

A correction of 0·2 c.c. has to be made for air in the bulb.

	Temperature.	Vapour Density.
Observation 1 at .	94° C. . .	2·541
„ 2 at .	52° C. . .	2·580

The theoretical vapour density of ether is $\frac{74}{2} \times \cdot0691 = 2\cdot5567$.

From these experiments we see that the vapours of alcohol and ether do not depart widely from the true gaseous character. When mixed with hydrogen, they preserve their specific gravity at temperatures much below the boiling points of their liquids.

The specific gravity of a gas is the quotient obtained by dividing the weight of a given volume of gas by that of the same volume of air under similar conditions of pressure and temperature. If the gas in question behave exactly like air when exposed to varying pressures and temperatures, the specific gravity of the gas must be invariable. If, on the other hand, the gas should not follow MARRIOTTE's law, or have an expansion coefficient different from that of air, the specific gravity of the gas would be a varying quantity.

The foregoing considerations will render intelligible the following inference drawn from our experiments on alcohol and ether. We have shown that the specific gravity of either of these vapours is lower when taken in presence of hydrogen than when taken alone. The circumstances, moreover, under which we have taken the specific gravities in mixture with hydrogen, are just those which are admitted to raise the specific gravities of gases. They are lower temperatures than the temperatures of the observations with which we make comparisons, and (in two of the experiments) slightly higher pressures.

It follows, therefore, that hydrogen hinders the contraction of alcohol and ether vapours; in other words, it diminishes the expansion-coefficient of these vapours.

The differences observable between the two sets of specific gravities are small, but they are constant—just, in fact, what might be expected.

Before leaving this division of the subject it may be useful to state the general behaviour of gases, as presented to us in our researches. We are led to the conclusion, that at very high temperatures all vapours and gases expand nearly, if not quite uniformly; but at lower temperatures, that there are differences in the rate of expansion of different vapours. The admixture with permanent gases, and more especially with hydrogen, effects a slight alteration in the expansion-coefficient of the vapour, rendering the vapour more truly gaseous.

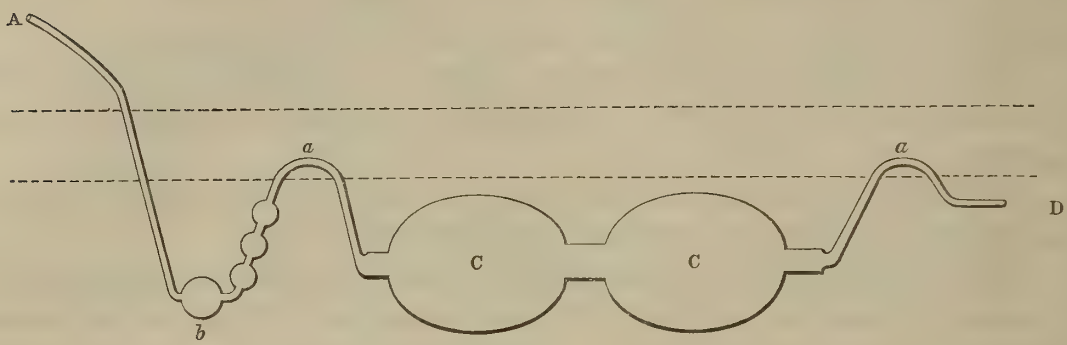
To pursue this division of the enquiry, and to estimate these small differences, will require a more delicate apparatus than the one we have been employing. We pass on to what in fact is the more immediate subject of the paper—viz., how to render available for research our knowledge that vapours may be made into gases, at whatever temperature they are evolved.

The method of research which we have hitherto described, involves the heating of the liquid to be examined above its boiling point; this is requisite in order to ensure its total conversion into vapour.

By the plan about to be described, the vapour is never heated higher than the temperature at which its density is to be taken. The principle is that of Dumas' method—viz., the weighing of a given volume of vapour; the mode of carrying it out is, however, so different, that a minute description of the apparatus will be necessary.

Those who have occupied themselves with Dumas' mode of taking vapour densities, will be well aware, that one of the difficulties of using it for temperatures near the boiling point of a liquid, is due to the circumstance that it is impossible to know when all the liquid has assumed the state of vapour.

Our modification of the method consists in placing the liquid to be vaporised outside of that part of the apparatus which, when hermetically sealed, will contain the vapour mixed with gas. The apparatus consists of a pair of large bulbs, connected together by means of a neck, and terminating on either side in narrow glass tubes, which are bent and blown into small bulbs, as represented in the drawing. The bulbs C and C are large, and together capable of holding from 200 to 400 cubic centimeters. The bulbs *b* are very small, being mere dilatations of the narrow tube. They are to contain the liquid to be examined. The bends *a*



and *a* should be on the same level, and thin, so as to admit of fusion by the lamp. Altogether, the apparatus should not weigh more than 65 grm. The following mode is employed in making an experiment with the apparatus.

After being cleaned and filled with the dry air of the balance-case, the bulb-apparatus is weighed, and then transferred to the bath, being grasped by a retort-holder, which takes hold of the neck connecting the large bulbs C and C. The end A is then jointed to a hydrogen-apparatus by means of a small caoutchouc tube; the other extremity D, which projects out of the bath through an orifice in the side of that vessel, is likewise connected by means of a caoutchouc tube, with a long narrow glass tube pointing downwards, and designed to prevent diffusion. Dry hydrogen gas is then passed through the apparatus to repletion. Whilst this is going on, warm water is poured into the bath—the hole in its side through which the extremity D passes being stopped up with putty, which makes a very convenient water-tight stopping. The addition of water is continued, until the bends *a a* are totally submerged. When the apparatus is full of hydrogen, the connection at A is interrupted, and the liquid, of which a vapour-density determination is made, introduced at A.

On re-establishing the communication with the hydrogen-apparatus, a stream of dry hydrogen passes through the dilatation *b*, and becoming more or less saturated with vapour, enters the great bulbs C and C.

No more liquid is placed in *b* than is sufficient to fill that bulb half-full; the three supplementary dilatations near *b* acting as safety-bulbs, to avoid the effects of splashing.

The temperature of the bath is raised very slowly, the water being constantly stirred, so as to ensure uniformity of temperature. When the temperature is three or four degrees below the point at which a vapour-density determination is required, the current of hydrogen is nearly stopped.

The object of this is to avoid complete saturation of the gas with vapour. By this device, the greater part of the gas which is present in C and C, at the end of the operation, has entered at a lower temperature than that at which the apparatus is sealed, and, consequently, is only partially saturated atthe moment of sealing the apparatus.

The desired temperature having been attained, sufficient water to expose the bends *a a*, but not the large bulbs C C, is suddenly let out of the bath, by opening a large tap situated close to the bottom of the bath. The current of hydrogen having been entirely stopped, the flame is applied to *a* and *a*, until the apparatus is sealed up in both places. The temperature of the bath having been again noted, and also the height of the barometer, the bulbs C and C which contain the vapour and hydrogen, are removed from the bath, carefully cleaned, and subsequently, along with the other two fragments (viz. the portion A to *a* and the portion *a* to D, also carefully cleaned), transferred to the balance-case and weighed.

The difference between this latter weighing and that at the beginning of the operation gives, when the weight of the displaced air is added to it, the weight of C C filled with a mixture of hydrogen and vapour at the barometric pressure and temperature of the bath at the time of sealing.

The remainder of the operation having for its object to find how much hydrogen is enclosed in C C, and also the capacity of C C, is conducted thus :—The hermetically sealed C C is placed in cold water, and one of its sealed extremities nipped off whilst still under water, which enters and occupies the space not filled by hydrogen. After remaining in water for a number of hours, until the vapour has been completely absorbed, the apparatus is lifted vertically out of the water, care being taken not to heat the hydrogen contained in the bulbs, for which purpose a holder is employed. The temperature of the water, also the height of the barometer, is observed.

The apparatus, together with the water which has thus entered, is then weighed. It is afterwards completely filled with water, and again weighed.

The difference between the weight of the bulbs empty, and the weight of them filled with water, gives the total capacity of the apparatus.

The difference between the weight after the first portion of water has entered, and the weight of the apparatus quite full of water, gives the volume of the hydrogen at temperature of the water and at the barometric pressure, minus the column of water contained in the bulbs when they are held over the water out of which they had been lifted. This column is measured after the first weighing of bulbs and water had been made.

Such is the process which we employ to take vapour densities of bodies incapable of being heated to their boiling points without decomposition.

Exception may perhaps be taken to the mode of measuring the hydrogen included on sealing the bulbs. We will answer some objections which might naturally be raised.

It might be feared that the vapour would not be perfectly absorbed by water; but when it is considered how much water there is, and how little vapour has to be acted upon by it, it will be evident, that only in those instances where the vapour is nearly insoluble in water, will there be any chance of appreciably incomplete absorption. Only in those instances where the substance is at once insoluble in water and possesses a high tension at ordinary temperatures, could error arising from this source become serious.

With regard to the absorption of hydrogen by water, it may be remarked, that since between 8° and 11° C. the absorption-coefficents of hydrogen and common air, as determined by Bunsen, are nearly identical, the measurement of hydrogen over water is so far unobjectionable.

As an example of the method, we subjoin the particulars of a vapour-density determination of absolute alcohol, made at 30° C. below its boiling point:—

Barometer (corrected to 0° C.) = 763·094 m. m.
Temperature of the balance-case, 7·5° C.
Weight of apparatus in dry air, = 69·959 grm.
Temperature at the time of sealing, 48° C.
Weight of the apparatus + H + vapour = 69·5275.

Weight of apparatus + water (at 5·2° C.) = 191·76 grm.
water column, 122 m.m.
Weight of apparatus filled with water = 545·36 grm.

Volumes corrected at 0° C. and 760 m.m. pressure, Cubic centimetres.			grm.
Hydrogen + vapour,	406·43	weighing	0·1695
Hydrogen,	341·27	„	0·0306
	65·16		0·1389

Therefore, 65·16 cub. c. of alcohol vapour weigh ·1389 grm.
But 65·16 cub. c. of air weigh ·0843 grm.

$$\text{Vapour density of alcohol} = \frac{\cdot 1389}{\cdot 0843} = 1\cdot 648.$$

In all quantitative operations there are two kinds or orders of inaccuracy. The one is relative, bearing a tolerably constant proportion to the quantities operated upon: thus, for instance, in a precipitation, the precipitate is liable to retain a certain very small proportion of the soluble matter. The error in percentage on an analysis in such a case would be neither increased nor diminished by varying the quantities of substance taken for the analysis—always supposing, of course, that the washing of the precipitate were continued as far as possible.

The other error is absolute, not bearing any relation to the quantity of substance operated upon. It may be illustrated by the error in weighing. Suppose the balance used in an analysis of a mineral were incapable of indicating differences of less than a grain: when 100 grains were taken for analysis, the error of weighing would amount to 1 per cent. If, however, the quantity employed were diminished to two grains, the error would rise to 50 per cent.

It is manifest that the test for absolute error in a process is extreme diminution of the quantities taken for experiment.

Some of the absolute errors which might be expected to exist in the process which has been described, are the following:—Loss or gain in the weight of the glass on sealing the bulbs. Variation in the state of cleanliness or hygrometric condition of the surface of the bulbs. This must be reckoned absolute, inasmuch as the capacity of a vessel increases far more rapidly than its sides.

Two determinations of the vapour-density of water have been made upon very small quantities. As will be evident on inspection, they have given results as nearly approximating to the truth as the balance will admit. If the method were affected by any considerable absolute errors, outrageous results ought to be obtained in these extreme cases.

I.

Barometer, 749·0 m. m.
Temperature of balance-case, 7·5° C.
Weight of tube in dry air = 93·8168 grm.
Temperature at sealing, 73° C.
Weight of tube + H + vapour = 93·6690 grm.

Tube + water (at 8·5° C.) = 121·66 grm.
Tube filled with water = 223·58 grm.
Water column, 100 m. m.

∴ Vapour-density of water = 0·671.

II.

Barometer, 749° m. m.
Temperature of balance-case, 7·5° C.
Weight of tube in dry air = 89·2922 grm.
Temperature at sealing = 91·9° C.
Weight of tube + H + vapour = 89·1805 grm.

Tube + water (at 6·2° C.) = 117·72 grm.
Tube filled with water = 188·35 grm.
Water column = 103 m. m.
Barometer, 750·8.

∴ Vapour-density of water = 0·654.

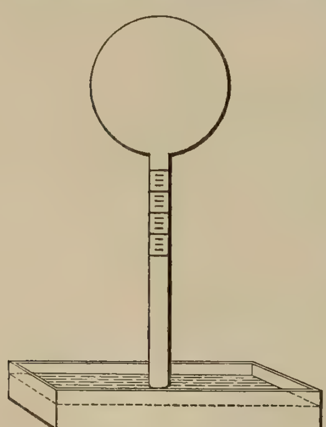
Theoretical density of water, $\frac{18}{2} \times \cdot 0691 = 0 \cdot 6219$.

In neither of these determinations did the weight of aqueous vapour reach 10 milligrammes.

Hitherto substances supposed to be normal in regard to their vapour-densities have been examined. We next proceed to examine an abnormal case of considerable interest. Acetic acid, as is well known, is very irregular in its vapour-density. CAHOURS, who has made many experiments upon it, gives its vapour density at different temperatures as follows :—

At 125° C. ...	3·180	At 200° C. ...	2·248
130° ...	3·105	220° ...	2·132
140° ...	2·907	240° ...	2·090
150° ...	2·727	270° ...	2·088
160° ...	2·604	310° ...	2·085
170° ...	2·480	320° ...	2·083
180° ...	2·438	336° ...	2·083
190° ...	2·378		

Chemists seem to be divided as to the true explanation of this irregularity, some referring it to abnormal physical properties inherent in acetic acid vapour; others, on the other hand, to a change in composition taking place during alteration of temperature. Some experiments of BINEAU'S, to which we have previously referred, are decidedly in favour of the latter view. At ordinary temperatures, and at extremely reduced pressures, BINEAU finds for the vapour-density of acetic acid a number nearly approaching 4·00. It would seem from their being so rarely quoted that these results of BINEAU'S have not met with the credit which they deserve; and, indeed, the method employed is not altogether free from objection. BINEAU made an imperfect barometer containing a chamber nearly void of air, and about 5 litres in capacity. He observed the temperature and the height of the column of mercury, comparing the latter with the height of a perfect barometer. A small weighed quantity of acetic acid, contained in a little bulb open at one end, was then introduced, a contrivance being used to prevent egress of the acid before the summit of the mercury was reached. As the capacity of the 5-litre dilatation was almost infinite compared with the capacity of a few millimetres length of the tube, it is evident that the volume of vapour could be directly measured by the depression caused in the column.* One of the causes of uncertainty in these experiments is the great accuracy with which the readings of the mercurial column must be made, in order to attain to even rough approximate values of the vapour-density. This will be at once understood when we quote from BINEAU'S memoir :—



* BINEAU, Ann. de Ch. et Phys., 3me série, xviii. p. 236.

Mercurial column. Millimeters.				Vapour-densities inferred therefrom.
2·34	.	.	.	3·80
2·43	.	.	.	3·66
2·50	.	.	.	3·56

Another cause of uncertainty is the doubt whether the acetic acid was completely volatilised. BINEAU says that he applied external heat until all the liquid acetic acid had disappeared; but any one who has seen GAY-LUSSAC's method practised will know that a small bulb containing a liquid, and open at one end, will often contain liquid when the whole apparatus has been heated during several minutes above the boiling point of the liquid.

These reasons have perhaps hindered the reception of BINEAU's results.

The acetic acid used in the following experiments had been purified and rendered free from water by repeated freezings. The portion taken for the first experiment had also been analysed.

The modification of GAY-LUSSAC's operation already described was employed in the following estimations, paraffine being used instead of water as the bath. A correction for the tension of mercurial vapour, according to AVOGADRO's table, is introduced for the high temperatures.

Weight of Acetic Acid = ·0690 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cub. Cent. corrected at 0° C. and 760 m. m.
Hydrogen, ...	68·05	10·4°	585·0	50·460
Hydrogen and Acetic Acid Vapour—Observation 1,	138·0	186°	721·4	77·[illegible]0
Hydrogen and Acetic Acid Vapour—Obs. 2, . . .	130·5	163°	715·0	76·897
Hydrogen and Acetic Acid Vapour—Obs. 3, . . .	120·7	132°	698·7	74·819
Hydrogen and Acetic Acid Vapour—Obs. 4, . . .	115·16	116·5°	686·3	72·909

Temperature.				Vapour Density.
At 186°	.	.	.	1·936
163°	.	.	.	2·017
132°	.	.	.	2·292
116·5°	.	.	.	2·371

The ratio of the volume of hydrogen taken to that of the acetic acid vapour was about 2 : 1, as inspection of the corrected volumes will show.

It will be apparent that these numbers are quite different from those obtained by CAHOURS.

At 130° CAHOURS obtains a specific gravity of 3·105, whilst at 132° C. we find the number 2·292.

It would seem, therefore, that mere admixture of acetic acid vapour with hydrogen is sufficient to alter the vapour-density belonging to it.

A second experiment appears to indicate that this alteration is dependent upon the proportion of diluent gas employed.

Acetic acid taken = ·0820 grm.

	Observed volume in Cubic Centimeters.	Temperature C.	Pressure in Millimeters.	Vol. in Cub. Cent. corrected at 0° C. and 760 m. m.
Hydrogen, ...	51·5	12·5°	546	35·38
Hydrogen and Vapour—Observation 1, ...	128·92	212·5°	693·5	66·176
Hydrogen and Vapour—Observation 2, ...	123·04	194°	699·7	66·243
Hydrogen and Vapour—Observation 3, ...	119·1	182°	695·5	65·418
Hydrogen and Vapour—Observation 4, ...	114·14	166·5°	668·6	62·393
Hydrogen and Vapour—Observation 5, ...	102·66	130·5°	672·7	61·496
Hydrogen and Vapour—Observation 6, ...	98·21	119°	662·0	59·594

Temperature.	Vapour Density.
212·5° . . .	2·060
194° . . .	2·055
182° . . .	2·108
166·5° . . .	2·350
130·5° . . .	2·426
119° . . .	2·623

In this series of observations the ratio of the hydrogen to the vapour was rather less than one of hydrogen to one of vapour.

From these results it is manifest that the specific gravity of acetic vapour can be altered by mixing it with different proportions of hydrogen. This fact, if it stood alone, would indicate that acetic acid is physically abnormal. If, however, the phenomenon were purely physical and not chemical, we should expect to find that dilution with a gas would alter the specific gravity at all temperatures. Further research has brought out that at low temperatures the specific gravity of acetic acid vapour is invariable, or only slightly variable,—a fact which points towards chemical change.

Determination made by the other method gave:—

I.

At 95·5°.

	Corrected vols. at 0° C. and 760 m. m. Cubic Cent.		Grm.
Air + Vapour,	217·68	weighing	·3547
Air,	182·21	„	·2357
	35·47	„	·1190

Vapour density = 2·594.
Ratio of vol. of air to vapour, about 5 : 1.

II.

At 86·5° C.

	Corrected vols. at 0° C. and 760 m. m. Cubic Cent.		Grm.
Hydrogen + Acetic acid,	228·12	weighing	·2618
Hydrogen,	167·95	„	·0150
	60·17	„	·2468

Vapour density = 3·172.
Ratio of vol. of hydrogen to vapour, $2\frac{1}{2}$: 1.

III.

At 79·9° C.

	Corrected vols. at 0° C. and 760 m. m. Cubic Cent.		Grm.
Hydrogen + Acetic acid,	147·07	weighing	·0815
Hydrogen,	130·94	„	·0117
	16·13	„	·0698

∴ Vapour density = 3·340.
Ratio of vol. of hydrogen to vapour, about 8 : 1.

IV.

At 62·5° C.

	Corrected vols. at 0° C. and 760 m. m. Cubic Cent.		Grm.
Hydrogen + Acetic vapour,	237·60	weighing	·0938
Hydrogen,	223·15	„	·0200
	14·45	„	·0738

Vapour density = 3·95.
Ratio of vol. of hydrogen to vapour, about 16 : 1.

	Temperature.	Vol. of H divided by vol. of vapour.	Vapour density.
I.	95·5°	5	2·594
II.	86·5°	$2\frac{1}{2}$	3·172
III.	79·9°	8	3·340
IV.	62·5°	16	3·950

Thus it appears that great dilution with hydrogen does not hinder the specific gravity from attaining to nearly 4·1 at low temperatures.

Acetic acid vapour at low temperatures is chemically different from acetic acid vapour at high temperatures. Two modes of representing the change at once suggest themselves—viz.,

$$1. \quad \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2} + \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2} = \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H_2\end{matrix}\right\}O_4}$$

$$2. \quad \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2} + \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2} + \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\H\end{matrix}\right\}O_2}$$

$$= \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3O_2\\C_4H_3O_2\end{matrix}\right\}O_2} + \overset{\text{2 vols.}}{\left.\begin{matrix}C_4H_3\\H_3\end{matrix}\right\}O_6}$$

The former equation is more in accordance with our results than the latter, requiring that acetic acid having (at high temperatures) a vapour density of 2·073, should double on cooling, so as to have a vapour density of 4·146. The second equation requires a change of 6 vols. into 4, or an increase of vapour density to 3·112—a number which is considerably exceeded in our experiments.

Further experiments are needed to decide between these different modes of representation. At a future opportunity we hope to have the honour of laying before the Society the results of a further enquiry, embracing different members of the Acetic Acid series. In particular, the results of a diffusion-analysis applied to these vapours, as it has been already by BUNSEN and FRANKLAND, to certain permanent gases, promise to throw much light upon the subject.

The following supplement contains some examples of vapour densities taken upon bodies which, from their proneness to decomposition, have not hitherto been attempted.

Supplement containing instances of the employment of the foregoing methods.

(Read 29th April 1861.)

Nitrate of Ethyl.

Among the nitrates, the nitrate of methyl alone has been made the subject of a vapour-density determination. Bodies of this kind become explosive on being raised only a few degrees above their boiling points, and hence are difficult to treat by the usual methods.

We have deemed it interesting to estimate the vapour-density of nitrate of ethyl.

The nitrate of ethyl used in our experiments had been prepared by the action of nitric acid upon alcohol, according to the directions of the hand-books, urea being added to destroy any peroxide of nitrogen. The ether was washed, dried by standing in contact with carbonate of potash, and afterwards distilled in the water-bath.

·1869 grm., on ignition with oxide of copper and copper turnings, gave ·1754 grm. of carbonic acid and ·0975 grm. of water.

No solid potash was employed in conjunction with the potash bulbs, wherefore the slight deficiency in the carbonic acid may be fairly ascribed to the passage of nitrogen gas.

Here are the results of the combustion compared with the formula of nitrate of ethyl, $\left.\begin{matrix}C_4H\\NO_4\end{matrix}\right\}O_2$ requires:—

	Calculated.		Found.
Carbon, . .	24	26·37	25·60
Hydrogen, . .	5	5·50	5·80
Nitrogen, . .	14	15·38	
Oxygen, . .	48	52·75	
	91	100·00	

The vapour-density determination was made by the modification of Gay-Lussac's method. The gas employed as the diluent was dry nitrogen.

·0786 grm. = amount of substance taken.

	Observed vol. in Cubic Cent.	Temperature C.	Pressure in Millimeters.	Corrected Vol. in Cubic Cent. reduced to 0° C. and 760 m. m.
Vol. of Nitrogen . .	45·28	12·9°	575·8	32·758
Vol. of Nitrogen + Vapour —Obs. 1, . . .	79·31	85·5°	660·3	52·484
The same—Obs. 2, .	80·30	90°	661·8	52·598
The same—Obs. 3, .	76·84	70·3°	656·4	52·784
The same—Obs. 4, .	75·67	64 9°	654·9	52·692

0·2 cub. cent. to be subtracted from the corrected volume at 0° C., and 760 m. m., being the correction for air introduced in the bulb containing the nitrate of ethyl.

		C.	Vapour Densities.
Obs. 1	at	85·5° . . .	3·112
„ 2	„	90° . . .	3·094
„ 3	„	70·3° . . .	3·065
„ 4	„	64·9° . . .	3·079

$\left.\begin{matrix}C_4H_5\\NO_4\end{matrix}\right\}O_2$ requires $\frac{91}{2}\times{}\cdot0691=3\cdot144$, which is sufficiently near the experimental density.

Nitric Acid.

It can hardly be said that the state of condensation of the acids has been determined by direct experiment. Most of the acids are too little volatile, or suffer decomposition at too low temperatures, to admit of such experiments. And those acids whose vapour-densities have been actually observed are seldom in perfect accordance with theory. The vapour-density of sulphuric acid, for example, is abnormal: and though we are far from demurring to the explanation that that acid suffers decomposition into anhydride and water, it must be allowed that direct experiment has not yet established the molecular weight indicated by the formula $\left.\begin{matrix} S_2O_4 \\ H_2 \end{matrix}\right\} O_4$.

Again, the series of fatty acids, although normal at high temperatures, are abnormal at low temperatures: indeed, it is difficult to find an example of an acid which does not offer some anomaly of the kind.

We have selected nitric acid for experiment. As will be apparent by-and-by, this acid is regular, having for its molecular weight the number answering to the formula $\left.\begin{matrix} N\,O_4 \\ H \end{matrix}\right\} O_2$.

The acid employed was distilled from sulphuric acid, then from dried sulphate of copper, and, lastly, warmed in a stream of dry carbonic acid, so long as its colour became less yellow. The final product was found to be quite free from sulphates and chlorides. Its strength, as indicated by alkalimetry, was satisfactory. Its colour was a very pale yellow, which the transmission of carbonic acid was incapable of rendering fainter.

From our observation, we are inclined to believe that the last yellow tinge cannot be removed from monohydrated nitric acid by warming for any length of time in a current of perfectly dry gas; but the presence of a minute trace of moisture in the transmitted gas at once decolorises the acid. The success of the employment of urea as a means of depriving nitric acid of colour, depends partly on the production of water. We need hardly remark that we avoided the use of urea. We believe, moreover, that the quantity of peroxide of nitrogen requisite to give the yellow tinge is imponderable.

As nitric acid attacks mercury, GAY-LUSSAC's process is quite inapplicable to it; and since nitric acid undergoes some decomposition on boiling, DUMAS' process would not answer without some modification.

The following determinations have been made by the method previously described. The gas used to dilute the nitric acid vapour was dried air.

I.

Determination of Vapour-density of Nitric Acid at 68·5° *C.*

	Cubic Centimeters at 0° C. and 760 m. m.		Grm.
Vol. of Air + Vapour =	394·60	weighing	·7255
,, Air =	262·48	,,	·3395
	132·12		·3860

Hence 132·12 cub. cent. of nitric acid vapour weighs ·3860 grm. Vapour-density = 2·258. In the above experiment the bulbs, when sealed up, were perfectly colourless.

II.

Determination of Vapour-density of Nitric Acid at 40·5° *C.*

	Cubic Centimeters at 0° C. and 760 m. m.		Grm.
Vol. of Air + Vapour,	317·62	weighing	·4664
,, Air, . .	286·38	,,	·3705
	31·24		·0959

Hence 31·24 C. C. of nitric acid vapour weigh ·0959 grm. Vapour density = 2·373. In this instance the bulbs were very faintly tinged with peroxide of nitrogen. Possibly this may be the real reason why in this case the number is a little higher than in the former experiment.

C.	Vapour Densities.
Obs. 1 at 68·5°	2·258
,, 2 ,, 40·5	2·373

The formula $\left.\begin{matrix} NO_4 \\ H \end{matrix}\right\} O_2$ requires $\frac{63}{2} \times \cdot 0691 = 2\cdot 1766$.

It thus appears that nitric acid vapour is pretty nearly normal, even at many degrees below the boiling point, under ordinary atmospheric pressures.

Here the remark may be made, that one of the sources of uncertainty belonging to Dumas' method is avoided.

Several grammes of substance are generally taken for a Dumas' vapour-density determination. Fractional distillation takes place in course of the operation, so that unless the substance be of extreme purity, the specific gravity obtained is liable to depart widely from the mean specific gravity of the sample.

The method which we have described completely avoids this. Only a small quantity of substance is necessary, and even that need not be completely evaporated, since the portion of the apparatus containing the substance is afterwards separated from the portion filled with gas and the vapour.

Peroxide of Nitrogen, N O_4.

Peroxide of nitrogen offers one of the examples of physical and chemical properties in opposition. Whereas NO_4 represents Cl. (one equivalent of NO_4, replacing just as much as one equivalent of Cl), NO_4 is physically equivalent to Cl_2. The wonderful deepening in colour which peroxide of nitrogen undergoes on being heated, led us to suspect that molecular change might also occur. This expectation has been fully realised. We deduce from our experiments that peroxide of nitrogen exists in two states; that there are two bodies having the same percentage composition as peroxide of nitrogen, but which are polymeric.

The body existing at high temperatures requires the formula NO_4, that existing at low temperatures requires the formula N_2O_8.

The peroxide of nitrogen used in this research was prepared partly by distilling nitrate of lead, and partly by distilling a mixture of nitrate of lead with chloro-chromate of potash. The products from several operations were purified together, and placed in a single hermetically sealed tube.

·2166 grm. of the liquid, weighed in a hermetically sealed and thin glass bulb, was enclosed along with a little water and some pure carbonate of baryta in a glass tube of 40 or 50 C. C. capacity, and containing oxygen instead of air. On shaking up, the enclosed bulb was broken. The apparatus was heated for some time in the water-bath and opened; the liquid boiled to drive off carbonic acid, and the amount of baryta which had dissolved was carefully estimated as sulphate of baryta. ·5498 grm. of BaO, SO_3 were obtained, or 149·26 per cent. of Barium.

By calculation, 100 parts of NO_4 should require 148·91 of Barium.

Therefore, the sample of peroxide of nitrogen was pure.

Before proceeding to take the specific gravity of peroxide of nitrogen at different temperatures by the methods under consideration, it was requisite to settle certain points relating to the reactions of the body.

In a preliminary determination of specific gravity, made by DUMAS' method, some months before the chief investigation, it was found that peroxide of nitrogen was completely absorbed by water, without any evolution of NO_2, at any rate at ordinary temperatures. In that experiment the Dumas flask filled completely with water, when opened under water at the end of the determination; and after several days even, no appreciable amount of gas had made its appearance in the flask.

At first we employed air as the diluent gas in these vapour-density determinations, but were subsequently compelled to have recourse to nitrogen; for direct experiment showed that, when a measured volume of air is sealed up with water and peroxide of nitrogen, absorption of oxygen takes place, the ultimate volume measuring much less than the initial volume of air. Notwithstanding this source of error, which would tend to make the peroxide of nitrogen seem lighter than it really was, the specific gravity of that body at 8·5° C. was obtained as high as 2·46.

The following determinations of the vapour-density of peroxide of nitrogen were made using nitrogen gas as the diluent. The gas had been prepared by burning phosphorus in air, collected in a gasholder, and finally passed through a strong solution of pyrogallate of potash, and dried with sulphuric acid:—

I.

Vapour-density determination at 97·5° *C.*

	Cubic Cent. at 0° C. and 760 m. m.		Grm.
Vol. of $N+NO_4$	263·97	weighing	·4473
„ N .	159·47	„	·2063
	104·50		·2410

Therefore 104·50 C. C. of NO_4 weigh ·2410 grm. Vapour density = 1·783. Dilute solution of potash (sp. gr. 1·0043) was used to absorb the peroxide of nitrogen. The residual nitrogen was then calculated as being quite saturated with moisture, for potash of so low a specific gravity would not sensibly differ from pure water in point of tension.

In this and the following experiments it was carefully ascertained that the residual nitrogen was quite colourless: also, on making repeated experiments, no coloration could ever be seen on admitting air to the residual gas.

II.

Vapour-density determination at 24·5° *C.*

	Cubic Cent. at 0° C. and 760 m. m.		Grm.
Vol. of $N+NO_4$	425·29	weighing	·8963
„ N .	244·39	„	·3070
	180·90		·5893

Therefore 180·90 C. C. of NO_4 weigh ·5893 grm. Vapour-density = 2·52.

The absorption of NO_4 was made by means of water.

III.

Vapour-density determination at 11·3° *C.*

	Cubic Cent. at 0° C. and 760 m. m.		Grm.
Vol. of $N+NO_4$	442·05	weighing	·7556
„ N .	349·4	„	·4390
	92·65		·3166

Therefore 92·65 cub. cent. of NO_4 weigh ·3166 grm. Vapour density = 2·645. In this determination strong caustic soda (sp. gr 1·348) was used to absorb the NO_4. In making the calculation the gas in contact with such a solution was considered half dry. By this means absolute precision is sacrificed to certainty. It cannot be doubted that the strong alkali would completely absorb all NO_4 without evolving NO_2.

The influence of the possible tension of aqueous vapour from strong solution of caustic soda does not seriously affect the calculation. If we reckon the gas absolutely dry, we get vapour-density of $NO_4 = 2·69$.

If absolutely wet, we have vapour-density of $NO_4 = 2·60$.

IV.

Vapour-density at 4·2° C.

	Cubic Cent. at 0° C. and 760 m. m.		Grm.
Vol. of $N + NO_4$	354·33	weighing	·5711
„ N .	294·15	„	·3695
	60·23		·2016

Therefore 60·23 C. C. of NO_4 weigh ·2016 grm. Vapour density = 2·588.

Here weak solution of caustic potash (sp. gr. = 1·0045) was employed, and considered to have the same tension as pure water.

The vapour density of NO_4, given in REGNAULT'S "Cours Elémentaire de Chemie," is 1·72,—a number which is a little less than the first number on the following list:—

C.	Vapour Densities.
Obs. 1 at 97·5°	1·783
„ 2 „ 24·5°	2·520
„ 3 „ 11·3°	2·645
„ 4 „ 4·2°	2·588

The formula NO_4 requires $\frac{46}{2} \times ·0691 = 1·5893$.

The formula N_2O_8 requires $\frac{92}{2} \times ·0691 = 3·1786$.

It will be observed that even at 97·5° C. the vapour density of peroxide of nitrogen is rather too high for the first formula, whilst at 24·5° and downwards, the vapour density is much nearer that required by the second formula than that required by the first.

If it be allowed that there exist two peroxides of nitrogen, NO_4 and N_2O_8, and that these bodies pass readily into one another, the above results find a simple and natural explanation. At 100° C., the gas consists chiefly of NO_4; at ordinary temperatures, chiefly of N_2O_8; whilst at intermediate temperatures, intermediate quantities of NO_4 and N_2O_8 are present.

If change of composition be denied, the peroxide of nitrogen must have an expansion-coefficient widely differing from that of other gases. To admit such an exception to one of the best physical generalisations seems unphilosophical, and contrary to the usual proceeding of science.

In general, gases when exposed to pressures not exceeding the usual barometric pressure, and when no incipient liquefaction is taking place, have an expansion-coefficient not differing widely from ·00366. No exception has yet been established; for, in those cases of which sulphur is the representative, it is at least probable that truly polymeric bodies exist.

Another illustration of the vapour-density methods above described consists in an inquiry into the existence of hydrated oxide of ammonium.

Can hydrated oxide of ammonium exist at 100° C., and in the gaseous state? To solve the problem, a quantity of dry ammonia was measured over mercury, then a small portion of water, which had been accurately weighed in a thin glass bulb, was introduced into the ammonia. The whole was then heated up to 100° C., and the volume of mixed gas and aqueous vapour noted. It will be obvious that the formation of hydrated oxide of ammonia would be indicated by contraction. If, on the other hand, the NH_3 and aqueous vapour, when mixed, had the same volume as when separate, no hydrated oxide of ammonium had been produced.

The following are the details of the experiment:—

	Observed Vol. in Cubic Cent.	Temperature Centigrade.	Pressure in Millimeters.	Corrected Vol. in Cubic Cent. at 0° C. and 760 m. m.
Vol. of dry NH_3, . .	34·19	12·5°	558·08	24·008
Vol. of NH_3 + water, .	107·32	102° C.	709·66	72·973

·0402 grm. of water taken.

But ·0402 grm. of water, when converted into vapour, measures 49·95 cub. centimeters at 0° C. and 760 m. m. The difference between the readings before and after the addition of that amount of water is 48·965 cub. cent. Therefore, at 100° C., ammonia and aqueous vapour can exist side by side without suffering any considerable contraction.

XX.—*The Bifilar Magnetometer, its Errors and Corrections, including the Determination of the Temperature Coefficient for the Bifilar employed in the Colonial Observatories.* By JOHN ALLAN BROUN, F.R.S., Director of the Trevandrum Observatory.

(Read 4th February 1861.)

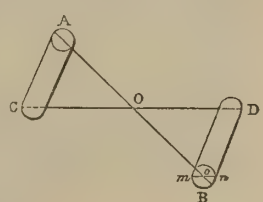
In 1845, a paper by me on the balance magnetometer was read to the Royal Society of Edinburgh (see Trans. vol. xvi. p. 67), which contained an examination of some of the difficulties to be considered and overcome in relation to that instrument. No similar examination has yet appeared, as far as I am aware, of the bifilar magnetometer. When it is considered that the value of the results obtained from this instrument in so many observatories is dependent on an exact knowledge and elimination or correction of its errors; and, as will appear hereafter, that the temperature coefficients employed in the discussion of the Colonial observations are in some cases so erroneous that the uncorrected observations would have been nearer the truth than after correction, the following communication may not appear unnecessary.

2. The bifilar magnetometer, as devised by Dr LLOYD, was employed in all the British and Colonial observatories with one exception; a description of the instrument will be found in the introductions to the "Makerstoun Observations," forming part of the Society's Transactions.

3. It is well known that if W represent the weight of the magnet and its appendages, m the magnetic moment, X the horizontal force of the earth's magnetism, l the length of the wires, a and b their intervals above and below, i the angle which they make with the vertical, v the angle of twist, and u the angle which the magnet makes with the magnetic meridian; then,

$$mX \sin u = \frac{Wab}{l \cos i} \sin v, \quad . \quad . \quad . \quad (1.)$$

This, however, is on the supposition that the wires are lines without elasticity; for if AC, BD, represent the vertical projections of the wires on the horizontal plane, then (to consider one wire only) it is evident that the upper end of the wire BD has turned through the angle v more than the lower end. Let us suppose that the wire BD is suspended alone with a weight equal $\frac{W}{2}$, whose magnetic moment $= m$ (or whose ratio to m is known); let the upper extremity of the wire be turned through the angle v, and the magnet be moved from the meridian through the angle δ, then, if the torsion force for unity of arc be p, we have



$$p\,(v - \delta) = mX \sin \delta,$$

or,

$$pv = mX \sin \delta', \quad . \quad . \quad . \quad . \quad . \quad . \quad (2).$$

4. If we now consider the wire BD in the bifilar arrangement, and suppose it moveable round an axis at o, so that mn which, when the wires were vertical, was parallel to OD, still remains parallel to OD, and we then turn B round the axis o, so that mn shall be in the same line as AB; the moment of this twist through the angle v, for both wires, in turning the magnet round O, must be added to equation (1), and we have, if $u = 90°$,

$$mX = \frac{Wab}{l \cos i} \sin v + 2pv \quad . \quad . \quad . \quad (3).$$

$$= G \sin v + 2mX \sin \delta', \quad . \quad . \quad . \quad (4).$$

where $G = \frac{Wab}{l \cos i}$

If we assume

$$mX = G \sin v', \quad . \quad . \quad . \quad (5).$$

neglecting the variation of i, we have

$$2mX = G \cos \frac{v + v'}{2} \sin (v - v), \quad . \quad . \quad (6).$$

Whence, approximately,

$$\sin (v - v') = \frac{2 \sin \delta'}{\cot v} \quad . \quad . \quad . \quad (7).$$

If $\sin (v-v')=\tan \beta$, then,

$$mX = G (\sin v - \cos v \tan \beta) = \frac{G \sin (v - \beta)}{\cos \beta}, \text{ since } (v' > v) \quad (8).$$

and, $$\frac{\Delta X}{X} = \cot (v + \beta) \Delta v \quad . \quad . \quad . \quad . \quad . \quad (9).$$

whereas by equation (1), $\frac{\Delta X}{X} = \cot v \Delta v \quad . \quad . \quad . \quad . \quad . \quad . \quad (10).$

If we know the torsion force of the wires, β may always be computed from equation (7). The following experiments have been made to determine the probable value of β.

5. *Torsion Force of Wires.*—Silver wire used in Grubb's bifilar, 0·007 inch diameter; magnet suspended whose moment = m (= 9·0 English units approximately), and weight = $\frac{W}{2}$, when it was found that 1° of torsion gave $\delta' = 1'·56$. If $v = 60°$, then by equation (7),

$$v - v' = 5° \; 22'$$

6. This implies an error in the unit coefficient so much greater than is shown by the different methods of determining it, that I made the following experiments for its verification. The same magnet suspended with the same wire as bifilar, $v = 47° \; 47'$ (weight = W), magnet at right angles to the magnetic meridian; *one* wire was turned through angles of 10° right and left; the corresponding changes of scale reading were found, for 1° of torsion = 1'·65; therefore, for two wires and for 47° 47' of torsion, $v' - v = 2° \; 37'·6$ nearly. By equation (7) we find,

$$\delta' = 2° \; 21'·6,$$

whereas by experiments with the magnet in the meridian, we find

$$\delta' = 2 \times 47{\cdot}8 \times 1'{\cdot}56 = 2^\circ\ 29'{\cdot}2.$$

7. In this experiment the angles of torsion with the bifilar wire were only estimated by means of a fibre attached to the wire below the point of suspension; but other experiments were made with a more perfect apparatus; the ends of the wires were passed through holes in a brass plate of such diameter as to allow them to turn freely without any lateral displacement, and the ends were soldered into two brass pins with points, which indicated the amount of rotation of each wire on small circles graduated on the brass suspension plate, having the wire holes for centres. In this way some accurate observations were made, of which the following is the summary:—

Magnet ($m = 7{\cdot}7$ nearly) suspended by one wire in the meridian δ' for 1° of torsion, $= 0'{\cdot}433$
... ... two wires at right angles Δv ... ... $= 1{\cdot}40$,

the latter being for two wires, $v = 57^\circ\ 13'$, and $v' - v = 1^\circ\ 20'$; then,

By equation (7), $\delta' = 26'{\cdot}4$;
By experiment, $\delta' = 24{\cdot}8$.

Magnet ($m = 2{\cdot}35$) suspended by one wire in the meridian, δ' for 1° of torsion, $= 1{\cdot}42$;
... ... two wires at right angles to meridian, Δv for 1° of torsion, . . . $= 0{\cdot}74$,

the latter as before being for the torsion of both wires, $v = 14^\circ\ 52'$, $v' - v = 11'$; then,

By equation (7), $\delta' = 21'{\cdot}7$;
By experiment, $\delta' = 21{\cdot}1$.

In all instances, the confirmation is as near as could be expected.

8. Equation (3), however, is on the assumption that the wires are wholly without twist before the torsion circle is turned; a supposition wholly gratuitous in fact, since the wires have generally been wound on bobbins before use, and the twist thus introduced is rarely ever wholly removed. Trials at Makerstoun in 1841, with all the conditions as equal as possible, showed that the angle v varied about 1° (one degree), according as the torsion circle was turned to the right or to the left.*

9. *Unit Coefficient.*—In 1846 I employed a new method, which was free from the objections applying to the torsion circle observations, and in which the bifilar magnet was deflected by another placed at known distances.† I have also since then employed the following processes. If we make W, a, b, or l to vary considerably in the hypothetical equation (1.), and take the differences, a given variation of $W = \pm \Delta W$, of $a = \pm \Delta a$, of $l = \pm \Delta l$, will be connected with the observed variation of $v = \Delta v$ ($u = 90^\circ$) by the equations.‡

* See Introduction to Makerstoun Observations, Trans. Roy. Soc. Ed., vol. xvii. part 1. p. 27

† Introduction to Mak. Obs., 1843, p. lxv.; 1844, p. xxviii.; 1845, p. xxvii.

‡ I have only lately learned that Mr Brooke has employed the process by weights for his self-registering instruments (Phil. Trans., p. 85, 1850).

$$\text{Cot } v \tan \Delta v = \frac{\Delta W}{W \pm \Delta W} = \frac{\Delta a}{a \pm \Delta a} = \frac{\Delta l}{l}$$

or, since Δv is always small $= n\,a$, where a is the arc value of one division of the scale, and n the observed number of scale divisions of deflection, then

$$a \cot v = k = \frac{\Delta W}{n\,(W \pm \Delta W)} = \frac{\Delta a}{n'\,(a \pm \Delta a)} = \frac{\Delta l}{n''\,l}$$

To these methods may be added that given by GAUSS, depending on the time of vibration of the magnet.

10. The following table contains a summary of the results for the value of k obtained for different bifilars by the processes indicated above.

TABLE I.—VALUES OF THE BIFILAR UNIT COEFFICIENT k BY DIFFERENT METHODS.

No.	Date.	Instrument.	Method.	Coefficient k.
				0·000 (prefix).
1	May 1847,	Grubb's bifilar, Silver wires,	Deflections 3 dist. 4 in. magnet,	1351
			„ „ 15 „	1356
			Comparisons with Unifilar force inst.,	1353
			Angle of torsion,	1251
2	Oct. 1852,	Grubb's bifilar, Silver wires,	Weights Δ W = +33·0 grains,	1365
			„ Δ W = +103·1 „	1367
			„ Δ W = +136·1 „	1370
			„ Δ W = −72·32 „	1368
			Intervals Δa = +0·01039 in.,	137
			„ Δa = −0·01039	124*
			Deflections 3 distances,	1369
3	Sept. 1854,	Grubb's bifilar, Platinum wires,	Deflections, 3·125 feet,	1503
			„ 2·625 „	1503
			„ 2·125 „	1503
			Weights Δ W = −72·0 gr. and +100 gr.	1505
			Angle of torsion,	138
4	Dec. 1854,	Idem,	Deflections 3 distances,	1503†
5	Sept. 1854,	Adie's bifilar, No. 3, Platinum wires,	Deflections 3 distances,	0578
			Angle of torsion,	0574
6	Nov. 1854,	Adie's bifilar, No. 1, Platinum wires,	Weights Δ W = ±20 gr.,	0700
			Angle of torsion,	0692
7	Dec. 1854,	Adie's bifilar, No. 3, Platinum wires,	Weights Δ W = ±41·5 gr.	0513
			Deflections 3 distances,	0510
			Angle of torsion,	0501
8	May 1855,	Adie's bifilar, No. 1, Platinum wires,	Deflections 3 distances,	0451
			Weights Δ W = −34·8 gr. and +30 gr.,	0451
			Angle of torsion,	0449
			Horizontal vibrations,	0436

No. 1, Makerstoun; Nos. 2 to 7, Trevandrum Observatory; No. 8, Agustier Malley Observatory, Ghats of Travencore. No. 2, weight suspended 8491 grains; Nos. 3 and 4, weight suspended 6354 gr.; No. 5, weight 2960 gr.; Nos. 6, 7, and 8, weight about 2200 gr.

* The wire was found to shift in the groove of the suspension screw.

† The whole instrument had been turned into different azimuths since the preceding determinations.

11. The results from the angle of torsion are always too little, though approaching the truth, for platinum wires with light weights. The result by vibrations shows the insufficiency of this method, without some better system of correction for arc. On the whole, it appears that by weights and deflections the same mean result is obtained very nearly; and both methods should be employed in the case of an instrument intended for a fixed observatory. The experiments by weights should, however, always be made first, as there is some danger in laying on and taking off the weights of an accident (the smallest shock producing a change of position in the magnet). When an instrument is closed up, and the line passing through the centre of the bifilar at right angles to its magnetic axis is marked, the deflections can always be made without disturbing the instrument.

12. *Temperature Corrections.*—Having satisfied ourselves that we have obtained the true value of the unit coefficient, it is desirable to consider what causes may influence the members of equation (3). The quantities may evidently all vary, but the variations of W and i may be neglected, since the only known causes which can make W to vary are the moon's attraction, producing a variation in all of less than 0·000002 of the horizontal force, and therefore inappreciable in our instruments; and the varying density of the atmosphere, producing for a variation of three inches of mercury no greater change than 0·00002 of the horizontal force X; the variation of i appears in equation (4) as $\tan i \, d \, i$, a quantity of the second order; m, a, b, l, and p, however, all vary with temperature. If we differentiate with respect to temperature, we shall obtain as corrections to equation (4)

$$\frac{d\,m}{m}+\frac{d\,a}{a}+\frac{d\,b}{b}-\frac{d\,l}{l}+2\sin\gamma\,\frac{d\,p}{p}. \quad . \quad . \quad . \quad . \quad (15)$$

The variation of m, the magnetic moment, has been usually obtained by Mr Christie's process; $\frac{d\,a}{a}$, $\frac{d\,b}{b}$, and $\frac{d\,l}{l}$, are the expansion coefficients of the metals separating the wires above and below, and of the wires themselves. These coefficients have been usually taken as obtained from the expansion of solid bars of these metals. My own experiments show that this is not accurate; the expansion coefficient of a wire stretched by a weight is considerably greater than for a bar of the same metal; this error, however, bears a small proportion to the whole temperature coefficient: $\frac{d\,p}{p}$ is the correction due to the variation of the elasticity of the wires with temperature.

13. If, then, we allow that the temperature coefficient obtained by placing a magnet in water of different temperatures is the same, or very nearly the same, as should be obtained when placed in air of different temperatures, we have still the effects of temperature on the wires undetermined, It is also by no means

certain that the varying temperature of the copper pillars supporting the torsion circle has no effect on the position of the magnet.

14. The following experiments will prove that we cannot at present determine the correction for the suspension of the magnet by mere theoretical considerations. Considering that the elasticity of the wires diminishes with increase of temperature, and that the twist of the wires in turning the torsion circle acts *with* the torsion force, an increase of temperature should be equivalent to a diminution of the total torsion moment, and the north end of the bifilar magnet should *approach* the north. The effect of temperature on the magnet itself being to diminish its moment, is to cause the north end to move *from* the north. The temperature coefficient should therefore be diminished by this action on the wires (excepting the case where the proper twist of the wires is greater than v, and in an opposite direction).

15. *Trevandrum Observatory, July* 1858.—Having suspended a lead cylinder, carrying a mirror (the whole weight being about 5000 grains), by the silver wires of Grubb's bifilar, a fine silk fibre from the cocoon was attached to one of the wires near the lower end, and the fibre was passed over a light copper friction wheel (whose axle was taken from a dipping needle); forty grains were suspended at the other end of the fibre. The torsion circle was then turned till the angle v was about 65°, the pull of the fibre over the friction roller being at right angles to the plane, passing through the lower ends of the two wires. The movements of the weight round the vertical axis were observed by means of a telescope and a glass scale at a distance of seven feet; the scale readings increased when the movement was direct, and one scale division was equal to 0′·327. According to hypothesis, if the torsion was direct, an increase of temperature should correspond to a retrograde movement, or a diminution of scale readings, and *vice versa*. Hourly observations were made during the months of June and July 1858; but as the slightest shocks touching the pillar of the instrument changed the position of the weight, the series was broken from day to day. In the first series all the observations comparable were obtained from July 21 to August 5, 1858. The temperature was obtained from a thermometer within the box, having its bulb resting on a brass cup.

16. A change of the daily mean scale reading from day to day throughout the period is obvious (see second column of Table II.). On the assumption that this change was regular, a correction of + 2·0 Sc. div. a day from July 21 has been applied; the reduced quantities are given in the third column. The individual results are by no means satisfactory. They show generally, however, an increase of reading for an increase of temperature; and the final result is, that +1°·0 Fahr. is equivalent to + 4·0 Sc. div., thus satisfying the hypothesis.

TABLE II.—Torsion Retrograde.

Trevandrum Observatory, Bifilar Weight.						
Date.	Mean Scale Reading.		Mean Temperature.	Mean Change.		
	Observed.	Reduced for Change.		Observed Scale Reading.	Reduced Scale Reading	Temperature.
July 21	37·59	37·59	78°·46			
,, 22	18·77	20·77	77·20	−18·82	−16·82	−1°·26
,, 23	13·35	17·35	77·29	− 5·42	− 3·42	+0·09
,, 24	22·23	28·23	77·71	+ 8·88	+10·88	+0·42
,, 26	31·91	41·91	78·37	+ 9·68	+13·68	+0·66
,, 27	31·32	43·31	79·18	− 0·59	+ 1·40	+0·81
,, 28	27·11	41·11	79·04	− 4·21	− 2·20	−0·14
,, 29	26·23	42·23	79·23	− 0·88	+ 1·12	+0·19
,, 30	22·71	40·71	79·15	− 3·52	− 1·52	−0·08
,, 31	21·82	41·82	78·74	− 0·89	+ 1·11	−0·41
Aug. 2	14·81	38·81	77·27	− 7·01	− 3·01	−1·47
,, 3	13·95	39·95	77·13	− 0·86	+ 1·14	−0·14
,, 4	10·88	38·88	77·09	− 3.07	− 1·07	−0·04
,, 5	6·02	36·02	77·96	− 4·86	− 2·86	+0·87

17. On August 7 a new series were commenced, the torsion being in this case *direct;* the following are the results :—

TABLE III.—Torsion Direct.

Trevandrum Observatory, Bifilar Weight.						
Date.	Daily Mean.		Mean Temperature.	Mean Change.		
	Observed Scale reading.	Reduced for change.		Scale reading.	Scale reading reduced.	Temperature.
Aug. 7	19·59	19·59	77°·86			
,, 9	15·56	16·90	78·60	−4·03	−2·69	+0°·74
,, 10	14·60	16·61	79·07	−0·96	−0·29	+0·47
,, 11	14·03	16·71	78·10	−0·57	+0·10	−0·97
,, 12	16·69	20·04	77·16	+2·66	+3·33	−0·94
,, 13	11·97	15·77	78·02	−4·92	−4·25	+0·86
,, 14	10·75	15·44	78·57	−1·02	−0·25	+0·55
,, 16	8·30	14·33	79·02	−2·45	−1·11	+0·45
,, 17	9·31	16·01	78·69	+1·01	+1·68	−0·33
,, 18	10·97	18·34	78·03	+1·66	+2·33	−0·66
,, 19	11·36	19·40	77·57	+0·39	+1·06	−0·46
,, 20	10·89	19·60	77·87	−0·47	+0·20	+0·30

The mean scale reading having changed about 9 sc. div. from the 7th to the 20th, a correction has been applied after the 7th, for the change supposed regular at the rate of 0·67 sc. div. a-day; the corrected quantities are given in the third column. A correction has been allowed for a shock to the instrument on the 11th, depending on the change at the hour of the shock; and the change 10th to 11th is on this account probably inaccurate. This series is, on the whole, consistent, an increase of temperature being accompanied by a diminution of scale reading (or *vice versa*) on every day with one exception; the final result is $+1·0°$ Fahr., equivalent to $-2·5$ sc. div. This also satisfies the hypothesis.

18. Perhaps the most curious fact connected with this series of observations is, that though the *daily* mean scale reading increased, torsion retrograde, with an increase of temperature, and torsion direct, with a diminution of temperature, there was in both cases a strongly and regularly marked *hourly* variation, whose direction was not changed by the direction of the torsion, and whose amount, as related to the temperature, was much greater than that obtained from the daily means. I shall have to consider this fact at another time: it does not, however, depend upon the bifilar suspension. Whatever conclusion we may arrive at with reference to the relation of these facts to the direction of torsion, it appears to me they are sufficient to prove that any trustworthy temperature coefficient must include their causes.

19. There still remains one considerable objection to the usual method of obtaining the temperature coefficient of the bifilar magnetometer; namely, that before we can correct the observations we must be certain that we have obtained the true value of the scale unit coefficient. Should that be at all inaccurate (as it frequently has been when derived from the angle of torsion only), the corrections, even by a true temperature coefficient, will be inaccurate. Thus, if n_0 be the scale reading from the zero, k the unit, and q the temperature, coefficients, the reduced result is

$$\frac{\Delta X}{X}=n_0\,k+t_0\,q. \qquad (16)$$

where t_0 is the number of degrees Fahr. from the zero. If n_1 be the part of n_0 due to change of the earth's magnetism, and n_2 the part due to temperature,

$$\frac{\Delta X}{X}=n_1k+n_2k+t_0q. \qquad (17)$$

the last two quantities should destroy each other if k and q be the true coefficients. If, however, $k_0=k+\alpha$ be the true unit coefficient, then

$$n_2k_0=-t_0q,$$

and

$$n_2k=-t_0q-\alpha\frac{q}{k_0}t_0. \qquad (18)$$

Substituting this value in equation (17),

$$\frac{\Delta X}{X}=n_1\,k-\alpha\frac{q}{k_0}t \qquad (19)$$

the corrected result, which *still* varies with temperature. Where the scale unit coefficient can be accurately determined, this consideration has no value; but where we have to deal with observations already made, it is one of much importance.

20. *Temperature Coefficient.*—Several facts, such as those already indicated, relatively to the effects of temperature on the parts of the balance magnetometer, induced me, in 1842, soon after I received charge of Sir THOMAS BRISBANE'S Observatory at Makerstoun, to seek some other method of obtaining the temperature coefficient in the terms of the *scale divisions.* This I sought first by artificially heating and cooling the room in which the instruments were placed; but the effects of currents of air thus engendered were too considerable to render the method satisfactory. I then sought to determine it by comparisons of the readings at the same hours of different days, when the temperatures were different; I finally employed successfully the daily means, at first from incomplete diurnal series of observations in 1842–43. This method, by the formula

$$\frac{\Delta X}{k X}=n_1+n_2+\frac{q}{k}t_0,$$

gave the result accurately corrected in scale divisions, from which the *laws* of variation could be determined even when ignorant of the value of k.*

21. When this method was first used by me, I selected periods free from large disturbances, and combined the daily means in different periods.† In determining the coefficient for the colonial and other observatories, I have thought it preferable (to avoid any doubt that might arise from such selection as to the character of the final results) to obtain the coefficients from the comparisons of all the daily means *without exception*, from the commencement to the end of the periods for which observations have been published. In general, each daily mean of scale divisions and of temperature has been compared with the succeeding daily mean only; but where the variation of mean temperature from day to day has been very small, comparisons with the second, and sometimes with the third day following, have been taken. The following are the discussions for the different bifilars:—

* I first proposed to Professor JAMES D. FORBES (in a letter dated 21st November 1842) to determine the temperature coefficient from the usual hourly observations. (See Trans. Roy. Soc. Ed., Vol. XVI. p. 74.)

P.S.—Since this paper was written, I have received the third volume of the Toronto Observations (London 1857), where I am glad to perceive that General SABINE has followed the principle described in the text, for the determination of the temperature coefficient. The *mode* he has adopted is however far from accurate, including as it does irregular annual secular and instrumental changes, with too few results to render *plus* and *minus* errors equally probable; as a consequence, the coefficient obtained by him is still erroneous (1·63 sc. div., whereas I find 1·36 sc. div.). General SABINE notices my result for the Makerstoun bifilar (Adjustments, &c., part v., Toronto Observations, vol. iii.), but he omits to remark that I had pointed out, twelve years before, the necessity of applying the process to all bifilars, and that I had applied it to the very magnet (the Toronto one) under his discussion. See Trans. Roy. Soc. Ed., Vol. XVI. p. 77 (20), p. 102 (11), and curves in No. 5, Plate IV.

† See the Introduction to the Makerstoun Observations for 1844 and 1845, where the process is described.

22. Cape of Good Hope, 1841–46.—The series of published observations closed June 1846.* The values of q' obtained by myself from the daily mean uncorrected scale readings and mean temperatures were as follow :—

Magnet R. $k = 0{\cdot}000180$

Table IV.—Sums of Successive Differences of Daily Mean Bifilar Temperature ($\Sigma \Delta t$) and Scale Reading ($\Sigma \Delta$ R).

Month.		$\Sigma \Delta t$.	$\Sigma \Delta$ R.	q'.	Month.		$\Sigma \Delta t$.	$\Sigma \Delta$ R.	q'.
		°	Sc. div.				°	Sc. div.	
1841.	Dec.	33·23	52·38	1·58	1842.	Dec.	29·65	45·09	1·52
1842.	Jan.	29·27	34·31	1·17	1843.	Jan.	32·55	44·80	1·38
	Feb.	34·43	24·73	0·72		Feb.	39·95	48·19	1·21
	March.	23·14	24·43	1·04		March.	26·23	18·43	0·70
	April.	33·31	46·16	1·39		April.	Magnet	removed.	
	May.	18·81	19·10	1·02		May.	18·60	33·57	1·80
	June.	27·56	36·88	1·34		June.	35·41	43·38	1·23
	July.	25·41	44·48	1·75		July.	29·38	30·56	1·04
	Aug.	20·13	13·69	0·68		Aug.	43·60	64·55	1·48
	Sept.	16·99	9·52	0·56		Sept.	28·30	25·14	0·89
	Oct.	39·70	50·65	1·28		Oct.	33·01	25·86	0·78
	Nov.	26·48	27·44	1·04		Nov.	Readjusted.		

The resulting value is

$$q' = \frac{\Sigma \Delta \text{R}}{\Sigma \Delta t} = \frac{763{\cdot}34}{645{\cdot}14} = 1{\cdot}183 \text{ sc. div.; mean temperature, } 63^\circ{\cdot}6.$$

As the magnet was removed for temperature experiments in April 1843, the value of q' after the readjustment may be determined apart. We find for May to October 1843,

$$q' = \frac{223{\cdot}06}{188{\cdot}30} = 1{\cdot}185 \text{ scale divisions.}$$

23. It should be repeated here, that the extent of agreement or disagreement in the partial results for q' given in the above table, is not to be considered as deciding the accuracy of this method, since the variation of these partial results is chiefly due to days of great magnetic disturbance, and no day has been rejected, *however great its irregularity*, in these calculations. These partial results give the probable error of the final value of q' to be, 0·05 sc. div.; or $q' = 1{\cdot}183$ scale divisions, with a probable error of 0·05 sc. div.

* Magnetic Observations, Cape of Good Hope, vol. i., printed under the superintendence of Lieut.-Colonel E. Sabine.

Whence, since

$$k = 0{\cdot}000180,$$
$$q'k = [q] = 0{\cdot}000213.$$

The value of q determined by hot water experiments was found for the magnet R,

$$q = 0{\cdot}000258 \text{ at the temperature of } 48^\circ$$
$$q = 0{\cdot}000304 \quad \text{,,} \quad 77^\circ$$

the value of q varying apparently with the temperature, as occurs with some bars. The value of q at the mean temperature of the bar for the months in Table IV. is

$$q = 0{\cdot}000290 \text{ at the mean temperature of } 63^\circ{\cdot}6\,;$$

whence $$[q] = 0{\cdot}734\,q.$$

The same value of q' ($=1{\cdot}18$) has been employed by me (for the discussions given in another paper) in the corrections for all temperatures.

24. *November* 1843 *to September* 1844.—New adjustment of magnet R,

$$k = 0{\cdot}00035.$$

TABLE V.—SUMS OF SUCCESSIVE DIFFERENCES OF DAILY MEANS.

Month.	$\Sigma\,\Delta\,t$.	$\Sigma\,\Delta$ R.	q'.	Month.	$\Sigma\,\Delta\,t$.	$\Sigma\,\Delta$ R.	q'.
	°	Sc. div.	Sc. div.		°	Sc. div.	Sc. div.
1843. Nov.	27·74	11·83	0·43	1844. May.	24·87	17·01	0·68
Dec.	32·24	21·01	0·65	June.	25·55	12·11	0·47
1844. Jan.	33·75	17·12	0·51	July.	24·41	14·15	0·58
Feb.	33·54	27·07	0·81	Aug.	22·71	15·07	0·66
March.	28·84	18·42	0·64	Sept.	25·74	13·54	0·52
April.	31·12	14·89	0·48	Oct.	New	Magnet	C_2

The resulting value, the mean temperature of the bar being 67°, is

$$q' = \frac{\Sigma\,\Delta\,\text{R}}{\Sigma\,\Delta\,t} = \frac{182{\cdot}22}{310{\cdot}51} = 0{\cdot}587 \text{ sc. div.},$$

with a probable error of 0·03 sc. div. Whence,

$$[q] = 0{\cdot}000205\,;$$

and since, $$q = 0{\cdot}000287 \text{ at the temperature of } 67^\circ$$
$$[q] = 0{\cdot}714\,q.$$

As it is quite possible that the temperature coefficient for the same bar might be different for $k = 0{\cdot}00018$ and $k = 0{\cdot}00035$, the coefficient $q' = 0{\cdot}587$ sc. div., has been employed by me from November 1843 to September 1844. It is rendered probable by the near agreement of the values of $[q]$ in these two adjustments, that the difference from the value of q is not due to error of the coefficient k.

25. *November* 1844 *to June* 1846.—Magnet C_2, new adjustment,

$$k = 0{\cdot}00022.$$

TABLE VI.—Sums of Differences of Bifilar Daily Means.

Month.		$\Sigma \Delta t$.	$\Sigma \Delta$R.	q'.	Month.		$\Sigma \Delta t$	$\Sigma \Delta$R.	q'.
			Sc. div.	Sc. div.			°	Sc. div.	Sc. div.
1844.	Nov.	34·46	13·79	0·40	1845.	Sept.	19·41	5·12	0·26
	Dec.	38·03	21·01	0·55		Oct.	32·39	7·55	0·23
1845.	Jan.	35·44	6·50	0·18		Nov.	33·36	13·70	0·41
	Feb.	23·90	11·59	0·49		Dec.	32·59	38·77	1·19
	March.	31·55	12·51	0·40	1846.	Jan.	37·03	24·47	0·66
	April.	28·03	2·92	0·10		Feb.	24·78	15·90	0·64
	May.	27·04	14·18	0·52		March.	33·04	11·63	0·35
	June.	26·73	2·66	0·10		April.	32·09	4·46	0·14
	July.	27·71	2·44	0·09		May.	23·47	16·41	0·70
	Aug.	27·87	25·06	0·90		June.	17·32	6·08	0·35

The final value is

$$q'=\frac{256·75}{586·24}=0·438 \text{ sc. div., with a probable error of } 0·04 \text{ sc. div.};$$

whence, since

$$k = 0·00022$$
$$[q] = 0·000096$$

By water experiments,

$$q = 0·000220$$

Therefore,

$$[q] = 0·484\ q.$$

26. St Helena, 1842–43.—The series of published observations in my possession extends till December 1843.* As the daily differences of temperature are small, the sums for each two months of the same name in 1842–43 are given; and as the majority of the daily differences of temperature were under half a degree Fahr., the sums were also taken for those days only for which the mean temperature of the following day differed half a degree or more. The results by both methods are given in the following Table:—

* Printed under the superintendence of Lieut.-Colonel E. Sabine.

TABLE VII.—SUMS OF DIFFERENCES OF BIFILAR DAILY MEANS AT ST HELENA FOR EACH MONTH, 1842–43.

Months, 1842–43.	Mean Temperature of Bifilar.	All.			Above 0°·5 Fahr.		
		$\Sigma\Delta t.$	$\Sigma\Delta$R.	q'	$\Sigma\Delta t.$	$\Sigma\Delta$R.	q'
	°	°	Sc. div.	Sc. div.	°	Sc. div.	Sc. div.
January,	67·6	22·50	46·37	2·06	15·94	22·54	1·41
February,	69·4	21·92	33·65	1·54	16·68	19·38	1·17
March,	69·8	26·49	47·11	1·78	21·01	32·38	1·54
April,	68·7	20·91	1·22	0·06	14·07	8·32	0·59
May,	66·1	23·82	17·63	0·74	16·18	13·98	0·86
June,	62·5	25·45	21·04	0·83	18·64	14·09	0·76
July,	60·8	25·08	−14·31	−0·57	18·88	6·80	0·36
August,	60·6	24·63	13·79	0·56	17·83	15·63	0·88
September,	60·7	24·89	26·72	1·07	17·89	18·81	1·05
October,	61·3	21·36	38·67	1·81	12·83	16·46	1·29
November,	63·3	23·01	29·17	1·27	14·83	15·65	1·06
December,	65·2	27·57	33·02	1·20	23·02	26·06	1·13

The resulting values are:—

From all, 1842, $q'=\frac{142·35}{145·25}=0·980$ scale divisions.

... 1843, $q'=\frac{151·73}{142·38}=1·066$ ... ...

Both years, $q'=\frac{294·08}{287·63}=1·02$ ... ...

From all above 0°·5 Fahr. 1842, $q'=\frac{107·62}{102·91}=1·046$ ... ...

... ... 1843, $q'=\frac{102·85}{104·89}=0·980$ ... ...

Both years, $q'=\frac{210·47}{207·80}=1·013$ sc. div.; probable error = 0·071.

27. An examination of the values of q' for the different months seems to show a variation with the season; the variation is shown also in the results for the separate years. If we discuss the quantities in the last column of Table VII. by the method of least squares with reference to the mean temperatures of the bifilar, we find the probable variation of q' for 1° Fahr. to be 0·0371 sc. div.; or if t be the temperature of the bifilar, that we may put,

$$q'=0·84+(t-60)\ 0·0371.$$

Therefore at the mean temperature of bifilar 65°

$$q'=1·02 \text{ sc. div., with a probable error of } 0·06 \text{ sc. div.}$$

The coefficient for the temperature variation of q' is very large, probably three times greater than has ever been found by water experiments for any magnet:

while it is pointed out that the series is not sufficiently good to give this result for the variation of q' a great value, it should not be forgotten that the rocks forming St Helena are of a highly magnetic nature, and that their magnetic force varies with the temperature.*

28. The coefficient $q' = 1{\cdot}02$ has been employed by me throughout. When $k = 0{\cdot}000189$, we find

$$[q] = 0{\cdot}000193.$$

The value of q was found by water experiments between the temperatures of 60° to 90° Fahr. to be

$$q = 0{\cdot}000276.$$

I am not certain that this includes the coefficient for the expansion of the wires, but it is suggested† that, on account of the variation of q with temperature, the true value might be more nearly

$$q = 0{\cdot}000260.$$

The value employed in the corrections of the fortnightly means in the "St Helena Observations"‡ seems to have varied; in 1842 and 1843 it was 1·47 sc. div. (=0·000278); in 1844 it was about 1·12 sc. div. =0·000213; and in 1845 about 1·29 sc. div. = 0·000245. Assuming the value by water experiments = 0·000260, we have

$$[q] = 0{\cdot}742\ q.$$

29. Hobarton, 1842–48.—The continuous observations (without weekly adjustments) commenced April 1842, and the observations in my possession terminate with September 1848.§ The torsion circle was turned 1st April 1846, causing a change of the coefficient k, and therefore of q'. The following are the results:—

174. April 1842 to June 1843. $k = 0{\cdot}000120$.

TABLE VIII.—Sums of Differences of Bifilar Daily Means at Hobarton.

Month.	$\Sigma\Delta t$.	$\Sigma\Delta$ R.	q'	Month.	$\Sigma\Delta t$.	$\Sigma\Delta$ R.	q'
	°	Sc. div.	Sc. div.		°	Sc. div.	Sc. div.
1842, April	59·95	94·42	1·57	1842, Dec.	58·33	103·14	1·77
May	61·68	102·43	1·66	1843, Jan.	60·46	97·44	1·61
June	61·78	81·76	1·32	Feb.	65·69	95·58	1·45
July	57·10	113·48	1·99	Mar.	65·59	108·00	1·65
Aug.	50·09	56·02	1·12	April	72·44	111·49	1·54
Sept.	40·00	69·62	1·74	May	45·84	58·90	1·29
Oct.	50·45	64·28	1·27	June	17·65	18·62	1·05
Nov.	71·96	100·56	1·39	Readjustment.			

* At least I have found this to be the case with magnetic rocks in South India.

† Adjustments, &c., "St Helena Observations," vol. i., p. 34.

‡ *Ibid.* p. 35. This Table has some inaccuracies. The coefficient varies, and the temperature zero is not always 60°, as stated.

§ Hobarton Observations, vols. i., ii., and iii., printed under the superintendence of Lieut.-Colonel E. Sabine.

The final result is,

$$q' = \frac{\Sigma \Delta R}{\Sigma \Delta t} = \frac{1275{\cdot}74}{839{\cdot}01} = 1{\cdot}520 \text{ sc. div.; with a probable error of } 0{\cdot}049 \text{ sc. div.}$$

$$[q] = 0{\cdot}000182$$

By water experiments,

$$q = 0{\cdot}000234$$

Whence

$$[q] = 0{\cdot}778\ q.$$

30. In order to render the following determinations comparable, the sums of scale readings after 1st April 1846 have been multiplied by 0·948 to reduce them to the value of k before that date.

August 1843 to March 1846, $k = 0{\cdot}000229$
April 1846 to September 1848, $k = 0{\cdot}000217$

TABLE IX.—Sums of Differences of Bifilar Daily Means at Hobarton, August 1843 to September 1848.

Month.	Σ Δ t.	Σ Δ R.	q'	Month.	Δ Σ t.	Σ Δ R.	q'	Month.	Σ Δ t.	Σ Δ R.	q'
1843				1845	°	Sc. div.	Sc. div.	1847	°	Sc. div.	Sc. div.
Jan.	...	...	...	Jan.	54·66	26·93	0·49	Jan.	38·58	18·90	0·49
Feb.	...	...	...	Feb.	35·16	29·51	0·81	Feb.	38·94	18·36	0·47
Mar.	...	...	...	Mar.	40·35	26·02	0·64	Mar.	48·30	40·00	0·82
April	...	...	...	April	40·71	44·43	1·09	April	35·10	29·23	0·83
May	...	...	...	May	37·21	21·66	0·58	May	35·64	17·52	0·50
June	...	...	...	June	34·30	29·96	0·87	June	23·20	16·57	0·71
July	...	...	...	July	35·50	32·66	0·92	July	26·51	21·88	0·82
Aug.	42·94	30·80	0·71	Aug.	27·26	24·09	0·88	Aug.	33·29	21·98	0·66
Sept.	39·21	31·20	0·80	Sept.	42·44	21·61	0·51	Sept.	40·00	34·04	0·85
Oct.	58·25	37·33	0·64	Oct.	55·73	43·35	0·78	Oct.	39·79	34·48	0·86
Nov.	42·72	32·99	0·77	Nov.	54·86	45·47	0·83	Nov.	38·87	18·95	0·48
Dec.	38·21	25·44	0·67	Dec.	39·99	37·15	0·93	Dec.	50·77	−0·74	−0·02
1844				1846				1848			
Jan.	49·27	30·22	0·61	Jan.	52·77	41·39	0·78	Jan.	54·93	38·91	0·71
Feb.	48·08	31·68	0·66	Feb.	51·57	48·70	0·94	Feb.	50·99	32·11	0·63
Mar.	53·21	45·11	0·85	Mar.	52·54	66·25	1·26	Mar.	40·52	32·27	0·80
April	40·05	27·43	0·68	April	39·98	32·45	0·81	April	58·25	23·35	0·40
May	38·65	29·17	0·75	May	31·96	12·48	0·39	May	27·38	19·15	0·70
June	27·46	21·61	0·79	June	30·82	22·36	0·73	June	23·83	12·25	0·51
July	29·56	22·05	0·75	July	20·94	7·87	0·38	July	22·69	5·56	0·25
Aug.	21·13	11·38	0·54	Aug.	34·41	28·01	0·82	Aug.	21·12	27·94	1·33
Sept.	25·53	20·44	0·80	Sept.	42·58	30·40	0·71	Sept.	36·69	16·09	0·44
Oct.	37·23	28·71	0·77	Oct.	51·58	26·77	0·52	...	...	...	...
Nov.	40·97	18·64	0·45	Nov.	42·58	31·09	0·73	...	...	...	...
Dec.	46·03	22·35	0·48	Dec.	48·48	27·15	0·56	...	...	...	...

The final result is—

For $k = 0{\cdot}000229$

$$q' = \frac{\Sigma\Delta R}{\Sigma\Delta t} = \frac{1703{\cdot}11}{2462{\cdot}27} = 0{\cdot}692 \text{ sc. div.; probable error, } 0{\cdot}017.$$

For $k = 0{\cdot}000217$

$$q' = 0{\cdot}730 \text{ sc. div.}$$

$$[q] = 0{\cdot}000158.$$

By water experiments,

$$q=0 \cdot 000230$$

Therefore,

$$[q]=0 \cdot 689\, q.$$

31. The quantities in Table IX. have been combined into periods of twelve months, and the following results obtained :—

1843, August—1844, July.	$q'=0 \cdot 72$ sc. div.,	probable error $=0 \cdot 02$ sc. div.
1844, ... 1845, ...	$=0 \cdot 80$ ...	... ... $=0 \cdot 04$ ...
1845, ... 1846, ...	$=0 \cdot 66$ ...	... ... $=0 \cdot 03$ ...
1847, ... 1848, Sept.	$=0 \cdot 59$ ...	... ... $=0 \cdot 06$ ...

32. The sums having been arranged according to the months, the following are the results, each being a mean of *five*, excepting those for August and September, which are the mean of six months :—

TABLE X.—Sums of Differences of Bifilar Means for each Month.

Month.	Mean Temperature of Bifilar.	q'	Probable Error.
	°	Sc. div.	Sc. div.
January, ...	63·90	0·62	0·06
February, ...	62·92	0·71	0·06
March, ...	61·63	0·89	0·07
April, ...	57·60	0·73	0·08
May, ...	53·19	0·59	0·05
June, ...	49·36	0·74	0·04
July, ...	47·73	0·67	0·12
August, ...	49·31	0·80	0·08
September, ...	52·44	0·68	0·06
October, ...	55·77	0·70	0·05
November, ...	59·04	0·67	0·07
December, ...	62·96	0·50	0·11

These values have been discussed by least squares, to determine if q' varies with t the temperature; and the coefficient for $+1°$ Fahr. was found $= -0 \cdot 004$ sc. div., or nearly zero; but the partial values of q' are too irregular to give the conclusion any great weight. The irregularities in the value of q' can be traced in general to large disturbances.

33. Trevandrum, 1842–45.*—The observations discussed include the years 1842–45 only. The results are as follows :—

1842, Magnet No. 3, $k = 0 \cdot 000135$.

* Observations in manuscript.

TABLE XI.—SUMS OF DIFFERENCES OF BIFILAR DAILY MEANS AT TREVANDRUM, 1842.

Month.	$\Sigma \Delta t$	$\Sigma \Delta R$	q'	Month.	$\Sigma \Delta t$	$\Sigma \Delta R$	q'
	°	Sc. div.	Sc. div.		°	Sc. div.	Sc. div.
January, . .	16·83	42·0	2·50	July, . . .	21·67	50·2	2·32
February, . .	15·43	35·3	2·29	August, . .	18·31	32·9	1·80
March, . .	18·54	13·2	0·71	September, .	15·29	22·0	1·44
April, . . .	17·51	34·1	1·95	October, . .	22·89	48·0	2·10
May, . . .	29·62	35·8	1·21	November, .	16·62	12·7	0·76
June, . . .	22·64	17·6	0 78	December, .	20·59	27·0	1·31

The partial results are very irregular, on account of the smallness of the differences of temperature. The final result is,—

$q' = 1·57$ sc. div., with a probable error of 0·15 sc. div.

When the differences of the daily mean readings, which were corrected for temperature and exceeded five scale divisions, were rejected, as well as all the differences corresponding to differences of temperature under 0°·5 Fahr., the result was found,—

$$q' = 1·56 \text{ sc. div.};$$

whence

$$[q] = 0·000212.$$

By water experiments,

$$q = 0·000253.$$

Therefore,

$$[q'] = 0·838\, q.$$

34. Bar, No. 5.

January 2, 1843, to April 25, 1843, $k = 0·000149$.
May 2, 1843, to March 30, 1844, $k = 0·000141$.
April 1, 1844, to „ 1846, $k = 0·000144$.

In the following table, the sums of readings have all been reduced to the value of $k = 0·000144$.

TABLE XII.—SUMS OF DIFFERENCES OF BIFILAR DAILY MEANS AT TREVANDRUM, 1843–45.

Months.	1843.			1844.			1845.		
	$\Sigma \Delta t$	$\Sigma \Delta R$	q'	$\Sigma \Delta t$	$\Sigma \Delta R$	q'	$\Sigma \Delta t$	$\Sigma \Delta R$	q'
	°	Sc. div.	Sc. div.	°	Sc. div.	Sc. div.	°	Sc. div.	Sc. div.
January, ...	18·29	26·3	1·44	16·64	37·4	2·25	11·96	33·0	2·76
February, ...	9·70	19·8	2·04	15·46	31·6	2·04	11·32	31·9	2·82
March, ...	16·26	32·3	1·99	12·31	27·3	2·22	26·49	50·8	1·92
April, ...	24·65	51·9	2·11	18·74	36·4	1·94	16·99	42·1	2·48
May, ...	34·02	79·6	2·34	21·13	50·2	2·38	21·01	50·9	2·42
June, ...	19·71	35·0	1·78	8·21	20·1	2·45	28·01	33·2	1·18
July, ...	18·66	43·6	2·34	23·43	42·7	1·82	19·28	35·0	1·82
August, ...	15·95	53·6	3·36	18·82	37·8	2·01	16·81	26·5	1·58
September, ...	10·74	26·0	2·42	14·81	16·5	1·11	11·70	8·0	0·68
October, ...	20·47	61·4	3·00	17·40	69·6	4·00	14·46	49·6	3·43
November, ...	19·07	51·2	2·68	15·47	1·9	0·12	16·21	54·1	3·34
December, ...	27·42	48·2	1·76	16·98	43·1	2·54	20·84	51·4	2·47

The final results are,

1843. $q' = \frac{\Sigma \Delta R}{\Sigma \Delta t} = \frac{528 \cdot 90}{234 \cdot 94} = 2 \cdot 25$ sc. div.; probable error $= 0 \cdot 11$ sc. div.

1844. $q' = \frac{\Sigma \Delta R}{\Sigma \Delta t} = \frac{414 \cdot 60}{199 \cdot 40} = 2 \cdot 08$ „ „ $= 0 \cdot 15$ „

1845. $q' = \frac{\Sigma \Delta R}{\Sigma \Delta t} = \frac{466 \cdot 50}{215 \cdot 16} = 2 \cdot 17$ „ „ $= 0 \cdot 18$ „

All,

$q' = \frac{\Sigma \Delta R}{\Sigma \Delta t} = \frac{1410 \cdot 00}{649 \cdot 50} = 2 \cdot 17$ „ „ $= 0 \cdot 09$ „

whence,

$$[q] = 0 \cdot 000312$$

In 1843 I found by water experiments,

$$q = 0 \cdot 000347.$$

Therefore,

$$[q] = 0 \cdot 899\ q.$$

35. SINGAPORE, 1842–45.* The changes of daily mean temperature by the bifilar thermometer were so small, that differences for the 1st, 2d, and 3d succeeding days were taken for the temperature coefficient. The following table contains the sums of all the differences taken three times for each of the years 1842, 1843, 1844, and 1845.

198. $k = 0 \cdot 0001946.$

TABLE XIII.—SUMS OF DIFFERENCES OF BIFILAR DAILY MEANS. SINGAPORE, 1842–45.

Month.	$\Sigma \Delta t$	$\Sigma \Delta R$	q'	Month.	$\Sigma \Delta t$	$\Sigma \Delta R$	q'
	°	Sc. div.	Sc. div.		°	Sc. div.	Sc. div.
January, . .	201·5	119·2	0·59	July, . . .	216·5	214.2	0·99
February, .	159·5	68·1	0·43	August, . .	235·4	161·2	0·68
March, . .	164·6	128·4	0·78	September, .	186·9	136·4	0·73
April, . . .	142·6	61·6	0·43	October, . .	199·5	210·6	1·05
May, . . .	220·9	89·2	0·40	November, .	168·8	111·3	0·66
June, . . .	222·4	157·9	0·71	December, .	194·7	166·7	0·86

The values of

$q' = \frac{\Sigma \Delta R}{\Sigma \Delta t}$ for the different years are:—

1842. $q' = \frac{394 \cdot 5}{628 \cdot 2} = 0 \cdot 63$ sc. div.; probable error $= 0 \cdot 17$ sc. div.

1843. $q' = \frac{358 \cdot 0}{557 \cdot 4} = 0 \cdot 64$ „ „ $= 0 \cdot 14$ „

1844. $q' = \frac{477 \cdot 3}{537 \cdot 2} = 0 \cdot 89$ „ „ $= 0 \cdot 12$ „

* Observations in manuscript and printed, but not published.

1845. $q' = \frac{395 \cdot 0}{590 \cdot 5} = 0 \cdot 67$ sc. div.; probable error $= 0 \cdot 09$ sc. div.

The value resulting from Table XIII. is,

$$q' = \frac{1624 \cdot 8}{2313 \cdot 3} = 0 \cdot 702 \text{ sc. div.; probable error } = 0 \cdot 04 \text{ sc. div.;}$$

whence,

$$[q] = 0 \cdot 0001366.$$

By hot-water experiments it was found

1841, June, $q = 0 \cdot 0002686$
1841, October $q = 0 \cdot 0001667$

By applying hot sand under the suspended magnet,

$$q = 0 \cdot 0002072$$

The value adopted was,

$$q = 0 \cdot 000214$$

Therefore,

$$[q] = 0 \cdot 638 \, q.$$

36. Toronto, 1842–45. The observations in 1843 till November have not been used in this determination, on account of a derangement of the bifilar wires.* The following are the results obtained :—

1842 to 1843, February 10. $k = 0 \cdot 0000743$.

Table XIV.—Sums of Differences of Bifilar Means. Toronto, 1842.

Month.	Σ Δ *t*.	Σ Δ R.	*q′*	Month.	Σ Δ *t*.	Σ Δ R.	*q′*
	°	Sc. div.	Sc. div.		°	Sc. div.	Sc. div.
January, .	76·55	165·73	2·16	July, . . .	44·71	161·54	3·61
February, .	72·72	189·88	2·61	August, . .	30·08	80·68	2·68
March, . .	62·77	171·53	2·73	September, .	46·81	117·75	2·51
April, . .	71·46	170·00	2·38	October, . .	35·95	77·37	2·15
May, . . .	48·46	140·02	2·89	November, .	43·99	104·77	2·38
June, . .	37·83	68·98	1·82	December, .	64·35	161·55	2·51

The final result is,

$$q' = \frac{1609 \cdot 80}{635 \cdot 68} = 2 \cdot 53 \text{ sc. div.;† probable error } = 0 \cdot 08 \text{ sc. div.;}$$

whence

$$[q] = 0 \cdot 000188.$$

* Toronto Observations, 1842–43, vols. i. and ii., printed under the superintendence of Lieutenant-Colonel E. Sabine.

† The value employed by me in 1845, to correct the Toronto bifilar observations for the annual law, was obtained from a few groups of days (the sums of differences of temperature being 117°), and was $q' = 2 \cdot 55$ sc. div., almost identical with that here obtained from the whole year.

By water experiments in

$$1843,\ q = 0\cdot000260$$
$$1849,\ q = 0\cdot000234$$

The latter value should be preferred, having been made with more care, though it is a question whether the temperature coefficient is constant. We have then, adopting the value of $q = 0\cdot000234$,

$$[q] = 0\cdot804\ q.$$

37. November 1843 to December 1845, $k = 0\cdot000087$.

TABLE XV.—SUMS OF DIFFERENCES OF BIFILAR MEANS. TORONTO, 1844–45.

Month.		$\Sigma\Delta t$.	$\Sigma\Delta R$.	q'	Month.		$\Sigma\Delta t$.	$\Sigma\Delta R$.	q'
		°	Sc. div.	Sc. div.			°	Sc. div.	Sc. div.
1843.	Nov.	57·12	83·03	1·45	1844.	Dec.	49·01	54·35	1·11
	Dec.	47·59	64·48	1·35	1845.	Jan.	71·29	98·70	1·38
1844.	Jan.	83·19	86·37	1·04		Feb.	63·68	63·40	1·00
	Feb.	54·19	78·87	1·46		March	48·18	53·38	1·11
	March	60·59	20·28	0·33		April	54·34	84·04	1·55
	April	66·64	67·50	1·01		May	82·21	117·57	1·43
	May	59·30	97·93	1·65		June	56·78	68·90	1·20
	June	43·27	64·93	1·50		July	59·37	61·05	1·03
	July	41·38	47·25	1·14		Aug.	41·74	67·68	1·62
	Aug.	40·38	57·70	1·42		Sept.	43·84	81·41	1·86
	Sept.	39·23	75·82	1·93		Oct.	58·94	84·00	1·43
	Oct.	58·73	85·84	1·46		Nov.	48·52	58·16	1·20
	Nov.	51·14	136·78	2·67		Dec.	67·15	69·61	1·04

The final results are,

$$1844.\quad q = \frac{873\cdot62}{647\cdot05} = 1\cdot350 \text{ sc. div.; probable error} = 0\cdot10 \text{ sc. div.}$$

$$1845.\quad q' = \frac{907\cdot90}{696\cdot04} = 1\cdot304 \quad ,, \quad ,, \quad = 0\cdot06 \quad ,,$$

$$26 \text{ months}\quad q' = \frac{1929\cdot03}{1447\cdot80} = 1\cdot33 \quad ,, \quad ,, \quad = 0\cdot05 \quad ,,$$

Therefore,

$$[q] = 0\cdot000116$$

By water experiments, last determination,

$$q = 0\cdot000234$$

and

$$[q] = 0\cdot496\ q.$$

The low value of q' obtained in this case, compared with that by water experiments, resembles the value obtained for the magnet C_2 at the Cape (§ 25), and both, it seems to me, indicate some derangement of the wires.

38. *P.S.*—I have discussed the observations made in 1846, 1847, and till June 30, 1848 (Toronto Obs., vol. iii., received since this paper was written), for the temperature coefficient: the observations for 1846 gave $q' = 1{\cdot}355$ scale divisions, but those for 1847 and 1848 were so vitiated by large disturbances (in some cases the daily differences being upwards of 100 scale divisions), that they were evidently unfitted for a good determination; and some mode of rejecting the larger disturbances was desirable. In order, however, that the same rule should be followed throughout, the differences which after correction for temperature (by $q' = 1{\cdot}33$ scale divisions) were found to exceed 10 scale divisions, were rejected *in all cases* from November 1843 to June 1848. The following are the results:—

1844.	$q' = \frac{790{\cdot}60}{630{\cdot}43}$	$= 1{\cdot}254$ sc. div.;	prob. error $= 0{\cdot}081$ sc. div.;	diffs. rejected $= 2{\cdot}7$ per cent.
1845.	$q' = \frac{914{\cdot}21}{679{\cdot}83}$	$= 1{\cdot}354$ „	„ $= 0{\cdot}038$ „	„ $= 2{\cdot}0$ „
1846.	$q' = \frac{790{\cdot}83}{626{\cdot}24}$	$= 1{\cdot}263$ „	„ $= 0{\cdot}074$ „	„ $= 6{\cdot}3$ „
1847.	$q' = \frac{863{\cdot}03}{583{\cdot}99}$	$= 1{\cdot}478$ „	„ $= 0{\cdot}077$ „	„ $= 12{\cdot}0$ „
[1848].	$q' = \frac{649{\cdot}23^*}{428{\cdot}31}$	$= 1{\cdot}516$ „	„ $= 0{\cdot}054$ „	„ $= 13{\cdot}3\dagger$ „

If we weight these results by the inverse squares of the probable errors, we obtain $q' = 1{\cdot}378$ sc. div.; but we obtain the most probable result by taking the sums of differences for the whole period, or

$$q' = \frac{4007{\cdot}90}{2948{\cdot}80} = 1{\cdot}359 \text{ sc. div.; probable error} = 0{\cdot}029 \text{ sc. div.}$$

This differs only 0·03 sc. div. from the result obtained for 1844 and 1845. There appears, however, to be an increase in the value of q' for 1847 and 1848, but whether this is a real increase (which is quite possible, if the value depends on the condition of the wires) would require a more careful discussion to determine. The daily means vary so similarly at all the stations that it only requires for such a discussion to have one station accurately corrected (or to take a station within the tropics where the temperature variations are small), when, by subtracting the corrected daily mean scale readings reduced to a common unit (rejecting days of large disturbance) from those for the station whose temperature coefficient is required, the remainders will depend almost entirely on the differences of temperature for the bifilar in question.

* This includes the six months of 1848, and the two months of 1843.

† Six months of 1848 only, no differences having been rejected in November and December 1843.

39. The following table contains the final results for each bifilar. An examination of it will show, that the true temperature coefficient is on an average only seven-tenths ($\frac{7}{10}$) of that previously obtained from experiments in water of different temperatures, and that in some cases the former is only one-half of the latter.

TABLE XVI.—VALUES OF THE BIFILAR TEMPERATURE COEFFICIENT q AS OBTAINED FROM COMPARISONS OF THE DAILY MEANS, AND FROM EXPERIMENTS IN WATER AT DIFFERENT TEMPERATURES.

Observatory.	Magnet.	Period Discussed.	Coefficient from Daily Means, $\frac{(q)}{k}=q$	Probable Error.	k.	$q'k=(q)$.	Coefficient by Water Experiments, q.	Ratio $\frac{q'k}{q}=\frac{(q)}{q}$.	Remarks.
			Sc. Div.	Sc. Div.					
Makerstoun,	...	1843-45	1·90	...	0·000140	0·000266	0·000304	0·875	
Cape of Good Hope.	R	Dec. 1841 – Oct. 1843	1·183	0·05	0·000180	0·000213	0·000290	0·734	q and q' for $t=63°·6$
Cape of Good Hope.	R	Nov. 1843 – Oct. 1844	0·587	0·03	0·00035	0·000205	0·000287	0·714	q and q' for $t=67°$
Cape of Good Hope.	C_2	Nov. 1844 – June 1846	0·438	0·04	0·00022	0·000096	0·000220	0·484	...
St Helena, .	...	1842-43	1·92	0·06	0·000189	0·000193	0·000260	0·742	q and q' for $t=65°$
Hobarton,	...	April 1842 – June 1843	1·520	0·05	0·000120	0·000182	0·000234	0·778	
Hobarton,	...	Aug. 1843 – Sept. 1848	0·692	0·02	0·000229	0·000158	0·000230	0·689	
Trevandrum,	No. 3	1842	1·56	0·15	0·000135	0·000212	0·000253	0·838	
Trevandrum,	No. 5	1843-45	2·17	0·09	0·000144	0·000312	0·000347	0·899	
Singapore, .	...	1842-45	0·70	0·04	0·000195	0·000137	0·000214	0·638	
Toronto, .	...	1842	2·53	0·08	0·000074	0·000188	0·000260	0·723	
Toronto, .	...	Nov. 1843 – June 1848	1·36	0·03	0·000087	0·000118	0·000234	0·500	

40. *Remaining and Accidental Errors.*—I shall notice briefly, in conclusion, the other sources of error to which the instrument is liable.

1*st*, In suspending the magnet, the wires are apt to receive a twist or kinch; as the wire gradually takes the *set*, the scale readings change, indicating an increase of horizontal force if the twist has been with the torsion (v), and a diminution of force if the twist has been in the opposite direction. An example of this is to be seem in the " Makerstoun Observations," between June and September 1841.

2*d*, From the wires lying on the *side* of the screw threads instead of in the hollow. An example of this (if not of the 1*st*) is to be found in the observations made at Toronto, when the force appeared to increase $\frac{1}{18}$th of its whole value between February 24 and October 9, 1843.

3*d*, From sudden shocks, including those due to concussions of the air by thunder-claps and sudden slamming of doors. Examples of both of these were observed at the Observatory on the Agustier Mountain in Travancore.

4th, From ill-closed boxes, currents of air, and entry of spiders. Examples of these are unfortunately not wanting.

5th, From the thermometer within the box not showing the true temperature of the magnet. The error due to this cause may be great; and it is considerable in observatories where stoves have been used, and where there are necessarily sudden changes of temperature.

6th, From the copper ring used as a quieter, which has sometimes changed its position, and which has a variable effect in different positions of the magnet.

7th, From the shifting of the telescope on its pillar.

8th, From the approach of magnets, or articles containing iron.

All these, and other sources of error, have to be cared for, and the corrections to be applied, wherever the errors exist, if it is wished to give the observations any real scientific value.

XXI.—*Fragmentary Notes on the Generative Organs of some Cartilaginous Fishes.* By John Davy, M.D., F.R.S. Lond. and Edin., &c. (Plate XXII.)

(Read 7th January 1861.

These notes have been made at different intervals of time, and in different places,—some, and the majority of them, in Malta, in 1832–33,—some at Constantinople in 1839–40, and a few at a still earlier period, viz. in 1816, when on a voyage to Ceylon.

Imperfect and brief as many of them are, I am induced to submit them to the Society, thinking they may be of some use as conveying the results of unbiassed observation, and that, as such, they may prove a small contribution to a difficult branch of icthyology,—difficult, not indeed so much from the nature of the subject as from the comparatively few opportunities enjoyed by naturalists of obtaining specimens.

In accordance with the heading, I may premise that, in the details to be given, I shall do little more than transcribe the account of the particulars observed, and nearly in the words employed at the time of noting them down,—and this, though the terms may not always be of the most approved and correct kind.

The only general remarks I shall have to offer will be a few in conclusion.

1. *Of the Squalus Squatina.*—The notes I have on this fish were all made in Malta. The subjects of them were two females in a gravid state, and the generative organs detached of other eight, which were procured from the fishmarket of Valetta,—the Squatina being a fish there in some request amongst the lower classes as an article of diet. I shall give them nearly in the order in which they were made, submitting a brief notice of the organs in question, conveying the idea I have been able to form of their general structure.

In most respects they are very similar to the same organs in the torpedo.* Like them, they may be said to consist chiefly of three parts: the ovaries, situated high up above the liver; of oviducts, with a common infundibulum; and of two uterine cavities, expansions as it were of the oviducts. Each oviduct has two glandular bodies, one above the other, not unlike the one belonging to the oviduct of the torpedo, but somewhat larger, and its transverse striæ more strongly marked. The uterine cavities differ from those of the torpedo, in being smooth and entirely destitute of villi. During gestation they seem to be virtually closed, so that though a probe can be passed, both in the direction of the ovaries

* See Physiol. and Anat. Res., vol. i. p. 55, for an account of these organs.

upwards, and in that of the cloaca downwards, yet they are capable of holding a fluid, of which a certain quantity has always been found present, associated with the contained ova and their embryos. These cavities, at least in the early period of gestation, have been found to communicate with the cloaca by two openings close to the papilla, in which is the common passage from two urinary bladders. Whether these openings do not become one at a more advanced period, I am doubtful. The figures in Plate XXII., from rude sketches with the pen made from nature, will help to give some idea of the several parts.*

The first specimen examined was procured on the 30th August. Each uterine cavity was found to contain two ova with an embryo attached to each by an umbilical cord,† in the midst of much transparent colourless fluid, without any traces of a common enveloping membrane. The ova were large; each weighed about $2\frac{1}{4}$ oz. They consisted entirely of yolk, and, like those of the torpedo, they had two membranes, one internal, very delicate and transparent, of little more consistence than that of the albumen ovi of the fowl, but thickening towards and in the cord, the other internal and vascular. The embryos were all small, and of about the same size.‡ The branchial filaments were very short, and of a bright red colour; the eyes large and projecting; the mouth and gullet very large; the stomach very small; the intestine large and empty; the liver large.

On the 31st of the same month another specimen was procured. Three ova, with embryos, were found in one uterine cavity; two in the other. They were nearly in the same stage of development as the preceding. One egg with its embryo weighed $3\frac{1}{2}$ oz.; the embryo, 22 grs.; another embryo, 17 grs. The former measured 1·7th inch in length, ·45 inch in width. Some yolk was found in its intestine. The branchial filaments of both were about the same length as the preceding. The other eggs were not weighed; their membranes were so delicate that they broke in the attempt. The oviducts entire, including the uterine cavities and their contents, weighed $22\frac{1}{2}$ oz.; emptied of their contents their weight was $1\frac{3}{4}$ oz. and 29 grs. Now, supposing the weight of all the five eggs to be nearly the same, the weight of the fluid in both cavities would be about $4\frac{1}{4}$ oz. The cavities differed from the preceding, in being distinctly vascular.

On the 12th September, a female fish was examined that weighed 6 lbs. An embryo was found in each uterine cavity, and attached to one of the ovaries a

* Fig. 1. The oviducts expanding into a uterine cavity. Fig. 3. Kidney and urinary bladders.

† I use this term for the sake of convenience in its ordinary sense, and not being aware of any sufficient reason for discontinuing it, seeing that it performs the same part as the umbilical cord in the mammalia, connecting the embryo with its source of nourishment: moreover, a mark remains of it, denoted by a depression, after its removal by absorption, which may be called an umbilicus. This at least I have seen in the young torpedo.—See my "Researches Physiol. and Anat.," plate vii. fig. 1., in which it is shown.

‡ See Plate XXII., fig. 2.

large egg. Its membranes had been broken; but from what remained, it might be inferred to be of its full, or nearly full size, and ready, or nearly so, to be detached, and to pass into the infundibulum. Many small ova were contained in the ovaries. Both embryos were very small, with short branchial filaments. Some small tortuous vessels, conveying fluid blood, were seen on the inner surface of the uterine cavities.

On the 13th September another specimen was obtained. In each uterine cavity were two ova, with an embryo attached to each. One egg weighed $4\frac{1}{2}$ oz. and 40 grs.; the embryo 28 grs. An egg from the other cavity weighed 4 oz. 5 drs.; the embryo 26 grs.: the other egg $4\frac{1}{2}$ oz. 40 grs.; its embryo 30 grs. This embryo was $2\frac{1}{4}$ inches in length. Its branchiæ were beginning to be covered; its branchial filaments were red, and very short. No yolk-substance was found in its intestine.

On the 30th September, a specimen then procured contained an unusual number of ova, four in one cavity, three in the other. The eggs weighed, with their embryos attached, and the latter, after their separation, gave the following results:—

	Eggs and Embryo.		Embryo.	
	Oz.	Dr.	Dr.	Gr.
1. . . .	3	5	1	46
2. . . .	3	5	1	57
3. . . .	3	$6\frac{1}{2}$	1	46
4. . . .	3	$4\frac{1}{4}$	1	57
1. . . .	3	$6\frac{1}{4}$	1	50
2. . . .	3	$3\frac{1}{8}$	1	50
3. . . .	3	6	1	55

Four of the embryos were females, three were males. In most of them the branchiæ were no longer naked, and the branchial filaments had disappeared. Put into fresh water, some of them showed signs of life—a movement of their gills was perceived. The internal yolk-membrane was stronger than that of any of the preceding at an earlier stage, allowing the egg to be lifted without breaking, the thickness increasing towards the end. The internal membrane was beautifully vascular. There appeared to be two orders of vessels, their branches anastomosing, one conveying a brighter blood than the other; the vessels conveying the former smaller than those conveying the latter. The intestine of two embryos was examined; a little greenish matter, but no yolk, was found in it; yet, using the blowpipe, air passed pretty freely into it through the vitello-intestinal canal. The gills were similar to the preceding. The brain was distinctly formed; the kidneys were comparatively large; all the fins were distinct. The quantity of fluid in the uterine cavity was considerable.

In a specimen procured on the 2d November, an embryo was found in each uterine cavity. The ovum of one was broken; the other, which was entire, weighed, with its embryo, 3 oz. $6\frac{1}{3}$ drs.; the weight of the embryo detached was 3 drs. and 11 grs. The gills were no longer naked, and they were without filaments; one embryo was opened. The substance of the egg was found passing into the intestine though a straight canal. The intestine was distended with a greenish matter, coloured by bile. The ovum presented a beautiful vascular appearance.

On the 9th of the same month another specimen was obtained. Two ova, with their embryos, were found in one uterine cavity, one only in the other. All the eggs were broken but one. It, with its embryo, weighed 3 oz. $3\frac{1}{3}$ drs.; the embryo alone weighed 1 dr. The branchial filaments were short, but distinct. The stomach was very small and empty. A little greenish matter was found in the intestine. A considerable quantity of fluid, as usual, was found in each uterine cavity, and of its ordinary appearance, clear and transparent, and colourless, and slightly saline to the taste; a portion of it evaporated yielded a considerable quantity of coagulated albumen; washed with alcohol, the solution obtained slowly evaporated, frothed at a temperature considerably below the boiling point, giving the idea of the presence of urea. When evaporated to a moderate degree of consistence, a drop of strong nitric acid was added, an immediate formation of white matter took place: this at the time I supposed to be nitrate of urea, as it dissolved on the addition of a little water, and as, when evaporated in its turn, a solid matter appeared in minute white scales, here and there giving off gas from decomposition: with these scales were intermixed a few minute prismatic crystals.

On the 8th February, the last specimen of which I have to make mention was obtained. This was a fish of about two feet in length. The oviducts, with the uterine cavities, formed a complete circle. The uterine cavities were thin, distended, and vascular, and were lined with much thick mucus or mucus-like matter. They contained each a single fœtus. Each fœtus was about six inches long, and appeared pretty perfect in form. The eggs were still large; one fœtus was opened. A yolk-sac was found in the cavity of the abdomen, freely communicating with the outer yolk, and with the upper part of the intestine. The intestine was distended with the substance of the yolk, which in its lower portion was of an orange hue. One of the young fish was in part corroded, as if by the action of the fluid with which it was in contact: it showed no signs of putridity.

2. *Of the Squalus Galeus.*—The only notes of the generative organs of this species which I have were made in Malta, and are very brief. On the 25th January a female was procured from the market. Its uterine cavities were semi-transparent, and lined with a very vascular chorion. Each cavity contained three young fish; and each of these was included in a very delicate membrane, together with some gelatinous fluid. There was no appearance of an internal yolk; but to each

fœtus was still attached the residue of the umbilical cord, still vascular; its floating extremity its thickest part. When the fœtal fish were opened, an internal yolk-sac was seen in each, communicating with the upper portion of the intestine. The sac was distended with the substance of the egg, and a substance of the same kind was found in the intestine.

From one of the ureters of the parent fish a fawn-coloured matter was pressed out, semi-fluid, not unlike lithate of ammonia. With equal parts of nitric acid and water it effervesced, and frothed when heated; but it became brown, not purple. There was not sufficient for further examination. It seemed to resemble the urine of the torpedo. May it not be a peculiar kind of animal matter?

3. *Of the Squalus Acanthias.*—The notes on this fish were made in part in Malta, and in part at Constantinople. The specimens examined were eight, one only of which was a male.

This male fish was procured from the fish-market of Galata. It was about two feet and a half long. Its anal appendages were of moderate size, composed of muscles and cartilages. Each organ communicated by a canal with an abdominal sac. These sacs, situated immediately under the common integuments, one on each side of the mesial line, were lined with a smooth, very vascular membrane, and contained a little opaque fluid, consisting, as seen under the microscope, of minute granules. The canal or duct of each terminated on the inner surface of its corresponding appendage. The appendages were without the glandular body met with in these organs of the rays, but each contained what I believe to be an auxiliary heart, such as I have described as occurring in the *Raia batis.** The proper generative organs were well developed. The testes, situated high up under the liver, were of a large size, about $3\frac{1}{2}$ inches long by $\frac{3}{4}$ inch broad, rounded at their extremities, of a pale hue, and indistinctly mammillated, as if composed of no well-marked lobules. Each was bordered by a milt-like appendix, similar to that belonging to the testes of the *Raia clavata*, of which a figure is to be found in the work just quoted. This latter part was connected with the epididymis, or commencement of the vas deferens, by several straight tubes passing across, and included, in a delicate peritoneal fold. The epididymis superiorly, was small, the vas deferens there composing it being very slender and convoluted, but not collected in a mass as in the instance of *Raia clavata.* As it descended, still tortuous, till about $2\frac{1}{2}$ inches from its termination, it suddenly enlarged and became very capacious, continuing so till it terminated in the common receptacle of the spermatic and urinary fluid—*i. e.*, that receptacle in which the ureters end as well as the vasa deferentia. The capacity of each vas deferens, when expanded, was at least equal to that of the common receptacle; each contained about half a cubic inch of a creamy-yellowish fluid. The same

* See Physiol. and Anat. Res., ii. p. 451.

kind of fluid was contained in the common receptacle, but of rather thicker consistence. This fluid, microscopically examined, was found to abound in spermatozoa. They were seen also in the fluid of the vas deferens, but not in the epididymis, testis, or in its milt-like appendix. The fluid obtained from these exhibited only granules similar to those found in the like parts in the *R. clavata*, suggestive of a growth, in transition, from granules into spermatozoa. The common receptacle or bladder terminated in a rudimentary penis, projecting about one-third of an inch into the cloaca, and about half an inch from the verge of the anus. The spermatozoa, of a spiral form, extremely fine at each extremity, were very long in proportion to their breadth—at least thirty-two times longer. Their length was about $\frac{1}{500}$ of an inch.*

The female generative organs of the Acanthias have a considerable resemblance to those of the torpedo, especially in the circumstance that the uterine cavity, when gravid (and it does not appear to exist except in this stage), has a distinctly villous structure.

All the female fish examined, with the exception of one, were procured in Malta.

The fish obtained at Constantinople was got from the market on the 17th February. It was shorter than the male fish already noticed, being about two feet long, but proportionally thicker. I expected to have found it gravid, but it was not; the generative organs were little developed. The ovaries, situated high up under the liver, were each about the size of a sixpence, and each only a few lines thick. They contained a small number of ova, the largest not bigger than a peppercorn. These, cut open, yielded a little glairy fluid, which, under the microscope, exhibited globules and granules. The oviducts were very small,—so much so as to be traced with difficulty. To each of them, near the ovary, a glandular body was attached, of about half an inch in length.

On the 3d March, in a female about a foot and a half long, an egg was found in each uterine cavity. It was of a long, oval form, within a delicate transparent membrane, containing a little clear fluid.† There was no appearance of fœtal development. The uterine cavity was of a bright vermilion colour, and covered with villi. The ovaries were situated nearly as in the torpedo; each was a small cluster of ova attached to the peritoneum. The ovdiucts joined the infundibulum over the superior margin of the liver. In each, a little higher than the uterine cavity, was a glandular structure.‡

On the 10th March two uterine cavities, which had been found gravid on opening the fish in the market at Malta, were brought to me. In each were two embryos, with the ova to which they were attached. They were free—that is, without any including shell or membrane. The lining coat of the cavity was

* Pl. XXII., fig. 4. † See fig. 5. ‡ Fig. 6.

strongly villous; the villi projected two or three lines; the surface, moreover, was beautifully vascular, and of a bright vermilion hue. The villi appeared to be formed of looped blood-vessels. The yolks belonging to the two embryos in each cavity were somewhat different, comparing the external and internal portion; in one instance the outer yolk bag was reduced very small,—the inner had become pretty large; in another the case was the reverse,—the outer was the largest. As might have been expected, there was a correspondence in the size of the young fish: the development of that to which the smaller internal yolk belonged was farthest advanced.

It may be mentioned that one of the uterine cavities, which made a very beautiful appearance from its vessels being distended with vermilion blood, was put into distilled vinegar; and that, when examined two days after, the vessels were found to contain air, as if extricated from the blood during its partial solution.

On the 1st April two small fœtal fish, each about two inches in length, attached to their ova, were procured from the market. On extraction from the parent fish they had been put into water, according to instructions given to the Maltese fisherman, and which were observed in other instances. The branchial filaments were nearly an inch long, and were numerous. The head was large, the eyes very large; distinct marks of spines were apparent anterior to the dorsal fins.

On the 15th April a fish was obtained in which several eggs were found, nearly of their full size, attached to the ovaries. In one uterine cavity there was a single fœtus; in the other, two. No membrane enveloped them; they seemed nearly fully formed, and were in immediate contact with the villous surface. This was very vascular,—its colour bright red. Two of the young fish were opened. The yolk of each egg was in part internal; but the inner yolk was small in comparison with the outer, and the sac containing it was even less in size than the intestine, which was distended with yolk substance. The stomach was empty. The communication between the gut and the inner yolk sac—the vitello-intestinal canal—was sufficiently large to allow of the free passage of an ordinary surgeon's probe. The contents of the intestine were of a brighter yellow than the yolk in either the inner or outer sac.

On the 1st October, in a small fish then examined, a single fœtus, tolerably advanced, destitute of branchial filaments, was found in each uterine cavity. In one of the ovaries were minute ova about the size of a millet seed; attached to the other were some that were pretty large—about the size of a boy's playing marble; their enveloping membrane was highly vascular.

On the 22d of the same month a fish was obtained about two feet long. An ovum was found in each of its uterine cavities, contained in a delicate transparent capsule, which, towards its ends, had a light olive hue and a slight horny appearance. It contained a considerable quantity of white, a pretty large yolk, and an embryo about $1\frac{1}{2}$ inch long. Large vessels passed from the yolk by the cord to the embryo. About one half of the yolk's proper membrane, at each side of the cord, at its margin, was beautifully vascular. The eyes of the embryo were large; the fins very small—only just appearing on the back, the pectoral more distinct. The branchial filaments were long, and of a bright red. Besides these filaments there were others similar, proceeding from the head, its back part, and also from each side of the abdomen, in a line extending from the pectoral fin.* Each filament—the branchial are specially mentioned—on careful examination with a lens, was found to contain four blood-vessels terminating in loops.

In a fish procured on the 15th May, of about the same size as the last, two eggs were found in each uterine cavity, with an embryo attached to each. The ova and embryos were contained in one common, very delicate, and transparent shell. Each embryo was in the same stage of development; each about three-quarters of an inch long. Viewed with a magnifying glass, its eyes were distinct and proportionally large; they were almost colourless, with hardly a trace of a pupil. The mouth was proportionally large, and apparently expanded wide. It gave the idea of the jaws being formed rather than the mouth itself. The branchial cartilages were distinct. Two or three short filaments were pendant from them on each side. Close to where the umbilical cord entered was a red spot—the heart. A vessel carrying red blood extended from it to the tail, and returned. The pectoral fins were small, the dorsal only just appearing, the tail gradually tapering. An attempt was made to lay open the cavity of the abdomen, but it failed, though using a very delicate and sharp scalpel, owing to the great tenderness of the parts,—it was torn rather than cut. The cartilaginous skeleton throughout seemed to be formed. The ovaries contained ova of different sizes; the largest were about the size of large cherries, the smallest about the size of a millet seed.

Another fish, also of about the same size as the two preceding, was obtained on the 13th June. Two eggs were found in each uterine cavity, with an embryo attached to each, in about the same stage of development as the last mentioned. Besides the branchial filaments, there were two filaments proceeding from the head, just behind the spiracula,—the water passages.

4. *Of the Squalus Carcharias.*—On a voyage to Ceylon, when within the tropics, an opportunity occurred of making a hasty examination of two gravid fish of this kind. In the uterine cavity of one, designated a small shark, taken in Lat. 8° 23′ N., four fœtal fish were found, each about a foot long, with "a placenta" attached to each. From three the placenta was immediately removed, —cut or torn off. These fish died almost instantly. The one from which it

* See Plate XXII., fig. 7.

was not removed lived in the open air at least three hours after its extraction. Its stomach and intestines were both found empty; no yolk was detected internally. No mention is made of any including capsule, seeming to warrant the inference that no membrane of the kind remained, and that the young fish were in contact with the walls of the uterine cavity.

The other shark, which was called a large one, was taken in Lat. 2° 34′ N. In its uterine cavities nine fœtal fish were found, five in one cavity, four in the other. Each was contained in its own membrane, full of "liquor amnii," and each was connected with "a placenta" by a long "umbilical cord." All of them were about the same size—about two feet long. When extracted and thrown on deck, they were active and vigorous. Though without advanced teeth, two or three of them were seen to make an effort to bite a stick thrust against them.*

The so-called "liquor amnii" was very salt to the taste, was slightly viscid, not quite transparent, and of a light grey colour. A few white flocculi were suspended in it. When boiled, it did not coagulate or undergo any apparent change. Evaporated, it thickened, became brown, and ultimately black from charring, when it emitted much smoke and a strong ammoniacal odour.

In the stomach and intestines of the parent fish, four different kinds of parasitical worms were observed,—two in the former, two in the latter.

5. *Of the Squalus Centrina.*—In the month of March, when at Constantinople, I procured two fish of this kind, which had been taken in the Sea of Marmora, and, it is worthy of remark, by the same cast of the net: they were male and female.

The male fish was about 2½ feet long, and rather slender. The testes† were pretty large, each nearly of the form of a date, its surface vascular, smooth, and equal. Its substance was soft; when cut it yielded some opaque fluid, which, under the microscope, was seen to abound in globules. The milt-like part superiorly was thin and small; cut into, it yielded a milky fluid, in which, under the microscope, numerous globules were seen, and one spermatozoon. The epididymis, itself small, was connected with the milt-like part by four or five delicate tubuli; these, divided under water, yielded a little milky fluid, also abounding in globules similar to those of the milt-like part. A milky fluid was also obtained from the epididymis, from its superior portion. This was rich in spermatozoa; it contained, besides, a few globular particles. The vas deferens and the vesicle in which it terminated yielded a cream-like fluid, rich also in spermatozoa. The vesicle in which, probably, the ureters also terminated (it was not ascertained by

* Other instances of a like kind might be mentioned, showing how provident Nature is in giving instincts and organs to young animals, suitable to their protection when in their feeblest state, and their lives, in consequence, most in danger. The fœtus of the torpedo, even before birth, I have found capable of giving a shock. In the fœtus of the viper (*Coluber berus*) I have found the poison-fangs developed. The young alligator I have seen, as soon as it left the egg—and that prematurely, from the egg being broken—make to the adjoining water, and, if stopt, attempt to bite the arresting object.

† See Plate XXII., fig. 8.

dissection), communicated with the cloaca through a papilla, the rudimentary penis. The spermatozoa were all similar. Many of them were collected in a cluster. They were all motionless in fresh water and in brine; but in salt water —that of the Bosphorus*—many of them were active. They were found to vary in length from about $\frac{1}{400}$ to $\frac{1}{200}$ of an inch. The diameter of the rounded extremity was about $\frac{1}{4000}$ of an inch.† The anal appendages were large, and proportionally thick. Each communicated with a subcutaneous sac similar to that of *S. acanthias*. The cavity of each was about an inch long, and follicular. The appendages, in their general structure, were "similar to those of the rays and squali."

In my "Researches Physiological and Anatomical," when treating of the male organs of cartilaginous fishes, I ventured to offer the conjecture—an old opinion—that the anal appendages, the characteristic of the male fish, are designed for the purpose of intromission in the performance of the generative act, and I then quoted a passage from Aristotle to the same effect: "Sunt qui se vidisse confirmant non nulla in cartilagineis aversa modo canum terrestrium cohærere." In examining these two fishes, I found what appeared to me to be circumstances favourable to the above supposition. In the instance of the male, the generative organs, as described, were clearly in the condition required at the breeding season. Those of the female were found to be so also. The female, about one-third larger than the male exclusive of the anal appendages, was similar to it in form and appearance. The cloaca, the common opening,—that in which the intestine and uterine cavities terminated, —was sufficiently large to admit the appendages; and it is worthy of remark, that the part was slightly lacerated at its superior commissure; also, that the mouths of the uterine cavities were protruding, and were very red and vascular. Within the cloaca, between the two uterine openings, above the opening into the intestine, was a clitoris, if I may so call a vascular conical projection, of about one-eighth of an inch in length, through which was a passage from the urinary bladder. The bladder was of a globular form, and pretty large; two ureters terminated in it, at its upper end. The ovaries contained ova of different sizes, the largest about the size of a boy's playing marble. They were enveloped in a delicate vascular membrane. Their contents were of a soft consistence, like the yolk of the egg of the common fowl, and of a light cream colour. Above the liver was situated the infundibulum of the oviducts. These ducts were thin and plicated. About two inches above the uterine cavities, on each side, was a glandular body, forming a part of the oviduct. The uterine cavities were long, wide, and capacious. Their superior opening was small, their inferior large. Their inner surface was red, and covered with villi—these about a quarter of an inch long; they were well displayed by immersion of the part in water. Both the oviducts were empty,

* This water is less salt than that of the sea—the Mediterranean and ocean—nearly the same as that of the Euxine. I have found it of sp. gr. 1012, that of the Euxine being 1011.

† See Plate XXII., fig. 9.

as were also the uterine cavities. A little fluid lubricating the latter was scraped off and subjected to the microscope; some blood corpuscles were seen in it, and minute globules, and also two spermatozoa, respecting which it is said in my notes, "I think there can be no mistake, their form being so peculiar."

6. *Of the Raia Aquila.*—Of this fish I have notes of two specimens only, both procured in Malta, and both females.

The first was procured on the 12th April. In each of its oviducts was a large membranous shell, which, independent of its horns, was about five inches long. One of them, opened, was found to contain a yolk about the size of the yolk of a hen's egg; a considerable quantity of glairy white enveloped it. The shell externally was nearly black—rough, tough, and very strong: internally it was lined with a delicate white glistening membrane. Above that part of the oviduct in which the egg was contained was a large globular body surrounding the duct, in appearance, as to structure, more like a testis than any other that at the instant I could call to mind. The lower end of the oviduct terminated in the cloaca; it was so contracted, that the little finger was introduced with difficulty. There was no appearance of development in the ova.

The second fish was obtained on the 22d September. Though quite fresh, its ovaries and oviducts were for most part reduced to a pulp, as if by a process like that which sometimes destroys the stomach, and has been referred to the action of the gastric juice. In this instance, however, the stomach was quite sound, without any traces of softening. It was of moderate size, full of *broken* food, suggesting the idea that this fish masticates its food, for which its strong, laminated molar teeth are so well adapted.

7. *Of the Squalus Canicula.*—Of this species I have notes of four, one of them a male. All were procured in Malta.

I shall first make mention of the male. It was obtained on the 11th September. Its anal appendages are merely stated to be similar in structure to those of the torpedo, the lateral anal fins uniting behind them and partly covering them. The testes were very distinct, and situated high up in the abdominal cavity; the spermatic tubes large and tortuous, terminating in vesiculæ seminales, and these in a single papilla situated in the cloaca, close to the anus. When the vesiculæ were pressed, a thick, creamy fluid was discharged, flowing from the papilla.

Of the other fishes, females, the first was obtained on the 22d April. A large cluster of eggs was situated over the spine: these of various sizes—the largest about the size of large cherries; their membrane was vascular, including a yolk. The upper part of each oviduct was also very vascular. The infundibulum was small. In the oviduct there were no ova and no enlargement. Each was provided with a glandular structure. Below the gland, where it is presumed the egg would rest and acquire its shell, the oviduct was very small and pale—not thicker than a crow quill—its sides in contact.

On the 15th of May another fish was obtained, of about a foot long. An egg was found in each of its oviducts, enclosed in a firm, hard shell,—so hard as not to be easily cut. The ovum was of a brownish hue, and was surrounded by a glairy white. No traces of development could be detected in it.

On the 28th of August two ova, each in its shell, were got from the market, said to have been extracted from the left oviduct of a catfish. Each shell was about two inches long, and about half an inch wide, tough, and yet transparent, pointed at its extremities, from both of which a strong fibre proceeded. The fibres, drawn straight—that from one end measured about a foot in length, that from the other about half a foot. The largest was in part divided into several delicate filaments.* The contained ovum, seen through the transparent shell, was situated midway. In one shell that was opened, a yellow yolk was found in a small quantity of colourless, transparent, and "very viscid white." This "white" did not mix readily with water, and was not coagulated by nitric acid.

On the 5th September two fish were obtained, both of them gravid. The condition of the generative organs of each was similar. In each oviduct an egg was found, surrounded by white, in a semi-transparent shell. One was immersed in boiling water. The yolk became hard after having been boiled about two minutes; the white did not coagulate, nor undergo any apparent change,—it remained transparent and viscid. On each side, above that part of the oviduct holding the egg, and about an equal distance from the infundibulum, was a glandular body surrounding the tube. The infundibulum was large, and very vascular. The ovaries, joined together, lay in the direction of the spine, about half-way between the oviducts, and about the same distance from the infundibulum. In them was a cluster of ova of different sizes, connected by a loose cellular tissue. The smallest of the cluster were about the size of mustard seed, hard, and opaque; the largest were nearly the size of the mature yolk, but spherical in form. Between the largest and the smallest there were many of intermediate grades. The largest were situated lowest, and consequently most distant from the infundibulum.†

8. *Of the Scyllium Melanostomum.*—Of this fish I have notes of two, both procured at Constantinople,—a male and a female,—and both in the same month, February.

The male was about two feet long, and slender. Its testes were proportionally large,—one on each side of the spine, not distinctly divided throughout.‡ They were of a light fawn colour and soft consistence, more resembling the testes of the osseous fishes than those of the majority of the cartilaginous kind. They tapered towards the cloaca, where it may be supposed their ducts terminated. The whole seemed homogeneous. Under the microscope, their soft substance seemed

* See Plate XXII., fig. 10. † See Plate XXII., fig. 11. ‡ See Plate XXII., fig. 12.

to be composed of globules, nearly transparent, of from about $\frac{1}{4000}$ to $\frac{1}{2666}$ of an inch in diameter. Different parts of the organ were examined, without any difference of result; no capillary spermatozoa could be detected, and the globules, except when moving in currents, were motionless. The anal appendages were small. They were not specially examined as to their structure.

The female was also about two feet long, but thicker in proportion to its length than the male. At the time it was obtained, it was not quite dead.* The ovaries were large and long, extending nearly the whole length of the abdomen. Their upper portion abounded in ova, from the size of a grape seed to that of a mustard seed, and smaller. The larger were not perfectly transparent; they contained a turbid fluid, which, under the microscope, exhibited globules of about $\frac{1}{4000}$ of an inch in diameter, and smaller. The confining membrane was thick and strong. The lower portion—more than one-half of the whole—had a milt-like appearance. Under the microscope it exhibited globular nucleated particles, of about $\frac{1}{2000}$ of an inch in diameter. The oviducts were large,—their infundibulum above the liver. To each oviduct a glandular body was annexed, just below which was a little enlargement of the tube; and towards the termination of each duct in the cloaca there was also an enlargement of it.

9. *Of the Raia Oxyrhynchus.*—Of this fish I have notes of two specimens, both examined at Malta, and both females. In one, opened on the 2d April, an egg was found in each oviduct, below its gland. The shell inclosing it was not perfectly formed; its lower moiety, which was perfect, was of a greenish brown, tough and strong; its upper portion was greyish, tender, and very easily broken.† Much thick, tenacious, mucus-like matter enveloped it. There was no appearance of an embryo.

The other fish was obtained about the same time. The precise date is not given. In this instance, also, an egg was found in each oviduct. Each egg was contained in a horny shell, the horns of which were short, as if not fully formed. A tough glutinous matter, of the colour of the shell, was found covering it, seemingly the material of which it was formed. The oviducts were red; their glandular structure large. The ovaries contained many ova; and there were several eggs loosely attached to the ovaries. They were of a spherical form,—the largest about the size of the yolk of a pigeon's egg.

In conclusion, recurring to the preceding notes, it is worthy of remark, that whilst there is a certain resemblance to be seen in the generative organs of the several species, there are also well-marked differences—differences which, it may be inferred, have relation to fœtal development. Under this head, do not the observations justify at least three divisions? 1*st*, The viviparous fish, of which the Squatina is an example, an instance, like that of the torpedo, of the ovum

* See Plate XXII., fig. 12.

† See Plate XXII., fig. 13.

passing into the uterine cavity, and there undergoing its full development, unin-closed in any shell or membrane. *2dly*, The ovo-viviparous fish, such as the *S. acanthias*, *S. galeus*, and probably *S. carcharias*, the ova of which, enveloped in a glairy white and contained in a delicate membrane, undergo their development in the same cavity. *3dly*, The oviparous fish, such as the *S. canicula*, *R. aquila*, the ova of which, provided with a horny shell the matter of which is secreted by one or more glands, are expelled from the oviducts before their development begins, and are hatched in the sea.

As regards the first division, are not the ova fully formed in the ovaries, and undergo no further increase of size after entering the oviducts? Also, as regards the fœtus, is not its growth in the uterine cavity not solely due to matter derived from the yolk, but in part to matter absorbed from the cavity itself? I am induced to suppose that this is the fact, from the analogy of the fœtal torpedo, which, at its full time of birth, I have found to be very much heavier than the egg;* and also from the circumstance that the uterine cavity, as I have seen both in the instance of the Torpedo and of the Squatina, has become much thinner as the period of gestation advanced and approached its maturity, comparing it with the average of the organ earlier.

As regards the second, is not the common including membrane or capsule of the ovum and embryo found in the uterine cavity as a temporary provisional membrane? and is it not absorbed, in part or in whole, before the young fish quit the uterine cavity? Some of the appearances described under the head of *S. acanthias* and *S. carcharias* seem difficult of explanation except on this idea. The absorption of the membrane, whilst it may conduce to the exit of the young, may aid also their growth.

Further, are not what I have called "placentæ"—the cotyledons of Muller—residual masses of vitelline vessels,—residuary after the absorption of the yolk,—the view long ago entertained by a distinguished naturalist?† and, though different from true placenta, yet do they not exercise a similar function, supposing, as I believe was the case, that in the instance of the young of the Carcharias there was an active circulation in the mass, owing to which the fœtus that had not the vascular mass detached from it lived so long?

As regards the third, are not the ova of these fish all hatched in the sea, their development altogether taking place after being laid? That they are, I have been led to believe, not so much from my own limited observations of a negative kind, never having, in the examination of the eggs whilst in the oviducts, seen any

* See Physiol. and Anat. Res., vol. i. p. 65.

† See Hist. Nat. des Poissons, par MM. Cuvier et Valenciennes. The remains of the vitellus is described by the former (inferring that the first volume was written by Cuvier) as adhering to the uterus almost as firmly as a placenta. This I have never witnessed; nor have I ever witnessed, till at an advanced period, the interior lobe of the vitellus, which is described by him as always existing in the fœtus,—" comme un appendice de l'intestin."—See *loc. cit.*

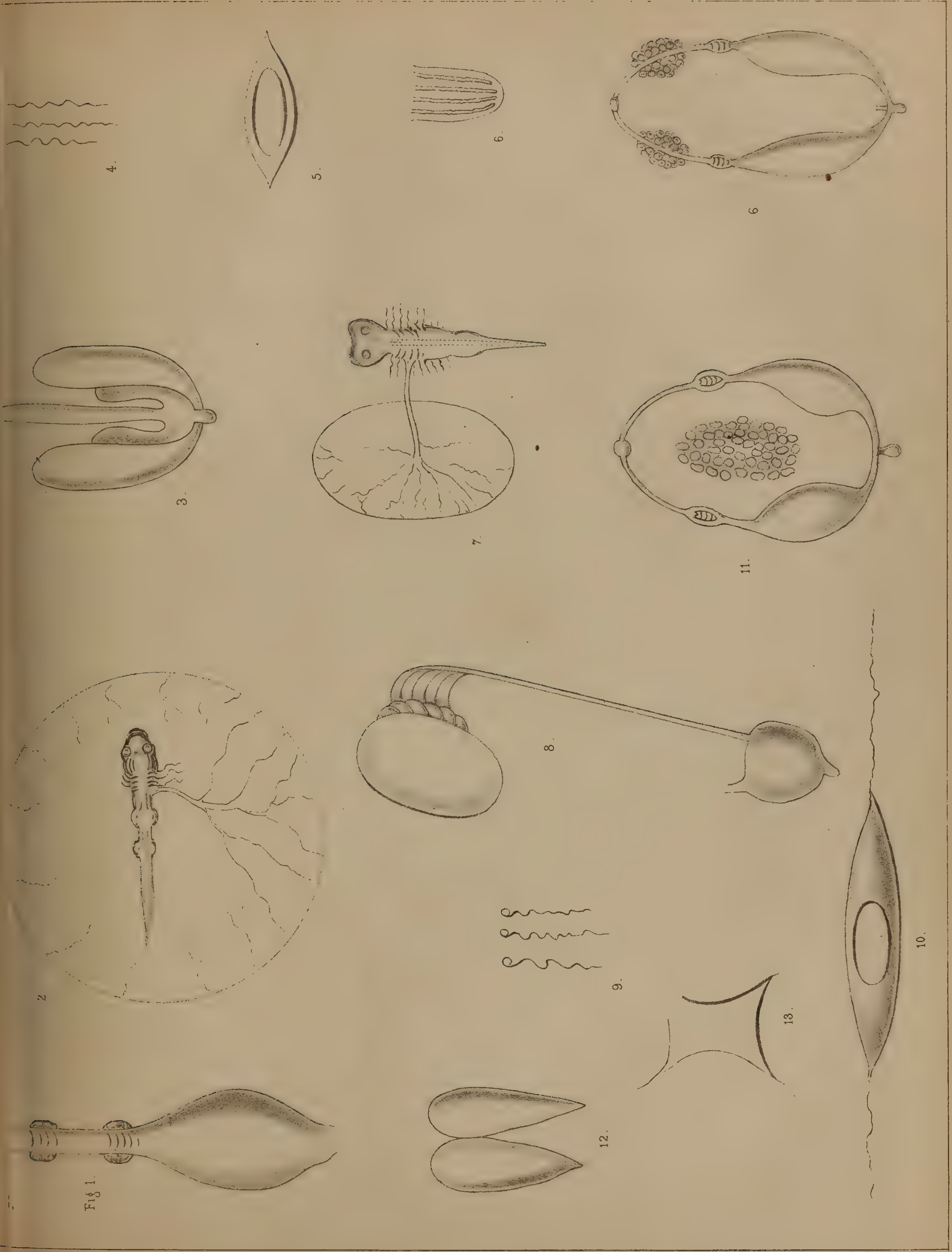
traces of embryonic growth, as from the experience of the Maltese fishermen, who, in opening hundreds of the species, I have been assured, have never found a young fish included.

The branchial filaments of the embryo of the cartilaginous fish have commonly been considered as concerned solely in aërating the blood of the young fish. Have they not another use also?—are they not concerned, in a formative way, in promoting the growth of the part to which they belong? The circumstances that they are absorbed about the time that the gills become covered,—*i.e.*, cease to be naked,—and that they are not always restricted to the branchia, seem to favour an affirmative answer.

As to the use of the anal appendages of the male cartilaginous fishes, respecting which there has been so much difference of opinion amongst naturalists,—some, as Rondelet, Willoughby, Ray, Artedi, Macri, de Blainville, following Aristotle in the opinion that they are penes, organs of intromission; others, as Bloch, Home, Cuvier, and most recent writers, maintaining that they are merely holders, "claspers," and in the generative act employed solely to embrace and retain the female,—I have been led to prefer the older view mainly from the consideration of the structure of the parts, seemingly so ill adapted for the use last referred to, especially keeping in mind the glands with which they are furnished. Which of the two hypotheses is the correct one, can only be determined by further and careful observation. The fact I have mentioned under the head of *S. centrina* must be admitted, I think, to favour most the old opinion. Theoretical arguments might be used in support of the same; but these, at best, cannot compel conviction.*

Lesketh How, Ambleside,
Sept. 22, 1860.

* Macri, in Atti della Reale Accademia Scienze (of Naples), vol. i, uses a very ingenious argument of the kind above alluded to: "In natura osservi una legge costante ed invariabile, stabilata dall' omnipotente, che quando gli animali maschi son corredati d'una sola verga, le lor femmine hanno eziando una sola vulva ed un sol utero. E all' opposto, dove le medesime son provvedute di due vulve, o d'una bifurca, e die due uteri, o d'un uteri bifido, posseggno i maschi o una verga bifida o un doppio membro generatore" (p. 83).



W H Mc Farlane, Lithr Edinr

XXII.—*Some Observations on the Albino.* By John Davy, M.D., F.R.S. Lond. and Edin., &c.

(Read 18th February 1861.)

Amongst the natives of Ceylon, the occurrence of the Albino, the offspring of dark-skinned parents, is not very uncommon. In looking over my note-books, kept whilst I was in that island, between the years 1816 and 1820, I find mention made of five several examples. Now that the subject of species and varieties is attracting so much attention, perhaps the particulars I then collected of these abnormal instances of the human race may not be altogether without interest, even if given a little in detail.

In a work "On the Interior of Ceylon," published in 1821, in describing the native races, I have stated that "The colour of their skin varies from light-brown to black;" that "the colour too of their hair varies, but not so much as that of the skin;" that "black hair and eyes are most common; that hazel eyes are less uncommon than brown hair; that grey eyes and red hair are still more uncommon; and that light-blue or the red eye of the Albino is the most uncommon of all."

The Albinos whom I had an opportunity of examining were all children of natives of ordinary colour. As already mentioned, they were five in number, and besides these, I heard of no others then alive, with the exception of one, whom I did not see.

Two of these Albinos were brother and sister. The latter was twenty-three years old, of average height, well made, and in the enjoyment of uninterrupted good health. Her skin was very white and soft, especially where it had not been exposed to the sun. Her eyes were of a very light colour, not very weak; she could bear moderate light well, but disliked strong light. The pupil showed the absence of the *pigmentum nigrum;* it was of a light flesh colour. The iris was nearly of the same colour, but lighter; its converging fibres were of a light grey hue, and very distinct, having interstices between them of a flesh colour. Her hair was nearly white, or rather of a light-cream colour, shining and fine, long, with a tendency to curl. Her eyebrows and eyelashes were of the same hue, but rather lighter. Her brother, who was three years older, had the same colour of skin, hair and eyes; and was well made, and in good health. He had a thin beard. His voice was feeble and somewhat effeminate. The disposition of both seemed to be mild and cheerful; the expression of their countenance not disagreeable. In conversation they expressed themselves readily, and seemed, if not acute, not deficient in intelligence. Neither of them was married. When questioned on the subject, the brother said he should like to have a wife, did not his poverty prevent him. They were orphans and beggars. I was informed that their parents had other two children, who were also Albinos; they died young.

The Albino of whom I have next to make mention was a young woman, well grown, and rather tall, the only child of black parents. Her hair and eyes differed in colour from those of the preceding. Her hair, long, and fine, was much darker, of a yellowish-brown. Her eyes were stronger, very like the eyes of a European of the same light complexion—a pure blonde—the pupil being black, the iris blue. In England, this young woman would be considered very fair, but not an anomaly. She too was unmarried.

The next I have to describe were sisters, two of a family of seven children, three of whom were Albinos, four of the colour of their parents. The eldest of the Albinos I did not see; she was married and living at a distance. She was described as being very like her sister next in age, a girl twelve years old. This girl was fully formed, her breasts well developed. Her skin was fair, but not remarkably so; where it had been exposed to the air it was a little sunburnt. Her hair was of a yellowish-brown colour, long and fine. The eyes were large, well formed, and not weak; the pupils were black, the iris bluish-grey, its outer margin hazel coloured. Her countenance was agreeable and intelligent; and she was described as lively and well disposed. Her sister, five years old, was fairer; the pupils of her eyes flesh-coloured, and much dilated; the iris bluish-grey. In features she resembled her sister.

All these Albinos were natives of the south-west coast of Ceylon, where the average heat is about 80° of Fahr., the yearly range remarkably small, little exceeding 10°, with a climate distinguished for salubrity, and the absence of malaria. The temperature of those I tried—the Albinos—was not peculiar; like that of the other natives and of European residents, it was about 1° higher than that of man in a cool climate.

I have heard it said that the Albino is held in contempt by the Singalese; this, on inquiry, I was assured was a mistake; on the contrary, as regards colour, that they are rather respected. Nor is such a feeling towards them surprising, considering that in the East a light hue is held to be distinctive of high caste, and *vice versa;* the lowest castes, those in least easy circumstances and most exposed to the sun, being dark. Moreover, the ethnologists of Ceylon, the Singalese savants, are of opinion, that the white races of mankind are sprung from the Albino, and *ab origine* were merely an accidental variety.

It would be interesting to know what would be the offspring of Albinos. The inquiry I made on this point was unsatisfactory; I could not learn of any descendant from Albino parents, either pure or mixed. Judging from analogy, whether we regard the blondes of the human race, or the white varieties of any domesticated animals, is it not probable that the complexion would be hereditary?

The distinctive quality of the Albino, at least in the highest degree, appears to depend on the absence of the *pigmentum nigrum*, and of its analogue in the skin, the *rete mucosum* (using the term conventionally), and of a like secreting structure, it may be inferred, in the bulbs of the hair. Now these, we know, exist greatly varied in different peoples, and even in different individuals of the same family. In those in whom the *rete mucosum* is least developed, the less we find their skin to be darkened by exposure to the sun's rays, and the fairer they remain, even within the tropics, and from generation to generation, as is witnessed in the whites of Barbadoes and of the other West Indian Islands longest settled. On the contrary, where there is a well developed *rete mucosum*, the action of the sun's rays is found to have a well-marked darkening effect. A gradation, feeble indeed, was noticeable in the skin of the Albinos I have described, and in one of them, the least colourless, a tendency to sunburn was mentioned. Taking into account this gradation, and this effect of the sun's rays, the speculation of the Singalese respecting the origin of the white races of men is not without the semblance of probability; and the more so, if we admit what seems to be proved by all experience, that the coloured races are best adapted for warm climates, and that in the most unwholesome of these climates, they have a better chance of escaping disease and a premature death, and thereby extinction of race, than the whites.

LESKETH HOW, AMBLESIDE,
February 3, 1861.

XXIII.—*On the Horizontal Force of the Earth's Magnetism.* By JOHN ALLAN BROUN, F.R.S., Director of the Observatories of His Highness the Rajah of Travancore. (With Six Plates.)

(Read 4th February 1861.)

The only observations made with Dr LLOYD's bifilar magnetometer, published with corrections applied to the individual observations, are those made in the Makerstoun Observatory, forming part of the Transactions of the Royal Society of Edinburgh. The results obtained from these observations (especially from those for 1844 and 1845), were first compared by me in 1856, with observations (also corrected by myself) made in the Trevandrum Observatory during the same years. The singular resemblance of the variations of daily mean intensity thus discovered at two places so distant, and so differently situated on the earth's surface, induced me to undertake the considerable labour of determining the temperature coefficients, and of correcting and discussing all the published (and some unpublished) observations made in the colonial observatories. This labour was too great to have been undertaken by me alone, in consistence with my other duties, and it is due to the liberality of His Highness the Rajah of Travancore, that I could employ in part for this work the computers attached to his Observatory. The coefficients obtained for the colonial bifilars, by a method already described by me,* are given in a paper on the errors of the instrument.† The results deduced after corrections applied, will be found in the following paper; the troublesome relations and connections of broken series and corrections for accidental errors, discovered after a most careful examination of all the observations, are given in an appendix, not to complicate the discussions.

Yearly Mean Value of the Horizontal Intensity and its Secular Variation.

2. It has been supposed that the secular variation of the horizontal intensity could only be determined by absolute observations. The readings of the bifilar magnetometer being liable to so many accidental errors, they have been considered valueless for this end. This conclusion, there can be no doubt, has had a considerable basis; yet it appears to me, that in many cases, the bifilar results may be employed with reference even to this question. The absolute intensity cannot be observed to the same degree of exactness as its variations by the bifilar, and this is a matter of much importance in determining the *law* of secular variation. It has appeared to me desirable to compare the results for different places, and especially those for Makerstoun and Hobarton, which have seemed trustworthy for this purpose.

* Trans. Royal Soc. Ed., vol. xvi. p. 74. See also "Introduction to Makerstoun Observations."
† See Trans. Royal Soc. Ed., vol. xxii. p. 467.

3. The following table contains the yearly means of the horizontal intensity, commencing the year with each month successively, and the rate of change of this mean from month to month.

TABLE I.—YEARLY MEAN HORIZONTAL FORCE (*minus* A CONSTANT), WITH ITS MONTHLY VARIATION AT MAKERSTOUN IN SCOTLAND, AND HOBARTON, VAN DIEMAN ISLAND, 1842–49. $1{\cdot}00 = \frac{X}{10000}$ (WHERE X IS THE WHOLE HORIZONTAL FORCE AT THE RESPECTIVE PLACES).

Year.		Makerstoun.		Hobarton.	
		Mean.	Change.	Mean.	Change.
1842 Jan. to	1842 Dec.	23·50	3·08	22·70	2·78
Feb.	1843 Jan.	26·58	3·00	25·48	2·60
Mar.	Feb.	29·58	2·46	28·08	2·27
April	Mar.	32·04	2·77	30·35	2·50
May	April	34·81	2·20	32·85	1·81
June	May	37·01	2·20	34·66	1·99
July	June	39·21	2·16	36·65	2·07
Aug.	July	41·37	2·22	38·72	1·75
Sept.	Aug.	43·59	2·24	40·47	1·83
Oct.	Sept.	45·83	2·08	42·30	1·64
Nov.	Oct.	47·91	2·57	43·94	2·25
Dec.	Nov.	50·48	2·52	46·19	2·20
1843 Jan.	Dec.	53·00	2·60	48·39	2·48
Feb.	1844 Jan.	55·60	2·68	50·87	2·68
Mar.	Feb.	58·28	2·73	53 55	2·53
April	Mar.	61·01	2·85	56·08	2·65
May	April	63·86	3·12	58·73	2·97
June	May	66·98	3·50	61·70	3·09
July	June	70·48	3·73	64·79	3·32
Aug.	July	74·21	3·43	68·11	2·96
Sept.	Aug.	77·64	3·18	71·07	2·82
Oct.	Sept.	80·82	2·98	73·89	2·73
Nov.	Oct.	83·80	2·63	76·62	2·33
Dec.	Nov.	86·43	2·62	78·95	2·38
1844 Jan.	Dec.	89 05	1·90	81·33	2·00
Feb.	1845 Jan.	90·95	1·81	83·33	2 24
Mar.	Feb.	92·76	1·94	85·57	2·56
April	Mar.	94·70	1·60	88·13	2·35
May	April	96·30	1·21	90·48	2·20
June	May	97·51	1·19	92·68	2·04
July	June	98·70	0·82	94·72	1·87
Aug.	July	99·52	0·86	96·59	2·03
Sept.	Aug.	100·38	0·60	98·62	1·85
Oct.	Sept.	100·98	0·93	100·47	2·06
Nov.	Oct.	101·91	0·92	102·53	2·03
Dec.	Nov.	102·83	0·57	104·56	1·72
1845 Jan.	Dec.	103·40	1·06	106·28	1·85
Feb.	1846 Jan.	104·46	1·09	108·13	1·54
Mar.	Feb.	105·55	1·14	109·67	1·41
April	Mar.	106·69	1·22	111·08	1·24
May	April	107·91	1·15	112·32	0·87
June	May	109·06	0.77	113·19	0·80

Year.		Makerstoun.		Hobarton.	
		Mean.	Change.	Mean.	Change.
1845 July to	1846 June	109·83	1·14	113·99	0·81
Aug.	July	110·97	0·81	114·80	0·70
Sept.	Aug.	111·78	0·97	115·50	0·85
Oct.	Sept.	112·75	0·84	116·35	0·78
Nov.	Oct.	113·59	1·10	117·13	1·03
Dec.	Nov.	114·69	1·56	118·16	1·28
1846 Jan.	Dec.	116·25	1·43	119·44	1·15
Feb.	1847 Jan.	117·68	1·04	120·59	0·79
Mar.	Feb.	118·72	1·21	121·38	0·62
April	Mar.	119·93	1·15	122·00	0·61
May	April	121·08	0·87	122·61	0·97
June	May	121·95	1·59	123·58	1·07
July	June	123·52	1·00	124·65	1·07
Aug.	July	124·52	1·36	125·72	1·14
Sept.	Aug.	125·88	1·35	126·86	0·77
Oct.	Sept.	127·23	0·42	127·63	0·60
Nov.	Oct.	127·65	0·35	128·23	0·23
Dec.	Nov.	128·00	0·68	128·46	−0·12
1847 Jan.	Dec.	128·68	−0·10	128·34	0·02
Feb.	1848 Jan.	128·58	0·06	128·36	0·17
Mar.	Feb.	128·64	0·22	128·53	0·38
April	Mar.	128·86	0·56	128·91	0·70
May	April	129·42	1·08	129·61	0·74
June	May	130·50	0·72	130·35	0·86
July.	June	131·22	0·97	131·21	0·45
Aug.	July	132·19	0·91	131·66	0·89
Sept.	Aug.	133·10	0·58	132·55	1·43
Oct.	Sept.	133·68	1·88	133·98	...
Nov.	Oct.	135·56	1·20	...	...
Dec.	Nov.	136·76	0·35	...	...
1848 Jan.	Dec.	137·11	1·32	...	...
Feb.	1849 Jan.	138·43	1·65	...	...
Mar.	Feb.	140·08	1·31	...	...
April	Mar.	141·39	1·31	...	...
May	April	142·70	1·56	...	...
June	May	144·26	2·01	...	...
July	June	146·27	1·72	...	...
Aug.	July	147·99	1·50	...	...
Sept.	Aug.	149·49	1·75	...	...
Oct.	Sept.	151·24	1·09	...	...
Nov.	Oct.	152·33	1·62	...	...
Dec.	Nov.	153·95	2·16	...	...
1849 Jan.	Dec.	156·11		...	

At both places the yearly mean horizontal force increased through the whole period, with one exception—namely, about the mean epoch July 1847 at both places.

4. If we could suppose that the mean horizontal force from year to year was unaffected by any other cause of change than that which produces the secular variation, the differences of the yearly means in Table I. would show at once the law of variation of the secular change itself. If, however, the yearly mean horizontal force at any place, independent of the secular variation, is not a constant quantity, but variable with some other argument, as the positions of the planets or the physical state of the sun, we may expect, from sufficiently long series of observations, to separate the results due to the two causes, and perhaps to determine what they are. In the present instance, I shall consider the changes from year to year as if they were of long period and due to one cause.

1*st*, The increase of the yearly mean was a maximum at both places about the mean epoch, January 1844.

2*d*, The increase of the yearly mean was a minimum at both places about the mean epoch July 1847.

3*d*, The epoch of maximum increase of the horizontal force was nearly that which has been found to be the epoch of minimum magnetic disturbance; while the epoch of minimum increase of the horizontal force approaches that of the maximum magnetic disturbance.*

4*th*, The interval between the maximum and minimum increase was, however, only 3·5 years.

5*th*, The variations of the yearly means agree very well at both places throughout the whole period, excepting before and after the mean epoch January 1845, and some part of the difference at this time may be instrumental.

5. It follows from these results, that what has been usually termed the secular variation is not a simple linear movement, and that it had nearly the same values, and obeyed nearly the same laws, at Makerstoun and Hobarton.

6. The question arises whether this similarity is to be found at all places. I have not been able to obtain any series of observations of sufficient length, and sufficiently free from instrumental errors, to answer this question completely; but the following are the yearly means at those places whose observations I have been able to discuss:—

* If we correct the yearly means for a *regular* secular change, the remaining quantities will show a maximum and minimum nearest the epochs of minimum and maximum disturbance, and with an interval of about *five* years.

TABLE II.—Yearly Mean Horizontal Force at Singapore (*minus* a Constant), with its Monthly Change, 1842–45. $1{\cdot}00=\frac{X}{10000}$.

Month.	1842.		1843.		1844.		1845.	
	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.
January,	[0·54]	1·21	14·91	0·80	22·33	0·90	31·15	0·74
February,	[1·75]	1·21	15·71	0·60	23·23	0·81	31·89	0·77
March,	2·96	2·26	16·31	0·55	24·04	0·70	32·66	0·87
April,	5·22	1·58	16·86	0·54	24·74	0·50	33·53	0·98
May,	6·80	1·33	17·40	0·41	25·24	0·59	34·51	0·80
June,	8·13	1·54	17·81	0·25	25·83	0·63	35·31	...
July,	9·67	1·21	18·06	0·38	26·46	0·62	...	...
August,	10·88	0·98	18·44	0·60	27·08	0·84	...	...
September,	11·86	0·87	19·04	0·63	27·92	0·91	...	...
October,	12·73	0·72	19·67	0·70	28·83	0·84	...	...
November,	13·45	0·63	20·37	0·98	29·67	0·75	...	...
December,	14·08	0·83	21·35	0·98	30·42	0·73	...	...

TABLE III.—Yearly Mean Horizontal Force (*minus* a Constant), with its Monthly Change at Trevandrum, 1842–45. $1{\cdot}00=\frac{X}{10000}$.

Month.	1842.		1843.		1844.		1845.	
	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.
January,	...	...	6·14	−0·44	4·10	+0·36	7·85	+0·68
February,	...	...	5·70	−0·43	4·46	+0·22	8·53	+0·65
March,	...	...	5·27	−0·33	4.68	+0·04	9·18	+0·69
April,	...	...	4·94	−0·32	4·72	−0·15	9·87	+0·98
May,	7·60	+0·53	4·62	−0·36	4·57	−0·03	10·85	+0·92
June,	8·13	+0·33	4·26	−0·55	4·54	+0·10	11·77	...
July,	8·46	+0·22	3·71	−0·49	4·64	+0·24	...	...
August,	8·68	−0·14	3·22	−0·19	4·88	+0·53	..	...
September,	8·52	−0·57	3·03	+0·04	5·41	+0·58	...	...
October,	7·95	−0·74	3·07	+0·22	5·99	+0·61	...	...
November,	7·21	−0·67	3·29	+0·34	6·60	+0.65	...	...
December,	6·54	−0·40	3·63	+0·47	7·25	+0·60	...	...

TABLE IV.—YEARLY MEAN HORIZONTAL FORCE (*minus* A CONSTANT) AT ST HELENA, 1842–45. $1{\cdot}00 = \frac{X}{10000}$.

Month.	1842.		1843.		1844.		1845.	
	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.
January,	...	...	65·20		42·55		26·02	
February,	...	...	64·74	−0·46	40·55	−2·00	24·50	−1·52
March,	...	...	64·03	0·71	38·59	1·96	22·88	1·62
April,	...	...	63·16	0·87	36·60	1·99	21·76	1·12
May,	...	...	62·05	1·11	34.58	2·02	19·88	1·88
June,	66·03		60·55	1·50	32·91	1·67	18·34	1·54
July,	66·72	+0·69	58·41	2·14	31·63	1·28	...	...
August,	66·74	+0·02	55·86	2·55	30·82	0·81	...	...
September,	66·58	−0·16	52·86	3·00	30·46	0·36	...	...
October,	66·37	−0·21	49·72	3·14	29·88	0·58	...	...
November,	65·99	−0·38	47·00	2·72	28·84	1·04	...	...
December,	65·50	−0·49	44·66	2·34	27·51	1·33	...	...
		−0·30		2·11		1·49		

TABLE V.—YEARLY MEAN HORIZONTAL FORCE (*minus* A CONSTANT) AT THE CAPE OF GOOD HOPE, 1842–45. $1{\cdot}00 = \frac{X}{10000}$.

Month.	1842.		1843.		1844.		1845.	
	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.
January,	...	...	46·28		35·78		64·10	
February,	...	...	47·07	+0·79	33·33	−2·45	68·74	+4·64
March,	...	...	47·68	+0·61	30·57	−2·76	73·28	+4·54
April,	33·34		48·17	+0·49	28·53	−2·04	76·76	+3·48
May,	36·43	+3·09	48·68	+0·51	28·20	−0·33	78·27	+1·51
June,	38·79	+2·36	48·83	+0·15	30·00	+1·80	77·50	−0·77
July,	40·66	+1·87	48·07	−0·76	33·56	+3·56	75·09	−2·41
August,	42·17	+1·51	46·71	−1·36	38·23	+4·67	71·58	−3·51
September,	43·22	+1·05	44·87	−1·84	43·65	+5·42	67·20	−4.38
October,	44·01	+0·79	42·63	−2·24	49·23	+5·58	62·27	−4·93
November,	44·69	+0·68	40·33	−2·30	54·51	+5·28	56·74	−5·53
December,	45·39	+0·70	38·04	−2·29	59·44	+4·93	50·84	−5·90
		+0·89		−2·26		+4·66		

7. The yearly mean horizontal intensity increases throughout the period 1842–45 at Singapore. At Trevandrum it diminishes from the mean epoch August 1842 to August 1843, after which it increases. At St Helena the yearly mean horizontal force diminishes from the mean epoch July 1842 till the end of the period July 1845. At the Cape of Good Hope it increases from the mean epoch July 1842 to June 1843, diminishes from June 1843 to May 1844, thence increases to June 1845, diminishing thereafter. At Toronto there was a rapid increase; but as

this was chiefly instrumental, I have not thought it necessary to give the yearly means.*

8. These results are affected by errors. The alternate increase and diminution at the Cape is doubtful, especially the sudden increase after the insertion of a new magnet October 1844. We may conclude, however, with considerable certainty, that the law of change of the yearly mean force is different at different places on the earth's surface. We may conclude also, especially when the results (§ 66) are known, that the yearly mean horizontal force for the whole surface of the earth is not a constant quantity.

9. From these conclusions it follows that the yearly mean change cannot be explained wholly by a mere movement of the magnetic poles and of the lines of force. As this movement is known to exist, we must conclude that the yearly mean change of horizontal force is a complex result, due partly to a movement of the magnetic poles, partly to an absolute change of the earth's magnetic force.

Monthly Mean Variation of the Horizontal Intensity and Annual Period.

10. No annual period of horizontal intensity has apparently been proposed as yet, carrying with it a sufficient weight to be adopted by physicists as a well-determined law. The great errors connected with instrumental changes have frequently rendered verification impossible. Erroneous temperature corrections also will give false results, even when the observations have been sufficient for the determination of the law. Nothing is more probable than to find an apparent connection between the maximum and minimum force and the maximum and minimum temperature; since, if the temperature coefficient be too great, we shall have the observed horizontal force increased in summer; and if it be too little, the force will be increased in winter. The error hitherto has been the employment of too great a coefficient, and consequent apparent maximum of force in summer.

11. In 1844, having computed the coefficient for the Makerstoun bifilar by the process described in the Introduction to the Makerstoun Observations, I obtained from the observations for the year 1842, corrected by this coefficient, the remarkable result that the horizontal intensity was a maximum near the solstices and a minimum near the equinoxes. This result, it should be remarked, was very unlikely to proceed from an error of coefficient, for the equinoxes (the

* Copy of Abstracts of Observations made at Simla (lat. 31° 6′ N., long. 5h. 9m. E. of Greenwich) under the direction of Colonel Boileau, is in the Library of the Trevandrum Observatory. I have not been able to discuss these observations satisfactorily, as the temperature of the magnet is not given, excepting for 1842. I have, however, taken some pains to arrive at an approximate correction, and can state as results that at Simla the horizontal force increased throughout the whole period. The curve for 1842 is projected, Plate XXIII.; but the range of temperature in the bifilar box is too considerable to allow us to put much value in the conclusion that may be drawn that the variations of the monthly means are less than at other places.

times of minimum force) are near the epochs of mean temperature; and one maximum was before the time of maximum, the other before that of minimum temperature. It was very improbable, however, if the process employed for the determination of the temperature coefficient had in this case given such a result by chance, that it could happen in any other instance. The Toronto observations for 1842 were, however, discussed in the same way as the Makerstoun observations, and the temperature coefficient obtained; the observations being corrected, the same law was deduced as from the Makerstoun observations.* Not only was the resulting law the same, but the monthly changes (omitting the secular variation) were nearly identical.

12. In 1846 I was able to confirm this law by the discussion of the Makerstoun observations for each of the years 1843, 1844, and 1845.† I was able in the following years to show the same law from the Makerstoun observations, and even to obtain it from Dr LAMONT's observations made at Munich by a wholly different apparatus.‡ I shall examine this question now more fully, and first consider the observations at Makerstoun and Hobarton. The monthly means will be found in Table VIII., and they are projected in Plate XXIII.

* 1845, Trans. Brit. Assoc.

† 1846, Jan. 5, Trans. Royal Soc. Edin., vol. xiv. p. 99. The Toronto and Makerstoun results are projected in Plate III., vol. xiv.

‡ Makerstoun Observations, 1844, p. 357 (foot note).

TABLE VI.—MONTHLY MEAN VALUES OF THE HORIZONTAL FORCE AT MAKERSTOUN AND HOBARTON IN TEN-THOUSANDTHS OF THE WHOLE HORIZONTAL FORCE AT EACH PLACE FOR THE YEARS 1842–49 (*minus* A CONSTANT AT EACH PLACE.)

MONTHS.	1842.		1843.		1844.		1845.		1846.		1847.		1848.		1849.
	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.
January . .	8·55	[8·30]	45·47	41·74	76·63	[71·55]	99·43	95·62	112·11	117·79	129·25	131·56	128·05	131·80	143·92
February . .	10·30	[10·05]	46·26	41·21	78·45	[73·37]	100·13	100·20	113·16	118·75	125·73	128·22	126·49	130·19	146·20
March . . .	14·27	[14·02]	43·84	41·19	76·61	[71·53]	99·88	102·26	113·54	119·16	128·06	126·59	130·64	131·15	146·38
April . . .	12·39	12·14	45·60	42·17	79·76	73·95	98·90	102·08	113·54	116·96	127·31	124·27	134·06	132·73	150·70
May . . .	22·92	22·12	49·29	43·82	86·79	79·50	103·40	105·99	117·16	116·41	127·51	128·00	140·54	136·88	158·33
June . . .	25·86	23·93	52·33	*47·82	94·25	84·86	106·45	109·27	115·70	118·87	134·55	131·78	143·16	142·04	167·38
July . . .	25·14	21·12	51·04	[45·96]	95·84	85·77	105·72	108·21	119·39	117·98	131·46	130·82	143·05	136·29	163·58
August . . .	25·96	26·46	52·57	[47·49]	93·76	83·07	104·07	107·44	113·88	116·37	130·16	130·06	141·16	140·72	159·21
September . .	28·54	28·41	55·42	[50·34]	93·60	84·17	100·78	106·34	112·33	116·04	128·57	125·29	135·52	142·50	156·47
October . .	32·82	33·02	57·74	[52·66]	93·44	85·34	104·61	110·07	114·80	119·32	119·81	126·46	142·30	...	155·40
November . .	34·92	33·59	65·79	[60·71]	97·40	88·75	108·51	113·14	121·61	125·53	125·84	128·28	140·29	...	159·75
December . .	40·39	39·22	70·65	[65·57]	102·12	94·09	108·95	114·72	127·75	130·15	135·91	128·78	140·10	...	166·00

NOTE—The mean values in brackets [ ] for Hobarton are interpolated from Makerstoun.

* June 1843, Hobarton is from half a month's observations; but the mean has been corrected to the mean of the whole month by the corresponding observations at Makerstoun.

13. The law of variation at both places is as follows:—The horizontal intensity diminishes in each year from February to March or April, and from June to July, August or September. It increases in the other months, the rate of increase being least rapid immediately before and after the diminution. This result is evidently a combination of the annual and secular variations.

14. We should now proceed to the examination of the results for other observatories. The series of observations at other places have unfortunately been so much broken up by accidental causes, spiders within the tropics, adjustments and changes of magnets everywhere, that observations for a moderate length of time, free from error, are not to be found. I have, however, taken much pains to determine the coefficients,* and, if possible, the errors and their amounts for all the observations in my possession; the details of these corrections are given in the Appendix to this paper. The following tables contain the concluded corrected monthly means; they have been projected in Plate XXIII.; and the means in the last columns of each table in Plate XXIV. I have also projected the means of the Munich Observations 1843–5 in the same plate.† I shall proceed first to examine the mode of variation of the monthly means at the different stations.

TABLE VII.—MONTHLY MEAN VALUES OF THE HORIZONTAL INTENSITY (*minus* A CONSTANT) AT TORONTO, 1841–48. $1{\cdot}00 = \frac{X}{10000}$.

MONTHS.	1841.	1842.	1843.	1844.	1845.	1846.	1847.	1848.
January, ...	...	17·84	22·02	50·10	99·11	132·85	152·43	152·23
February, ...	...	15·00	...	50·86	101·98	132·00	148·69	153·47
March, ...	...	17·68	...	48·25	101·18	129·76	146·70	154·09
April, ...	...	15·13	...	47·62	100·23	127·81	144·38	154·37
May, ...	...	21·88	...	54·71	103·81	126·47	146·53	157·63
June, ...	...	20·54	...	64·83	108·77	129·41	150·97	161·21
July, ...	...	12·93	...	72·00	109·92	131·48	147·61	...
August, ...	0·30	17·05	...	77·66	114·55	132·77	148·41	...
September, . . .	0·11	15·13	...	84·60	118·60	134·97	145·64	...
October, ...	6·58	16·06	...	90·89	126·03	138·31	148·78	...
November, . . .	10·34	16·80	44·09	94·97	130·11	144·76	147·79	...
December, . . .	13·65	21·49	47·57	100·05	132·64	151·69	155·17	...

15. TORONTO.—The observations were interrupted in February 1843, and when resumed after a new adjustment of the magnet in March, it was found that there was an instrumental derangement which appeared to be removed on turning

* See Bifilar Magnetometer, Trans. Royal Soc. Ed. vol. xxii. p. 467.

† Resultate des Mag. Obser. in München, 1843–4–5. See also Makerstoun Observations, 1844, p. 357 (foot-note); and General Results (Trans. Royal Soc. Edin., Vol. xix., part ii.) p. xxxiii. For convenience of comparison, I shall repeat here the quantities projected in Plate XXIV, and to be found in the works cited:—

Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
−0·29	−0·86	−0·29	−1·58	+2·65	+2·38	+2·80	+1·36	−4·21	−3·28	−0·45	+1·72

the torsion circle in October 1843; the position of the mean for November 1843 relatively to that for January of the same year, has been assumed with some reference to Hobarton and Makerstoun.

16. The variations from August 1841 till February 1843 resemble generally the corresponding variations at all the other places:* from November 1843 till April 1844, the movement resembles that at Makerstoun; after April the force increases continuously till December 1844, wanting wholly the inflection towards August and September which is shown at Makerstoun and Hobarton (see Plate XXIII.); from December 1844 till April 1845, the variation resembles that at Makerstoun again; after which, as in the previous year, the force increases continuously (with a slight inflexion, however, in July) till December 1845.

17. This movement (1843–5) at Toronto is very remarkable. It is small from November till April in each of the two years, resembling that at Makerstoun; it is large in the remaining part of each year, not resembling at all the movement at Makerstoun. It is impossible to determine whether this difference is real; but it is very difficult to suppose that an accidental cause of movement should operate at exactly the same epochs in each of two years. I have not in my possession the observations for 1846, &c., of the bifilar magnet, though the monthly means of the bifilar are given in vol. ii. of the Toronto Observations. From these, after an approximate correction, I am induced to believe that the difference shown in 1844, 1845 (April to December), between the Toronto and Makerstoun movements is not shown in the following years.†

18. Cape of Good Hope.—The series was interrupted in April and November 1843, again in October 1844, when a new magnet was employed. The movement resembles generally that at Makerstoun and Hobarton from October 1841 to October 1843, but with a less secular increase after May 1842; from November 1843 till March 1844, the force diminishes continuously, differing wholly from the other two places; but from March till September 1844, the law of movement resembles that at Hobarton and Makerstoun. At this time (October 1844) a new magnet was substituted, and the force increased rapidly and continuously from

* It should be noted that the monthly means depend upon hourly observations, excepting in the following cases, which depend on two-hourly observations:—Toronto, 1841 till July 1842; St Helena, 1841 till September 1842; Trevandrum, 1841 till February 1842; Singapore, till June 1842; and in the case of Makerstoun, where the monthly means 1841–2 depend on 4 three-hourly observations; 1843, on 9 two-hourly observations; 1846, on 9 two-hourly observations; 1847, on 5 three-hourly observations; and 1848–9, on two observations daily. For this reason the means at the different places are not strictly comparable.

† I have corrected the Toronto Observations for 1846, 1847, and till June 1848, at which date the observations stop in vol. iii. (received since this paper was written). These are added in Table VII., and have been projected (Plate XXIII); they show so considerable a resemblance to the observations at Hobarton and Makerstoun as to render it probable that the different character of the movement in 1844–5–6 was due to instrumental causes, a supposition which is rendered more probable by the great difference between the temperature coefficient derived from the usual observations and from hot and cold water experiments.

September till February 1845, after which it diminished rapidly and continuously (with slight inflections) till June 1846, the end of the series.

TABLE VIII.—MONTHLY MEAN VALUES OF HORIZONTAL INTENSITY (*minus* A CONSTANT) AT THE CAPE OF GOOD HOPE, 1842–46. $1{\cdot}00=\frac{X}{10000}$.

MONTHS.	1842.	1843.	1844.	1845.	1846.	Means.	
						182–45.	1843–46.
January,	29·03	48·29	34·04	84·10	49·54	48·87	53·99
February,	29·93	46·82	28·37	90·26	40·70	488·4	51·54
March,	37·73	45·97	20·35	88·48	32·91	48·14	46·93
April,	36·95	47·48	19·13	84·90	22·11	47·11	43·40
May,	43·85	49·73	22·80	83·71	13·77	50·02	42·50
June,	43·43	54·13	26·02	83·38	11·77	51·74	43·82
July,	39·43	50·38	24·27	78·71	...	48·20	...
August,	42·70	50·62	17·97	74·93	...	46·55	...
September,	42·39	49·18	15·66	67·58	1841.	43·70	...
October,	44·01	48·82	33·17	64·74	0·86	47·68	...
November,	42·88	50·38	58·06	62·57	11·93	53·47	...
December,	46·04	42·26	77·97	55·04	20·21	55·33	...

19. The movement at the Cape after November 1843, like that at Toronto during the same period, is very remarkable; and it is difficult to determine to what extent the great increase before February 1845, and decrease after that epoch, are real phenomena. The introduction of a new magnet, if the old wires were used, would render an apparent *decrease* of force after its insertion most probable. No explanation can be offered by me for the sudden decrease commencing after February 1845.

20. ST HELENA.—The series was interrupted in February 1844. The movements from December 1841 till February 1842 resembles generally those at the other places; the mean for March 1843 shows a slight increase from January, whereas at all the other places it is a decrease; from June 1843 the force decreased till January 1844, when there was an adjustment. From November 1843 till September 1844 the movement at St Helena resembles that at the Cape; from June 1844 the force diminishes, with slight exceptions, till December 1845 (the end of the series in my possession). The exceptions indicate maxima between December 1844 and February 1845, and in June and November 1845.

21. When we compare the movements at St Helena and the Cape, we find the following differences. The force increased at St Helena till March 1842, after which it began to diminish: first gently; then, after June 1843, more rapidly; it then increased till June 1844, diminishing thereafter. At the Cape the force increased rapidly till the month of May 1842, two months after the turn at St Helena; it then increased slowly till June 1843, during which period the force

was nearly constant or diminished slowly at St Helena; it then diminished more slowly till October, and from November till March more rapidly than at St Helena. The movement from March till September1844 resembles that at St Helena.

TABLE IX.—MONTHLY MEAN VALUES OF HORIZONTAL FORCE (*minus* A CONSTANT) AT ST HELENA, 1842–45. $1{\cdot}00=\frac{X}{10000}$.

MONTHS.	1842.	1843.	1844.	1845.	Means.
January, . . .	66·38	66·98	38·1	23·9	48·84
February, . . .	64·86	64·66	[32·3]	27·2	47·25
March, ...	70·44	66·98	27·4	23·9	47·18
April, ...	68·18	66·51	30·8	20·3	46·45
May, ...	72·52	65·05	35·3	20·7	48·39
June, ...	70·25	65·77	39·5	22·2	49·43
July, ...	63·99	61·54	37·2	18·8	45·38
August, . . .	65·58	56·91	33·2	15·2	42·72
September, . . .	63·60	55·27	31·9	11·0	40·44
October, . . .	64·88	52·35	27·7	9·9	38·71
November, . . .	63·60	49·40	25·8	10·4	37·30
December, . . .	66·07	44·00	27·4	5·9	35·84

December 1841 = 57·76.

22. On the whole, the variations of force at the Cape and St Helena confirm each other (with some small exceptions) from 1841 till September 1844. This general agreement renders it probable that the unusual movements shown at the Cape after September 1844, which differ so completely from the movements for the same time at St Helena (and at every other place), are *chiefly* instrumental. It has already been pointed out by me* that the results at St Helena may be affected by the magnetic character of the whole island. At present, however, I feel inclined to believe that any effect due to this cause must be of a very minute kind; and I would rather attribute the small differences of the movements observable at the Cape and St Helena, in the period before September 1844, to instrumental causes acting at the latter place, if they may not always be explained by variations due to the cause of the secular change.

23. It is obvious, I think, that even in the first period (before September 1844) the movement (continuous increase or diminution) which we attribute to the secular cause, does not commence or terminate at exactly the same epochs at these two places. Both at the Cape and St Helena (as, indeed, at Toronto) the progressive movement appears to be interrupted and inverted by the annual movement; on this account it must be very difficult to disengage the annual law from a variation which has no certain period, and which commences to act or ceases to act at different times at places not very distant, such as the Cape and St Helena.

* Makerstoun Observations 1844, p. 395 (foot-note).

24. It ought to be remarked, that the part of the secular variation which is due to the movement of the poles of force will depend not only on the amount of that movement and its direction, but also on the angle which the isodynamic lines make at the place with the direction of motion of the poles.

TABLE X.—MONTHLY MEAN VALUES OF HORIZONTAL FORCE (*minus* A CONSTANT) AT SINGAPORE, 1842–45. $1{\cdot}00 = \frac{X}{10000}$.

MONTHS.	Monthly Means.				(Monthly *minus* Yearly Means) *plus* 5·00.				
	1842.	1843.	1844.	1845.	1842.	1843.	1844.	1845.	Means.
January, . .	5·63	21·36	23·91	30·03	10·09	11·45	6·58	3·88	8·00
February, . .	4·09	17·32	24·47	33·42	7·34	6·61	6·24	6·53	6·68
March, . .	5·40	15·57	22·58	33·66	7·44	4·26	3·58	6·00	5·32
April, . .	3·32	14·24	22·29	33·04	3·10	2·38	2·55	4·51	3·13
May, . . .	7·94	14·21	24·70	34·06	6·14	1·81	4·46	4·55	4·24
June, . . .	7·76	16·60	28·10	37·10	4·63	3·79	7·27	6·79	5·62
July, . . .	5·73	17·00	28·97	37·31	1·06	3·94	7·51	6·20	4·68
August, . .	9·65	17·46	26·94	36·61	3·77	4·02	4·86	4·70	4·34
September, . .	10·74	17·25	27·20	36·06	3·88	3·21	4·28	3·35	3·68
October, . .	13·37	19·94	26·67	38·36	5·64	5·27	2·84	4·85	4·65
November, . .	15·48	22·16	27·76	39·59	7·03	6·79	3·09	5·28	5·55
December, . .	19·12	22·13	30·79	38·15	10·04	5·78	5·37	3·04	6·06

25. SINGAPORE.—The movement is a gradual and slight increase of force from the commencement to the end of 1845, being most rapid in the end of 1842, as in the other places. Maxima are generally shown near the solstices, and minima near the equinoxes.

26. TREVANDRUM.—The movement resembles on the whole that at Singapore, the force diminishing, however, in 1843, and then increasing more slowly than at Singapore. The appearances of maxima near the solstices and minima near the equinoxes are also evident as at Singapore.

27. On the whole, the movements at Trevandrum and Singapore confirm each other: it must be remembered, however, that the observations at both places have undergone several corrections for accidental errors, spiders and movement of telescope at Trevandrum, and unknown causes, perhaps movement of telescope, at Singapore. The means for these two places are therefore not wholly trustworthy; the limits of error are probably small, but there is no doubt that there are several errors due to spiders and movement of telescope uncorrected at Trevandrum, and probably also at Singapore.

28. SIMLA.—The movement at Simla for 1842 resembles much that at Singapore and the Cape, being nearly a mean between the two. The dotted line (Plate XXIII.) is a mere approximate correction, the temperatures having been obtained

from those for the barometer: it confirms generally the results at Trevandrum and Singapore.

TABLE XI.—Monthly Mean Values of Horizontal Force (*minus* a Constant) at Trevandrum, 1842–45. $1{\cdot}00 = \frac{X}{10000}$.

Months.	Monthly Means.				(Monthly *minus* Yearly Means) *plus* 5·00.				
	1842.	1843.	1844.	1845.	1842.	1843.	1844.	1445.	Means.
January, . .	9·73	12·57	4·45	5·66	9·13	11·43	5·35	2·81	7·18
February, . .	6·58	9·11	5·60	10·23	5·48	8·41	6·14	6·70	6·68
March, . . .	10·54	4·13	3·02	11·14	8·94	3·86	3·34	6·96	5·77
April, . . .	7·46	0·17	2·11	7·85	5·36	0·23	2·39	2·98	2·74
May, . . .	10·19	0·25	3·54	12·46	7·59	0·63	3·97	6·61	4·70
June, . . .	7·97	1·83	6·82	13·66	4·84	2·57	7·28	6·89	5·40
July, . . .	3·99	0·13	6·10	13·62	0·53	1·16	6·46	6·01	3·54
August, . .	7·98	1·58	4·13	12·87	4·30	3·36	4·25	4·36	4·07
September, . .	6·43	2·58	5·15	12·00	3·91	4·55	4·74	2·59	3·95
October, . .	8·86	4·68	3·01	13·13	5·91	6·61	7·98	2·82	5·83
November, . .	9·49	5·85	4·14	17·27	7·28	7·56	7·46	6·06	7·09
December, . .	10·93	5·99	6·97	15·58	9·39	7·36	5·28	3·47	6·38

29. In examining the values projected in Plate XXIII., it will be remarked that all the observatories show a large increase of force in the end of 1841, and that it is only at St Helena and the Cape, after June 1843, that any decrease of force is marked. The space included by these observations leaves the whole Pacific and South America untouched; but as far as they go they show in the end of 1841 an increase of force everywhere, and in the mean of the whole a considerable increase of force throughout the whole period.* It would be difficult to make a satisfactory hypothesis as to the movements of the poles of force which alone would satisfy these results.

30. Annual Variation.—In order to eliminate the secular variation, we would require to know its law; this could only be obtained by an empirical process. I have preferred adopting the following method. The *yearly* mean corresponding to the *middle* of each month was obtained, as in the following formula, for the middle of July 1842:—

$$\frac{(1842)\ \text{Jan.} + 2\ \text{Mar.} + \ldots\ldots + 2\ \text{Dec.} + \text{Jan.}\ (1843.)}{24}$$

* It may be supposed that the increase everywhere shown in the end of 1841 might have been in some way connected with the commencement of the series; but I think there is no ground for this supposition. The observations were commenced early in 1841; the magnets were removed monthly from their stirrups for observations of absolute intensity; and any tendency to stretch in the wires would have been got rid of in this frequent manipulation. At Toronto, indeed, the second month projected (September 1841) shows a diminution of force. I think there is every probability that the increase was a real increase of horizontal force at all the stations.

Where (1842) January represents the mean force for that month; 2 February, twice the force for February, and so on; the difference betwixt the yearly means thus obtained and the corresponding monthly means were then taken, and these differences, *plus* a constant quantity (that all may have the same sign*), are entered in Table XII. This method, it is evident, is equivalent to making a line parallel to that of the yearly mean values, the axis of x; and we may consider the ordinates from this line to that of the monthly mean differences as varying with season.

* I adopt this in preference to giving the quantities with the algebraic signs + and −, since some persons in glancing at such results may fail to perceive a maximum if it has the negative sign prefixed.

TABLE XII.—MONTHLY MEAN VALUES OF HORIZONTAL FORCE *minus* THE YEARLY MEANS CORRESPONDING TO THE RESPECTIVE MONTHS (*plus* 10·00) FOR MAKERSTOUN AND HOBARTON, DURING THE YEARS 1842–48, 49, IN TEN-THOUSANDTHS OF THE WHOLE HORIZONTAL FORCE AT EACH PLACE.

MONTHS.	1842.		1843.		1844.		1845.		1846.		1847.		1848.		1849.
	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.
January, . .	11·75	[12·45]	15·18	14·06	14·29	[15·10]	10·32	9·97	11·71	13·39	15·23	16·38	6·35	10·37	6·79
February, . .	10·46	[11·16]	13·78	11·61	12·53	[13·78]	10·18	7·40	11·79	13·60	10·53	11·93	3·85	8·09	7·46
March, . .	11·39	[12·09]	9·13	9·81	7·38	[9·05]	9·20	7·28	11·28	13·24	11·51	9·35	7·75	7·89	6·02
April, . . .	6·47	7·17	8·73	9·05	7·45	8·70	7·46	9·42	10·37	10·22	9·87	6·34	9·44	8·34	8·92
May, . . .	13·96	14·11	10·10	8·76	11·68	11·72	11·03	12·44	13·02	8·77	9·69	9·66	14·38	11·23	15·19
June, . . .	13·86	12·88	10·59	10·53	17·03	14·72	13·34	13·85	10·23	10·07	16·21	13·38	16·23	15·23	22·35
July, . . .	10·10	7·03	6·74	[6·33]	15·84	13·44	11·79	11·01	12·43	7·97	12·83	12·47	15·28	8·32	16·93
August, . .	7·88	9·68	5·63	[5·28]	11·91	8·62	9·07	8·54	5·68	5·39	11·55	11·62	12·91	11·59	10·94
September, . .	7·73	9·20	5·78	[5·53]	9·87	7·32	4·66	5·97	3·01	4·35	9·82	6·57	4·79	12·21	6·58
October, . .	9·40	11·42	5·31	[5·26]	7·94	6·04	7·31	8·37	4·30	7·02	0·67	7·20	10·26	...	3·89
November, . .	9·01	9·84	10·37	[10·50]	10·50	7·17	10·03	10·39	10·10	12·43	5·88	8·30	6·81	...	6·62
December, . .	12·28	13·57	11·92	[12·32]	14·02	10·39	9·51	11·13	15·02	16·04	15·05	8·00	4·84	...	11·25

31. In order to eliminate to some extent variations of monthly mean values, which may be due to accidental causes (to which I shall allude afterwards), I have combined these differences for Makerstoun and Hobarton for pairs of years; the resulting numbers will be found in Table XIII., and they are projected in Plate XXIV.

TABLE XIII.—MONTHLY MEANS IN GROUPS OF YEARS FROM TABLE XIV., FOR MAKERSTOUN AND HOBARTON.

MONTHS.	1842–43.		1843–44.		1844–45.		1845–46.		1846–47.		1847–48.		1848–9.	July 1844 to June 1848 *minus* 5·00.		1842–45. *minus* 5·00.	
	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Hobar.	Makers.	Makers.	Hobar.	Makers.	Hobar.
January,	13·46	13·25	14·73	14·58	12·30	12·53	11·01	11·68	13·47	14·88	10·79	13·37	6·57	5·90	8·12	7·88	7·90
February,	12·12	11·38	13·15	12·69	11·35	10·59	10·98	10·50	11·16	12·76	7·19	10·01	5·66	4·09	5·96	6·74	5·99
March,	10·26	10·95	8·26	9·43	8·29	8·17	10·24	10·26	11·39	11·29	9·63	8·62	6·89	4·93	4·71	4·28	4·59
April,	7·60	8·11	8·09	8·88	7·45	9·06	8·92	9·82	10·12	8·28	9·66	7·34	9·18	4·29	3·62	2·53	3·58
May,	12·03	11·44	10·89	10·24	11·35	12·08	12·02	10·60	11·35	9·22	12·03	10·44	14·78	7·03	5·58	6·69	6·76
June,	12·23	11·71	13·81	12·62	15·18	14·28	11·78	11·96	13·22	11·72	16·22	14·30	19·29	9·00	8·07	8·70	8·00
July,	8·42	6·68	11·29	9·89	13·81	12·22	12·11	9·49	12·63	10·22	14·05	10·40	16·10	8·22	5·45	6·12	4·45
August,	6·76	7·49	8·77	6·95	10·49	8·58	7·38	6·97	8·62	8·50	12·23	11·60	11·92	4·55	2·72	3·62	3·03
September,	6·76	7·37	7·83	6·43	7·27	6·65	3·84	5·16	6·42	5·46	7·31	9·39	5·69	1·84	0·92	2·01	2·00
October,	7·36	8·34	6·63	5·65	7·63	7·20	5·81	7·70	2·49	7·11	5·47	...	7·07	0·06	1·92	2·49	2·77
November,	9·69	10·17	10·44	8·84	10·26	8·78	10·06	11·41	7·99	10·36	6·35	...	6·72	4·13	4·85	4·98	4·48
December,	12·07	12·94	12·97	11·35	11·76	10·76	12·26	13·58	15·03	12·02	9·95	...	8·05	8·40	6·93	6·93	6·85

32. An examination of these numbers and the corresponding curves will show in each case that there is an annual period of horizontal intensity, consisting of two maxima and two minima—the maxima near the solstices, the minima near the equinoxes; the principal maximum being sometimes at the December solstice, sometimes the June solstice. The most marked minimum in the pairs of years has been in September or October.

33. When we examine the observations, especially the daily means, it will be obvious that the exact epochs, as well as the values of the maxima and minima for different years, depend greatly on the disturbances: if these are greater near the winter solstice than near the summer solstice, as they generally are, the winter maximum will become less marked than it ought to be, since the principal disturbances are negative at all places.

34. I have calculated the constants for the annual curve at Makerstoun and Hobarton from the monthly means for the four years July 1844 to June 1848 (the longest period of years at Hobarton without any break in the series of observations), by the formula,

$$y = a_0 + a_1 \sin(\theta + c_1) + a_2 \sin(2\,\theta + c_2) + a_3 \sin(3\theta + c_3), \quad \ldots \quad (1.)$$

The resulting equations are ($\theta = 0$, July 16),

Makerstoun,

$$y = 5{\cdot}20 + 1{\cdot}66 \sin(\theta + 161^\circ 47') + 2{\cdot}98 \sin(2\theta + 129^\circ 34') + 0{\cdot}80 \sin(3\theta + 31^\circ 42') \quad (2.)$$

Hobarton,

$$y = 4{\cdot}90 + 1{\cdot}64 \sin(\theta + 217^\circ 38') + 2{\cdot}54 \sin(2\theta + 129^\circ 11') + 0{\cdot}45 \sin(3\theta + 172^\circ 46') \quad (3.)$$

—the values of a being in ten-thousandths of X at the respective places.

35. If we consider the partial curves we find,

For the single curve at { Makerstoun, the maximum May 4; the minimum Nov. 3.
Hobarton, „ Mar. 9; „ Sept. 8.

It should be remembered that the Hobarton result is derived from hourly observations, whereas at Makerstoun in 1846–7–8 there were only a few observations daily (see 16; foot-note).

36. The annual period from the partial curve at Hobarton has its maximum near the March equinox and its minimum near the September equinox. This, however, is not satisfied at all times, since in some cases the spring minimum of the whole variation is as marked as that in autumn.

37. For the double curve at Makerstoun and Hobarton, . { the maxima are June 29, and December 26.
the minima are March 27, and September 25.

This is the most important movement; the coefficient is about one-seventh less at Hobarton than at Makerstoun, but the epochs are the same at both places. This curve at both places has its maxima a few days after the solstices, and its minima a few days after the equinoxes.

38. If we consider the total curve as derived from the three partial ones, we find the epochs of maxima and minima as follows:*—

	Makerstoun.	Hobarton.
Principal minimum	October 1	September 16
Maximum	December 22 . . .	January 9
Minimum	March 6·5 . . .	April 4
Maximum	June 30·5	June 17

For the total curve, therefore, we have as before the epochs of maxima near the solstices, and of minima near the equinoxes.

39. The monthly means for the period 1842–45, as given in the last columns of Tables VIII. to XII., have been projected in Plate XXIV.; from these we may conclude for the horizontal intensity,—

1*st, Makerstoun and Hobarton.*

Maxima in June and January.
Minima in September and April.

2*d, Munich.*

Maxima in June and December.
Minima in September and March.

It should be remembered that Dr LAMONT'S instrument is not a bifilar, but a

* The usual method to determine the epochs of maxima and minima is to obtain by approximation the roots of the equation to the maximum or minimum. The following method has been adopted by me for the computation of the above epochs:—

Let the general term of the equation (1) to the curve be

$$p_i = a_i \sin (i\theta + c_i),$$

and let

$$q_i = a_i \cos (i\theta + c_i).$$

If, then, we obtain an approximate value of θ for the maximum (or minimum) from the projected results (observed or calculated), and substitute this value in the above equations, and if α be the correction of the approximate value of θ to the true value, we shall have

$$\alpha = \frac{\Sigma i q_i}{\Sigma i^2 p^i};$$

or, for a very accurate determination,

$$\alpha = \frac{1}{\dfrac{\Sigma i^3 q_i}{2\Sigma i^2 p_i} + \dfrac{\Sigma i^2 p_i}{\Sigma i q_i}}.$$

In the same way we may obtain the correction α' of the approximate epoch for the *mean* value of y from the equation

$$\alpha' = \frac{\Sigma p_i}{\Sigma q_i};$$

and for points of contrary flexure, which ought not to be neglected in some cases, we have the correction α'' to the approximate epochs substituted as before in the values of p_i, q_i

$$\alpha'' = \frac{\Sigma i^2 p_i}{\Sigma i^3 q_i}.$$

These values are easily calculated with the aid of a table of natural sines to three decimal places for every 15′ of the circumference, and of a table of multipliers like CRELLE'S.

unifilar magnet deflected by two bar magnets, so as to make a large angle with the meridian. As the suspension thread is of silk cocoon fibre, and the possible error from the smallest change in its structure from continued tension considerable, the directive force being small, the confirmation of epochs is in this case the more marked.

3*d*, *Cape of Good Hope*, 1842–45, uncorrected for secular change.

Maxima in December and June.
Minima in September and April.

Our examination of the monthly means will have shown how impossible it is in this case to make any correction for the secular change: the coincidence in the epochs derived from these means seems purely accidental.

4*th*, *St Helena*, 1842–45, uncorrected for secular change.

Maximum in June.
Minimum in April.

The same difficulty occurs in this case for the secular correction as for the Cape, though to a less extent: the existence of the minimum in September and the maximum in December is barely indicated by a diminution of the *rate* of decrease of force after July, as will be seen in the dotted curve below that for St Helena (Plate XXIV.), which shows the change from one monthly value to the next following. No satisfactory result can be obtained for the annual law where the secular variation changes its rate and sign during the period considered.

5*th*, *Singapore*.

Maxima in January and June.
Minima in April and September.

6*th*, *Trevandrum*.

Maxima in December and June.
Minima in April and August.

40. The maximum in June and minimum in September are less marked at Singapore and Trevandrum than at Makerstoun, Hobarton, and Munich, or than is indicated generally at the Cape and St Helena. Though this may be due, to some extent, to instrumental causes, it is probably partly a consequence of the less effect of disturbances on the mean force near the equator.

41. The double epochs may be considered to exist in all the series in spite of the various errors or movements that cannot easily be eliminated.* That the variations follow the same law everywhere, independently of the secular change, may be best shown by an example. The year 1845 exhibits considerable difference in the character of the monthly variations (see Plate XXIII.); let us then consider the differences of the values of each month with that following it, in the year 1845; these differences are projected in Plate XXIII. It will be seen

* The means of the Toronto Observations, July 1846 to June 1848, corrected for secular change at the rate of $-1{\cdot}33$ per mensem, are projected in Plate XXIV.

that the curves thus formed agree wonderfully in their inflections—the increasing rapidity of diminution of force at the Cape being indicated by a descending curve; the increasing rapidity of increase at Toronto by an ascending curve; the slight differences at Trevandrum and Singapore are, I have no doubt, due to instrumental errors.

42. On the whole, it seems probable that the monthly mean variations, independent of secular change, obey the same law. It does not appear from the curves last considered that the range of these variations is diminished near the equator, though the variations for Singapore are somewhat less marked than at the other places. If we take the variation of the monthly means from maximum to minimum and minimum to maximum for the years 1842–55 (see the projections, Plate XXIV.) we find the range at Trevandrum and Singapore less than for higher latitudes. Thus—

TABLE XIV.—Range of Annual Period.

Station.	Jan. to April.	June to April.	June to September.	Jan. to September.
Makerstoun, . . .	5·31	6·20	6·70	5·90
Hobarton, ...	4·30	4·40	6·00	5·90
Munich, ...	3·20	4·40	6·70	5·40
Singapore, ...	4·90	2·50	2·00	4·30
Trevandrum, . . .	4·40	2·70	2·00	4·70

43. These are the approximate variations; and were the Singapore and Trevandrum results as trustworthy as the others, we might conclude at once that the range was less in low than in high latitudes. We shall see afterwards the effect of disturbance on the daily means near the equator, already referred to as a cause for such a diminution.

44. On account of the doubt as to the perfect accuracy of some of these results, I have not thought it necessary to compute the representative equations of sines.

45. It is always desirable, when a law has been found differing from that obtained by others, that we should not only give good grounds for our own conclusion, but, if possible, show the error or insufficiency of the one opposed to it. The only results with which I am acquainted, which it appears to me merit examination, are those obtained by General Sabine from the observations of absolute horizontal intensity made at the Colonial observatories.

46. These observations, it should be remarked, are affected by the error of

the bifilar temperature coefficient, as they are reduced to the mean bifilar for the month, which mean is corrected to a constant temperature; this error, it may be supposed, will obey some law depending on the mean temperature, or the amount of its variation during each month, which will have a single period, and be included in the term $a_1 \sin(\theta + c_1)$ of the equation (1) of sines; whereas we may expect, if the observations are sufficiently numerous, that the term $a_2 \sin(2\theta + c_2)$ will be little affected. On this ground I have discussed the observations of absolute intensity made at Toronto, the Cape of Good Hope, and Hobarton: those which merit the greatest consideration, on account of the number of observations, are from the Toronto Observatory.

47. *Annual Period from Observations of Absolute Intensity, Toronto.*—General Sabine has discussed the Toronto monthly means for the years 1845 to April 1849 in the Transactions of the Royal Society, 1850 (p. 205), and the means for the years 1845 to 1852 in the Introduction to the Toronto Observations, vol. ii. (p. xc); in the latter he has however omitted the observations for 1852, on account of a considerable change in the monthly values after April 1852. I have not been able to see the propriety of this omission, as the changes in other years for an interval of two months (as May to July, June to August, September to November, 1850) are even greater than those from March to May 1852. In order, however, that the result may not depend on the rejection of the observations for this year, I shall consider the means both inclusive and exclusive of 1852.

48. The following are the monthly means (1845–52) with secular change eliminated at the rate of 0·00035 per mensem, *minus* the lowest mean (that for October), the monthly means 1845–51 according to General Sabine's discussion; and (I have added) the monthly means for Makerstoun (from the bifilar) for the eight years 1842–49, all reduced to the units $\frac{X}{10000}$.

TABLE XV.—Annual Period from Observations of Absolute Intensity at Toronto.

Place.	Years.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Toronto, . .	1845–52	5·4	1·1	9·1	1·7	13·0	9·6	7·9	8·2	3·1	0·0	3·7	6·5
Makerstoun, .	1842–49	5·3	3·9	3·1	2·5	6·2	8·8	6·6	3·3	0·4	0·0	2·5	5·6
Toronto, . .	1845–51	4·2	0·8	9·3	8·5	15·0	15·5	11·0	9·3	3·7	0·0	3·7	6·5

49. If we compare the results at Toronto 1845–52 with those at Makerstoun 1842–49, it will be obvious that the most marked difference is to be found in the high value for March at Toronto; there can be no doubt, however, that the

maximum in December is as well shown at Toronto as at Makerstoun. The coincidence in these results, it appears to me, is quite remarkable. It is, indeed, to some extent accidental, since the errors of the observations are not only considerable (as an examination of the partial results will show), but the corrections for temperature employed in the reductions are very inaccurate.*

50. I have computed the constants in the equation of sines for the mean of the eight years, and find ($\theta=0$, Jan. 16)—

$$X=3{\cdot}5301+0{\cdot}0008\sin(\theta+315^\circ)+0{\cdot}0011\sin(2\theta+135^\circ)\,; \quad . \quad . \quad (4)$$

or, putting the coefficient of the last term in ten-thousandths of X, it becomes—

$$3{\cdot}12\sin(2\theta+135^\circ), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad 5)$$

which gives the same epochs for the double maximum and minimum within three days as the Hobarton and Makerstoun results (§ 34), the coefficient being slightly greater.

51. If we examine General SABINE's means (1845–51) in a similar manner, we shall find—

$$X=3{\cdot}5309+0{\cdot}0020\sin(\theta+313^\circ)+0{\cdot}0010\sin(2\theta+155^\circ), \quad . \quad . \quad (6)$$

and the last term with the coefficient in ten-thousandths of X becomes—

$$2{\cdot}83\sin(2\theta+155^\circ). \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (7).$$

52. If we compare this also with the corresponding terms for Makerstoun and Hobarton, we shall find that the coefficient for Toronto has a value nearly equal to the mean of the two, and that the epochs of the double maximum and minimum at Toronto are within thirteen days of those at the two other places.

53. *Annual Period from Observations of Absolute Intensity, Cape of Good Hope.*—The observations of absolute intensity made at the Cape of Good Hope are

* I have taken the trouble to deduce the absolute force for the year 1845, the only year for which the data are in my possession, so as to eliminate the error due to the bifilar temperature coefficient. The following are the values in absolute measure from the Toronto volume, and according to my corrected computation :—

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Toronto volume, *minus* 3·5370,	·0027	·0022	·0047	·0025	·0041	·0093	·0033	·0035	·0032	·0042	·0000	·0031
Corrected by me, *minus* 3·5385,	·0025	·0005	·0035	·0021	·0049	·0063	·0056	·0024	·0011	·0010	·0000	·0040

The law is evidently to be traced even in these results; the greatest error of a monthly mean is that for July, $=0{\cdot}0038$, or in ten-thousandths of X, $=10{\cdot}8$. The errors are chiefly due to the difference between the mean temperature of the bifilar for the three days on which the absolute observations are made and for the month; in July, for example, this difference is 9°·0 Fahr.

from November 1846 till February 1850, but with no observations in the months February to June 1849. The following are the changes from month to month of the absolute values:*—

TABLE XVI.—MONTHLY CHANGES OF HORIZONTAL FORCE AT THE CAPE OF GOOD HOPE, FROM OBSERVATIONS OF ABSOLUTE INTENSITY.

Months.	1846.	1847.	1848.	1849.	1850.	Mean.
December to January, . . .	...	−·0002	+·0009	+·0029	−·0137	−·0025
January „ February, . . .	...	−·0055	−·0050	...	+·0012	−·0031
February „ March, . . .	...	−·0009	+·0026	...	...	+·0008
March „ April, . . .	...	−·0027	+·0004	...	...	−·0011
April „ May, ...	...	+·0019	+·0029	...	...	+·0024
May „ June, ...	...	+·0038	+·0015	...	...	+·0026
June „ July, ...	...	−·0007	−·0051	...	...	−·0029
July „ August, . . .	...	−·0008	+·0038	−·0021	...	+·0003
August „ September, . .	...	−·0054	−·0008	−·0033	...	−·0032
September „ October, . . .	...	−·0038	−·0062	−·0027	...	−·0042
October „ November, . .	...	−·0016	−·0049	−·0008	...	−·0024
November „ December, . .	+·0007	−·0009	+·0020	+·0012	...	+·0008

54. If we assume the value for January to be 0·0107, we shall obtain the values for the other months as in the second column of the following table; by repeating the month of January we find the secular change for one year to be −0·0124; correcting the quantities in the second column at the rate of +0·00103 per mensem, and subtracting the resulting value for February from all, we obtain the quantities in the third column.

TABLE XVII.—MONTHLY VARIATIONS OF HORIZONTAL FORCE, DEDUCED FROM TABLE XVI.

Months.	Mean.	Mean Corrected for Sec. Change.
January, ...	·0107	·0020
February, ...	·0076	·0000
March, ...	·0084	·0018
April, ...	·0073	·0017
May, ...	·0097	·0052
June, ...	·0123	·0088
July, ...	·0094	·0069
August, ...	·0097	·0083
September, ...	·0065	·0061
October, ...	·0023	·0029
November, ...	·0000	·0017
December, ...	·0008	·0035

* See Cape of Good Hope Magnetical Observations, vol. i. Table xxxvi. p. lxx.

55. These quantities, by the equation of sines, give ($\theta=0$, January 16)

$$X=4\cdot4921+0\cdot0035\sin(\theta+261°)+0\cdot0013\sin(2\theta+111°). \qquad (8)$$

Considering again the last term (which we may suppose as before to some extent independent of error of corrections) in units of $\frac{X}{10000}$, we have

$$2\cdot84\sin(2\theta+111°), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (9)$$

Comparing this with the mean result for Makerstoun and Hobarton, or

$$2\cdot76\sin(2\theta+129°), \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \qquad (10)$$

we find nearly the same coefficient, and the same epochs for the double maximum and minimum within nine days.

56. *Annual Period from Observations of Absolute Intensity, Hobarton.*—There remain now only the observations at Hobarton to discuss. These observations were made during the five years 1846–50; and the result obtained by General SABINE is just the reverse (as he has pointed out*) of that he obtained from the Cape.

57. Only one observation was made monthly in 1846 and till April 1847; from April 1847 till October 1848, three observations were made monthly; from November till the end of the series, one observation was made weekly. From the commencement till October 1848, the observations were made at the beginning of each month; and as the observations were reduced to the mean bifilar for the month, or that corresponding to the middle of the month, there will generally be an error on account of the difference of bifilar temperature for the two epochs, and the error of the temperature coefficient employed. I have attempted to correct this error, but the data are not sufficient, and there appear to be accidental errors, which could only be corrected by reference to the original observations.† Thinking it possible that the accidental errors might destroy each other, I have taken the results as they are in vol. ii. (Introduction, pp. 39, 40). In order that the value of the determinations for each month might depend on the number of observations made, I have given the change of the force from any one month to the next following, a value equal to the sum of the numbers of deflections made

* Cape Observations, vol. i., p. lxxi.

† The bifilar temperature is not given with the observations of absolute intensity. In attempting to determine this temperature by the date and the ordinary hourly observations, it appears to me that there are several errors in the tables. Thus, as to the dates 1847, March $2^d\ 0^h$, August $1^d\ 0^h$, September $5^d\ 0^h$, October $3^d\ 0^h$, &c. &c., of Hobarton time, they are all noon of Sunday, when no observations were made; the days are perhaps Göttingen time, and the hours Hobarton time? Again, the bifilar readings given as those during the observations 1846, April $3^d\ 1^h$; 1847, February $2^d\ 0^h$, March $1^d\ 0^h$, April $1^d\ 0^h$, December $3^d\ 0^h$, December $4^d\ 0^h$, &c., appear to be erroneous; in some cases, perhaps, the error is one of 10 divisions.

in the two months; that is to say, if six deflections were made in February and six in March 1848, the change, February to March, had a value of twelve.*

58. The following are the changes with their values:—

TABLE XVIII.—Monthly Changes of Horizontal Force at Hobarton, from Observations of Absolute Intensity, 1846–50.

Months.	1846.		1847.		1848.		1849.		1850.		Resulting Mean.
	Value.	Change.	Value.	Change.	Value.	Change.	Value.	Change.	Value.	Change.	
Jan. to Feb., .	3	+·0144	3	−·0033	12	+·0034	18	+·0003	18	−·0053	−·0005
Feb. „ Mar., .	3	−·0133	3	−·0044	12	−·0043	16	−·0020	16	−·0016	−·0032
Mar. „ April, .	3	−·0019	9	−·0022	12	−·0022	16	+·0006	18	+·0013	−·0013
Apr. „ May, .	3	+·0004	12	0000	12	+·0018	18	−·0016	16	+·0004	0000
May „ June, .	3	−·0046	12	+·0007	12	−·0009	18	+·0003	14	+·0012	+·0001
June „ July, .	3	+·0045	12	−·0002	12	−·0025	16	+·0017	18	+·0032	+·0011
July „ Aug., .	3	−·0008	12	+·0010	12	+·0025	18	−·0022	18	−·0036	−·0016
Aug. „ Sept., .	3	−·0003	12	−·0014	12	+·0048	18	−·0004	16	+·0023	+·0012
Sept. „ Oct., .	3	+·0014	12	−·0001	12	−·0051	18	+·0013	18	−·0025	−·0013
Oct. „ Nov., .	3	+·0002	12	−·0004	16	+·0012	18	+·0002	18	+·0013	+·0006
Nov „ Dec., .	3	+·0006	12	+·0018	18	+·0029	16	+·0005	18	+·0010	+·0015

59. Considering the value for January as ·0040, we obtain the following variations:—

TABLE XIX.—Monthly Variations deduced from Table XVIII.

Month.	Mean.	Month.	Mean.
January, . . .	·0040	July, ...	·0028
February, . .	·0035	August, . . .	·0012
March, . . .	·0003	September, . .	·0024
April, . . .	·0000	October, . . .	·0011
May, ...	·0001	November, . . .	·0017
June, ...	·0012	December, . . .	·0032

General Sabine finds the secular change (giving the month's equal values) for twelve months = −·0006. The yearly means (excepting that for 1846, which depends on only twelve observations) would give about +·0004. So that in any case we may neglect the secular change as small.

60. Treating the preceding quantities for the equation of sines, we obtain—

$$X = 4{\cdot}5025 + 0{\cdot}0011 \sin(\theta + 133°) + 0{\cdot}0013 \sin(2\theta + 83°); \quad . \quad . \quad . \quad (11.)$$

* This is the same as if each whole observation had a value, since each complete observation was made up of two deflections, excepting in 1846, and January to March 1847, when three deflections were made to complete the observation.

or for the last term, putting the coefficient in $\frac{X}{10000}$, we have:—

$$2{\cdot}90 \sin (2\theta + 83°), \quad . \quad . \quad . \quad . \quad . \quad . \quad (12.)$$

This coefficient agrees nearly with that for Toronto, the Cape, Hobarton, and Makerstoun, but the epochs of the maxima and minima differ twenty-three days from those for the last two places.

61. We may place the results for the second term thus:—

			Coefficient.	Epochs of Maxima and Minima after the days of Solstices and Equinoxes.
Bifilar observations,	Makerstoun	(1844–48),	2·98	6d
,, ,,	Hobarton	(1844–48),	2·54	6
Absolute intensity,	Toronto	(1845–52),	3·12	3
,, ,,	The Cape	(1847–49),	2·84	15
,, ,,	Hobarton	(1846–50),	2·90	29

The agreement of these results shows that the assumption (46) was well founded; and the results, from the observations of absolute horizontal intensity, confirm the annual law derived from the bifilar observations.

62. In the previous investigations, we have considered the annual movement as represented by twelve monthly means, corresponding to the middle day of each month; it must be obvious that we in this way fail to perceive all the minor variations of the monthly mean. In order to compare these variations at the four places, Makerstoun, Hobarton, Singapore, and Trevandrum, I have obtained the four weekly means corresponding to every day in the years 1844 and 1845, for these places. These four weekly means are projected in Plates XXV. and XXVI.

63. In comparing these variations, we observe that even the minute changes are followed similarly at each place, but that they are combined at certain periods of the year with a greater continuous increase or diminution of force at one place than at another. This similarity of movement depends on the similarity of the variations of the daily means, which we shall consider immediately.

64. If only *one* daily mean be much less at one place than at the others, there will be a sudden drop of the curve for four weeks, with as sudden a rise thereafter as we see in Plate XXV., March 14th to 15th, and April 11th to 12th, 1844, at Makerstoun, due to the fall, March 29, 1844 (see Plate XXVII. of daily means); if, however, the force should increase suddenly and *permanently* at any epoch, the curve will show an increase *continuously* for the four weeks following this sudden change. Some such cause, real or accidental, produces the difference between the curve for Makerstoun and for the other places in January 1845 (see Plate XXVI.) The further consideration of these variations I shall leave till another occasion.

Variations of the Daily Means.

65. The daily means for four places in $\frac{14}{100000}$ of the value of X at each place, will be found for the years 1844 and 1845, in Table XXXIII, p. 550.* In considering the daily means of horizontal force, we shall perhaps derive the most general information from an examination of the projections in Plate XXVII. It should be remarked *first*, that the daily means, commencing each week at any place, are not strictly comparable with the means for the corresponding days at other places; since the means are for the Göttingen astronomical day (0^h to 23^h), one mean in each week is made up partly of observations on Saturday afternoon, and partly of observations on Monday morning; and as Saturday ends and Monday begins at different hours (Göttingen) on different meridians, the hourly observations forming the day, made up of these two parts, are not simultaneous at the different places. It should be remarked, *second*, that the means of 24 hourly observations, are not in all cases enough to give the true daily mean force; and this is especially true for days of disturbance in high latitudes.

66. The conclusions deducible from Plate XXVII. are as follow:—

1*st*, The movements from day to day resemble each other *generally*, at all the places; and this whether we consider the amount or direction of movement.

2*d*, In certain seasons there is the appearance of a period of about 26 to 30 days, equally well marked, or nearly so, at all the stations. I shall proceed to examine these conclusions more minutely.

67. From the first it follows, that the daily mean horizontal intensity increases at the same time at all the stations, and diminishes at the same time at all the stations; so that, if this holds for all the points on the earth's surface (as it does for all the points on which observatories have been placed), we may conclude that the intensity of the magnetism of the whole earth is variable, increasing or diminishing from day to day.

68. The only marked cases in which the direction of movement in the curves, Plate XXVII., is different at one place from that at any other, are those of the daily means for April 17 and June 28, 1844, which show an increase at Makerstoun, while there is a diminution at all the other places on the first date, and little or no movement on the second; all the other differences are of the smallest kind, and generally within the amount of errors of correction, or of means, when disturbances have existed. The increase at Makerstoun, April 17, 1844, which was not experienced in the places farther south, was due solely to an increase of horizontal force during the disturbance, from $17^d\ 1^h$ to 6^h (Göttingen mean time) at

* The value of the unit coefficient of the bifilar magnetometers at Makerstoun and Trevandrum was very nearly $k=0{\cdot}000140$. As the results in this paper were first deduced from the observations at these two places, the same value of the unit was adopted for the other places in these tables.

Makerstoun; at the other places, a diminution of force was then experienced. Considering that the disturbances affect the dip as well as the intensity, the rarity of this opposition is not a little extraordinary. Some of the differences to be found on careful comparison, are probably due to accidental causes; such as spiders (of which Trevandrum, February 18 to 23, 1844, is probably an example).

69. The *amounts* of movement also do not appear much different. When we take the differences from day to day, for each of the two years, subtracting the difference of the first daily mean of each year from the last of the corresponding year, to eliminate the effects of secular change, we obtain the amounts of movement at the respective places, as follows :—

TABLE XX.—SUMS OF POSITIVE AND NEGATIVE DIFFERENCES OF SUCCESSIVE DAILY MEANS OF HORIZONTAL FORCE. (1·00=0·00014 X.)

STATIONS.	1844.	1845.	1844–45.	Approximately as
Makerstoun, . . .	664·44	644·00	1308·00	1·42
Trevandrum, . . .	578·66	576·12	1154·78	1·25
Singapore, . . .	478·44	448·62	927·06	1·01
Hobarton, . . .	466·96	453·66	920·62	1·00

70. The differences of amounts has evidently no relation to the value of the horizontal force at each place, since Trevandrum and Singapore have each X=7·9 nearly, whereas at Hobarton the value is only 4·5, and at Makerstoun 3·4. It would be easy to show that the inequality of the movements is chiefly due to large disturbances; for if we omit the differences due to only three daily means, namely, those for March 29, 1844, January 9, and April 13, 1845, we obtain the following differences of movements:—

TABLE XXI.—SUMS OF TABLE XX. DIMINISHED BY OMITTING THREE LARGE DISTURBANCES.

STATIONS.	1844.	1845.	1844–45.	Approximately as
Makerstoun, . . .	610·22	574·36	1184·58	1·33
Trevandrum, . . .	570·42	553·13	1123·25	1·26
Singapore, . . .	469·42	429·58	899·00	1·01
Hobarton, . . .	452·23	435·48	887·71	1·00

71. It thus appears, that the sums of the differences for Makerstoun and Tre-

vandrum differ little; while they differ little also for Hobarton and Singapore; but the sum for the two former exceeds that for the two latter nearly in the ratio of 13 to 10. If we could assume that the differences shown in these sums are due to the different effect of disturbance, we should arrive at the curious result, that the effect is the same at Singapore on the equator and at Hobarton in 43° south latitude; while the difference between Trevandrum (in $8\frac{1}{2}$° N.) and Makerstoun (in $55\frac{1}{2}$° N.) is also not so great as between Trevandrum and Singapore. It must be remembered, however, that 1844 and 1845 were years of minimum disturbance, and therefore not the best fitted for this determination.

72. It follows from these sums, that the amount of movement is wholly independent of the value of the magnetic inclination, since that is nearly the same at Hobarton and Makerstoun, and nearly zero at Trevandrum.

73. Since the disturbance appears to affect the movements of the mean horizontal force more at Makerstoun than at the other places, we should expect that those months containing the greatest amount of disturbance would show the greatest difference in the ratio of the amounts of movement at Makerstoun, and at the more southern stations. The following table contains the sums of the positive and negative differences of daily means, from January 1, 1844, to December 28, 1845, for each period of four weeks:—

TABLE XXII.—Sums of the Positive and Negative Differences of the Successive Daily Means of Horizontal Force, in Fourteen Hundred-thousandths of the whole Horizontal Force at Makerstoun, Trevandrum, Singapore, and Hobarton, respectively. (1·00 = 0·00014 X.)

Four Weeks.	1844.				Four Weeks.	1845.				1844–45.			
	Makerstoun.	Trevandrum.	Singapore.	Hobarton.		Makerstoun.	Trevandrum.	Singapore.	Hobarton.	Makerstoun.	Trevandrum.	Singapore.	Hobarton.
Jan. 1 to Jan. 28,	28·02	32·35	26·81	24·05	Dec. 29 to Jan. 26,	81·95	57·76	39·88	46·52	109·97	90·11	66·69	70·57
Jan. 28 ,, Feb. 25,	60·03	45·46	33·23	27·30	Jan. 26 ,, Feb. 23,	38·66	33·69	32·01	37·81	98·69	79·15	65·24	65·11
Feb. 25 ,, Mar. 24,	49·69	38·60	29·31	39·49	Feb. 23 ,, Mar. 23,	40·46	26·49	24·19	28·07	90·15	65·09	53·50	67·56
Mar. 24 ,, Apr. 21,	103·32	57·95	50·21	49·94	Mar. 23 ,, Apr. 20,	66·52	41·06	35·35	37·49	169·84	99·01	85·56	87·43
Apr. 21 ,, May 19,	55·13	44·32	37·48	37·71	Apr. 20 ,, May 18,	36·78	43·66	31·85	30·92	91·91	87·98	69·33	68·63
May 19 ,, June 16,	36·84	32·34	26·95	25·46	May 18 ,, June 15,	37·83	32·79	22·65	31·69	74·67	65·13	49·60	57·15
June 16 ,, July 14,	38·41	39·23	30·99	28·49	June 15 ,, July 13,	29·52	31·55	25·48	17·91	67·93	70·78	56·47	46·40
July 14 ,, Aug. 11,	60·15	53·71	42·01	37·30	July 13 ,, Aug. 10,	46·66	45·70	34·81	38·31	106·81	99·41	76·82	75·61
Aug. 11 ,, Sept. 8,	30·10	36·17	36·11	32·74	Aug. 10 ,, Sept. 7,	51·97	45·77	36·55	43·07	82·07	81·94	72·66	75·81
Sept. 8 ,, Oct. 6,	54·70	54·02	46·57	52·91	Sept. 7 ,, Oct. 5,	45·71	60·77	43·79	39·60	100·41	114·79	90·36	92·51
Oct. 6 ,, Nov. 3,	51·56	45·98	31·26	42·21	Oct. 5 ,, Nov. 2,	70·39	53·68	46·74	41·32	121·95	99·66	78·00	83·53
Nov. 3 ,, Dec. 1,	65·41	62·78	52·65	50·02	Nov. 2 ,, Nov. 30,	53·79	56·86	38·89	38·62	119·20	119·64	91·54	88·64
Dec. 1 ,, Dec. 29,	45·63	42·85	38·47	28·97	Nov. 30 ,, Dec. 28,	57·06	65·29	52·28	44·52	102·69	108·14	90·75	73·49

74. The law of the annual period will be shown better from a larger series; but as far as these go, all show the greatest amount of movement in the four weeks March 23 to April 20, and in the four weeks September 7 to October 5, or

October 5 to November 2; while the most marked minimum at all the places occurs near the summer solstice.

75. It should be noted that the differences in the above table include the variation due to the annual period and secular change. If we put the differences into four groups, each having an equinox or solstice as the middle point, and subtract the difference between the first and last daily mean of each group, from the sum for that group (in order to eliminate approximately the effect of secular change), we shall obtain the following quantities:—

TABLE XXIII.—Sums of Differences, with Effect of Secular Change eliminated for each Season, 1844–45. (1·00=0·00014 X.)

Period.	Makerstoun.		Trevandrum.		Singapore.		Hobarton.	
	Sum.	Ratio.	Sum.	Ratio.	Sum.	Ratio.	Sum.	Ratio.
Feb. 5 to May 7, . .	365·92	1·40	260·69	1·05	223·04	1·19	233·47	1·27
May 7 „ Aug. 6, . .	260·32	1·00	248·52	1·00	186·78	1·00	183·95	1·00
Aug. 6 „ Nov. 5, . .	322·14	1·24	319·88	1·26	253·24	1·36	263·60	1·43
Nov. 5 „ Feb. 5, . .	379·06	1·46	348·88	1·40	281·22	1·51	250·48	1·36

76. The number of years' observations here included is too few for certain conclusions on small differences, but there can be little doubt these numbers show that, in both hemispheres, the variation of daily mean horizontal force is less in the quarter about the June solstice (when the sun is in apogee) than in any other quarter.

77. The ratios of the sums for the summer solstice to those for the winter solstice differ little for all the four places; and if we add the sums for Makerstoun to those for Trevandrum (which do not differ greatly), and those for Hobarton to the sums for Singapore (which also are nearly equal to each other), we shall find—

Makerstoun *plus* Trevandrum, June solstice : December solstice = 1·000 : 1·431
Hobarton *plus* Singapore, June solstice : December solstice = 1·000 : 1·434

78. If we compare the amounts in each quarter at Hobarton with those at Makerstoun, we obtain the following results:—

March equinox, Hobarton : Makerston = 1 : 1·57;
June solstice, „ „ = 1 : 1·41;
September equinox, „ „ = 1 : 1·22;
December solstice, „ „ = 1 : 1·51;

or the excess of the movements in the northern hemisphere over those in the southern hemisphere was least at the September equinox and greatest at the March equinox (in 1844–45).

79. If we subtract from the first group in Table XXIII. the differences due to March 29, 1844, and April 13, 1845, and from the last group the differences due to January 9, 1845, three days of marked disturbance that we have subtracted from the sums in Table XXI., we shall have—

TABLE XXIV.—Sums from Table XXIII., omitting Three Days of Large Disturbance, with Ratios to Hobarton.

Period.	Makerstoun.		Trevandrum.		Singapore.		Hobarton.	
	Sums.	Ratio.	Sums.	Ratio.	Sums.	Ratio.	Sums.	Ratio.
Feb. 5 to May 7, . .	282·75	1·33	246·13	1·16	207·90	0·98	212·41	1·00
May 7 „ Aug. 6, . .	260·32	1·41	248·52	1·35	186·78	1·02	183·95	1·00
Aug. 6 „ Nov. 5, . .	322·14	1·22	319·88	1·21	253·24	0·96	263·60	1·00
Nov. 5 „ Feb. 5, . .	340·05	1·42	335·29	1·38	270·80	1·12	242·00	1·00

The ratios of Hobarton to Makerstoun are more nearly constant here than in (78). In all cases we have to remark the nearness to equality in the amount of movements at Trevandrum and Makerstoun, as well as in those at Hobarton and Singapore.

80. From all the sums we arrive at the following important result:—That the amount of variations of daily mean horizontal force does not depend (or depends but little) on season in the meteorological sense, the amounts of movement being least in both hemispheres in the quarter when the sun is in apogee—that is, during the northern summer and southern winter. More extensive series will prove that the amount is greatest also in the equinoctial quarters, though the difference betwixt the amounts for these and the December solstice is not considerable.

81. If we now examine Plate XXVII. again, we shall perceive a series of movements having a period of about 26 to 30 days (66, 2d.), which are, however, only marked in certain seasons. The months of 1844–45 in which this period is seen are January to April and August to December,—perhaps least distinctly in December and January; it is not visible in May, June, or July.

82. When we attempt to determine the duration of this period from the projected results for all the places, we find the time from minimum to minimum approximately as follows:—

1844.	Jan. 9 to Feb. 5	=27 days	Sum of 4 periods=108 days; mean=27·00 days.
	Feb. 5 „ Mar. 5	=29 „	
	Mar. 5 „ Mar. 30	=25 „	
	Mar. 30 „ Apr. 26	=27 „	
	Apr. 26 „ Aug. 3	.	Sum of periods=99 days.
	Aug. 3 „ Sept. 1	=29 „	Sum of 4 periods=111 days; mean=27·75 days.
	Sept. 1 „ Sept. 30	=29 „	
	Sept. 30 „ Oct. 26	=26 „	
	Oct. 26 „ Nov. 22	=27 „	
	Nov. 22 „ Feb. 5	.	Sum of periods=75 days.
1845.	Feb. 5 „ Feb. 25	=20 „	Sum of 3 periods=73 days; mean=24·33 days.
	Feb. 25 „ Mar. 24	=27 „	
	Mar. 24 „ Apr. 20	=26 „	
	Apr. 20 „ Aug. 3	.	Sum of periods=103 days.
	Aug. 3 „ Aug. 30	=27 „	Sum of 4 periods=106 days; mean=26·50 days.
	Aug. 30 „ Sept. 27	=28 „	
	Sept. 27 „ Oct. 24	=27 „	
	Oct. 24 „ Nov. 17	=24 „	

83. Some of the periods whose duration has been noted are by no means well determined. Thus the period commencing February 5, 1844, is not well marked, while that ending April 20, 1845, has more the appearance of ending April 13 or 14; any other points, however, which might be taken would not alter appreciably the mean period derived from these groups. If we examine them separately, we shall find that no period appears greater than 29 days, while some are only 24 days. In some cases a period appears broken into two, especially in the end of 1845; but this is generally on such days that we can determine, by the distance of preceding or succeeding minima, whether the break is the periodic minimum: thus December 3, 1845, is a marked minimum, but we can assume it to belong to the true period only by supposing some of the preceding periods to last 14 or 40 days, both completely without the limits of well-marked periods.

84. If, then, we assume for the instant that the groups given above show the true number of periods, we shall have—

15 periods, with a sum of 398 days or 1 period=26·53 days.

We may suppose that the sums of days intervening betwixt each group should equal a *whole* number of periods; and if we take the value of the period approximately as above, we must allow 4 periods to the first interval, 3 to the second, and 4 to the third, or

11 periods, with a sum of 277 days and 1 period=25·18 days.
The mean of the whole 26 periods gives 1 period=25·96 days.

85. No distribution of the periods would alter this result much. The consideration of a much longer series will show, what indeed seems to follow from the above, that the period has a variable duration of 20 to 30 days.

86. The first question that follows the appearance of such a period is as to its cause. Mr Kreill's results and my own seem to indicate a period of the dura-

tion of a lunation; but there are several reasons against the hypothesis of a lunar cause in this case, besides the duration. The *nearness* of our satellite would render it extremely probable, if she were the cause of this variation, that the amount of the variation should depend upon the latitude of the place and the moon's declination; we shall see that it does not depend on the latter, and probably little on the former. In the next place, we would expect some relation between the amount of the mean diurnal variation and the change of daily mean values. Such a relation exists between the solar diurnal variation and the change of daily mean value; but no such relation exists between the latter and the lunar diurnal variation, or it is but slightly marked; the amount of the change for this period is too large to be explained by the cause which produces the lunar diurnal variation. On the whole, I think we cannot attribute this period to the moon; and the range of the period is so considerable as to render it probable that the sun is the cause. The true period of rotation of the sun is about 25·63 days, and the synodical rotation with reference to the earth is about 27·22 days; the latter number differs little from the first two series of well-marked groups in 1844, and the former differs little from the mean as obtained from the two years. A careful investigation of a much larger series of observations leads me to believe that the period is variable within certain limits; and I think it may be possible, when this additional series of observations is examined, to show a probable cause for this variation: meanwhile, without entering into any theory, I shall proceed to notice some results to be derived from the quantities under consideration.

87. We have already considered the differences of the daily means, or the changes from day to day at different places; we may now examine the ranges of the best-marked of the 26–27 day period. The following are the approximate ranges (mean of rise from minimum to maximum, and of fall from maximum to minimum) of these movements where best marked at the four places in 1844 :—

TABLE XXV.—Ranges of 26–27 Day Period: January to April 1844.

Period.	Makerstoun.	Trevandrum.	Singapore.	Hobarton.
Jan. 9 to Feb. 5, . . .	8·39	5·93	5·07	5·50
Feb. 5 ,, Mar. 6, . . .	12·81	11·49	8·96	8·60
Mar. 6 ,, Apr. 1, . . .	12·93	9·48	8·68	8·88
Sum, ...	34·13	26·90	22·71	22·98
Ratio to Hobarton, . .	1·49	1·17	0·99	1·00

88. These ranges show nearly the same ratios as the sums of daily changes (Table XXII.); but when we take the movements after August 1844, where they again become well marked, we find—

TABLE XXVI.—Ranges of (26–27) Day Period: August to November 1844.

Period.	Makerstoun.	Trevandrum.	Singapore.	Hobarton.
Aug. 2 to Sept. 2, .	6·26	9·37	7·08	7·73
„ 30 „ Oct. 1, .	10·81	13·80	10·01	11·30
Sept. 30 „ Oct. 21, .	12·55	14·88	12·44	13·55
Oct. 20 „ Nov. 22, .	14·97	11·48	10·91	12·47
Sum, ...	44·59	49·53	40·44	45·05
Ratio to Hobarton, .	0·99	1·10	0·90	1·00

In these instances the ranges are nearly equal at all the places.

89. And if we combine the sums of both groups, we have—

TABLE XXVII.—Sums of Ranges of both Groups.

Argument.	Makerstoun.	Trevandrum.	Singapore.	Hobarton.
Sum of both groups, .	78·72	76·43	63·15	68·03
Ratio to Hobarton, .	1·16	1·12	0·93	1·00

90. The ranges of these movements are only affected by disturbances in as far as the maxima or minima are concerned; and we might expect that, if the movements should be equal at all places independently of local disturbance, the ratio would be much nearer a ratio of equality than in the case of the sums of daily changes. This is the case in the means of the ranges for these eight periods; and it follows as very probable that the range of the 26–27 day period is nearly equal at all the stations.

91. In order to examine more carefully the relation of these movements, I chose one of the most marked, that included within five weeks February 4 to March 8, 1844; though the agreement of the smaller movements within this period is by no means so well marked as in many others, and I included two other stations, the Cape and Toronto. Commencing with January 28, I obtained

the daily mean corresponding (for its middle point) to every *hour* from near noon on Monday till near noon on Saturday. Each week gives in this way 121 daily means; but as the first observation on Monday morning at Hobarton is 14 hours earlier than the first observation obtained at Toronto on the same morning, the whole 121 means have not simultaneous equivalents at all the stations. The daily means thus obtained for Makerstoun, Cape of Good Hope, Trevandrum, Singapore, Hobarton, and Toronto were corrected by a quantity depending on the differences of the weekly means, February 4–9 and March 3–8, for the secular increase or diminution. The corrected values are projected in Plate XXVIII.

92. In these curves we may study the differences as well as agreements of movements. Some differences, it is believed, are due to accidental causes, as in the commencement of the week February 19^d–24^d, at Trevandrum, where spiders were probably acting on the bifilar wires. In other cases we may suppose the differences due to different directions of movement of dip.

93. In the first week, January 29 to February 3^d, we find the apex about January 31^d, 10^h–14^h, at all the stations excepting Hobarton, where this apex seems cut off. The turning point occurs at the Cape of Good Hope at 11^h; Trevandrum, $8\frac{1}{2}^h$; Singapore, 10^h; Toronto, 10^h; at Makerstoun it is later, and is followed by a higher point.

94. In the following week we find the increase of force at Makerstoun at 6^d 18^h greater than at the other stations; the epochs of maximum and minimum are as follow:—

TABLE XXVIII.

Station.	Maximum.		Minimum.	
	D.	H.	D.	H.
Trevandrum, ...	6	14	8	0
Makerstoun, ...	6	18	7	20
Cape, ...	6	20	7	20
Toronto, ...	6	20	7	20
Singapore, ...	7	2–10	8	1
Hobarton, ...	7	2–6	8	3

The order of succession of the maximum or of the minimum does not seem to depend either on the latitude or longitude, though, on the whole, the places farthest east are latest.

95. In the third and fourth weeks we find the maxima and minima to be as in the following table:—

TABLE XXIX.

Station.	Third Week.				Fourth Week.			
	Maximum.		Minimum.		Maximum.		Minimum.	
	D.	H.	D.	H.	D.	H.	D.	H.
Toronto,	14	2	15	5	20	10	23	0
Makerstoun,	14	16	15	16	20	9	22	1–18
Cape,	14	9	15	8	20	11	22	17
Trevandrum,	14	7	15	14	20	12	23	2 ?
Singapore,	14	9	15	14	20	11	22	8
Hobarton,	14	0	15	14	20	11	21	12

The greatest difference in the epochs is to be found in the minima of the fourth week, varying from $21^d\ 12^h$ at Hobarton, to $23^d\ 0^h$ at Makerstoun. The fourth week is also remarkable for the considerably greater movement at the Cape and Trevandrum than at Makerstoun.

96. The fifth week includes a rather marked disturbance; we may note the hour when the daily mean force attained a maximum, commenced to diminish, and then began to increase.

TABLE XXX.

Station.	Maximum.		Minimum.	
	D.	H.	D.	H.
Toronto,	27	19	28	19
Makerstoun,	27	18	28	19
Cape of Good Hope,	27	18	28	19
Trevandrum,	27	19	29	2–5
Singapore,	27	19	29	2–5
Hobarton,	27	18–21	29	1

The commencement of the diminution may be considered simultaneous at all the stations, but the termination is not so. The end of the fall is simultaneous at Toronto, Makerstoun, and the Cape; and nearly simultaneous at the three other stations, though from 6 to 10 hours later than at the former three. The Cape, after the minimum, presents a curious difference from the other stations; the mean force, instead of increasing continuously after the minimum, increases only till $29^d\ 0^h$, after which it diminishes anew to a second and more marked minimum at $29^d\ 18^h$.

97. The sixth week has two types, that of Makerstoun, Toronto, and Hobarton, consisting of marked minima about $5^d\ 16^h$, and $7^d\ 4^h$, with a secondary minimum about $6^d\ 10^h$; and that of the Cape, Trevandrum, and Singapore, having only one well-marked minimum at $6^d\ 10^h$, the time of the secondary minimum at the other stations.

98. The best marked movement at all the stations during the six weeks is that after February $27^d\ 18^h$; the amounts of movement between 27 18^h or 19^h, and $28^d\ 19^h$, and $27^d\ 18^h$ or 19^h, and the minima, are as follows—

TABLE XXXI.—Ranges of Movement (1·00=0 00014 X).

Station.	$27^d\ 18^h$ to $28^d\ 19^h$.	$27^d\ 18^h$ to Min.
Toronto, ...	9·92	9·92
Makerstoun, ...	10·30	10·30
The Cape, ...	6·62	6·62
Trevandrum, ...	8·00	8·74
Singapore, ...	5·06	5·68
Hobarton, ...	5·02	5·50

The amount of the movement thus seems to diminish from the north towards the south; the diminution is, however, still small at Trevandrum, and it is nothing between Singapore and Hobarton.

99. It is not easy to state the law of these differences from the consideration of a single period. It will be seen, Table XXVI., and by an examination of the projections, Plate XXVII., that the amounts of movement are frequently equal at all the stations; but we cannot state exactly how much of the differences aredu e to changes of magnetic dip, since there was no instrument well fitted to mark these changes at all the stations. An examination of the six weeks under discussion will show that the irregular variations of mean horizontal intensity are greatest and most common in the higher north latitudes, though some of the continuous movements are greatest near the equator.

100. If we consider the whole range of the curves for the six weeks, Plate XXVIII., taking the difference between the highest point and the mean of the lowest preceding and following (by which we eliminate secular change, &c.), we shall have—

	Makerston.	Toronto.	Trevandrum.	Singapore.	The Cape.	Hobarton.
Ranges, . . .	14·27	11·91	12·12	9·02	12·60	9·89.

101. And if we omit the point February $27^d\ 18^h$ before the great disturbance, we find—

	Makerstoun.	Toronto.	Trevandrum.	Singapore.	The Cape.	Hobarton.
Ranges, . .	12·86	11·06	12·12	9·02	12·60	9·89

In either case the ranges for the stations Singapore and Hobarton are those which differ most from the others.

102. If, in order to avoid points which may be supposed due to local disturbance, we take the mean of five days in the week having the highest mean, and in the two weeks (one preceding, one following) having the lowest means, the five days being those (corresponding to the Göttingen hour, $12\frac{1}{2}$) having simultaneous observations at all the stations, we find—

TABLE XXXII.—Ranges of Five-day Means (1·00=0·00014 X).

Five Days.	Hobarton.		Singapore.		Trevandrum.		Cape.		Makerstoun.		Toronto.	
	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.	Mean.	Change.
D. H. D. H. Feb. 5 0— 9 23	5·00		5·80		5·98		13·52		6·76		11·91	
		6·13		5·18		7·18		6·52		6·48		6·30
19 0—23 13	11·13		10·98		13·16		20·04		13·24		18·21	
		6·50		5·28		7·02		6·41		7·20		6·46
Mar. 4 0— 8 23	4·63		5·70		6·14		13·63		6·04		11·75	
Mean range,		6·31		5·23		7·10		6·46		6·84		6·38

103. The excess at Trevandrum and the defect at Singapore may be accidental; but in any case we are entitled to conclude, that the amount of variations of the mean force in the period of 26 to 27 days, was equal (or nearly so) at all the stations when the effects of local disturbance are eliminated; and, that the directions of the variations were the same.

104. I would only notice at present the curious repetition of movements shown in each of the six weeks projected in Plate XXVIII., indicating a period of from 60 to 70 hours. It will require a more extended induction to determine the true length of this period, if it be constant, and to make any suggestion as to its cause. It does not seem improbable, however, that this cause, like the 26–27 day period, may be connected with great physical movements in the envelope of our great heat-giver, the sun.

TABLE XXXIII.—DAILY MEANS OF HORIZONTAL FORCE AT MAKERSTOUN, TREVANDRUM, SINGAPORE, AND HOBARTON, IN 14 HUNDRED-THOUSANDTHS OF THE HORIZONTAL FORCE AT THE RESPECTIVE PLACES, FOR THE YEARS 1844 AND 1845. (1·00=0·00014 X.)

Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.
1844.					1844.					1844.				
Dec. 31	...	...	...	...	Mar. 1	21·40	07·42	16·40	16·46	May 1	22·97	06·08	15·85	17·43
Jan. 1	17·40	08·03	17·51	[15·11	2	...	...	...	...	2	23·77	06·49	15·98	17·26
2	15·35	05·56	14·87	13·85	3	18·34	05·25	14·18	13·98	3	22·40	05·25	15·71	18·12
3	21·15	08·14	17·93	14·65	4	16·53	06·42	14·59	14·49	4	...	...	...	...
4	20·93	09·79	17·93	16·37	5	11·43	04·43	12·79	10·04	5	24·26	08·34	18·21	19·36
5	17·09	05·97	15·29	14·53	6	13·94	01·85	10·42	9·66	6	25·53	07·31	17·79	20·20
6	...	...	...	...	7	12·99	04·12	12·37	9·98	7	23·97	07·52	16·96	18·61
7	18·04	07·31	15·85	13·77	8	16·94	03·81	13·62	11·50	8	22·90	04·12	15·85	16·81
8	16·88	07·21	16·40	12·82	9	...	...	...	...	9	23·76	04·53	16·12	19·26
9	15·74	06·18	15·71	11·73	10	19·12	04·33	14·87	14·07	10	25·47	08·14	18·07	20·56
10	17·25	06·69	16·26	13·12	11	17·64	05·87	14·87	13·97	11	...	...	...	...
11	17·37	06·49	15·15	13·72	12	18·05	06·28	15·01	14·22	12	24·90	07·93	18·63	19·36
12	18·47	08·55	16·96	14·35	13	23·25	09·58	17·65	16·18	13	27·34	10·71	18·90	21·83
13	...	...	...	...	14	23·66	10·61	18·90	17·81	14	24·25	05·97	16·26	19·28
14	18·89	09·17	17·65	14·53	15	22·12	10·09	18·63	16·85]	15	26·07	07·21	16·54	19·20
15	20·45	11·33	18·76	16·50	16	...	...	...	...	16	26·20	06·69	17·51	19·83
16	20·97	11·23	18·90	16·97	17	21·30	11·54	19·74	19·12	17	25·67	07·42	18·90	20·72
17	20·56	07·83	17·24	17·37	18	20·11	07·62	17·65	17·08	18	...	...	...	...
18	20·04	06·69	17·51	16·50	19	21·73	08·55	16·26	13·59	19	30·17	08·03	18·07	22·74
19	19·64	06·80	17·37	16·19	20	22·00	07·83	17·24	16·20	20	32·73	10·71	21·27	25·39
20	...	...	...	...	21	23·15	09·06	18·35	17·06	21	29·77	09·78	19·18	23·09
21	20·17	09·17	18·21	16·45	22	22·47	08·14	18·35	19·12	22	23·19	05·46	15·57	18·11
22	20·20	09·58	18·35	16·91	23	...	...	...	...	23	27·96	06·28	16·40	18·68
23	22·14	09·68	17·65	16·59	24	22·30	09·58	18·76	18·99	24	27·91	05·77	16·54	19·77
24	20·17	09·27	16·12	14·67	25	23·71	10·09	18·76	19·25	25	...	...	...	...
25	19·09	07·21	14·87	12·50	26	25·22	09·48	20·29	20·10	26	29·26	08·86	17·79	20·55
26	20·00	09·17	18·35	15·94	27	22·24	10·81	18·63	19·33	27	28·53	08·45	18·21	21·08
27	...	...	...	...	28	22·16	07·52	17·79	16·73	28	28·86	08·65	18·21	21·38
28	18·26	07·42	17·10	15·70	29	−5·97	03·50	11·54	7·82	29	27·72	07·00	17·79	22·02
29	18·95	06·90	16·26	15·47	30	...	...	...	...	30	28·94	08·96	19·18	22·82
30	19·17	08·34	17·24	17·41	31	17·06	02·27	11·81	10·27	31	32·06	11·74	20·85	24·69
31	20·95	11·23	19·60	17·74	April 1	13·15	03·40	12·79	12·37	June 1	...	...	...	...
Feb. 1	18·39	04·42	14·04	13·67	2	15·20	03·30	12·93	12·97	2	32·27	09·27	19·18	22·69
2	14·74	06·59	15·15	14·25	3	16·77	04·12	12·93	13·25	3	30·87	[10·30	20·15	22·57
3	...	...	...	...	4	19·40	06·28	[14·90]	15·25	4	30·70	09·89	19·46	23·53
4	18·73	08·45	15·57	13·66	5	20·01	07·42	16·00	16·25	5	31·13	10·51	20·29	23·69
5	11·96	04·43	13·90	13·49	6	...	...	...	...	6	31·45	12·67	22·52	25·09
6	17·98	07·11	15·29	12·38	7	20·56	05·77	14·59	17·13	7	28·79	10·09	20·02	23·95
7	15·29	07·00	15·85	13·50	8	21·15	07·83	17·51	17·98	8	...	...	...	...
8	18·40	06·59	15·29	13·37	9	23·69	12·15	18·90	19·58	9	30·01	10·30	20·15	23·66
9	20·66	09·06	16·54	15·43	10	23·95	08·96	18·76	18·12	10	30·52	09·48	19·32	23·09
10	...	...	...	...	11	23·70	10·30	18·35	19·09	11	31·64	09·37	19·04	22·90
11	17·71	08·24	16·96	15·87	12	23·94	10·30	19·60	19·69	12	33·25	09·48	19·32	22·90
12	20·64	07·93	17·24	15·22	13	...	...	...	...	13	33·22	09·78	19·74	23·83
13	22·38	08·96	18·21	15·91	14	24·95	09·89	19·04	20·27	14	32·07	10·30	20·29	24·32
14	23·82	10·71	19·88	16·77	15	20·99	07·62	16·26	17·36	15	...	...	...	...
15	19·96	07·83	17·10	15·73	16	15·61	05·15	12·79	12·18	16	30·87	08·65	19·74	23·62
16	23·60	10·51	19·32	17·08	17	27·30	−5·46	5·14	8·82	17	30·87	07·62	18·49	22·10
17	...	...	...	...	18	20·33	06·49	15·15	15·89	18	32·03	07·83	18·35	22·48
18	23·93	10·51	20·15	18·68	19	19·94	06·59	16·26	15·94	19	30·67	08·75	19·04	23·76
19	21·82	12·77	19·74	17·54	20	...	...	...	...	20	33·13	11·02	21·13	24·18
20	23·57	14·63	21·13	20·00	21	21·52	07·83	18·63	18·55	21	32·05	07·83	18·35	22·82
21	21·95	12·26	18·63	17·55	22	26·19	08·55	20·29	19·09	22	...	...	...	...
22	21·27	10·71	17·93	18·54	23	26·65	09·06	18·21	18·53	23	30·41	11·84	22·24	25·58
23	23·05	09·99	19·04	18·94	24	26·77	11·23	20·99	19·71	24	29·59	11·43	21·82	26·06
24	...	...	...	...	25	22·95	05·36	15·29	15·47	25	30·31	11·12	21·41	25·56
25	24·51	11·84	20·29	19·84	26	14·32	01·03	11·40	12·78	26	30·77	09·37]	19·74	25·54
26	22·61	11·23	19·32	18·27	27	...	...	...	...	27	33·16	11·74	21·96	26·43
27	23·63	11·74	19·04	19·01	28	22·07	05·77	16·26	17·77	28	36·98	11·54	21·68	27·07
28	16·38	06·39	16·40	15·72	29	21·52	05·25	15·98	17·28	29	...	...	...	...
29	19·25	05·05	15·01	14·44	30	19·47	05·05	15·01	15·89	30	33·26	06·49	18·21	23·27

TABLE XXXIII.—*Continued.*

Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.
1844.					1844.					1844.				
July 1	32·23	10·92	20·99	24·83	Sept. 1	28·14	05·56	18·21	22·03	Nov. 1	34·47	08·96	20·57	29·34
2	32·74	09·27	20·57	25·59	2	27·50	07·42	18·90	23·39	2	...	...	...	...
3	33·94	10·51	21·68	25·52	3	31·09	10·61	20·15	25·13	3	33·61	08·14	19·60	27·19
4	32·77	11·33	21·13	25·36	4	31·96	10·09	18·35	22·52	4	33·71	08·65	20·85	26·50
5	30·78	10·61	20·99	24·74	5	30·09	10·30	19·88	22·97	5	35·17	10·81	21·54	28·26
6	...	...	...	...	6	33·24	11·43	22·10	25·80	6	34·73	07·31	20·29	27·63
7	33·23	09·06	20·99	26·89	7	...	...	...	...	7	34·67	10·09	22·10	28·69
8	33·95	06·39	18·07	21·40	8	32·87	10·40	20·15	25·39	8	36·05	11·12	22·38	29·18
9	29·61	07·83	18·90	22·00	9	31·51	11·54	20·71	24·45	9	...	...	...	...
10	31·43	09·48	20·71	24·17	10	32·40	11·33	21·54	25·75	10	38·58	12·46	22·52	30·10
11	33·58	09·89	20·15	25·02	11	34·96	13·70	23·07	26·86	11	30·20	06·08	18·21	26·70
12	34·54	09·00	20·57	25·03	12	33·11	12·98	23·07	26·84	12	33·25	07·72	19·18	28·05
13	...	...	...	...	13	36·40	13·60	23·91	28·08	13	33·73	10·81	20·99	26·73
14	34·10	08·96	20·71	25·23	14	...	...	...	...	14	36·60	10·51	21·82	28·47
15	34·85	09·89	20·43	25·37	15	31·90	09·37	19·88	23·73	15	37·45	12·26	23·77	29·51
16	33·90	10·40	20·71	25·02	16	32·54	10·20	20·57	24·81	16	...	...	...	...
17	32·04	10·61	21·96	25·23	17	30·70	08·75	19·74	23·86	17	29·20	02·06	14·32	21·06
18	29·05	07·83	20·29	23·90	18	33·01	09·48	20·85	26·57	18	30·42	05·66	20·85	23·89
19	32·50	10·09	21·82	24·91	19	32·71	09·17	19·88	23·76	19	30·84	03·71	17·24	25·05
20	...	...	...	...	20	27·57	04·84	17·24	21·19	20	31·97	05·46	19·18	25·96
21	35·49	11·12	22·80	26·79	21	...	...	...	...	21	33·18	06·39	19·74	25·70
22	32·52	10·81	21·82	26·84	22	29·70	09·17	20·02	24·42	22	23·25	01·96	14·46	19·41
23	32·64	09·37	21·82	26·75	23	33·89	07·83	16·96	23·81	23	...	...	...	...
24	34·66	09·58	23·49	26·70	24	32·07	08·65	22·10	25·07	24	30·69	05·46	17·79	25·00
25	29·31	03·19	16·68	20·70	25	27·85	07·42	19·88	22·79	25	34·70	08·14	19·60	27·30
26	31·39	08·45	18·76	22·53	26	26·02	02·06	15·98	19·26	26	37·26	10·40	20·15	27·82
27	...	...	...	...	27	28·27	05·46	17·37	21·37	27	39·07	09·27	20·43	29·10
28	33·50	07·11	18·76	22·66	28	...	...	...	...	28	35·48	06·80	18·63	27·00
29	31·07	07·93	20·71	24·07	29	26·57	04·43	14·87	18·53	29	36·14	08·65	19·60	28·42
30	32·18	10·61	20·29	24·18	30	23·68	−00·10	11·95	17·44	30	...	...	...	...
31	36·97	12·57	22·93	25·74	Oct. 1	29·36	−03·60	12·09	14·29	Dec. 1	37·72	10·20	20·85	30·93
Aug. 1	27·26	04·94	15·98	20·00	2	29·94	04·63	17·24	23·20	2	38·64	11·74	23·83	32·50
2	25·85	05·46	17·24	18·48	3	29·11	05·15	16·54	22·05	3	38·48	10·61	23·07	32·40
3	...	...	...	...	4	30·96	04·22	18·07	22·84	4	37·38	08·14	20·99	30·23
4	28·50	04·22	16·68	21·03	5	...	...	...	...	5	36·69	09·06	22·10	30·48
5	30·13	07·62	17·71	22·42	6	30·91	06·08	19·18	25·72	6	38·17	11·84	23·07	30·48
6	30·41	08·34	17·79	22·62	7	32·14	09·68	19·32	25·07	7	...	...	...	...
7	30·31	07·00	18·07	22·39	8	33·07	08·75	20·02	25·56	8	39·09	12·87	24·32	31·55
8	34·38	08·45	19·32	23·08	9	34·51	09·37	20·99	24·71	9	40·75	12·77	24·19	31·31
9	30·77	03·91	15·29	18·47	10	34·14	11·43	21·82	26·07	10	40·51	12·87	25·02	31·21
10	...	...	...	...	11	34·37	11·74	21·96	26·34	11	40·80	[14·63	25·44	32·38
11	31·49	08·65	19·32	22·69	12	...	...	...	...	12	40·19	13·80	24·88	31·91
12	31·02	08·96	19·18	23·55	13	36·21	13·08	24·05	28·41	13	40·72	14·73	25·85	32·53
13	31·98	09·37	20·29	24·74	14	34·66	10·30	23·63	27·30	14	...	...	...	...
14	32·94	11·12	21·27	25·61	15	34·80	09·06	22·66	27·41	15	33·55	09·06	20·02	29·01
15	32·67	12·36	21·41	25·70	16	34·89	11·54	23·21	26·91	16	34·70	08·96]	19·74	30·12
16	32·50	13·18	22·66	25·36	17	33·07	10·30	22·38	27·90	17	37·59	08·34	21·41	30·61
17	...	...	...	...	18	36·37	10·51	21·13	28·62	18	39·39	10·92	22·52	32·97
18	33·65	11·33	21·68	25·41	19	...	...	...	...	19	33·43	07·11	19·74	30·00
19	33·59	08·75	21·41	25·45	20	23·96	01·34	15·01	22·27	20	34·94	08·55	20·71	30·18
20	35·02	09·99	22·24	26·60	21	26·60	00·00	11·26	15·84	21	...	...	...	...
21	35·43	10·30	23·21	26·52	22	30·22	06·59	15·85	22·32	22	33·79	09·89	21·13	30·38
22	30·70	05·97	16·68	21·46	23	28·89	06·28	17·10	22·68	23	37·76	09·99	21·82	30·21
23	32·43	04·22	16·54	19·90	24	28·64	06·80	16·82	21·21	24	38·43	10·92	[22·93]	30·85
24	...	...	...	...	25	24·32	03·19	17·10	23·41	25	39·57	12·26	24·19	31·49
25	29·80	06·59	18·21	22·27	26	...	...	...	...	26	38·87	10·51	23·21	31·46
26	30·05	07·62	19·88	23·21	27	27·52	05·15	18·76	23·31	27	36·67	09·68	22·93	32·55
27	30·27	08·55	21·68	23·34	28	30·36	06·28	18·90	25·92	28	...	...	...	...
28	31·29	08·34	21·27	24·22	29	30·68	07·21	18·21	25·16	29	29·95	00·93	13·90	24·74
29	30·19	08·03	19·46	23·01	30	34·87	09·27	20·29	28·07	30	31·62	03·91	17·24	27·07
30	28·20	03·40	15·85	19·26	31	33·35	08·75	20·71	28·30	31	33·50	05·05	18·76	28·55
31	...	...	...	...										

TABLE XXXIII.—*Continued.*

Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.
1845.					1845.					1845.				
Jan. 1	33·04	07·72	20·29	29·87	Mar. 4	38·17	13·60	25·16	38·18	May 5	36·04	12·46	20·58	37·76
2	35·65	10·09	20·71	30·48	5	38·01	15·45	25·16	37·36	6	36·83	15·96	25·30	39·41
3	37·25	09·17	22·10	31·95	6	39·12	14·32	26·55	39·20	7	37·17	14·63	26·00	39·94
4	...	...	...	...	7	38·73	14·93	26·27	38·51	8	39·24	15·35	26·41	40·18
5	39·06	10·51	23·21	33·12	8	...	...	...	...	9	40·09	15·45	26·69	40·45
6	39·88	11·33	24·19	31·73	9	36·59	14·01	25·02	37·65	10	...	...	...	...
7	40·85	12·46	23·91	33·94	10	35·76	14·01	24·33	38·47	11	38·04	16·79	26·55	40·21
8	40·13	13·29	24·46	32·76	11	36·70	13·49	25·58	38·34	12	40·62	15·55	26·41	40·91
9	18·29	02·68	16·54	26·81	12	37·78	14·83	25·72	38·12	13	38·71	15·86	26·41	39·77
10	34·46	05·66	19·04	29·34	13	37·25	15·04	24·75	36·80	14	40·92	14·01	26·00	40·76
11	...	...	...	...	14	33·50	12·67	23·36	34·91	15	38·95	14·52	23·49	38·82
12	34·13	[06·80	20·43	28·29	15	...	...	...	...	16	37·11	11·84	23·08	37·57
13	36·69	10·40	23·35	32·11	16	34·83	09·87	23·77	36·35	17	...	...	...	...
14	37·80	10·40]	23·77	32·15	17	36·43	12·87	24·19	36·80	18	36·54	10·91	22·80	36·95
15	38·02	13·18	24·74	33·38	18	36·53	13·80	25·02	37·47	19	36·75	13·08	24·19	36·38
16	37·87	12·57	25·02	33·80	19	31·83	13·70	[22·94]	34·40	20	38·89	15·04	24·19	38·67
17	37·63	12·46	22·66	34·26	20	35·53	13·90	24·00	36·00	21	38·01	14·11	24·88	39·58
18	...	...	...	...	21	34·55	12·26	21·00	34·11	22	39·52	13·29	24·19	37·98
19	29·22	06·80	17·93	28·42	22	...	...	...	...	23	38·52	13·39	24·19	38·15
20	34·19	02·68	17·93	29·70	23	33·30	10·51	20·44	33·88	24	...	...	...	...
21	34·84	09·27	19·46	31·52	24	30·00	08·55	19·19	33·50	25	38·45	12·67	25·02	40·59
22	39·84	10·61	21·55	34·42	25	34·11	11·54	21·97	34·52	26	40·03	14·52	25·30	41·32
23	33·18	08·14	20·58	30·49	26	34·13	10·40	20·71	34·57	27	41·10	15·04	26·55	42·63
24	33·68	06·69	20·85	31·36	27	33·70	[12·05	22·66	36·00	28	42·47	15·66	26·69	41·64
25	...	...	...	...	28	34·50	12·05	22·10	35·05	29	40·92	14·83	26·97	41·22
26	34·28	06·79	20·44	32·58	29	...	...	...	...	30	37·90	12·36	24·05	39·37
27	38·11	08·65	22·52	33·28	30	36·35	12·36	22·52	37·03	31	...	...	...	...
28	35·04	07·83	20·30	33·45	31	36·62	14·32	25·02	38·90	June 1	37·50	08·96	[21·40]	37·01
29	34·32	09·48	20·02	30·08	April 1	37·02	14·21	24·33	38·25	2	39·18	09·48	23·77	39·64
30	33·44	07·72	20·58	35·01	2	37·73	15·86	26·00	39·59	3	40·71	[12·46	24·88	40·56
31	33·34	10·81	22·52	33·71	3	37·42	14·73	25·30	38·53	4	39·25	12·05	24·19	39·80
Feb. 1	...	...	...	...	4	34·40	11·84	23·77	36·22	5	41·55	13·60	25·86	41·67
2	36·33	10·81	23·08	34·34	5	...	...	...	...	6	40·98	16·07	28·08	43·12
3	36·55	11·43	23·91	34·96	6	35·74	14·32	25·16	39·12	7	...	...	...	...
4	37·02	11·12	23·36	34·89	7	38·28	14·42	25·02	37·90	8	40·20	14·21	26·00	40·72
5	33·12	08·14	19·32	33·67	8	35·79	16·69	27·11	37·60	9	43·53	16·48]	27·25	42·18
6	34·24	11·64	22·94	32·66	9	39·45	15·86	26·41	38·67	10	42·65	16·48	27·53	41·59
7	35·37	12·05	24·19	34·89	10	38·68	16·48	26·97	39·37	11	38·01	13·90	26·27	40·24
8	...	...	...	...	11	37·86	16·48	26·97	39·85	12	36·10	15·14	26·69	41·53
9	35·77	11·84	24·85	35·67	12	...	...	...	...	13	36·14	15·24	27·11	42·28
10	35·80	13·80	24·75	34·60	13	18·70	12·36]	23·49	33·88	14	...	...	...	...
11	37·60	13·80	26·55	37·91	14	31·55	06·90	18·35	30·15	15	40·05	15·66	27·39	41·70
12	37·38	14·21	25·30	36·70	15	34·70	09·27	22·10	34·57	16	39·69	16·17	27·66	42·57
13	37·92	13·80	25·86	38·20	16	34·02	10·51	22·38	35·13	17	37·72	14·83	26·55	42·46
14	37·54	15·35	26·27	36·81	17	35·29	12·26	23·08	36·11	18	40·52	17·82	28·78	43·14
15	...	...	...	...	18	35·37	09·37	21·69	34·59	19	40·72	17·20	29·05	42·74
16	39·01	14·83	25·86	37·03	19	...	...	...	...	20	41·07	16·48	27·94	42·58
17	37·82	14·01	25·72	37·78	20	32·88	10·51	21·27	33·99	21	...	...	...	...
18	37·46	14·32	25·72	36·81	21	32·62	12·36	22·10	34·65	22	39·87	14·42	27·11	42·18
19	41·45	18·02	28·08	39·62	22	34·28	14·01	23·77	36·81	23	41·93	14·42	26·27	41·82
20	38·29	12·67	23·36	35·51	23	38·52	11·84	24·47	37·93	24	42·24	16·07	26·55	42·02
21	32·50	11·43	22·28	33·62	24	37·55	13·49	23·36	36·70	25	40·30	17·20	27·66	42·60
22	...	...	...	...	25	34·27	10·30	21·55	33·69	26	40·42	16·99	28·22	44·10
23	31·60	11·64	21·69	32·07	26	...	...	...	...	27	42·62	16·69	28·50	43·72
24	30·07	10·09	22·24	32·02	27	32·45	13·49	23·77	35·30	28	...	...	...	...
25	34·01	09·37	20·71	30·28	28	33·83	08·96	20·71	33·78	29	39·87	11·43	22·94	38·82
26	33·06	09·58	20·99	33·13	29	32·92	11·54	23·22	35·59	30	40·21	14·32	25·44	39·20
27	35·07	10·92	22·66	34·04	30	32·71	09·68	21·27	34·47	July 1	40·77	14·01	26·27	39·94
28	32·90	10·61	21·69	33·82	May 1	35·25	08·55	19·88	33·93	2	40·50	13·60	24·26	39·65
Mar. 1	...	...	...	...	2	34·48	12·05	17·93	33·44	3	40·70	13·60	23·50	40·73
2	36·38	12·87	23·22	34·97	3	...	...	...	...	4	42·47	14·32	24·34	41·53
3	37·17	13·60	24·33	37·27	4	35·34	13·18	18·91	38·64	5	...	...	...	...

TABLE XXXIII.—*Continued.*

Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.	Date.	Maker.	Trevan.	Sing.	Hobar.
1845.					1845.					1845.				
July 6	42·59	15·66	25·45	40·42	Sept. 7	34·64	11·54	24·19	36·97	Nov. 9	42·19	18·13	28·64	45·02
7	39·43	14·63	25·59	40·34	8	37·88	15·04	25·86	40·32	10	43·34	17·10	28·08	44·31
8	40·60	13·80	26·42	40·46	9	36·74	14·42	27·11	41·16	11	42·17	16·79	29·05	43·82
9	37·92	15·66	27·12	40·50	10	38·97	16·89	28·36	41·82	12	43·41	18·75	30·03	45·64
10	38·92	14·93	27·53	40·91	11	38·76	14·32	26·83	40·21	13	44·72	19·36	30·72	45·78
11	40·59	17·51	27·95	41·59	12	36·94	13·70	26·00	39·54	14	44·46	19·05	31·28	46·27
12	...	...	...	...	13	...	...	...	...	15	...	...	...	...
13	40·27	15·45	28·43	43·23	14	36·72	13·60	26·27	41·43	16	45·33	19·36	31·14	46·66
14	42·03	18·44	29·61	43·42	15	39·02	19·47	28·78	42·09	17	35·75	10·30	22·80	39·23
15	41·68	15·65	27·94	42·28	16	38·77	16·07	27·80	42·60	18	39·10	15·96	26·27	43·99
16	41·22	16·48	29·47	42·85	17	35·27	15·35	25·02	39·96	19	41·02	16·07	27·39	43·93
17	40·89	17·82	29·43	42·90	18	35·18	13·18	24·19	36·92	20	41·47	17·92	28·36	43·81
18	40·14	18·23	29·19	42·68	19	33·93	13·08	24·75	39·78	21	43·21	17·51	29·75	43·86
19	...	...	...	...	20	...	...	...	...	22	...	...	...	...
20	40·82	16·07	26·69	41·04	21	35·36	16·17	26·83	41·43	23	43·35	17·30	29·43	44·64
21	38·56	16·79	27·25	40·79	22	38·64	18·13	28·78	42·55	24	43·75	17·20	29·89	44·61
22	40·61	16·79	28·02	42·25	23	42·83	19·98	30·86	43·25	25	47·06	18·75	30·17	48·21
23	43·36	15·45	27·12	41·11	24	37·30	11·23	24·47	39·00	26	47·70	20·70	31·70	47·89
24	33·17	07·83	20·72	32·87	25	34·88	06·49	20·99	35·92	27	44·69	19·88	30·31	47·27
25	35·89	07·83	22·39	34·99	26	35·24	10·92	23·77	37·37	28	40·54	15·45	26·83	42·05
26	...	...	...	...	27	...	...	...	...	29	...	...	...	...
27	36·59	12·77	24·20	38·63	28	32·74	11·54	23·63	36·54	30	40·75	18·23	29·19	43·81
28	37·56	11·74	24·89	40·16	29	35·44	12·05	25·72	38·41	Dec. 1	44·00	17·61	27·66	44·31
29	38·90	13·80	25·87	40·81	30	38·44	13·29	26·83	38·53	2	42·85	16·48	26·97	45·16
30	39·45	12·67	26·42	42·74	Oct. 1	37·32	09·78	25·58	39·18	3	30·03	00·62	14·04	34·91
31	41·07	16·27	29·27	42·58	2	38·83	12·87	28·22	40·62	4	37·93	11·12	22·52	40·68
Aug. 1	41·54	11·43	23·08	36·76	3	38·04	12·15	26·55	39·91	5	36·02	09·27	21·13	39·86
2	...	...	...	...	4	...	...	...	...	6	...	...	...	...
3	35·10	11·33	23·77	37·04	5	38·67	16·27	28·22	42·91	7	39·45	14·42	25·44	43·61
4	37·17	10·00	23·36	36·95	6	40·55	13·60	26·83	42·49	8	43·08	16·38	27·39	44·54
5	36·53	12·67	24·75	39·31	7	39·73	14·52	28·22	42·36	9	44·75	16·79	29·61	46·26
6	38·48	14·63	24·88	40·16	8	41·41	14·01	29·47	42·71	10	44·52	18·23	29·61	46·84
7	35·84	14·83	24·61	38·07	9	32·66	13·80	26·00	39·10	11	44·03	18·75	29·75	46·94
8	38·30	13·70	24·61	38·43	10	36·25	10·40	24·61	39·20	12	41·95	18·44	28·64	46·38
9	...	...	...	...	11	...	...	...	...	13	...	...	...	...
10	38·81	14·21	26·00	39·96	12	38·15	15·04	27·53	40·70	14	38·38	14·42	26·27	44·37
11	37·91	13·90	27·25	41·37	13	41·06	15·86	29·05	41·77	15	38·36	14·83	26·55	42·98
12	39·90	17·51	27·80	41·89	14	40·15	18·85	30·31	43·06	16	39·22	15·24	25·72	43·37
13	42·36	17·30	27·94	42·47	15	38·48	17·30	29·47	42·78	17	40·54	16·17	26·97	45·31
14	42·96	17·72	28·78	43·55	16	39·88	15·66	29·89	42·96	18	40·79	15·35	26·97	43·99
15	37·86	13·29	25·30	40·53	17	38·15	13·39	27·11	42·14	19	44·82	17·82	28·50	46·84
16	...	...	...	...	18	...	...	...	...	20	...	...	...	...
17	37·57	13·18	24·75	38·72	19	43·22	17·41	30·03	45·32	21	45·22	18·75	29·33	49·37
18	35·79	12·67	24·47	38·99	20	36·92	11·23	25·02	40·23	22	45·77	17·92	30·03	48·83
19	40·05	17·19	28·22	42·09	21	31·45	11·12	24·47	38·99	23	46·84	20·08	31·42	50·69
20	38·90	17·30	28·64	42·79	22	38·25	13·80	25·86	42·39	24	45·41	16·89	[28·36]	50·72
21	39·88	17·51	30·03	43·77	23	39·53	14·42	26·00	41·64	25	45·80	19·88	30·17	50·75
22	41·47	14·83	27·25	41·62	24	37·71	10·61	22·66	38·80	26	46·83	16·69	31·70	49·75
23	...	...	...	...	25	...	...	...	...	27	...	...	...	...
24	39·64	13·49	26·00	39·86	26	38·30	14·11	25·58	43·06	28	43·25	19·88	29·75	46·95
25	40·93	16·48	29·05	43·33	27	41·62	[15·55	26·55	43·65	29	46·69	20·29	29·19	48·24
26	34·74	13·18	26·27	41·30	28	42·28	16·48	28·92	44·58	30	38·19	15·66	24·75	42·79
27	37·08	13·49	28·08	42·36	29	41·28	15·14	27·66	43·88	31	42·08	17·61	27·25	45·26
28	39·85	16·48	27·94	42·26	30	43·06	17·72	30·17	46·84	1846.				
29	35·15	09·68	23·22	35·21	31	43·08	17·10	29·75	45·24	Jan. 1	43·75	...	...	46·87
30	...	...	...	...	Nov. 1	...	...	...	...	2	44·64	...	...	46·89
31	32·87	10·92	23·91	37·58	2	34·04	12·87]	25·44	41·21	3	...	...	...	...
Sept. 1	35·01	11·02	24·47	36·20	3	38·57	20·19	27·53	42·30	4	43·67	...	...	48·74
2	32·44	10·09	24·33	36·49	4	39·85	17·92	26·97	44·17	5	45·38	...	...	48·82
3	34·03	08·65	23·08	38·47	5	38·67	16·38	25·86	43·04	6	45·92	...	...	48·28
4	35·92	12·98	24·88	38·30	6	42·02	18·75	25·86	42·55	7	42·57	...	...	45·81
5	35·64	13·70	26·00	40·53	7	37·83	13·49	24·19	41·16	8	43·70	...	...	45·52
6	...	...	...	...	8	...	...	...	...	9	44·67	...	...	47·46

APPENDIX.

Determinations of Corrections employed in the preceding Paper on account of Turning the Torsion Circle, or Accidental Causes of Change of Scale-Reading; with the Connection of Series before and after Readjustment.

105. MAKERSTOUN.*—During disturbances, when the scale went out of the field of the reading telescope, the torsion circle arms were turned till the magnet was again forced into the field: it was necessary, after the disturbance had terminated, to return the arms of the torsion circle to the original reading, when it was supposed that the scale-reading for the same force would be as before the disturbance. Experiments made in 1842, by turning the arms of the torsion circle backwards and forwards, and then returning them to the original reading, supported this supposition. A more extensive induction, however, has shown that the smallest shocks, and the most careful manipulations, are frequently accompanied by change of instrumental readings.

106. The occasions (after 1841) on which the arms of the torsion circle were moved, and afterwards returned to their former positions, were—1842, July 2; 1843, May 6; 1844, November 16; 1845, April 13 and December 3.

The Makerstoun bifilar was also readjusted after 1841; 1843, April 28 and November 10; 1846, January 1.

On the latter occasion the arms of the torsion circle were simply moved through a small angle without returning them afterwards. In the case of the readjustments, the series of observations after adjustment were connected with the series before, by assuming that the mean force for three days before adjustment was equal to the mean force for the three days following it. This supposition may manifestly be inaccurate. In the investigations which have occupied the preceding pages, it was necessary to correct the errors of these hypotheses; and it will be evident from these investigations themselves, that the errors may be determined within small limits by comparing the daily means at the place in question with those for other places, where the secular change does not differ much, or the interval is small. This method has been adopted throughout (taking care to avoid days of great disturbance) in determining the true changes of force at any place where an instrumental adjustment or accident has rendered this necessary.

107. The series of observations at Makerstoun in 1842 was too limited (con-

* Lat. 55° 34′ 45″ N., Long. $0^h\ 10^m\ 3{\cdot}5^s$ W. Height above the sea, 213 feet. Observations, Trans. Royal Soc. Edin., vols. xvii., xviii., xix.

sisting of only four observations daily) to determine in this way the error, if any, in returning the arms of torsion circle 1842, July 2. A comparison of the *monthly* means with those elsewhere would render it probable, however, that the mean at Makerstoun for July is too great compared with that for June; but no correction has been applied. In 1843 the series of observations was still incomplete, but as it consisted of nine daily observations, the means for the same hours for the periods in question were taken for places near the same meridian; though, owing to the difference of the diurnal law of disturbance at different places, the corrections obtained cannot be considered so satisfactory as if the whole day had been employed.

108. 1843, April 28.—Adjustment at Makerstoun. The following are the mean forces in ten-thousandths* of the whole horizontal force at each place:—

TABLE XXXIV.

Days.	Makerstoun.	Change.	St Helena.	Change.	Brussels.	Change.	Hobarton.	Change.
April 24, 25, 26, 28. Adjust.	27·27		21·27		21·98		39·68	
May 1, 2, 3, ...	28·60	+1·33	21·35	+0·08	19·67	−2·31	38·73	−0·95
„ 4, 5, 6, ...	28·89	+1·62	22·26	+0·99	22·39	+0·41		
Mean Change, ...		+1·47		+0·53		−0·95		−0·95

By St Helena, the values at Makerstoun, after April 28, require the correction —0·94
„ Brussels, ... −2·42
„ Hobarton, ... −2·42

The correction −1·00 was adopted before the results at Brussels and Hobarton were obtained. This correction is probably too little, though, since the correction for temperature at Brussels was only approximate, and the difference of meridians at Hobarton is so great, the results by the two latter places should perhaps have a less value than the result from St Helena.

109. 1843, May 6.—Torsion circle arms turned and returned.

By the mean of the three places (see Table XXXV.) the values at Makerstoun, after turning the arms of the torsion circle, require the correction −7·95. The correction adopted after May 6 was −8·00. A more extended comparison, including more days, and the observations at Hobarton, would render it probable that this correction is also slightly too little.

* In this Appendix the units are always ten-thousandths of the force, unless when sc div. (scale divisions) is affixed.

TABLE XXXV.—MEANS BEFORE AND AFTER TURNING THE TORSION CIRCLE May 6, 1843. $1{\cdot}00 = \frac{X}{1000}$

Days.	Makerstoun.	Brussels.	St Helena.	Cape of Good Hope.
May 4, 5, . . .	31·44	23·27	23·80	29·28
,, 8, 9, . . .	17·77	2·76	0·67	7·97
Change, ...	−13·67	−20·51	−23·13	−21·21
Correction of Makerstoun, .		−6·84	−9·46	−7·54

110. 1843, November 10.—Adjustment.

TABLE XXXVI.—MEANS BEFORE AND AFTER ADJUSTMENT.

Days.	Makerstoun.	St Helena.	Cape of Good Hope.	Hobarton.
November 6, 7, 8, . .	4·18	2·08	3·59	9·95
,, 11, 13, 14, .	4·18	2·32	5·42	10·57
Change, ...	0·00	+0·24	+1·83	+0·62

The correction to Makerstoun after November 10 should be + 0·90. No correction has been applied in this case.

111. 1844, November 16.—Arms of torsion circle turned and returned.

Trevandrum (November 18, 19, 20, 21), *minus* (November 11, 12, 13, 14),	−7·00
Singapore, ...	−3·07
Hobarton, ...	−4·26
Mean of three places, ...	−4·78
Makerstoun, ...	−5·27

The means at Makerstoun after November 16 should therefore be corrected by + 0·5; but as in other cases where the correction is small, none has been made.

112. 1845, April 13.—Arms of torsion circle turned and returned.

Bifilar mean (April 14, 15, 16, 17), *minus* bifilar mean (April 8, 9, 10, 11).

Cape of Good Hope, ...	$=-8{\cdot}23$
Trevandrum, ...	$=-9{\cdot}24$
Singapore, ...	$=-7{\cdot}18$
Hobarton, ...	$=-6{\cdot}83$
Mean of four places, ...	$=-7{\cdot}87$
Makerstoun, ...	$=-5{\cdot}68$

The means at Makerstoun after April 13 should therefore be corrected by $+2{\cdot}2$. This correction has not been applied.

113. 1845, December 3.—Arms of torsion circle turned and returned.

Bifilar mean (November 28, 30, December 1, 2) *minus* (December 4, 5, 7, 8).

Trevandrum, ...	$=-6{\cdot}02$
Singapore, ...	$=-4{\cdot}96$
Hobarton, ...	$=-2{\cdot}32$
Mean of three, ...	$=-4{\cdot}43$
Makerstoun, ...	$=-4{\cdot}07$

The means of Makerstoun after December 3 should therefore be corrected by $-0{\cdot}36$. The correction has not been applied.*

114. 1846, January 1.—Arms of torsion circle moved forward. In this case the amount of scale reading changed was found to agree with the change of torsion circle reading. To verify the change we have the following comparison:—

Bifilar mean (December 28, 29, 30, 31) *minus* (January 2, 4, 5, 6).

Makerstoun, ...	$=+3{\cdot}29$
Hobarton, ...	$=+3\ 29$

The exact agreement is of course accidental.

115. Cape of Good Hope,† 1843, April.—Adjustment. No observations of the bifilar at the Cape have been published for the month of April 1843; it has been difficult, therefore, to connect the series before and after the adjustment of that month. Had the monthly means before and after the adjustment agreed with those at St Helena for the corresponding months, St Helena observations might have been employed as guides. This, however, is not the case, the monthly changes *after* May being very different at the two places. The only other monthly means available for such a correction are those at Singapore and Trevandrum, where the secular variation for the same epoch resembles somewhat that at the Cape.

* The Cape means not employed, as the readings were descending rapidly by secular or instrumental change at the time.

† Lat. 33° 56′ S., Long. $1^h\ 13^m\ 56^s$ E. of Greenwich. Observations, vol. i, printed under the superintendence of Lieutenant-Colonel E. Sabine.

By Singapore,	April *minus* March = −1·32;	May *minus* April = −0·04
„ Trevandrum,	... ... = −3·72	... ... = +0·07
„ St Helena,	... ... = −0·79	
„ The mean,	... ... = −1·94	... ... = +0·01

These quantities have been employed to obtain the value for March 1843 at the Cape; though it is evident that the value so obtained can be considered only approximative, owing to the very different change at St Helena.

116. 1843, November 1.—Adjustment. As in this case only two days observations were lost, the series has been connected by means of the corresponding observations at St Helena as follows:—

By St Helena, November 2, 3, 5, *minus* October 27, 29, 30 = +2·58.

This change from before to after the adjustment, being applied to the mean of the three days October 27, 29, 30 at the Cape, gives the value for November 2, 3, 5 at the same place, upon the supposition that the series was unbroken. This value, compared with the mean for November 2, 3, 5 after the adjustment, gives a correction to be applied to all the following means.

117. 1844, October 5.—Magnet changed, and readjustment. Not having the observations at St Helena for 1844, I have determined the connection of the series as follows:—

Makerstoun, October 9, 10, 11, *minus* October 2, 3, 4, .	= +6·09
Trevandrum, ...	= +8·50
Singapore, ...	= +5·94
Hobarton, ...	= +4·24
Mean, ...	= +6·19

This mean has been applied as in the last case.

118. St Helena,* 1843, July 24.—In substituting a double rectangular case for the single cylindrical case previously in use, the instrument had received a shock which changed the scale reading. In order to determine the amount of change, the mean five days previously was compared with that five days subsequently; the difference was found 19·6 scale divisions, which was assumed as the error due to the shock.† We find, however, by the observations at the Cape of Good Hope—

Cape bifilar mean (July 26, 27, 28) *minus* (July 20, 21, 22) . .	= − 5·74
St Helena	= +37·88
The correction of observations after the shock to those before is therefore	= −43·62
Or, in St Helena scale divisions, ...	= −23·08.

This correction has been applied.

119. 1844, February.—The magnet was removed for the determination of its temperature coefficient. The fortnightly means only for 1844 and 1845 are given in vol. i. of the St Helena Observations; the monthly means given in Table IX.

* Lat. 15° 56′ 41″ S., Long. $0^h\ 22^m\ 42^s$ W. Height above sea, 1760 feet. Observations, vol. i., printed under the superintendence of Lieutenant-Colonel E. Sabine.

† Adjustment, &c., St Helena, vol. i. p. 33.

have been obtained by interpolation from the projected four weekly means; and the series before and after February 1844 were connected by a mean for February obtained from the projected four weekly means, reference being made to the Cape curve, which the St Helena curve resembled at this epoch, and to the facts that there was a diminution of force till January, whilst after March the force increased at St Helena.

120. HOBARTON,* 1842, April.—The last monthly adjustment was made April 1842. The monthly means for January, February, and March 1842 are interpolated from those at Makerstoun.

121. 1843, June.—No observations were made during the first half of the month on account of repairs in the Observatory. The correction of the mean of the last thirteen days to the whole month was found as follows:—

By Makerstoun bifilar mean (June) *minus* (June 16 to 30) $= -0{\cdot}86$.

The correction including four other stations, Trevandrum, Singapore, Cape, and St Helena, was found $= -1{\cdot}52$; but the similarity of movements at Hobarton and Makerstoun gives the result from the latter alone much the greater weight. $-0{\cdot}86$ was employed as the correction.

122. 1843, July.—After the adjustment at this time, the bifilar readings increased with much rapidity, showing some cause of error similar to that at Toronto after February 1843. A careful examination of the means has induced me to reject all the monthly means from July 1843 to March 1844, both inclusive; for the purposes of comparison, the Makerstoun monthly mean changes have been substituted for these months in Table VI. The daily means also for January, February, and to March 14, 1844, have been corrected, upon the assumption of a regular accidental change, by $-0{\cdot}15$ $(1 = 0\ 00014)$ counting backwards from March 15 to January 1. (See Table XXXIII.)

123. 1846, March 31.—The arms of the torsion circle were turned through a small angle (1° 27′), to diminish the scale readings, which had increased considerably since the previous adjustment. By comparative readings with a small bifilar before and after moving the arms of the torsion circle, the alteration caused in the scale readings was found $-75{\cdot}5$.† The first observation noted after turning the arms was 45·0, at 1846, April $1^d\ 0^h$ Gött. (temp. 54°·0), which, according to the comparison with the small bifilar, may be considered equivalent to about 120·5 before turning the arms; hence, to convert the series before turning the circle-arms into ten-thousandths of X, we have the formula

$$(N - 120{\cdot}5)\ 0{\cdot}000229\ ;$$

* Lat. 42° 52′·5 S., Long. $9^h\ 49^m\ 50^s$ E. Height above the sea, 105 feet. Hobarton Observations, vols. i., ii., and iii., printed under the superintendence of Lieutenant-Colonel E. SABINE. The temperature coefficient employed for 1842–43 was $q' = 1{\cdot}50$ sc. div., instead of the more accurate value 1·52 (see Trans. Royal Soc. Ed., vol. xxii. p. 481).

† Hobarton Observations, vol. i., Adjustments, &c., p. xliii.

and the corresponding values after turning the circle-arms are found by the formula

$$(N' - 45{\cdot}0)\ 0{\cdot}000217,$$

where N and N′ are the scale readings before and after the change corrected to 54°·0 Fahr. These formulæ have been employed.

124. It has to be remarked, that about 1·5 per cent. of hourly observations were omitted at Hobarton; and the daily means given in the Hobarton volumes were obtained simply by dividing the sum of the scale readings at the hours of observation in each day by the number of observations; thus, if only 22 hours (out of 24) were observed, the sum was divided by 22. It is obvious that this method must frequently cause error in the means, since, if the observations omitted were near the time of a minimum, the mean would be too low; and if near the time of a maximum, the mean would be too high. To avoid these errors as far as possible, all the observations from 1841 till 1848, which were omitted, have had their places supplied by quantities interpolated from preceding and succeeding observations, and the means have been taken anew.*

125. TREVANDRUM.†—In correcting the observations for the preceding paper, the value of the temperature coefficient,

$$q = 1{\cdot}98 \text{ sc. div. } (k = 0{\cdot}000144),$$

was employed. This result was obtained from the observations for 1844 alone, and when these observations contained some errors that were afterwards discovered. As the changes of daily mean temperature at Trevandrum are generally less than 1° Fahr., the conclusions of this paper will be unaffected by this error, and it has not been thought desirable to repeat the projections of daily means, or to recompute the four weekly means; but the daily means, Table XXXIII., have been recorrected by the true value of $q' = 2{\cdot}17$ sc. div. (See Bifilar Magnetometer, Trans. Royal Soc. Ed., vol. xxii. p. 484). The following corrections were applied to the observations at Trevandrum:—

126. 1842, January.—The first day after the adjustment showed a considerable increase, probably due to the wires; ten divisions were subtracted on this account from January 2 to 7. The means for January 9 and 10 were interpolated from Singapore‡ and St Helena.

127. 1842, April 3^d to 11^d, both inclusive. The telescope was moving; the differences from April 1^d at Singapore were substituted instead, and 4·3 *scale divisions* have been subtracted from all the means before April 1^d. This correction was found as follows:—

* The error here noted is much more marked in the case of the hourly means for each month, where the same method of summation and division is followed. With some classes of observations (as those of the barometer and thermometer), the hourly means are scarcely comparable through these omissions.

† Lat. 8° 30′ 32″ N., Long. $5^h\ 7^m\ 59^s$ E. Height above the sea, 200 feet. Observatory of his Highness the RAJAH of TRAVANCORE; JOHN CALDECOTT, F.R.S., Director 1838–1849. The observations in manuscript are in the archives of the Royal Society of London.

‡ The agreement between the Trevandrum and Singapore means is so considerable, that for all ordinary purposes, a few days wanting in the one may always be supplied from the other without any risk of error.

Bifilar mean, Singapore (April 12–22), *minus* (March 21, to April 1)	$=-\ 7{\cdot}59$
... Trevandrum	$=-13{\cdot}30$
Correction to Trevandrum before April 1 ($=-4{\cdot}3$ *sc. div.*)	$=-\ 5{\cdot}71$

128. 1842, December 18ᵈ, 19ᵈ, and to the end of the month.—Bifilar readings affected by spiders; bifilar differences, from December 17 to 31, at Singapore, substituted.

129. 1842, December 30, 31.—Adjustment and new magnet, No. 5, employed

Bifilar mean, Singapore (1843, January 8–13), *minus* (1842, Dec. 11–16)	$=+\ 3{\cdot}57$
... Trevandrum	$=+45{\cdot}44$
Trevandrum bifilar correction during 1842 . . .	$=+41{\cdot}87$

130. 1843, April 25.—The bifilar magnet was exposed to the sun while the observatory was being re-thatched; this produced a loss of magnetism, and rendered another adjustment necessary. The means April 25 to May 5 were supplied from Singapore, the difference from the means of preceding eight days being taken. After which the scale readings, corrected to 70° Fahr., were diminished by 100 and multiplied by 1·06, to reduce to the same value of k. The following comparison was made:—

By Singapore bifilar means (May 7, 8, 9), *minus* (April 21, 23, 24)	$=-12{\cdot}85$
By Trevandrum, ...	$=-13{\cdot}17$

The difference being so small, no correction has been applied.

131. 1843, June 20, 21; July 17–23.—Affected by spiders, and the means interpolated with reference to other places.

132. 1843, July 24 to 30.—Evidently affected by a constant strain of spider thread; in consequence, from comparison with Singapore, July 24–28, are corrected by $-2{\cdot}8$ and July 30 (in the middle of which day the threads were removed) by $-1{\cdot}4$.

133. 1843, December 15–31.—Some accidental cause produced a change, December 15.

By Singapore (December 17–22), *minus* (December 3–8)	$=+2{\cdot}24$
By Trevandrum, ...	$=-1{\cdot}97$
Correction applied to Trevandrum after December 15, .	$=+4{\cdot}21$

134. 1844, March 31.—Adjustment,—

By Singapore (April 1–3) *minus* (March 25–27) . . $=-8{\cdot}38$

This difference applied to the mean at Trevandrum for April 1–3, showed that the means before the adjustment should have 43·1 (=30·8 sc. div.) added, to connect the series. The means at Makerstoun, taken 14 days before and 14 days after adjustment, gave the correction 30·9 sc. div., almost exactly the same. The daily means before March 31 were reduced to those after by the formula,—

$$(\mathrm{N}-178{\cdot}2)\ 0{\cdot}98+209{\cdot}0 \text{ sc. div.},$$

where N is the daily mean before March 31.

135. The following daily means are supplied from Singapore, on account of

the action of spiders:—1844, June 3 to 26, December 11 to 16; 1845, January 12 to 14, March 27 to April 13, June 3 to 9, October 27 to November 2. Besides these dates, there are some others in which it is extremely probable, that spiders' threads were attached to the magnet; but as this could not be proved, no alteration has been made in these cases.

136. SINGAPORE.*—On comparing the Singapore bifilar observations with those at Trevandrum, &c., the daily mean scale readings were found to have altered suddenly on different occasions; the corrections for these changes were determined as follows:—

137. 1842, January 20.—A sudden change occurs;—

By Trevandrum bifilar means (Jan. 20, 21, 24, 25, 26) *minus* (Jan. 12, 13, 14, 17, 18)	= −2·37
By Singapore	= +5·05
Correct Singapore means before January 20 by	+7·42

138. 1842, February 2.—A change occurs in this day,—

By Trevandrum bifilar means (February 7–10) *minus* (Jan. 24–28)	= −2·55
By Singapore	= +3·69
Correct Singapore means before February 2, by . . .	+6·24

February 2, is interpolated from Trevandrum.

TABLE XXXVII.—CHANGES OF DAILY MEAN BIFILAR SCALE READING, May 13, 1842, $k = 0{\cdot}00014$.

Date 1842.	Hobarton.	Trevandrum.	St Helena.	Singapore.	Corrected *minus* Observed.
	Sc. div.	Sc. div.	Sc. div.	Sc. div.	Sc. div.
May 15 *minus* May 13	+ 0·92	+ 0·17	+ 1·39	− 2·50	+ 3·33
16 „ 15	−11·77	−12·78	−13·24	−14·18	+ 4·91
17 „ 16	+ 5·59	+ 4·78	+ 4·52	+ 4·72	+ 5·15
18 „ 17	+ 4·53	+ 3·34	+ 3·02	+ 0·98	+ 7·80
19 „ 18	− 0·50	− 0·39	− 0·10	− 1·11	+ 8·58
20 „ 19	+ 2·69	+ 2·77	+ 2·93	+11·53†	− 0·15
22 „ 20	+ 2·39	+ 0·30	+ 2·01	−11·43	+12·82
23 „ 22	+ 0·75	− 0·90	+ 1·85	+ 7·79	+ 5·60
24 „ 23	− 0·65	+ 1·25	+ 0·08	+ 4·31	+ 1·51
25 „ 24	− 0·41	− 0·36	− 0·89	− 0·70	+ 1·66
26 „ 25	− 0·66	− 0·62	− 0·89	+ 2·50	− 1·56
27 „ 26	+ 0·52	+ 2·18	− 0·50	+ 1·53	− 2·36
29 „ 27	+ 0·12	− 1·62	+ 0·01	− 1·80	− 1·06
30 „ 29	+ 0·25	+ 2·09	− 0·74	0·00	− 0·53
31 „ 30	+ 0·16	+ 0·67	+ 0·85	+ 0·55	− 0·52

* Lat. 1° 18′ 32″ N., Long. $6^h\ 55^m\ 46^s$ E. Height above the sea, a few feet. Observatory of the East India Company; Director, Captain C. M. ELLIOT, F.R.S. The observations in manuscript are, it is believed, in the archives of the Royal Society. Copies of some of the observations are also in the Library of the Trevandrum Observatory. The observations have also been printed, but not published as yet.

† It is not improbable that there is an error in the mean for May 20 of 10 sc. div. ($k = {\cdot}0001946$), or 13·9 sc. div. of the table.

139. 1842, May 13.—It appears to me that some accidental cause of change was acting at Singapore from this date till May 25. The preceding table of daily changes of force from the 13th May at Hobarton, Trevandrum, St Helena, will show the grounds on which this belief is founded. The Singapore daily means after May 13, being corrected by the means of the changes at Hobarton, Trevandrum, and St Helena, and the differences (corrected means *minus* observed means) taken, the last column was obtained. The daily means, May 14–25, corrected from the observations at the three places, have been substituted; and as the last days, May 26–30, show a mean permanent diminution of 1·2 sc. div. (=1·68), this quantity has been added to the observations before May 14th.

140. 1842, July 24.—An accidental change appears to occur,—

By Trevandrum bifilar means (July 25–29) *minus* (July 18–22)	= + 1·86
St Helena	= + 1·93
Hobarton	= + 1·37
Mean	= + 1·72
Singapore	= + 19·26
Therefore, correct Singapore before July 24, by . . .	+ 17·54

July 24 is supplied from the three places—changes from the 22d being,

	Trevandrum.	St Helena.	Hobarton.	Mean.
July 24, *minus* 22,	−2·55	−3·32	−2·56	−2·81

141. 1843, February 25.—An accidental change appears to occur,

By Trevandrum bifilar means (Feb. 27, to March 3) *minus* (Feb. 20–24)	= + 3·82
Hobarton	= + 3·99
St Helena	= + 2·58
Cape of Good Hope	= + 5·43
Mean	= + 3·95
Singapore	= + 8·53
Correct Singapore *before* February 25, by	+ 4·58

142. 1844, April 28.—Accidental change at Singapore,—

By Trevandrum bifilar means (April 28–30) *minus* April (22–24)	= − 5·70
Singapore	= − 11·75
Correct Singapore before April 28, by	− 6·05

143. 1845, January 21–22.—An accidental change occurs between 21st and 22d:

By Trevandrum bifilar means (Jan. 27–31) *minus* (Jan. 13–17)	= − 4·06
Singapore	= + 3·19
Correct Singapore *before* January 21, by	+ 7·25

The correction of + 7·0 was applied.

144. The accidental changes at Singapore, it appears to me, may have been due to some slight variation in the position of the telescope; as the accidental

changes *after* February 1843 have been on the average about 6·0, and that alternately *plus* and *minus*, the error may have been due to turning the telescope on its Ys through 90° or 180°, the error of collimation being doubled in the latter case, and for a different wire in the former.*

145. 1845, July.—Three of the weeks in this month seem to be affected by some error, similar to that noticed above; thus, taking the mean of each five days out of six (neglecting the first day in each week as not strictly comparable at different places), we have the following Table:—

TABLE XXXVIII.—CHANGES OF FIVE DAILY BIFILAR MEANS, $k = 0{\cdot}00014$.

Period.	Trevandrum.	Singapore.	Hobarton.	Singapore Corrected.
	Sc. div.	Sc. div.	Sc. div.	Sc. div.
June 23–27. Mean	16·60	27·44	42·85	27·44
(June 30–July 4) *minus* (June 23–27)	− 2·82	− 0·53	− 2·64	− 2·70
(July 7– 11) „ (June 30–July 4)	+ 1·08	+ 4·31	+ 0·55	+ 2·18
(July 14– 18) „ (July 7– 11)	+ 1·98	− 2·08	+ 2·07	+ 2·22
(July 21– 25) „ (July 14– 18)	− 4·28	− 1·03	− 4·43	− 4·04
(July 28–Aug. 1) „ (July 21– 25)	+ 0·24	+ 0·81	+ 2·21	+ 0·81
(Aug. 4– 8) „ (July 28–Aug. 1)	− 0·02	− 4·48	− 2·03	− 1·47
(Aug. 11– 15) „ (Aug. 4– 8)	+ 2·70	+ 2·97	+ 3·38	+ 2·97

The changes at Trevandrum and Hobarton agree very nearly, with the exception of the mean for July 28 to August 1, which is two divisions greater at Hobarton than Trevandrum. A careful examination of the daily means at the three places induces me to conclude, that the error with the telescope occurred July 2; that the telescope was returned to its original position July 13; again moved July 22, and finally returned July 31. If we take the error due to this movement (say turning the telescope round on its Ys) as before, at 6·0 or 4·3 scale divisions (1 sc. div. = ·00014), and correct the days on which the change occurred by only half this amount, we shall obtain the differences as in the last column of Table XXXVIII., which agree very well with those for the other places.

146. In making this alteration it should be remarked, that errors at Singapore at the times noted are very probable (founding on many cases where I have been able to discover the causes of errors by this means); but no conclusions are based upon this correction, and it is not wished that any greater weight should be placed upon the agreement of the means, corrected by this hypothesis, with those at

* Errors from this cause were found to have occurred at Trevandrum.

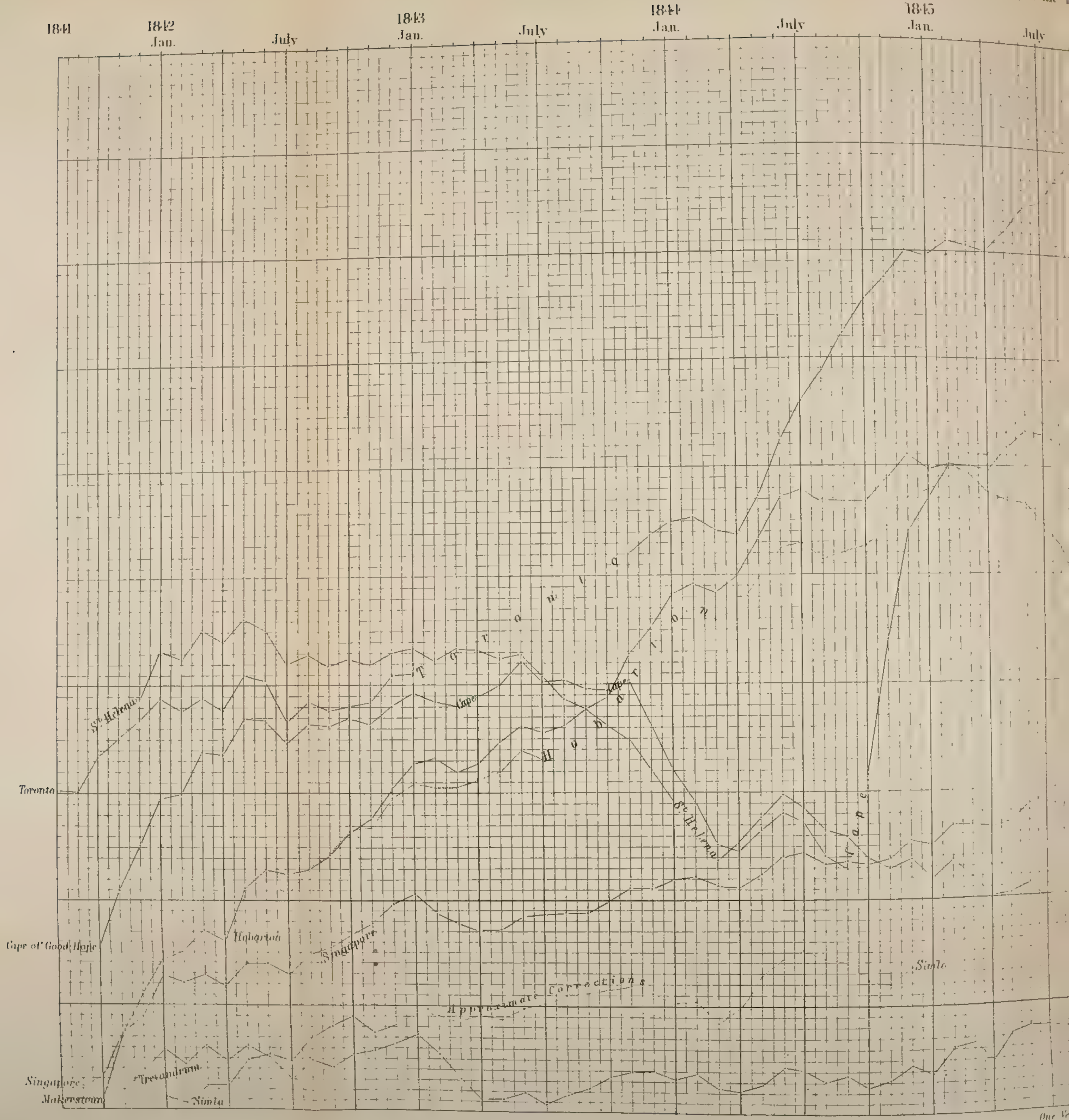
Trevandrum and Hobarton, than it may seem to merit. This agreement is shown in hundreds of other cases; and disagreement is an exception which can be traced in most cases to specific causes, as unusual disturbance.

147. On some days observations were wanting, and the Trevandrum value was interpolated: all interpolations are indicated in the tables by brackets [ ]. At Singapore, also, observations had been omitted in taking daily means, on account of disturbances; all these omissions have been restored by me, and the true daily means obtained.

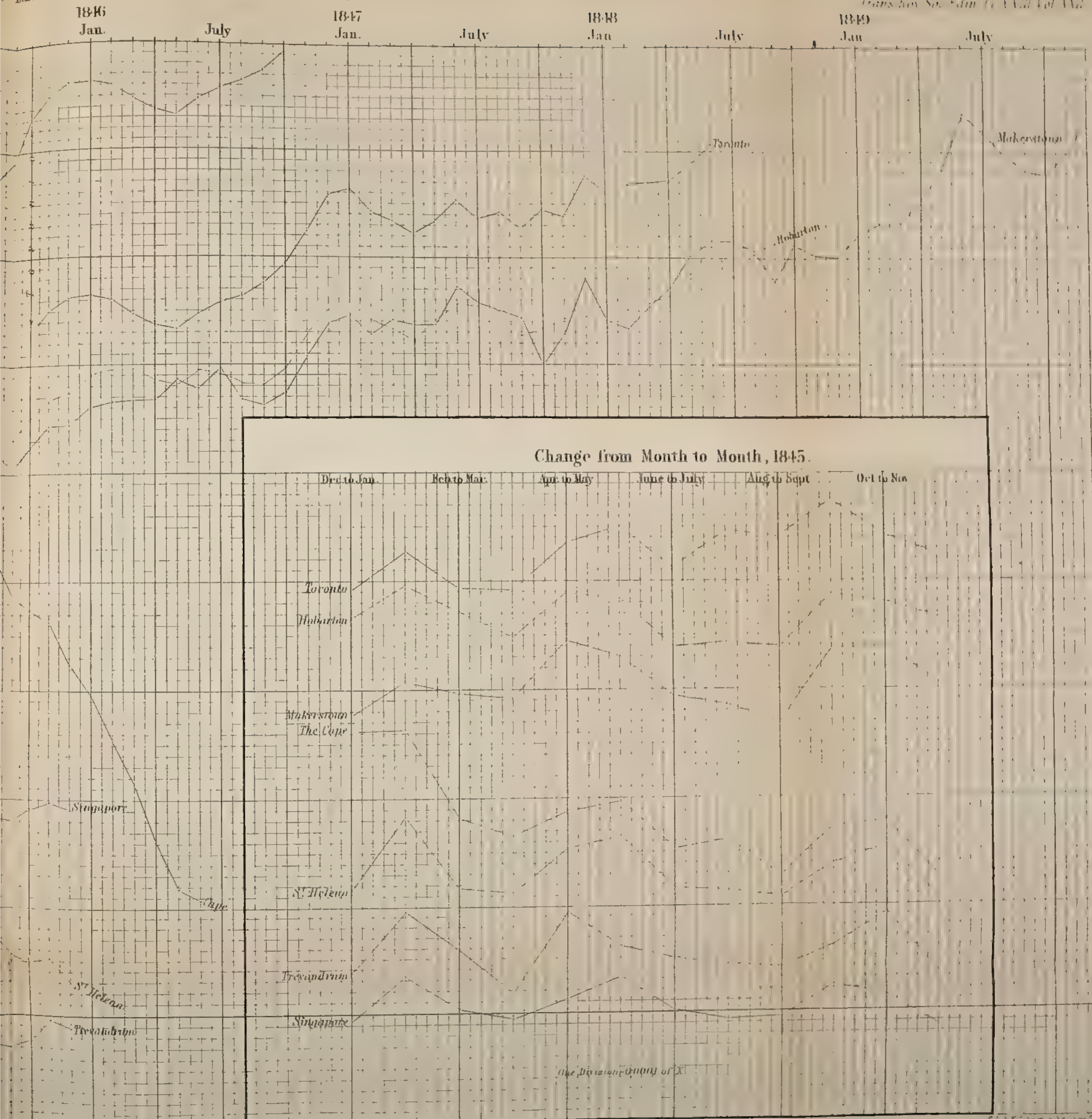
148. TORONTO.*—No attempt has been made to correct the great change of scale readings between February and October 1843. It may be noted that the temperature of the bifilar magnet was considerably influenced by the heat of the stove, as will be seen from a comparison in winter, of the last observation on Saturday evening with the first on Monday morning; the latter is generally from 2° to 10° lower than the former, the stove probably not having been used on Sunday, or not so strongly heated.

149. *P.S.*—I should have noted, that the conclusions in the preceding paper have been confirmed in various ways; and that where other observations discussed by me have not shown the same results, it has been from causes that it might have seemed invidious to mention. Before any value can be given to results opposed to those obtained in the preceding pages, it will be necessary, in the first instance, to have the truly corrected daily means; their projection, as in Plate XXVII., will always show where the errors have occurred, and probably from what cause.

* Lat. 43° 39′ 45″ N., Long. 5^h 17^m 26^s W. Observations, vols. i. and ii., published under the superintendence of Lieut.-Colonel E. SABINE.

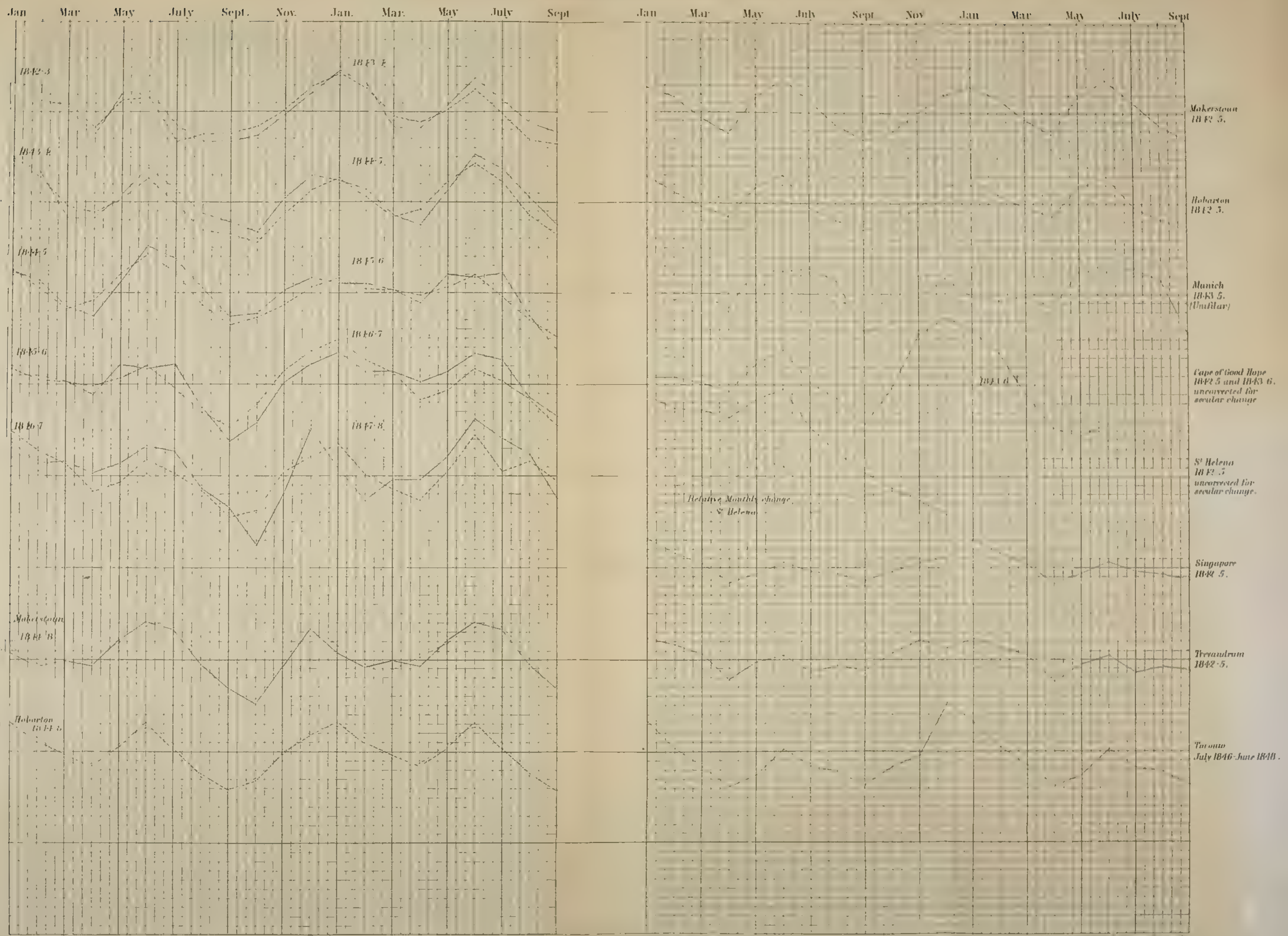

1841
1842
Jan.
July
1843
Jan.
July
1844
Jan.
July
1845
Jan.
July
Toronto
Cape of Good Hope
Singapore
Makerstoun
St. Helena
Cape
Hobarton
Singapore
Trevandrum
Simla
Approximate Corrections
Sable
One

e Earth's Magnetism, Deduced by John Allan Broun, F.R.S.



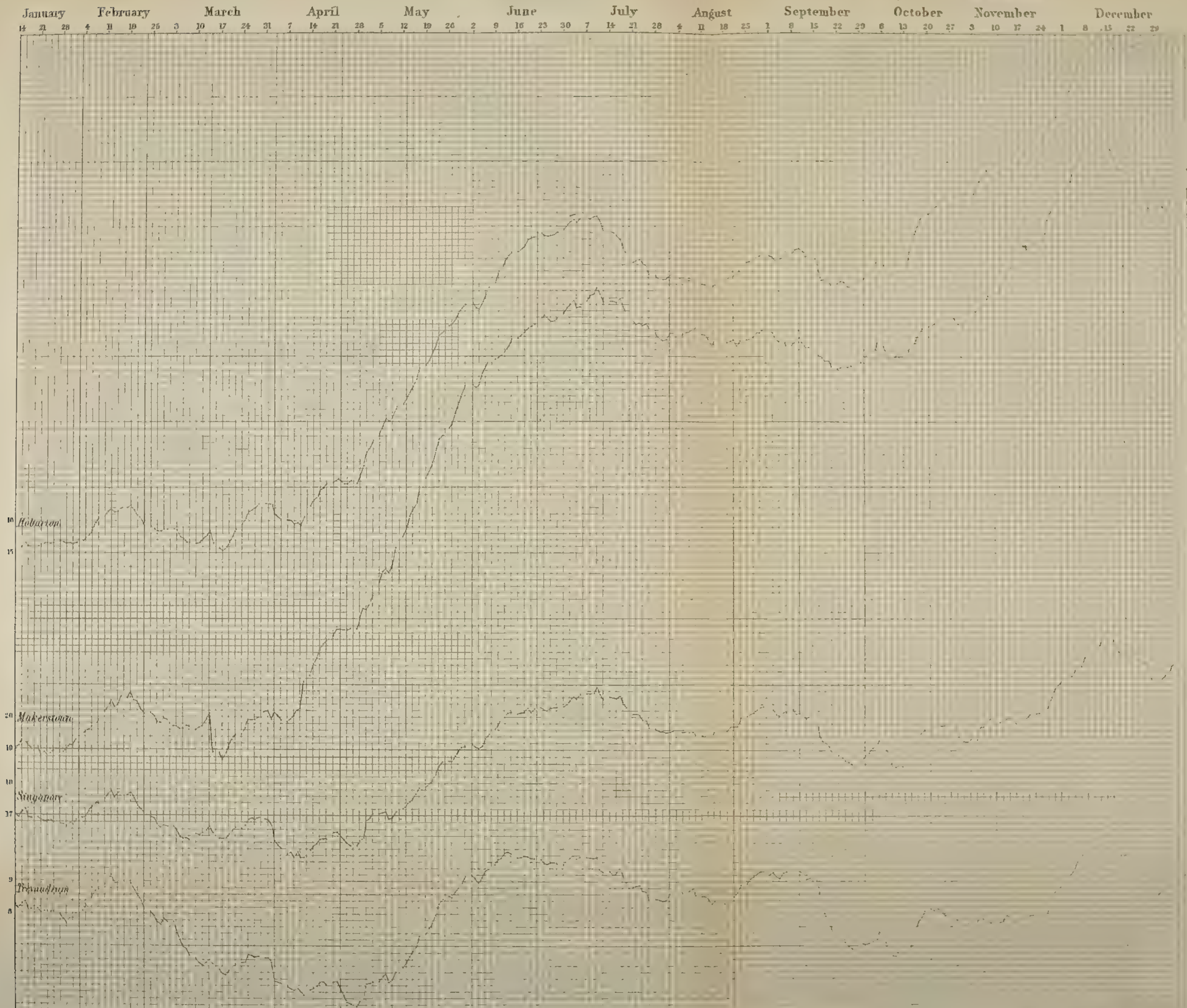
ical Division -0.0002 X

Annual Periods, of the horizontal force, of the Earths Magnetism, in 1842-8. Deduced by John Allan Broun, F.R.S.



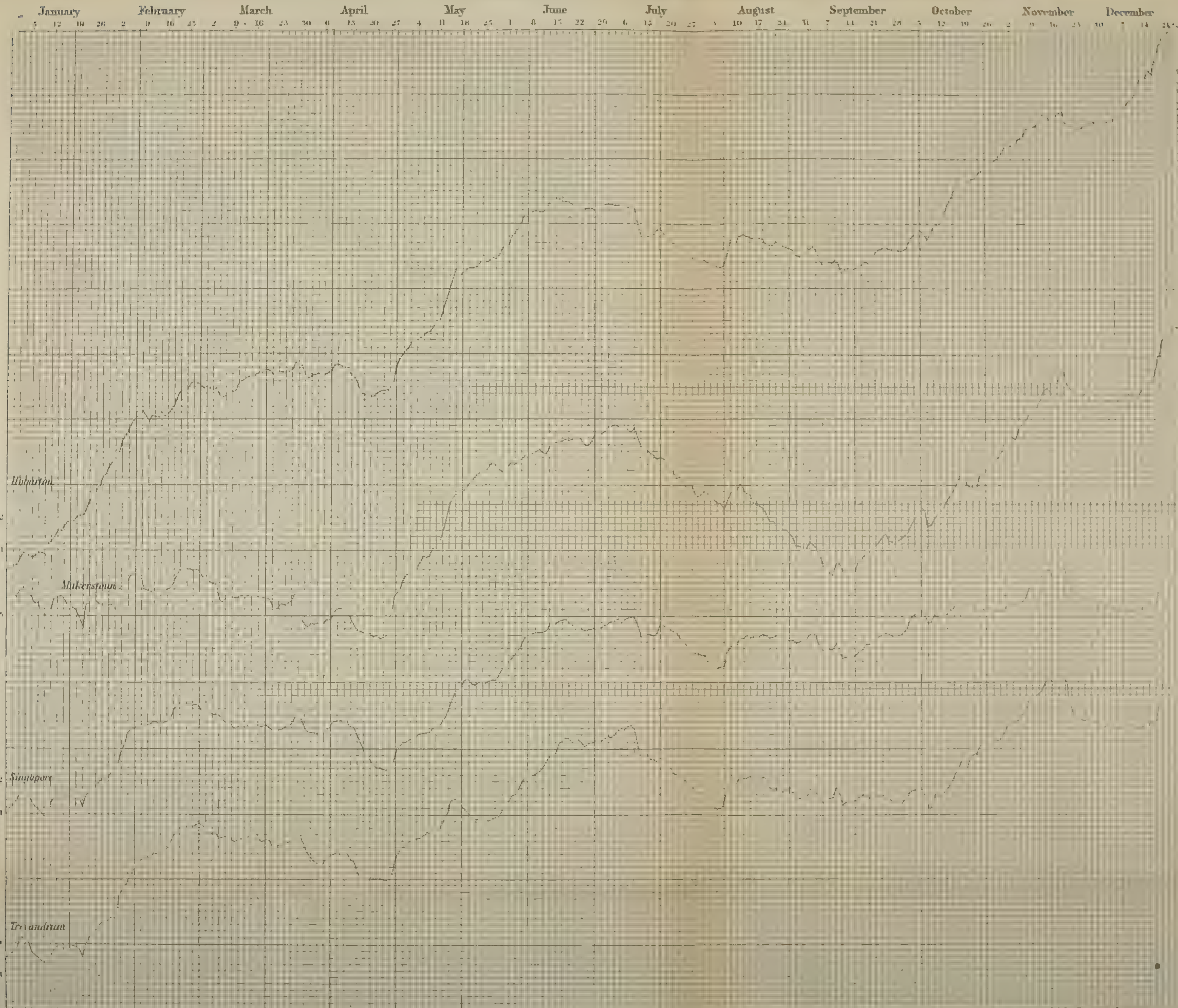
One Vertical Division = 0.0001 of X

Four weekly Means of the horizontal force of the Earths Magnetism, corresponding to each day after January 14 in 1844 Deduced by John Allan Broun F R S



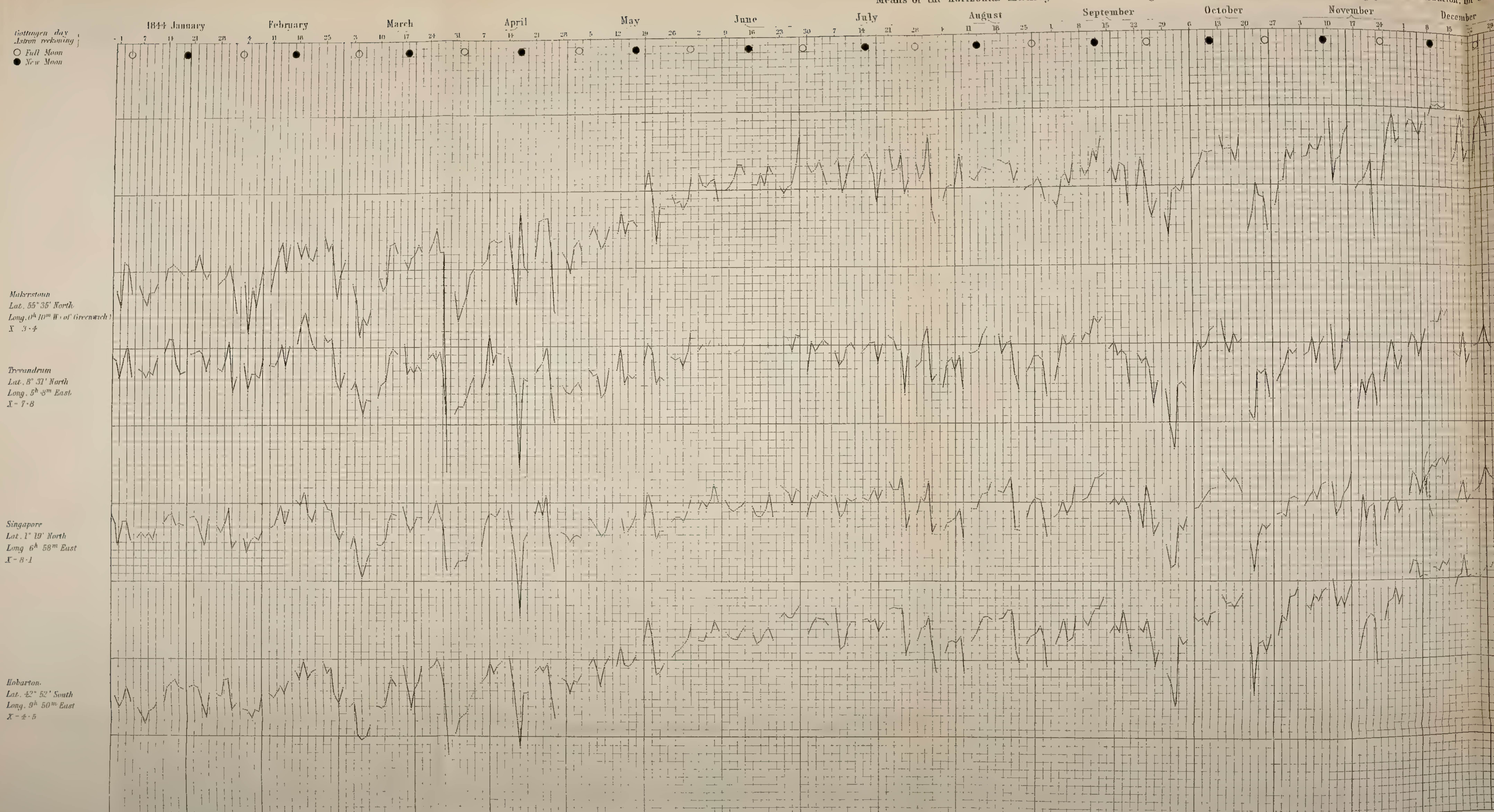
One Vertical Division = 0.00028 X

Four weekly Means of the horizontal force of the Earths Magnetism corresponding to each day Sundays excepted in 1845. Deduced by John Allan Broun, F.R.S.



One Vertical Division = 0.00028

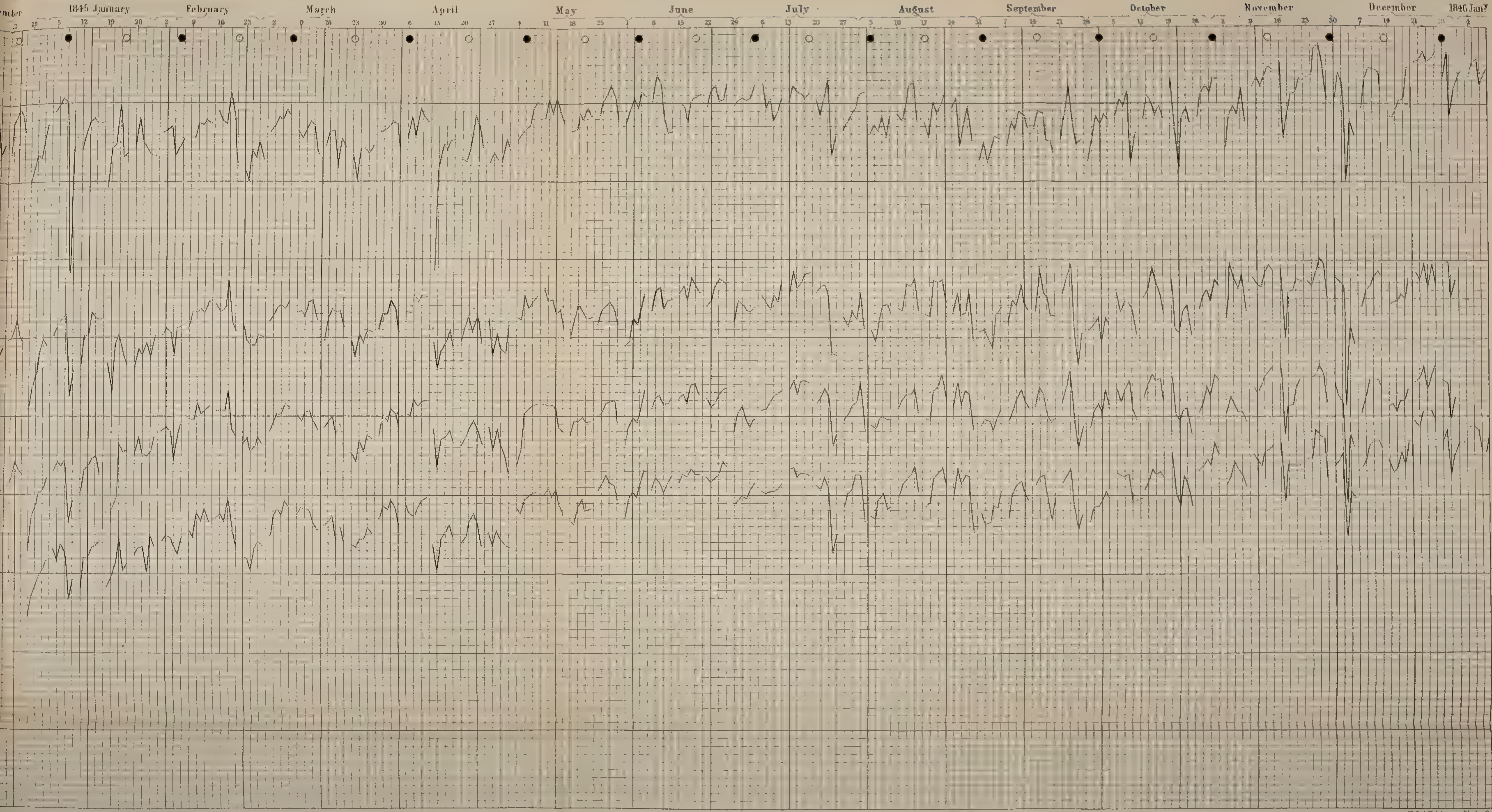
Means of the horizontal intensity of the Earth's Magnetism, at Makerstoun, Trevandrum, Singapore, and Hobarton, for each



One division of the Scale is equal to 0·00014 (fourteen hundr

., for each, Göttingen day, astronomical reckoning, (Sundays excepted) in the years, 1844 and 1845. Deduced by John Allan Broun. F.R.S.

Trans. Roy. Soc. Edin. Pl. XXVII. Vol. XXII.

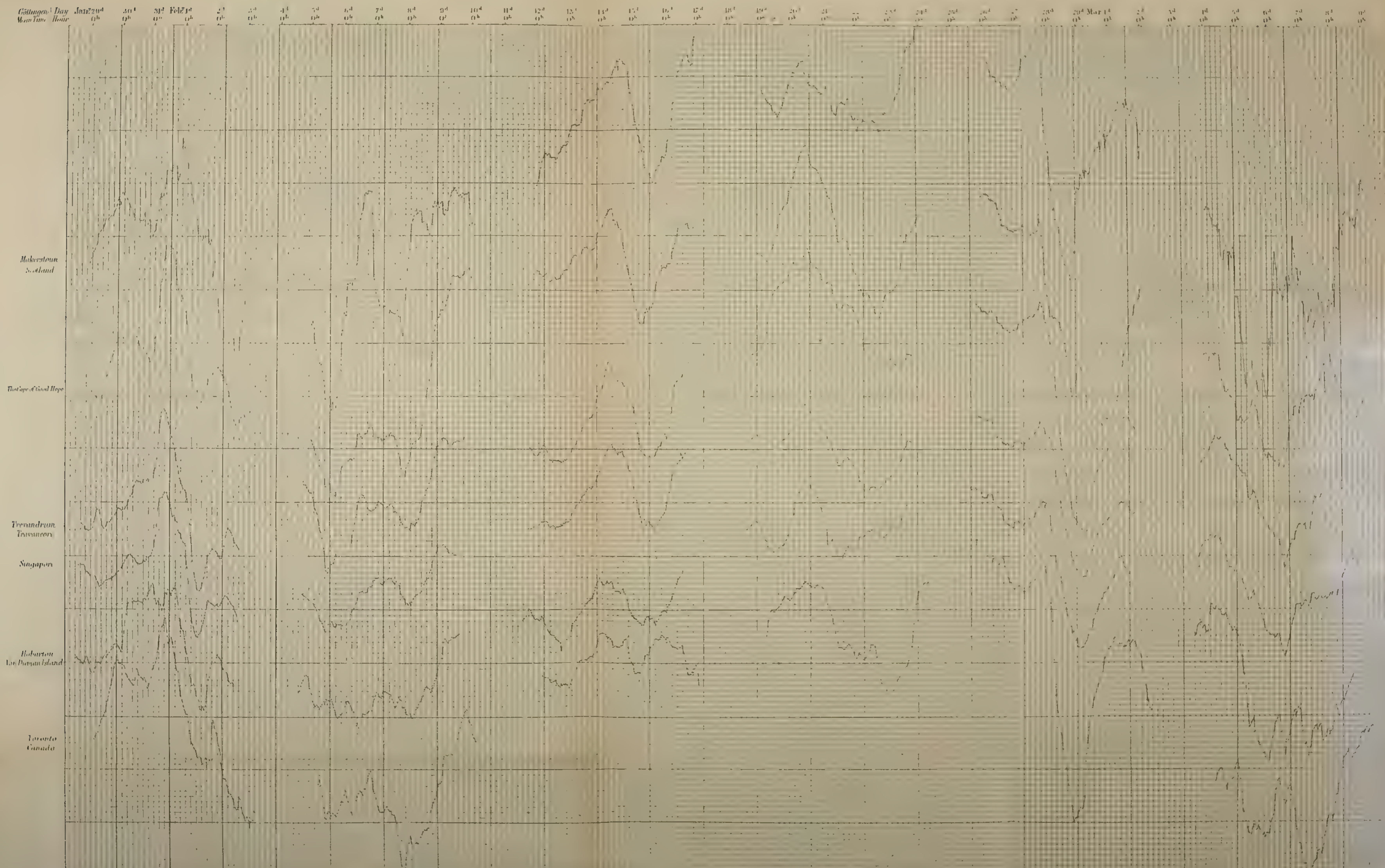


W. & A. K. Johnston Edinburgh

ndred thousandths) of the whole horizontal intensity X at the respective places.

Trans Roy Soc Edin Pl XXVIII Vol XVII.

Daily Means of the horizontal intensity of the Earth's Magnetism corresponding to each hour from January 28ᵈ 14½ʰ to March 9ᵈ 5½ʰ 1844. Deduced by John Allan Broun, F.R.S.



One division of the Scale is equal to [illegible] of the whole horizontal intensity [illegible] at the respective places.

N.B. The points of the curves [illegible] the Means of the [illegible] observations from [illegible] M.T. corresponding to [illegible]

XXIV.—*On the Pediculi infesting the Different Races of Man.* By Andrew Murray, Esq., of Conland. (With two Plates—XXIX. and XXX.)

(Read 17th December 1860.)

The bearing which the subject of the following communication has upon the much-vexed question of the unity of the human species, and the inferences which may be drawn from it in relation thereto, invest it with an importance which would not otherwise belong to it.

The position which the question I allude to at present occupies is this. On the one hand, the advocates of the view that all men are not of the same species, but that they compose a genus consisting of many species, maintain that the parasites which infest the different races of man are distinct; and because we usually find that distinct species of parasites are allotted respectively to the different species of the lower animals, they infer that the same rule must hold with man, and that therefore each different race possessing a distinct parasite must be a distinct species. Their opponents, on the other hand, deny the fact that these parasites are distinct, asserting that one and the same species of Pediculus, and no other, infests all the races of man in every quarter of the globe; and I believe they add, that, even although they were found to be distinct, the inference thence drawn is neither necessary nor warranted. But, in the first instance, the parties are at issue as to the question of fact. It may seem strange that this should be the case, as the very circumstance that the statement has been made and denied, implies that the subject or object has been examined by at least two observers (the first affirmer and the first denier), and probably by many more; and unless the inquiry be attended with more than common difficulty, such an examination should have furnished materials for its settlement. The explanation of the discrepancy, and of the opposing opinions entertained on the subject, lies, I believe, in this, that the affirmative statement has probably been made on the strength of a comparison between the Pediculi found on the negro and those found on white men, the former being the exotic race most accessible to the observation of American ethnologists, from whom the above statement has chiefly emanated; and as the parasite of the negro is blackish, while that of the European race is whitish, the hasty observer has thereupon jumped to the conclusion that they are different; while the more deliberate observer, who has noticed that the colour is greatly owing to the contents of the semi-transparent body, has, with similar inconsequence, come to the conclusion that there is no difference but that of colour; and that the colour of the parasite is solely owing to the hue of the pasture-ground. No other differences, so far as I know, have ever been noticed.

Feeling it to be desirable that the matter of fact should be ascertained,—that, whatever may be the result, and whatever effect that result may have on the question into which its services have been pressed, we should at least know what the truth really is,—I have taken advantage of the opportunities which a somewhat extended correspondence with foreign countries has put in my hands, to endeavour to find out how the fact stands; and I propose now to submit to the Society the result of my inquiry.

I would premise, however, that the inquiry has not been made without difficulty, and on that ground solicit indulgence for the imperfections and blanks which I have been unable to supply. The chief difficulty was to procure specimens, which could only be done by inducing friends to interest themselves in the matter.

But the difficulty of procuring specimens is not all. There are other elements involving doubt which must be kept in view: one is their size, and the other their colour; what attention, if any, is to be bestowed upon either? As the Pediculus does not, like most other insects, pass through metamorphoses after issuing from the egg, but merely changes its skin, individuals are to be found of all sizes; and, unlike the beetle or the butterfly (which, after emerging from the chrysalis, never increase in size), individuals grow larger, merely changing their skins a certain number of times. All comparison of actual size is thus excluded up to a certain age. After their last moult, however, the skin assumes a stronger consistency and more decided colour, and a full-grown specimen can usually be recognised as such. In my examinations I have uniformly rejected half-grown individuals, and only compared those which, from their size, texture, and colour, appeared to be adult.

The value of colour as a character is a point of greater difficulty. As I have already remarked, it is colour which has given rise to the statement that different species are peculiar to different races. There is no doubt that the species found on the white man are pale, and those on the black man dark. But in most other cases among insects, colour *per se* is either ignored as a character altogether, or admitted with the greatest diffidence. Further, colour may be derived from the nature of the feeding-ground; and it is stated by some, that if a white specimen, taken from a white man, be put upon a black man, it will become black, and *vice versa*. The Rev. Mr HISLOP, known as well for his scientific as for his missionary labours in India, informs me that at Nagpore he thinks he has seen dark Pediculi, which have found their way from coloured nurses to white children, after a time becoming white; and another friend has informed me that on one occasion, when seated in church behind two lads—the one dark-haired and the other light-haired, both swarming with vermin—he noticed that those upon the dark-haired lad were darker than those on the light-haired one. Such circumstances would seem to indicate that colour was accidental, and therefore of no consequence; but it is not wholly so. The animal owes its colour to two different sources: the one (its true colour) to its chitonous external covering—this colour it cannot lose; the other (its accidental colour) to the food it has swallowed. Being semi-transparent, the contents of the body are seen through the chitonous skin or outer skeleton. This colour it loses when the intestines, &c., are emptied. I have seen a living specimen of the dirty-coloured European Pediculus, after a few days' abstinence in a quill, lose all its dirty colour, and become entirely of a pale horny, almost colourless, hue, which is the natural colour of its external skeleton. The black Pediculus, gorged with the blood of a negro, would, I have no doubt, under similar treatment, get rid of the blackness due to the contents of the body, but retain that amount of brown tint which belongs to the external covering. Colour, therefore, is not to be wholly discarded; and when it goes along with other distinctions, may be properly used as a subsidiary, although subordinate character in determining species.

A difficulty of a different kind arises from there being, or being supposed to be, more than one species infesting the same race or the same individual. There are usually said to be four species found on Europeans. One of these (*Phthirius inguinalis*) is, however, not a true Pediculus, and therefore does not fall within the limits which I have assigned to myself in this paper—limits which I have adopted not from any wish or intention so to limit myself, but solely from necessity, as I have not been fortunate enough to procure any specimens of Phthirius from other nations. That other varieties or species of Phthirius exist, however, is possible, for we hear of a parasite specially infesting the eye-lashes of some of the natives in the East Indies, which probably may be a Phthirius. But as I have not received any specimens of this or any other exotic Phthirius, I am compelled to leave them out of the inquiry. This does not, however, at all interfere with the accuracy of the results drawn from the Pediculi proper, as the Phthirius is generically distinct from the Pediculus, the grasping or scansorial claws, as they are called, being on the posterior feet instead of the anterior, so that they cannot possibly be confounded with them. A third so-called species of Pediculus may also be discarded from our consideration, as having no existence in nature—the *P. tabescentium*, said to be peculiar to diseased persons. Denny, in his work on the Anopleuræ, seems to believe in it; but he never saw it, doubtless for the best of all possible reasons, viz., that it does not exist. Every instance of the supposed occurrence of this species, which has fallen under the notice of any competent observer, has turned out to be merely an unusual profusion of the common *Pediculus vestimenti*. In the only instance which fell under my own observation, this was the case. Dr Jackson of this city, some years ago consulted me regarding a case of the kind, where a patient, a young lad, was supposed to be infected. Repeated washings seemed to have no effect upon this terrible disease. A few hours after washing, the unfortunate victim was found again to be swarming as badly as ever; and Dr Jackson could speak to this fact from personal observation. I expressed my disbelief in the supposed disease, and recommended a more searching inquiry into collateral circumstances, and, above all, the securing specimens for examination. Dr Jackson soon procured these; and neither of us will, I think, readily forget the examination of the specimens. Not being supplied with entomological apparatus, he had put them into an old pomatum pot, which happened to be at hand. With justifiable pride he announced that he had secured the desiderated specimens, and had three in this pomatum pot, which he had carefully enveloped in several folds of brown paper. On removing the paper, however, and opening the pot, to our dismay, instead of the three specimens we only found one. The other two had escaped from the insufficiently secured vessel; but whether in Dr Jackson's pocket or in my room we could not tell. Friendship has its limits; and I confess I was unfriendly enough to hope that the escape had taken place before the pomatum pot reached me. Fortunately their comrade remained behind to settle the question, that the supposed *Pediculus tabescentium* was only the common *Pediculus vestimenti.* Dr Jackson had further ascertained the fact that although the patient was frequently and carefully washed, he was always immediately thereafter re-indued in his old dirty flannel jacket, whence the swarms were successively supplied which astonished beholders; and the further history of the case was, that so soon as the dirty flannels were burned, the mysterious disease disappeared, and the patient recovered. Such, I have no doubt, would be found to be the rationale of Lady Penruddock's case, and of all similar recorded cases of the disease of *P. tabescentium*, which have obtained credence from not having been examined at the time; and believing it to be so, I dismiss that species of Pediculus as a fiction.

The two remaining kinds, *Pediculus capitis* and *P. vestimenti* (the former appropriated to the head and the latter to the body), are more embarrassing—for hitherto no very good characters of them have ever been indicated.

I think, indeed, that I have found such characters, but have not examined a sufficient series of specimens to be able to decide with certainty. The form of the head species is smaller, more elongate, and narrower than the other, and it has a series of dark markings on the margin of the abdomen; but the body species has the margin also similarly margined, only with yellowish instead of dark markings, and individuals in both species vary in breadth and length so as greatly to destroy the value of the characters drawn from their relative proportions. As might be anticipated, their specific distinctness while maintained by some authors is denied by others, who consider the larger variety as merely indicating more liberal diet and less active habits. As already said, I think they are distinct; and in addition to the difference in the general appearance, it will be found that the *P. vestimenti* always wants the spine at the top of the thumb, and has little or no projections on the inner side of the penultimate joint—characters which accord with its less scansorial mode of life, which requires less powerful appliances for seizing and tenaciously retaining hold of the hairs through which it passes. The concurrent opinion of those who are practically familiar with the animals and their habits also confirms the view that they are distinct species.

I remember the remark of a young private soldier on his return, wounded, from the Crimea, who, in speaking of the sufferings of the troops before Sebastopol, dwelt upon the annoyance experienced from these parasites; and in reply to some suggestion of mine as to the specific virtues of a small-toothed comb, which I believed formed part of a soldier's necessaries, answered, "Oh! we did not mind the head ones; it was the body ones,"—thus implying a clear and well recognised distinction between the two in power of annoyance. We have thus two scarcely decipherable species infesting the same race; and when we receive specimens from a foreign race, we are subjected to the disadvantage of being unable positively to say to which of these two kinds they belong. In all but one or two instances, however, I have, I think, been able to refer the specimens received to their proper kind; and if in these instances I have failed to do so, still this can scarcely affect the result to which I have come, because, in the first place, the very similarity which prevents me distinguishing between them with certainty, renders a misplacement of less consequence, and, in the next place, an error in one or two only out of several cannot have any material effect on the general result, so far as the inquiry into the existence of different species or different races is concerned.

I annex at the close of this paper a detailed description of the differences which I have found between the specimens from the different races and localities, and shall briefly notice their general tenor, and the bearing they have upon the main question which I propose to solve.

First, is there really any difference at all in the specimens from different races?

As to colour, I find there is a considerable difference. The coloured races of man have correspondingly coloured parasites. Those of the West African negro and Australian are nearly black; those of the Hindu, dark and dusky; those of the Africander and Hottentot, orange; of the Chinese and Japanese, yellowish brown; of the Indians of the Andes, dark brown; of the Californian Indians, dusky olive; and those of the more northern Indians, near the Esquimaux, paler, approaching to the light colour of the parasites of the European.

As to form, there is not much scope for difference. In other insects, the difference between species of the same genus chiefly consists in the sculpture upon the body and in the different form of some of its parts; but in the Pediculi, the body being soft, there is not much room for sculpture. It has a certain kind of wrinkled sculpture approaching to the texture which gives mother of pearl its iridescent lustre; and from this cause, in certain lights under the microscope, something of this iridescence may be observed on the body of the Pediculi; but of more decided sculpture, or special marks, we can have little. The soft flexible skin allows what might be a hollow or depression in one case to be raised into a ridge or an elevation in another. The only parts which are sufficiently hard to retain their form under some degree of pressure are the legs and the antennæ; but unfortunately, in the insect world, these parts are usually so constant throughout all the species of a genus, that the existence of differences there seldom fail to indicate a different genus. We can only expect a very trifling amount of difference there, and this, when found to exist, must be reckoned of greater value than a larger difference in some more variable parts. After a careful search for decipherable characters, I have found the best in the form and proportions of the legs and claws, and more especially in the anterior legs and claws of the male, which are (as is frequently the case in all orders of insects) larger and more dilated than those of the female.

Using these as characters, then, it is impossible to deny that there are tolerably well-marked differences between the parasites of different races; and as in several of these races I have had the benefit of a large series of specimens, I am able to add that these differences are constant. A glance at the drawings (Plates XXIX. and XXX.), which have been made with every care and precaution by the aid of the *camera lucida*, will show the nature of these differences. The teeth of the claw vary considerably. In some, as in the European, the Caffre, and the Japanese, they are scarcely visible. In others, as the Hindu, Indian of the Andes, &c., they are numerous, large, and almost tubercular. In others, as the negro and King George Sound Australian, they are limited to two or three well-marked serrations. The form and proportions of what I shall call the thumb, are also different. In some, as the Mozambique Africander, Californian Indian, and Indian of the Andes, the thumb is excessively developed; in others, as the European, the Japanese, and Australian, only moderately so. The form of the penultimate joint also varies to a very considerable extent, in some being long, narrow, elongate and straight; while in others it is conical, curved, short, and broad at the base.

There remains the question, what is the value of these differences as bearing upon the unity of the human species? I am bound to confess that I think the question is left exactly where it was before. It has been proved that there are differences, and that these differences are constant and permanent—that is no doubt something. But, unluckily, these differences are most singularly similar to the differences in the races whose unity is the question in dispute, and to solve which this evidence has been adduced. If I cannot believe that the negro is a different species from the European, on account of his being black instead of white, neither should I believe that the Pediculus of the Negro is different from that of the European because it is black instead of white. If I cannot believe that the Australian is different from the Esquimaux because he has proportionally a much longer leg, neither can I believe that the Australian Pediculus is different from the Slave Lake Pediculus, because it has a longer and straighter penultimate joint to its tarsus. If the curved tibia of the African does not constitute him a different species from races with straight tibias, neither should the greater or less curvature of the joints of the tarsi in the Pediculi be considered to form specific distinctions in them. It happens, however, that not only are the differences, both between man and man, and Pediculus and Pediculus, very similar in degree, but they are also differences of the same kind. They are differences in colour and proportion of the very same, or, at all events, analogous parts in both. To attempt to draw any deductions from these differences in the Pediculi, would therefore, as it appears to me, be something very like begging the whole question.

Unsatisfactory though the result of my inquiry may thus be deemed, I cannot look upon it as wholly thrown away. We now know what the truth of the matter really is, and no longer need to argue in the dark upon doubtful premises.

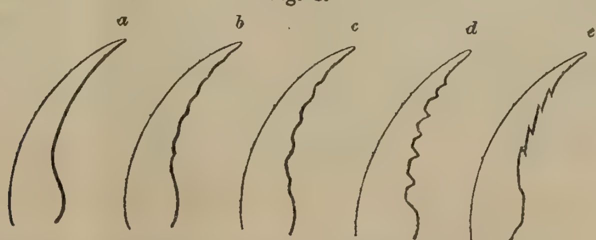
Explanation of Terms.

Fig. 1. Male.

Fig. 2. Female.

a. Claw. *b.* Penultimate joint. *c.* Tibia. *d.* Femur. *e.* Shoulder joint. *f.* Thumb. *g.* Apical spine of thumb. *h.* Tassel. *i.* Lamina. *j.* Salient angle. *k.* Re-entering angle.

Fig. 3.



a. Simple. *b.* Rippled. *c.* Waved. *d.* Toothed. *e.* Serrated.

Descriptions.

The following is a brief description of the different kinds I have examined, preliminary to which I furnish an explanation of the terms applied to the different parts, not hitherto been used as characters:—

British.—Dirty white; elongate; antennæ short, and rather robust.

♂ Anterior leg—Thumb moderate, slightly curved on exterior side; apical spine strong; penultimate joint of tarsus curved, not much broader at base than at apex; projection or inner plate small; claw equal in length to penultimate joint, moderately curved, very slightly irregularly rippled on the edge.

♀ Anterior leg—Thumb almost awanting; apical spine the length of the penultimate joint, which is short and narrow; claw more than twice its length —not toothed.

Scotland.

Russian.—Dirty white; claws and tip of thumb yellow; obovate.

♂ Anterior leg—Thumb large, with a slight exterior bend; spine at tip awanting, and seems never to have been there;* penultimate joint broad at base, its termination more conical; inner projection or plate almost awanting; claw longer than the latter, more powerful than in the Scotch; teeth irregular and shallow, like a slight ripple.

♀ St Petersburg. (Count Motschulsky.)

Slave Lake.—Dusky blackish; obovate.

♂ Anterior leg—Thumb large and thick, very slightly rounded externally, and with scarcely any bend; spine at top awanting; penultimate joint short, and nearly as broad at top as at base; inner projection or plate almost awanting; claw nearly twice as large as the latter, thick and powerful, very considerably curved, with two or three smallish teeth.

Slave Lake, from the head and body of a child. (Mr Bernard R. Ross.)

Californian Indians.—Dusky olive brown. Long and narrow.

♂ Anterior leg—Thumb large, thick and long, not bent, only slightly rounded exteriorly; apical spine small and short; penultimate joint thick and robust, not very much wider behind than in front; inner projection almost wanting; claw longer than penultimate joint, moderately broad edge, not toothed, slightly waved or rippled.

* Perhaps this is the specific character of *P. vestimenti.*

♀ Anterior leg—Thumb large; apical spine strong, as long as the thumb itself; penultimate joint moderate; claw a half longer, not toothed.

California. (Mr W. Murray.)

A very distinct form.

South American Andean Indians.—Rich brown; body obovate; antennæ more slender and slightly more elongate than in European.

♂ Anterior leg—Thumb very long, bent like a quarter-bent thumb; apical spine robust; penultimate joint long, straight, and almost as broad in front as at the base; the inner projection small, but well defined and distinct, nearly midway between the base and apex; claw shorter than penultimate joint, robust, abruptly thickened and enlarged at the base, so as to form a sort of head nearly of the same thickness until towards the tip—strongly toothed or serrated in the middle.

Quito. (Prof. Jameson.)

This is the most peculiar species I have met with. The long thumb, and long, nearly cylindrical straight penultimate joint, are very peculiar; and it is the only species I have seen which has the claw shorter than the penultimate joint.

South American Indians, Tierra del Fuego.—Dusky olive; obovate.

♂ Not seen.

♀ Anterior leg robust—Thumb small; apical spine comparatively very strong, and parallel almost to the point, more than half the length of the penultimate joint, which is moderate, not much narrower at the point than the base, and only half the length of the claw, which is rather narrow, not rapidly tapering, and without teeth.

Tierra del Fuego (Mr Darwin, "Voyage of the Beagle"). (Mr Denny.)

Japanese.—Burnt Sienna brown; obovate.

♂ Anterior leg—Thumb short and slender, subserrated at the top, not elbowed exteriorly; apparently without a spine (probably the spine foreshortened); penultimate joint long, conical, not greatly broader at base than at tip; inner plate or projection slight; claw long, equal in length to penultimate joint, nearly of uniform thickness throughout, a very little thicker at the base, not serrated, edge slightly rippled towards the base.

From a Japanese in the hospital at San Francisco. (Mr W. Murray.)

Chinese.—Rich burnt Sienna brown; obovate.

♂ Anterior leg—Thumb long and well separated from the penultimate joint, slightly bent on exterior; apical spine distinct; penultimate joint twice as long as thumb, wider at base than at top, salient angle slight, re-entering angle distinct, filled with a rather broad lamina below the tassel; claw about the length of the penultimate joint, simple, the distal half of its length narrow and slender, the base thicker.

From a Chinaman in San Francisco. (Mr W. MURRAY.)

East Indian.—♂ Dusky. Anterior leg—Thumb tolerably long, not very thick, projecting, scarcely bent on the exterior; apical spine distinct, but not very strong; penultimate joint wider at bottom than top; salient angle distinct and well defined, but small; claw of the length of the penultimate joint, rather thick, and tapering sharply towards the point; very much toothed, the teeth sharp, somewhat irregular, half serrated and half waved, pointing backwards.

♀ Anterior leg—Thumb distinct, about length of apical spine, which is short; penultimate joint short, and rather narrow; claw a half longer than the penultimate joint; not toothed, a good deal curved, and tapering all the way from the base to the apex.

From both Hindus and Mahomedans in Calcutta. (Dr FAYRER.)

This Pediculus has the claw more toothed than any other I have examined. In some the teeth or serrations are better defined and larger, but in these instances they are fewer in number; here almost the whole edge of the claw is tolerably deeply toothed, so much so as to be visible with an ordinary lens.

Australian (*King George's Sound*).—Dark brown; obovate.

♂ Anterior leg—Thumb projecting, but not robust; antennæ more slender than in the European species, less so than in the Andean species; apical spine moderate; penultimate joint robust, very little curved, not greatly wider at base than apex, inner plate nearly awanting; claw longer than penultimate joint, not slender, and with two very well marked serræ or teeth, one in the middle, the other intermediate between it and the apex, and the trace of a third intermediate between the second and the apex.

From the natives of King George's Sound. (Mr G. MAXWELL.)

Australian, Wimmera Tribe.—Dusky; rather elongate.

♂ Anterior leg—Thumb slender, about half the length of the penultimate joint, slightly rounded, not bent on the exterior; apical spine rather short. Penultimate joint truncato-conical, much wider at the base than the apex, with scarcely any inner plate or projection; claw curved, and tapering gradually, not toothed.

Wimmera tribe, Australia. (Mr LEARMONTH.)

Caffre.—Orange-coloured, oblong ovate.

♂ Anterior leg—Thumb small, narrow, and applied pretty closely to penultimate joint, with a long spine. Penultimate joint elongate, a little broader at the base than at the apex, inner projections almost awanting, or, rather, a hollow before the place where the projection usually is; claw narrow, equal in length to the penultimate joint, nearly equal in breadth, except at base and apex, without teeth.

South Africa. (Mr DENNY.)

Hottentot.—Yellow, oblong ovate.

♀ Anterior leg—Thumb scarcely existing; apical spine slender and tapering to a fine point, sharply from the base. Penultimate joint very long and conical, narrow at point, not very wide at the base, without inner projection; claw small, tapering slowly until near the top, when it comes rapidly to a point about three-fourths of the length of the penultimate joint,—toothless.

Cape of Good Hope. (Mr DENNY.)

Mozambique Africander.—Orange-coloured, black in the middle; large, obovate. ♂ Anterior leg—Thumb large, long, and with a decided bend like a quarter bent thumb, with a long and strong spine at tip. Penultimate joint shorter than claw, somewhat curved, wider at base than apex; inner plate large and well defined, with shoulders and a projecting rounded point: claw long, but comparatively not very robust, rather curved, and with sharp pointed, ripple-formed teeth.

♀ Anterior leg—Thumb distinct, apical spine very long (bent outwards), more than twice the length of the thumb. Penultimate joint very long for a ♀ and truncate-conical; inner plate distinct; claw narrow, sub-parallel, shorter than penultimate joint—not toothed.

South Africa. (Mr DENNY.)

The largest kind which I have seen. Very distinct and well marked.

West African Negro.—Dark, olive black, somewhat elongate.

♂ Anterior leg—Thumb short, with a strong thick spine, without exterior bend, or nearly so. Penultimate joint as long as claw, not much curved, broader at base than at top, inner plate distinct, but not large; claw comparatively slender towards tip, with three serriform teeth.

♀ Anterior leg—Thumb almost awanting; apical spine rather slender, only half the length of penultimate joint; claw long and narrow, without teeth.

Georgia—from a genuine freshly imported West African negro.

(Mr DENNY.)

Explanation of Plates.

Plate XXIX.

Anterior claws of—

1. Pediculus capitis (Scottish) ♂
2. Do. Do. ♀
3. Do. (Hindu, Calcutta) ♂
4. Do. Do. ♀
5. Do. (Caffre)
6. Do. (Mozambique, Africander) ♂
7. Do. Do. ♀
8. Do. (Californian Indian) ♂
9. Do. Do. ♀
10. Do. (Australian, King George Sound) ♂
11. Do. (Genuine West African Negro, imported into Georgia) ♂

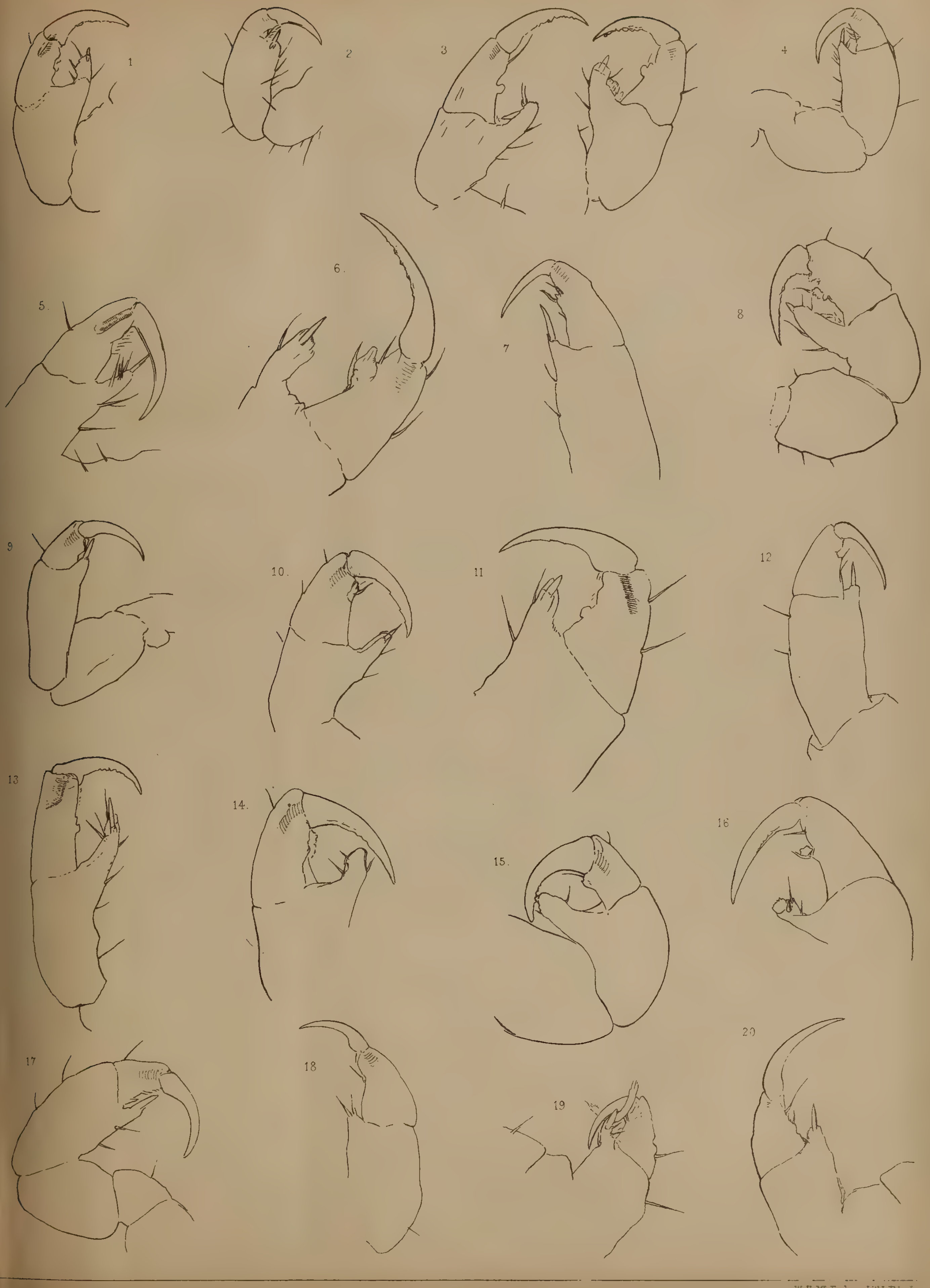
Anterior claws of—

12. Pediculus capitis (Genuine West African Negro, imported into Georgia) ♀
13. Do. (South American Indian, Andes, Quito) ♂
14. Pediculus vestimenti (Russian) ♂
15. Do. (North American Indian, Slave Lake) ♂
16. Do. (Japanese) ♂
17. Pediculus capitis (Tierra del Fuego) ♀
18. Do. (Hottentot) ♀
19. Do. (Australian, Wimmera tribe) ♂
20. Do. Do. ♀

Plate XXX.

Anterior claw of—

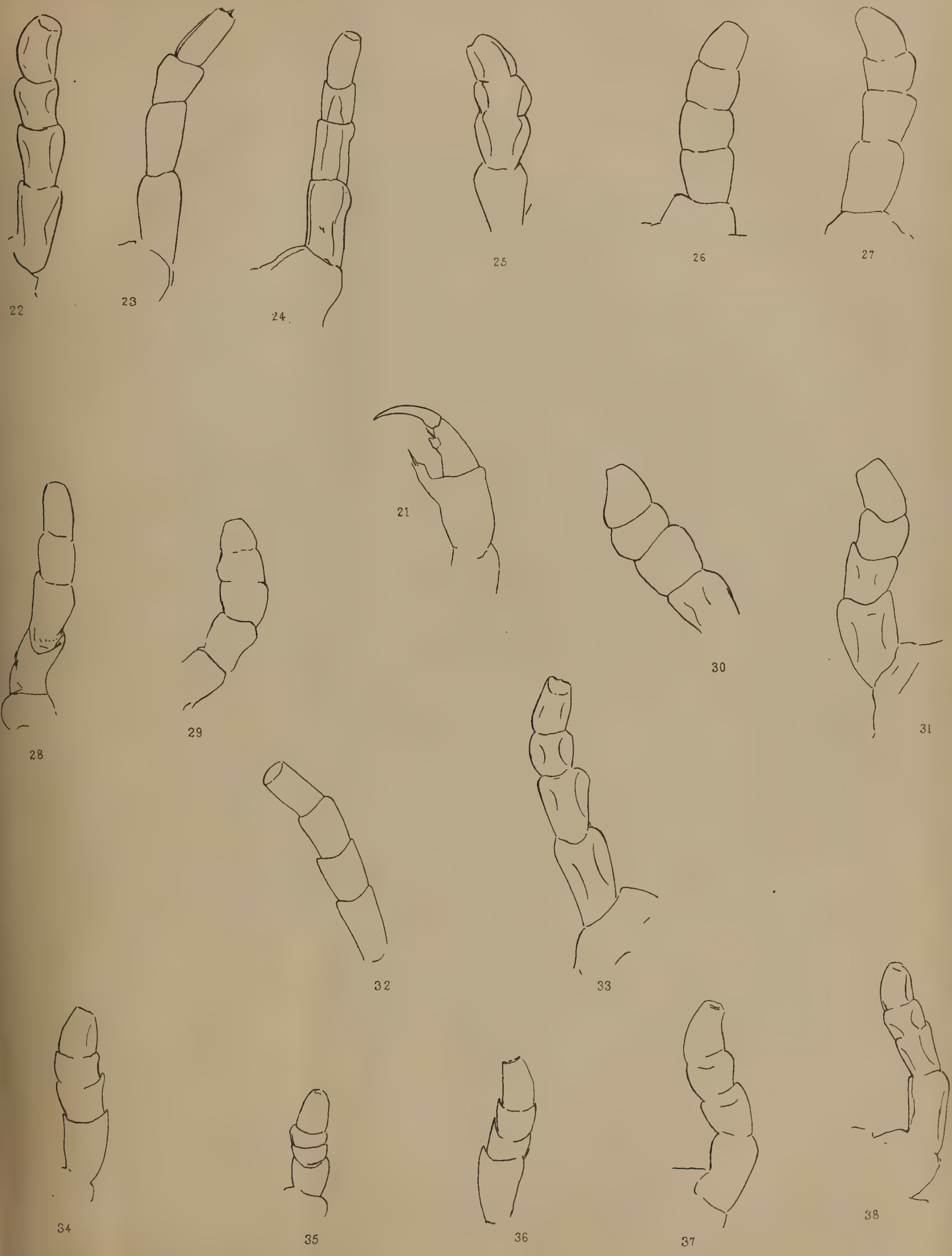
21. Pediculus capitis (?) (Chinese) ♂
22. Antennæ of No. 13 (Quito)
23. Do. No. 10 (King George's Sound)
24. Do. No. 16 (Japanese)
25. Do. No. 17 (Tierra del Fuego)
26. Do. No. 19 (Wimmera tribe, Australia)
27. Do. No. 3 (Hindu)
28. Do. No. 6 (Mozambique, Africander)
29. Do. No. 18 (Hottentot, Cape)
30. Do. No. 8 (Californian Indian)
31. Antennæ of No. 15 (Slave Lake Indian)
32. Do. No. 21 (Chinese)
33. Do. No. 1 (Scottish)
34. Do. No. 11 (West African Negro, from Georgia)
35. Do. (American Negro, full blood)
36. Do. (West African Negro, W. Africa)
37. Do. No. 5 (Caffre)
38. Do. No. 14 (Russian)



W H Mc Farlane, Lithr Edinr

MURRAY ON PEDICULI.

Trans Roy. Soc Edin^r. Vol. xxii. Pl xxx.



W. H. M^c Farlane, Lith^r. Edin^r.

XXV.—*Expedition to the Higher Ranges of the Anamalai Hills,* Coimbatore, in* 1858. By Hugh Cleghorn, M.D., Conservator of Forests, Madras Presidency. Communicated by Professor Balfour. (With seven Plates, XXXI.–XXXVII.)

(Read 29th April 1861.)

The excursion described in the following pages was planned by Dr Macpherson, Inspector-General of Hospitals, and myself, with a view to explore the Southern Range of the Anamalai (*i.e.* Elephant Hills), in the district of Coimbatore, which are sparingly laid down in the Great Trigonometrical Survey Map, while the peculiarities of their Fauna and Flora had not been recorded.

The project was approved by the Right Honourable Lord Harris, then Governor of the Madras Presidency, and the services of Major D. Hamilton were sanctioned by His Excellency Sir Patrick Grant, Commander-in-chief, to accompany us as artist, to delineate the characteristic features of the country.

On the 15th September 1858, according to previous agreement, the village of Kotúr, ten miles from Pulachy, and six from Anamalai,† was the place of rendezvous. The party consisted of J. W. Cherry, Esq., Collector of Coimbatore; Drs Macpherson and Cornish, Major D. Hamilton, 21st N. I.; Captain Fane, Lieut. R. H. Beddome, 42d N. I.; T. B. French, S. L. Koe, W. Fraser, C.E., and O. B. Irvine, Esq., Assistant-Collector, accompanied with seven elephants. We started at 4 a.m., and arrived at the Anamalai river at 20 minutes past 5; the distance six miles, and the road much trodden by sheep and cattle. By the light of early dawn, we distinguished the candelabrum-like stems of *Euphorbia antiquorum*, and the drooping foliage of *Salvadora indica*, which in habit resembles the weeping-willow, and here attains a large size, the trunk being 10 inches in diameter. After crossing the river, which was deep and rapid, in leaky basket-boats, we traversed a number of rice fields, and entered the bamboo and tree jungle which lies in the hollow between the river and the ascent to Punachi, and which becomes exceedingly thick and wet along the water-courses. After proceeding about a mile, we ascended by a winding bullock path, and reached Punachi at 9·30. The ghat we calculated to be at least three miles long. It is very steep, but easy enough for coolies; and in one or two places we dismounted. The ponies scrambled over the boulders easily; but the elephants, though lightly

* The reader will find an interesting narrative of an Expedition over the Anamalai mountains (northern range), by Capt. (General) F. C. Cotton, Engineer, in the "Madras Journal of Literature and Science," vol. ii. N. S., p. 80 (1857).

† North latitude 10″ 27, East longitude 77. Plate XXXII., Panorama of mountain range from this village, showing the eastern aspect of the hills.

laden, followed slowly and with difficulty, not reaching the huts till near dusk. The most trying work (see Plate XXXIV.) for laden elephants is crossing the bed of mountain streams, as the sloping boulders offer a precarious footing for these heavy animals. From the top of the ghat to Punachi is above three miles of ascent and descent; about two miles from the top may be seen a magnificent precipice about 200 feet high. The bluff rock overhanging the Torakudu river is reddish porphorite. The hills, like the Nilghiris and the Coimbatore district generally, consist of gneiss, and belong to the metamorphic rocks; veins of felspar and quartz were common, some of them very large, crossing the foliated gneiss at right angles. The gneiss was generally of a grey colour, but in some places it was reddish. No crystalline limestone such as is found associated with the gneiss in Coimbatore was observed.

According to instructions given by Mr Cherry, the Kaders had prepared three huts and stabling for us, in an open space about 50 yards east of the coffee plantation belonging to Ramasami Mudelliar. These huts were admirably constructed, much superior to their own dwellings, and quite water-tight; the uprights were made of jungle trees tied together by strips of bark, the cots of bamboo, and the thatch of the glabrous leaves of a species of *Saccharum*. The coffee plantation was commenced twelve years ago; the soil is rich, the trees are at least 14 feet in height, left entirely to nature; a beautiful stream, however, is taken advantage of to irrigate the garden. The produce is much smaller than it might be under systematic management. There are some good teak trees standing in the middle of the plantation.

In the neighbourhood of Punachi, three or four large cattle kraals were seen, each containing from 50 to 80 head of cattle. Behind our hut was a waterfall, which is distinctly seen from Anamalai. The Punachi river tumbles over a precipice, which seems to be the edge of a considerable tract of table land; this we regretted we had no opportunity to explore. Near to it are several dense *sholas* (thickets); and above the cascade, some bison pasture ground and ibex rocks.

Teak occurred for the first time on some undulating knolls, two or three miles before reaching the village, and on the slopes of the basin leading to the river. The teak tree here is not of superior dimensions, but is widely diffused, forming nearly half of the forest at this place. Many of the trees would yield second-class logs, and they improved in size as we descended the gorge. Being in flower, the white cross-armed panicles formed a striking feature in the landscape. There is much fallen and decaying teak within three miles of the huts. I inspected the jungle both in going and returning, and walked across in different directions, to estimate approximatively the number and size of the trees; the value of standing wood is about Rs. 50,000, and of fallen timber at least Rs. 5000. I counted fifty trees on the ground, well worth removal if there was easy transport. We saw further up the valley much Vengé (*Pterocarpus marsupium*), and black wood

(*Dalbergia latifolia*), which became more abundant as the elevation increased These trees seem to prefer an altitude somewhat greater than teak; whilst the Vella naga (*Conocarpus latifolius*), of great size, occurs with the teak or prefers a lower range. The sholas near Punachi, between 3000 and 4000 feet above the sea, are very dense and rich in their flora. The following are a few remarkable forms observed: a new species of *Jenkinsia* (Wallich);* *Solenocarpus indicus*, a tree called by the Kaders "Palle-ille," the leaves of which are eaten; *Elæocarpus*, *Moneceros*, a new species of *Cookia*, "Mur kuringi," with a delicious fruit; *Glycosmis pentaphylla*, *Pierardia macrostachys*, with an edible fruit; *Cleidion javanicum* ("Walle"); *Mesua*, with very large fruit; *Calophyllum*, a species with narrow lanceolate leaves; *Orophea*, two new species; *Unona pannosa*, *Guatteria coffeoides*, *Cyathocalyx zeylanicus*; *Garcinia*, *Pterospermum obtusifolium*, *Sterculia guttata*, *Machilus*, *Casearia*, a new species; *Euonymus*, two apparently new forms, one with downy leaves and the other much like a lime tree; *Agrostemma*, two species; *Ophioxylon*, a new species, with falcate bracts; *Pothomorphe subpeltata*, *Acranthera zeylanica*, *Nephelium erectum*, a very gorgeous species of *Pachycentria*; and two rare euphorbiaceous trees, *Dimorphocalyx glabellus* and *Desmostemon zeylanicum*, lately described by Mr Thwaites.

Many of the trees in the dark sholas are covered with beautiful epiphytes, especially the *Hoya pauciflora*, *Æschynanthus zeylanicus*, and *Sarcanthus filiformis;* the dripping rocks, with *Klugia*, two species, *Epithema*, &c. Cardamoms, with rich aroma, and the true ginger plant, abound in these sholas. The rocks in the beds of all the rivers, from 3000 to 4500 feet, are covered with a showy, orange-coloured balsam (*Impatiens verticillata*). It often forms a fringe at the line of water-mark, or appears in patches between the forks of a cascade. At a higher elevation other species take its place, especially one figured in the "Madras Journal of Science, 1859"—*Impatiens Tangachi*, Beddome.

16*th*.—Started at 8 A.M., having left five elephants and our heavy baggage. After two miles we came to a river. There is a large body of water, 100 feet wide, 1½ to 2 feet deep. Immediately below the ford is a village of low-caste people. Much time was lost in crossing on elephants, and afterwards in cutting a road through tangled brushwood, each man being furnished with a bill-hook or shikaree knife. In the bed of the river we observed *Entada Pursætha* and *Adelia neriifolia*. At 4 P.M. we agreed to bivouac, and erected temporary huts. Plate XXXIII. presents the view up the valley from our camp, and gives a good outline of the Tangachi and Akka mountains. About two miles after crossing the river, we made a detour to avoid a mass of rocks which descends to the water edge. We could ride as far as the waterfall at the foot of the Tangachi. In this place, as there are few bamboos and no *Saccharum*, we employed other hut-

* We also found *Agrostistachys indica* (Dalzell), described in "Kew Miscellany," vol. ii. p. 41.

ting materials. Some gigantic *Crotolaria* and *Indigofera* stems were used for the walls, the stems being interwoven between the uprights, and the thatch was made of *Andropogon Schœnanthus*, L. (ginger-grass). Fortunately no rain fell during the night. In the short march to-day the teak gradually became smaller and less frequent, and disappeared altogether two miles before reaching the Torakudu waterfall.

Opposite our bivouac was a remarkable rock, called Cundita-malai, apparently 200 feet in height, on the precipitous scarp of which was a rattan cable 80 feet long, securely fixed above. This chain was formed of large rings of the *Calamus* stem, connected by another straight rattan, which passed down through the centre of the loops; by means of this the Kaders descend the face of the rock to collect honey, &c. (*vide* Plate XXXVI.) The river, during this day's march, tumbles over huge boulders of broken rock, and takes a south-east direction.

17*th.*—Started at a quarter to 8, and reached the huts near the Torakudu waterfalls at half-past 9, which are picturesque and very beautiful. About two miles below these falls Major HAMILTON discovered an ancient cairn or cromlech (*vide* Plate XXXV.), a quarter of a mile to the left of the path, similar to those found in other parts of Coimbatore, and consisting of four immense stones, the upright slabs about 5½ feet high, and the covering stone 11 feet by 5 feet. On the south of the valley where the cromlech was found, is the ridge from the end of which Major HAMILTON's sketch was taken, showing the general course of the river, which is here north-west. The site of the huts was not well chosen, being in the bed of a stream below the falls, while there was no lack of good encamping ground around. There are here three waterfalls—a true fall of about 50 feet; another of about 100 feet; and a rapid cascade of 120 feet, which could not easily be approached.

Opposite the encampment is an Erular village of eight or ten houses, with a patch of Ragi (*Eleusine Coracana*, Gärtn.) cultivation; and near this was another village of Mudowars. The day was fine; sometimes rather hot at night. Blankets were necessary, as it became cold towards morning. Very little dew fell, and at 6 A.M. there was none.

18*th*, 9 A.M.—As the two remaining elephants could not proceed further, the beds were carried by coolies, and each of the party took his own provisions for the day. We now ascended a steep rugged hill, impassable for horses on account of the immense masses of detached rocks; one, in particular, resembling a hay-stack, about 40 feet high, from the summit of which a rattan chain similar to that described was suspended. We proceeded through dense sholas for three miles, in the middle of which we crossed the river by a temporary bridge formed of a large tree, felled by the Kaders for the purpose. *Rubus lasiocarpus* (bramble) was first seen here.

After walking six miles round the base of the Tangachi, we emerged from the woods, in which were traces of wild elephants upon a steep, open grass hill; at this point the view across the valley of the Torakudu was very grand, extensive dense sholas skirting the rocky and precipitous hills, the summits being shrouded in mist. The *Rhododendron arboreum* first occurred here—the elevation, ascertained by Mr FRASER, about 5000 feet. We continued to ascend the steep side of the hill till we arrived at the huts, which were situated on a lower spur of the Akka, near the edge of a large shola. Thick mist and violent rain came on soon afterwards; a herd of twenty-five bison were seen grazing on the opposite hill, and there were fresh traces of others near the hut.

19*th*, *Sunday*.—Nothing seen. Thermometer, minimum 54°, maximum 60°. Elevation calculated to be 5600 feet. Cold wind whistled freely through the grass huts, the stakes were loosened, and the temporary erection nearly came down.

20*th*.—It rained all morning. The Kader guides were unwilling to proceed. However, we started at 10 A.M. in search of the great valley alluded to in Captain MICHAEL's Report,* and in an hour reached a beautiful ridge, shooting out from the base of Akka-malai; there was short sweet pasture, and numerous indications of bison. The weather continued unfavourable, and so misty, that, except during a few gleams of sunshine, we saw little of the country.

From this ridge ("Bison Ridge") we skirted the base of the Akka-malai, keeping above the sholas, and ascended the western side of the high range, which is clothed with remarkably short grass, to the right of the Akka. The previous afternoon some of the party ascended the shoulder of the Akka, which is considerably higher. Unfortunately, owing to the dense mist, they were not rewarded by a good view of the surrounding country. Mr BEDDOME has favoured me with the following note of his ascent:—

"The rocky Akka mountain, which is probably upwards of 8000 feet, is quite covered, near its summit, with several undescribed species of *Impatiens*. The only other new form I observed on this mountain was a curious Crassulaceous plant, with fleshy peltate leaves, growing in sheltered moist nooks of the rock. Balsams are very abundant on these hills. *Impatiens Balsamina*, *dasysperma*, *albida*, *maculata*, *campanulata*, *chinensis*, *tomentosa*, *verticillata*, *oppositifolia*, *Kleinii*, *tenella*, *rivalis*, *acaulis*, *modesta*, *latifolia*, *lucida*, *rufescens*, *Goughii*, *cordata*, and several undescribed species."

Having proceeded several miles along this range, the summit of which was hidden in mist, we turned to the south-east. The mist suddenly cleared, and we got a glimpse of numerous ibex on the rocks above, and saw a valley which appeared to be 5 miles long and 2 broad, with large sholas on the other side. The wind and rain increased as we proceeded. We came to the junction of the

* Captain J. MICHAEL, 39th N.I., visited these ranges in 1851; his MS. Report was of great use to us.

streams, near which is a beautiful waterfall, about 350 feet high. The general character of the valley struck several as being like Pykara on the Nilghiris. The weather continuing very unfavourable, our attendants fatigued, and our provisions exhausted, it was necessary to retrace our steps.

Some of the herbaceous plants adorning the higher hillside pastures are,—*Flemingia procumbens*, *Phaseolus Pulniensis*, *Anemone Wightiana*, *Lysimachia Leschenaultii* and *deltoidea*, *Utricularia*, *Ranunculus reniformis*, *Gentiana pedicellata*, with many others; but these examples are sufficient to show the similarity of the flora to that round Utakamand. Two curious and new species of *Podostemaceæ* cover the rocks in the beds of the rivers.

21*st*.—We left early, and much regretted our inability to remain another day. In looking back, we could see the highest range, distant about twelve miles north-east; the outline of this is well represented in Major HAMILTON's sketch, Plate XXXI.

22*d*.—Major HAMILTON and Messrs KOE and FRASER descended into the gorge to examine the entrance to the hills by the valley of the Torakudu river, when the Major took the sketch given in Plate XXXVII. If a path can be constructed in this direction, the ghat near Punachi would be avoided, and the distance shortened by several miles. The rest of the party explored the forest, and descended the ghat by which we ascended. The day of our departure was fine and bright, and we obtained a clear view of the higher ranges from the lower valley of the Torakudu. Plate XXXI. is a faithful representation.

About a month after our visit (8th November), Lieutenant BEDDOME rode up in one day to the higher ranges, and had a fine view of the summit. He writes, "The part that we traversed forms only a small portion of the valley, and is shut out from the rest by a sloping ridge covered with dense shola (which rises out on the opposite bank of the river). The greater part of the valley lies beyond this ridge. Another meandering river runs through the larger portion of the valley, and towards the further extremity there is a large swamp, which could be converted into a fine lake. The valley extends two or three miles beyond the succession of waterfalls which we visited; it is widest just beyond these falls, where it must be four miles across, and the whole of the centre is comprised of undulating hillocks, very fine sites for building. From the Akka mountain, which I ascended, there run two high ridges, almost of the same height as the mountain itself; between these is a narrow valley, through which a river runs, eventually reaching Michael's Valley by the series of falls we visited. The mountains on the opposite side of the valley seem very high, and, from the top of the Akka, there appeared to be a good extent of table-land there. My time was very limited, or I should have explored the higher unknown portions of these mountains. I ascended the Tangachi peak, which is very different in character from the Akka. The ascent lies through dense sholas till within half-a-mile of the summit; thence the mountain is covered with almost impenetrable brushwood 6 to 10 feet in height, consisting chiefly of *Rhodomyrtus*, *Dodonœa*, *Rubus*, *Litsœa*, and *Atylosia*. The mountain has a great many rocky caverns and crags towards the summit."

Again, under date 25th February 1859, Lieutenant BEDDOME writes, "that he and Mr BRYCE went to that high land beyond Michael's Valley where there is a good extent of undulating table-land. The highest peak of the Anamalais, below which there appears to be table-land, is at least twenty-five miles beyond the valley, and seems to be very difficult of access. We had white frost in the valley."

I now append Dr MACPHERSON'S views on the eligibility of this range for a sanatarium, and for future colonization:—"The general appearance and character of these high lands resemble the Nilghiris. Here are the same rounded eminences and dense sholas, extending continuously for miles, their edges fringed with *Strobilanthes*, and ceasing abruptly; the hills are conical, and the slopes are covered with short rich grass, abounding with medicinal plants, as *Exacum bicolor* and *Ophelia elegans* (Gentians); the woods contain *Hymenodyction excelsum*, and other species of the Cinchona family. Heavy rains, evidently the breaking up of the south-west monsoon, fell continuously during the period of our stay in these upper regions. The want of shelter, and the difficulty of procuring supplies, prevented us from proceeding to the highest parts of the range, which appeared to be about twelve miles in a south-east direction from the extreme point the party reached. We therefore reluctantly returned to the low country without fully attaining our object, having been absent eight days. Three distinct tribes inhabit the Anamalai Hills; they are denominated Kaders, Paliars, and Malsars. The Kaders perform no menial labour; as their name implies, they are the lords of the hills; they carry a gun, and loads also as a favour, and are expert at stalking game, but are deeply offended if called coolies. They are a truthful, trustworthy, and obliging tribe, and exercise some influence over the Paliars and Malsars. Small in stature, their features resemble the African; they have curly hair, tied in a knot behind, and file the four front teeth of the upper jaw to a point as a marriage ceremony. The Paliars are chiefly herdsmen and merchants, while the Malsars are cultivators of the soil. None of these tribes reside at a higher elevation than 4000 to 5000 feet above the sea. All deal in the rich produce of these hills, and barter with the people in the plains their cardamoms, turmeric, ginger, honey, wax, resins, millets, soap-nuts, gall-nuts, &c., for rice, tobacco, &c. They are very expert in climbing trees and the precipitous face of rocks in search of honey. To accomplish the former, where there are no boughs, they drive short bamboo spikes into the tree, and thus form a ladder by means of which they ascend the highest forest trees; and they reach the latter by means of chains formed by rings made with rattan, which, being secured to a point above, drops down the face of the rock. We observed some of these chains full 50 and 80 feet in length. The upper ranges are in undisturbed possession of wild beasts. We saw a large herd of bison, with deer and ibex in numbers, and also traces of wild elephants.

"The best period to prosecute inquiry into the upper ranges of the Anamalai Mountains would be after October, or in the hot season. From their position, they are considerably under the influence of the south-west monsoon, but less so than the Kundahs at Sisipara; and I think it is worthy of inquiry to ascertain whether here also may not be found a climate as bracing and welcome to the enervated constitution of the European invalid as exists on our better-known hill stations. The soil on the summit of these fine mountains is deep, and covered with rich pasture. Streams of water are numerous, and appear as if they flowed throughout the year. From the extent of forest, the resemblance of the flora to that of Ceylon, and the corresponding altitude of these hills, I believe they are suitable for the cultivation of coffee on a large scale, and for colonization of small communities of Englishmen, a measure which would be attended with the happiest results, as it adds at once to our military strength, and in course of time would give us the means, to a certain extent, of recruiting our army."

It will thus be seen that the result of our excursion was not without interest. Some curious botanical novelties were found; the timber resources of the district were ascertained; and a large tract of country suitable for coffee culture was traversed, which will doubtless be the scene of future colonization.

Description of Plates.

Plate XXXI.

High Range from the Lower Valley of the Torakudu.

View of the whole range from the lower valley of the Torakudu. The Tangachi and the Akka being nearer than the level range on the right, they look higher than they really are.

Plate XXXII.

Panorama of the Anamalai Mountains from the Village of Anamalai.

We ascended the valley seen to the left, which is the lower valley of the Torakudu River. The Tangachi, or younger sister, is that curious peak seen to the right of the valley. The Akka, or elder sister, the highest peak, does not stand out clear, because a spur beyond it is visible from Anamalai. We proceeded round the other side of the Tangachi, and our highest encampment was between the further spur and the ridge joining the Tangachi and Akka. Michael's Valley is two miles beyond, and to the right of the further ridge. The Anamalai Teak Forest is beyond the low saddle to the right of the Kader women. The mountains on the extreme right overlook Palghat. The small detached hill is the Anamalai Droog.

Plate XXXIII.

The Tangachi and Akka, from the Upper Valley of the Torakudu.

A mile or two further up the valley where our bivouac was for the night, we had a superb view of these two mountains, rising 800 to 1000 feet above the surrounding forests.

Plate XXXIV.

Foot of the Punachi Pass.

We entered the mountains to the right of the gorge, where the Torakudu descends into the plain. We crossed the river, and turned to the left beyond the large rock, and passed over the mountain beyond the peaked cliff.

Plate XXXV.

Ancient Cromlech.

The upper slab was 11 feet by 5, and the lower slabs were about $5\frac{1}{2}$ feet high. We intended to have visited it on our return, but missed the place. Similar tombs are found near Coimbatore.

Plate XXXVI.

Kader Rattan Chain.

On the opposite side of the valley was a rocky precipice over which hung a chain 70 or 80 feet long, formed of large loops of rattan connected to another rattan, which passed down through the centre of the loops. The Kaders told us it is used for collecting honey from the fissures of the rocks; as the chain did not reach within six feet of the overhanging ledge, part of it must have been broken.

Plate XXXVII.

Gorge of the Torakudu River.

On our return to Punachi, Major Hamilton tried to find an easier way through the gorge of the Torakudu river. He did not succeed; and from the view he obtained, the gorge appeared to be very narrow and precipitous.

HIGH RANGE FROM THE LOWER VALLEY OF THE TORAKUDU

Plate XXXII

KADER MEN AND WOMEN TIMBER SLIP

D Hamilton delt

PANORAMA OF ANAMALAI MOUNTAINS FROM THE VALLEY OF ANAMALAI.

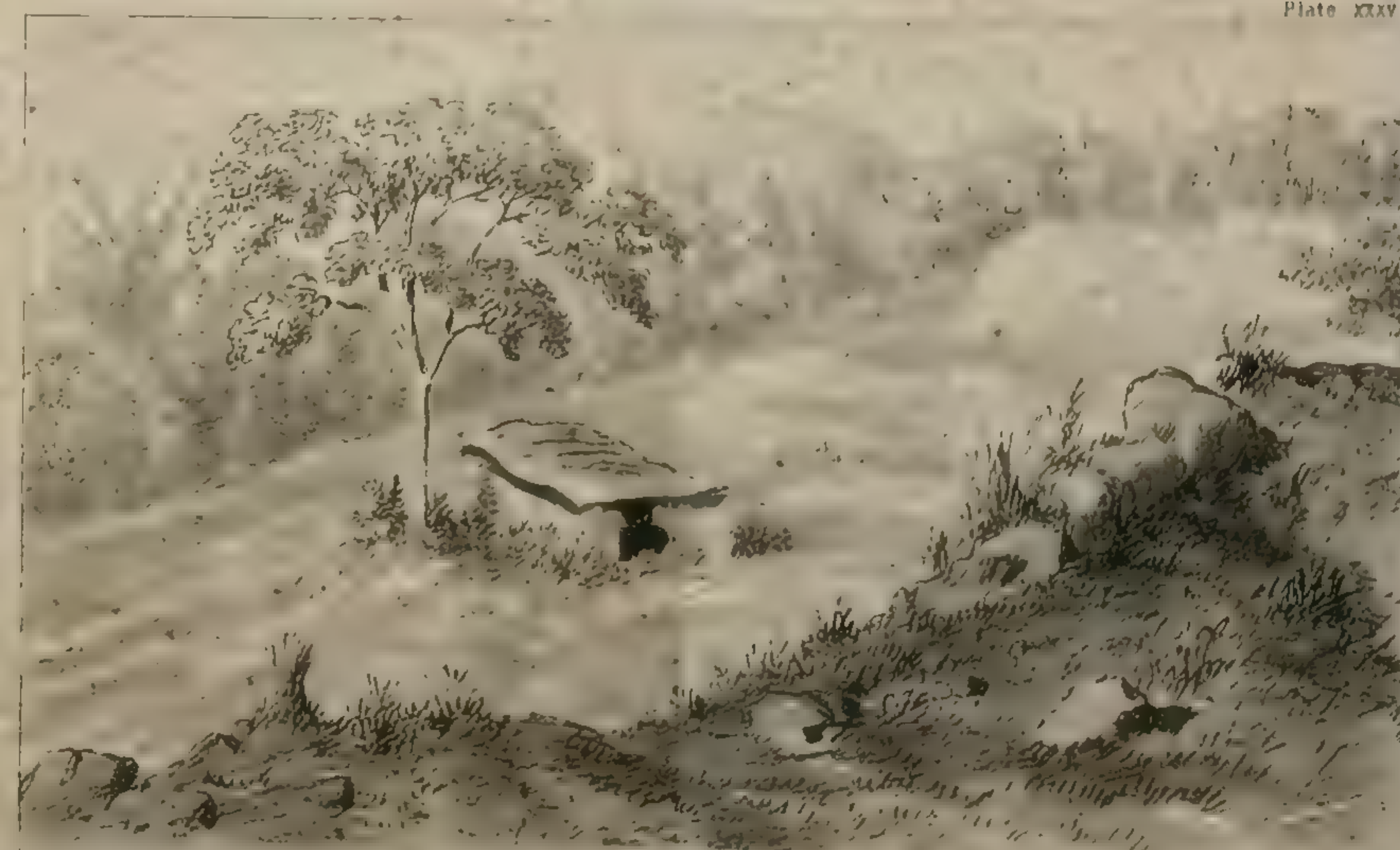
THE SISTER MOUNTAINS, TANGACHI AND AKKA FROM THE UPPER VALLEY OF THE TORAKUDU.

Plate XXXIV

W H M'Farlane, Lith' Edin' D Hamilton del'

FOOT OF PUNACHI PASS, CROSSING THE TORAKUDU RIVER

Plate XXXV



D Hamilton del'

ANCIENT CROMLECH

M'Farlane, Lithr. Edinr.

D. Hamilton delt.

RATTAN CHAIN FOR COLLECTING HONEY.

W. H. McFarlane, Lithr. Edinr. D. Hamilton delt.

GORGE OF THE TORAKUDU RIVER.

XXVI.—*Memoir of General Sir Thomas Makdougall Brisbane, G.C.B., &c., President of the Royal Society of Edinburgh.* By Alexander Bryson, Esq., P.R.S.S.A.

(Read 4th January 1861.)

Sir Thomas Brisbane was born at Brisbane House, Largs, on the 23d July 1773. He was descended from the Brisbanes of Bishopton, one of whom, according to Hailes, "held the office of Chancellor of the kingdom of Scotland in 1332." They possessed a large tract of country, extending from Erskine Ferry to Largs; and had this estate been still in their possession (consisting, as it did then, of Bishopton, Greenock, Ardgowan, Skelmorlie, Largs, and Brisbane), its revenues would have been princely; but Sir Thomas only inherited the smaller portion of the possessions of his ancestors, Largs and Brisbane.

The father of Sir Thomas served under the Duke of Cumberland at Culloden in the rank of a Captain, as Aide-de-camp to the Earl of Home, along with the Duke of Argyll. He died in 1812 at the age of 92, distinguished not less by his bravery than by his scholarship. It is worthy of remark, that the father of our late president and the grandfather of the distinguished nobleman who now occupies the chair were at the same battle, and of equal military rank in 1746. Sir Thomas's mother was a daughter of Sir William Bruce, Baronet, of Stenhouse, and was thus a descendant in a direct line from Robert the Bruce.

In youth, Sir Thomas was educated under tutors at home, and then at the University of Edinburgh, from whence he went to an academy at Kensington, where, in mathematics and astronomy, he maintained a high position. Sir Thomas entered the army as an ensign in the 38th infantry in 1789, although his commission is dated in 1782 (a practice common at that time), he being then only in his ninth year. He was thus at his death the oldest officer in the British army, having held his commission for seventy-eight years, and been in actual service for seventy-one. In 1790, he joined the 38th Regiment in Ireland, where he formed an intimate acquaintance with the future Duke of Wellington, then a lieutenant in a regiment of cavalry. Both of the young heroes were at this period distinguished only by their love of field sports.

When the war broke out in 1793, Sir Thomas raised an independent company in Glasgow, and joined the 53d Regiment, then quartered in Edinburgh. The 53d formed part of the army of the Duke of York, and served in Holland under that prince. Captain BRISBANE, then in his 20th year, took part in all the affairs of the Flanders campaign, from St Amand to Nimeguen. In his reminiscences, he has left a spirited account of the affair at St Amand which is worthy of quotation, more especially as it was so often the theme of his after-dinner talk. It was his first battle, and he remembered it best. He says, "The first action of the war took place in the wood of St Amand, from which it became necessary to dislodge the enemy, who were there in large force, their object being to invest Valenciennes, and lay siege to it. The Prince of Cobourg commanded the Austrian army, which consisted of about 80,000 men, finely equipped and appointed, and in a high state of discipline. On the 23d May the enemy, who were strongly entrenched for the purpose of covering Valenciennes, were attacked by the whole of the allied army at day-break, and after a severe action, were completely routed. Several of the enemy's regiments of cavalry made a full charge, but another part of them gave way before the allied army, and the enemy shortly afterwards fled. This engagement presented perhaps one of the grandest spectacles that ever was exhibited in war. The fog, at 3 o'clock in the morning, was so dense, before the action began, that it was impossible to see from the right to the left of the regiment. All at once the fog cleared away like the rising of the curtain of a theatre, and the armies were close in the presence of each other, when the action instantly began. The conflict did not terminate till 9 o'clock at night; and although we gained possession of the enemy's works, the firing did not cease till the darkness of night descended."

Sir THOMAS was wont to remark, that his first and his last military appearance was on the same field. At Valenciennes, in 1793, he fleshed his maiden sword, and there he sheathed it with the army of occupation in 1816. At the engagement at Lille he lost in killed and wounded, twenty-two men out of the thirty-three whom he had brought into action, he himself being also wounded. Of this disastrous campaign, Sir THOMAS remarks, "This was the severest winter I have ever seen in Europe. The troops were literally frozen to the ground every morning, and in one of those severe nights 800 men were frozen to death, and both the Rhine and the Waal were so completely ice-bound, that the 24-pounders, each of which could not be less than three tons in weight, passed with the greatest facility. The former was covered with a layer of ice six feet deep. The British army was ordered to march from Holland into Hanover, where we embarked in the spring of 1795, on the Weser river, for England, at which we landed and marched to Norwich."

From Norwich, Sir THOMAS went with the army to Southampton, in the autumn of 1795, where a large army was forming under Sir RALPH ABERCROMBY, to attack the West India Islands. They sailed in the month of October, but were driven back by severe gales, and did not leave port until November. During this voyage an incident occurred which confirmed Sir THOMAS's love of astronomy. The transport in which he and his regiment were embarked, was the ‘William and Mary,’ a Newcastle collier, which had separated from the fleet. Sir THOMAS says, “After our vessel had sailed alone for some weeks, the mate came to my cabin one morning at 4 o’clock and awoke me, to say that they had made the land; but he was afraid it was the main continent. I immediately got upon deck and found the ship among the breakers; and the captain on seeing the danger, said,—‘Lord have mercy on us, for we are all gone.’ I said that is all very well, but let us do everything we can to save the ship. He ordered the helm to be put hard down; but so completely were the seamen paralysed by their awful situation, that not one of them would touch a rope. With the assistance of the officers, I, with my own hands, eased off the main-boom to allow the ship to pay off, and the sail to draw upon the other tack. Most providentially the wind came from the coast, and filled the sails, and though we were from four till ten in the morning in this critical juncture, yet we found ourselves at length off the bank.

“Reflecting that I might often, in the course of my life and services, be exposed to similar errors, I was determined to make myself acquainted with navigation and nautical astronomy; and for that purpose, I got the best books and instruments, and in time became so well acquainted with these sciences, that when I was returning home I was enabled to work the ship’s way; and having since crossed the tropics eleven times, and circumnavigated the globe, I have found the greatest possible advantage from my knowledge of lunar observations and calculations of the longitude. In proof of which, in sailing from Port Jackson to Cape Horn in 1825, a distance of about 8000 miles, I predicted our making the land to within a few minutes. We steered our course to Cape Frio on the Brazil coast, and when I expected it to be near, on account of my observation and reckoning, I got upon deck at 4 o’clock in the morning, to tell the captain to shorten sail, as we had not a run till day-light, upon which he replied, that by his reckoning he was not within 500 miles of it; but when daybreak appeared we were within one league of it, and anchored that evening in Rio de Janeiro. In the course of our passage, we touched at Madeira, and took in supplies. For in one of the severe gales, our ship was struck by a sea which laid her on her beam-ends, carried away all her boats and bulwarks, and the whole of our stock, so that we were literally compelled to live on the salt provisions for six weeks.” Of this occurrence Colonel Mansel, who was under Sir THOMAS’s command thus writes,—“On the 12th or 13th of December at midnight, a heavy sea struck us which laid the bark on her beam-ends, carried away our long boat, which was strongly lashed to the deck, and all our live stock we had laid in for our passage to the West Indies, where we arrived on the 29th of February, having lived all that time on salt beef and pork, with lobscouse for an occasional change. We could not light a fire in our small bark for a whole fortnight, and we lived mostly upon raw ham and biscuit, washed down by a moderate quantity of good old port; and upon these occasions, I well remember Major BRISBANE's ejaculation,—

"I sheath my sword for lack of argument,"

setting aside the knife he had been using, such being the happy temperament of his mind."

At the taking of St Lucia, Sir THOMAS was ordered to attack a fort deemed almost impregnable. On his march up he was met by a brother officer, who remarked, "It cannot be taken," when he gallantly replied, "It can,—I have the order in my pocket;" and he and his men took it. His health having suffered from the climate of the West Indies, his friends purchased for him the lieutenant-colonelcy of the 69th regiment, which had recently come from the West Indies, and was not likely soon to return. In his reminiscences he says, "I instantly embarked for England, and landed at Portsmouth in 1799, when I waited upon General Whitelock to know where the 69th regiment was stationed. He informed me that it had sailed three weeks before for Jamaica. Finding, from a four years' residence and hard service in the West Indies, that my health had suffered, I was recommended to go to Cheltenham, and in the following year, being 1800, I joined the 69th at Jamaica, and took the command of it, and continued with it until the regiment was ordered home. As soon as I arrived, I called the officers together, and addressed them. I told them that they were well acquainted with the cause that had brought them to this colony, and that I expected the support of every officer in the corps. I warned them that, if this was not promptly and fully afforded, I should report them to the commander-in-chief, to have them removed out of the regiment or out of the service. Fortunately I had no occasion for such a proceeding. On taking the command of the regiment, which was lying at Kingston, I found the men in a very demoralized and unhealthy state from two causes: first, the want of proper discipline and arrangements for their comfort; and second, the soldiers being allowed to lay out nearly all their money on intoxicating drinks in place of vegetables and other things needful for their health and comfort. By a little attention to discipline and the messes of the men, I very soon effected a wonderful change in the health and character of the troops; so much so, that two military hospitals, which had previously been filled with sick, were both shut up, and when we embarked for England only one man was unable to be removed."

For this signal service Sir George Nugent, governor of Jamaica, thanked Sir THOMAS in these terms:—

PEN, 27*th June* 1802.

DEAR SIR,—When I made a very favourable report to His Royal Highness, the Duke of York, of the state of the 69th regiment since you took command of it, I merely did you justice; for I must beg leave to repeat, that I never saw so rapid an improvement on any *corps* during so short a period. I really consider the 69th regiment in every respect as good a *corps* as any in the service; and I did not think it possible they could become so from the very bad state they were in, while under the command of the late lieutenant-colonel and senior captain."

A brother officer who served under Sir THOMAS in the West Indies, and who survives him, relates the following incident, which occurred during their passage home:—"Unfortunately," says he, "we embarked on board an unsound ship, and on our passage from St Vincent to St Kitts she foundered; but before she went down, a boat from the convoy ship arrived to save the lives on board; and as Colonel BRISBANE was in the act of stepping in from the sinking ship, with his nautical instruments in his hands, the lieutenant in charge stopped him, and said his captain had given him peremptory orders to take no baggage of any sort whatever; he therefore could not allow these things to be put into the boat. Colonel BRISBANE immediately retraced his steps, desiring the lieutenant to give his respects to the captain, and to tell him that 'before I part with these things I hold in my hands, I will go down with the ship.' Honest Jack immediately replied, 'Step in, sir.'"

On arriving in England with the 69th regiment, he was stationed at Colchester; and so excellent had been the discipline of the regiment, that the mayor stated that the 69th was the only one which had left that place for a long period without even a single soldier having been brought before a magistrate for any irregularity.

In 1804, when the 69th regiment was ordered to India, Sir THOMAS retired on half-pay, as another campaign in a hot climate was deemed dangerous. During this period he occupied himself in erecting an observatory on his patrimonial estate at Brisbane, and furnishing it with instruments. This observatory is situated in Latitude 55° 49′ 6″ north, and in Longitude 4° 52′ west. It contained a transit instrument of $4\frac{1}{2}$ feet focal length, and an altitude and azimuth instrument by the celebrated Troughton; also a mural circle and equatorial instrument, a sidereal and two assistant clocks. With the exception of the observatory on Garnet Hill at Glasgow, it was, at the period of its erection, the only one in Scotland, and was much more complete in its equipment. A plate above the entrance bears the inscription, "Ad Scientiam Astronomicam colendam extruxit T. BRISBANE, Anno Domini 1808."

In 1810 he was appointed assistant adjutant-general to the staff at Canterbury, which he held until he obtained the command of a brigade under the Duke of Wellington, whom he joined at Coimbra in 1812. Sir THOMAS was received with the utmost kindness by the Duke, who said he had two brigades vacant for him,—one in the third and the other in the 7th division; the former commanded by his old friend Sir Thomas Picton, under whom he had served in the West

Indies, and the other under the Earl of Dalhousie. He selected the third division, which he joined at Leo Mill, where he remained until they passed the Douro, to attack the enemy at Vittoria, where they were collected in great force. Of this battle, Sir Thomas says, "When we got on the height overlooking the town and plain, I examined closely for the French army, but could see no force, and therefore was under the impression that there was to be no action. In this, however, I was very soon undeceived, by a heavy fire commencing from Lord Hill's division, in the wood on our right, on the morning of the 21st June 1813; and, after a considerable period of hard fighting, we saw the enemy give way. I was then ordered to pass the bridge of Cadova with my brigade; and so completely did we take the enemy by surprise, that I passed a large body of French cavalry with the tails of their horses turned towards my brigade.

"We pursued, and seized a strong position from which we drove the enemy, and opened our fire, and continued in pursuit of them through the village of Pontaslin, where the enemy were strongly posted, with formidable artillery. The remainder of the division joined us in the attack, and we soon drove back the enemy, taking from them twenty-eight pieces of artillery, and pressing them under the walls of Vittoria, where they were attacked by the whole army and completely routed.

"So signal was the defeat, that King Joseph's carriages, plate, and wines, and everything belonging to him, fell into our hands; and that same evening I ate off His Majesty's plate and partook of his wine. Had I allowed my men to follow, and pick up the boxes of money which could have been gathered, they might have enriched themselves to a great extent. As it was, I waylaid the stragglers, and made them disgorge their plunder; and next morning I had three such piles of dollars as enabled me to divide five dollars to every soldier belonging to the brigade. This day's action cost the division severely, as we lost 90 officers and 1800 men. My Aide-de-camp, Captain Hay, was severely wounded in the knee by a grape-shot. The enemy were so completely routed that they fled to Bayonne, with the loss of their artillery, camp equipage, and equipments, and without even a single gun."

It was on the evening of this eventful day that Sir Thomas, standing on a commanding eminence, and while sheathing his sword, remarked to a companion, "Ah, what a glorious place for an observatory!"

Sir Thomas highly distinguished himself at the battle of the Nive, where the two brigades under his command had 700 killed and wounded. For his conduct in this action he received the thanks of Parliament. He was also present at the battles of Orthes and Toulouse. In speaking of the latter, he relates the following curious anecdote:—"A very singular occurrence happened to myself in this engagement. While standing on the banks of the canal, exposed to a heavy fire from the enemy's artillery and musketry, a cannon shot took off my cocked hat, spun me round with irresistible force, and knocked me flat on the ground. I was so confused with the violence of the concussion, that I deemed it prudent to send for the officer next in command to be near me, and to take the command of the brigade in case of necessity. While in this state of confusion, I was shot through the left arm by a musket ball, when the blood flowing profusely from the wound immediately relieved my head, and restored me to my senses. This is perhaps a rare instance where a musket ball has proved beneficial to an individual, and even rendered him medical assistance when absolutely requisite."

At the abdication of Napoleon, and when Wellington broke up his army on the Garonne, after the battle of Toulouse, Sir Thomas was ordered to take the command of a brigade and embark for North America. The embarkation took place at Bordeaux, on board line-of-battle ships, and he arrived at Quebec and proceeded to Montreal, where he did good service in covering the retreat of Sir George Prevost in the affair of Plattsburgh. This he accomplished, without loss of life, by the destruction of the bridge across the Dead Creek. On his assuming the command of the advance, Sir Thomas found every possible atrocity committed on both sides. The sentries were attacked and isolated individuals murdered. This mode of warfare, so opposite to what had characterized the Duke of Wellington's army, was speedily ended by Sir Thomas intimating to the American commander, General M'Comb, that the same system should be followed as in European wars. General M'Comb returned a polite reply, and the tomahawk and scalping knife were henceforth laid aside.

The late Colonel Campbell, who accompanied Sir Thomas from Bordeaux to Quebec, has left a memorandum of the voyage, so characteristic of the General, that it deserves quotation:—"Being curious," says the Colonel, "in matters connected with the navigation of the ship, I occasionally begged to be shown the spot where we were supposed to be, by the officers required to keep reckonings, when I found that the difference of sixty or many more miles in longitude amongst them seemed to be looked upon as trifles; and the bounds or retrograde movements which some of them caused His Majesty's ship to take over the ocean were quite amazing. I had, however, the pleasure of accompanying Sir Thomas on this voyage, and he was not a little amazed when I told him how gaily, as well as apparently heedlessly, they were all dashing across the Atlantic.

"To a man they looked upon Sir Thomas Brisbane's *attempts* to keep a reckoning as truly absurd, and only laughed when they saw him taking lunars by means of an excellent repeating circle and other instruments, which it was very odd that a *soldier-officer* should possess or know how to use; but from him I always knew within a mile or two our true place upon the globe. On approaching the banks of Newfoundland, as we were comforting ourselves as well as we could, after the dinner had been removed, upon a fashionable and limited allowance of Bourdeaux wine, before coffee was as usual announced, a master's mate walked into the cabin, followed by a seaman carrying the deep-sea lead. 'Soundings, Sir, at —— fathoms,' the seaman holding up at the same time the greased end in order to show some sand or gravel adhering to it. 'Have the goodness, sir, to desire Mr —— to heave the ship to, and sound again at 8 o'clock.' 'What think you of this, General?' said the captain, addressing Sir Thomas; 'I believe you told us that we would not have soundings before to-morrow at the soonest.' 'I only lament,' replied Sir Thomas, 'that a country like Great Britain should not furnish her ships-of-war with better charts; for, according to that—pointing to a large Admiralty one—we ought only, if the ship maintains her present rate of sailing and course, to be in soundings on the edge of the bank at 8 o'clock to-morrow morning, but I am aware that some of your officers have the ship already high and dry in Newfoundland.' The captain who, like the rest, only laughed at the idea of a soldier-officer making observations, finding that his intended good joke had not taken, upon some pretence or other left the cabin for a few minutes, but having returned to it, he resumed his seat as if nothing had occurred: in walked once more the master's mate. 'I beg pardon, Sir, but I find there has been a mistake; for in some way or other the arming of the lead has been allowed to touch the deck, and a little sand having stuck to it, we were led to conclude that we had struck soundings; the ship was, however, hove to at 8 P.M., midnight, and 4 A.M., but still no soundings. Eight A.M. approached, and we were all on deck.' 'Well, Sir Thomas, what say you now, how many fathoms?' Sir Thomas, who, in spite of the prevailing fogs, had, in the course of the night, been able to get a squint, as he usually called it, at some of the heavenly bodies, whilst I noted the time for him by his chronometer, without the least hesitation he mentioned even the number of fathoms, which, to their surprise, were struck accordingly. It may be supposed that no remarks were made, nor any more jokes attempted, but the ship remained hove to, and many a fine cod fish soon thumped the decks with their broad tails, as if to prove that there was no mistake on the part of the *soldier-officer*.

"A ship-of-war was sometime after made out to the westward. She as usual showed her number; it was the —— sloop-of-war cruising off the coast of Newfoundland; her captain not long after came on board; he had only left the land the night before, and being asked whereabouts we were, he replied that we were then off French Mistaken Point; but Sir Thomas Brisbane, without hesitation, affirmed that we were off English Mistaken Point; and, at the same time observed, that if the captain would only stand on a little further, and, as the fog usually disperses as the land is approached, the point could be easily ascertained. This was accordingly done, and Sir Thomas, after crossing the Atlantic, was found to be more correct than the captain of the sloop-of-war, who had only stood out from the land the previous night; indeed, he could not have been a mile out of his reckoning."

On Napoleon's escape from Elba in 1815, the brigade which Sir THOMAS commanded was recalled, and he arrived off the coast of France with twelve regiments of the line just as Waterloo was won. On landing at Portsmouth, he received orders to put himself and his army under the command of the Duke of Wellington, and he joined his Grace at Paris. When he arrived, Wellington directed him to draw up his brigade in two lines of 5000 men each; and his Grace on looking down the lines, exclaimed, "Had I had these men at Waterloo, I should not have wanted the assistance of Prussians."

In 1816, Sir THOMAS was elected corresponding member of the Institute of France, in a manner worthy of the Institute and himself. It was reported to him that a detachment of the Allies were threatening the observatory and the buildings of the Institute; he at once ordered them to desist and sent them to quarters. At the next meeting of the Institute, ALEXIS BOUVARD, the celebrated astronomer, proposed that Sir THOMAS's name should be added to their roll; and although five others were candidates for this distinguished honour, their names were withdrawn, and he was unanimously elected.

In the following year, His Majesty conferred on him, through the Duke of Wellington, the title of Knight of the Cross of Hanover.

While in France with the Army of Occupation, though at leisure he was not idle, for he busied himself in calculating tables for the reduction of English weights and measures to those of France, and *vice versa*. He also computed tables for determining the apparent time from altitudes of the sun and stars. So important were these tables in the estimation of the Duke of Wellington, that he had them printed at the head-quarters of the army. This work is perhaps unique in being printed at and published by the press of an army. It is marked as having been printed by Sergeant BUCHAN of the 3d Foot Guards, at the head-quarters of the army in France in 1818. This work is also interesting, as containing a series of tables calculated by our late President, for the purpose of simplifying the determination of the time with accuracy, from observations of altitudes of the sun taken on the same side of the meridian. Although Sir THOMAS joined this Society in 1811, this was the first paper he contributed to our records, and it was an important one. It was read on the 2d February 1818, and was published in the 8th volume of the Transactions.

For the determination of the time by the sextant, it was usual to make a double set of observations of equal altitudes, before and after meridian. This method was liable to the objection—in our climate a serious one—that it was rarely possible to obtain observations free from clouds at equal intervals, before and after noon; and also, that the coefficient for refraction, caused by differences of temperature was increased; and as this correction was frequently overlooked, the results were generally inaccurate. To obviate these, Sir THOMAS proposed to observe simple altitudes of the sun's lower limb at eleven successive intervals, commencing two hours before noon, and near the prime vertical. For this purpose, he employed a 10-inch sextant by TROUGHTON, divided on platina to 10″, with a mercury artificial horizon, or a surface of oil, protected from currents of air by a Troughton's angular roof. Having set his sextant to an even 10′ or 20′ greater than the sun's altitude, he waited the contact, and noted the time by the chronometer. If it was necessary to take the time after the meridian, he set his sextant 10′ or 20′ less than the sun's altitude; and having noted the barometer and thermometer to obtain the correction for mean refraction, he found by these means his time as accurately as if deduced from observations of equal altitudes. For the convenience of observers using this method, he compiled the tables published at the head-quarters of the Army of Occupation in France, to which I have alluded.

He continued with the army in France until 1818, when he was appointed to the command of the southern district of Ireland.

In 1819 Sir THOMAS married Anna Maria, heiress of Sir Henry Hay Makdougall, who survives him. The fruit of this marriage was two sons and two daughters, all of whom predeceased their honoured father.

In 1821 Sir THOMAS was, on the recommendation of the Duke of Wellington, appointed Governor of New South Wales, the arduous duties of which he administered during four years. This appointment was alike honourable to the Duke and Sir THOMAS. The latter used to tell that while the two heroes were walking arm and arm one day in Paris, Sir THOMAS remarked, that he would gladly accept the Governorship of New South Wales, as he was tired of inaction. The Duke remarked that he would write to Lord Bathurst, the Colonial Secretary, on the subject. Not many days after the Duke met him, and with a hearty laugh said, "Do you know, Sir THOMAS, what Lord Bathurst writes me this morning?—that he wants one that will govern not the heavens but the earth, in New South Wales." Sir THOMAS replied warmly, "Your Grace can testify, that during all the years which I have had the honour to serve under you in the Peninsula, whether I have ever suffered my scientific predilection to interfere with my military duties?" "Certainly not, certainly not!" replied the great captain; "I shall write his Lordship that, on the contrary, you were never in one instance absent or late, and that, in addition, you kept the time of the army."

While Sir THOMAS was Governor of New South Wales he marked his administration by many wise reforms. He relieved the press from a rigid censorship, improved the condition of the convicts, and made their reformation more probable by giving them the blessing of hope, by shortening the periods of servitude. When he arrived in the colony, he found only 25,000 acres cleared, and after a residence of four years, he had more than doubled the amount. At his own expense, he introduced good breeds of horses, and promoted the cultivation of the vine, sugar-cane, cotton, and tobacco. One grand feature of his administration was the entire toleration and protection which he gave to all Christians.

At Parramatta, fourteen miles from Sydney, he erected an observatory, which has been fitly styled the Greenwich of the Southern Hemisphere. It was furnished with the best instruments by TROUGHTON and REICHENBACH. Some idea may be formed of the labours which, besides his duties as Governor, he voluntarily undertook, when it is stated, that he and his assistants, HERR RÜMKER, and Mr DUNLOP, fixed the position and catalogued 7385 stars, hitherto little known to astronomers. For this magnificent work, "The Brisbane Catalogue of Stars," he received perhaps the highest honour of his life,—certain it is he felt it so. The glory of the many battles he had won, or helped to win, had been rewarded by knighthood and a baronetcy, with stars and medals; but the gold medal awarded him by the Royal Astronomical Society outshone, in his estimation, all his other honours.

The address delivered by the President of the Society, Sir J. F. HERSCHEL, on that occasion, is so highly honourable to Sir JOHN, and so complimentary to Sir THOMAS, that I make no apology for its quotation:*—"In pursuance of the award of your Council which you have just heard, I have now to call your attention to the subject of the honorary marks of this Society's approbation, which it is part of our business at this meeting to bestow. The selection of objects on which such distinction may most deservingly and most usefully be conferred has been, in this instance, of much interest and some difficulty, not from a paucity of claims, but from their variety and magnitude. On all sides, both abroad and at home, the spirit of astronomical research and discovery has been diligently alive. The great work which has been commenced on the continent, for the determination of the places of all the stars of our hemisphere in zones, has been continued with a patient ardour to which no words can do justice. The heavens have been ransacked for double stars, and the results of the search developing a most rich and unlooked for harvest of striking discoveries, being the first fruits of the great telescope of FRAUENHOFER, have been consigned to immortality, in a work which does honour to its age and nation, and which has already been brilliantly rewarded in another quarter. The ingenuity of one of our own countrymen has placed new, simple, and powerful means in the hands of observers for verifying the stability of their instruments, and determining their fluctuations; and in every quarter, to go no further in this detail, an activity worthy of the high ends and dignity of our science has been remarkably displayed.

* Transactions Royal Astronomical Society, vol. iii. p. 399.

"Among so many important labours, however, some of which are awaiting their final completion, or receiving the last touches of their authors, the attention of your Council has been fixed by the imposing mass of valuable observations which has emanated, during a series of years, from the observatory at Parramatta, established by the late governor of the colony of New South Wales, Sir Thomas Makdougall Brisbane, one of our vice-presidents, long distinguished among us by his ardent love of astronomy, and an intimate familiarity both with its theory and practice.

"Nothing can be more interesting in the eyes of a European astronomer, especially to those whose field of research, like our own, is limited by a considerable northern latitude, than the southern hemisphere, where a new heaven as well as a new earth is offered to his speculation, and where the distance, the novelty and the grandeur of the scenes thus laid open to human inquiry, lend a character almost romantic to their pursuit. A celestial surface equal to a fourth part of the whole area of the heavens, which is here for ever concealed from our sight, or whose extreme borders, at least, if visible, are only feebly seen through the smoky vapours of our horizon, affords to our antipodes the splendid prospect of constellations different from ours, and excelling them in brilliancy and richness. The vivid beauty of the southern cross has been sung by poets, and celebrated by the pen of the most accomplished of civilised travellers; and the shadowy lustre of the Magellanic clouds has supplied imagery for the dim and doubtful mythology of the most barbarous nations upon earth. But it is the task of the astronomer to open up these treasures of the southern sky, and display to mankind their secret and intimate relations.

"Apart, however, from speculative considerations, a perfect knowledge of the astronomy of the southern hemisphere is becoming daily an object of greater practical interest, now that civilization and intercourse are rapidly spreading through those distant regions, that our own colonies are rising into importance, and that the vast countries of South America are gradually assuming a station in the list of nations corresponding with their extent and natural advantages. It is no longer possible to remain content with the limited and inaccurate knowledge we have hitherto possessed of southern stars, now that we have a new geography to create, and latitudes and longitudes without end to determine by their aid. The advantages, too, to be obtained, even for the perfect and refined astronomy of the north, by placing nearly a diameter of the globe between the stations of observatories, and taking up the objects common to both hemispheres in a point of view and under circumstances so every way opposite to those which exist here, have been strongly pointed out by a venerable and illustrious member of this Society, in an elaborate paper published in its Memoirs, and would alone suffice to justify a high degree of interest as due to every well-conducted series of observations from that quarter.

"The observations of HALLEY at St Helena had made known the places of a moderate number of the brighter southern stars; but the only catalogue of any extent and accuracy which existed previous to the establishment of the observatories at the Cape and Parramatta, was that of LACAILLE, who spent three years at the Cape of Good Hope and the Isles of France and Bourbon, and though with very inadequate instrumental means, yet, by dint of the most indefatigable industry, succeeded in observing and registering upwards of 10,000 stars.

"But by far the greater part of these observations have never been reduced; a selection only from them of 1942 of the principal ones, not amounting to a fifth of their whole number, having been formed into a catalogue and published by this meritorious astronomer. It must be admitted, however, that the degree of accuracy stated by LACAILLE himself to have been probably attained by him is hardly such as to make us now very deeply regret their want of reduction, especially as the observations themselves are printed with every requisite for that purpose when required. Still, however, from his method of observing, which was with a fixed telescope and rhomboidal network, his observations have what may be termed a dormant value, as they most probably give correct differences for each night's work; and when a catalogue of standard southern stars shall be completed, LACAILLE'S observations will become available by regarding these as Zero points, and referring all the rest to them.

"Such was nearly, with little improvement, the state of the astronomy of the southern hemisphere when Sir THOMAS BRISBANE was appointed governor of the colony of New South Wales. The intention of our Government to found an observatory on the largest scale at the Cape of Good Hope was indeed already fixed; and the observer, a member of this Society, supplied with instruments sufficient for the purpose of constructing a preliminary catalogue, occupied himself with the necessary observations, while awaiting the arrival of those ultimately destined to adorn that establishment, and the building of his observatory. The appropriate catalogue so constructed and reduced, containing all the southern stars observed by LACAILLE, down to the fifth magnitude, is already printed by the Royal Society in their Transactions.

"Sir THOMAS BRISBANE'S attachment to astronomy had ever been a prevailing principle of his mind, and one which, even amidst the distractions of a military life of no ordinary degree of activity and adventure, he found means to indulge, and which never deserted him, however the calls of his country might demand his services in a different and more splendid career. His appointment to the important office of governor of New South Wales, however, put it in his power to execute to their fullest extent, and under the most favourable circumstances, plans of astronomical investigation which to a private individual would have been utterly impracticable. The opportunity was embraced with eagerness. The best instruments, consisting of an excellent transit of $5\frac{1}{2}$ feet focal length, by TROUGHTON; a mural circle of 2 feet in diameter, the workmanship also of TROUGHTON, and said to have been the model on which that of Greenwich was constructed, and which had long been in his possession; and a fine 16-inch repeating circle of REICHENBACH, were destined for this service, and two gentlemen engaged as assistants at considerable salaries,—the one a foreigner of high estimation as a mathematician and calculator, the other Mr DUNLOP, of whom I shall have occasion to say much more. It ought to be mentioned that this noble equipage was furnished entirely from Sir THOMAS'S private fortune, and maintained wholly at his own expense.

"Immediately on his arrival in the colony in 1821, and so soon as an observatory could be erected and the instruments established, the work of observation commenced, and continued, with little interruption, under the immediate superintendence and direction of Sir THOMAS BRISBANE himself, who, though the pressing and important duties of his high office would of necessity seldom admit of his devoting any material proportion of his time to actual observation, yet frequently took a personal share in the labours of the observatory as a relaxation from higher duties; and, in particular, a great portion of the transits were made by himself. The first fruits of this enterprise were the observations of the December solstice of 1821, which were published in the astronomical notices of SCHUMACHER; in which work also appear those of both the solstices of 1822, and a number of detached and occasional observations, which reached Europe at different times by a variety of channels, and found their way into that valuable collection.

"The solstices of 1823 were communicated by Sir THOMAS BRISBANE to this Society in a letter to our late worthy President, together with a considerably extensive series of observations of principal stars, chiefly those visible in both hemispheres, and which have undergone a careful reduction and close scrutiny in the hands of Dr BRINKLEY, the details of which, as well as the original observations, are printed in the first part of the second volume of the Memoirs of this Society, and which justify in the eyes of that experienced observer, as they must in those of every practical astronomer, a decided opinion of the great care and skill with which they have been made.

"A great number of occasional observations, such as eclipses, occultations and observations of the planets Venus and Uranus near their conjunctions and oppositions, and of comets from the same source, are also printed in the same volume. One of the most remarkable single results we owe to the establishment of Sir THOMAS BRISBANE'S observatory, consists in the re-discovery of the comet of ENCKE in its predicted place, on the 2d of June 1822.

"The history of this extraordinary body is well known to all who hear me, and as its re-discovery at Parramatta by Mr RÜMKER has already been on a former occasion distinctly noticed and rewarded by this Society, there is no occasion that I should here enlarge on it; and yet I cannot help pausing a moment to figure the delight its celebrated discoverer must have experienced to find the calculations on whose exactness he had pledged himself thus verified beyond the gaze of European eyes, and this strange visitant, gliding, as if anxious to elude pursuit, into its primitive obscurity, thus arrested on the very eve of its escape, and held up to mankind a trophy at once of the certainty of our theories and the progress of our civilization.

"Observations of the length of the pendulum were not neglected by Sir Thomas Brisbane; and the determination of this important element at Parramatta forms the subject of a highly interesting and valuable communication to the Royal Society, and printed by them in their Transactions for 1823, and discussed by Captain Kater, with his usual ease and exactness.

"The remainder, and indeed the great mass of the observations made with the mural circle and transit instrument, have at different periods been communicated to the Royal Society, and are, for the present, deposited in its archives.

"Forming our judgment only upon those of which an account has been publicly read at meetings of that illustrious body, but which are understood to constitute only a comparatively small part of the whole, they form one of the most interesting and important series which has ever been made, and must ever be regarded as marking a decided era in the history of southern astronomy.

"It is for this long catalogue of observations, whether scattered through the journals of Europe, printed in our own memoirs, or deposited as a precious charge in the care of a body so capable of appreciating their merits, but still more for the noble and disinterested example set by him in the establishment of an observatory on such a scale, in so distant a station, and which would have equally merited the present notice had every observation perished on its voyage home, that your Council have thought Sir Thomas M. Brisbane deserving the distinction of a medal of this Society, which, as he is unable personally to attend this meeting, I will now deliver to his proxy, Mr South.

"Mr South, we request you to transmit to Sir Thomas Brisbane this medal, accompanied with the strongest expressions of our admiration of the patriotic and princely support he has given to astronomy in regions so remote. It will be a source of honest pride to him while he lives, to reflect that the first brilliant trait of Australian history marks the era of his government, and that his name will be identified with the future glories of that colony, in ages yet to come, as the founder of her science. It is a distinction truly worthy of a British governor. The colonial acquisitions of other countries have been but too frequently wrested from unoffending inhabitants, and the first pages of their history blackened by ferocious conquests and tyrannical violence. The treasuries of gold and silver they have yielded—the fruits of rapine—have proved the bane of those who gathered them; and in return, ignorance and bigotry have been the boons bestowed on them by their parent nations. Here, however, is a brighter prospect.

Our first triumphs in those fair climes have been the peaceful ones of science; and the treasures they have transmitted to us are imperishable records of useful knowledge, speedily to be returned with interest to the improvement of their condition, and their elevation in the scale of nations."

Since this beautiful address was delivered by Sir JOHN HERSCHEL, the observations made at Parramatta of ENCKE's comet have formed the basis—and a solid one—for the most sublime speculations of the astronomers of our time. This remarkable body performs its revolution round the sun in $3\frac{1}{3}$ years, and has been observed to complete its rotation in a constantly decreasing period, verging year by year nearer to the sun. From this fact, astronomers have concluded, that all the planets are moving in a thin, attenuated, but yet resisting medium, and that our earth, and all its associates, are winding through a long spiral orbit towards the sun, and must fall at last into its burning atmosphere.

On his return from Australia, Sir THOMAS resided chiefly at Makerstoun, where he established an astronomical observatory surpassing any other in Scotland at the time; the equatorial alone, by TROUGHTON and SIMS, having cost him upwards of £600.

When the British Association undertook the question of the laws of the earth's magnetism, Sir THOMAS joined most zealously in the cause; and had it not been for his almost princely munificence, Scotland would have been left unrepresented in the great congress of magnetic inquiry. In 1841 he established his magnetic observatory at Makerstoun, certainly not inferior to any in Europe. With the assistance of a very able staff of assistants, of whom Mr ALLAN BROUN (now astronomer to the Rajah of Travancore) was director, he sent forth three large volumes of Observations, which were published at the joint expense of this Society and Sir THOMAS, and for which he was awarded the highest honour in their gift, the Keith Medal. Principal FORBES has well said of these works, that "they form probably the greatest contribution made to science by Sir THOMAS BRISBANE—hardly even excepting the establishment of the Australian observatory. They have a double interest for us, as being a unique contribution to the science of his native country; and he was liberally anxious that the Royal Society should be so far associated with him in this truly patriotic work."

Whilst resident at Makerstoun he was offered the command of the troops in Canada, and shortly afterwards the chief command in India, but the advice of his medical friends constrained him to decline both of these honourable preferments. On the death of Sir WALTER SCOTT in 1833, he was elected President of this Society, and showed his high appreciation of the honour by the deep interest he always took in its welfare, and lastly, by founding the Brisbane Biennial Medal for scientific merit.

To the Royal Society of Arts he also presented a similar token of his zeal for practical science.

During the latter years of his life he resided on his patrimonial estate at Brisbane, devoting his whole time to science and philanthropy. For the education of the young he always displayed a deep solicitude; and the Brisbane Academy at Largs, which he endowed, will ever be a monument of his enlightened zeal and munificence.

He died at Brisbane on the 27th January 1860, in the same room in which he was born eighty-seven years before, regretted and beloved by all who esteem bravery and science, and the best graces of the Christian character.

XXVII.—*On the Action of Uncrystallised Films upon Common and Polarised Light.** By Sir David Brewster, K.H., F.R.S.

(Read 20th February 1860.)

In a paper on the Polarisation of Light by Refraction, published in the "Philosophical Transactions" for 1814, I have shown that when a pencil of light is incident on a number of uncrystallised plates, inclined at the same or different angles to the incident ray, all their surfaces being perpendicular to the plane of the first incidence, the transmitted pencil will be wholly polarised, when the sum of the tangents of the angle of incidence upon each plate is equal to a constant quantity, depending upon the refractive power of the plates and the intensity of the incident pencil.

This law, though admitted by M. Arago in his article on Polarisation in the "Encyclopædia Britannica,"† was called in question by Dr Young,‡ on the ground that no finite number of plates could polarise the whole transmitted beam, as a small portion of light must always remain unpolarised, or in the state of natural light. This is doubtless true; but, as Sir John Herschel has shown, it does not affect the truth of the law, which involves the intensity of the incident pencil. According to the law of geometrical progression, indeed, a small portion of unpolarised light exists mathematically in the transmitted beam, but a beam of light may be said to be completely polarised when the unpolarised portion is invisible, vanishing entirely in certain positions of the analysing prism.

Neither M. Arago nor Dr Young has made the slightest reference to that portion of the refracted light which is reflected at the surfaces of each plate, and returned into the transmitted beam. Sir John Herschel, however, has distinctly referred to it, and remarks, that "it mixes with the transmitted beam, and, being in an opposite plane, destroys a part of its polarisation."§

Although the law of the tangents, which I have mentioned, refers only to the transmitted pencil, yet, in the paper which contains it, I have shown that the light reflected back into that pencil is distinctly visible, not as ordinary light, as Sir John Herschel maintains, but as light polarised in an opposite plane to the refracted pencil.

When the angle of incidence is considerable, this oppositely polarised light appears as a nebulous mass, like the nebulous image in the agate, and, after exa-

* This paper was read at the meeting of the British Association held at Aberdeen in Sept. 1859.
† Encyc. Brit., vol. xviii. part 1, sect. v. ‡ Ibid., in the passage within brackets.
§ Treatise on Light, art. 868.

mining it, I found it to have the same relation to the refracted pencil "*as the nebulous image has to the bright image of the agate, or as the first has to the second pencil of doubly refracting crystals.*"*

In making the experiment with a small bright image of a candle, and using plates of parallel glass, I found that the reflected images *a*, *a*, *a*, *a*, were distinctly separated from the bright or refracted image A, and were all polarised by reflection in a plane opposite to that of A.†

Although these two facts, which have much theoretical importance, were not only minutely described, but represented in diagrams, in my paper of 1814, yet they escaped the notice of the three distinguished philosophers I have named, and of all subsequent writers; and the consequence of this has been, that the true action of a pile of plates, or films, has never been the subject of research during the last forty-six years, though such piles have been used in some of the most delicate and important researches in physical optics.

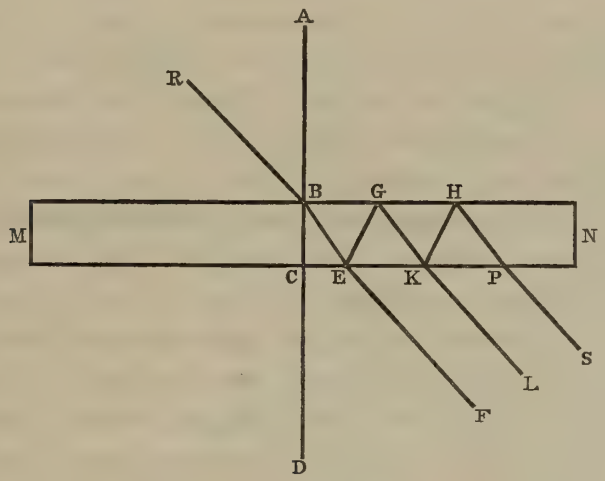
The difficulty of procuring transparent plates with parallel surfaces, and of sufficient thinness, would have prevented the most skilful observer from making any progress in the inquiry; and had I not been fortunate enough to obtain, from the museum of the Marquis Campana in Rome, a large quantity of glass in different stages of decomposition, I could hardly have done more than confirm the result which I obtained in 1813, that the light transmitted by a pile of transparent plates consists of two portions of light polarised in opposite planes.

In submitting the films of decomposed glass to the polarising microscope, I observed a number of polygonal portions, approaching more or less to circles, but often perfectly circular, and exhibiting the black cross with coloured sectors and rings, analogous to those produced by uniaxal crystals. This observation, which was made with decomposed glass given me forty years ago by the late Marquis of Northampton, was communicated to the British Association at Glasgow in 1855; but at that time I regarded the black cross and its accompanying tints, as shown in the drawings on the table, as produced by the refraction and polarisation in different azimuths of the light transmitted through the spherical shells, like a group of watch-glasses, of which the circular portions were composed. The light surrounding the black cross was so highly coloured with the colours of the thin plates which composed the film of glass, that I failed in every attempt to analyse it. After examining, however, many hundreds of these films, from the new specimens which I have mentioned, I succeeded in finding a few in which there were no such colours, and which enabled me to arrive at results that could not have been obtained from the finest and the thinnest plates of glass artificially produced.

* Phil. Trans., 1814, p. 226, and Plate VIII., figs. 2, 3.

† Ib., ib.

These results will be understood from the annexed diagram, in which M N is a thin plate and A B a ray of common light incident perpendicularly at B, and emerging at C in the direction C D. As a portion of the ray B C is reflected at C, and again reflected at B and transmitted at C, the pencil C D will consist of two distinct portions, one of which has been twice refracted, and the other and much feebler portion twice reflected. As neither of these portions are polarised, no physical change is produced by their combination, unless when the plate M N is so extremely thin as to produce the colours of thin plates, by the interference of the reflected with the refracted portions.



When a ray R B is incident obliquely at B, it suffers refraction at B and E, and the emergent pencil E F contains a portion of light polarised by refraction. This ray, in passing through other plates or films parallel to M N, is at last completely polarised in one plane, having grown feebler in intensity by the abstraction of the light reflected at the two surfaces of each plate.

The portion of the refracted pencil B E which is reflected at E and G, and a portion of it polarised, emerges at K as a pencil, K L, partly polarised by reflection. A portion of G K is again reflected at K and H, and emerges at P as a pencil P S more polarised by reflection than K L. Hence the principal or refracted pencil, E F, is combined with the pencils K L, P S (and others by reflections at P, &c.), polarised in an opposite plane, so that with a certain number of plates, varying with the angle of incidence, the emergent pencil E F, K L and P S, consists of two oppositely polarised portions of light approximately equal.

When polarised light is incident upon a pile of these thin and colourless films, and subsequently analysed, it exhibits all the properties of a plate cut perpendicularly to the axis of an uniaxal crystal. The line A D corresponds with the axis of the crystal; and the different azimuths in which the polarised ray may be inclined to this axis corresponds with the principal sections of an uniaxal crystal. The polarised tints have the same value in every azimuth at the same angle of incidence, and therefore form rings which, when crossed with plates of sulphate of lime, descend in Newton's Scale like the tints of negative uniaxal crystals.

Out of hundreds of specimens now on the table, I have found a few so colourless and so perfect as to produce, at different incidences, all the polarised tints or rings up to the *blue* of the second order of Newton's Scale. These colours are so pure, and so regularly developed by the inclination of the plate, that the most skilful observer could not fail to pronounce it to be a portion of a doubly refracting crystal.

The production of the leading phenomena of doubly refracting crystals,—namely, two oppositely polarised pencils,—and the system of coloured rings by the interference of these pencils, is certainly one of the most remarkable facts in physical optics; and, in a theoretical point of view, no less remarkable is the fact that one of the interfering portions is a fasciculus of pencils returned into the refracted beam by different routes, and having different origins.

Owing to the extreme thinness of the combined films, we cannot, as with thick plates of uniaxal crystals, see at once the black cross and its attendant rings; but in numerous specimens of decomposed glass to which I have already referred, the films are spherical shells of different diameters and thicknesses, and exhibit the black cross with the greatest sharpness and beauty. In many specimens these circular combinations are perfectly colourless; and the colours of the four luminous sectors which embrace the black cross rise only to the *white* of the first order.

When the films are so thin as to give the colours of thin plates, the colour of the luminous sectors is generally the same as that of the film in which the circular portions occur, and the rings or bands which surround them have a very peculiar character, owing to the manner in which the spherical shells are joined to the films which compose the plate.

How far these results may lead to new views of the structure which produces double refraction, it would be unprofitable to inquire in the present state of our knowledge of the atomical constitution of transparent bodies.

XXVIII.—*On some Derivatives from the Olefines.* By FREDERICK GUTHRIE, F.R.S.E., Professor of Chemistry in the Royal College of the Mauritius.

(Read 18th March 1861.)

Some years ago I commenced an examination of the behaviour of the so-called olefines towards certain compound halogens. I was induced to this by the conviction that the bodies resulting from the union of a group of unequally chemico-negative elements with an olefine, would place an instrument of great power into the hands of systematic chemists, especially of synthesists. My expectations have been more than realized. The few olefines which I have examined in their relation to compound chemico-negative groups have given rise to a series of new bodies remarkable alike for their great number and for the elegance and importance of the reactions attending their formation and recompositions.

It will probably be found that the Ketons and other oxygeniferous bodies may enjoy some of the properties of the olefines proper: but we must be content to define an olefine provisionally as a hydrocarbon capable of uniting directly with halogens. According to this definition, we find olefines falling naturally into two groups. Of the one group, Naphthaline is the sole representative. This olefine unites with two or four equivalents of halogen, to form, expressed generally,

$$C_{20}\,H_8\,XX, \qquad C_{20}\,H_8\,XXXX,$$

and the numerous class of bodies idiotypic with these, of which the following are examples:

$$C_{20}\,{}^{H_7}_{Y}\,XX, \qquad C_{20}\,H_8\,YXXX.$$

The other group of olefines has the general formula

$$C_{2n}\,H_{2n}.$$

For the chemical saturation of the members of this group, two equivalents of halogen are necessary and sufficient:

$$C_{2n}\,H_{2n}\,XX.$$

BERTHELOT has shown that an olefine of the latter form may indeed unite with a hydrohalogen and that the result is a body identical with the halide of the corresponding radicle.

$$C_{2n}\,H_{2n}+\;HX=C_{2n}H\,(_{2n+1})H$$
$$C_4\,H_4+H\,Br=C_4\,H_5\,Br$$

The question, which has been already partly discussed,* and the continued discussion of which forms the subject of the present communication, is, whether olefines of the form

$$C_{2n}\ H_{2n}$$

may not, like naphthaline, unite with groups consisting of dissimilar halogen elements: and amongst what class of organic salts such combinations are to be ranked.

Since with such olefines there appears to be only one stage of saturation, we are induced to examine the behaviour of the compound halogens already formed towards the olefines, rather than to effect the same purpose by the successive application of dissimilar ones.

The olefines whose behaviour in this direction I have as yet chiefly examined are Ethylen or Olefiant gas, and Amylen. These olefines have been principally considered in their relation to the sulphides of chlorine.

The ethylen employed was formed by heating quickly a mixture of three parts by volume of oil of vitriol with one part of alcohol of 85°/₀ and sufficient sand to make a thick paste, passing the gas in succession through dilute caustic soda and strong sulphuric acid, and collecting over lime water. Ethylen so prepared, which, before used, is dried by passing through strong sulphuric acid, I have analyzed on several occasions, and found absolutely pure.

The amylen† employed had been prepared by the action of chloride of zinc on amylic alcohol. After a few rectifications it boiled constantly at 38° C. at 758 m.m. pressure. It has the specific gravity of 0·6727 at 12°C. On burning with oxide of copper it showed the following composition:—

I. 0·2346 grm. gave 85·77 per cent. carbon and 14·11 hydrogen.
II. 0·2627 grm. gave 85·79 per cent. carbon and 14·22 hydrogen.

	$C_{10}\ H_{10}$ requires	Found. I.	II.	Mean.
C	85·71	85·77	85·79	85·78
H	14·29	14·11	14·22	14·16
	100·00			99·94

The results which I have already obtained in this direction are briefly as follows: ‡—

* I. Chem. Soc. Quart. Jour., vol. xii. p. 109. Ann. der Ch. u Ph., cxiii. p. 266; Annales de Ch. et Phys., vol. lix. p. 461.
II. Chem. Soc. Quart. Jour., vol. xiii. p. 35. Ann. der Ch. u Ph., cxvi. p. 234.
III. Chem. Soc. Quart. Jour., vol. xiii. p. 129.

† From Messrs Simpson, Maule, and Nicholson.

‡ M. Wurtz (Ann. de Ch. et Phys., vol. lix.), in referring to the bodies (1), (2), (3), (4), (9), (10), remarks,—

" SCl_2 correspondant à SO_2 etant diatomique, il en résulte en effet que $SCl_2 - Cl$ c'est à dire SCl doit être monatomique. Vous ferons remarquer, néanmoins, que l'on peut envisager la constitution de ces composées d'une autre manière, en supposant qu'ils renferment le groupe diatomique,
" Sulphure d'ethylène $(C_4\ H_4\ S_2)''$ et

The bodies $Cl\,S_2$ and $S\,Cl$ unite directly with the olefines $C_4\,H_4$ and $C_{10}\,H_{10}$ to form

* (1) $C_4\,H_4\,S_2\,Cl_2$ Bichlorosulphide of ethylen.
* (2) $C_4\,H_4\,Cl\,S_2$ Bisulphochloride of ethylen.
* (3) $C_{10}\,H_{10}\,S_2\,Cl_2$ Bichlorosulphide of amylen.
* (4) $C_{10}\,H_{10}\,Cl\,S_2$ Bisulphochloride of amylen.

At elevated temperatures, $C_4\,H_4$ acts upon $S_2\,Cl$ to produce

(5) $C_4\,H_3\,S_2\,Cl_2$ Bisulphochloride of chlorethylen.

" Sulphure d'amylène $(C_{10}\,H_{10}\,S_2)''$ correspondant aux oxydes. Ces groupes en se combinant à 2 atomes de chlore forment les deux chlorures suivants—

Dichlorure de Sulphethylène $(C_4\,H_4\,S_2)''\ Cl_2$
Dichlorure de Sulphamylène $(C_{10}\,H_{10}\,S_2)''\ Cl_2$

" Quant aux chlorure $C_{10}\,H_{10}\,S_2\,Cl$ nous doublons son equivalent et nous representons sa constitution par la formule

$$\left.\begin{matrix} C_{10}\,H_{10}\,S_2 \\ C_{10}\,H_{10}\,S_2 \end{matrix}\right\}''Cl_2$$

" On sait que 2 atomes d'oxyde d'ethylène peuvent se réunir pour se combiner à 1 atom d'eau. Il n'est pas donc extraordinaire que 2 atomes de sulphure d'amylène de reunissent pour se combiner a 2 atomes de chlore. Si cette manière de voir est exacte on doit representer la constitution de l'oxyde de disulphamyléne et cette de hydrate d'oxyde de disulphamylène par les formules

" Oxyde de sulphamylène $\left.\begin{matrix} C_{10}\,H_{10}\,S_2 \\ C_{10}\,H_{10}\,S_2 \end{matrix}\right\}''O_2$

" Hydrate de sulphamylène $\left.\begin{matrix} C_{10}\,H_{10}\,S_2 \\ C_{10}\,H_{10}\,S_2 \\ H_2 \end{matrix}\right\}''O_2$ "

With regard to the first portion of M. Wurtz's remark relative to the bichlorosulphides, I have to observe that the body SCl_2 has not been shown to exist, and, therefore, how its atomicity would be affected by a withdrawal of chlorine is a premature speculation.

Further, if the diatomic olefines are combined with two atoms of sulphur (" corresponding to the oxides "), why do they combine with two more atoms of halogen? Not, I think, because they have two stages of saturation, as M. Wurtz's view would indicate, but because halogen groups may have the same index of saturation as simple halogens. In this manner

$$C_4\,H_4\,\begin{matrix} O \\ O \end{matrix} = \text{Ethylenether}$$

$$C_4\,H_4\,\begin{matrix} HO_2 \\ HO_2 \end{matrix} = \text{Glycol.}$$

Concerning the bisulphochlorides, there is perhaps as much reason for doubling their formulæ as for doubling that of water; and so for the bisulphoxide.

M. Wurtz's proposed formula for the hydrated bisulphoxide of amylen, viz.,

$$\left.\begin{matrix} C_{10}\,H_{10}\,S_2 \\ C_{10}\,H_{10}\,S_2 \\ H_2 \end{matrix}\right\}''O_4$$

I cannot interpret, unless it belong to the class of " mixed types."

On the other hand, we may regard it as

$$C_{10}\,H_{10}\,\begin{matrix} S_2 \\ HO_2 \end{matrix}$$

which, I insist, is more congenial to analogy.

But, in truth, if the function of a formula be to express potential recomposition, these bodies eminently show the insufficiency of a single formula.

When the latter body is submitted to the action of chlorine, there is formed

(6) $C_4 H_2 S Cl_3$ Chlorosulphide of bichlorethylen,

A body identical with that got by the action of chlorine upon the bisulphide of ethyl—

(7) $C_4 Cl_3 S$ Sulphide of terchlorethyl.

Further, chlorine acts upon the bisulphochloride of amylen to form

(8) $C_{10} H_7 S Cl_4$ Chlorosulphide of terchloramylen;

Moreover, oxide of lead converts the body (4) into

* (9) $C_{10} H_{10} S_2 O$ Bisulphoxide of amylen,

while hydrated ammonia and hydrated potash give rise to the hydrate of (9)

* (10) $C_{10} H_{10} S_2 O HO$ Hydrate of bisulphoxide of amylen.

The manner of the formation of these bodies, and the definite and integral nature of the reactions which they show, is alone sufficient to prove that they are true single chemical compounds, and not mixtures. Since, however, they are none of them volatile without decomposition, their boiling points and vapour condensation, useful criteria of homogeneousness, are wanting. The same fact, however, may be equally well established by another method; that, namely, of "fractional solution." This method, which is of very wide application, has been already successfully employed in determining the homogeneous nature of gases. The principle may be enunciated as follows:—

"If a body be partly dissolved in a solvent, and if the dissolved part and the undissolved part, or the dissolved part and the whole, have the same composition, then the body is a simple one."

The converse of this law is not true, because solution may effect decomposition. Nor is the law itself any more or less true than that no two different bodies are soluble under the same circumstances to exactly the same extent in the same medium. This seems to be true in all cases but where the solubility is infinite, or indefinite miscibility possible.

This method was applied to the bisulphochlorides of amylen and ethylen, because, as we shall immediately see, they give rise to numerous derivatives, and because their definite nature should be therefore set at rest.

A few grammes of the bisulphochloride of ethylen were warmed with strong alcohol until about half dissolved. The alcoholic solution was poured off, evaporated to expel the alcohol, then washed with water, and dried over sulphuric acid in *vacuo*.

On analysis,

	Grms.	
I.	0·4436	gave 25·27 per cent. carbon and 4·36 hydrogen.
II.	0·4280	gave 33·88 per cent. sulphur.
III.	0.2838	gave 36·00 per cent. chlorine.

Comparing this analysis with the one given of the entire substance, "Quarterly Journal of Chemical Society," we find—

$C_4H_4S_2Cl$ requires	Entire subst.	Dissolved portion.
C=25·13	25·93	25·27
H= 4·19	4·32	4·36
S=33·51	33·47	33·88
Cl=37·17	36·29	36·00
100·00	100·01	99·51

Which proves that the substance is single. The bisulphochloride of amylen, on being treated in a similar manner, gave a substance which showed the following composition :—

I. 0·3934 grms. gave 23·81 per cent. sulphur.
II. 0.2677 grms. gave 25·66 per cent. chlorine.

Comparing this with analysis, "Quarterly Journal of Chemical Society," vol. xii. p. 113,

$C_{10}H_{10}S_2Cl$ requires	Total subst.	Soluble portion.
C=43·64	43·80	...
H= 7·27	7·47	...
S=23·27	23·93	23·81
Cl=25·82	24·73	25·66
100·00	99·93	

I considered a determination of the carbon unnecessary.

Having thus established the right of these bodies to be considered pure and homogeneous, the next thing was to examine the action of chlorine upon the bisulphochloride of ethylen.

If dry chlorine be made to act upon bisulphochloride of ethylen in the dark, hydrochloric acid is evolved, together with chloride of sulphur: the temperature rises considerably. If the action be assisted by the heat of a water bath, and the excess of chlorine be expelled by a current of dry carbonic acid, a product is obtained which is identical with that got by the action of chlorine either upon the bisulphochloride of clorethylen $C_4 \frac{H_3}{Cl} Cl\ S_2$, or upon the bisulphide of ethyl.*

For on analysis,

I. 0·3824 grms. gave 70·69 per cent. of chlorine.
II. 0·4380 grms. gave 10·63 per cent. of sulphur.

$C_4H_2Cl_3S$ requires	I.	II.
C=16·16	...	...
H= 1·35	...	...
S=10·76	...	10·63
Cl=71·73	70·69	...
100·00		

* Chem. Soc. Quart. Jour., vol xiii.

Showing that the product, as in the two other cases, is the chlorosulphide of bichlorethylen.

Hence we are led to the general conclusion that, *towards chlorine a body of the form* $C_n\ H_n\ S_2\ Cl$ *behaves like one of the form* $C_n\ H_{n+1}\ S_2$. For the three bodies $C_4\ H_4\ S_2\ Cl$, $C_4\ H_5\ S_2$, and $C_4\ H_3\ S_2\ Cl_2$ all yield, when acted upon by chlorine, $C_4\ H_2\ S\ Cl_3$. Accordingly, the most rational formulæ for these three bodies *towards chlorine* will be—

Bisulphide of ethyl.	Bisulphochloride of ethylen.	Bisulphochloride of chlorethylen.
$C_4\left.\begin{matrix} H_2 \\ H \\ H \\ H \end{matrix}\right\} S_2,$	$C_4\left.\begin{matrix} H_2 \\ H \\ H \\ Cl \end{matrix}\right\} S_2,$	$C_4\left.\begin{matrix} H_2 \\ H \\ Cl \\ Cl \end{matrix}\right\} S_2$

—the ultimate action of chlorine (at 100° C. in the dark and at ordinary pressures) being in all cases to form the body,

$$C_4\left.\begin{matrix} H_2 \\ Cl \\ Cl \\ Cl \end{matrix}\right\} S \left\{\begin{matrix}\text{The chlorosulphide of bichlorethylen,} \\ \text{or sulphide of terchlorethyl.}\end{matrix}\right.$$

I shall not assert that the identity of the ultimate products is a decisive proof, even in this case, of the identity of original constitution; but if it be admitted as such, the union of the olefines with the bisulphide of chlorine must be placed side by side with the union of hydrobromic acid with ethylen; namely, we must look upon the resulting products in the first case as being the bisulphides of the monochlorinated radicals.

Further, if we indulge in the assumption that the bichlorosulphides of ethylen and amylen,

$$C_4\ H_4\ S_2\ Cl_2,\ C_{10}\ H_{10}\ S_2\ Cl_2,$$

are constructed upon the same type, we are induced to the formulæ,

$$C_4\left.\begin{matrix} H_4 \\ Cl \end{matrix}\right\} S_2\ Cl, \qquad C_{10}\left.\begin{matrix} H_{10} \\ Cl \end{matrix}\right\} S_2\ Cl,$$

which would in truth compel the admission, that S_2Cl *may* saturate a single hydrogenoid. This proposal will startle us the less when we remember on the one hand the equality in saturating power between chlorine and cyanogen; and, on the other, the monosaturating power of sulphocyanogen.* We shall hereafter see that the olefines may unite with the elements of one equivalent of sulphocyanogen, and with compound groups of which such an equivalent forms a part,

* I may not here discuss the composition of the sulphocyanides. Whether they be isotypic with the cyanates or the cyanides, or whether such a distinction be at all a substantial one, is here a matter of secondary importance.

showing that either the olefines have more than one index of saturation, or that the diverse grouping of the halogen equivalents must compensate for the absolute number of their equivalents concerned.

The general direction of argument then, hitherto, tends to show that *towards chlorine, the bisulphochlorides of ethylen and of amylen behave like the sulphides of chlorine-containing radicals.*

Other reactions show these bodies in a different perspective.

The Hydrated Bisulphoxide of Ethylen.

$C_4 H_4 S_2 OHO.$

If an alcoholic solution of hydrated potash be added to an alcoholic solution of the bisulphochloride of ethylen, an immediate precipitation of the chloride of potassium ensues—a precipitation which removes the whole of the chlorine, provided the first solution be in excess. The alcoholic filtrate from the precipitated chloride of potassium is then freed from the excess of alcohol by the gentle heat of a water bath, and the heavy oily drops which appear are washed with water, to remove the still adhering alcohol and chloride of potassium, and then dried *in vacuo* over sulphuric acid.

On analysis—

I. 0·4333 grms. gave 31·33 per cent. carbon, and 6·67 hydrogen.
II. 0·2984 grms. gave 42·26 per cent. sulphur.

$C_4 H_4 S_2 OHO$

Requires	I.	II.
C=31·17	31·33	...
H= 6·49	6·67	...
S=41·56	...	42·26
O=20·78	...	...
100·00		

Hence, the body formed is the hydrate of the bisulphoxide of ethylen, its formation having taken place according to the equation,

$$C_4 H_4 S_2 Cl + KOHO = K Cl + C_4 H_4 S_2 OHO,$$

a reaction precisely similar to that which directs the formation of the hydrate of the bisulphoxide of amylen. Of course both of these reactions may be viewed as consisting in the replacement of the chlorine by peroxide of hydrogen.

I must leave the further description of this body, and of the bisulphoxide of ethylen $C_4 H_4 S_2 O$, and of some other derivatives from the bisulphochloride of ethylen, for another opportunity—merely insisting here upon the curious fact, that *towards oxides and hydrated oxides, the bisulphochlorides of amylen and ethylen behave like the chlorides of radicals of the form* $C_n H_{n+1}$

$C_4 H_5 Cl + Ag O$	$C_{10} H_{11} Cl + Ag O$
$= C_4 H_5 O + Ag Cl$	$= C_{10} H_{11} O + Ag Cl$
$C_4 H_5 Cl + KOHO$	$C_{10} H_{11} Cl + KOHO$
$= K Cl + C_4 H_5 OHO$	$= K Cl + C_{10} H_{11} OHO$
$C_4 H_4 S_2 Cl + Pb O$	$C_{10} H_{10} S_2 Cl + PbO$
$= C_4 H_4 S_2 O + Pb Cl$	$= C_{10} H_{10} S_2 O + Pb Cl$
$C_4 H_4 S_2 Cl + KOHO$	$C_{10} H_{10} S_2 Cl + KOHO$
$= C_4 H_4 S_2 OHO + K Cl$	$= C_{10} H_{10} S_2 OHO + K Cl.$

Viewed from this aspect, the bisulphochlorides of ethylen and amylen are the chlorides of sulphur-bearing radicals,—

$$C_4 \begin{matrix} H_4 \\ S_2 \end{matrix} Cl \qquad C_{10} \begin{matrix} H_{10} \\ S_2 \end{matrix} Cl,$$

which may indeed be isotypic with the chlorides of ethyl and amyl; but if they are so, they indicate that 32 of sulphur may replace 1 of hydrogen. Certainly the sulphur is combined with great energy, as we have seen formerly in the preparation of sulphide of fusyl,

$$C_{10} H_9 S,$$

and the numerous other reactions. Further instances of this are furnished by Bithiocyanide of amylen, $C_{10} H_{10} \begin{matrix} S_2 \\ Cy \end{matrix}$, and Bithiosulphocyanide of amylen, $C_{10} H_{10} \begin{matrix} S_2 \\ S_2 \end{matrix} Cy$.

The formation of these substances is so akin to the already described formation of the oxide and hydrated oxide of bisulphide of amylen, that a detailed description is superfluous. In both cases, an alcoholic solution of the bisulphochloride of amylen is heated on a water bath with an alcoholic solution of the cyanide or sulphocyanide of potassium. The precipitated chloride of potassium is separated by filtration, the excess of alcohol expelled on a water bath, and the resulting product washed with water and dried *in vacuo*.

The bithiocyanide of amylen showed the following percentage composition on analysis:—

I. 0·2432 grms. gave 55·65 per cent. carbon and 7·60 hydrogen.
II. 0·3881 grms. gave 24·66 per cent. sulphur.

$C_{10} H_{10} \begin{matrix} S_2 \\ Cy \end{matrix}$ requires	Found. I.	II.
C=56·25	55·65	...
H= 7·81	7·60	...
S=25·00	...	24·66
N=10·94	...	...
100·00		

The bithiocyanide of amylen has the specific gravity 1·07 at 13° C. It appears as a yellow liquid of nauseous smell.

The bithiosulphocyanide of amylen gave, on analysis,

I. 0·2336 grms. gave 44·46 per cent. carbon, and 6·54 hydrogen.
II. 0·3768 grms. gave 39·32 per cent. sulphur.

$C_{10}\,H_{10}\,\overset{S_2}{\underset{S_2}{}}\,Cy$ requires,	Found— I.	II.
C=45·00	44·46	...
H= 6·25	6·54	...
S=40·00	...	39·32
N= 8·75	...	...
100·00		

The specific gravity of the bithiosulphocyanide of amylen is 1·16. Like the preceding compound, it is also a liquid.

These bodies are perhaps chiefly interesting as showing how many halogens may be introduced to an olefine, provided they be offered in a systematic manner.

Looking at these manifold substitutions of chlorine in the bisulphochloride of amylen there seems to be no reason why oxygen acids should not be also introduced in place of the chlorine; that is, why such bodies as

$$C_{10}\,H_{10}\,\overset{S_2}{\underset{C_4}{}}\,H_3\,O_4$$

should not be formed, which would be the analogue of acetic ether.

The alcoholic nature of the hydrated bisulphoxide of amylen appears to be further evinced by its forming a copulated acid when dropped into a large excess of sulphuric acid, which is kept quite cold.

The Bisulphide of Amylen, $C_{10}\,H_{10}\,S_2$.

The behaviour of the bisulphide of chlorine towards the olefines of the form

$$C_{2n}\,H_{2n},$$

and the varied transformations which we have seen presented by the compound resulting from the union of bisulphide of chlorine with amylen, lend additional interest to the formation and properties of the bisulphide and bichloride of amylen,

$$C_{10}\,H_{10}\,S_2$$
$$C_{10}\,H_{10}\,Cl_2.$$

As neither of these bodies has been described, a short account of their preparation will not be out of place here.

If an alcoholic solution of the bisulphochloride of amylen be treated with zinc and sulphuric acid, the whole of the chlorine is removed, as chloride of zinc and hydrochloric acid, after a few hours' digestion on a water bath. The reduction, however, does not stop at this point; sulphuretted hydrogen is evolved. The organic compound, however, under all the conditions I have employed, refuses to part with the whole of its sulphur, the result being a product which, after purification from the alcohol by evaporation and washing with water, is indeed rich in sulphur and wholly volatile, with but trifling decomposition. But both analysis and the fact of the evolution of sulphide of hydrogen show that it contains less sulphur than belongs to the compound

$$C_{10}\,H_{10}\,S_2.$$

Its boiling point rises from *circa* 60° C. to 260° C.

Nascent hydrogen proves, therefore, too powerful a dehalogenizer for the end in view.

Metallic zinc enjoys the curious power of removing the whole of the chlorine and leaving the sulphur intact, according to the equation,

$$C_{10}\,H_{10}\,S_2\,Cl + Zn = C_{10}\,H_{10}\,S_2 + Zn\,Cl.$$

The necessity for only one equivalent of zinc in the above equation attaches the reaction rather to the reduction of kakodyl from its chloride by means of zinc

$$(C_2\,H_3)_2\,As\,Cl + Zn = Zn\,Cl + (C_2\,H_3)_2\,As,$$

or the reduction of ethyl from its iodide by sodium

$$C_4\,H_5\,I + Na = Na\,I + C_4\,H_5,$$

than to the reaction obtaining between the iodide of ethyl and zinc.

To prepare the bisulphide of amylen, an alcoholic solution of the bisulphochloride is treated with water, nearly sufficient to produce precipitation. Granulated zinc is added, and the retort containing the reagents is attached to an inverted condenser, and gently boiled in a water bath for some hours.

To test whether the reaction is accomplished, a few drops of the solution are evaporated in a crucible until the alcohol is expelled. The residual liquid is then washed with water, redissolved in alcohol, and treated with a fragment of sodium. The whole is then gradually heated to redness, and the chlorine tested for in the ordinary way. The slightest trace of chlorine may be thus detected in all bodies soluble in alcohol.

The whole of the chlorine being eliminated, the product is treated with water, and the oil which rises to the surface is removed. After repeated washings with water, it is dried over chloride of calcium and rectified. The portion which boils between 200° and 208° is collected apart. From this a large product is obtained, which boils constantly at 200° C.

On analysis,

I. 0·8012 grms. gave 30·60 per cent. of sulphur.
II. 0·2833 grms. gave 58·32 per cent. carbon and 10·36 hydrogen.
III. 0·3270 grms. gave 58·26 per cent. carbon and 10·24 hydrogen.

$C_{10}\,H_{10}\,S_2$ requires,	Found—			
	I.	II.	III.	Mean.
C=58·82	...	58·32	58·26	58·29
H= 9·80	...	10·26	10·24	10·25
S=31·37	30·60	...	...	30·60
99·99				99·14

From this analysis it would appear that the repeated distillation which the body had undergone had not materially affected its constitution.

The bisulphide of amylen is a light yellow, limpid liquid, of offensive smell. Its specific gravity at 13° C. is 0·907. Its boiling point *circa* 200° C. It shows no tendency to combine with the oxides of lead or mercury, like a mercaptan; nor does it, under ordinary conditions, combine with oxygen acids or sulphide of hydrogen, showing, in this respect, an essential difference from its oxygen isotype the binoxide of ethylen, which unites directly and readily with oxygen acids and chloride of hydrogen.

The Bichloride of Amylen, $C_{10}\ H_{10}\ Cl_2$.

All my efforts to combine chlorine directly with amylen have failed. Both dry and wet chlorine are absorbed with the greatest avidity by amylen. But the reaction is not a simple union. Even when freshly-made ice-cold chlorine water is shaken with amylen in the dark, conditions perhaps the most favourable for direct union, abundance of hydrochloric acid is eliminated, and the product, which, after the expulsion of the amylen, is heavier than water, shows no constant boiling point, and contains chlorine-substitution products, either of amylen or of its chloride.

But, indirectly, the bichloride of amylen may be prepared with facility; and as the method is both elegant and remarkable, I may describe it here. It is based upon the power which amylen enjoys of reducing the pentachloride of phosphorus to the state of terchloride, a reaction which at once reminds us of the analogous one which is frequently used to prepare the bichloride of ethylen; namely, the elimination by that olefine of two equivalents of chlorine from the pentachloride of antimony.

If pentachloride of phosphorus be finely powdered and treated with perfectly dry amylen, a rise in temperature of a few degrees Centigrade takes place. No hydrochloric acid is evolved. The amylen disappears after a time, and the solid becomes more bulky. Successive quantities of amylen are added as long as these changes occur, and the mixture is allowed to stand for some days. The pasty mass is then transferred to a basin, which is set to float upon a bowl of water, the whole being loosely covered. The moist atmosphere causes the whole to become liquid in about twelve hours, and the uncombined amylen escapes. The residual liquid has now to be washed, at first with water, and finally with dilute caustic potash, till all acid reaction disappears. It should be then gently warmed on a water bath to expel all traces of amylen, then dried over chloride of calcium, and rectified.

The product, which, after some rectifications, boils constantly between 141° C. and 147° C., is pure bichloride of amylen, $C_{10}\ H_{10}\ Cl_2$.

On analysis,

I. 0·2866 grms. gave 42·22 per cent. carbon and 7·40 hydrogen.
II. 0·4279 grms. gave 50·88 per cent. chlorine.

$C_{10}H_{10}Cl_2$ requires,	Found— I.	II.
C=42·55	42·22	...
H= 7·09	7·40	...
Cl=50·35	...	50·88
99·99		100·50

The bichloride of amylen is a colourless liquid, of aromatic smell, and sweet and camphorous taste. It burns with a smoky flame. Its boiling point is between 141° C. and 147° C. Its specific gravity at 9° C. is 1·058. It is insoluble in water, but miscible with ether. In alcohol, it dissolves freely on boiling; but on cooling an alcoholic solution saturated with the bichloride of amylen, the greater quantity separates out.

It is evident that, if the recomposition which takes place were a simple transference of two equivalents of chlorine from the pentachloride of phosphorus to the amylen, the entire product should be a liquid. This is never the case, even when a great excess of amylen is employed.

On the other hand, in the preparation of the bichloride of amylen, if the mixed product got by the action of the damp air upon the solid mass be exposed for only some hours, and then treated with water, a large quantity of amylen is still found in it.

From these two considerations, it seems probable that the terchloride of phosphorus, which is the supplementary product to the first equivalent of bichloride of amylen formed, unites with a second equivalent of amylen to form a solid easily decomposable by water, and analogous to the pentachloride of phosphorus,

$$P\,Cl_5 + 2\,C_{10}\,H_{10} = C_{10}\,H_{10}\,Cl_2 + P\,Cl_3\,C_{10}\,H_{10}.$$

Whether this be the case or not, the bichloride of amylen requires long-protracted washing before it ceases to yield acid to the water.

Binitroxide of Amylen.

$C_{10}\,H_{10}\,2\,NO_4$

Although the distinction between halogen salts, of which chloride of sodium is the prototype, and oxygen salts, of which sulphate of soda may be taken as the representative, is a convenient one, the line which separates the two classes has always been vague, and is becoming gradually obliterated. The isolation of the constituent groups in oxygen salts, supplementary to the metallic base, has contributed largely to this obliteration. Anhydrous sulphuric acid, peroxide of hydrogen and sulphocyanogen stand in the same relation respectively, to sulphite of potash, hydrate of potash, and sulphocyanide of potassium, as chlorine does to chloride of sodium,

$$Na,\ Cl;\ K,\ SO_3,\ K,\ HO_2;\ K,\ Cy\ S_2.$$

This analogy between the simple and compound halogens is perhaps conserved most completely in the case of the nitrates,

$$MNO_4.$$

Not only is NO_4 known in the free state; but, like chlorine, it possesses in a high degree the power of replacing hydrogen in organic compounds, equivalent for equivalent, giving rise to the endless catalogue of nitro-compounds. In all instances is the introduction of NO_4 analogous to that of chlorine,

$$Q_m H_n + Cl\,Cl = Q_m H_{(n-1)} Cl + HCl$$
$$Q_m H_n + ONO_4 = Q_m H_{(n-1)} NO_4 + HO$$
$$*Q_m H_n + NO_4 NO_4 = Q_m H_{(n-1)} NO_4 + HNO_4.$$

In all cases of nitro-substitution hitherto observed there, is formed some body supplementary to the nitro-compound, namely, water or nitrous acid, corresponding to the hydrochloric acid of the chlorous substitution products.

This analogy may be carried one step further: just as chlorine may combine with an olefine directly, without the liberation of hydrochloric acid, so free NO_4 may combine with an olefine directly, such union being perfectly analogous to that effected by chlorine.

For these reasons we may call NO_4 "Nitroxine." Hence the following bodies are analogues:—

Chlorine.	Nitroxine.
Cl or Cl Cl	NO_4 or $NO_4\,NO_4$
Chlorhydric Acid. HCl	Nitroxhydric Acid, Nitrite of Hydrogen. HNO_4
Hypochlorous Acid. OCl	Anhydrous Nitric Acid. ONO_4
Bichloride of Olefine. $C_n H_n Cl_2$	Binitroxide of Olefine. $C_n H_n 2NO_4$

The Binitroxide of Amylen, $C_{10} H_{10} 2NO_4$.

This remarkable body may be formed in two ways, either by the action of nitric acid upon amylen, or by the direct union of nitroxine with amylen.

At ordinary temperatures, nitric acid is without action upon amylen. At the temperature at which nitric acid boils, the action between the two is energetic. The difference between the boiling points of nitric acid and amylen involves too great a loss of the olefine, if the two be heated together until the nitric acid boils.

If air be saturated with amylen vapour, by being forced through a series of bulbs containing that hydrocarbon, and be then led into boiling nitric acid in such a manner that the products of the action may be collected, crystals are found in the receiver, which after washing with cold alcohol and recrystallizing from dry ether, are pure binitroxide of amylen.

* I only find one example of this last recomposition, namely, the formation of nitronapthaline by the action of NO_4 upon napthaline described by LAURENT.

I. 0·3680 grms. gave 37·20 per cent. carbon, and 6·24 hydrogen.
II. 0·1336 grms. gave 18·04 per cent. nitrogen.

$C_{10}\,H_{10}\,2NO_4$ requires,	Found—
C=37·09	37·20
H= 6·18	6·24
N=17·28	18·04

The formation of binitroxide of amylen under these circumstances may be explained in two ways,—either there is an initial oxidation of the amylen, the nitric acid being thereby reduced to nitric oxide, which joins with the oxygen of the air present to form nitroxine. This last thereupon unites with a fresh portion of amylen; or the nitric acid, on being boiled, splits up into NO_4 and O, whereof the former unites directly with one portion, while the oxygen goes to oxidize another portion of the amylen. Probably both actions are simultaneous, the result being the formation of $C_{10}\,H_{10}\,2NO_4$, along with another product, containing apparently oxide of amyl and nitric acid.

If the gas obtained by the ignition of well-dried nitrate of lead be passed into amylen which is kept quite cold, a rapid absorption results, and crystals of binitroxide of amylen are obtained in great abundance. After washing and recrystallizing as before,

0·2682 grms. gave 37·26 per cent. carbon, and 6·51 per cent. hydrogen.
0·2290 grms. gave 17·66 per cent. nitrogen.

$C_{10}\,H_{10}\,2NO_4$ requires,	Found—
C=37·09	37·26
H= 6·18	6·51
N=17·28	17·66

The product, as in the other method of preparation, is mixed with a liquid soluble in alcohol, resulting probably in this case from the presence of anhydrous nitric acid along with the nitroxine.

Binitroxide of amylen crystallizes in square and rectangular colourless, transparent tables, without taste or smell. It decomposes at 95° C. when heated alone, giving rise to a gas HNO_4, and an oily liquid heavier than water. It is insoluble in water, in cold alcohol, and in amylen. It dissolves in hot ether and alcohol; also readily in warm glacial acetic acid. Its most convenient solvent, however, is chloroform. Thrown upon oil of vitriol it is instantly and violently decomposed, a conjugate acid being formed, which forms a soluble salt with baryta.

The binitroxide of amylen is decomposed in alcoholic solution by caustic potash and by sulphide of potassium; in the former case the binoxide of amylen, in the latter the bisulphide of amylen, being formed. Of these, the first will probably be soon described by those who are occupying themselves with the biatomic alcohols and ethers; the latter has been already described.

One of the most noteworthy transformations which this remarkable body undergoes, is its conversion into

The Bicyanide of Amylen, $C_{10}\, H_{10}\, Cy_2$, 5HO.

The bicyanide of an olefine is a compound which almost every chemist has sought to obtain, on account of the probability of such a body giving rise to an acid derivative, analogous to oxalic acid, on treatment with a hydrated alkali, in the same manner as cyanide of ethyl, under these circumstances, gives rise to propionic acid,*

$$C_n\, H_{n+1}\, C_2\, N + KO,\ 3HO = NH_3 + KO\ C_{n+2}\, H_{n+1}\, O_3$$
$$C_n\, H_n\, C_4\, N_2 + 2KO,\ 6HO = 2NH_3 + 2KO\ C_{n+4}\, H_n\, O_6$$

The bicyanide of amylen is formed in the following manner:—Binitroxide of amylen in alcoholic solution is treated with an excess of alcoholic solution of cyanide of potassium; an abundant precipitate is formed, which, after washing and drying, is found to be pure nitrate of potash KNO_4, or nitroxide of potassium. The filtrate from this salt is then evaporated on a water bath, until it becomes syrupy. It is then washed repeatedly with small quantities of water, and dried *in vacuo* over sulphuric acid.

So prepared, the bicyanide of amylen appears as a syrupy liquid, of pleasant smell and bitter taste.

Submitted to analysis,

I. 0·2760 grms. gave 9 16 per cent. hydrogen.
II. 0·3500 grms. gave 9·16 per cent. hydrogen, and 51·26 per cent. carbon.
III. 0·3079 grms. gave 16·00 per cent. of nitrogen.

$C_{10}\, H_{10}\, Cy_2 + 5HO$ requires,	Found— (1.)	(2.)	(3.)
C=50·30	...	51·26	...
H= 8·98	9·16	9·16	...
N=16·77	...	...	16·00

The presence of five equivalents of water with the bicyanide of amylen, indicated by the above analysis, might appear an accident. Analyses (1.) and (2.) were of the same preparation, but exposed *in vacuo* for different lengths of time. Analysis (3.) was of a fresh preparation.

The five equivalents of water may be fairly compared to water of crystallization of solid salts—(1.) Because, as will be afterwards shown, an anhydrous bicyanide of amylen exists; (2.) because the penthydrate of the cyanide is decomposed on heating, giving off water; (3.) because *four* equivalents of water are

* Dr M. Simpson has already announced the formation of bicyanide of ethylen, and the derivation therefrom of succinic acid.

essential to the recomposition pointed out above; where, besides the two equivalents of water of the hydrate of potash, four others are necessary.

The penthydrated bicyanide of amylen is soluble to a considerable extent in water; it mixes with alcohol and ether. Under certain conditions, it enjoys basic properties.

As before indicated, one would expect that, on boiling with an aqueous solution of caustic potash, ammonia would be formed, and pinelate of potash generated,—

$$C_{10}\,H_{10}\,Cy_2 + 2KO,\,6HO = 2KO\,C_{14}\,H_{10}\,O_6 + 2NH_3$$

The discussion of the actual recomposition which takes place must be reserved for a subsequent communication.

The Bichloride of Amylen.

The relation between amylen, amyl, and hydride of amyl, and nitroxide of amyl,

$$C_{10}\,H_{10}, \quad C_{10}\,H_{10}\,H, \quad C_{10}\,H_{10}\,H_2, \quad C_{10}\,H_{10}\,HNO_4,$$

induced me to try the action of nitroxine upon the second and fourth, in the expectation of some such body as the binitroxide of amylen resulting. In both cases the result was negative.

Connected with the binitroxide of amylen, are the bodies produced by the action of nitric acid on the bisulphochloride of amylen. Such action is twofold. The first stage seems to be a nitroxine replacement; the second, a more precise oxidizing action. The result of the first is the formation of a neutral insoluble body containing NO_4; that of the second, the production of a peculiar acid, containing sulphur, carbon, and hydrogen, but neither chlorine nor nitrogen. This has not been further examined. The latter of these two stages is naturally accompanied by the separation of hydrochloric acid; sulphuric acid is also formed, together with the ultimate product of the oxidation of the carbon, namely, oxalic acid. In tracing so complicated a reaction, it was necessary to employ a somewhat large quantity.

Nitrosulphide of Nitroxamylen, $C_{10}\,{}^{H_9}_{NO_4}\,SNO_4$

Twenty grammes of the bisulphochloride were treated, in a retort having a well-cooled condenser, with a large excess of nitric acid. On applying a gentle heat, copious fumes were evolved of nitric oxide, and these collected in the condenser, along with an acid distillate, a large quantity of a heavy liquid unmixable with it. This, after washing and drying, showed the following composition:—

I. 0·2579 grms. gave 34·82 per cent. carbon, and 4·82 hydrogen.
II. 0·2620 grms. gave 34·26 per cent. carbon, and 5·25 hydrogen.
III. 0·1838 grms. gave 9·39 sulphur.

$C_{10} H_9 2 (NO_4) S$ requires,	Found— I.	II.	III.
C = 33·89	34·82	34·26	...
H = 5·08	4·82	5·25	...
S = 9·04	...	...	9·39

The body contained no chlorine, but abundance of nitrogen.

Writing, as before, the bisulphochloride of amylen

$$C_{10} H_{10} \begin{matrix} S \\ SCl, \end{matrix}$$

we may suppose that the nitric acid replaces one equivalent of hydrogen and one of Cl S by nitroxine, giving rise to the body

$$C_{10} \begin{matrix} H_9 \\ NO_4 \end{matrix} \begin{matrix} S \\ NO_4. \end{matrix}$$

In fact, a similar phenomenon is here presented as was observed in studying the action of the same body upon chlorine,—that is, the group S Cl is, under both circumstances, more easily replaced than the remaining equivalent of sulphur.

The body formed by the action of nitric acid upon the bisulphochloride of amylen is therefore, according to the previously adopted nomenclature, the nitrosulphide of nitramylen, or, according to analogies already pointed out, the sulphide of binitramyl. It is a green, viscous liquid. It mixes with ether and strong alcohol, but is insoluble in water. Its taste is remarkably bitter and alliaceous, producing nausea.

They who have had occasion to prepare the organothionic acids, got by the action of nitric acid upon the various organic sulphides or sulphocyanides will have noticed that, before complete reaction,—that is, before the conversion of the whole of the substance acted upon by the nitric acid into the organothionic acid soluble in water,—it is generally possible, by arresting the action with water, to procure a liquid insoluble in and heavier than water, although the original organic body itself be lighter than that liquid. Such bodies do not appear to have been further examined, owing, probably, to the uncertainty as to whether an integral reaction has occurred, and the probability of the product being a mixture, the separation of whose constituents would present great difficulties. Bearing, however, in mind the analogies already pointed out between the chlorine substitution products of bisulphide of ethyl, bisulphochloride of chlorethylen, and bisulphochloride of ethylen, it seems highly probable that the bodies in question are analogous with the nitrosulphide of nitramylen.

The Synthesis of Œnanthyl.

The construction of isotypic series in organic chemistry, which has proved of such great worth in classifying known bodies, and in indicating the possible existence of yet undiscovered ones, confers an unique importance on the study of the olefines; for the latter bodies stand in much the same relation to many such series as does the "common difference" to an arithmetical one.

A common difference, whose successive chemical additions to any one term of such a series would yield, theoretically, every higher successive term, is methylen $C_2\ H_2$.

According to some chemists, methylen has been obtained; according to others, its existence is possible, although never obtained; while, in the eyes of a third class, its existence is an impossibility. Up to the present time it is perhaps safe to assume that this hydrocarbon has not been prepared in the pure state.

Although, if we had only one term of such a series from which to start, the existence of methylen would be necessary and sufficient for the theoretical solution of the problem of the successive syntheses of the following terms in the manner above indicated, any multiple of methylen would furnish the means of forming successive terms, situated from one another at intervals of the magnitude of the hydrocarbon employed.

In general terms,—If $C_m\ H_n\ Q$ be the formula of the starting term, where Q denotes the whole of whatever constituents are present besides $C_m\ H_n$, then, by means of methylen, we may get, in succession,

$$\begin{array}{ll} & C_m\ H_n\ Q \quad \ldots\ldots \quad (1) \\ C_2\ H_2 & \\ & C_{m+2}\ H_{n+2}\ Q \quad \ldots\ldots \quad (2) \\ C_2\ H_2 & \\ & C_{m+4}\ H_{n+4}\ Q \quad \ldots\ldots \quad (3) \\ C_2\ H_2 & \\ & C_{m+6}\ H_{n+6}\ Q \quad \ldots\ldots \quad (4) \\ C_2\ H_2 & \\ & C_{m+8}\ H_{n+8}\ Q \quad \ldots\ldots \quad (5) \\ & \text{\&c.} \end{array}$$

But if the difference be ethylen, we can only form every alternate term—

$$\begin{array}{ll} & C_m\ H_n\ Q \quad \ldots\ldots \quad (1) \\ C_4\ H_4 & \\ & C_{m+4}\ H_{n+4}\ Q \quad \ldots\ldots \quad (3) \\ C_4\ H_4 & \\ & C_{m+8}\ H_{m+8}\ Q \quad \ldots\ldots \quad (5) \\ & \text{\&c.} \end{array}$$

With propylen, every third term; and so on.

Further, it is clear that, supposing we have ethylen as the common difference, we can fill up the entire series provided we have two starting points which differ by methylen—

$$\begin{array}{ll} & C_m\ H_n\ Q \quad \ldots \quad (1) \\ C_4\ H_4 & \\ & C_{m+4}\ H_{n+4}\ Q \quad \ldots \quad (3) \\ C_4\ H_4 & \\ & C_{m+8}\ H_{n+8}\ Q \quad \ldots \quad (5) \\ & \text{\&c.} \end{array} \qquad \begin{array}{ll} & C_{m+2}\ H_{m+2}\ Q \quad \ldots \quad (2) \\ C_4\ H_4 & \\ & C_{m+6}\ H_{m+6}\ Q \quad \ldots \quad (4) \\ C_4\ H_4 & \\ & C_{m+8}\ H_{m+8}\ Q \quad \ldots \quad (6) \\ & \text{\&c.} \end{array}$$

in which the two series, derived from the two initial terms, are supplementary of one another.

Again, if we had only propylen at our disposal as a difference, we could still complete the series provided we had *three* consecutive starting terms. And so, *mutatis mutandis*, for the other limitations.

It will be shown that, with regard to certain alcohols of the formula $C_m H_{m+2} O_2$, and their derivatives, the above scheme is not merely a representation of an arithmetical possibility, but is the general expression of the result of a series of chemical phenomena, and that we are in possession of the means of deriving many of the higher alcohols from the lower ones by the introduction of olefines of the form $C_n H_n$.

I confine myself at present to the solution of the following problem:—To obtain a compound of ænanthyl from vinic alcohol and amylen.

The key to the solution of this problem is furnished by the facility with which the bisulphochloride of amylen parts with its chlorine, and the firmness with which it retains its sulphur. We have, in fact, seen numerous examples of the exchange of the chlorine in this body for other simple or compound halogens, as oxygen, peroxide of hydrogen, cyanogen, sulphocyanogen, &c., by the action of the corresponding compounds of the metals upon the bisulphochloride of amylen.

In zinc-ethyl, the ethyl is certainly the halogen; hence we may anticipate the reaction which in fact takes place between zinc-ethyl and the bisulphochloride of amylen—namely, the replacement of the chlorine in the latter body by the ethyl of the former.

$$C_4 H_5 Zn + C_{10} H_{10} S_2 Cl = C_{10} H_{10} S_2 C_4 H_5 + Zn Cl.$$

Bisulphochloride of amylen and an ethereal solution of zinc-ethyl mix with one another in all proportions, giving a clear, light yellow product. Such a mixture, however, unless one or other of the constituents is present in very great excess, becomes hot after standing a few minutes; and unless ether be present to cool the liquid by its evaporation, a dangerous projection of zinc-ethyl may result. It is difficult to regulate the action by cooling from without. I have found the following the most convenient process:—

Three ounces of bisulphochloride of amylen are placed in a flask, having a doubly bored cork. Through one hole passes the zinc-ethyl delivery tube from the copper digester; the other holds a tube, which is bent down into a large narrow-mouthed bottle, containing a few drops of ether. The charge of iodide of ethyl for the above quantity of bisulphochloride of amylen should be about five ounces. This is mixed, as usual, with its own volume of dry ether. If these proportions are observed, the zinc-ethyl formed will be in excess. The charge of zinc-ethyl is distilled off in about six hours, and the recipient containing the bisulphochloride is not artificially cooled.

The product is found to consist of two layers,—the lower, a dark-brown sluggish mass, almost solid when cold, contains the chloride of zinc; the upper, which is of a light-yellow colour, contains the bisulphide of ethyl-amylen (or bisulphide of œnanthyl), along with ether, and the excess of zinc-ethyl.

The upper layer is poured into water, whereon the zinc-ethyl is decomposed, and the alcohol formed is dissolved, while the precipitated oxide of zinc carries with it most of the bisulphide of œnanthyl, either in a purely mechanical manner, or in a state of the feeblest union. The pale-yellow mass so obtained is drained on a wet filter, then boiled and exhausted with strong alcohol. This gives an alcoholic solution (*a*) of bisulphide of œnanthyl, and an insoluble residue, consisting of pure oxide of zinc.

The lower layer* is also treated with water, whereupon chloride of zinc is dissolved out, and a liquid separates. The latter is dissolved in alcohol, and added to the solution *a*.

The mixed alcoholic solution is then heated in a water-bath, until most of the alcohol is expelled. Finally, it is washed with water, and dried over chloride of calcium and a few fragments of caustic potash.

On distillation, a few drops pass over about 140° C.; this is probably a little bisulphide of ethyl.

The great bulk passes over at 240° to 250° C. On rectification, its boiling point is nearly constant at 243° C.† A slight residue is formed on each distillation.

On analysis,—

(1.) 0·2730 grms. gave 65·31 per cent. of C., and 11·22 of H.
(2.) 0·4122 grms. gave 65·42 per cent. of C., and 11·26 of H.
(3.) 0·4186 grms. gave 23·72 per cent. of S.

$C_{14} H_{15} S_2$ requires,	Found— I.	II.	III.	
C=64·12	65·31	65·42	65·36	Mean.
H=11·46	11·22	11·26	11·24	Mean.
S=24·42	...	...	23·72	
100·00			100·32	

The rather large excess in the carbon, and the defect in the sulphur, are perhaps owing to the presence of some monosulphide of œnanthyl. The bisulphide of œnanthyl is a light-yellow liquid, of perfect limpidity. Its smell is exceedingly offensive. It is quite insoluble in water, but readily soluble in ether and alcohol. Towards the oxides of lead and mercury it shows perfect indifference.

The so perfect reactional analogy between the bisulphochlorides of ethylen and of amylen, which I have had the honour of pointing out, and the perhaps equally well-established resemblance between the compounds of methyl, ethyl, and amyl

* The physical properties of this body, and the large quantity of liquid which water separates from it, seem to point to its being a compound of chloride of zinc, with bisulphide of œnanthyl.

† Bisulphide of ethyl boils *circa* 150° C. If Kopp's law hold good, a successive increment of 19° C. for every $C_2 H_2$ would point to 245° C. as the boiling point of bisulphide of œnanthyl. But in the cases of other bisulphides, a common increment of 33 would more nearly represent experimental results. Hence it is possible that this substance may only be an isomer of bisulphide of œnanthyl.

with zinc, place beyond doubt the possibility of the construction of various other compounds of the higher alcohol radicals from compounds of the lower ones. From the bisulphochloride of ethylen on the one hand, and zinc-methyl and zinc-ethyl on the other, we may confidently expect to obtain the bisulphides of all the radicals of the form $C_m H_{m+1}$ above the bisulphide of propyl, inclusive: while the formation of the corresponding alcohols from the bisulphides of the radicals may be a matter of labour, but cannot be one of uncertainty.

So far my examination of the behaviour of the olefines to compound chemico-negative groups has led to the formation of the following bodies:—

From Ethylen, $C_4 H_4$.

$C_4 H_4 S_2 Cl$ Bisulphochloride of ethylen.
$C_4 H_4 S_2 Cl_2$ Bichlorosulphide of ethylen.
(*a*.) $C_4 H_2 S Cl_3$ Chlorosulphide of bichlorethylen.
(*b*.) $C_4 H_2 S Cl_3$ Sulphide of terchlorethyl.
$C_4 H_4 S_2 OHO$, Hydrated bisulphoxide of ethylen.

From Amylen $C_{10} H_{10}$.

$C_{10} H_{10} S_2 Cl$ Bisulphochloride of amylen.
$C_{10} H_{10} S_2 Cl_2$ Bichlorosulphide of amylen.
$C_{10} H_7 S Cl_4$ Chlorosulphide of terchloramylen.
$C_{10} H_{10} S_2 O$ Bisulphoxide of amylen.
$C_{10} H_{10} S_2 OHO$ Hydrated bisulphoxide of amylen.
$C_{10} H_9 S_2$ Bisulphide of fusyl.
$C_{10} H_{10} S_2$ Bisulphide of amylen.
$C_{10} H_{10} Cl_2$ Bichloride of amylen.
$C_{10} H_{10} Cy_2$ 5HO Penthydrated bicyanide of amylen.
$C_{10} H_{10} S_2$ Cy Bithiocyanide of amylen.
$C_{10} H_{10} S_2 Cy S_2$ Bithiasulphocyanide of amylen.
$C_{10} H_{10} 2(NO_4)$ Binitroxide of amylen.
$C_{10} H_{10} S_2 C_4 H_5$ Bisulphide of œnanthyl.

In the foregoing pages, I have been induced to employ some expressions which may need a word of explanation.

The term *recomposition* has been often used in place of decomposition. When the reaction which ensues between bodies is unaccompanied by the destruction of their form or type, the change may be more fitly called a recomposition than a decomposition. The latter word is suggestive of a degeneration, which the former word avoids, and the idea of which is in such cases out of place. Recomposition corresponds more nearly to the happier German term "Umsetzung," as distinguished from "Zersetzung."

Isotype, idiotype, isotypic, idiotypic. A body is an isotype of another, or isotypic with it, when the two are built on similar types. Thus, the fatty acids are isotypes. Idiotypic are bodies which are built on the same type. Thus all elementary replacement derivatives of a body are its idiotypes, or are idiotypic with it.

Consequently, the isotypes and idiotypes of one and the same body are related to one another as an atom complex is to an atom simple.

Certain of the bodies were procured in too small a quantity for their specific gravities to be taken in the ordinary method. When this was the case, and the substances were insoluble in water, a solution of nitrate of ammonia, or of chloride of calcium was so graduated by water, that a drop of the liquid under examination remained in indifferent equilibrium in the saline solution. The specific gravity of the saline solution is then taken in the ordinary manner, and is of course identical with that of the liquid examined.

I allow myself, in conclusion, to express a regret, that circumstances have prevented me from offering my results to the Society in a more elaborated form. I shall take the earliest opportunity of prosecuting this direction of research. Meanwhile, let me offer my thanks to Professor Roscoe of Manchester, and Dr Playfair of Edinburgh, for having allowed me to carry on my experiments in their laboratories. To Professor Kolbe in Marburg I am also indebted, for having on all occasions, placed the resources of his laboratory at my disposal.

Edinburgh University Laboratory,
March 1861.

XXIX.—*On the Chronology of the Trap-Rocks of Scotland.* By ARCHIBALD GEIKIE, Esq., F.G.S. (One Plate, XXXVIII.)

(Read 19th March 1860, and 15th April 1861.)

In the Geology of Scotland, no feature comes at once more prominently before the observer than the number and variety of the trap-rocks.* From the Sheant Isles to the Cheviot Hills the map is dotted over with trappean patches, which occur sometimes as long, narrow dykes, and often as irregular sheets, that extend almost over entire counties. The appearance of the rocks on the face of the country is scarcely less marked than on the map, and to their ever-changing varieties, we owe not a little of the characteristic scenery of Scotland. Throughout the wilds of the Inner Hebrides it is the trap-rocks which form many of the precipitous cliff-lines, and the craggy irregular hills. The soft pastoral valleys of the Ochils and the Pentlands lie among trappean rocks, while the hill-ranges, which break up the great central valley of Scotland, more especially the abrupt solitary crags that form such prominent landmarks, owe their existence to the permanence of the trap-rocks of which they consist. In short, there is no group of rocks more constantly found throughout the length and breadth of the island, and none, therefore, which so frequently obtrudes on the geologist or more imperatively demands his attention.

Definition and Classification of Trap-Rocks.

Under the designation of *trap* are included, in this communication, all the igneous rocks of the country which do not fall within the limits of the granite family; excluding, however, at least in the meantime, such rocks as the hypersthene of Skye, which I have long suspected to be metamorphic. The usual classification of trap-rocks is according to their mineralogical characters. But in unravelling the structure of a trappean region, such a classification will be found in many cases insufficient. It is the great province of the geologist to determine the succession in time of the materials with which he deals. His terms are, for the most part, either founded on this chronological order, or are virtually referred to it, whatever be their real import. By *Oolite*, for example, he means not necessarily a *roe-like* stratum, but a series of strata, whether *roe-like* or not, possessing a

* The word trap is here used in a generic, not in a specific sense. It includes greenstones, basalts, felstones, ashes, &c.; in short, all the truly igneous rocks of former geological periods, whether volcanic (erupted at the surface) or intruded as dykes and irregular masses into other rocks. Granite, serpentine, and the granitoid porphyries I regard as not truly igneous, and they are therefore excluded.

certain organic type, and referable to a certain place in the scale of geological time. Hence, too, when he comes to a district abounding in igneous rocks, he often finds it insufficient to separate them out into augitic, or felspathic, or hornblendic, as the case may be, for such a subdivision tells nothing of the relations in time of these rocks, to the stratified deposits with which they are associated. Over and above this mineralogical distribution, another must be adopted, which shall enable him, as far as possible, to throw each igneous mass into its true chronological place, that in this way the succession of events in the geological history of the district may be clearly and methodically detailed.

In carrying on a detailed examination of the trap-rocks throughout a considerable part of the country, I have found by much the best classification for practice in the field to be that adopted by the Geological Survey throughout the trappean region of Wales. There the traps were divided into,—1*st*, Felspathic ash and ashy sandstones, and slates; 2*d*, Interbedded felspathic rocks; 3*d*, Intrusive felspathic rocks; and, 4*th*, Greenstones and basalts. In extending this Welsh type into Scotland, it is necessary to subdivide the greenstones and basalts, as the felstones were subdivided, into two groups—interbedded and intrusive. The arrangement is thus exceedingly simple. There are, *first*, the ashy rocks, as to the origin and age of which we can seldom be at a loss, and which can be modified in the colouring of the map according to their composition. Then come the two great groups of the melted traps,—the felspathic and the augitic or hornblendic. The former are arranged, according to their mode of occurrence (which points of course to their relative age), into *interbedded* or *contemporaneous*, and *intrusive* or *subsequent* felstones. The latter group is similarly classified into *interbedded* or *contemporaneous*, and *intrusive* or *subsequent* greenstones and basalts.*

It may be well to state here very briefly, the characters on which this classification rests. The ashes, representing showers of volcanic dust and cinders which settled down upon the sea-bottom, or on the surface of the land in more or less stratified layers, yield by much the clearest evidence as to the age of any igneous eruption, inasmuch as their position in a series of rocks marks the relative date of their production precisely, as though they were beds of sandstone or limestone, while, in addition to this, they in many cases, contain fossil remains, both vegetable and animal, which still further contribute to define their geological horizon.

The truly interbedded melted traps are regarded as *contemporaneous*, that is, of the same age as the strata among which they lie as interstratified conformable

* In the colouring of the maps of the Geological Survey, this arrangement is followed, by using crimson for the augitic, and a brighter red for the felspathic traps. The dark shade of each colour marks the intrusive masses, while the lighter shade is used for the interbedded sheets. The age of the latter, as well as of the ash-beds, is always shown by the geological position of the strata with which they are associated.

beds. The ground of this conclusion is, that the stratum on which a bedded trap rests may be more or less altered, while that which covers it shows no sign of alteration, but reposes undisturbed on the upper surface of the trap, of which it sometimes contains pebbles, and to which it must therefore be posterior.

The intrusive trap-rocks occur sometimes as apparently conformable beds, sometimes as amorphous masses, and frequently as vertical walls or *dykes.* In all cases they alter the contiguous surfaces of the rocks through which they pass, so that, even though they appear as bedded masses, their true intrusive character is made evident by the metamorphism which they have produced on the under surface of the strata which cover them. They are accordingly always subsequent to the rocks with which they are associated; and though they of themselves afford no test of their age, it can sometimes be approximately reached by an examination of the surrounding country. This classification of the trap-rocks is an eminently geological one, and as such depends for its extension to all the trappean districts of the country,—not upon the identification of the mineralogical similarity of the rocks, but upon a large and thorough survey of their geological relations. Since, therefore, the trap family plays so important a part in the geology of Scotland, it becomes of the highest importance to ascertain how far these rocks are referable to distinct geological periods. No geological map of the country can be considered complete which does not indicate in some way the horizons of its igneous rocks. This is a task, however, which still remains to be done; and the present paper, containing the results of about five years' labour in various trappean districts of Scotland, must be regarded as merely a preliminary outline of the work that has to be performed before we can regard the history of igneous action in the country as in any way complete. I shall place here in order examples of trappean districts of successive ages, and show how their geology may be satisfactorily worked out, while I hope from time to time to be able to lay before the Society other instances, extending our knowledge of the chronology of the trap-rocks of Scotland.

Trap-rocks of Scotland of Different Ages.

It is well-known that the trap-rocks of Scotland are of various ages,—that some, as those of the Sidlaw Hills, are intercalated in the Old Red Sandstone; that a large number are Carboniferous; that some are probably Oolitic; and that others are without doubt Tertiary. At the same time, it would not improbably be correct to say, that of by much the larger part of the trappean hills of the country little further is known than that they are trappean. Their age, the details of their structure, their inter-connection with each other, and their relations to the stratified rocks among which they occur, are subjects in which almost nothing has been done. By far the most philosophical account of any of the Scottish traps was that given of Arthur's Seat and Pentland Hills by

Mr MACLAREN upwards of twenty years ago,* and his work will ever rank among the classics of British geology. Much, undoubtedly, has been done in the *mineralogy* of the trap-rocks, as the works of JAMESON, BOUÉ, MACCULLOCH, and others sufficiently show; but in the department of trappean *geology* the labourers have been comparatively few. A wide and well-nigh untrodden field of research thus lies open, than which no other branch of physical geology in Scotland will yield a richer harvest of results.

Traces of Trappean Rocks among Lower Silurian Strata.

The metamorphic rocks which constitute the Scottish Highlands, though abounding in granites, syenites, porphyries, serpentines, and other so-called igneous rocks, do not appear to show any evidence of truly interbedded trap-rocks. If any such originally existed, they must have suffered from the metamorphic action which has produced the gneiss and schists of the Highlands, and which would undoubtedly impart to any lava-form rock a new and very different lithological character. It seems vain, therefore, to hope for the discovery of igneous rocks ejected over the area of the Highlands during the deposition of the strata which are now visible as gneiss and schist.

It is otherwise, however, with the equivalents of these strata in the south of Scotland. There the greywacke and slate are comparatively little altered; and we may reasonably hope yet to detect amongst them traces of contemporaneous volcanic action. Throughout the lower Silurian grits and conglomerate bands of the Lammermuir Hills, felspathic material is especially abundant. I do not refer to the dykes and masses of felstone by which these strata are everywhere traversed, but to the material of which the strata are themselves composed, and which, of course, points to the existence of rocks at or near the sea-level, when the grits and shales of the Lammermuirs were deposited. Many of the grits consist of a yellow felspathic paste, with small rounded grains of quartz. Such beds scarcely differ from certain Old Red grits among the Pentland Hills, which lie upon and have been formed out of yellow felstones. It seems probable, therefore, that some of the currents which deposited sediment across the site of the Lammermuirs came from a region where felspathic trap abounded, similar, apparently, to part of what at the present day forms the chain of the Pentlands. Pebbles of various felstones are likewise of frequent occurrence among the thin conglomerate bands intercalated in the Lammermuir grits. It may be mentioned, in passing, that these features are not confined to the low place in the Silurian series represented by the grits of Berwickshire. I have traced the same admixture of felspathic matter in the grits and conglomerate bands throughout the entire thickness of the Lammermuir series, and across into the grits of the Pentland Hills, which an

* Geology of Fife and the Lothians. Edinburgh, 1839.

abundant suite of fossils, lately detected by the Geological Survey, has shown to be on the parallel of the Ludlow Rock. We cannot, of course, from such evi dence, decide upon the actual eruption of volcanic matter during the Lower Silurian period in Scotland, though, considering the great volcanic activity at that time manifested in North Wales, such eruption seems highly probable. Future labours in the great Silurian region of the south of Scotland will doubtless clear up this interesting question. In the meantime we have evidence that, whether erupted then or previously, there were at that time felstones in sufficient abundance to contribute, by their drifted debris, a marked feature to many of the grits and conglomerates throughout a large part of the Silurian district of South Scotland, from Berwickshire to the borders of Lanark.

Traps of Upper Silurian (?) and Lower or Middle Old Red Sandstone.

The junction of Lower and Upper Silurian strata in Southern Scotland has still to be traced. That it will be found to exist as an unconformity seems probable, though it is impossible at present to conjecture whether or not the unconformity is a violent one, and what amount of denudation the older series underwent before the deposition of the newer. If it be shown that the amount of the disturbance prior to the Upper Silurian was great, then we may perhaps refer to this period of movement part at least of the igneous rocks by which the lower Silurian region is intersected. At the same time, it must be borne in mind that felspathic dykes occur abundantly in the Upper Silurian and lower Old Red Sandstone series of Lanark and Ayrshire; and as these strata are often much tilted and broken, we shall probably not err in referring the igneous protrusions to the period of disturbance. It is quite possible, therefore, that the igneous rocks which so diversify the otherwise monotonous geology of Southern Scotland may be of two ages, one during the uptilting of the Lower Silurian, the other during that of the Upper Silurian and Lower Old Red Sandstone. At present I can determine only the latter series, and I shall present here the proofs on which this determination rests.*

The great Silurian tract which extends from St Abb's Head to Portpatrick consists, as is well known, of flexured grits and slates, often much shattered and broken, and almost everywhere traversed by dykes of various felstones, and

* Since the earlier part of this paper was written, I have had an opportunity of examining the geology of the east part of Berwickshire; especially the great ashy series in the neighbourhood of Reston, and along the coast from near Coldingham to Eyemouth. The structure of this region is often very obscure. It is possible that some of the felspathic conglomerates of the Ale Water may belong to the Lower Silurian series, but the greater part, if not the whole, of the ashy rocks of this district must, I think, be regarded as of Lower Old Red Sandstone age. Near the village of Reston I have found, in some shales in the ashy strata, remains of plants and broken crustacean fragments, which my colleague, Mr Salter, is inclined to consider as belonging to the *Pterygotus*. These strata are covered unconformably by the Upper Old Red Sandstone.

sometimes by masses of syenite or granite. While conducting the Geological Survey of the Lammermuir Hills during the summer of 1859, the number of these igneous protrusions astonished me. In nearly every glen I found the Silurian strata traversed by dykes, sometimes very small, and never very large, except in one or two instances. In some localities, indeed, the vertical grits and hardened shales seemed riddled, as it were, with interjected veins, and these, as a general rule, were observed to occur sporadically,—so much so, that when, after passing over a space free from dykes, I at last came upon one or two together, it could generally be predicted that a congregated group of veins and irregular knobs would be found in close proximity.

All these igneous rocks are intrusive; and in noting their varieties of colour and composition, their vast numbers, and their multiform intersections through the Silurian strata, I could not but wish to obtain, if possible, some clue to their date. For this purpose I examined the conglomerates of the Upper Old Red series, by which the Silurian strata of this region are unconformably covered. It required no long or careful search to discover among the rounded and subangular fragments of these conglomerates abundance of felspathic pebbles, often of considerable size, and plainly referable to the numerous dykes of the neighbourhood. Hence it became evident that the igneous rocks in question were older than the Upper Old Red Sandstone. And this conclusion received further confirmation from the fact that, though the Silurians are everywhere intersected by felspathic dykes, such dykes do not penetrate into the overlying Old Red Sandstone. After a survey of the whole of Lammermuir, I have discovered only four trifling felstone dykes among the Old Red Sandstone strata, while, in the Silurian grits and shales immediately adjoining, they may be counted by the score and the hundred. There could be no doubt, therefore, that the felspathic porphyries of Lammermuir date anterior to the deposition of the Upper Old Red Sandstone, and posterior to that of the Lower Silurian. The interval between these two formations was very great. It seemed possible, however, to define the age of the dykes more closely.

With this aim I sought, as a preliminary step, to connect the Old Red Sandstone of Lammermuir with the same formation in other parts of South Scotland, and to determine how far the Upper Old Red Sandstone descended in regular sequence towards the Silurian system. The district selected as best calculated to throw light upon the matter was the neighbourhood of Lesmahagow, along the borders of Lanark and Ayrshire.

The results of this examination I have described in a paper read before the Geological Society, 18th January 1860.* They may be briefly summed up in the statement that the Upper Silurian and Lower Old Red Sandstone, which form one

* See Quart. Jour. Geol. Soc., vol. xvi. p. 312.

consecutive series, are overlaid unconformably by the Carboniferous Limestone series, and that the same unconformity extends eastward between the Upper Old Red Sandstone and the lower member of that formation. The Carboniferous and Upper Old Red Sandstones form, therefore, one great physical series, and the Lower Old Red Sandstone and the Upper Silurian form another, while between the two conjoint groups there occurs a marked physical break. This new fact in Scottish geology is fraught with interest when viewed in connection with the intrusive rocks of the Silurian region.

The Silurian shales and Lower Old Red Sandstones of Lesmahagow are traversed by numerous dykes and masses of porphyritic felstone. These do not extend into the overlying Carboniferous strata, but are covered unconformably by them. They must therefore be later than the Lower Old Red Sandstone, and earlier than the Carboniferous Limestone. There can be little doubt that these igneous rocks, though probably not themselves the agents in tilting and shattering the strata among which they occur, nevertheless were ejected during a period of movement and disturbance. The structure of the Pentland Hills showed me very clearly that the great tilting of the Lower Old Red Sandstone in South Scotland had taken place before the deposition of the upper member of that formation; and the inference is probably not too hasty that the Lesmahagow felstones may have been produced during this period of subterranean movement, and that they must consequently be of an age intermediate between the Lower and the Upper Old Red Sandstone.*

From this region as a base line, and with this definite date, the igneous geology of the southern part of the island may perhaps be eventually worked out. We have here the clue to the history of that great series of felspathic rocks which traverse the higher part of Lanarkshire, and rise into such bold hills as Tinto. They are all probably of Lower or Middle Old Red Sandstone age, and it is not improbable that intercalated sheets of ash and sandstone may occur, especially towards the north-east, linking in this way the intrusive felstones of Lanark and Ayrshire, with the Upper Old Red interbedded sheets of the Pentland Hills.

To return to the Lammermuir region. The examination of the geology of Lesmahagow, though revealing many new facts in the igneous history of the country, did not directly throw any light on the date of the Lammermuir dykes. The evidence at present is briefly this:—We find the south of Scotland traversed by vast numbers of felspathic masses; some of these are of Old Red Sandstone age, and were thrown up during a tilting of the Lower Old Red Sandstone and older beds; others may possibly be older still, and may mark another period of subterranean movement anterior to the Upper Silurian. The district which promises best to

* How far the Middle Old Red is represented in the great series of purplish sandstones of Lanarkshire cannot at present be determined. It would probably be nearest the truth, however, to regard these felspathic dykes as of Middle Old Red Sandstone age.

clear up the relations of the Upper and Lower Silurian series and their igneous rocks is that which lies between West Linton, in Peebleshire, and the town of Lanark, and stretches southward to the flanks of the Silurian hills. When that district is worked out we shall probably know whether the felstones of the south of Scotland are referable to two separate periods of movement as I have suggested, or should be classed with the Old Red Sandstone igneous rocks of Lanark and Ayrshire. In the meantime, there is no direct evidence in Scotland of igneous action during the upper Silurian period. The oldest Scottish trappean rocks now visible at the surface, and of which the geological date is certainly known, belong to the Old Red Sandstone period ; although it may be possible to prove that part at least of the felspathic protrusions in the great Silurian region of the south were produced during or even previous to the Upper Silurian period.

The era of the Old Red Sandstone, almost from its commencement to its close, was characterised in Scotland by the frequency and magnitude of its igneous eruptions. Throughout the southern part of the country, as already remarked, there is proof, that after the accumulation of the lower, and it may be of the middle zone of that formation, a marked, and occasionally even a violent, tilting of the strata took place. This movement seems to have been accompanied by the extrusion of much igneous matter in the form of veins, dykes, and amorphous masses. Such are the rocks in the neighbourhood of Lesmahagow, and they not improbably occur over a wide stretch of country. These felspathic rocks may have been produced at some depth below the surface, and facts are not wanting to lead one to suspect that in not a few instances they are the results rather of a metamorphism of the adjacent rocks, than of actual protrusion from an independent mass of melted matter below. Be this, however, as it may, the date of their production is clearly fixed as intermediate between the Lower and the Upper Old Red Sandstone.

Viewing these felspathic protrusions of the south of Scotland as a whole, one cannot fail to be struck by the evidence of their comparatively deep-seated origin. There may have been instances over that wide area where the igneous forces found a vent for themselves at the surface, and poured out these melted rocks and ashy ejections. The Cheviot Hills, and one or two groups of minor eminences in the south-west of Berwickshire, may possibly have had such an origin. But the immense numbers of dykes and veins of felstone that traverse the Lower Silurian and Lower Old Red Sandstone districts of the south of Scotland, must undoubtedly be regarded as having been protruded and cooled, not at the surface, but at a considerable depth below it.

When we pass to the north side of the great Carboniferous belt that bisects the island, we find abundant evidence that the same powerful igneous action which characterised the southern part of the country also exhibited itself north of the Forth in great activity, during the Lower Old Red Sandstone period.

We there meet with lava streams and thick bands of interstratified ash and conglomerate, forming sometimes long chains of hills, and showing that the igneous forces not only existed below, as they did in the south, but that they continued to operate at the surface during a long geological period. The Sidlaw Hills, and the chain of heights cut through by the Tay at Perth, are illustrations of the character and extent of these ancient volcanic eruptions.

There is one characteristic section, hitherto (so far as I am aware) undescribed, laid open by the railway, about a mile south of Dunkeld. It shows the great difference lithologically between the felspathic rocks of the Highland region and those ejected contemporaneously with the deposition of the Lower Old Red Sandstone of Perthshire. During the greater part of last summer I was engaged, along with Sir R. I. MURCHISON, examining the crystalline metamorphic rocks of the Highlands, and devoted particular care to the discrimination of the various granites, granulites, syenites, porphyries, and felstones, which occur in that excessively altered region. Returning southward by Dunkeld, we visited the railway cutting there, beginning near the south end and walking northwards to the town. The first rock which met us was a pebbly conglomerate, which I was surprised to find consisted almost wholly of felspathic fragments. A scrutiny of several yards of the rock was sufficient to satisfy me that the fragments in question were not derived from the Grampians. They differed altogether from the compact crystalline quartziferous felstones of the metamorphic region, and resembled the interbedded rocks of other districts with which I was familiar. As we proceeded towards Dunkeld, lower beds of the series came successively into view, and the component fragments became gradually coarser, until they occurred as large as two feet, or even more, in diameter. They were dark, vesicular, slaggy-like masses, often quite angular, and were accompanied with only rare and small fragments of slate. At last we came to a band of dark cellular felstone, identical with some of the larger blocks just referred to. It was clearly a contemporaneous ejection, and showed the vesicular scoriaceous aspect, so common on the upper surface of a sheet of interbedded trap-rock. Below this band of felstone another, but less felspathic, series of conglomerate beds succeeded, which rested finally on the broken and twisted edges of the clay-slate.

From the railway we could see that this igneous series stretched towards the north-east as a line of rounded eminences. It seems probable, also, that not a few of the trappean patches inserted on the maps across the area of Perth and Forfar may have had a similar origin, and may belong to the same geological period. It becomes important also to inquire whether, as the conglomerate of Dunkeld is undoubtedly connected with the operation of volcanic forces, other portions of the great conglomerate series which flanks the Grampians may not have arisen, to some extent at least, from the same source.

There is thus clear proof of the existence of active volcanic force in Perthshire, and in the Sidlaws of Forfar, during the accumulation of the Lower Old Red Sandstone. To the same period, I am at present disposed to refer part of the range of the Ochils. The north-eastern prolongation of these hills is undoubtedly of the age, not of the lower, but of the Upper Old Red Sandstone, since the felstones and conglomeritic bands pass upward, and become intercalated with the yellow sandstones of Dura Den. But to the south-west, beyond Kinross, there appears to be unconformity of the Mountain Limestone on the trappean series, which is highly inclined, and ought probably to be connected with the Lower Old Red Sandstone of the valley to the north. But much careful research is still needed before the geological structure and age of this group of hills are understood.

The Campsie Hills, notwithstanding the able descriptions of them by Colonel IMRIE and others, are not yet brought into thorough chronological order. From the paper and sections by Mr YOUNG of the Hunterian Museum, Glasgow,* and from the information he has given me personally, I infer that these hills are on the whole contemporaneous with the north-east end of the Ochils; that is, of the age of the Upper Old Red Sandstone.

Passing still south-west, parallel to the boundary of the metamorphic region of the Highlands, other chains of hills are met with, consisting, like those already noticed, of igneous rocks. They stretch to the Clyde at Dumbarton, whence they spread southwards into a high undulating tract of country, forming the main ridge or water-shed of the counties of Renfrew, and part of Lanark and Ayrshire. From observations made at various parts of this range of hills, I regard the whole provisionally as belonging to the Old Red Sandstone. As in the case of the Ochil and Campsie Hills, the great Lower Carboniferous series of the Lothians is here absent, and we find the Mountain Limestone group fringing these old volcanic banks.

No better section of part of these trap-rocks exists than that which has been laid open by the waves of the Atlantic, along the coast of Ayrshire, from the Heads of Ayr southward to beyond Turnberry Point. The true interbedded character of the masses is there abundantly evident. Beds of compact felstone, sometimes strongly amygdaloidal, are intercalated among strata of ashy conglomerate, red sandstone, and marl,—the trappean ridges running out to sea as reefs, while the softer beds have been worn into sheltered bays, that look across the blue firth to the grey mountains of Arran.

Much still remains to be done in the region between the Ayrshire coast and the southern end of the Pentland Hills. In the course of a rapid excursion made in bad weather, towards the close of last autumn, I saw, at Corsancon Hill, some felspathic conglomerate of Lower Old Red Sandstone age (hitherto marked as trap), and have little doubt that part of the felstone ridge which bounds the

* Transactions of the Geological Society of Glasgow, Part I., 1860.

Silurian hills between Dalmellington and Straiton must be the source from which that conglomerate was derived; and consequently that, in Nithsdale as well as in Perth, the volcanic forces were at work during the Old Red Sandstone period. There are few areas of Scotland that promise to reward the observer with more interesting results than the high ground on the borders of the Silurian region, in the south of Lanarkshire and Ayrshire.

Allusion has been made to the felstones of the Campsie Hills and part of the Ochils, as belonging to the era of the Upper Old Red Sandstone. Another, and perhaps a still more characteristic example of volcanic rocks of this period, occurs in the chain of the Pentland Hills.

Trap-Rocks of the Upper Old Red Sandstone.

After the movements which resulted in the uptilting of the Lower Old Red Sandstone and Upper Silurian of central Scotland, the Upper Old Red Sandstone began to be thrown down upon the edges of the inclined and fractured strata. The base of this part of the series is well seen in the southern prolongation of the Pentland Hills, where it consists of a great thickness of conglomerate and sandstones resting on highly inclined and vertical Ludlow shales. The higher part of the series is intercalated with sheets of interbedded felstones and ashes, forming the northern part of the chain. Since these igneous rocks may serve as the type of contemporaneous traps of Old Red Sandstone date, I shall briefly sketch their general features.*

The Pentland Hills reach a height of about 1900 feet above the sea, and stretch south-west from Edinburgh, until they merge into the moorlands of Lanark and Peebles. They are bounded on either side by long parallel faults, which have brought down the carboniferous strata, sometimes vertically, and even reversed, against the older parts of the chain. The basement rocks of the hills are highly inclined grits, and slates, or shales, some of which, as I have already mentioned, contain a great abundance of fossils.† The general aspect of these fossils is regarded by Mr Salter as clearly placing them on the horizon of the Ludlows. Upon the tilted and denuded edges of these Silurian beds, there rests a great thickness of conglomerates and grits, which, though they have not yet yielded any organisms, are unquestionably parts of the Upper Old Red Sandstone. Northward, this series becomes thinner, until it finally disappears. Its upper part is intercalated with, and covered by, beds of felstone, which, swelling out towards the north, where the grits and conglomerates have thinned off, rest directly on the irregular surface presented by the upturned edges of the Silurians.

* See Mr Maclaren's "Sketch of the Geology of Fife and the Lothians," p. 124, and "The Geology of Edinburgh," in the Memoirs of the Geological Survey, where I have described the hills in detail. Compare also the Survey Map of this district, sheet 32 (Scotland).

† See Memoir to accompanying sheet, 32 of Geol. Survey of Scotland.

The upper part of the Old Red is consequently to a marked extent felspathic; the conglomerate there consists largely of various felstone fragments broken from the subjacent beds, and the grits in like manner display a considerable quantity of felspathic matter as a cementing paste. The felstone beds which follow vary greatly in texture and composition. Sometimes they are dark and crystalline, or pale and dull in texture, or earthy and highly amygdaloidal. Throughout the central and southern part of the range, these felstones are well defined, each sheet being traceable for a considerable distance,—sometimes for six or eight miles. Between these beds there occur thinner interstratifications of felspathic ash, sandstone, conglomerate, and breccia. At the north end of the chain much confusion supervenes, owing to the multitude of minor lenticular beds which occupy the long parallel sheets that run southward. Beds of felstone of all shades and textures, porphyritic, compact, and amygdaloidal, follow each other, or are interblended together with no apparent order, further than that their general line of strike corresponds with that of the central and south part of the hills. The bedded character of these masses is rendered more apparent by the occasional interstratification of ashy bands. These, however, are also of limited extent. In short, the whole aspect of the north end of the chain renders the conjecture of Mr M'Laren * a very probable one, that here or hereabouts lay the centre of eruption round which the minor flows accumulated, while the larger lava streams flowed for miles to the south-west, covering over or lapping round the islets of slate which had not been enveloped by the grits and conglomerates of the Old Red group. These igneous rocks are covered by conglomerates usually more or less felspathic, and these again gradually pass up into the finer calcareous conglomerates, sandstones, and shales of the Lower Carboniferous group.

In short, the Pentland Hills afford evidence that, at the time of the Upper Old Red Sandstone, the district to the south-west of Edinburgh was for a long while the seat of a powerful volcano, which sent out massive streams of lava and showers of ash, and continued active until well-nigh the dawn of the Carboniferous period. It will be the work of future years to ascertain the areas in Scotland which formed contemporaneous centres of volcanic eruption.

Trap-Rocks of Carboniferous Age.

We pass now to the Carboniferous system, which contains a more abundant series of the volcanic rocks than any other Scottish formation. The whole of the broad Carboniferous band which bisects the country from the Firth of Clyde to the mouth of the Forth and of the Eden is intersected in every direction by dykes and masses of trap. Nor is it merely their number that renders these igneous rocks remarkable. They take a large variety of forms, occurring as intru-

* Geol. of Fife and Lothians, p. 183. In this volume the structure of the Pentland Hills is delineated with great clearness, and in a truly philosophical spirit.

sive and interbedded, and as greenstones, basalts, felstones, and ashes. Moreover, they are found intercalated in nearly every horizon throughout the system, from the top of the Old Red Sandstone up to the top of the flat coals which, in the Lothians, form the highest part of the series. Every district has its dykes or hills of greenstone and basalt, and there are perhaps few areas of any considerable size which do not show traces of one or more distinct centres of eruption, by the beds of ash and melted trap intercalated among unaltered strata. As an illustration of these features, reference may be made to the area of the Lothians. There a continuous series of ashes, with associated greenstones and basalts, may be traced from the top of the Old Red Sandstone up into the upper coals of Stirlingshire. In this district there is no large group of the Carboniferous rocks without, in some locality, its traces of contemporaneous trap. Such traces are not, however, found over the entire area. On the contrary, they possess a markedly local character, so that a series of beds, which at one point displays interbedded trap, may exhibit it nowhere else, or may show at another distant point traces of another distinct series of eruptions. These features will perhaps be most clearly understood if we trace in outline the geological history of the region during the deposition of the Carboniferous rocks, marking, as we pass on, some of the principal volcanic ejections by which the succession of the series was diversified.*

At the dawn of the Carboniferous system the area now forming the basin of the Forth appears to have been covered by a broad but shallow firth, into which a variety of currents carried a constant burden of sand and silt. The sandstones and marly shales thus formed have yielded a few shells, as *Myalina*, *Anthracosia*, *Edmondia*, and *Athyris*, along with the spines of *Ctenacanthus*, and a considerable admixture of vegetable remains. This early period was marked by at least one centre of volcanic eruptions,—that of the trappean hills of Edinburgh. Streams of various lava-form traps and showers of ash were ejected at successive intervals, the pauses being marked in some cases by intercalated seams of sandstone and shale, with land plants and fish remains. After a mass of igneous matter, some 700 or 800 feet thick, had been thrown out at this locality, the volcanic forces became quiescent, and the old condition of deposition returned. Another unimportant eruption took place between Granton and Cramond, and then by degrees the firth seems to have silted up into a network of interlacing sandbanks, separated by ponds and lagoons of brackish water. The mud-flats and shallows nourished a luxuriant growth of the characteristic vegetation of the coal period, while the winding channels between had their floor covered with a thickening growth of *Cyprides*, *Anthracosiæ*, &c. The congregated remains of the *Cyprides* gave rise to a varying seam of limestone, which, occurring at

* For the details of part of this region, see the Memoir of the Geological Survey on the "Geology of Edinburgh" already referred to.

intervals all over the Lothians, has long been known as the limestone of Burdiehouse.

Some time before, and also during the formation of this calcareous seam, the volcanic forces, which had been at rest for a considerable period, broke forth again with great energy. There were at least two areas of eruption perfectly distinct from each other, alike in the character and amount of the material ejected. By much the most vigorous action was that displayed throughout the region from North Berwick to Dunbar, the long line of cliffs between the two towns still bearing forcible evidence of the fact. Immense quantities of red felspathic dust, mingled with stones of all sizes, up to a yard or more in diameter, were thrown out over an area of at the least a hundred square miles. It was on a floor of this volcanic sediment that the Burdiehouse limestone in East Lothian was deposited. In many localities, as at Tantallon, the limestone is markedly ashy in composition, and abounds with fine laminæ of silica, disposed in crumpled layers, like the deposits of some thermal springs. Above it comes another series of ash-beds and conglomerates, succeeded by a still higher group of sheets of felstone, which, attaining a great thickness, form the chain of the Garlton Hills. With the ejection of these lava-form traps, the igneous action in East Lothian appears to have ceased. A long bank of volcanic matter was left above the level of the surrounding water, and not until the lower part of the Carboniferous limestone group began to be deposited was the inequality of surface removed, and the whole area reduced, by subsidence and deposition of fresh sediment, to one continuous level. Upon the submerged beds of felstone the limestones began to accumulate in undisturbed succession; nor throughout the remainder of the Carboniferous rocks of East Lothian, is there any trace of further contemporaneous eruptions.

I have said that the volcanic rocks of the Carboniferous system throughout the Lothians are of a markedly local character. This is nowhere more conspicuously displayed than on the horizon of the Burdiehouse limestone. In East Lothian, as we have seen, that bed accumulated amid the multiform ejections of an active volcano. In Mid-Lothian, however, the calcareous sediment gathered in undisturbed lagoons. Although the active volcanic focus of North Berwick was only twenty miles distant, yet, so far as the evidence goes, no ash seems ever to have fallen among the cypris-shoals of Burdiehouse; but *Stigmariæ* clustered thickly along the shallower swamps, and *Lepidodendra* shed their catkins among the matted ferns and rotting leaves that floated on the surface of the water, or sank among the limy mud at the bottom.

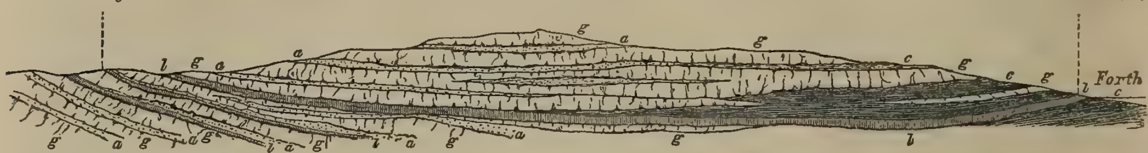
On the west side of this undisturbed area, that is in Linlithgowshire, and the south-west of Mid-Lothian, there are traces of another centre of volcanic action on the same horizon with the ash-beds of North Berwick and Dunbar. A green, fine-grained felspathic ash is there found in several localities, below and above the Burdiehouse limestone; and at one locality (Corston Hill) a large sheet of felstone, intermingled with ashy layers. But it is possible that among the exposures of these rocks we have parts of several local eruptions, at all events, they do not exhibit the strongly marked features, and wide extent of the East Lothian ashes.

After the period of the Burdiehouse limestone, volcanic rocks ceased to be ejected over the counties of Edinburgh and Haddington, while Linlithgowshire became eventually the seat of a vigorous and long continued volcanic activity. During the accumulation of the sandstones and shales which cover the Burdiehouse limestone, showers of ash were of frequent occurrence, and these, along with ejections of greenstone, continued to increase in number up to the beginning of the Carboniferous Limestone. The range of hills from Bathgate to Borrowstounness exhibits on a grand scale the character and extent of the trappean rocks with which that limestone is associated. Beds of limestone are there seen passing into seams of ash, each full of the characteristic organisms of the series. Sheets of greenstone run horizontally among limestones, shales, and ash-beds; lenticular beds of limestone sometimes laminated with silica,* as in those of North Berwick, occur isolated among the ashes and basalts; while the whole series is traversed by dykes, and broken through by huge amorphous masses of greenstone that sweep up into rugged hills. It would be foreign to the purpose of the present paper to enter into the details of this most interesting region, I can only remark further, that when the lower part of the coal-field began to accumulate above the Carboniferous Limestone in this region, there existed a low volcanic bank which probably rose above the water-level and separated the coal swamps of Bathgate from those of Borrowstounness. From this bank, during the growth of the adjoining coal-fields, there issued several flows of greenstone and basalt, which, accumulating to a greater depth on the north side, now form enormous sheets in the coal-fields, and have to be sunk through for upwards of 400 feet, before the lower seams of the Borrowstounness coal-field are reached. The slow subsidence which had been going on all through the Carboniferous period, gradually brought down the volcanic islet beneath the sea-level, and eventually there formed over it and over the adjacent coal-fields, a thick series of sandstones and shales, with two seams of marine limestone. During these later changes, the old igneous forces had not become wholly dormant, as is sufficiently proved by several sheets of ash between the limestones and thick beds of greenstones above them. Another series of coal swamps, similar to the first, at length sprang up over the entombed limestones and traps, and stretched away to the east over the site of the old island. Yet these forests also eventually disappeared beneath a new succession of igneous ejections. How much further this history may be

* A beautiful example occurs in the East Quarry, Kirkton, first noticed by Dr Hibbert (Trans. Royal Soc., Edinburgh, vol. xiii. p. 278). See also "Geology of Edinburgh" (Memoirs. Geol. Survey).

pursued, will be known when the geology of Stirlingshire and the area to the south-west comes to be thoroughly worked out, but my examinations have carried me no further at present. The trap-rocks of Linlithgowshire are, so far as I yet know, the latest Carboniferous traps in Scotland.

Fig. 1.—Diagram-section to show the intercalation of sheets of volcanic material among the Carboniferous strata of the Bathgate Hills.



c. Carboniferous Sandstones, Shales, Coal, and Ironstones. *l.* Carboniferous Limestone.
g. Sheets of Greenstone and Basalt. *a.* Beds of Stratified Ash.

In quitting the Carboniferous system, let me repeat in one sentence that this group of rocks, as displayed in the region of the Lothians, shows a regular succession of contemporaneous igneous rocks throughout its entire thickness; that the volcanic forces first broke out about the centre of the district at Edinburgh; that, after becoming quiescent there, they reappeared simultaneously at the time of the Burdiehouse limestone in East and West Lothian; that by the time of the Carboniferous Limestone they had become extinct in the former area, but gradually increased in energy in the latter, where they continued in operation at intervals throughout the rest of the Carboniferous period.

At this point there lies a wide gap in the evidence. Of Permian or Triassic trap-rocks I am not aware that Scotland has yet furnished any examples; and thus, leaving the greenstones of the Carboniferous, we pass to those of the Oolitic group.

Traps of Oolitic Age.

That wild, rocky chain of islands known as the Inner Hebrides, extending from Oban to the Shiant Isles, consists mainly of vast trappean masses, overlying and interstratified with limestones, shales, and sandstones, which in their fossils correspond to the English Lias and Oolite as far upwards as the Oxford Clay.

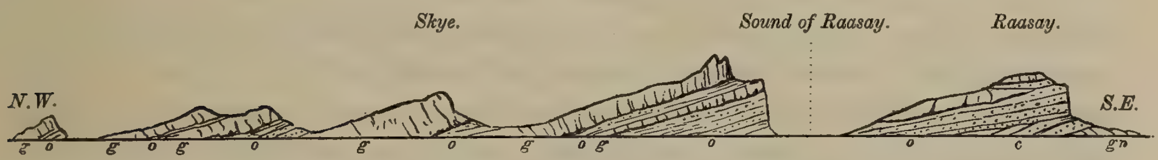
The Lias of Skye is much traversed by dykes of greenstone and basalt, and likewise cut through and metamorphosed by great hills of syenite. It presents, however, no trace of contemporaneous ejections, though, as I have elsewhere shown,* some of its beds, by their brecciated and unconformable character, afford indications of such subterranean movements as, in the succeeding Oolitic period, produced the greater part of the mountains of Skye and Raasay. The dykes and likewise the syenites are of two ages, the whole being probably later than the

* Quart. Jour. Geol. Soc., vol. xiv.

Oxford Clay. To the age of these syenites must be attributed the remarkable metamorphism of the Lias Limestone of Strath,* and possibly also that of the hypersthene of the Cuchullin Hills.

It is not, however, until we pass up into the upper part of the Lower Oolite that we meet with continuous sheets of greenstone. These, often beautifully columnar, are found resting on the precipitous line of cliffs north of Portree, and capping the higher part of the opposite island of Raasay. In their lower portion they appear intruded among the limestones, shales, and sandstones; but as we trace them across the north-western part of Skye, they are seen to be regularly interbedded among estuary limestones and shales. The deep indentations along the northern shore of the island are due to the wasting away of these strata; while between the lochs the sheets of greenstone swell into rugged heathy hills, or shoot up as precipitous cliffs, which the frosts of winter are carving out into grotesque pillars, and wearing down into heaps of rubbish.

Fig. 2.—Diagram-section to show the intercalation of Igneous Rocks among the Oolitic Strata of Skye and Raasay.



The estuary beds of Loch Staffin, worked out by Edward Forbes in 1851, form the lowest of the group, and are succeeded by enormous sheets of greenstone and basalt (*g*, fig. 2), between which occur other estuary limestones and shales, along with several seams of coal (*o*). During part of the autumn of 1858, I ascertained this to be the structure of the wide sweep of country, hitherto coloured as one sheet of trap, extending from the Atlantic to the Sound of Raasay, but I was prevented from working out the details. It is not one sheet of greenstone, but a series of successive sheets, with fossiliferous bands between. The fossils collected by me from these bands are now in the hands of Dr Wright, who has kindly undertaken their examination.

That these greenstone beds are contemporaneous with the strata among which they occur I have little doubt, though another visit will be needed before this statement can be fully verified. Their mere extent and regularity, as well as the unaltered character of the shales, limestones, and coal beds, wherever I have seen them, seem indications of synchronism rather than intrusion, an opinion that was very strongly maintained by Dr Boué.†

* Quart. Jour. Geol. Soc., vol. xiv. p. 1, *et seq.*
† Essai Geologique sur l'Ecosse, p. 220, *et seq.*

Trap-rocks of Tertiary Age.

Among the Trappean islands of the Hebrides and the adjacent shores of the mainland, there is still a wide field for investigation. My own researches have reached upward from the base of the Lias to the top of the Middle Oolite; and it seems highly probable that some connecting links will yet be found between the Oolites and the leaf-beds discovered by the Duke of Argyle at Ardtun in Mull. Meantime, however, the links are wanting: from the Middle Oolite basalts of Skye we pass to the Tertiary basalts of Mull. The age of the latter is marked by the dicotyledonous character of the leaves, which occur in bands of clay intercalated among beds of basalt and volcanic ashes. The existence of these leaf-beds, with their associated volcanic rocks, is of great interest when regarded in connection with the basalts of Ireland on the one side, and with the great extent of similar beds among the Hebrides on the other. It is not impossible, however, that traces of volcanic rocks of the same, that is, of tertiary age, may be found on the mainland, even in localities considerably removed from the Ardtun district.

In examining the geology of Arthur's Seat for the Geological Survey, I was particularly struck with the features of the newer which rest on the older volcanic rocks of the hill. When studied in connection with the surrounding country, the interval of time represented by the unconformity seemed constantly to widen, until it became evident that the upper series of basalts and ashes was not only later than the Carboniferous system, but possibly later than even any part of the Palæozoic rocks. I was afterwards made aware of a suggestion of the late Professor Edward Forbes, that the upper part of Arthur's Seat might possibly be of Tertiary age. Until a large portion of Scotland has been minutely examined, it will be impossible to decide this question. In the meantime it is sufficiently evident that these Arthur's Seat rocks are long posterior to the Carboniferous system, and if not tertiary, must at least belong to the later part of the Secondary series.*

Later Trap-dykes of Scotland.

It is a point of some interest to determine the general direction and probable age of the great greenstone or basalt dykes, by which all the rocks of Scotland, whether of aqueous or igneous origin, are more or less traversed. Their direction, when viewed in a broad way, is strikingly persistent from north-west to south-east—*i.e.*, across the prevalent strike of the rock-formations. Variations occur in many localities, being determined either by some change in the strike of the rocks, or more usually by the position of faults along which the igneous matter has risen from below.

* For a full statement of the evidence on which this conclusion is based, see "Geology of Edinburgh" (Mem. Geol. Surv.).

Beginning at the south-east side of Scotland and the northern part of England, we find long dykes of greenstone traversing the country in rectilinear lines. One of these was described by Mr MILNE-HOME* in his Memoir on the Geology of Roxburghshire. It runs in a west north-west direction from beyond Hawick to the crest of the Cheviot Hills near Hyndhope, whence it runs eastward to the sea. Another dyke, with a nearly similar direction, was observed by myself in the north part of Northumberland. One branch crosses the Tweed below Coldstream and meets another a few miles toward the east, whence both range south-eastward to Holy Island. If the line of the Hawick dyke be prolonged towards the north-west, it will be found to pass through the small coal-field of Douglas. It is remarkable that in that coal-field, passing north-westwards across the Haughshaw Hills, a large greenstone dyke does occur, the direction of which I found to be similar to that of the Hawick one. In the same district also I detected another massive dyke running parallel to the last, and crossing the upper part of the valley of Muirkirk. These dykes cross all the other igneous rocks of the district in which they occur, and are plainly the latest formed.

In the Lothians, the larger dykes have an east and west, or west-by-north-east by-south direction, sometimes, however, veering to west-by-south, east-by-north. Their line of strike appears to be, in most cases, determined by some previous line of fissure, and their course can usually be determined with ease even where they cut through masses of greenstone of similar lithological characters. Some instructive examples of this kind occur in the hilly ground south of Linlithgow.

In Bute and Cantyre a north-westerly trend characterises the greenstone dykes, and the same direction is maintained in Islay and Jura.† From these islands northward, along the whole of the wild western coast, nothing can be more striking than the persistence of this north-westerly trend. Whether the rock traversed be crystalline syenite, metamorphic gneiss, contorted schist, or gently-inclined oolitic sandstones and shales, the dykes of greenstone are seldom diverted from their course. They run across lonely glens and up the sides of rugged mountains like lines of ruined ramparts, and then away out to sea like huge moles and breakwaters raised by some superhuman agency against the fury of the western waves. In some localities, as, for example, in the little island of Pabba, between Skye and the mainland, they occur in such numbers that one might almost cross the district by stepping from dyke to dyke.‡

* On the Geology of Roxburghshire.—Trans. Roy. Soc. Edinb., vol. xv. p. 456.

† In these islands there is an older group of magnesian greenstones, which run *parallel* to the strike of the schists—*i.e.*, from south-west to north-east. It is instructive to see how completely these are cut through by the newer group. I have described these features in a joint paper on the Metamorphic Rocks of the Highlands, by Sir RODERICK MURCHISON and myself (Quart. Jour. Geol. Soc., vol. xvii. p. 210). The same facts have been observed by Mr JAMESON in Cantyre and Knapdale (Quart. Jour. Geol. Soc., vol. xvii. p. 140).

‡ See my paper on Skye and Pabba (Quart. Jour. Geol. Soc., vol. xiv. p. 1, *et seq*).

The age of these dykes can of course only be approximately reached. One cannot fail to observe, even at the outset, that they all point towards the great volcanic centre of the Inner Hebrides. Further, as we examine the country more closely, we discover that they increase in number as they are traced from south-east to north-west; that is, towards this volcanic area. I have already shown that the igneous rocks of Skye and the adjoining islands are later than the lias, and are probably of the age of the Middle Oolite. It seems to me, therefore, a reasonable inference, that the long north-west and south-east dykes which range from these islands across central and southern Scotland may be, partly at least, if not entirely, of Oolitic age. And this inference is strengthened by the curious fact, that when we trace one of these long dykes out of the palæozoic rocks of the Border country into the northern counties of England, we find it traversing liassic and lower oolitic strata. Thus, at both ends of the series, Secondary rocks exist, and at both localities they are cut through by the prolongation of the series of north-west and south-east dykes which occur in the central and southern Scottish counties.

In conclusion, the points in Scottish geology which I have endeavoured to prove in this communication are,—

1. That in the metamorphosed Lower Silurian region of the Highlands, there appears to exist no trace of interbedded igneous rocks, but that in the less altered equivalents of these Lower Silurian strata, in the south of Scotland, there are traces, if not of the actual eruption of felspathic rocks, at least of their existence at the surface during the Lower Silurian period.

2. That the vast number of felspathic dykes in the south of Scotland may perhaps be referred to two geological ages,—one prior to the deposition of the Upper Silurian series (but this requires further evidence); the other, between the Lower and the Upper Old Red Sandstone, as is shown by the hills of Lesmahagow.

3. That while, in the south of Scotland, during the earlier ages of the Old Red Sandstone period much, if not all of the igneous activity went on at some depth below the surface; in the central counties, it manifested itself in the eruption of vast sheets of melted lava, and showers of ash and scoriæ; that these volcanic materials occur both in the lower and upper zones of the formation, and have given rise to chains of hills, as the Sidlaws, the Ochils, the Pentlands,, the Campsie Hills, and the range of high ground extending for many miles to the south-east of Greenock.

4. That after the cessation of the volcanoes of the Upper Old Red Sandstone, and the deposition of the earlier part of the Carboniferous series, the igneous agencies broke out again, not however to the same extent as during the previous period; that the Carboniferous era in Scotland was characterised by the abun-

dance and activity of its volcanic foci—so much so that there is not a well defined zone of Carboniferous beds in the Lothians which does not at some point display its intercalated sheets of ash or greenstone; but these eruptions were markedly local alike in their extent and in the character of their erupted material.

5. That after the Carboniferous series, there is at present a great gap in the chronology of the Scottish trap-rocks, the next known records of volcanic action being the greenstone and basalt hills of Skye, Rasay, and the islands to the south, which probably belong to the epoch of the Middle Oolite.

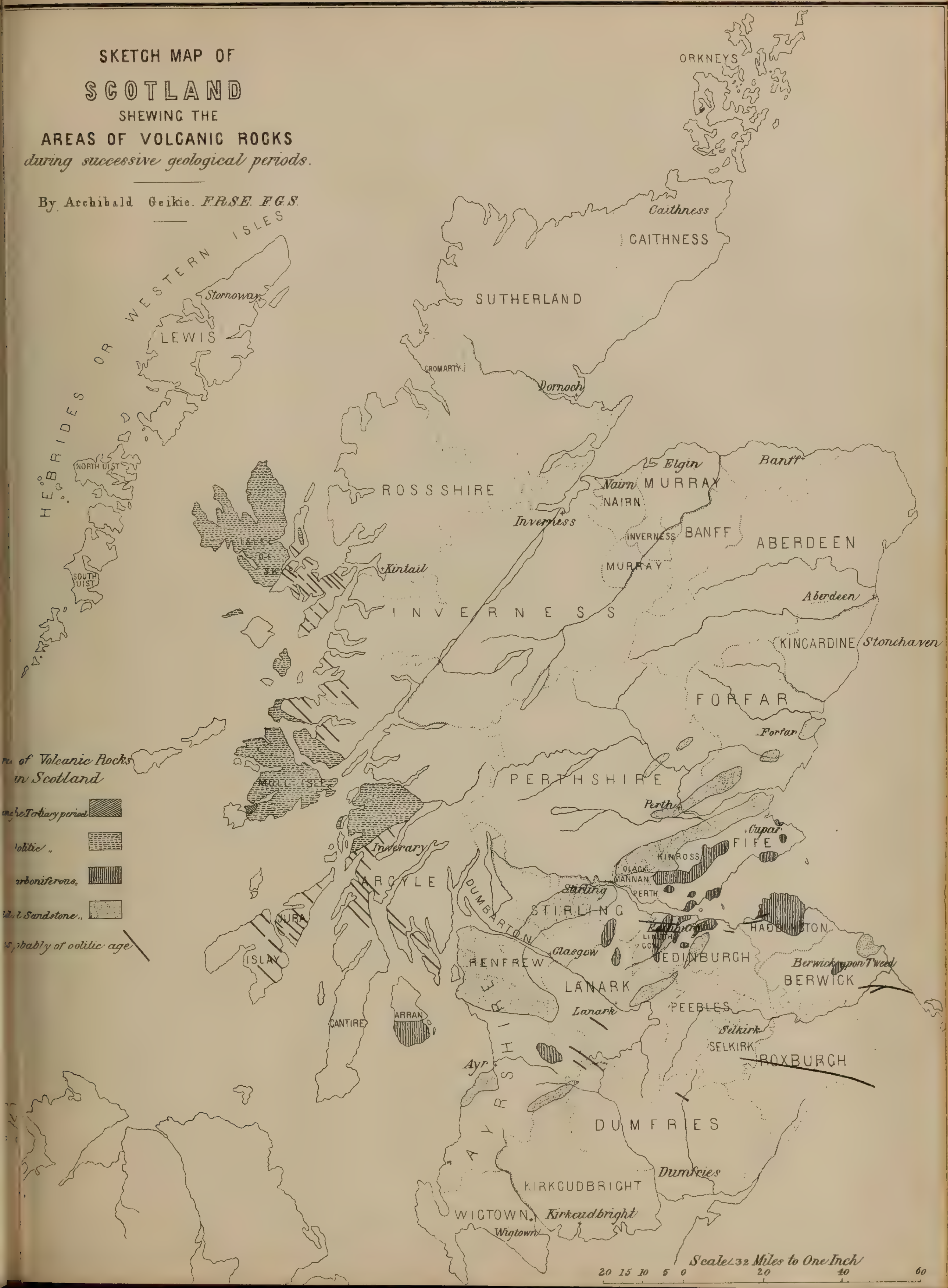
6. That to the same Oolitic period we ought probably to refer the long north-west and south-east dykes which range from the Inner Hebrides across Scotland to the coast of Northumberland and Durham.

7. That of Upper Secondary igneous rocks, Scotland has not yet furnished any trace; but that in Mull there occur basalts and ash-beds which, from the association with them of dicotyledonous leaves, have been referred to the age of the Miocene Tertiary.

8. That the upper part of Arthur's Seat is long subsequent to the igneous rocks on which it rests, and may possibly be of the same age with the Miocene lavas of Mull.

The facts stated in the preceding pages suggest some curious reflections on the question whether or not the volcanic forces are deep-seated. Thus the contemporaneous trap-rocks of the Old Red Sandstone are highly felspathic—felstones, porphyries, and felspathic ashes and conglomerates. The lava-form traps of the Carboniferous series are nearly all augitic—greenstones, basalts, &c. The felstones as a rule, cover large tracts of country; the greenstones occur only as local and sporadic patches. Again, the dykes that traverse the Silurian and Lower Old Red Sandstone districts are almost entirely felstones; those in the Carboniferous tracts are as uniformly basalt or greenstone. These latter dykes are dark crystalline rocks; those of the Upper Old Red Sandstone of adjoining tracts (as in Haddingtonshire and the Pentland Hills) are dull, compact, and ferruginous. In short, we can hardly resist the conclusion, that the nature of the igneous dyke has some relation, whatever it may be, to the nature of the rock which the dyke traverses. And if this be so, we are led to ask, whether the force which produced the dyke may not have been less deeply seated than is commonly sup- posed?

In another paper on this subject, I shall endeavour to show, that during the accumulation of the Upper Old Red Sandstone and the Carboniferous rocks of central Scotland, the subterranean forces operated not only in the eruption of volcanic material, but to a marked degree in the elevation and depression of part of this district; and that these movements were attended by some important changes in the physical geography, and in the Fauna and Flora, of that ancient period.


SKETCH MAP OF
SCOTLAND
SHEWING THE
AREAS OF VOLCANIC ROCKS
during successive geological periods.
By Archibald Geikie. F.R.S.E. F.G.S.
of Volcanic Rocks
in Scotland
the Tertiary period
olitic „
rboniferous,
l Sandstone „
probably of oolitic age
ORKNEYS
Caithness
CAITHNESS
SUTHERLAND
CROMARTY
Dornoch
HEBRIDES OR WESTERN ISLES
Stornoway
LEWIS
NORTH UIST
SOUTH UIST
ROSS SHIRE
Inverness
Elgin
Banff
Nairn
MURRAY
NAIRN
INVERNESS
BANFF
ABERDEEN
MURRAY
Kintail
INVERNESS
Aberdeen
KINCARDINE
Stonehaven
FORFAR
Forfar
PERTHSHIRE
Perth
Cupar
FIFE
KINROSS
CLACKMANNAN
PERTH
MULL ISLE
Inverary
ARGYLE
DUMBARTON
Stirling
STIRLING
JURA
ISLAY
HADDINGTON
Edinburgh
EDINBURGH
Glasgow
RENFREW
LANARK
Berwick upon Tweed
BERWICK
PEEBLES
Lanark
ARRAN
CANTIRE
Selkirk
SELKIRK
ROXBURGH
Ayr
AYRSHIRE
DUMFRIES
Dumfries
KIRKCUDBRIGHT
WIGTOWN
Kirkcudbright
Wigtown
Scale 32 Miles to One Inch
20 15 10 5 0 20 40 60

XXX.—*Memoir of Rev. John Fleming*, D.D., F.R.S.E. By ALEXANDER BRYSON, Esq., P.R.S.S.A.

(Read 4th March 1861.)

If it be true that "there is a history in all men's lives, figuring the nature of the times deceased,"* how much more worthy of record the lives of those who have left an impress upon their age, who have corrected popular errors, have made clear much that was obscure, and, from the force and fulness of truth in them, have become the great teachers of their time. The histories of such lives figure more than the "times deceased,"—they teach us how to occupy our time; and though these earnest men are dead, their works are yet living epistles, ever speaking to those "who have ears to hear."

It was wise in this Society to encourage the production of memoirs of those who have contributed, by their labours, patronage, or example, to further the cause of science and literature. The following memoir of a deceased member is a humble addition to the many already published in this Society's Transactions.

JOHN FLEMING was the third son of ALEXANDER FLEMING and CATHERINE NIMMO, and was born at the farm-house of Kirkroads, near Bathgate, on the 10th of January 1785, and baptized on the 13th of the same month. FLEMING's ancestors had long been tenants of the farm of Kirkroads; and his father, during JOHN's boyhood, worked a limestone quarry near at hand, for his own farm purposes, as well as for sale. It may be said that he was thus early initiated into a knowledge, however limited, of economic geology. Few, if any, of his contemporaries remain, from whom might have been gleaned the history of his schoolboy days. This much at least is known,—he was not distinguished for maintaining any high position in his class; nor was any great love of scholastic lore a feature of his after life. But he had an inner life, little sympathized with then, as he rambled about the rocks of Kirkton, studying the strange metamorphoses they exhibit, and laying up a store of facts which were to bear rich fruit in his riper years. While at the University of Edinburgh, studying for the ministry of the Church of Scotland, he attended Dr HOPE's chemical class in 1802, and about this time made the acquaintance and acquired the friendship of THOMAS THOMSON, then a young and ardent lecturer on chemistry in Edinburgh, To this early friendship FLEMING referred his fondness for chemical analysis, and gave THOMSON the credit of instilling into him the opinion that chemistry was the only basis

* King Henry IV., Second Part, Act iii. Scene 1.

on which mineralogy should rest. This subject was indeed his first love, and the last effort of his life was devoted to its advancement. When Thomson died in 1852, Fleming said that he had lost his best and earliest friend.

In the year 1805 Fleming had completed his clerical curriculum, and was licensed as a preacher of the gospel by the Presbytery of Linlithgow on the 22d April 1806. Fleming's father and mother were attached to the Old Light Dissenters, who strove after a higher and more strict observance of the ordinances of religion (as they thought) than the Church of Scotland at that time. He was, however, carried to the parish church to be baptized; and when the clergyman gave out the second verse of the forty-seventh paraphrase,—

> "When to the sacred font we came,
> Did not the rite proclaim
> That, washed from sin and all its stains,
> New creatures we became?"—

the verse was very repugnant to Fleming's father, as he held that it implied the doctrine of baptismal regeneration; so the old stern dissenter put on his hat and walked out of the church until the offensive paraphrase was sung. This incident was of course well known in the family circle; and when Fleming had been licensed to preach, he was requested to officiate in the same church where, twenty-one years before, he had been baptized. Among the other relatives who came to hear the youthful clergyman was his father; and whether to test his parent's adherence to his old views, or perhaps to show his independence, Fleming chose for his first hymn the same distasteful paraphrase. No sooner were the verses announced than old Fleming, as before, put on his hat, and remained outside until the psalmody was concluded. He inherited from his father at least one quality which distinguished him through life—inflexibility of purpose.

Towards the end of 1807 he made a mineralogical tour through Orkney and Shetland, the first fruit of which was a paper on Papa Stour, one of the Shetland Islands. This paper was communicated to the Wernerian Society, and found a place in the first volume of their Transactions. It exhibits considerable knowledge of mineralogy, and is worthy of notice on account of his having given there, for the first time, the true definition of the term Breccia, which geologists had previously applied to denote formations as identical which were very different in structure. He says,—"I have employed this word (breccia), which is of frequent use, to express an aggregated rock of angular fragments, cemented by a basis of a different composition. It differs from pudding-stone not only in the cement, but in the fragments not being rounded. From conglomerate it likewise differs, in the fragments not being the same with the cement." He also, in this paper, indicates his belief that the filling up of cavities in amygdaloidal rocks by quartz, fluorspar, carbonate of lime, and carbonate of barytes, is due to subsequent molecular changes after the deposition of the beds.

By a strange accident, this mineralogical tour was the means of introducing him to his first ministerial charge at Brassay, in Zetland, vacant for some time previous to his visit to the islands. The patron, Lord Dundas, had not presented within the prescribed period, and the Presbytery of Lerwick claimed the exercise of the *jus devolutum*. Mr Fleming had preached with considerable acceptance to the congregation whose pulpit had been so long vacant, and the charge was offered to him by the Presbytery. With his usual deep sense of duty, and as a proof of how early he had imbibed a dislike to patronage as then exercised, he consented to accept the vacant charge only on condition of a large majority of the elders and heads of families desiring him for their pastor. This proof of their esteem and confidence was not long withheld, and he was duly presented to the parish of Bressay. But the document presenting him to the charge had only been a short time completed when a vessel which had been detained by stress of weather arrived at Lerwick with Lord Dundas's presentee on board. In this dilemma his Lordship wrote to Mr Fleming, urgently entreating him to resign the charge, and promising him instead the first vacancy which opened to his patronage. To this request Fleming replied, that he would be guilty of injustice to his parishioners, who had so unanimously desired his ministry, and also to the Presbytery of Lerwick, whose nominee he was, adding, with his usual causticity, that "a bird in the hand was worth two in the bush." This straightforward conduct, instead of irritating Lord Dundas, was the means of drawing patron and pastor more closely together, and, as we shall see in the sequel, procured for Fleming all the advancement which lay in his Lordship's power. While settled at Brassay he began to collect zoophytes, molluscs, and other marine productions so profusely thrown on shore in that boreal region, and there obtained the nucleus of perhaps the most extensive and perfect collection illustrative of the natural history of the British Islands in the possession of any private individual. Among the first captures that he made was a small-headed narwhal, which was thrown on shore at the entrance of the Sound of Weesdale, in Zetland, on the 27th September 1808. The description of this animal he communicated to the Wernerian Society, and it was published in the first volume of their Transactions. This paper derives some importance from its proving that Lacepède, the famous French ichthyologist, was wrong in not admitting the *Monodon microcephalus* to a place in the British fauna, as well as from its being the means of procuring for Fleming the friendship and correspondence of Sir Joseph Banks. About this period, at the request of the late Sir John Sinclair, he undertook an examination of the economic mineralogy of the Orkney and Shetland Islands. In this paper he regards the mineral products of these islands strictly in an economic view, the scientific points being previously discussed in his paper on Papa Stour. On the recommendation of Sir John Sinclair, the Government had agreed to defray all the expenses of the survey; but, with the usual liberality of our Government to scientific men, the young minister of Brassay was left twenty pounds minus his expenses. In 1809, while still at Brassay, he considered himself labouring under consumption, and in the concluding passage of a letter to the late Dr Neill thus alludes to his condition:—"The very vermes which I am now so fond of examining will soon examine me—nay, consume me. If it must be so, I hope to die in peace."

But the *vis medicatrix naturæ* was strong within him, and he lived for nearly half a century after this, to do battle for the truth, and to crush many a crude hypothesis which authority had made current. Had he died then, Buckland's "Reliquiæ Diluvianæ" might have reached a third edition, instead of being recalled, and some of Cuvier's assertions have remained unchallenged, or left perhaps for Owen in our own day to refute. From Brassay, Fleming sent to the Wernerian Society a paper—the fruit of his rambles in his native county—entitled "An Outline of the Flora of Linlithgowshire," specifying only such plants as are omitted by Mr Lightfoot, or are marked as uncommon by Sir James Edward Smith. This he stated was to be considered as the first of a series of communications illustrative of the natural history of his native country, and was the chrysalis of which his work on "British Animals" was the imago. Towards the end of this year (1809) he communicated to the same Society a description of several rare vermes discovered by him in Shetland. This paper does not appear either in the Proceedings or Transactions of the Wernerian Society. In 1810, the parish of Flisk, in Fifeshire, became vacant, and the patron, Lord Dundas, placed the presentation in the hands of Mr Fleming, on the 30th of July. Having preached acceptably to the congregation, he received an unanimous call, and entered on the duties of his sacred office. In this comparatively civilised district, he found more leisure than in the wide-spread though thinly-peopled parish of Brassay. He was also near to St Andrews, so as to permit him to enjoy the society of many of his early friends who were there resident. Flisk is distinguished as one of the smallest parishes in Scotland, and the least populous, as at this time it only numbered 213 souls. It neither had a village nor a resident proprietor. There was not even a baker or butcher, and, what is still more surprising, there was not a public-house in the parish. The stipend, though higher than at Brassay, was nearly as limited as the extent of the parish, scarcely averaging L.150 per annum, during his incumbency, and he often complained of the *res angustæ domi*. In Flisk he spent twenty-two years of the most active, and certainly the happiest, period of his life. One of the first visits he paid after his settlement at Flisk, was to the manse of the adjoining parish of Kilmany, where Chalmers had been for five years the pastor. We should feel ourselves unfaithful to the memory of Fleming did we not take notice of three entries in the diary of Chalmers which allude to this period. These remarks are interesting as incidents in the lives of two eminent men, but still more so as they exhibit what John Foster in his Essay has shown so forcibly to be the great difficulty of even the greatest of mankind—to write a diary wherein they who, with a fine scalpel, lay bare the hearts of their fellows, shall yet exhibit the secret recesses of their own. In this respect Chalmers was like other men, and, with all his largeness of heart and intellect, exhibits in these passages how prone we all are to err, when writing a memoir of ourselves. In his diary Chalmers says, at date 8th September 1810—

"Walked to Monzie. At dinner we had Mr Fleming, presentee to Flisk; accomplished in some interesting branches of science, and promises to be a great acquisition to me, from the congeniality of some of our pursuits. Let me never forget the pre-eminence of religion!

"*Sunday, September 9th.*—Preached twice as usual. Had a pleasant scientific conversation with Mr Fleming all evening. Find him a valuable accession in this point of view, but I must keep up with him a tone of seriousness upon religious subjects. Have to thank God for giving me courage to go through the exercise of family worship.

"*September* 11*th.*—Had a long walk with Mr Fleming, and am happy to find he expresses a high sense of duty on the subject of the clerical office."

When the admirable memoir of Chalmers appeared, by his gifted son-in-law, Dr Hanna, Dr Fleming asked me if I had read these passages, and what impression they made? My answer was, that he (Dr Fleming) was evidently more interested in discussing scientific and natural history topics than those more suited to the Sunday evening fireside of a Presbyterian clergyman. His reply was short and characteristic. "Yes," he said, "the world will not blame Chalmers; but if sin there was that night, he was the sinner. I was his guest, he was my senior, and through the whole evening he led the conversation."

From hints afforded by his letters, he appears at this time to have observed the fact (which he has not brought forward so prominently as it deserves), that all basalts rest perpendicularly on the strata beneath; or rather, that by observing the angle which the axis of a basaltic pillar makes with the horizon, we may predict that the strata on which it rests are at right angles to that plane. From this he deduced that the columnar arrangement of basalt was not due, as had been *a priori* assumed, to igneous fusion, but was derived from volcanic action, either primarily, in a muddy condition, or, like the peperino of Italy, thrown up from the bowels of the earth, but afterwards arranged by water. Further, that the apparent crystalline form was due to the effect of shrinkage, as we see finely exampled in the peculiar forms—almost basaltic—assumed by starch, from its shrinking during the operation of drying. In support of this view he laid it down as an axiom, that no crystallization takes place without a definite chemical composition; and that as basalt was only a mechanical one, the forms were due to shrinkage, not crystallization. Among many examples in proof of his views on this subject, he adduced the Rock and Spindle near St Andrews, in a paper published in the second volume of the "Wernerian Society's Transactions," of which he says,—"This rock is about 40 feet in height. Towards the base, there is a spherical concretion of basalt, in the form of five or six-sided lengthened pyramids meeting at the apex, giving to the mass a stellate appearance. The mass is likewise divided into concentric layers. The basalt contains crystals of augite with olivine, and glassy felspar. This concretion of basalt is surrounded with the tufa into which it gradually passes; and must have been completely enveloped by it previous to its partial wasting away by the action of the sea and atmosphere. It may be mentioned in this place, that the regular basaltic columns at Elie are a portion of a spherical concretion contained in trap tuff. Here the concretion is only about ten feet in diameter, at Elie it is several hundred feet. In other parts of the tuff, small masses of amygdaloid and basalt occur, leading directly to the conclusion, that the bed is partly mechanical and partly a chemical deposit; since these rocks imperceptibly pass into one another. If the regular forms of basalt induced Dr Hutton to conclude that they furnished proofs of the action of a central heat, he would have found considerable difficulty in applying his heat to those enclosed masses of basalt without fusing the bed of tufa which surrounds them. He who has the boldness to build a theory of the earth without a knowledge of the natural history of rocks, will daily meet with facts to puzzle and mortify him." During the winter 1811 and 1812, while a new manse was building for him at Flisk, he was necessitated to take up his abode at Cupar for a season, and when residing there he gave a short course of lectures on Chemistry and Natural History. He also at this period contributed the article Conchology to Brewster's Encyclopædia. On the 15th of March 1813, he married Melville, second daughter of Andrew Christie, Esq., banker in Cupar-Fife. The fruit of this marriage was two sons; Alexander, who died in his thirteenth year, and Andrew, now a medical officer in the Indian Service, and author of a valuable report on the "Geological Structure and Mineral Wealth of the Salt Range in the Punjab." This service he undertook at the instance of the Indian Government, who appointed him chief of the survey. He has also contributed largely to our knowledge of the Fossil Fauna of India. To Mrs Fleming's sympathy with her husband's pursuits, and to her artistic pencil, which was ever ready to illustrate the objects of his research, he has gratefully alluded in his "Philosophy of Zoology." From the plates in this work, but a meagre idea can be formed of the genius and devotion displayed by Mrs Fleming in aiding her husband while engaged on his "History of British Animals." It was necessary for him to consult, during the progress of this work, a scarce book, the "Zoologia Danica" of Müller, so rare in Britain that he knew of but a single copy. This he borrowed, along with Müller's

"Entomostraca and Hydrachnæ;" with a perseverance seldom equalled, and with a rare artistic talent, Mrs FLEMING copied the whole of these works of the admirable Dane. In this labour—truly one of love—Mrs FLEMING copied 687 quarto pages, and 1308 most exquisite figures! Flisk was no longer a "science-inspiring solitude," as a friend had called it, but a centre of great attraction to many who loved its genial inmates. The Rev. Dr M'VICAR, now of Moffat, was at this time frequently a guest at Flisk, of which, in a letter lately received, he says, "I shall never forget the charm of Flisk Manse. After an interval of thirty years, it seems to me like a beautiful dream to remember it. All was so intellectual, so sweet, and so sacred, and the welcome always so full and friendly. Though eight miles from a market, Mrs FLEMING seemed always prepared for visitors; and the last idea that could enter into one's head was that he was giving trouble, or putting people out of their way."

In 1814, FLEMING read a paper to the Wernerian Society entitled "Contributions to the British Fauna." This communication contains the description of nine animals new to the fauna of the British Islands—namely, *Sorex fodiens*, or water-shrew, *Pleuronectes punctata*, or top-knot turbot, *Lepas fascicularis*, or banded barnacle, *Hirudo verrucosa*, *Echinus miliaris*, *Lucernaria fascicularis*, *Caryophyllia cyathus*, *Fungia turbinata*, and lastly, *Flustra Ellisii*, which he named in honour of ELLIS, distinguished by his accurate industry in the investigation of zoophytes. He also in the same year communicated to the Wernerian Society a paper describing eight new species of Orthoceratites which he had discovered in the Carboniferous formation of Linlithgowshire. This paper was published, with illustrative drawings of the various species, in Thomson's "Annals of Philosophy." In the introduction he shows how early (though at this time a most determined *Geognosist*) he was urging the necessity of studying the zoology of rocks. "Had this department," he says, "been studied with greater care, geologists would not have been so frequently perplexed in accounting for the phenomena of nature. How often do we hear it asserted, that the plants, corals, and shells, which are found in a fossil state in the rocks of this country, bear the strongest resemblance to those of Africa and India. Yet when these are subjected to a close examination, they are found to be specifically distinct, and the distracted philosopher is saved the trouble of deluging the earth by a comet, or of changing its axis of motion. Naturalists were long employed in searching for the means which transported the monsters of the equatorial forests to the frozen regions of the north, until the systematic accuracy of a CAMPER and a CUVIER proved the fossil elephant to be a new species, differing in form and character from the elephants of Africa or India. Before the physical distribution of petrifactions can be investigated with success, the particular species must be previously ascertained." This latter sentence, penned in 1814, points to what is as much a desideratum now as it was then—a want of knowledge of species, and where a species ends and a genus may begin. Fleming's intuitive perception of the bearing of this truth, and its inherent value, was almost the first axiom he expressed in his philosophical works, and it continued throughout a long life as a main topic of his teaching, In this year (1814) he contributed to the "Annals of Philosophy" a paper on a bed of Fossil shells which occurs to the westward of Borrowstounness. It derives some importance from its containing views of the causes of raised sea-beaches adopted by its author at this time, and, with his well-known conservancy of opinion, maintained until the last. This bed of shells is 33 feet above high-water mark. It contains only such shells as now exist in the adjacent waters, the common oyster being the most abundant; more sparingly occur *Patella vulgaris*, *Buccinum undatum*, *Purpura lapillus*, *Littorina littorea*, *Littorina littoralis*, and *Tapes pullastra*. At first, Fleming was inclined to believe that this bed of shells—removed certainly ten miles from the nearest oyster-scalp—was a proof of the " gradual diminution of the water of the ocean, and retreat of the sea from the British shores." But the peculiarity of the shells, littoral, laminarian, and pelagic, all mingled in one incongruous mass, seems to have arrested his attention, and convinced him that no calm slow change of elevation of the land or recession of the sea could at all account for the fact of the oyster leaving its deep muddy bed to fraternize with the *Turbo littoreus* on shore. He believed and taught that there had been, throughout all the geological epochs of the earth's history, great changes of elevation of sea and land ; but that masses of shells belonging to various zones or depths of the ocean should be found all huddled together, could not, he contended, be evidence of the recession of the sea, or upheaval of the land. From these facts he concluded that this bed of shells had been thrown up by a violent agitation of the sea, when the waves rose at least 33 feet above their ordinary limits. Nor was this a hypothetical conjecture, as Boece, in his " Historia Scotorum," relates the effects of a storm which took place about the year 1266 in these words :—" In the seventeenth year of the reign of Alexander the Third, a tide very much higher than usual—a consequence of storms—overflowed the channels of the rivers, especially the Tay and the Forth, and caused an inundation which overthrew many villas, laying waste the districts, and occasioned a very great loss both of men and cattle." " Such a storm," says Fleming, " must have left some visible traces of its existence. Tradition indeed mentions one of the effects of this mighty flood, in the destruction of a town and in the elevation of the sands of Barrie, at the mouth of the Tay. And what prevents us from concluding that the same mighty tempest raised from the bottom of the channel of the Frith of Forth the oysters and mussels, and deposited them in a regular bed along the banks of the river?"

We have said that this paper contains his early theory to account for the phenomena of raised sea-beaches, and that he never saw any reasons which induced him to change his views. These he stated very fully on several occasions, while criticising papers on supposed raised sea-beaches read before the Royal Physical

Society, by the late Hugh Miller and the writer of this Memoir. In these discussions, he alluded to the great recession of the sea during the famous Lisbon earthquake, and the subsequent wave, nearly 90 feet in height, which swept over the land, leaving the detritus of the ocean-bed high up on the shore. He also affirmed, that many so called raised sea-beaches were the refuse of extinct fishing villages, as he had in his possession a fragment of an earthenware pipkin or "greybeard" which he had found deeply imbedded among shells of the edible species; and he hence concluded, that these so called raised sea-beaches dated no further back than a time which he called the "Picnic era." This question of raised sea-beaches recalls to remembrance the last geological excursion we were privileged to enjoy with him, during the last summer of his life, in company with his and my esteemed friend Dr M'Bain, to the caves near Wemyss Castle, on the shores of Fife. These caves had been to him for many years objects of great interest in regard to this question. They are not so far above the present level of the sea as to make the idea improbable that they were caused by the action of high tides, though a bank now prevents the highest wave approaching. He appealed to the small select jury, to decide whether the land had been raised or the sea depressed? or (and this was the verdict), that old Ocean, in some wild fitful mood, had, by raising up a barrier of shells and shingle, barred itself from caves which its billows had hollowed, and where, for thousands of years, they had rung their echoes, and abandoned them, as we saw on that bright summer day, to the more peaceful sounds of lowing cattle, who were their tenants then.*

In a most interesting memoir, read to the Wernerian Society on the 4th February 1815, on the Mineralogy of the Red Head in Angusshire, he gives his views in regard to the conflicting theories of Werner and Hutton, a fertile field

* While Fleming never denied the existence of raised sea-beaches, he refused to believe that the layers of shells and marine debris occurring along our west coast were, in any of the cases which he had examined, true raised sea-beaches or sea-bottoms; but that the character and arrangement of the marine contents of the deposits clearly indicated that they owed their origin to some violent effort. Thus, in the instance first noticed and described by Mr R. Chambers, occurring at Granton Quarry, he found all the materials of a raised sea-beach, but how were they arranged? The shells whose natural habitat was different were confusedly huddled together; the boulders also, which had long lain on the beach, and been rounded by the action of the waves, were there, with the limpets adhering to them; but these, in many instances, were discovered attached to the under surface of the stones, or lying with their cavities empty and upturned when the stones were removed, clearly showing that they had died in this position—a position in which they certainly could not have lived.

On a closer examination of the materials, it was found that the stones had a general inclination towards the north-west, showing that the wave—for it was now evident that it was a storm-raised beach—had come in that direction, and that the catastrophe producing the phenomena had been short-lived, as the returning waves had been unable to affect the sand which forms the large proportion of the bed, so as to enable the stones to regain the horizontal position which gravity required. In the case also of the so-called raised sea-beach at Fillyside, described by Hugh Miller, Fleming noticed that the molluscs here also were often found firm in the boulder clay, when the large boulders to which they were attached were removed—evidence of the origin of the bed which the strongest advocate of raised sea-beaches was unable to gainsay.

of contention among the geologists of that period. To neither of their theories could he assent, but boldly asserted his freedom, declaring that the true theory of the earth must embrace both, and paved the way for his friend Sir CHARLES LYELL, who has won so many laurels in this independent field of inquiry. Not that they agreed on particular questions, but their general views were consistent, the chief difference between them being on the question of metamorphosis. While FLEMING taught that molecular changes were due to mechanical and chemical action, Sir CHARLES LYELL has held that heat was the principal agent in changing the structure of rocks. This paper on the mineralogy of the Red Head will well repay a perusal, more especially where he discusses the formation of the famous pebble beds which occur in the amygdaloidal rocks of the district around Montrose.

FLEMING was proposed as a Fellow of the Royal Society of Edinburgh by Professor JAMIESON, Dr BREWSTER, and Professor PLAYFAIR, and was elected on the 24th January 1814. The first paper which he communicated was read on the 17th June 1816, and is printed in its Memoirs. It contains his observations "On the Junction of the Fresh Water of Rivers with the Salt Water of the Sea." From observations made at different states of the tide in the Firth of Tay, he proved that when currents of fresh and salt water come in opposition, the lighter fluid, or fresh water, will be raised upon the surface of the denser, or salt water; and when the stronger current of the tide has reversed the direction of the stream, the salt water will be found occupying the bottom of the channel, while the fresh water will be suspended or diffused on the surface. That the sea water reaches a higher point of the river than the sensible qualities of the water at the surface would indicate, was proved by the occurrence of the *Fucus vesiculosus* in fructification on the beach of Flisk. He also found the coralline *Tubularia ramosa* of ELLIS, and a *Sertularia* resembling the *gelatinosa* of PALLAS. Another fact he also established, that near land, more especially continents, the water of the surface of the sea contains less salt than the water at the bottom, and that this varies considerably in regard to summer and winter. During winter, owing to the larger amount of fresh water poured into the ocean, and the lessened evaporation, he found the difference to be as eighteen in summer to sixteen in winter, and this obtained as far down the Firth of Forth as Prestonpans.

In the summer of this year (1816) FLEMING delivered a course of lectures on botany to the Cork Institution, Ireland, with a view to his permanently accepting the chair as Professor. On his return from Ireland, he communicated a valuable paper to the Wernerian Society on the "Mineralogy of Cork," in which he has briefly though clearly stated his views regarding the crystallization of minerals, more especially pseudomorphs. The phenomenon of some crystals possessing a more determinate power of crystallization than others, even while containing a large amount of foreign matter mixed mechanically with the crystallizing substance (which was a true chemical compound), had early arrested his attention; and we cannot but regret that views so simple, and borne out by so many examples, had not been given in a more connected form to the world. We hope yet to be able to present a digest of these views, which have so important bearings on physical geology. In a paper read to the Wernerian Society in March 1823, on the *Sertularia cuscuta*, and on a new species of *Vorticella*, it appears that he was the first to describe and figure the cilia by which currents are produced along the tentacula of polypi. He referred these cilia to the branchiæ, and connected, therefore, more with the aërating than the prehensile functions. Our space will not permit us to describe even the salient points of the many contributions which Fleming gave about this period to the literature of natural history. To "Brewster's Encyclopædia" he furnished the articles Hybernation, Conchology, Ichthyology, Insecta, Helminthology, Natural History, and Aphiology.

To the periodicals of the day he furnished many valuable papers. Among these may be mentioned his reviews in the "Edinburgh Monthly Journal" and "New Edinburgh Review," edited by Dr Poole. These contributions range over a wide field of natural history, and display a deep and varied knowledge of so extensive a subject; they contain, also, the germs of his first great work, the "Philosophy of Zoology." This work was published in 1822, in two volumes. It is divided into four parts. The first portion treats of biology in its widest sense; the second part is devoted to the investigation of the characters of animals; the third to systems and nomenclature; and the fourth to classification.

The "Philosophy of Zoology" met with considerable favour, and its author received from the celebrated Ferrusac of Paris and Signor Zandrini of Pavia the most flattering testimonials of their approbation. Signor Zandrini showed his appreciation of the work by translating it into Italian; and for many years it has been the standard work amongst the savans of Italy.

Cuvier was not so hearty in his approval of the work, as Fleming had been rather hard in some strictures on the great anatomist's too hasty generalizations. His reply to Fleming, on receiving a copy of the work, is interesting even for one passage, where he repudiates having shown any leanings to materialism in his great work the "Regne Animal." The letter is dated Paris, 30th Nov. 1824, and is in these words:—

"Sir,—I was well aware previously of all the merit and interest of the work which you have published on zoology, and of which I did not fail to possess myself at the time; but I attach a new value to the same by receiving a copy direct from the author's own hand. This mark of esteem is infinitely precious to me, and I feel most grateful for it. I might have wished, however, that you had more deeply or completely understood my theory of the co-existences of organisation, and the numerous applications which I have made of them in my work on fossil bones. You would then probably have allowed that my ideas on the subject are less separate from your own after all, and especially you would have avoided representing them as in favour of materialism. I do not pray you the less, Sir, to receive with many thanks the expression of my most distinguished sentiments." (Signed) "BARON CUVIER."

It required no common courage, especially in a clergyman, to teach a doctrine so opposed to all the opinions of his fellows at this time, that "life and death are co-ordinate," and it is interesting to find a passage in the "Philosophy of Zoology" on that *quæstio vexata* the origin of species (as unsettled now as it was then), to which we, in absence of better evidence, may attach our faith. He says, "Is the generation of organised beings simultaneous or successive? Have they all been created at once, but, in the progress of time, so modified by the influence of external agents as now to appear under different forms? Or have they been called into being at different periods, according as the state of the earth became suitable for their reception? The latter supposition is countenanced by many geological documents." Before we can estimate the value of Fleming's dichotomous method, and its bearings on natural history, we must take a short retrospective view of the systems and methods of his predecessors.

Two great divisions of the animal kingdom have been generally acknowledged and justly appreciated since the days of Aristotle,—animals possessing warm and red blood, and those without blood—proper.* Those positive and negative distinctions, under various forms and modifications, still constitute the foundation of all our scientific systems and classifications. This primary division was adopted by Aristotle, and is essentially founded upon physiological principles. Man was selected as the standard of comparison, and the viviparous animals, birds, reptiles, and fishes, follow in succession. From the time of this great master of science until the beginning of the sixteenth century, no advance was made in these "dark ages," of which OWEN remarks, "The well-lit torch, which should have guided to further explorations of the mighty maze of animated nature, was suffered to fall from the master's hands, and left to grow dim and smoulder through many generations, ere it was resumed, fanned anew into brightness, and a clear view regained both of the extent of ancient discovery and of the right course to be pursued by modern research."

The elder Pliny made no attempt at a scientific method of arrangement further than commencing with the largest group and ending with the smallest. During the sixteenth century, with the revival of learning, a better era dawned upon the study of natural history. This originated with BELON of Mans, who was born in 1517, and seems to have devoted himself to the study of birds, fishes, and botany.

* See Aristotle's System, Linnean Transactions, vol. xvi. p. 24.

In the year 1554 two works on fishes appeared—one by RONDLLETIUS, Professor of Medicine at Montpellier, the other by SALVIANUS, a physician at Rome. These were soon followed by two writers on general zoology—CONRAD GESNER and ULYSSES ALDROVANDUS, the former a physician at Zurich, the latter a Professor of Philosophy and Natural History in the University of Bologna. GESNER, in his "History of Animals," classifies them into two great divisions—those that reside on land, and those that live in water. The viviparous quadrupeds are subdivided into six orders, into which animals are disposed according to the accident of their being wild or tame. ALDROVANDUS adopts PLATO's division of the animal kingdom, corresponding to the four elements of the ancients, fire, air, earth, and water. He begins with birds, "that division," as he says, "seeming to offer itself first in order; for as to those corresponding to fire," he observes, "I consider none such exist." There are many important anatomical and physiological details in the works of ALDROVANDUS. For example, he describes the process of incubation in the egg for each day, the "*punctum saliens*" having been seen on the third, with the "*truncus venosus*" arising from it. The first British Zoological work appeared in 1634, under the title of "Theatrum Insectorum," by Dr MOUFFET, physician to the Earl of Pembroke.

The next original work was published in the year 1667, entitled "Pinax Rerum Naturalium Brittanicarum," by Dr Christopher Merrett, and is deserving of notice as the first of our local faunas and floras, being entirely devoted to British plants and animals. It was at this period that the names of LISTER, RAY, WILLOUGHBY, and SIBBALD began to spread the fame of Great Britain. This has been called the physiological or golden age of natural history; and the impulse given to this study by the writings and discoveries of these eminent men has continued and increased to the present time. These men were the objects of Fleming's greatest admiration.

RAY's system of classification, although based on that of his predecessors, was so far in advance of theirs that it received general acceptance among naturalists until it was superseded by the more simple and effective one of LINNÆUS. The primary divisions of LINNÆUS are founded upon the structure of the heart and nature of the blood, the characters of the teeth being chosen for his mammalian orders. By thus adopting exclusive characters, his system, although powerful in the discrimination of groups, is highly artificial. The fame of LINNÆUS rests on his invaluable nomenclature, commonly known as the Binomial system. For the system of LINNÆUS, FLEMING ever expressed his utmost admiration as a means to an end, but he roundly rated those who blindly accepted a table of contents as a book, or an index to names when the pages were awanting. To the earnest student of nature the illustrious Swede had pointed the way, though he had not traversed it himself. He had furnished sailing directions, yet no chart of the immense ocean of facts, which he had descried from afar, but had not navigated; whose depths and shallows he had not himself sounded. The followers of LINNÆUS were the objects of FLEMING'S condemnation rather than the master himself. They had been content with the mere entry of a name, when they ought to have supplied a pregnant page to the great book of nature.

The classification of LINNÆUS was followed by that of CUVIER, which, unlike that of the great Swede, is founded on the anatomical structure of the animals. The animal kingdom is divided by CUVIER into four sub-kingdoms, and the primary groups in his first division, Vertebrata, are founded upon the different kinds of motion and respiration of the animals. These are the two most celebrated systems of modern times. They both embrace the whole animal kingdom and form the basis of all other scientific methods of arrangement.

The defect in the system of LINNÆUS consists in his having assigned characters to the primary classes which do not apply to the orders included in them; whilst the error of the Cuvierian arrangement is in using modifications of positive characters along with positive and negative ones in the formation of the primary classes. It was to remedy this defect, and to establish a more scientific principle in the use of positive and negative characters, that FLEMING proposed and explained his Binary or Dichotomous method in the "Philosophy of Zoology." Of this method he says, "The investigation and distribution of animals would be comparatively easy, if the forms and modifications of the different systems of organs exhibited constant mutual relations. Thus, if we consider the organs of any system to be in their most perfect state when they admit into their structure the greatest variety of combinations, and execute the greatest number of motions or functions, does it happen that, when we have discovered in any species one system of organs in its most perfect state, all the other systems may be expected to be in the same condition? The whole history of the animal kingdom contradicts such expectations of *co-existing* characters, and justifies the conclusion that, in the same species, one or more of the systems of organs may be in a perfect state, in co-operation with others which may be considered as imperfect." In a note appended to this paragraph he gives the offence to CUVIER of which that illustrious anatomist complained in his letter already quoted. FLEMING says, "It is truly surprising to find such an observer as CUVIER, in the face of observations and his own experience, asserting the existence of this mutual dependence of the different organs, or, as he is pleased to term them, the *necessary conditions of existence.* In his 'View of the Relations which exist amongst the Variations of the several Organs' (Comp. Anat., vol. i. p. 47), he says—'It is on this mutual dependence of the functions, and the aid they reciprocally yield to one another, that the laws which determine the relations of their organs are founded—laws which have their origin in a necessity equal to that of the metaphysical or mathematical laws; for it is evident that a suitable harmony between organs which act on one another is a necessary condition of the existence of the being to which they belong, and that if any one of the functions were modified in a manner incompatible with the regulations of the others, that being could not exist.' That such harmony prevails in every species is evident; but instead of being always produced by the same agents in the same state of mutual dependence, it is maintained in the midst of a diversity of combinations by a variety of *compensating* means, which display in a most astonishing manner the endless resources of the wisdom and power of the great Creator."

In illustration of the same views he adds, "An animal, therefore, which can only digest flesh must, to preserve its species, have the power of discovering its prey, of pursuing it, of seizing it, of overcoming it, and tearing it in pieces. It is necessary, then, that this animal should have a penetrating eye, a quick smell, a swift motion, address and strength in the claws and in the jaws. Agreeably to this necessity, a sharp tooth fitted for cutting flesh is never co-existent in the same species with a foot covered with horn, which can only support the animal, but with which it cannot grasp anything; hence the law by which all hoofed animals are herbivorous, and also those still more detailed laws which are but corollaries of the first, that hoofs indicate *dentes molares* with flat crowns, a very long alimentary canal, a capacious or multiplied stomach, and several other relations of the same kind" (p. 55). "This specious reasoning," says FLEMING, "would certainly lead to the admission of these necessary laws of co-existence, were the statements advanced correct in all their bearings. But the operations of nature are not restrained by such trammels. Quadrupeds possessing the common quality of being carnivorous have not all the same number of teeth, nor of the same shape, neither the same kind of stomach or intestines. Again, all herbivorous animals are not hoofed, for many of them are digitated, as the hare. All hoofed animals have not flat-crowned teeth like the bull, nor pointed teeth like the boar, nor a simple stomach like the horse, nor deciduous horns like the stag, nor a reservoir for drink like the camel, nor digestive organs that do not require any, like the sheep. Indeed, the number of varieties included under one species, the number of species belonging to a genus, and the number of genera in an order, intimate the variableness of the conditions of co-existence, and the absence of those supposed laws of relation, the belief in the *mathematical necessity* of which has contributed to augment the clumsy fabric of modern materialism."

From 1824 to 1826 FLEMING contributed many papers on geological subjects to the "Edinburgh Philosophical Journal." Among these may be noticed his admirable one "On the Influence of Society on the Distribution of British Animals," and that "On the Geological Deluge as interpreted by Baron CUVIER and Professor BUCKLAND." In the first of these memoirs he took up a position against BUCKLAND'S views, as shown in his "Reliquiæ Diluvianæ," to which BUCKLAND replied in a subsequent number of the Journal. Had the future Dean of Westminster known what he was evoking, he would have kept his discourse on the deluge for a place where to reply would not be etiquette. FLEMING's rejoinder, in his paper "On the Geological Deluge as interpreted by Baron CUVIER and Professor BUCKLAND," was so crushing, that the third edition of the "Reliquiæ Diluvianæ," then in the press, was withheld. Professor SEDGWICK said of this paper, "that he had often heard of the tomahawk and scalping-knife in warfare, but this was the first time he had ever seen it employed in scientific literature."

Another paper contributed to the "Edinburgh Philosophical Journal" in 1829, "On the Evidence from the Animal Kingdom tending to prove that the Arctic Regions formerly enjoyed a Milder Climate," deserves notice for the philosophic views it contains. In this paper FLEMING has shown, 1st, If two animals resemble each other in structure, their habits may be dissimilar; 2d, If two animals resemble each other in external appearance, their habits may be dissimilar and, 3d, If two animals resemble each other in form and structure, their physical and geographical distribution may be widely different. He has also shown, in this most conclusive and masterly paper, how far analogy should be our guide in studying the former and present condition of animals on the earth.

CUVIER had been successful in the employment of this guide, but he followed it too far, and fell into errors at variance with well-known facts, which FLEMING did not spare in this paper. CUVIER says,—"Any one who observes only the print of a cloven foot, may conclude that the animal which left this impression ruminates; and this conclusion is quite as certain as any other in physics or in moral philosophy." In his criticism of this passage FLEMING says,—"Observation had discovered many animals with cloven hoofs which ruminated, but in such circumstances would it be safe to infer that all cloven-hoofed animals ruminate? Conceive ourselves contemplating the footmarks of a sheep and sow. Under the guidance of CUVIER's declarations, we would conclude that both ruminated—an inference true in one case and false in the other. Observation here warns us against the employment of a guide so liable to deceive us."

It is not easy to condense a paper such as this on the question of the former condition of the earth; suffice it to say, that he triumphantly set the question at rest, in regard to the argument of the Siberian mammoth being a proof of a higher temperature obtaining in those regions, and in alluding to the supposed scarcity of food he says,—"There is no difficulty in conceiving the elephant capable of securing food, when we know that many of our largest quadrupeds at present people those regions, such, for example, as the musk ox, the mouse deer, and the bison. We may know the kind of food the existing species prefer, but this yields no aid in determining the taste of the extinct species. Who is there acquainted with the gramineous character of the food of our fallow deer, stag, or roe, that would have assigned a lichen to the rein-deer."

In 1828, FLEMING published his "History of British Animals," which will ever be a monument of his patient and philosophic discrimination. Some idea may be formed of this work, by a glance at the number of genera and species he there described, belonging to the British Islands:—

Mammalia,	38	genera with	60	species.
Birds,	102	,,	237	,,
Reptiles,	7	,,	12	,,
Fishes,	89	,,	170	,,
Recent Mollusca,	153	,,	597	,,

And extinct Mollusca no fewer than 1031 species.

All these he not only fully described, but supplied the synonymes, and gave the authorities and reference to each individual of the species. The "History of British Animals" is still a standard book, and formed the model for FORBES and HENLEY's beautiful work, on the "British Mollusca." In 1829, FLEMING contributed to the Quarterly Review, an article on BICHENO'S "Systems and Methods in Natural History." Its appearance was most opportune, as naturalists were at war in regard to the systems of LINNÆUS, JUSSIEU, MACLEAY, and the supporters of the Dichotomous method, of which FLEMING was the most puissant champion. In this admirable paper he claims for the study of natural history the respect of every educated gentleman, and hopes that the time is not far distant when a naturalist and a *natural* will cease to be synonymous. He had no doubt in his remembrance, when he penned this passage, the case of Lady GLANVILLE, whose will was attempted to be set aside on the ground of lunacy, because she had shown a great partiality for insects, and RAY, the author of "The Wisdom of God manifested in the Works of Creation," had to appear and bear testimony on the day of trial to her Ladyship's sanity. MACLEAY, who proposed the Quinary system, suffered severely in this most trenchant article. To these strictures MACLEAY replied in a violent attack in the seventh volume of the "Philosophical Magazine," under the title "On the Dying Struggles of the Dichotomous System." It would not be edifying to quote the gross personalities which characterize this paper; in the heat of his ire he asserts that BUCKLAND had stript from FLEMING his borrowed plumes, and claims credit for forbearance in not plucking the last feather. Mr MACLEAY'S absence from England, being then resident in Cuba, perhaps was the cause of his not being informed that the Oxford Professor was, instead of his opponent, the plucked. To this most ungenerous attack FLEMING replied in a forcible letter to the same Journal, which, as it gives a fair example of his style, is worthy of quotation:—

"Art thou thus bolden'd, man, by thy distress?—or else a rude despiser of good manners, that in civility thou seem'st so empty? Your Magazine for June having reached me at the ordinary period, I proceeded to an examination of its contents, with the usual degree of interest. The article from the pen of Mr MACLEAY, 'On the Dying Struggles of the Dichotomous System,' naturally attracted my notice, not merely as an attack against myself, but as the exhibition of a mode of conducting philosophical discussion I had never witnessed before. Whether this new style be calculated to advance the interests of science, to increase the respectability of your Journal, or to promote friendship among naturalists, must be left to the decision of the moral feeling of your readers and the public. In the meantime, however, I may take the liberty of stating, that if there be any of your readers capable of relishing such kind of lucubrations, they may blame you for having hitherto neglected to gratify their taste; while I assure them that I have no wish to secure their favour. The subject of 'Methods in Natural History,' is one of very great importance to the interests of science, though hitherto, in this country, in a great measure disregarded. Discussions connected with it, and conducted in a suitable manner, could not in such circumstances fail to be useful. Had Mr Macleay, therefore, confined his attack against me as one who admired the Dichotomous method and held Quinarianism in derision, to the merits of the respective systems, he would have received the satisfaction of a candid reply, as I am not aware of having published any opinion which I am afraid to defend, or would be ashamed to modify or abandon with increasing knowledge. But Mr Macleay, having laid aside the language of a gentleman, and violated the customary civilities of life, has compelled me, in due regard to my own character, to pass over in silence this effusion of his pen, which is probably without a parallel in the records of science. As Mr Vigors has thought proper to appear in connection with the publication in question, I request him to assure his friend at Cuba that he never was the object of my malice or envy, but that at present he shares largely of my pity.

"Before concluding, I beg to assure your scientific readers that I still adhere to the opinions I formerly expressed in my 'Philosophy of Zoology,' and more recently in 'British Animals,' respecting the value of the Dichotomous or Binary method in natural history. With regard to the opinions advanced in the 'Quarterly Review,' I presume that the editor and his coadjutors are fully qualified to defend themselves, or rather that they are disposed to smile at the harmless abuse which Mr Macleay has thought proper to send forth against them. They are accustomed to witness the 'dying struggles' of harpooned whales. It is indeed their pastime."

In a paper read to the Wernerian Society in May 1830, he described the occurrence of the scales of vertebrated animals in the Old Red Sandstone of Fifeshire. He was thus the first to discover the remains of animal life in a formation which prior to this period was held to be Azoic, and opened the field for Hugh Miller, on which he earned distinguished laurels.

In 1832 Fleming was presented by Lord Dundas to the parish of Clackmannan, which he held until 1834, when the patrons of King's College, Aberdeen, appointed him to the vacant chair of Natural Philosophy. During his residence at Aberdeen he was mainly instrumental in forming the Natural History Society, to which he contributed many valuable papers. We have said that Fleming, at an early period of his life—indeed, before he had accepted his first charge at Brassay—had expressed a strong dislike to patronage, and this dislike did not decrease with his increasing years. At the Disruption he thought it therefore his duty to inform the patrons of King's College that he intended to leave the Established Church with others of his brethren. Some circumstances made his occupancy of the chair of Natural Philosophy no longer agreeable, and he readily accepted the offer made to him of the Natural Science chair in the New College, Edinburgh, instituted by the broad and wise policy of Dr Chalmers. This election was made at a meeting of the General Assembly at Inverness, in a manner very gratifying to Fleming. Of the event he writes thus to Mrs Fleming:—"The result of the conference (or private assembly) in my case was so very flattering that I cannot give you the details. I really hope that little will be said when brought before the House; I can stand abuse, but flattery is not congenial. I feel the importance of the chair in so many respects, that I wish I were quietly at home to give it the grave consideration which it demands."

Fleming was now placed in a position much more congenial to his tastes and pursuits than the one he previously filled, and he soon showed that his merits as a teacher were in no respect inferior to his qualifications as a writer and original observer. He had a felicity of expression at once most logical and clear; and the love which he felt for all branches of natural science soon kindled the enthusiasm of his students.

As a guide to his class, he published in 1846 his "Institutes of Natural Science," in which he has given, in an intelligible form, short descriptions of the three great divisions of natural history—synthology, biology, and geology. In 1851 Fleming published a popular work on the "Temperature of the Seasons," in which the influence of temperature on the various animals and plants is the most instructive portion. While engaged in the weekly excursions with his pupils, examining the geology around Edinburgh, he collected a valuable series of facts, which he communicated in several short notices to the Royal Society.

These were afterwards embodied in his last work, the "Lithology of Edinburgh," the last page of which was going through the press as its distinguished author died. This work has been published under the editorship of the Rev. Mr Duns of Torphichen, who prefaced it with an able memoir. In considering the various views held by previous writers on the geology of Edinburgh, Fleming never relaxed hold of those which he had originally published in early life; and in discussing the formation of trap and its tufas, never yields the point to his opponents of the igneous origin of these rocks. The boulder clay was the *pons asinorum* of his life: he had studied it even from his boyhood; and it was always a source of grief to him to confess that he knew nothing of its origin after a study of upwards of sixty years. He was wont to say, "That he who could unravel the history of the boulder clay would be the Newton of geology."

"On Tuesday the 17th November 1857 he had lectured to his class with his usual vigour, and talked to his friends with a lightheartedness which to them did not presage any sudden change. Had he known the call was so near, would he have been otherwise? Those who knew him best can safely answer, No! Seldom has it been our experience, or rather happiness, to meet with one who, enjoying life so much, yet talked of death as a most blessed change.

On his return home, between three and four in the afternoon, he was suddenly seized with severe cramp of the extremities and spasm of the bowels. The pain continued during the night. About 10 A.M., on Wednesday the 18th, the pulse became weak and intermitting; the countenance sunk and anxious; extremities cold, with hiccup; abdominal pain and tympanitis leading to the suspicion of the rupture of some internal viscus. Two hours afterwards the pain ceased, and he appeared to have fallen asleep, and expired at a quarter before 2 P.M., less than twenty-three hours from the first seizure. On the examination of the body after death, a simple penetrating ulcer, at the posterior surface of the small curvature of the stomach, near the pylorus, half an inch in diameter, was found, permitting the escape of the contents of the stomach into the abdominal cavity, and causing peritonitis. At his funeral, which took place on 24th November, all the students of the New College were present; and he was interred in the Dean Cemetery, close to his friend Professor EDWARD FORBES, in that boulder clay which had been to him of so much interest during all his life.

I have now endeavoured to give a short, though perhaps meagre memoir of one who occupied, for nearly the first fifty years of this century, a most prominent place among the naturalists of our country.

The most marked features of FLEMING'S mind were his love of truth, his distrust of speculation, and the force and clearness of his reason. In his controversies on science (for in ecclesiastical discussions he was no polemic), his love of truth was too strong to permit of tenderness in his censures; and the grace of indifference, for which he sometimes prayed during the warfare, was so liberally granted, and so freely dispensed, as to be seldom pleasing to his opponents. He could and did pardon ignorance, but pretension he could not pardon. If professions of originality were made, he expected a due performance; but for negligence he had no forgiveness. But he nursed his wrath for those who entered not into the temple of science by the door, but were helped on the backs or heads of their fellows to scale its walls. His keen appreciation of character, which enabled him at once to detect the spurious from the true, often subjected him to the criticism of singularity in his behaviour, when the fault lay alone with the critic. Those who approached him with the ostentatious display of their acquirements, he froze; but to others who came to him in doubt or ignorance, he was all warmth and geniality. He resembled a large lens of ice, which, when approached on the side on which the sun is shining, is cold and repulsive, yet, on the other side, it burns with fervent heat.

It is not for me to estimate his usefulness as a clergyman; every congregation which was privileged to have him as its pastor has long ago testified publicly to his worth. As a teacher, none has yet arisen to fill his place; as an original observer and writer on natural history, he was, in Scotland, for the last fifty years, "*Facile princeps rerum naturalium indagator.*"

List of Dr Fleming's Contributions to Natural Science.

1. Mineralogical Account of Papa Stour, one of the Zetland Islands. (*Wernerian Society Memoirs*, vol. i. p. 162.—Read 12th Nov. 1808.)
2. Description of a Small-headed Narwal, cast ashore in Zetland. (*Wer. Soc. Mem.*, vol. i. p. 131.—Read 10th Dec. 1808.)
3. Report on the Economical Mineralogy of the Orkney and Shetland Islands. (*Statistical Account of Scotland*, 1809.)
4. An Outline of the Flora of Linlithgowshire, specifying only such plants as are omitted by Mr Lightfoot, or are marked uncommon by Sir J. E. Smith. (*Wer. Soc. Proceedings*, vol. ii. p. 640.—Read May 13, 1809.)
5. Description of several rare Vermes, lately discovered in Shetland. Read to the Wernerian Society, 9th Dec. 1809, but not noticed in their Proceedings. (*Tilloch's Phil. Mag.*, vol. xxxiv. p. 470.)
6. On Marine Animals found in Shetland. (*Wer. Soc. Pro.*, vol. ii. p. 643.—Read 19th May 1810.)
7. Chemistry and Natural History. Pamphlet, 16 pp., 1811.
8. On a Bed of Fossil Shells at Borrowstounness. (*Wer. Soc. Pro.*, vol. ii. p. 647.—Read 11th Nov. 1811. See also *Thomson's Annals*, vol. iv. p. 133.)
9. Short Account of the Rocks which occur in the Neighbourhood of Dundee. (*Wer. Soc. Mem.*, vol. ii. p. 138.—Read 22d Feb. 1812.)
10. Contributions to the British Fauna. (*Wer. Soc. Mem.*, vol. ii. p. 238; 1812 to 1813.)
11. Observations on the Mineralogy of the Neighbourhood of St Andrews. (*Wer. Soc. Mem.*, vol. ii. p. 145.—Read 5th Feb. 1813.)
12. Notices respecting the Old Silver Mines in Linlithgowshire. (*Thomson's Annals*, vol. v. p. 118.)
13. On the Species of Moss found in Scotland. (*Wer. Soc. Pro.*, vol. ii. p. 653.—Read 16th April 1814. Also *Thomson's Annals*, vol. iv. p. 71.)
14. Description of Ten Species of British Orthoceræ. (*Wer. Soc. Pro.*—Read 12th Nov. 1814. Also *Thomson's Annals*, vol. v. p. 199.)
15. On the Mineralogy of the Red Head in Angus-shire. (*Wer. Soc. Mem.*, vol. ii. p. 339. —Read 4th Feb. 1815.)

16. Observations on the Junction of the Fresh Water of Rivers with the Salt Water of the Sea. (*Royal Society of Edin. Trans.*, vol. viii. p. 507.—Read 17th June 1816.)

17. Hybernation of Animals. (*Edinburgh Encyclopedia*, 1817.)

18. On the Transpiration of Dew-like Drops on Leaves of Corn. (*Wer. Soc. Pro.*, vol. iii. p. 528.—Read 4th April 1818.)

19. Observations on the Mineralogy of the Neighbourhood of Cork. (*Wer. Soc. Mem.*, vol. iii. p. 83.—Read 2d May 1818.)

20. Review of Knight's Theory of the Earth. (*Edin. Monthly Review*, vol. i. p. 340; March 1819.)

21. Review of the Cornwall Geological Transactions. (*Ed. Mon. Rev.*, vol. i. p. 395; April 1849.)

22. On the Arctic and Skua Gulls. (*Edin. Phil. Jour.*, vol. i. p. 97; June 1819.)

23. Review of Savigny on the Invertebrate Animals. (*Ed. Mon. Rev.*, vol. ii. p. 391; Oct. 1819.)

24. Ichthyology, Article on, in *Edinburgh Encyclopædia.* 1819.

24. Review on the Mammoth or Fossil Elephant found in Siberia. (*Ed. Mon. Rev.*, vol. ii. p. 525; Nov. 1819.)

26. On the Water-Rail. (*Wer. Soc. Mem.*, vol. iii. p. 174.—Read Nov. 27, 1819.)

27. On the Changes of Colour in the Feathers of Birds independent of Moulting. (*Ed. Phil. Jour.*, vol. ii. p. 271; Dec. 1819.)

28. Observations on the Natural History of the *Sertularia gelatinosa* of Pallas. (*Ed. Phil. Jour.*, vol. ii. p. 82; 1820.)

29. Review of Samaulle's Entomologist's Compendium. (*Ed. Mon. Rev.*, vol. iii. p. 146; Feb. 1820.)

30. Insecta, Article in *Edinburgh Encyclopædia.* 1820.

31. Review of Macculloch's Western Islands. (*Ed. Mon. Rev.*, vol. iii. p. 255; March 1820.)

32. Helminthology, Article in *Edinburgh Encyclopædia.* 1820.

33. Review of Lamarck's Invertebrate Animals. (*Ed. Mon. Rev.*, vol. iii. p. 403; April 1820.)

34. Review of Scoresby's Arctic Regions. (*Ed. Mon. Rev.*, vol. iii. p. 609; June 1820.)

35. Review of the Transactions of Linnean Society, 12 volumes. (*Ed. Mon. Rev.*, vol. iii. p. 37; July 1820.)

36. Review of Humboldt's Personal Narrative. (*Ed. Mon. Rev.*, vol. iv. p. 262; Sept. 1820.)

37. On the British Species of the Genus Beroe. (*Wer. Soc. Mem.*, vol. ii. p. 400.—Read 18th Nov. 1820.)

38. Review of Atkinson's Ornithology. (*Ed. Mon. Rev.*, vol. v. p. 648; June 1821.)

38 A. On a Remarkable Plant of the Order Fungi, found growing in a Solution of Succinate of Ammonia. (*Ed. Phil. Jour.*, vol. v. p. 164. 1821.)

39. Philosophy of Zoology. Published 1822.

40. Review of Parry's Expedition. (*New Ed. Rev.*, vol. i. p. 186; July 1821.)

41. Review of Hooker's Flora Scotica. (*New Ed. Rev.*, vol. i. p. 467; Oct. 1821.)

42. Observations on the *Sertularia cuscuta*, of Ellis, and on a New Species of Vorticella called Coalita. (*Wer. Soc. Mem.*, vol. iv. p. 485.—Read March 8, 1823.)

43. On a Reversed Species of Fusus (*F. retroversus*). (*Wer. Soc. Mem.*, vol. iv. p. 498.—Read 5th April 1823.)

44. Observations on some Species of the Genus Vermculum of Montagu. (*Wer. Soc. Mem.*, vol. iv. p. 564.—Read April 5, 1823.)

45. Gleanings of Natural History during a Voyage in 1821. (*Ed. Phil. Jour.*, vol. viii. p. 294; 16th April 1823.)

46. Gleanings of Natural History during a Voyage in 1821. (*Ed. Phil. Jour.*, vol. ix. p. 248; Oct. 1823.)

47. Gleanings of Natural History during a Voyage in 1821. (*Ed. Phil. Jour.*, vol. x. p. 95; Jan. 1824.)

48. Description of *Plumularia bullata*, a New Species, collected by the Arctic Expedition under Captain Parry in Hudson's Straits in 1821. (*Wer. Soc. Mem.*, vol. v. p. 303. —Read 20th March 1824.)

49. On a New British Species of Spatangus (*ovatus*). (*Wer. Soc. Mem.*, vol. v. p. 287.—Read 21st March 1824.)

50. On the Distribution of British Animals. (*Ed. Phil. Jour.*, vol. xi. p. 287; Oct. 1824.)

51. Remarks on the Modern Strata. (*Ed. Phil. Jour.*, vol. xii. p. 116; Jan. 1825.)

52. On the Neptunian Formation of Siliceous Stalactites. (*Brewster's Jour.*, vol. ii. p. 307. —Read at Royal Society of Edinburgh, 7th March 1825.)

53. On British Testaceous Annelides. (*Ed. Phil. Jour.*, vol. xii. p. 238; April 1825.)

54. On the Defoliation of Trees. (*Brewster's Jour.*, vol. iv. p. 72; 1826.)

55. The Geological Deluge, as interpreted by Baron Cuvier and Professor Buckland, inconsistent with the Testimony of Moses and the Phenomena of Nature. (*Ed. Phil. Jour.*, vol. xiv. p. 205; April 1826.)

56. Remarks on the Genus Scissurella of M. D'Orbigny; with a Description of a Recent Species. (*Wer. Soc. Mem.*, vol. vi. p. 384.—Read 19th May 1827.)

57. British Animals. Published 1828.

58. Remarks on the Evidence from the Animal Kingdom tending to prove that the Arctic Regions formerly enjoyed a Milder Climate. (*Ed. Phil. Jour.*, vol. vi., 2d series, p. 277; March 1829.)

59. Additional Remarks on the Climate of the Arctic Regions, in answer to Mr Conybeare. (*Ed. Phil. Jour.*, vol. viii. p. 65; October 1829.)

60. Review on "Systems and Methods in Natural History," by J. E. Bicheno, Esq. Linnean Transactions, 1829. (*Quart. Rev.*, vol. xli. p. 302; 1829.)

61. Notice of a Submarine Forest in Largo Bay, in the Firth of Forth. (*Brande's Jour.*; March 1830.)

62. On the Superposition of Strata on the Banks of the Tay. (*Wer. Soc. Mem.*, vol. vi. p. 577.—Read 1st May 1830.)

63. On the Occurrence of the Scales of Vertebrated Animals in the Old Red Sandstone of Fifeshire. (*Wer. Soc. Pro.*, vol. vi. p. 577.—Read 1st May 1830. *Cheek's Ed. Jour. of Nat. and Geographical Science*, vol. iii. p. 81.)

64. Reply to Mr Macleay's Attack on the Dichotomous System. (*L., E., and D. Phil. Jour.*, vol. vii.; July 1830.)

65. Observations tending to establish the Identity of the Deal Fish of Orkney with the Vaagmaer of Iceland. (*Mag. of Nat. Hist.*, vol. iv. p. 215 ; 1st Feb. 1831.)

66. Notice of the Remains of a Fish found connected with a Bed of Coal at Clackmannan. (*Ed. Phil. Jour.*, vol. xix. p. 314 ; 1835.)

67. On a Bed of Fossil Shells on the Banks of the Forth. (*Wer. Soc. Pro.*, vol. vii. p. 474. —Read 7th Feb. 1835.)

68. Mollusca, Article on, in *Encyclopædia Britannica.* 1837.

69. Remarks on the Trap-rocks of Fife. (" Geological Society of London," *Lond. and Edin. Phil. Jour.*, vol. xiv. p. 147 ; 5th Dec. 1838.)

70. On a Vein of Animal Origin occurring on a Reef of Rocks called Skerryvore, on the West of Scotland.—(Read at Aberdeen Natural History Society, 7th Feb. 1840.)

71. On the Geology of Aberdeen. (Read at Aberdeen Natural History Society, 1840.)

72. On a New Species of Skate. (*Ed. Phil. Jour.*, vol. xxxi. p. 236 ; 1841.)

73. On Mr Thom's Method of Purifying Moss-water by Filtration through pounded Amygdaloid. (Read at Aberdeen Natural History Society, 1841.)

74. On the Act relating to Weights and Measures. (Read at Aberdeen Natural History Society, 1842.)

75. On the Glaciers of Switzerland. (Read at Aberdeen Natural History Society, 1843.)

76. On the Expediency of forming Harbours of Refuge between the Moray Firth and Firth of Forth. (*Ed. Phil. Jour.*, vol. xxxiv. p. 306 ; 1843.)

77. On Crystallization. (Read at Aberdeen Natural History Society, 1844.)

78. Review of Gould's Birds of Australia. (*North Brit. Rev.*, vol. i. ; August 1844.)

79. Review of Dana's Mineralogy. (*North Brit. Rev.*, vol. ii. p. 297 ; Feb. 1845.)

80. Review of the Memoirs of William Smith, LL.D. (*North British Review*, vol. iv. p. 96 ; Nov. 1845.)

81. Remarks on certain Grooved Surfaces of Rock on Arthur Seat. (*Roy. Soc. of Ed. Pro.*, p. 67.—Read 2d Feb. 1846.)

82. On the recent Scottish Madrepores ; with Remarks on the Characteristics of the Extinct Races. (*Ed. Phil. Jour.*, vol. xli. p. 203 ; 2d March 1846.)

83. Two Verbal Notices,—1*st*, On the Geology of Arthur Seat ; and, 2d, On the Dentition of the Walrus. (*Roy. Soc. Pro.*, vol. ii. p. 98.—Read 20th April 1846.)

84A. Institutes of Natural Science. October 1846.

85. Notes on the Superficial Strata of Edinburgh. (*Roy. Soc. Pro.*, vol. ii. p. 111.—Read 4th Jan. 1847.)

86. On the Defoliation of Trees. (" Edin. Botanical Society," *Annals Nat. Hist.*, vol. xix. p. 277.—Read 11th Feb. 1847.)

87. Verbal Communication on Fossils of the Lias Formation from South Africa. (*Roy. Soc. Pro.*, vol. ii. p. 133.—Read 5th April 1847.)

88. Geological Notices. (*Roy. Soc. Pro.*, vol. ii. p. 159.—Read 17th Jan. 1848.)

89. On the Anthracite of the Calton Hill. (*Roy. Soc. Pro.*, vol. ii. p. 175.—Read 20th March 1848.)

90. Remarks on Marine Vegetation in Estuaries. ("Ed. Bot. Soc.," *Annals Nat. Hist.*, vol. ii. p. 167.—Read 11th May 1848.)

91. An Address on the Present State and Capabilities of the Royal Physical Society. (*Roy. Phy. Soc. Minutes.*—Read 7th Nov. 1848.)

92. The Zoology of the Bass Rock. Published 1848.

93. Verbal Notice of Siliceous Stalactites on Arthur Seat. (*Roy. Soc. Pro.*, vol. ii. p. 216. —Read 15th Jan. 1849.)

94. Remarks on the Origin of Plants, and on the Physical and Geographical Distribution of Species. (" Edin. Bot. Soc.," *Ann. Nat. Hist.*, vol. iv. p. 202.—Read 14th June 1849.)

95. Verbal Geological Notices. (*Roy. Soc. Pro.*, vol. ii. p. 219 ; 5th Feb. 1849.)

96. On the Fossil Oxen of the United Kingdom. (*Roy. Phy. Soc. Min.*—Read 14th Feb. 1849.)

97. On the Occurrence of the *Alasmodon margaritifer* in Zetland. (*Roy. Phy. Soc. Min.* —Read 15th Feb. 1849.)

98. On the Occurrrence of *Holothuria squamata* of Müller in Zetland. (*Roy. Phy. Soc. Min.*—Read 14th March 1849.)

99. On the Remains of the Epidermis of the *Mytilus crassus* from the Carboniferous Limestone. (*Roy. Phy. Soc. Min.*—Read 11th April 1849.)

100. On a Simple Form of Rain-Gauge. (*Roy. Soc. Pro.*, vol. ii. p. 234.—Read 16th April 1849.)

101. As President of the Royal Physical Society, read an Address, having reference principally to the Defective State of the Public Museums of Edinburgh.—(Read 14th Nov. 1849.)

102. An Account of Different Forms of Marine Dredges. (*Roy. Phy. Soc. Min.*—Read 12th December 1849.

103. Remarks on the Velvet-like Periostracum of *Trigonia ventricosa* of Gray. (*Roy. Phy. Soc. Min.*—Read 27th February 1850.)

104. Exhibited and described a Specimen of *Deiopeia Pulchella* of Stephens from Aberdeenshire. (*Roy. Phy. Soc. Min.*—Read 27th February 1850.)

105. On the Geology of Edinburgh. (*Roy. Phy. Soc. Min.*—Read 10th April 1850.)

106. On the Physical and Scottish Statutory Limits of Sea and River as applicable to Salmon Fisheries. (*Roy. Soc. Pro.*, vol. ii. p. 333.—Read 15th April 1850.)

107. Introductory Lecture on Natural Science, delivered at the Opening of the New College, Edinburgh, 8th November 1850.

108. The Temperature of the Seasons. Published January 1851.

109. Review on the Geology of the Surface and Agriculture. (*North Brit. Rev.*, vol. xvi. p. 390 ; February 1852.)

110. On the Injurious Effects of Cedar Wood Cabinets. (*Roy. Phy. Soc. Min.; Ed. Phil. Jour.*, vol. iii. p. 185, 3d series.—Read 11th December 1852.)

111. On the Structural Character of Rocks—Part 1st. (*Roy. Soc. Pro.*, vol. iii. p. 169.—Read 7th February 1853.)

112. On the Mineralogy of the Neighbourhood of Edinburgh. (*Roy. Phy. Soc. Min.*—Read 9th April 1853.)

113. On the Structural Character of Rocks—Part 2d. (*Roy. Soc. Pro.*, vol. iii. p. 197.—Read 18th April 1853.)

114. Notice of an Attempt to Naturalize the Crawfish (*Astacus fluviatilis*) in the South ot Scotland. (*Roy. Phy. Soc. Min.*—Read 23d November 1853. Also *Ed. Phil. Jour.*, vol. lvi. p. 136.)

115. What is Coal? (*Roy. Soc. Pro.*, vol. iii. p. 216.—Read 16th January 1854.)

116. What are the Characteristics of Parrot or Cannel Coal? (*Roy. Phy. Soc. Min.*—Read 22d February 1854.)

117. Review on Botanical Geography. (*North Brit. Rev.*, vol. xx. p. 501; February 1854.)

118. On certain Vegetable Organisms in the Old Red Sandstone. (*Roy. Phy. Soc. Min.*—Read 19th April 1854.)

119. On the Structural Character of Rocks—Part 3d. (*Roy. Soc. Pro.*, vol. iii. p. 268.—Read 18th December 1854.)

120. Remarks on Rain-Gauges, with a view to secure Conformable Observations. *Roy. Phy. Soc. Min.*—Read 25th April 1855.)

121. Remarks on the Coal Plant called Stigmaria. (*Roy. Soc. Pro.*, vol. iii. p. 316.—Read 30th April 1855. Also *Ed. Phil. Jour.*, vol. ii. p. 189.)

122. Remarks on the Calamite and Sternbergia of the Carboniferous Epoch. (*Ed. Phil. Jour.*, vol. ii., 3d series, p. 205; 14th June 1855.)

123. On the Different Branches of Natural History, the Chairs which have been instituted for their Illustration, and the Manner in which they should be Subordinated. (*Ed. Phil. Jour.*, vol. iii., 3d series, p. 125.—Read before the British Association at Glasgow, 13th September 1855.)

124. An Opening Address to the Royal Physical Society. (*Roy. Phy. Soc. Min.*—Read November 28, 1855.)

125. On the State and Prospects of the Scottish Meteorological Association. (*Literary Spectator.* 1856.)

126. On the Duration of the Life of Plants. (*Bot. Soc. Pro.;* June 1856.)

127. On the Collection of Rain-Water for Domestic purposes. (*Literary Spectator.* 1856.)

128. On the Chalk-Flints of the Firth of Forth. (*Roy. Phy. Soc. Min.*—Read 22d April 1857.)

129. The Lithology of Edinburgh. In the press at the date of his lamented death, 18th November 1857. Edited by the Rev. Mr Duns of Torphichen, with a Memoir. Published by Kennedy, 1859.

XXXI.—*On the Constitution of Anthracene or Paranaphthaline, and some of its Products of Decomposition.* By Thomas Anderson, M.D., F.R.S.E., Professor of Chemistry in the University of Glasgow.

(Read 29th April 1861.)

The solid compounds of carbon and hydrogen form a class of substances to which chemists have scarcely, as yet, paid that attention which their importance and interest appear to merit. With the exception of naphthaline, very little is known regarding them, and it is remarkable that the numerous and varied products of decomposition obtained from that singular substance should not have induced a more minute examination of the kindred compounds, whose existence has been indicated by different chemists. The interest attaching to these compounds is all the greater because, according to their discoverers, several of them are isomeric, or at least polymeric, with naphthaline; and a more careful examination of them might be expected to throw some light on their intimate constitution, and relations to that body.

Not less than five substances said to be polymeric with naphthaline have been described. These are paranaphthaline or anthracene, metanaphthaline or retisterene, pyrene, and two substances not yet named, which occur along with benzine and benzophenone among the products of the destructive distillation of benzoate of lime, and are apparently quite distinct from one another and the other three. All of these substances, except naphthaline, have hitherto been obtained in small, and some of them in very minute quantity, so that their constitution has been in most instances fixed by analysis alone; and the difficulties attending the analysis of highly carbonaceous compounds at the time they were made, as well as the absence of any control derived from the examination of their products of decomposition, have naturally occasioned some doubts as to the accuracy of the formulæ assigned to them.

Paranaphthaline or anthracene, which was discovered by Dumas and Laurent in the year 1832,* is the only one of these substances whose examination has extended beyond the mere analysis; and the determination of its vapour density by the former chemist gave for it the formula C_{30} H_{12}, which the examination of some of its decomposition products by the latter was supposed to confirm. A critical examination of Laurent's experiments by no means bears out this opinion. They are in many respects extremely imperfect, have obviously been

* Annales de Chemie et de Physique, vol. l. p. 187.

made on a very small quantity of material, and the formulæ (mostly deduced from a single analysis) are so improbable, that there can be but one opinion as to the necessity for submitting the subject to a further investigation.

Anthracene, as is well known from the observations of DUMAS and LAURENT, is met with only among the latter portions of the distillation of coal-tar. It has been little seen by chemists, because hitherto the distillation has not generally been pushed so far as to yield it in quantity; but during the last few years, the demand for the asphalt and the higher oils having increased, the distillation has been carried further, and it has been found abundantly in some of the products, and even been used in the manufacture of machinery grease. I have availed myself of the opportunity which a large supply afforded of extending the examination of anthracene, and with the result of showing that its constitution differs from that attributed to it by its discoverers, and that it is not polymeric with naphthaline.

Before entering on the details of my own experiments, it may be advisable to recapitulate shortly the history of the substance. As already stated, it was discovered by DUMAS and LAURENT, working in concert, in 1832, and described by the former chemist, who attributed to it the formula $C_{30}\,H_{12}$, with which his results corresponded very closely. In 1835 LAURENT* described, under the name of paranaphthalese, a compound for which he gives the formula $C_{30}\,H_8\,O_4$, and he appears to have considered it to be a direct product of the action of nitric acid on anthracene. In a subsequent paper† he extends his investigation in this direction, and describes no less than five different nitro-compounds, and assigns to them very problematical formulæ. In this paper he again refers to paranaphthalese, but under the name of anthracenuse, giving for it the formula $C_{30}\,H_7\,O_5$, and stating that it is not a product of the direct action of nitric acid on anthracene, but formed by the decomposition of a nitro-compound, in a manner precisely similar to that in which naphthase is obtained from nitronaphthaline. He mentions that a substance of similar properties is obtained from several of the nitro-compounds he prepared, but leaves it an open question whether it is in all cases the same, or whether it differs in constitution according to the nitro-compound from which it is produced. He also describes a chlorine substitution product, and adopts the name of anthracene; a change even then advisable, and which the results of my investigation show to be quite indispensable.

Crude anthracene is in the form of a soft yellow mass, not unlike palm oil, but with a greenish tinge and harder consistence; in this state, it contains a little naphthaline and a considerable quantity of oil of high boiling point, which causes it to leave a greasy stain on paper, and to melt easily when rubbed between the fingers. It has a decided though not a strong smell, due partly to the naphthaline,

* Annales de Chemie et de Physique, vol. lx. p. 220. † *Ibid.*, vol. lxxii. p. 415.

but still more to the oil with which it is contaminated, and which it loses on purification. It is soluble, though not abundantly, in alcohol, but dissolves with tolerable facility in ether, turpentine, and still better in benzole. Methylated spirit was in the first instance used for its purification, and the first solution, on cooling, deposited thick oily globules, along with a small quantity of crystals; but after several successive quantities of spirit had been used, crystals were deposited free from oil, but still retaining the yellow colour of the original substance, and apparently, owing to the removal of the oil, they were much less soluble in new quantities of spirit. By repeated crystallisations, it was found possible to obtain the anthracene quite colourless; but the process was too tedious to be employed for preparing it on the larger scales. Other solvents, and more particularly benzole, were likewise tried; but, though preferable, the complete removal of the colouring matter is difficult with them also, and it was found necessary to commence by distilling the crude substance in a small iron still. The first portions which passed over during the process contained much naphthaline and oil, but they were quite free from colour. As the distillation proceeded, however, the colour gradually increased, and at the end a small quantity of a dark green substance remained in the retort. The first portions of the distillate were pressed to remove the oil, and the last portions redistilled so as to get rid of the colour as completely as possible, and the purification finished by repeated crystallisation from benzole, and sometimes by sublimation.

Anthracene is deposited from its solutions in perfectly colourless scales, generally of very small size even when large solutions have been allowed to cool. Those obtained from spirit are generally the best, and when suspended in the solution have a fine satiny lustre, which they lose to some extent when dried. From benzole its crystals are somewhat granular, and less brilliant in appearance. By sublimation, it is got in thin plates resembling those of naphthaline, but smaller and of inferior lustre. When quite pure it has no smell, but it is apt to retain a trace of oil, which communicates to it a faint empyreumatic odour. It is entirely devoid of taste. It is not volatile at ordinary temperatures, but is slowly volatilised in the water bath. At higher temperatures it sublimes freely. It melts at 416° F. into a transparent colourless fluid, which, on cooling, solidifies into a foliated crystalline mass, and at a higher temperature distils unchanged. It is insoluble in water, sparingly soluble in alcohol, but more so in ether, benzole, and the volatile oils. The alkalies are without action upon it, but sulphuric acid dissolves it, and acquires a green colour, with the formation of a sulpho-acid; and nitric acid, even when moderately dilute, acts rapidly upon it. Chlorine and bromine form substitution products.

The analysis of anthracene at first presented some difficulties. When oxide of copper was employed in the usual way, the carbon was always deficient, while chromate of lead gave an accurate result with that element, but a marked excess on the hydrogen.* Oxide of copper and chlorate of potash were therefore resorted to, and with success. The results are:—

I. { 4·715 grains of anthracene gave
16·250 grains of carbonic acid, and
2·435 grains of water.

II. { 4·546 grains of anthracene gave
15·720 grains of carbonic acid,
2·420 grains of water.

III. { 4·975 grains of anthracene gave
17·180 grains of carbonic acid, and
2·650 grains of water.

	Experiment. I.	Experiment. II.	Experiment. III.	Mean.	Calculation.		
Carbon, . . .	94·00	94·31	94·18	94·16	94·38	C_{28}	168
Hydrogen, . .	5·74	5·91	5·92	5·85	5·62	H_{10}	10
	99·74	100·22	100·10	100·01	100·00		178

The results correspond exactly with the formula $C_{28}\ H_{10}$. This is precisely the constitution of a substance described some years since by FRITSCHE† as a new carbo-hydrogen, obtained from coal-tar, with which also its properties closely agree. A careful comparison of the two substances made by Professor FRITSCHE and myself, during a visit he paid to Glasgow some time since, satisfied us that his substance really is anthracene. The picric-acid compounds of the two are completely identical, and have a fine ruby-red colour, which distinguishes it from those obtained from the other carbo-hydrogens. An analysis of the compound obtained from anthracene gave—

{ 5·120 grains of picrate of anthracene gave
11·016 grains of carbonic acid and
1·629 grains of water.

	Experiment.	Calculation.		
Carbon, ...	58·71	58·97	C_{40}	240
Hydrogen, ...	3·54	3·17	H_{13}	13
Nitrogen, ...	...	6·88	N_3	42
Oxygen, ...	...	30·98	O_{14}	112
	100·00			407

This corresponds with the formula $C_{28}\ H_{10}+C_{12}\ H_3\ (NO_4)_3\ O_2$, which is that given by FRITSCHE for his compound.

* I have had frequent occasion to observe, that in the analysis of carbo-hydrogens with chromate of lead a considerable excess of hydrogen is often obtained. I at first attributed this to impurities in the chromate, but analyses made with a pure material, specially made for the purpose, showed the same excess. I have not examined into the cause of this phenomenon.

† Erdmans Journal für Practische Chemie, vol. lxxiii. p. 282.

Action of Nitric Acid on Anthracene.

Anthracene is but little acted on by cold nitric acid, but the boiling acid, even when moderately dilute, attacks it with considerable rapidity, and the products depend upon the strength of the acid and the length of time during which the action is continued.

Oxanthracene.—When anthracene is boiled for some days with nitric acid of SG. 1·2, red fumes are evolved, and a resinous mass is obtained, which becomes hard and gritty in cooling. The same change may be more rapidly effected with acid of SG. 1·4, but the product is then liable to be contaminated with some other compounds. The substance was washed with water, and purified by crystallisation from alcohol or benzole. It is then obtained in crystals, which, when deposited from alcohol, are long silky needles, but from benzole are shorter and more compact. They have a light buff colour, have neither taste nor smell, and are insoluble in water, sparingly soluble in alcohol, and more so in benzole. They are completely soluble in boiling nitric acid of SG. 1·4, and are deposited unchanged on cooling. Concentrated sulphuric acid in the cold dissolves them with an orange colour, which becomes deep red on heating, and on dilution with water the oxanthracene is deposited unchanged. It sublimes when heated, and is deposited unaltered in fine needles of considerable length. It may be distilled without decomposition over quick-lime. Its volatility may be taken advantage of as a means of preparing it, as it is only necessary to boil anthracene in a retort with nitric acid, and to continue the heat until the acid has distilled over and the oxanthracene sublimes, any other compounds formed at the same time being decomposed. It contains no nitrogen, and analysis gave the following results:—

I. { 4·600 grains of oxanthracene gave
13·525 grains of carbonic acid and
1·670 grains of water.

II. { 4·987 grains of oxanthracene gave
14·770 grains of carbonic acid and
1·760 grains of water.

III. { 4·600 grains of oxanthracene gave
13·600 grains of carbonic acid and
1·650 grains of water.

	Experiment.			Calculation.		
	I.	II.	III.			
Carbon, . .	80·19	80·77	80·63	80·77	C_{28}	168
Hydrogen, . .	3·99	3·92	3·99	3·85	H_8	8
Oxygen, . .	15·82	15·31	15·38	15·38	O_4	32
	100·00	100·00	100·00	100·00		208

Its formula, therefore, is $C_{28} H_8 O_4$, and it is derived from anthracene by the removal of two equivalents of hydrogen, and the addition of four of oxygen. It belongs to a class of substances of which there are very few examples, and for which we have no satisfactory system of nomenclature. I have given it the provisional name of Oxanthracene, as recalling its mode of formation.

Binitroxanthracene.—When anthracene was boiled for a long time with nitric acid, with occasional additions of fuming acid, red fumes continued to be given off, and a resinous substance was gradually produced. The substance was washed with water and dried. It appeared to be a mixture of some of the last substance with a new compound, which was obtained by heating it with a small quantity of alcohol, and cooling. It is deposited as a red powder which shows but little disposition to crystallise. A combustion gave—

4·907 grains of nitro-binitroxanthracene gave
10·558 grains of carbonic acid, and
1·210 grains of water.

	Experiment.			
Carbon, . . .	58·66	56·37	C_{28}	168
Hydrogen, . . .	2·73	2·02	H_6	6
Nitrogen, . . .	...	9·40	N_2	92
Oxygen, . . .	...	32·21	O_{12}	32
		100·00		298

This is a distant approximation to the formula $C_{28} H_5 (NO_4)_2 O_4$, and it is probable that this is its constitution; but as its properties showed nothing of interest, I did not prosecute its purification further.

Anthracenic Acid.—When the nitric acid and the washings of the preceding compound are carefully evaporated in the water-bath, a yellow crystalline acid, to which I give this name, is obtained. It is very soluble in water, and gives crystallisable salts with ammonia and potash, and precipitates the salts of lead and baryta. I reserve the further investigation of this substance for a future communication.

Action of Bromine on Anthracene.

Bromine acts somewhat slowly upon anthracene in the cold. When mixed together, they concrete into a resinous-looking mass, the interior of which is not completely saturated with bromine, and it was found most convenient to expose the anthracene in a thin layer under a bell glass, along with a capsule containing bromine. After a day or two's exposure, the anthracene has agglutinated into a mass which must be removed, reduced to powder, and reintroduced; and this is repeated as long as bromine is absorbed. This mass, which has a brown colour, dissolves in benzole, and on cooling deposits hexabrom-anthracene in crystals, which are purified by solution in benzole or ether. It is thus obtained in small hard white granular crystals, apparently rhomboidal. They are sparingly soluble in alcohol, ether, and benzole. Nitric acid acts upon them but slightly. When heated with strong sulphuric acid they fuse, and bromine and hydrobromic acid are expelled. On digestion with alcoholic potash they immediately become yellow, and are converted into another compound. When heated to 348° F. they become brown, and at 361° fuse and give off bromine. Analysis gave the following results:—

I. { 5·313 grains of sexbromide of anthracene gave
4·990 grains of carbonic acid, and
0·760 grains of water.

II. { 6·159 grains of sexbromide of anthracene gave
5·835 grains of carbonic acid, and
0·880 grains of water.

III. { 5·652 grains of sexbromide of anthracene gave
5·310 grains of carbonic acid, and
1·730 grains of water.

IV. { 7·540 grains of sexbromide of anthracene gave
12·818 grains of bromide of silver.

	Experiment.				Calculation.		
	I.	II.	III.	IV.			
Carbon,	25·62	25·84	25·62	...	25·53	C_{28}	168
Hydrogen,	1·59	1·59	1·72	...	1·52	H_{10}	10
Bromine,	...	...	...	72·33	72·95	Br_6	486
					100·00		658

The formula is $C_{28}\ H_{10}\ Br_6$, and the substance is produced by the direct absorption of six equivalents of bromine.

Quadribrominated Anthracene.—When the preceding compound is treated with an alcoholic solution of potash, it swells up considerably and acquires a bright sulphur-yellow colour, and the solution contains bromide of potassium. This change occurs in the cold, but it is more convenient to heat the solution. The yellow powder is collected on a filter, washed, dried, and crystallised from boiling benzole. It is thus obtained in long yellow needles, having a fine silky lustre. It is very sparingly soluble in cold alcohol, ether, and benzole—more so when hot. Boiling benzole is its best solvent, but even of this it requires above a hundred times its weight. It fuses at 460°, and gives a dark coloured mass, which has undergone partial decomposition. The portions used for analysis were crystallised from benzole, and then washed with ether:—

I. { 5·110 grains of quadribrominated anthracene gave
6·400 grains of acid, and
0·780 grains of water.

II. { 5·021 grains of quadrobrominated anthracene gave
6·250 grains of carbonic acid, and
0·750 grains of water.

III. { 5·271 grains of quadribrominated anthracene gave
6·560 grains of carbonic acid, and
0·792 grains of water.

	I.	II.	III.			
Carbon, ...	34·16	33·94	33·95	33·87	C_8	168
Hydrogen, . . .	1·39	1·66	1·66	1·61	H_8	8
Bromine, ...	...	...	...	64·52	Br_4	320
				100·00		496

This gives for the constitution of the compound C_{28} H_8 Br_4, a somewhat unusual formula, differing from that of most similar compounds. In general, when a bromide or chloride of an organic compound is treated with potash, one half of the haloid is removed in combination with hydrogen, the remainder passing into the radical. In this case, however, only two equivalents of hydrogen are removed, and the formula of the compound ought in all probability to be written C_{28} H_8 Br_2+Br_2.

Action of Chlorine on Anthracene.

The examination of the compounds produced by the action of chlorine on anthracene is attended with some difficulty, the changes occurring being of a somewhat complicated kind; more than one substance being generally obtained, and the nature and proportion of the products depending very greatly on the circumstances of the experiment. Chlorine is readily absorbed by anthracene in the cold; and if the current is rapid it becomes warm, gives off hydrochloric acid in abundance, and is eventually converted into a hard cake. If the chlorine be passed through it in a slow current, the evolution of hydrochloric acid is greatly diminished, although it cannot be altogether avoided; and when this is done, and the chlorine is not continued too long, the principal product is bichloride of anthracene.

Bichloride of Anthracene.—The mass obtained by the action of chlorine dissolves readily in benzole, and on cooling, groups of radicated needles, often of considerable length, are deposited. The bichloride is readily soluble in alcohol, but only very sparingly in ether. When crystallised from alcohol, it is very liable to lose hydrochloric acid, and this change always takes place to some extent, which causes a slight excess of carbon and deficiency of chlorine in analyses:—

I. { 5·074 grains of bichloride of anthracene gave
12·564 grains of carbonic acid, and
1·795 grains of water.

II. { 4·614 grains of bichloride of anthracene gave
11·524 grains of carbonic acid, and
1·717 grains of water.

III. { 4·474 grains of bichloride of anthracene gave
5·14 grains of chloride of silver.

	Experiment. I.	II.	III.	Calculation.		
Carbon,	67·53	68·11	...	67·47	C_{28}	168
Hydrogen,	3·93	4·13	...	4·02	H_{10}	10
Chlorine,	...	...	28·40	28·51	Cl_2	71
				100·00		249

corresponding very closely with the formula $C_{28} H_{10} Cl_2$.

Chloranthracene.—When anthracene is treated with a rapid current of chlorine continued for a short time only, this compound is produced. It may also be obtained by decomposing the preceding substance with alcoholic potash. It is soluble in alcohol, ether, and benzole, from the last of which solutions it is deposited in small hard scaly crystals. Analysis gave the following numbers :—

4·285 grains of chloranthracene gave
12·375 grains of carbonic acid, and
1·720 grains of water.

	Experiment.	Calculation.		
Carbon,	78·74	79·06	C_{28}	168
Hydrogen,	4·46	4·24	H_9	9
Chlorine,	...	16·70	Cl	35·5
		100·00		212·5

The formula, therefore, is $C_{28} H_9 Cl$.

When chlorine is passed over anthracene kept hot, it is absorbed in much larger quantity, and hydrochloric acid is abundantly evolved. The compounds thus obtained depend entirely on the length of time during which the current is continued, and products analysed at different periods were found to contain very different quantities of carbon and chlorine; and as the substances produced differ little in solubility, it was found difficult to effect their separation. When the chlorine is continued for about eight days, the product is semisolid, and the greater part dissolves easily in cold ether; and when this solution is evaporated, first an oily chloride and then crystals are deposited. The crystals are soluble in benzole, alcohol, and ether, and were found to have the following composition:—

5·558 grains of chlorine compound gave
9·680 grains of carbonic acid, and
1·280 grains of water.

	Experiment.	Calculation.		
Carbon,	47·50	47·39	C_{28}	168
Hydrogen,	2·56	2·54	H_9	9
Chlorine,	...	59·07	Cl_5	177·5
		100·00		354·5

This agrees very well with the somewhat improbable formula $C_{28} H_9 Cl_5$, but it is quite possible that it may be a mixture—a point which, owing to the small quantity of substance at my disposal, I was unable to determine. The oily chloride gives more than one crystalline substance when treated with alcoholic potash.

The facts now detailed are sufficient to fix the constitution of anthracene, and to show that its chemical relations are of considerable interest. Its formula connects it with certain substances derived from oil of bitter almonds; and more especially with stilbene, the carbo-hydrogen discovered by LAURENT, from which it differs by two equivalents of hydrogen. A similar relation exists between oxanthracene and benzil, as is seen by the following comparison of their formulæ:—

Anthracene, . . .	$C_{28}\,H_{10}$	Stilbene, . . .	$C_{28}\,H_{12}$
Oxanthracene, . .	$C_{28}\,H_{8}\,O_{4}$	Benzil, . . .	$C_{28}\,H_{10}\,O_{4}$

These relations merit a further examination, and I propose to return to the subject in a subsequent paper, which will also include the results of a further investigation of the anthracene compounds.

PROCEEDINGS

OF THE

STATUTORY GENERAL MEETINGS,

AND

LIST OF MEMBERS ELECTED AT THE ORDINARY MEETINGS,

Since November 22, 1857;

WITH

LIST OF DONATIONS TO THE LIBRARY,

From Dec. 7, 1857, till April 29, 1861.

PROCEEDINGS, &c.

Monday, November 23, 1857.

At a Statutory General Meeting, Dr Christison, V.P., in the Chair, the following Office-Bearers were duly elected:—

Sir T. Makdougall Brisbane, Bart., G.C.B., President.

Sir David Brewster, K.H., The Very Rev. Principal Lee, The Right Rev. Bishop Terrot, Dr Christison, Dr Alison, Professor Kelland,	Vice-Presidents.

Professor Forbes, General Secretary.

Dr Gregory, Dr J. H. Balfour,	Secretaries to the Ordinary Meetings.

J. T. Gibson-Craig, Esq., Treasurer.

Dr Douglas Maclagan, Curator of Library and Museum.

COUNCILLORS.

Dr Maclagan.	Robert Chambers, Esq.
Wm. Swan, Esq.	John Russell, Esq.
Dr Traill.	John Hlll Burton, Esq.
Hon. Lord Neaves.	David Stevenson, Esq.
Dr Thomas Anderson.	Wm. Thos. Thomson, Esq.
Rev. Dr Hodson.	Dr Allman.

(Signed) R. Christison, *V.P.*

Monday, November 22, 1858.

At a Statutory General Meeting, Dr Alison, V.P., in the Chair, the following Office-Bearers were duly elected:—

Sir T. Makdougall Brisbane, Bart., G.C.B., President.

Sir David Brewster, K.H., The Very Rev. Principal Lee, The Right Rev. Bishop Terrot, Dr Christison, Dr Alison, Professor Kelland,	Vice-Presidents.

Professor Forbes, General Secretary.

Dr J. H. Balfour. William Swan, Esq.	Secretaries to Ordinary Meetings.

J. T. Gibson-Craig, Esq., Treasurer.

Dr Douglas Maclagan, Curator of Library and Museum.

COUNCILLORS.

Dr Thomas Anderson.	Wm. Thomas Thomson, Esq.
Rev. Dr Hodson.	Dr Allman.
Robert Chambers, Esq.	The Duke of Argyll.
John Russell, Esq.	Andrew Murray, Esq.
J. H. Burton, Esq.	Very Rev. Dean Ramsay.
David Stevenson, Esq.	Dr George Wilson.

The following Gentlemen were named as Auditors:—

James Cunningham, Esq. John MacKenzie, Esq. Wm. Thomas Thomson, Esq.

(Signed) R. Christison, *V.P.*

Monday, November 28, 1859.

At a Statutory General Meeting, Dr Christison, V.P., in the Chair, and afterwards Dr Maclagan, the following Office-Bearers were duly elected:—

Sir Thomas Makdougall Brisbane, Bart., G.C.B., President.

Sir David Brewster, K.H., The Right Rev. Bishop Terrot, Dr Christison, Professor Kelland, Hon. Lord Neaves, Very Rev. Dean Ramsay,	Vice-Presidents.

Professor Forbes, General Secretary.

Dr J. H. Balfour, Dr Lyon Playfair, C.B.,	Secretaries to Ordinary Meetings.

J. T. Gibson-Craig, Esq., Treasurer.

Dr Douglas Maclagan, Curator of Library and Museum.

COUNCILLORS.

J. H. Burton, Esq.
David Stevenson, Esq.
Wm. Thomas Thomson, Esq.
Dr Allman.
The Duke of Argyll.
Andrew Murray, Esq.
Rev. Dr Lee.
D. Milne-Home, Esq.
Professor Cosmo Innes.
Dr Lowe.
Professor W. J. M. Rankine.
James Dalmahoy, Esq.

The following Gentlemen were then, on the motion of the Rev. Dr Lee, appointed to audit the Treasurer's accounts:—

John MacKenzie, Esq. Wm. Thomas Thomson, Esq. Cosmo Innes, Esq.

(Signed) R. Christison, *V.P.*

Memorandum.—Monday, February 6, 1860.—At the Ordinary Meeting of this date, the following motion was made by Lord Neaves, and unanimously adopted:—

That the Society, at this its first meeting after the death of Sir Thomas Makdougall Brisbane, should place upon record the expression of its deep regret for that event, and its high estimate of the character of Sir Thomas Brisbane, who, besides other eminent public services, was, during a long life, conspicuous as a sincere lover and active promoter of Science, and who worthily presided over this Society for a period of twenty-seven years.

That an Excerpt from this Minute be sent to Sir Thomas Brisbane's relatives.

Monday, February 20, 1860.

The following Minute of the Council was taken into consideration :—

" The Council took into consideration the course that should be followed in consequence of the vacancy in the office of President, and resolved to bring this matter under the notice of the Society at its next Meeting, and to suggest that a Special Meeting should be called for the Election of President, on a day to be fixed by the Society.

" The Council at the same time resolved to suggest to the Society, that while the laws relative to the Election of Office-Bearers should remain unchanged, the footing on which the office of President is held should be slightly altered.

" Hitherto the election, although taking place annually, has virtually been for life; but the Council venture to recommend that in future the President shall be expected to retire from Office after he has held it for a period of five years, and that this understanding should be recorded in the Minutes of the Society.

It was resolved, on the suggestion of the Chairman, that Monday, 27th February, should be fixed as the day for the Election of President, and that the hour should be 3 P.M.—the Ballot being kept open for half an hour. It was also agreed that the Election should take place by One Ballot, and that each Fellow should vote by puting into the Ballot-box a paper containing the name of the person whom he recommended for the office of President.

It was moved by Lord NEAVES, seconded by Dr BALFOUR, and unanimously agreed to :—

" That while the President, with the other Office-Bearers, should still be subject to an annual election, his re-election in future shall not be expected to take place after he has held office for a period of five years; and that this understanding shall be recorded in the Minutes of the Society."

The following Minute of Council was then read :—

"The Council adhere to their resolution not to propose any one for the office of President, but to leave the matter in the hands of the Fellows of the Society; and at the same time they agreed that the following Statement should be communicated to the Society at its Meeting on 20th February.

" The Council, on the present occasion, deem it advisable not to recommend any one for the office of President, but they have no objections to hand forward to the Society the names suggested to them."

The following have already been suggested :—

The Duke of ARGYLL. Sir DAVID BREWSTER. Professor FORBES.

The Council will in like manner receive and state, on the day of Meeting for election, any further names that may be sent in by any Fellow of the Society.

The Society then adjourned till Monday, 27th February, at 3 P.M., when a Special Meeting was to be held for the Election of a President.

(Signed) R. CHRISTISON, *V.P.*

Monday, February 29, 1860, 3 P.M.

Special Meeting for Election of President, Lord NEAVES, V.P., in the Chair.

The Chairman stated that Professor FORBES had requested his nomination for the office of President to be withdrawn. Dr Lyon Playfair made a similar intimation on the part of Sir David Brewster.

A Ballot took place,—each Fellow voting by putting into the Ballot-box a paper containing the name of the person in whose favour he gave his vote for the office of President.

The Ballot was kept open till $3\frac{1}{2}$ P.M. Dr Adam Hunter and Mr Robert Chambers were appointed Scrutineers; and after examining the votes they reported that the Duke of Argyll had been elected President.

The Chairman then announced the election of the Duke of Argyll as President of the Society; and the Secretary was requested to intimate this to his Grace, and to transmit at the same time a copy of the Minute of the previous Meeting of the Society relative to the duration of the tenure of office. The Society adjourned.

(Signed) R. Christison, *V.P.*

Monday, November 26, 1860.

At a Statutory General Meeting, Dr Christison, V.P., in the Chair, the Minutes of General Meetings of 28th November 1859 and of 20th and 27th February 1860 were read and confirmed.

The Secretary stated that the Duke of Argyll had accepted the office of President, and had sent the following letter:—

LONDON, 29*th February* 1860.

Sir,—I have the honour to acknowledge receipt of your letter of the 27th inst., intimating that I have been elected President of the Royal Society of Edinburgh, in room of Sir Thomas Makdougall Brisbane, deceased.

May I request you to convey to the Members of the Society an expression of my most grateful thanks for so high an honour, and an assurance of my desire to promote the interests of the Society in the position in which they have been pleased to place me.—I have the honour to be, Sir, your obedient Servant, (Signed) Argyll.

Principal Jas. D. Forbes, Secretary,
Royal Society, Edinburgh.

The following letter from Principal Forbes was read by the Chairman:—

ST ANDREWS, 24*th November* 1860.

Sir,—May I beg you to acquaint the General Meeting of the Royal Society, on Monday next, that I beg to withdraw from the office of General Secretary, which, through the kindness of the Society, I have held for nearly twenty years.

The causes of my removal from Edinburgh, which makes it necessary to break a connection so honourable and gratifying to myself, are too well known to require notice.

I beg leave through you, Sir, to convey to the Society the cordial expression of my appreciation of the many marks of confidence and regard which, during so many years, I have received from the Society; they are indeed such as I never shall forget.

I hope still to be able occasionally to forward the interests of the Society as an individual Member. I hope sometimes to attend its Meetings, and to contribute papers.—I have the honour to be, Sir, your obedient Servant, (Signed) James D. Forbes.

To the Chairman of the
General Meeting of the Royal Society.

On the motion of Dr Christison, seconded by Dr Traill, it was remitted to the Council to prepare a reply to Principal Forbes' letter.

The following Office-Bearers were elected:—

His Grace the Duke of Argyll, K.T., President.

Sir David Brewster, K.H. Dr Christison, Professor Kelland, Hon. Lord Neaves, The Very Rev. Dean Ramsay, Principal Forbes,	Vice-Presidents.

Dr John Hutton Balfour, General Secretary.

Dr Lyon Playfair, C.B., Dr George James Allman,	Secretaries to the Ordinary Meetings.

J. T. Gibson-Craig, Esq., Treasurer.
Dr Douglas Maclagan, Curator of Library and Museum.

COUNCILLORS.

Andrew Murray, Esq.	James Dalmahoy, Esq.
Rev. Dr Lee.	Dr John Brown.
D. Milne-Home, Esq.	Professor Fraser.
Professor C. Innes.	James Leslie, Esq., C.E.
Dr Lowe.	Dr Schmitz.
Professor W. J. M. Rankine.	Dr Seller.

The following Gentlemen were then, on the motion of Dr Burt, appointed to audit the Treasurer's Accounts:—

David Smith, Esq. Wm. Thomas Thomson, Esq. Professor C. Innes.

The Meeting then adjourned.

MEMBERS ELECTED.

April 19, 1857.

Edmund C. Batten, Esq. (omitted in last volume.)

December 7, 1857.

Dr Thomas Williamson. Dr Robert B. Malcolm.
Dr James Duncan.

January 4, 1858.

Alexander Bryson, Esq.

January 18, 1858.

Frederick Field, Esq.

February 1, 1858.

James Leslie, Esq., C.E. Professor Cosmo Innes.
Professor A. C. Fraser.

March 15, 1858.

Rev. Dr Stevenson.

January 3, 1859.

William F. Skene, Esq.
G. W. Hay, Esq.
Robert Russell, Esq.
Dr Joseph Fayrer.
George Robertson, Esq., C.E.
Dr Lyon Playfair, C.B.

January 17, 1859.

Dr John Brown. Professor Richardson.

February 7, 1859.

Rev. John Duns.

March 21, 1859.

Lieut. John Hills.

December 5, 1859.

Captain Gordon Forlong.

January 16, 1860.

Dr William Robertson. Dr Frederick Guthrie.
J. Alfred Wanklyn, Esq.

February 6, 1860.

Professor MacDougall.

April 2, 1860.

George A. Jameson, Esq.
Rev. Leonard Shafto Orde.
Patrick Dudgeon, Esq. of Cargen.

April 17, 1860.

William Chambers, Esq. of Glenormiston.

January 7, 1861.

W. A. F. Browne, Esq.
Dr R. E. Scoresby-Jackson.
Rev. Thomas Brown.
Dr James M'Bain, R.N.
Professor P. Guthrie Tait.

February 4, 1861.

John Muir, D.C.L.
William Turner, M.B.
Dr W. Lauder Lindsay.

February 18, 1861.

James Lorimer, Esq.

March 4, 1861.

Archibald Geikie, Esq.
William Handyside, Esq.

March 18, 1861.

George Berry, Esq.

April 1, 1861.

Dr Thomas Herbert Barker.
Robert MacLachlan, Esq.
James Young, Esq.

April 29, 1861.

Dr Alexander Eugene Mackay, R.N.

LIST OF THE PRESENT ORDINARY MEMBERS.

Corrected up to November 1, 1861.

IN THE ORDER OF THEIR ELECTION.

His Grace the DUKE OF ARGYLL, K.T.,

PRESIDENT.

Date of Election.

1808 James Wardrop, Esq., London.
Sir David Brewster, K.H., LL.D., F.R.S. Lond., *Principal of the University of Edinburgh.*
1812 James Pillans, Esq., *Professor of Humanity.*
Sir George Clerk, Bart., F.R.S. Lond.
1813 William Somerville, M.D., F.R.S. Lond.
1815 Henry Home Drummond, Esq., *of Blair-Drummond.*
William Thomas Brande, Esq., F.R.S. Lond., *Professor of Chemistry in the Royal Institution.*
1816 Leonard Horner, Esq., F.R.S. Lond.
1817 Alexander Maconochie Wellwood, Esq., *of Meadowbank.*
Robert Bald, Esq., *Civil Engineer.*
1818 Patrick Miller, M.D., *Exeter.*
1819 Thomas Stewart Traill, M.D., *Professor of Medical Jurisprudence.*
1820 James Keith, M.D., *Surgeon.*
Charles Babbage, Esq., F.R.S. Lond.
Sir John F. W. Herschel, Bart., F.R.S. Lond.
Dr William Macdonald, *Professor of Natural History, St Andrews.*
1821 John Cay, Esq., *Advocate.*
Robert Kaye Greville, LL.D.
Robert Hamilton, M.D.
1822 James Smith, Esq., *of Jordanhill,* F.R.S. Lond.

Date of Election.

1822 William Bonar, Esq.
George A. Walker-Arnott, LL.D., *Professor of Botany, Glasgow.*
Sir James South, F.R.S. Lond.
Sir W. C. Trevelyan, Bart., *Wallington, Northumberland.*
John Russell, Esq., P.C.S.

1823 Captain Thomas David Stuart, *of the Hon. East India Company's Service.*
Andrew Fyfe, M.D., *Professor of Medicine and Chemistry, King's College, Aberdeen.*
Admiral Norwich Duff.
Warren Hastings Anderson, Esq.
Alexander Thomson, Esq., *of Banchory.*
Liscombe John Curtis, Esq., *Ingsdon House, Devonshire.*
Robert Christison, M.D., *Professor of Materia Medica.*

1824 Robert E. Grant, M.D., *Professor of Comparative Anatomy, University College, London.*
Rev. Dr William Muir, *one of the Ministers of Edinburgh.*
James Pillans, Esq.
James Walker, Esq., *Civil Engineer.*

1825 Honourable Lord Wood.

1827 John Gardiner Kinnear, Esq.
James Russell, M.D.
Very Rev. Edward Bannerman Ramsay, A.M., Camb., LL.D.

1828 David Maclagan, M.D.
Sir William A. Maxwell, *of Calderwood*, Bart.
John Forster, Esq., *Architect, Liverpool.*
Thomas Graham, A.M., *Master of the Mint, London.*
David Milne-Home, Esq., *Advocate.*
Dr Manson, *Nottingham.*

1829 A. Colyar, Esq.
Sir William Gibson-Craig, Bart., *of Riccarton.*
Right Honourable Duncan M'Neill, *Lord Justice-General.*
Venerable Archdeacon Sinclair, *Kensington.*
Arthur Connell, Esq., *Professor of Chemistry, St Andrews.*
James Walker, Esq., W.S.

1830 J. T. Gibson-Craig. Esq., W.S.
Sir Archibald Alison, Bart., *Sheriff of Lanarkshire.*
James Syme, Esq., *Professor of Clinical Surgery.*
Thomas Barnes, M.D., *Carlisle.*

1831 James D. Forbes, D.C.L., F.R.S. Lond., *Principal of the United College, St Andrews.*
David Boswell Reid, M.D., *London.*

1832 Robert Allan, Esq., *Advocate.*
Robert Morrieson, Esq., *Hon. E.I.C. Civil Service.*
Montgomery Robertson, M.D.

1833 Rear-Admiral Sir Alexander Milne, R.N.
His Grace the Duke of Buccleuch, K.G., *Dalkeith Palace.*
David Craigie, M.D.

Date of Election.

1833 Sir John Stuart Forbes, Bart., *of Pitsligo.*
Alexander Hamilton, LL.B., W.S.
1834 Mungo Ponton, Esq., W.S., *Clifton, Bristol.*
Isaac Wilson, M.D., F.R.S. Lond.
Patrick Boyle Mure Macredie, Esq., *Advocate, of Perceton.*
William Sharpey, M.D., *Professor of Anatomy, University College, London.*
1835 John Hutton Balfour, A.M., M.D., F.R.S. Lond., *Professor of Botany.*
William Brown, Esq., F.R.C.S.
R. Mayne, Esq.
1836 David Rhind, Esq., *Architect.*
Archibald Robertson, M.D., F.R.S. Lond.
1837 John Archibald Campbell, Esq., W.S.
John Scott Russell, Esq., A.M., *London.*
Charles Maclaren, Esq.
Archibald Smith, Esq., M.A., Camb., *Lincoln's Inn, London.*
Richard Parnell, M.D.
Peter D. Handyside, M.D., F.R.C.S.
1838 Thomas Mansfield, Esq., *Accountant.*
Alan Stevenson, Esq., *Civil Engineer.*
1839 David Smith, Esq., W.S.
Adam Hunter, M.D.
Rev. Philip Kelland, A.M., *Professor of Mathematics.*
F. Brown Douglas, Esq., *Advocate.*
Major-General Swinburne, of Marcus.
1840 Alan A. Welwood Maconochie, Esq.
Martyn J. Roberts, Esq., *Fort-William.*
Robert Chambers, Esq.
James Forsyth, Esq., *of Dunach.*
Sir John M'Neill, G.C.B.
John Cockburn, Esq.
Sir William Scott, Bart., *of Ancrum.*
Right Rev. Bishop Terrot.
Edward J. Jackson, Esq.
John Mackenzie, Esq.
James Anstruther, Esq., W.S.
1841 John Millar, Esq., *Civil-Engineer, Millfield House, Polmont.*
George Smyttan, M.D.
James Dalmahoy, Esq.
1842 James Thomson, Esq., *Civil-Engineer, London.*
John Davy, M.D. *Inspector-General of Army Hospitals.*
Robert Naysmith, Esq., F.R.C.S.
James Miller, Esq., *Professor of Surgery.*
John Goodsir, Esq., *Professor of Anatomy.*
1843 A. D. Maclagan, M.D., F.R.C.S.

Date of Election.

1843 John Rose Cormack, M.D., F.R.C.P., *Putney.*
Allen Thomson, M.D., *Professor of Anatomy, Glasgow.*
Joseph Mitchell, Esq., *Civil-Engineer, Inverness.*
Andrew Coventry, Esq., *Advocate.*
John Hughes Bennett, M.D., F.R.C.P., *Professor of Physiology.*
D. Balfour, Esq., *of Trenaby.*
Henry Stephens, Esq.
1844 J. Burn Murdoch, Esq., *Advocate, of Gartincaber.*
Archibald Campbell Swinton, Esq., *Professor of Civil Law.*
James Begbie, M.D., F.R.C.S.
James Y. Simpson, M.D., *Professor of Midwifery.*
David Stevenson, Esq., *Civil Engineer.*
Thomas R. Colledge, M.D., F.R.C.P.E.
1845 John G. M. Burt, M.D.
Thomas Anderson, M.D., *Professor of Chemistry, Glasgow.*
1846 A. Taylor, M.D., *Pau.*
S. A. Pagan, M.D.
Alexander J. Adie, Esq., *Civil Engineer.*
L. D. B. Gordon, Esq., C.E.
L. Schmitz, LL.D., Ph.D., *Rector of High School.*
Charles Piazzi Smyth, Esq., *Professor of Practical Astronomy.*
1847 William Thomson, Esq., M.A. Camb., *Professor of Natural Philosophy, Glasgow.*
J. H. Burton, Esq., *Advocate.*
James Nicol, Esq., *Professor of Natural History, Aberdeen.*
William Macdonald Macdonald, Esq., *of St Martins.*
Alexander Christie, Esq.,
John Wilson, Esq., *Professor of Agriculture.*
Moses Steven, Esq., *of Bellahouston.*
1848 Thomas Stevenson, Esq., C.E.
James Allan, M.D., *Inspector of Hospitals, Portsmouth.*
Henry Davidson, Esq.
Patrick Newbigging, M.D.
William Swan, Esq., *Professor of Natural Philosophy, St Andrews.*
Patrick James Stirling, Esq.
1849 William Stirling, Esq., *of Keir*, M.P.
John Thomson Gordon, Esq., *Sheriff of Mid-Lothian.*
D. R. Hay, Esq.
William Thomas Thomson, Esq.
Honourable Lord Ivory.
William E. Aytoun, D.C.L., *Professor of Rhetoric and Belles Lettres.*
W. H. Lowe, M.D., *Balgreen.*
Honourable B. F. Primrose.
David Anderson, Esq., *of Moredun.*
W. R. Pirrie, M.D., *Professor of Surgery, Marischal College, Aberdeen.*

Date of Election.

1849 His Grace The Duke of Argyll, *Inverary Castle.*
The Most Noble the Marquis of Tweeddale, K.T.
Edward Sang, Esq.
1850 William John Macquorn Rankine, Esq., C.E., *Professor of Civil Engineering, Glasgow University.*
Alexander Keith Johnston, Esq.
Sheridan Muspratt, M.D., *Liverpool.*
James Stark, M.D. (Re-admitted.)
Captain W. Driscoll Gossett, R.E.
William Seller, M.D., F.R.C.P.E.
Hugh Blackburn, Esq., *Professor of Mathematics, Glasgow.*
R. D. Thomson, M.D., *London.*
Beriah Botfield, Esq., *Norton Hall, Northamptonshire.*
J. S. Combe, M.D.
1851 Sir David Dundas, Bart., *of Dunira.*
John Stewart, Esq., *of Nateby Hall.*
E. W. Dallas, Esq.
Rev. James Grant, D.C.L., D.D., *one of the Ministers of Edinburgh.*
1852 Eyre B. Powell, Esq., *Madras.*
Thomas Miller, Esq., A.M., LL.D., *Rector, Perth Academy.*
Allen Dalzell, M.D.
James Cunningham, Esq., W.S.
Alexander James Russell, Esq., C.S.
Andrew Fleming, M.D., *Bengal.*
1853 James Watson, M.D., *Bath.*
Capt. Robert Maclagan, *Bengal Engineers.*
Rev. Dr Robert Lee, *Professor of Biblical Criticism and Biblical Antiquities.*
Rev. John Cumming, D.D., *London.*
Hugh Scott, Esq., *of Gala.*
Græme Reid Mercer, Esq.
1854 Sir John Maxwell, Bart., *of Polloc.*
Dr John Addington Symonds, *Clifton, Bristol.*
Dr William Bird Herapath, *Bristol.*
Robert Harkness, Esq., *Professor of Mineralogy and Geology, Queen's College, Cork.*
James Coxe, M.D.
Ernest Bonar, Esq.
1855 James P. Fraser, Esq.
Stevenson Macadam, Ph.D.
Robert Etheridge, Esq., *Clifton, Bristol.*
Right Honourable John Inglis, *Lord Justice Clerk.*
Rev. James S. Hodson, D.D., *Oxon., Rector of the Edinburgh Academy.*
Wyville T. C. Thomson, LL.D., *Professor of Geology, Belfast.*
Dr Wright, *Cheltenham.*
James Hay, Esq.

Date of Election.

1855 R. M. Smith, Esq.
1856 David Bryce, Esq.
William Mitchell Ellis, Esq.
George J. Allman, M.D., *Professor of Natural History.*
Honourable Lord Neaves.
Dr Frederick Penny.
Thomas Laycock, M.D., *Professor of the Practice of Medicine.*
Thomas Cleghorn, Esq.
James Clerk Maxwell, Esq., *Professor of Natural Philosophy, King's College, London.*
1857 James Black, M.D.
John Ivor Murray, M.D.
John Blackwood, Esq.
Reverend Dr James Macfarlane, *Duddingston.*
W. M. Buchanan, M.D.
Thomas Login, Esq. C.E., *Pegu.*
1857 Edmund C. Batten, M.A., *Lincoln's Inn, London.*
Thomas Williamson, M.D., *Leith.*
Robert B. Malcolm, M.D.
James Duncan, M.D.
1858 Alexander Bryson, Esq.
Frederick Field, Esq., *Chili.*
James Leslie, Esq., C.E.
Cosmo Innes, Esq., *Professor of History.*
Rev. Alexander C. Fraser, *Professor of Logic.*
Rev. William Stevenson, D.D., *Professor of Ecclesiastical History.*
1859 William F. Skene, Esq., W.S.
G. W. Hay, Esq.
Robert Russell, Esq.
Joseph Fayrer, M.D.
George Robertson, Esq., C.E.
Lyon Playfair, C.B., *Professor of Chemistry.*
John Brown, M.D.
Professor Richardson, *Durham.*
Rev. John Duns, *Torphichen.*
Lieut. John Hills, *Bombay Engineers.*
Captain Gordon Forlong.
1860 William Robertson, M.D.
Frederick Guthrie, M.D., *Professor of Chemistry, Mauritius.*
J. Alfred Wanklyn, Esq.
Patrick C. MacDougall, Esq., *Professor of Moral Philosophy.*
George A. Jameson, Esq.
Rev. Leonard Shafto Orde.
Patrick Dudgeon, Esq., *of Cargen.*
William Chambers, Esq., *of Glenormiston.*

Date of Election.

1861 W. A. F. Browne, Esq., *one of H. M. Commissioners in Lunacy for Scotland.*
Rev. Thomas Brown.
Robert Edmund Scoresby-Jackson, M.D.
James M'Bain, M.D., R.N.
Peter Guthrie Tait, Esq., *Professor of Natural Philosophy.*
John Muir, D.C.L., LL.D.
William Turner, M.B.
William Lauder Lindsay, M.D.
James Lorimer, Esq., *Advocate.*
Archibald Geikie, Esq.
William Handyside, Esq.
George Berry, Esq.
Thomas Herbert Barker, M.D.
Robert MacLachlan, Esq. *of MacLachlan.*
James Young, Esq.
Alexander Eugene Mackay, M.D., R.N.

LIST OF NON-RESIDENT AND FOREIGN MEMBERS.

ELECTED UNDER THE OLD LAWS.

NON-RESIDENT.

Richard Griffiths, Esq., *Civil Engineer.*

LIST OF HONORARY FELLOWS.

His Majesty the King of the Belgians.
His Imperial Highness the Archduke John of Austria.
His Royal Highness the Prince Consort.

FOREIGNERS (LIMITED TO THIRTY-SIX.)

Prof. A. D. Bache,	*United States.*
* M. Biot,	*Paris.*
M. Agassiz,	*United States.*
M. Cousin,	*Paris.*
M. Dumas,	*Do.*
M. Charles Dupin,	*Do.*
M. Ehrenberg,	*Berlin.*
M. Elie de Beaumont,	*Paris.*
M. Encke,	*Berlin.*
M. Flourens,	*Paris.*
M. Guizot,	*Do.*
M. Haidinger,	*Vienna.*
M. Hansteen,	*Christiania.*
M. Hausmann,	*Göttingen.*
M. Lamont,	*Munich.*
M. Leverrier,	*Paris.*

N.B.—The name marked thus * in the preceding list, was included in the original Honorary List prior to the change of the Law distinguishing British Subjects from Foreigners.

M. Liebig,	*Munich.*
Dr Von Martius,	*Do.*
M. Milne-Edwards,	*Paris.*
M. Mitscherlich,	*Berlin.*
M. Necker,	*Geneva.*
M. Plana,	*Turin.*
M. Quetelet,	*Brussels.*
M. Regnault,	*Paris.*
Prof. Henry D. Rogers,	*Pennsylvania.*
M. Gustav Rose,	*Berlin.*
M. Studer,	*Berne.*
M. Struve,	*Pulkowa.*

BRITISH SUBJECTS (LIMITED TO TWENTY, BY LAW X.).

J. C. Adams, Esq.,	*Cambridge.*
G. B. Airy, Esq.,	*Greenwich.*
Dr Faraday,	*London.*
Thomas Graham, Esq.,	*Do.*
Sir W. R. Hamilton,	*Dublin.*
Sir John F. W. Herschel, Bart.,	*Collingwood.*
Sir William J. Hooker,	*Kew.*
W. Lassell, Esq.,	*Liverpool.*
Rev. Dr Lloyd,	*Dublin.*
Sir William E. Logan,	*Canada.*
Sir Charles Lyell,	*London.*
Sir Roderick I. Murchison,	*Do.*
Richard Owen, Esq.,	*Do.*
Sir John Richardson, M.D.,	*Lancrig, Westmoreland.*
Earl of Rosse,	*Parsonstown.*
W. H. Fox Talbot, Esq.,	*Lacock Abbey, Wiltshire.*
Rev. Dr Whewell,	*Cambridge.*

LIST OF FELLOWS DECEASED, RESIGNED, AND CANCELLED,

FROM AUGUST 1857 TO NOVEMBER 1861.

HONORARY FELLOWS DECEASED.

M. de Hammer, *Vienna.*
Baron Humboldt, *Berlin.*
M. Müller, *Do.*
M. Thenard, *Paris.*
M. Tiedemann, *Heidelberg.*
Robert Brown, Esq., *London.*
Henry Hallam, Esq., *Do.*
Robert Stephenson, Esq., *Do.*

ORDINARY FELLOWS DECEASED.

Alexander Monro, M.D.
General Sir Thomas Makdougall Brisbane, Bart., G.C.B., G.C.H., F.R.S. Lond.
James Jardine, Esq., *Civil Engineer.*
Alexander Gillespie, Esq., *Surgeon.*
Right Honourable Viscount Arbuthnot.
John Fleming, D.D., *Professor of Natural Science, New College.*
William P. Alison, M.D., *Emeritus Professor of Practice of Physic.*
John Watson, M.D.
Right Honourable John Hope, *Lord Justice-Clerk.*
Patrick Murray, Esq., *of Simprin.*
Alexander Adie, Esq.
George Forbes, Esq.
John Schank More, Esq., *Professor of Scots Law.*
Sir John Hall, Bart. *of Dunglass.*
John Lizars, Esq., *Surgeon.*
Very Rev. John Lee, D.D., *Principal of the University of Edinburgh.*
Robert Bell, Esq., *Advocate.*
William Wood, Esq., *Surgeon.*
Sir David Hunter Blair, Bart., *Blairquhan.*
Honourable Mountstuart Elphinstone.
Right Honourable Lord Dunfermline.
John Sligo, Esq. *of Carmyle.*
William Gregory, M.D., *Professor of Chemistry.*
Right Honourable Earl Cathcart.

Professor Low.
John Davies Morries Stirling, Esq.
Thomas Jameson Torrie, Esq.
John Haldane, Esq.
Right Honourable Lord Campbell.
William Alexander, Esq. W.S.
John Learmonth, Esq. *of Dean.*
Sir James Forrest, Bart. *of Comiston.*
Honourable Lord Murray.
James Andrew, M.D.
Rev. James Robertson, D.D., *Professor of Ecclesiastical History.*
Honourable Lord Handyside.
James Tod, Esq., W.S.
Right Honourable The Earl of Minto, G.C.B.
Right Honourable The Earl of Aberdeen, K.T.
Right Honourable The Earl of Haddington, K.T.
Mortimer Glover, M.D.
Sir James Ramsay, Bart.
James M. Hog, Esq. *of Newliston.*
George Buist, M.D., *Bombay.*
William Murray, Esq., *Monkland.*
Sir James M. Riddell, Bart., *Strontian.*
Erskine Douglas Sandford, Esq., *Advocate.*
George Wilson, M.D., *Professor of Technology.*
Sir John Melville.
John Gordon, Esq. *of Cairnbulg.*

RESIGNATIONS.

John Stenhouse, M.D., *Islington.*
Sir George Douglas, Bart. *of Springwood Park.*
Thomas A. Wise, M.D.
Sir Robert K. Arbuthnot, Bart.
Horatio Ross, Esq. *of Netherley.*
Brinsley de Courcy Nixon, Esq.
Andrew Murray, Esq. *of Conland*, W.S.
George Makgill, Esq. *of Kembach.*

ELECTION CANCELLED.

Henry Dunlop, Esq. *of Craigton.*

The following Public Institutions and Individuals are entitled to receive Copies of the Transactions and Proceedings of the Royal Society of Edinburgh :—

ENGLAND.

The British Museum.
The Bodleian Library, Oxford.
The University Library, Cambridge.

The Royal Society.
The Linnean Society.
The Society for the Encouragement of Arts.
The Geological Society.
The Royal Astronomical Society.
The Royal Asiatic Society.
The Zoological Society.
The Royal Society of Literature.
The Horticultural Society.
The Royal Institution.
The Royal Geographical Society.
The Statistical Society.
The Institution of Civil Engineers.
The Institute of British Architects.
The Hydrographical Office, Admiralty.
The Medico-Chirurgical Society.
The Athenæum Club.
The Cambridge Philosophical Society.
The Manchester Literary and Philosophical Society.
The Yorkshire Philosophical Society.
The Chemical Society of London.
The Museum of Economic Geology.
The United Service Institution.
The Royal Observatory, Greenwich.
The Leeds Philosophical and Literary Society.
The Historic Society of Lancashire and Cheshire.
The Royal College of Surgeons of England.

SCOTLAND.

Edinburgh, University Library.
... Advocates' Library.
Edinburgh, College of Physicians.
... Highland and Agricultural Society.
... Royal Medical Society.
... Royal Physical Society.
... Royal Scottish Society of Arts.
Glasgow, University Library.
St Andrews, University Library.
Aberdeen, Library of Kings' College.

IRELAND.

The Library of Trinity College, Dublin.
The Royal Irish Academy.

COLONIES, &c.

The Asiatic Society of Calcutta.
The Literary and Historical Society of Toronto.

CONTINENT OF EUROPE.

Amsterdam, Royal Institute of Holland.
Berlin, Royal Academy of Sciences.
... Physical Society.
Berne, Society of Swiss Naturalists.
Bologna, Academy of Sciences.
Bonn, Cæsarean Academy of Naturalists.
Brussels, Royal Academy of Sciences.
Buda, Literary Society of Hungary.
Copenhagen, Royal Academy of Sciences.
Frankfort, the Senkenbergian Museum.
Geneva, Natural History Society.
Giessen, University Library.
Göttingen, University Library.
Haarlem, Natural History Society.
Leipzig, Royal Saxon Academy.
Lille, Royal Society of Sciences.
Lisbon, Royal Academy of Sciences.
Lyons, Agricultural Society.
Milan, Royal Institute.

Moscow, Imperial Academy of Naturalists.
Munich, Royal Academy of Sciences of Bavaria (2 copies).
Neufchatel, Museum of Natural History.
Paris, Royal Academy of Sciences.
... Geographical Society.
... Royal Society of Agriculture.
... Society for Encouragement of Industry.
... Geological Society of France.
... Ecole des Mines.
... Marine Depôt.
... Museum of Jardin des Plantes.
Rotterdam, Batavian Society of Experimental Philosophy.
Stockholm, Royal Academy of Sciences.
St Petersburg, Imperial Academy of Sciences.
... M. Kupffer.
St Petersburg, Pulkowa Observatory.
Turin, Royal Academy of Sciences.
... M. Michelotti.
Venice, Royal Institute.
Vienna, Imperial Academy of Sciences.
... Geological Society.

UNITED STATES OF AMERICA.

Boston, the Bowditch Library.
New York State Library.
Philadelphia, American Philosophical Society.
... Academy of Natural Sciences.
Yale College, Professor Silliman.
Washington, the Smithsonian Institution.

(*All the Honorary and Ordinary Fellows of the Society are entitled to the Transactions and Proceedings.*)

The following Institutions and Individuals receive the Proceedings only :—

ENGLAND.

The Scarborough Philosophical Society.
The Whitby Philosophical Society.
The Newcastle Philosophical Society.
The Geological Society of Cornwall.
The Ashmolean Society of Oxford.
The Literary and Philosophical Society of Liverpool.

SCOTLAND.

The Philosophical Society of Glasgow.
The Botanical Society of Edinburgh.

COLONIES.

The Literary and Philosophical Society of Quebec.
The Literary Society of Madras.

CONTINENT OF EUROPE.

Utrecht, the Literary and Philosophical Society.
Paris, Editor of L'Institut.
Cherbourg Society of Natural Sciences.

UNITED STATES.

Professor Dana, Connecticut.
Academy of Natural Science, Philadelphia.

LIST OF DONATIONS.

(Continued from Vol. XXI. p. 699.)

The following List of Donations, announced at the Society's Meeting on 2d March 1857, was omitted in its proper place in the Proceedings :—

Philosophical Transactions of the Royal Society of London. Vol. cxliv., Part 2, cxlv., and cxlvi. London, 1854–56. 4to.	The Society.
Proceedings of the Royal Society, Vol. viii., No. 24.	Ditto.
Annales de l'Observatoire Physique Central de Russie. No. 2. Correspondence Météorologique pour l'année 1854. St Petersbourg, 1855. 4to.	The Observatory.
Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. March 1857. Edinburgh. 8vo.	The Society.
The American Journal of Science and Arts. January, 1857. 8vo.	The Editors.
Bulletin de la Société de Geographie, Quatrième serie, Tome xii. 1857. 8vo.	The Society.
Transactions of the Royal Scottish Society of Arts. Vol. iv., Part 4.	The Society.
Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Deel. xii., tweede verzameling.	Ditto.
On certain Trains of Erratic Rocks on the Western borders of Massachusetts, U.S. By Sir Charles Lyell, F.R.S. 8vo.	Ditto.

November 5, 1857.

DONATIONS.	DONORS.
Scheikundige Verhandelingen en Onderzoekingen door G. J. Mulder. Eerste Deele. Rotterdam, 1857. 8vo.	Dutch Government.
List of Members of the Institute of Actuaries. 8vo.	The Institute.
Letter to Lord Viscount Palmerson on Medical Reform. By John G. M. Burt. Edinburgh, 1857. 8vo.	The Author.
Collection of Admiralty Charts, and relative Lists, and other Documents.	The Admiralty.
Proceedings of the Berwickshire Naturalists' Club. Vol. iv. Part 1. 8vo.	The Club.
Notices of the Meetings of the Members of the Royal Institution of Great Britain. Part 7. 8vo.	The Society.
Transactions of the Historic Society of Lancashire and Cheshire. Vol. ix. London, 1857. 8vo.	Ditto.
Charts of Tract-Survey of the Rivers Salado, Parana, and Colastiné. By Commander Thomas J. Page, U.S.S. Water Witch. 1855.	The Author.
Annalen der Königlichen Sternwarte bei Münich. Band ix. 8vo.	The Observatory.
Fortschritte der Physik. Jahr 1847, zweite abthielung ; 1853 ; 1854. Berlin. 8vo.	The Physical Society, Berlin.

DONATIONS.	DONORS.
Proceedings of the Royal Astronomical Society. Vol. xvii. No. 9. 8vo.	The Society.
Resultate aus den an der Königl. Sternwarte veranstalteten meteorologischen Untersuchungen, nebst Andentungen über den Einfluss des Clima von München auf die Gesundheits-Verhältnisse der Bewohner. Von Dr J. Lamont. München, 1857. 4to.	The Observatory.
Catalogue of the New York State Library. 2 vols. Albany, 1856. 8vo.	The State.
Documents relative to the Colonial History of the State of New York, procured in Holland, England, and France, by John Romeyn Brodhead. Edited by E. B. O'Callaghan, M.D. Vols. v., vi., and ix., Albany, 1855. 4to.	The American Geo. and Stat. Society.
Proceedings of the Academy of Natural Sciences of Philadelphia for 1856–57. 8vo.	The Academy.
Proceedings of the American Philosophical Society. Vol. vi. No. 56. 8vo.	The Society.
Transactions of the American Philosophical Society. New Series. Vol. ii. Part i. Philadelphia, 1857. 4to.	Ditto.
Reports of the Commissioners of Patents for 1855. 8vo.	The American Geo. and Stat. Society.
First Annual Report on the Improvement of the Central Park, New York. New York, 1857. 8vo.	Ditto.
Memoirs of the American Academy of Arts and Sciences. New Series. Vol. vi. Part I. Cambridge and Boston, 1857. 4to.	The Society.
Smithsonian Contributions to Knowledge. Vol. ix. Washington, 1857. 4to.	The Smith. Inst.
Report on Insanity and Idiocy in Massachusetts. By the Commission of Lunacy. Boston, 1855. 8vo.	The American Statistical Society.
Report of the Superintendent of the Coast Survey, showing the progress of the Survey during the year 1855. Washington, 1856. 4to.	Professor Bache.
Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. Quarters ending 31st March 1857, 30th June 1857, and 30th September 1857. 8vo.	The Registrar-General.
Calcul Decidouzinal par M. le Baron Silvio Ferrari; traduction sur l'original Italien. Turin, 1857. 4to.	The Author.
Magnetische Ortsbestimmungen ausgeführt an verschiedenen Puncten des Königriechs Bayern und an einigen auswärtigen Stationen. Von Dr J. Lamont. 2 Thiel. München, 1856. 8vo.	Ditto.
Specimen of Tables, calculated and stereomoulded by the Swedish Calculating Machine of George and Edward Scheutz. London, 1857. 8vo.	The Authors.
Report of Council read at the Annual General Meeting, held 4th May 1857, of the Royal Institute of British Architects. 4to.	The Institute.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Nos. 2, 3. Wien, 1856.	Ditto.
Quarterly Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. July and October 1857.	The Society.
Transactions of the Linnean Society of London. Vol. xxii. Part 1. London, 1856. 4to.	Ditto.
American Journal of Science and Arts, conducted by Professors Silliman and Dana. May and September 1857.	The Editors.
Resumen de Los Trabajos Meteorologicos correspondientes al año 1854, verificados en el Real Observatorio de Madrid bajo la direccion de D. Manuel Rico y Sinobas. Madrid, 1857. 4to.	The Observatory.
Compte-Rendu Annuel adresse a s. exc. M. De Brock, Ministre des Finances, par le Directeur de l'Observatoire Physique Central, A. T. Kupffer. Annee 1855. St Petersburg, 1856. 4to.	Ditto.
Assurance Magazine and Journal of the Institute of Actuaries. July and October 1857. 8vo.	The Institute.
Descriptions of four new species of Unios, &c. By Isaac Lea, LL.D. Philadelphia, 1857. 8vo.	The Author.
Report of the Secretary of War, communicating Colonel Graham's Report of the Harbours, &c., in Wisconsin, Illinois, Indiana, and Michigan. Washington, 1856. 8vo.	The Secretary of War, U.S.

DONATIONS.	DONORS.
Statistical Report on the Sickness and Mortality in the Army of the United States, compiled from the Records of the Surgeon-General's Office; embracing a period of sixteen years, from January 1839 to January 1855. By Richard H. Coolidge, M.D. Washington, 1856. 4to.	The Surgeon-General, U.S. Army.
Astronomische Beobachtungen auf der Königlichen Universtäts Sternwarte zu Königsberg. Sieben und zwanzigste, acht und zwanzigste und dreissigste Abthiel. Königsberg, 1856. 8vo.	The Observatory.
Verslagen en Mededeelingen der Koninklijke Akademie van Wetenschappen. Afdeeling Natuurkunde, vijfde Deel, tweede und derde Stuk; zesde deel, eerst, tweede, und derde Stuk. Afdeeling Letterkunde, tweede Deel, tweede, derde, und vierde Stuk. Amsterdam, 1856–57. 8vo.	The Academy.
Octaviæ Querela. Carmen cujus auctori Johanni van Leeuwen, e Vico Zegwaart, certaminis poetici præmium secundum e legato Jacobi Henrici Hoeufft adjudicatum est in consessu publico Academiæ Regiæ Scientiarum, die 9m. Martii anni 1857. Amstelodami, 1857. 8vo.	Ditto.
Report of the Geological Survey in Kentucky, made during the years 1854 and 1855. By David Dale Owen. Frankfort, Kentucky, 1856. 8vo.	The Smithsonian Institution.
Report of the Commissioners of Patents for the year 1855. Agriculture, Arts, and Manufactures. Washington, U.S., 1856. 8vo.	The U.S. Patent Office.
Report of the Secretary of State on the Criminal Statistics of the State of New York. Albany, 1855. 8vo.	The State.
Annual Report of the Commissioners of Emigration of the State of New York, for the year ending 31st December 1856. New York, 1856. 8vo.	Ditto.
Annual Report of the Canal Commissioners of the State of New York, for 1854. Albany, 1855. 8vo.	Ditto.
Report of the Joint Special Committees of the Chamber of Commerce, and American Geographical and Statistical Society, on the extension of the decimal system to Weights and Measures of the United States. New York, 1857.	The American Statistical Society.
Annual Report of the Secretary of State, relative to Statistics of the Poor of New York. Albany, 1855. 8vo.	The State.
On the Statistics and Geography of the Production of Iron. By Abram S. Hewitt. New York, 1856. 8vo.	The American Geo. and Stat. Society.
Report of the State Engineer and Surveyor on the Canals of the State of New York, for 1854. Albany, 1855. 8vo.	The State.
Bulletin of the American Geographical and Statistical Society. Vol. ii. New York, 1857. 8vo.	The Society.
The Growth of Cities. By Henry P. Tappan, D.D. New York, 1855. 8vo.	The N.Y. Geo. Soc.
Eighth Annual Report of the Governors of the Alms House, New York, for the year 1856. New York, 1857. 8vo.	The Governors.
Access to an open Polar Sea, in connection with the search after Sir John Franklin, and his Companions. By E. K. Kane, M.D. New York, 1853. 8vo.	The American Geo. and Stat. Society.
Annual Report of the Board of Regents of the Smithsonian Institution, for the year 1856. Washington, 1857. 8vo.	The Institution.
An Account of the Smithsonian Institution, its Founder, Building, Operations, &c. By William J. Rhees. Washington, 1857. 8vo.	Ditto.
The Transactions of the Academy of Science of St Louis. Vol. i. St Louis, 1857. 8vo.	The Academy.
Annual Reports of the Board of Agriculture of the State of Ohio, for the years 1850, 1851, 1852, 1853, 1855. 8vo.	The State of Ohio.
On the New Red Sandstone Formation of Pennsylvania, &c. By Isaac Lea, LL.D. Philadelphia, 1856. 8vo.	The Author.
Archæologia; or, Miscellaneous Tracts, relating to Antiquity, published by the Society of Antiquaries, London. Vol. xxxvi. Part 2. and Vol. xxxvii. Part 1. London, 1857. 4to.	The Society.
Proceedings of the Boston Society of Natural History. 1856–7. 8vo.	Ditto.

DONATIONS.	DONORS.
Nova Acta Regiæ Societatis Scientiarum Upsalensis. Seriei tertiæ, Vol. i. Fasc. 1 et 2; Vol. ii. Fasc. 1. Upsal, 1855–6. 4to.	The Society.
Mémoires Couronnés et Mémoires des Savants Étrangers, publies par l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tomes xxvi., xxvii., xxviii. Bruxelles, 1855–6. 4to.	The Academy.
Mémoires de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome xxx. Bruxelles, 1857. 4to.	Ditto.
Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou. Tome x. Moscou, 1855. 4to.	The Society.
Astronomical Observations made at the Royal Observatory, Edinburgh. By Charles Piazzi Smyth, F.R.SS.L. and E. Vol. xi. for 1849–54. Edinburgh, 1857. 4to.	The Observatory.
Report on the Adjudication of the Copley, Rumford, and Royal Medals; and appointment of the Bakerian, Croonian, and Fairchild Lectures, compiled from the original Documents in the Archives of the Royal Society. By James Hudson. London, 1834. 4to.	The Society.
Six Discourses delivered before the Royal Society at their Anniversary Meetings, on the award of the Royal and Copley Medals; preceded by an Address to the Society on the Progress and Prospects of Science, by Sir Humphry Davy, Bart. London, 1827. 4to.	Ditto.
Mémoires de l'Académie Impériale des Sciences de St Petersburg. Sixième Serie. Sciences Naturelles, Tome vii.; Sciences Politiques, Histoire, Philologie, Tome viii. St Petersbourg, 1855. 4to.	The Academy.
Mémoires Présentés a l'Académie Impériale des Sciences de St Petersbourg par divers Savants, et lu dans ses Assemblées. Tome vii. St Petersbourg, 1854. 4to.	Ditto.
Annuaire de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique, 1856, 1857. Bruxelles, 12mo.	Ditto.
Almanach der Kaiserlichen Akademie der Wissenschaften. Siebenter Jahrgang, 1857. Wien. 8vo.	Ditto.
Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in the year 1855, under the superintendence of Manuel J. Johnston, M.A., Radcliffe Observer. Vol. xvi. Oxford, 1856. 8vo.	The Observatory.
Journal of the Asiatic Society, 1856, No. 6; 1857, Nos. 1, 2, and 3. Calcutta, 8vo.	The Society.
Etioles Filantes. Télégraphe Électrique. Phénomènes periodique. Par A. Quetelet. 8vo.	The Author.
Rapport adressé a M. le Ministre de l'Interieur, sur l'Etat et les Travaux de l'Observatoire Royale, pendant l'année 1856; par le Directeur A. Quetelet.	Ditto.
Proceedings of the Royal Astronomical Society. Vol. xvii., Nos. 4–7.	The Society.
Des Observatoires du Nord de l'Allemagne et de la Hollande et du Magnétisme Terrestre dans ces deux Contrees. Par Ernest Quetelet. 8vo.	The Author.
Rapport de M. Ad. Quetelet sur une Memoire concernant l'etat actuel des lignes isoclimiques et isodynamiques dans la Grande Bretagne, la Hollande, la Belgique et la France, d'après les Observations de l'auteur M. Mahmoud-Effendi, Astronome Egyptien. 8vo.	M. Quetelet.
Proceedings of the Society of Antiquaries of London. Vol. iii., Nos. 43–46. London. 8vo.	The Society.
List of the Society of Antiquaries of London. 1856. 8vo.	Ditto.
Journal of the Geological Society of Dublin. Vol. vii., Part 4. Dublin, 1857. 8vo.	Ditto.
Bulletin de la Société Impériale des Naturalistes de Moscou. Année 1853, Nos. 3, 4; 1855, Nos. 2, 3, et 4; 1856, No. 1. Moscou. 8vo.	Ditto.
Extrait du Programme de la Société Hollandaise des Sciences à Harlem, pour l'année 1857. 4to.	Ditto.
Monthly Returns of the Births, Deaths, and Marriages registered in the eight principal Towns of Scotland. March, April, May, June, July, Sept, 1854. 8vo.	The Registrar-General.

DONATIONS.	DONORS.
Memoirs of the Geological Survey of India. Calcutta, 1856. 8vo.	The Gov.-Gen. of India.
Journal of the Royal Geographical Society. Vol. xxvi. London, 1856. 8vo.	The Society.
Flora Batava. 181 aflevering. 4to.	King of Holland.
Método lexiologica y hermeneutico para aprender la lengua francesa fundado en las leyes de entomologia, analogia, y onomatopeya, que presiden à la formacion de las Lenguas. Par Don Vicente Alcober y Larbo. Madrid, 1857. 4to.	The Author.
Quarterly Journal of the Chemical Society. No. 37. 8vo.	The Society.
Nouveau Mémoire sur la Question relative aux Ægilops triticoides et speltiformis. Paris, 1857. 8vo.	
Archives du Museum d'Histoire Naturelle publiées par les Professeurs-Administrateurs de cet Etablissement. Tome ix. Paris, 1856. 4to.	The Museum.
Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome iv., premier cahier. Neuchatel, 1856. 8vo.	The Society.
Transactions of the Architectural Institute of Scotland. Vol. v. (Session 1855–6). Edinburgh, 1856. 8vo.	Ditto.
Astronomical, and Magnetical, and Meteorological Observations made at the Royal Observatory, Greenwich, in the year 1855, under the direction of George Biddell Airy, M.A., Astronomer-Royal. London, 1857. 4to.	The Board of Admiralty.
Tables de la Lune construites d'après de principe Newtonien de la gravitation universelle, par P. A Hansen, Directeur de l'Observatoire Ducal de Gotha. Imprime aux frais du Gouvernement Britannique. Londres, 1857. 4to.	Ditto.
Ophthalmic Hospital Reports and Journal of the Royal London Ophthalmic Hospital. Edited by J. F. Streatfield. No. 1, October 1857. London. 8vo.	The Editor.
Magnetical and Meteorological Observations made at the Hon. East India Company's Observatory, Bombay, under the superintendence of Lieutenant E. F. T. Ferguson, I.N. For years 1854–5. Bombay, 1855–6. 4to.	The Hon. E. India Company.
Catalogue of the Library of the Philosophical Institution of Edinburgh. Edinburgh, 1857. 8vo.	The Institution.
Jahresbericht über die Fortschritte der reinen, pharmaceutischen und technischen Chemie, Physick, Mineralogie und Geologie. Unter Mitwirkung von H. Buff, F. Knapp, H. Will, F. Zamminer, herausgegeben von Justus Liebig und Hermann Kopp. Für 1856. Giessen, 1857. 8vo.	The Editors.
Journal of the Proceedings of the Linnean Society. Vol. ii., Nos. 5 and 6. London, 1857. 8vo.	The Society.
Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome iv., deuxième cahier. Neuchatel, 1857. 8vo.	Ditto.
Proceedings of the Royal Geographical Society of London, No. 8. London, 1857. 8vo.	Ditto.
Address delivered at the Anniversary Meeting of the Geological Society of London, on 20th February 1857, by Colonel J. E. Portlock, R.E., President of the Society. London, 1857. 8vo.	The Author.
A new Classified Catalogue of the Library of the Royal Institution of Great Britain, with indexes of Authors and Subjects, and a list of Historical Pamphlets chronologically arranged. By Benjamin Vincent. London, 1857. 8vo.	The Institution.
Die Bohmischen Exulanten in Sachsen. Von Christian Adolph Pescheck. Leipzig, 1857. 8vo.	The Author.
Abhandlungen der Königlichen Akademie der Wissenschaften zu Berlin. 1855, 1856. Berlin, 4to.	The Academy.
Transactions of the Zoological Society of London. Vol. iv., Part 4. London, 1857. 4to.	The Society.
Twenty-fourth Annual Report of the Royal Cornwall Polytechnic Society, 1856. Falmouth. 8vo.	Ditto.
Proceedings of the Zoological Society. Nos. 310–338. London. 8vo.	Ditto.
The Bakerian Lecture. Experimental Relations of Gold (and other Metals) to Light. By Michael Faraday, D.C.L. London, 1857. 4to.	The Author.

DONATIONS.	DONORS.
Sur le Climat de la Belgique. De l'Etat du Ciel en général, par A. Quetelet. Bruxelles, 1857. 4to.	The Author.
Annales de l'Observatoire Royal de Bruxelles, publieés, aux frais de l'Etat, par le Directeur, A. Quetelet. Tome xi. Bruxelles, 1857. 4to.	The Observatory.
Observations des Phénomènes Périodiques. Bruxelles. 4to.	M. Quetelet.
Contributions to the Meteorology and Hydrography of the Indian Ocean. By Charles Meldrum, A.M. Part 1. Mauritius, 1856. 4to.	The Author.
Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin. Januar–August 1857.	Berlin Academy.
Denkschriften der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe, Zwolfter Band. Vienna, 1856. 4to.	The Academy.
The Quarterly Journal of the Geological Society. Vol. xiii. Parts 2 and 4. London, 1857. 8vo.	The Society.
Ueber die Placodermen des Devonischen Systems. Von Dr Christian Heinrich Pander. St Petersburg, 1857. 4to.	Corps des Ingénieurs des Mines de Russie.
Monographie der Fossilen Fische des Silurischen Systems der Russisch-Baltischen Gouvernements. Von Dr Christian Heinrich Pander. St Petersburg, 1856. 4to.	Ditto.
Bulletin de la Société Impériale des Naturalistes de Moscou. Tome xxvii., No. 1. Moscou, 1854. 8vo.	The Society.
The Canadian Journal of Industry, Science, and Art, conducted by the Canadian Institute. New Series, Nos. 8 and 10, July–September 1857. Toronto. 8vo.	The Institute.
Bulletins de l'Académie Royale des Sciences, des Lettres, et des Beaux-Arts de Belgique. Tome xxii. 2ieme partie; Tome xxiii. Bruxelles, 1855–6. 8vo.	The Academy.
Journal of the Statistical Society of London. Vol. xxii., Part 2. (June 1857). London, 8vo.	The Society.
Compte Rendu de l'Académie Impériale des Sciences de St Petersbourg. 1852, 1853, 1854, 1855. St Petersbourg. 8vo.	The Academy.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenshaftliche Classe, Band xxii.; Band xxiii., Heft. 1. Philosophisch-Historische Classe, Band xxi., Heft 3; Band xxii., Heft 1 und 2. Vienna, 1856–7. 8vo.	The Imperial Academy, Vienna.
Annuaire de l'Observatoire Royal de Bruxelles, par A. Quetelet, 1856, 1857. Bruxelles. 12mo.	The Author.
Berichte über die Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Mathematisch-Physiche Classe, 1856, No. 2; 1857, No. 1. Leipzig. 8vo.	The Royal Saxon Society.
Abhandlungen der K. S. Gessellschaft der Wissenschaften zu Leipzig. Mathematisch-Physische Classe, 1857. Leipzig. 8vo.	Ditto.
Proceedings of the Literary and Philosophical Society of Liverpool. Session 1856–7. Liverpool, 1857. 8vo.	The Society.
Memorias de la Real Academia de Ciencias de Madrid, Tomo iv. Madrid, 1857. 4to.	The Academy.
Judicial Statistics, Part 1, England and Wales. Police Criminal Proceedings.—Prisons. Returns for the year 1856.	Secretary of State.
Proceedings of the Royal Society of London. Vol. viii., Nos. 26 and 27. London, 1857. 8vo.	The Society.
Memoire della Reale Accademia delle Scienze di Napoli. Vol. i., Fasc 1, 2. 4to.	The Academy.
Rendiconto della Societa Reale Borbonica. Napoli, 1856. 4to.	The Society.
Quarterly Journal of the Chemical Society. July 1857. London. 8vo.	Ditto.
Journal of the Statistical Society of London. Vol. xx., Part 3. London, 1857. 8vo.	Ditto.
List of Fellows of the Statistical Society of London. 8vo.	Ditto.

DONATIONS.	DONORS.
Oversigt over det Kongelige Danske Videnskabernes Selskabs Forhandlinger og dets Medlemmers Arbeider i Aaret 1856. Kjobenhavn, 1856. 8vo.	The Society.
Biographical Notice of the late Thomas Thomson, M.D. 1857. 8vo.	The Author.
Address at the Anniversary Meeting of the Royal Geographical Society, 25th May 1857. By Sir Roderick I. Murchison, President. London, 1857, 8vo.	The Society.
M. le Baron Cauchy: Lettre de M. Biot a M. de Falloux. Paris, 1857. 8vo.	E. Cauchy.
Silliman's American Journal of Science and Arts. July 1857. 8vo.	The Editors.
Monthly Notices of the Royal Astronomical Society. Vol. xvi. London, 1856. 8vo.	The Society.
Memoirs of the Royal Astronomical Society. Vol. xxv. London, 1857. 4to.	Ditto.
Philosophical Transactions of the Royal Society of London, for the year 1856. Vol. cxlvi., Part 3 ; do. for 1857, Vol. cxlvii., Part 1. London. 4to.	Ditto.
Memoire della Reale Accademia della Scienze de Torino. Serie Seconda, Tomo xvi. Torino, 1857. 4to.	The Academy.
Kongliga Svenska Vetenskaps-Akademiens Handlingar ny foljd. Första Bandet, första häftet. Stockholm, 1855. 4to.	Roy. Acad. of Sciences, Stockholm.
Exposition des Operations faites en Laponie pour la determination d'un arc du méridien. Stockholm, 1805. 8vo.	Ditto.
Ofversigt af Kongl. Vetenskaps-Akademiens Forhandlingar, för är 1856. 8vo.	Ditto.
Kongl. Vetenskaps-Akademiens Handlingar, för är 1854. 8vo.	Ditto.
Berättelse om Framstegen i Insekternas, Myriapodernas och Arachnidernas Natural Historia för 1853 och 1854, till Kongl. Vetenskaps-Akademien afgifven af C. H. Boheman. Stockholm, 1857. 8vo.	Ditto.
Arsberättelse om Botaniska Arbeten och Upptäckter under ären 1852, 1853, och 1854. (2 Bandet.) Till Vetenskaps-Akademien afgifven af J. Em. Wilkström och N. J. Andersson. 8vo.	Ditto.
Om förflutna tiders svenska Ordboksföretag, Tal i K. Vetens, Akademiens vid Præsidii nedläggande den 9 April 1856 af Bernh. v. Beskow. Stockholm, 1857. 8vo.	Ditto.
Bulletin de la Société de Geographie. Quatrième serie, Tome xiii. Paris, 1857. 8vo.	The Society.
Brief Extract from Memoranda of the Earl of Dundonald, on the use, properties, and products of the Bitumen and Petroleum of Trinidad. London, 1857. Folio.	Lord Dundonald.
The U. S. Naval Astronomical Expedition to the Southern Hemisphere during the years 1849–50, 1851–52. Vol. vi., Magnetical and Meteorological Observations, under the direction of Lieut. J. M. Gilliss, LL.D., Superintendent. Washington, 1856. 4to.	Dr Gilliss.

December 21, 1857.

American Journal of Science and Arts, conducted by Professors Silliman and Dana, November 1857. 8vo.	The Editors.
Report on the Observatories of His Royal Highness the Maha Rajah of Travancore, at Trevandrum, and on the Agustier Peak of the Western Ghats. By John Allan Broun, F.R.S., Director of the Observatories. Trevandrum, 1857. 8vo.	The Author.
Natuurkundige Verhandelingen van de Hollandsche Maatschappij der Wetenschappen te Haarlem. Tweede verzameling, derteinde Deel. Haarlem, 1857. 4to.	The Society.
Journal of the Statistical Society of London. December 1857. 8vo.	Ditto.
Returns of Births, Deaths, and Marriages registered in the eight principal towns of Scotland. November 1857. 8vo.	The Registrar-General.
Journal of the Geological Society of Dublin, Vol. vii., Part 5. Dublin, 1857. 8vo.	The Society.

DONATIONS.	DONORS.
Thirtieth Annual Report of the Council of the Royal Scottish Academy of Painting, Sculpture, and Architecture. Edinburgh, 1857. 8vo.	The President and Council.
Report of the Geological and Polytechnic Society of the West Riding of Yorkshire. 1856-7. 8vo.	The Society.
Memoirs of the Literary and Philosophical Society of Manchester. Second Series, Vol, xiv. London, 1857. 8vo.	Ditto.
Meteorological Observations and Essays. By John Dalton, D.C.L. Second edition. Manchester, 1834. 8vo.	Phil. Society, Manchester.
A New System of Chemical Philosophy. By John Dalton. Vols. i. and ii., Part 1. 8vo.	Ditto.
Publications of the Dépôt de la Marine, viz:—	Dépôt-Général de la Marine, Paris.
Collection of Charts.	
Description Nautique de la Côte n. du Maroc, par C. A. Vincendon-Dumoulin et C. P. De Kerhallet. Paris, 1857. 8vo. Instructions pour entrer dans le port d'Alexandrie. Paris, 1856. 8vo.	
Instructions Nautiques sur les Mers de l'Inde, par James Horsburgh. Traduites de l'Anglais en 1857, par M. le Predour. 2e edition. Tome deuxième. Paris, 1856. 4to.	
Instructions sur la Nouvelle-Calédonie, suivies de Renseignements Hydrographiques et autres, sur la Mer du Japon et la Mer d'Okotsk, par M. Tardy de Montravel. Paris, 1857. 8vo.	
Supplément au Pilote de la Mer Baltique. Paris, 1857. 8vo.	
Annales Hydrographiques, Recueil d'Avis, Instructions, Documents, et Mémoires, relatifs a l'Hydrographie et a la Navigation, publiés par le Dépôt des Cartes et Plans de la Marine. Paris. 1854–5, 1856, 1857.	
Description des Iles et des Passages compris entre la partie nord de l'Ile Luçon et les Iles du Japon. Par M. A. Le Gras. Paris, 1857. 8vo.	
Observations Chronométriques et autres, faites en 1853 dans l'Archipel des Pomotous, par M. Parchappe et M. de la Marck. Paris, 1857. 8vo.	
Explication et Usage des Wind and Current Charts. Par M. E. Tricault. Paris, 1857. 8vo.	
Annuaire des Marées des Côtes de France, pour l'an 1857, publié au Dépôt de la Marine sous le Ministère de M. l'Amiral Hamelin, par A. M. R. Chazallon. Paris, 1856. 16mo.	
Phares des Mers du Globe, d'aprés les Documents Français et Étrangers recueillés au Dépôt des Cartes et Plans de la Marine, et publiés par Alexandre Le Gras. Paris, 1856. 8vo.	
Manuel de la Navigation dans le Rio de la Plata. Par A. Boucarut. Paris, 1857. 8vo.	
Observations sur la Navigation des Paquebots qui traversent l'Atlantique. Paris, 1856. 8vo.	
Observations Générales sur l'Ocean Pacifique, par C. Phillipe de Kerhallet, suivies des Prescriptions Nautiques pour echapper aux Ouragans. Deuxième edition. Paris, 1856. 8vo.	
Mémoires de l'Academie Impériale des Sciences de Saint Petersbourg. Sixième serie. Sciences Mathématiques et Physiques. Tome vi. St Petersburg, 1857. 4to.	The Academy.
Archives du Musuem d'Historie Naturelle publiées par les Professeurs-Administrateurs de cet établissement. Tome ix., lvr 4ème Paris, 1856–7. 4to.	The Museum.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe, Band xxiii., heft 2, xxiv., hefte 1, 2; Philosophisch-Historische Classe, Band xxiii., hefte 1, 2, 3, 4. Wien, 1857. 8vo.	Vienna Academy of Sciences.
Denkschriften der K. Akademie der Wissenschaften. Mathematisch-Naturwissenschaftliche Classe, Dreizehnter Band. Phil.-Hist. Classe, Achter Band. Wien, 1857. 4to.	Ditto.

January 4, 1858.

DONATIONS.	DONORS.
The Canadian Journal of Industry, Science, and Art, conducted by the Canadian Institute. New Series, No. 12. Toronto. 8vo.	The Institute.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1856, No. 4; 1857, No. 1. Wien, 1856–7. 8vo.	The Vienna Academy.
Proceedings and Papers of the Historic Society of Lancashire and Cheshire. 1848–54. Liverpool. 8vo.	The Society.
Address of Lord Wrottesley, the President, delivered at the Anniversary Meeting of the Royal Society on 30th November 1857. London, 1857. 8vo.	Royal Society of London.
Papers read at the Royal Institute of British Architects. Sessions 1855–6 and 1856–7. London. 4to.	The Institute.
Return of Births, Deaths, and Marriages, registered in the eight principal towns of Scotland. November 1857.	The Registrar-General.
Quarterly Journal of Agriculture, and Transactions of the Highland and Agricultural Society. January 1858.	The Society.
Transactions of the Pathological Society of London. Vol. viii. London, 1857. 8vo.	Ditto.
Medico-Chirurgical Transactions, published by the Royal Medical and Chirurgical Society of London. Vol. xl. London, 1857. 8vo.	Ditto.

January 18, 1858.

Scheikundige Verhandelingen en Onderzoekingen uitgegeven door G. J. Mülder. Eerste deel, derde stuk. Het Bier scheikundig beschouwd door G. J. Mülder. Rotterdam, 1857. 8vo.	The Author.
Flora Batava, 182 Aflevering. Amsterdam. 4to.	King of Holland.
A Catalogue of 3735 Circumpolar Stars, observed at Redhill in the years 1854, 1855, and 1856, and reduced to mean positions for 1855-6. By Richard Christopher Carrington. London, 1857. Folio.	The Lords of Admiralty.
Denkschriften der Kaiserlichen Akademie der Wissenschaften, Mathematisch-Naturwissenschaftliche Classe, Zehnter und eilfter bände.	The Vienna Academy.
Annales de l'Observatoire Physique Central de Russie. Par A. T. Kupffer. Année 1854. St Petersbourg, 1856. 4to.	The Observatory.
Bulletin de la Société Vaudoise des Sciences Naturelles. Tome v., No. 41. Lausanne, 1857. 8vo.	The Society.
Proceedings of the Natural History Society of Dublin, for the Session 1856–57. Dublin, 1857. 8vo.	Ditto.
The Assurance Magazine and Journal of the Institute of Actuaries. Vol. viii., Part 4, January 1858. 8vo.	The Institute.
Isothermal and Rain Charts, illustrating the Climatology of the United States, and of the Temperate Latitudes of the North American Continent. By Lorin Blodget. Philadelphia, 1857. Folio.	Professor Henry D. Rogers.

February 1, 1858.

Proceedings of the Royal Society, London. Vol. ix., No. 28, London. 8vo.	The Society.
Proceedings and Papers of the Historic Society of Lancashire and Cheshire. Sessions 1 to 6. Liverpool, 1849–54. 8vo.	Ditto.
Papers read at the Royal Institute of British Architects. Sessions 1855–56 and 1856–57. London, 1856–7. 4to.	The Canad. Inst.
The Canadian Journal of Industry, Science, and Art. November 1857. Toronto. 8vo.	The Editors.
Atlantis: A Register of Literature and Science Conducted by Members of the Catholic University of Ireland. No. 1. January, 1858. London. 8vo.	Ditto.

DONATIONS.	DONORS.
Œuvres Complètes de N. H. Abel, Mathématicien, avec des notes et développements. Rédigées par B. Holmboe. 2 Tomes. Christiania, 1839. 4to.	The University Christiania.
Quelques Observations de Morphologie Végétale faites au Jardin Botanique de Christiania, par J. M. Norman. Christiania, 1857. 4to.	M. Norman.
Inversos vessicæ urinariæ og lŭxationes femorum congenitæ hos samme Individ, iagttagne af Lektor Voss. Christiania, 1857. 4to.	The University Christiania.
Observations sur les Phénomènes d'Erosion en Norvège, recueillies par J. C. Hörbye. Christiania, 1857. 4to.	Ditto.
Bemerkungen über den mechanischen Bau der Baumwoll-Faser, von Gilbert J. French. Hanover, 1857. 8vo.	G. Lawson, Ph. D.
Journal of the Asiatic Society of Bengal, 1857, No. 4. Calcutta, 1857. 8vo.	The Society.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1856, No. 4; 1857, No. 1. Wien. 8vo.	The Vienna Institute.
Nyt Magazin for Naturvidenskaberne Binds I.—IX. Christiania, 1842. 8vo.	The University.
Astronomical Observations made at the Observatory of Cambridge, by the Rev. James Challis. Vol. xviii., for the years 1849, 1850, and 1851. Cambridge, 1857. 4to.	The Syndicate Observatory of Cambridge.
Bulletin de la Société Vaudoise des Sciences Naturelles. Nos. 34–40. Lausanne, 1854–7. 8vo.	The Society.
Address of Thomas Bell, F.L.S., President to the Linnean Society, London, May 25, 1857. London, 1857. 8vo.	Ditto.
Ueber die Geologie des Südlichen Norwegens von Theodor Kjerulf, mit Beiträgen van Tellef Dahll. Christiania, 1857. 8vo.	The Author.
Lehrbuch der Mechanik von Dr P. J. Broch. Christiania, 1854. 8vo. Beiträgen zur Lateinsischen Grammatik, I. Von L. C. M. Aubert. Christiania, 1856. 8vo.	Ditto.

March 1, 1858.

Quarterly Return of the Births, Deaths, and Marriages registered in the Divisions, Counties, and Districts of Scotland. Quarter ending 31st December 1857.	The Registrar-General.
Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. March 1858.	The Society.
Documents and Proceedings connected with the Donation of a Free Public Library and Museum by William Brown, M P., to the Town of Liverpool. Liverpool, 1858. 8vo.	Dr Hume.
Philosophical Transactions of the Royal Society of London for the year 1857. Vol. clxvii., Part 2. London. 1858. 4to.	Royal Society of London.
List of the Royal Society of London. 1857.	Ditto.
Six Discourses delivered before the Royal Society, &c. By Sir Humphrey Davy, Bart. London. 1827. 4to.	Ditto.
Report on the Adjudication of the Copley, Rumford, and Royal Medals, &c. London. 1834. 4to.	Ditto.
Portugaliæ Monumenta Historica, a sæculo octavo post Christum usque ad quintumdecimum, jussu Academiæ Scientiarum Olisiponensis edita. Leges et Consuetudines, volumen I. fasc. I., Scriptores, volumen 1. fasc. 1. Olisipone. 1856.	The Royal Acad. Lisbon.
Memorias da Academia R. das Sciencias de Lisboa, 2^a serie, Tom. i. ii. iii. Do. Nova serie 1^a e 2^a classe, tom. I., p^t 1 e 2; 2 p^t 2.	Ditto.
The Canadian Journal of Industry, Science, and Art. January 1858.	The Canad. Inst.
Almanaque Nautico para el ano 1859. Calculado de Orden de S. M. en el Observatorio de Marina de la Ciudad de S. Fernando. Cadiz, 1857.	The Observatory, S. Fernando.
Sulle forme cristalline del Boro Adamantino, per Quintino Sella. Torina. 1857. 4to.	The Author.
Sulle forme cristalline di Alcuni sali de Platino e del Boro Adamatino, per Quintino Sella. Torino, 1857. 4to.	Ditto.
Translation from Dutch Pamphlets on Herring Fisheries. 1857. (Board of Trade). London, 1858. 8vo.	Dr Stark.

DONATIONS.	DONORS.
Proceedings of the Royal Astronomical Society. Vol. xviii. No. 3.	The Society.
Quarterly Journal of the Chemical Society. No. 40.	Ditto.
Collecçào de Noticias para a Historia e Geografia das Naçòes Ultramarinas, que vivem nos dominios Portuguezes ou Lhes Sao Visihhas; publicada pela Academia Real das Sciencias. Tom. v., vi., vii. Lisboa, 1836–56. 8vo.	Royal Acad. of Lisbon.
Viagens extensas e dilatadas do celebre Arabe Abu-Abdallah, mais conhecido pelo nome de Ben-Batuta. Traduzidas por Jose de Santo Antonio Moura. Tomo ii. Lisboa, 1855. 8vo.	Ditto.
Annales das Sciencias e Lettras, publicados debaixo dos auspicios da Academia Real das Sciencias 1ª Classe, Sciencias, Mathematicas, Physicas, Historico-Naturaes, e Medicas, Tomo i. Marco–Septembro 1857. 2ª Classe, Sciencias, Moraes, e Politicas, e Bellas Lettras, tome i. Marco–Julho, 1857.	Ditto.
Transactions of the Linnean Society of London. Vol. xxii. Part 2. London, 1857. 4to.	The Society.

March 15, 1858.

A Treatise on Electricity in Theory and Practice. By Aug. De la Rive. Translated for the Author by Charles V. Walker, F.R.S. London, 1858. 8vo. Vol. iii.	The Author.
Journal of the Statistical Society, March 1858.	The Society.
The American Journal of Science and Art. January 1858. 8vo.	The Editors.
Transactions of the Royal Scottish Society of Arts. Vol. v. Part 1. Edinburgh, 1857. 8vo.	The Society.
Memorie della Accademia delle Scienze dell' Istituto di Bologna. Tomo VII. Bologna, 1857. 4to.	The Academy.
Proceedings of the Royal Astronomical Society. Vol. xviii. No. 4.	The Society.
Proceedings of the Royal Society of London. Vol. ix. No. 29.	Ditto.
Map of England and Wales, showing the Path of the Centre of the Moon's Shadow on the 15th March 1858.	H. F. Talbot, Esq.

April 5, 1858.

Monthly Return of the Births, Deaths, and Marriages registered in the eight principal towns of Scotland, with the Causes of Death, at four periods of Life. March 1858.	The Registrar-General.
Supplement to the Monthly Returns of Births, Deaths, and Marriages. Year 1857.	Ditto.
Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin. Sept., Oct., Nov., Dec. 1857. 8vo.	The Berlin Academy.
The American Journal of Science and Art. March 1858. 8vo.	The Editors.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. ii., No. 1. London, 1858. 8vo.	The Society.
Catalogue of the Antiquities of Stone, Earth, and Vegetable Materials in the Museum of the Royal Irish Academy. By W. R. Wilde, M.R.I.A. Dublin, 1857.	The Academy.
Account of the Astronomical Experiment of 1856, on the Peak of Teneriffe. By Professor C. Piazzi Smyth, Astronomer-Royal for Scotland.	The Author.
Monthly Notices of the Royal Astronomical Society, from November 1856 to July 1857. Vol. xvii. London, 1857. 8vo.	The Society.
Memoirs of the Royal Astronomical Society. Vol. xxvi. London, 1858. 4to.	Ditto.
Mémoire sur un rapprochement nouveau entre la Théorie moderne de la propagation linéaire du Son, dans un tuyau cylindrique, horizontal d'une longueur indéfinie, et la Théorie des Pulsions exposée par Newton dans les deux Propositions xlvii. et xlix. du second Livre des Principes. Par Jean Plana. Turin, 1857. 4to.	The Author.

DONATIONS.	DONORS.
Mémoire sur la Mouvement conique à double courbure d'un Pendule simple dans le vide Abstraction faite de la Rotation diurne de la Terre. Par Jean Plana. Turin, 1858. 4to.	The Author.
Abhandlungen der Köeniglich Bayerischen Akademie der Wissenschaften. Mathem.-Physikalischen Classe, achten Bandes, erste abtheilung. Philos.-Philologischen Classe, achten Bandes, erste and zweite abtheil. Munchen, 1856. 4to.	The Academy.
Proceedings of the Zoological Society, Nos. 339–348. London. 8vo.	The Society.
Gelehrte Anzeigen der K. Bayerischen Akademie der Wissenschaften. Bände 42–45. Munchen, 1856-57. 4to.	The Academy.
Comptes Rendus hebdomadaires des Séances de l'Academie des Sciences. Par MM. les Secretaires perpetuels. Paris, 1857–8.	Ditto.
Madras Journal of Literature and Science, edited by the Committee of the Madras Literary Society, and Auxiliary Royal Asiatic Society. Vols. i., ii., and iii. of New Series.	Dr Cleghorn, Madras.

November 22, 1858.

Proceedings of the Royal Society, London. Vol. ix. No. 31. 8vo.	The Society.
The Twenty-fifth Annual Report of the Royal Cornwall Polytechnic Society, 1857. 8vo.	Ditto.
Journal of the Statistical Society of London. Vol. xxi. Parts 2 and 3. 8vo.	Ditto.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. ii. No. 2. 8vo.	Ditto.
Proceedings of the Zoological Society. Nos. 349–61. 8vo.	Ditto.
Memoirs of the Literary and Philosophical Society of Manchester. Vol. xiv. 8vo.	Ditto.
Journal of the Royal Geographical Society. Vol. xxvii. 8vo.	Ditto.
Proceedings of the Royal Geographical Society. Vol. ii. Nos. 3, 4, and 5. 8vo.	Ditto.
Notices of the Proceedings of the Royal Institution of Great Britain. Part viii. 8vo.	The Institution.
List of the Members, Officers, &c., of the Royal Institution of Great Britain for 1857. 8vo.	Ditto.
The Quarterly Journal of the Chemical Society. No. 42. 8vo.	The Society.
Journal of the Geological Society of Dublin. Vol. viii. Part 1. 8vo.	Ditto.
Proceedings of the Literary and Philosophical Society of Liverpool. No. 12. 8vo.	Ditto.
Journal of the Proceedings of the Linnean Society. Vol. ii. No. 8; Vol. iii. Nos. 9 and 10. 8vo.	Ditto.
The Quarterly Journal of the Geological Society. Nos. 54, 55, and 56. 8vo.	Ditto.
Journal of the Royal Dublin Society. Vol. i. 8vo.	Ditto.
The Journal of Agriculture, and the Transactions of the Highland and Agricultural Society of Scotland No. 62. 8vo.	Ditto.
The Assurance Magazine and Journal of the Institute of Actuaries. Nos. 32 and 33. 8vo.	The Institute.
List of Members of the Institute of Actuaries, 1858–59. 8vo.	Ditto.
The Canadian Journal of Industry, Science, and Arts. Nos. 15 to 17. 8vo.	Canad. Inst.
The American Journal of Science and Arts. Nos. 75 to 77. 8vo.	The Editors.
Madras Journal of Literature and Science. Vol. iii. No. 6. 8vo.	Mad. Lit. Soc.
The Atlantis: A Register of Literature and Science. No. 2. 8vo.	The Editors.
Proceedings of the Academy of Natural Sciences of Philadelphia. From April 7, 1857, to April 27, 1858. 8vo.	The Academy.
Notice of some Remarks by the late Mr Hugh Miller. By Mr W. P. Foulke. 8vo.	The Author.
Reports on the Meteorology of Scotland for 1857. 8vo.	Meteorol. Soc.

DONATIONS.	DONORS.
Address to the Meteorological Society of Scotland. By Jas. Stark, M.D. 8vo.	The Author.
Translation from the Dutch Pamphlets on Herring Fisheries. 8vo.	Dr Hunter.
Journal of the Asiatic Society of Bengal. Nos. 264, 266, and 267. 8vo.	The Society.
History of Scientific Ideas. By Wm. Whewell, D.D. Vols. i. and ii. 8vo.	The Author.
Canal and River Engineering. By David Stevenson, F.R.S.E. 8vo.	Ditto.
Notes on the Prior Existence of the Castor Fiber in Scotland. By Charles Wilson, M.D. 8vo.	Dr Wilson.
Reports of Continental Children's Hospitals. 8vo.	Ditto.
A Treatise on Light, Vision, and Colours. By Thos. Bett, Esq. 8vo.	The Author.
Der Naturen Bloeme, van Jacob van Maerlant. 8vo.	Ditto.
Rhymbal von Jacob van Maerlant: Erste Deel. 8vo.	Ditto.
Bulletin de la Société Impériale des Naturalistes de Moscou. Nos. 1 to 4. 8vo.	The Society.
Compte Rendu de l'Académie Impériale des Sciences de St Petersbourg. 1856. 8vo.	The Academy.
Mittheilungen der Naturforschenden Gesellschaft in Bern. Nos. 360 to 407. 8vo.	The Society.
Verhandlungen der Schweizerischen naturforschenden Gesellschaft in Basil. 1856. 8vo.	Ditto.
Bulletin de la Société Vaudoise de Sciences Naturelles. Tome v., Bulletins 41 et 42. 8vo.	Ditto.
Bulletin de la Société de Geographie, Paris. Tomes 14 et 15. 8vo.	Ditto.
Verslagen en Mededeelingen der Köninklijke Akademie van Wetenschappen, Amsterdam. Afdeeling Natuurkunde, Deel vii. 8vo. Afdeeling Letterkunde, Deel iii. 8vo.	The Academy.
Variations Annuelles et Horaires des Instruments Météorologiques à Bruxelles. Par M. Quetelet. 8vo.	The Author.
Observations des Passages de la Lune et des Étoiles de même culmination. Par M. Quetelet. 8vo.	Ditto.
Composition de l'Atmosphère. Par M. Lamont. 8vo.	M. Quetelet.
Rapport sur l'Etat et les Travaux de l'Observatoire Royal, pendant l'Année 1856. Par M. Quetelet. 8vo.	Ditto.
Eclipse de Soleil du 15 Mars 1858. Par M. Quetelet. 8vo.	Ditto.
Catalogues van de Bockerij du Köninklijke Akademie van Wetenschappen, Amsterdam. Deel i. 8vo.	The Academy.
Jaarboek van de Köninklijke Akademie van Wetenschappen, Amsterdam. 1857–58. 8vo.	Ditto.
Bibliografia Italiana delle Scienze Mediche. Serie I. Vol. Prima. 8vo.	
Rendiconto delle Sessioni dell' Accademia delle Scienze dell' Istituto di Bologna. 1855–56. 8vo.	The Academy.
Die Fortschritte der Physik in Jahr, 1855. Dargestellt von der Physikalischen Gesellschaft zu Berlin. 8vo.	The Society.
Jahresbericht ühn die Fortschritte der reinen, Pharmaceutischen und technischen Chemie, Physik, Mineralogie, und Geologie.—Chemie und verwandter Theile anderen Wissenschaften von Hermann Kopp und Henrich Will.—Physik von Frederich Zamminer. Für 1857. Register zu den Berichten für 1847 bis 1856. 8vo.	The Editors.
Publications of the Dépôt Général de la Marine:—	
Collection of Charts.	Dépôt Général de la Marine.
Erreurs des Compas dues aux attractions locales a Bord des Navires en Bois et en Fer. Par M. Darondeau. 8vo.	
Supplement au Catalogue Chronologique des Cartes. Plans, Vues de Côtes, &c. 8vo.	
Manuel de la Navigation dans le Detroit de Gibraltar. Par Dumolin et de Kerhallet. 8vo.	
Reconnaissance Hydrographique des Côtes occidentales du Centre Amerique, Province de Veraquas (Nouvelle Grenada). Par M. De Rosencoat. 8vo.	

DONATIONS.	DONORS.
Publications of the Dépôt Général de la Marine—*Continued*:—	
Note sur les Courants de l'Ocean Atlantique entre l'Equateur et le 10e degré de latitude N. Par M. Lefebvre. 8vo.	Dépôt Général de la Marine.
Supplement au Livre des Pharas. Par M. Le Gros. 8vo.	
Annales Hydrographiques. Vol. xiii. 8vo.	
Notes sur la Navigation de l'Archipel des Marquises. Par M. Jouan. 8vo.	
Instruction a Levivre pour allier mouller sur la Rade de Santa Cruz. 8vo.	
Annuaire des Maries des Côtes de France, pour 1858. Par M. Chazallon. 32mo.	
Annaes des Sciencias e Lettras publicados debaixo dos auspicios da Academia Real das Sciencias.—Sciencias Mathematicas-Physicas, Historico-Naturaes, e Medicas, Vol. i. Nos. 1–7. Sciencias Moraes e Politicas, e Bellas Lettras, Vol. i. Nos. 1–5. Noticias para a Historia e Geografia das Naçoes Ultramarinas. Tomo vi. 8vo.	The Academy.
Berichte über de Verhandlungen der Königlich Sächsischen Gesellschaft der Wissenschaften zu Leipzig. Philologisch-Historiche Classe, 1856, iii. and iv.; 1857, i. and ii.; 1858, i.—Mathematische-Physiche Classe. 1857, ii. and iii.; 1858, i. 8vo.	The Society.
Bulletin de l'Academie Royale de Belgique. II. Series. Tomes i., ii., and iii. 8vo.	The Academy.
Mémoires Couronnés et Autres Mémoires. Tome vii. Publies par l'Académie Royale de Belgique. 8vo.	Ditto.
Annuaire de l'Académie Royale de Belgique. 1858. 8vo.	Ditto.
Annuaire de l'Observatoire Royal de Bruxelles. Par M. Quetelet. 1858. 32mo.	The Author.
Annales de l'Observatoire Royal de Bruxelles Par M. Quetelet. Tome xii. 4to.	Ditto.
Observations des Phénomènes Periodiques. 4to.	Ditto.
Jahrbuch du Kaiserlich-Koniglichen Geologischen Reichsanstalt. Wien. 1857. Nro. 2, 3, and 4. 8vo.	The Institution.
Monatsbericht der Königlichen Preuss. Akademie der Wissenschaften zu Berlin. Januar, Februar, März, April, Mai, Juni, 1858.	The Academy.
Geological and Topographical Map of London and its Environs. By R. W. Milne, F.R.S. 8vo.	The Author.
Collection of Maps of the Basin of La Plata, &c. By Thomas J. Page, U.S. Navy.	Ditto.
Explanations and Sailing Directions to accompany the Wind and Current Charts. By M. F. Maury, LL.D., U.S. Navy. Vol. i. 4to.	Ditto.
Report of Progress 1853–56 of Geological Survey of Canada. 8vo.	Sir W. E. Logan.
Plans of Lakes and Rivers between Lake Huron and the River Ottawa, to accompany the Geological Reports. 4to.	Ditto.
Memoirs and Papers of Hugh E. Strickland, M.A. By Sir W. Jardine, Bart. 8vo.	The Author.
Astronomical and Meteorological Observations made at the Radcliffe Observatory, Oxford, in 1856. Vol. xvii. 8vo.	The Radcliffe Trustees.
Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Zurich. Band xv. 4to.	The Society.
The Habeeb-os-Seear. By Mirza Gheeos-od-Deen bin Mirza Hamaeem-od-Deen. Being a General History of the World from the Earliest Times to the Year of the Hijira 930., A.D. 1520. 2 vols. 4to.	Ali Muhammed Khan, Ottoman Consul, Bombay.
Compte-Rendu Annuel. Par A. T. Kupffer. Année 1856. 4to.	The Author.
Memorie della Reale Accademia delle Scienze de Torino. Tom. xvii. 4to.	The Academy.
Sulle Forme Cristalline di Alcuni Sali di Platino e del Boro Adamantino. Per Q. Sella. 4to.	The Author.
Sulle Forme Cristalline del Boro Adamantino. 2do. Memoria. Per Q. Sella. 4to.	Ditto.

Donations.	Donors.
List of Members, Report of Council, &c., of the Royal Institute of British Architects. 1858. 4to.	The Institute.
Verhandlingen du Koninklijke Akademie van Wetenschappen. Amsterdam. Deels. iv., v., and vi. 4to.	The Academy.
Flora Batava. Part 183. 4to.	King of Holland.
Observations on the Genus Unio. By Isaac Lea, LL.D. Vol. vi. Part 1. 4to.	The Author.
Judicial Statistics, 1857, England and Wales.—Police, Criminal Proceedings, Prisons; Common Law, Equity, Civil and Common Law. 4to.	Secretary of State Home Depart.
Meteorological Tables of the Board of Trade. Nos. i., ii., and iii. 4to.	The Board.
Report on the Meteorological Department of the Board of Trade. 1858. 8vo.	Ditto.
Barometer and Weather Guides. By R. Adon. Fitzroy. 8vo.	Ditto.
Transactions of the Society of Antiquaries of London. Vol. xxxvii., No. 2. 4to.	The Society.
Proceedings of the Society of Antiquaries of London. Vol. iv. No. 47. 8vo.	Ditto.
List of Members of the Society of Antiquaries of London for 1858. 8vo.	Ditto.
Observations Météorologiques faites à Nijné-Taguilsk. Résumé des Dix Années 1845–54; et Année 1855, et Année 1856. 8vo.	
Danzigs Handels und Gewerbsgeschichte unter dur Herrschaft des Deutschen Ordens. Von du Theodor Hirsch. 8vo.	Roy. Sax. Soc. Science, Leipsic.
Elektrische Untersuchungen. Zweite Abhandlung: über die Thermo-Elektrischen Eigenschaften des Boracites. 1857. 8vo.	Ditto.
Elektrische Untersuchungen. Dritte Abhandlung: über Elektricitäts; erregung Zwischen Metallen und erhitzten Salzen. 1858. 8vo.	Ditto.
Nouveau Principe sur la Distribution des Tensions dans les Systèmes Elastiques. Par M. L. F. Ménabria. 4to.	The Author.
Archives de Museum d'Histoire Naturelle. Tome x. Liv[ons] 1 et 2. 4to.	The Museum.
Den Magnetische Inclinations Forandringer i den Nordlige og Sudlige Halvkugle. Af Christopher Hansteen. 4to.	The Author.
Astronomical, Magnetical, and Meteorological Observations made at the Greenwich Observatory. 1856. 4to.	Royal Society.
Magnetical and Meteorological Observations made at Bombay Observatory. 1856. 4to.	East India Coy.
Abhandlungen du Königlichen Gesellschaft du Wissenschaften zu Göttingen. Band vii. 1856–57.	The Society.
Abhandlungen du Königlichen Akademie du Wissenschaften zu Berlin. 1857.	The Academy.
Compendio Storico della Scuola Anatomica di Bologna. Scritto da Michele Medici. Folio.	The Author.
Rendiconto della Societa Reale Borbonica. Anno V. 4to. Napoli.	The Society.
Memorie della Reale Accademia delle Scienze. Napoli. Vol. i., 1852–54; Vol. ii., 1855–57. 4to.	The Academy.
Account of the Principal Triangulation, and of the Figure, Dimensions, and Mean Specific Gravity of the Earth, as derived therefrom. By Captain A. R. Clarke of the Ordnance Survey. 4to.	Secretary of State for War.
Details au Sujet de la Formation des Oolites Calcaires. Par M. J. Fournet. 8vo.	The Author.
Index Map to the Ordnance Survey of England and Wales.	Board of Ordnance
Compte-Rendu de l'Académie Imperiale des Sciences de St Petersbourg. 1857.	The Academy.
Abhandlungen, Herausgegeben von der Senkenbergischen Naturforschenden Gesellschaft. Band ii., Lief. 92.	The Society.
Engravings of the Ganglia and Nerves of the Uterus and Heart. By Robert Lee, M.D., F.R.S. 8vo.	The Author.
Proceedings of the Royal Geographical Society of London. Vol. ii. No. 6. 8vo.	The Society.
Transactions of the Cambridge Philosophical Society. Vol. x. Part 1. 8vo.	Ditto.

December 20, 1858.

DONATIONS.	DONORS.
Quarterly Journal of the Medico-Chirurgical Society, No. 43. 8vo.	The Society.
Bulletin de la Société Impériale des Naturalistes des Moscou. 1857, Nos. 2, 3, and 4. 1858, No. 1. 8vo.	Ditto.
Transactions of the Pathological Society of London. Vol. ix. 8vo.	Ditto.
Schriften der Universität zu Kiel. 1856, Band iii. 1857, Band iv. 4to.	The University.
Journal of the Statistical Society of London. Vol. xxi. Part 4. Dec. 1858. 8vo.	The Society.
Memoirs of the Literary and Philosophical Society of Manchester. Vol. xv. Part 1. 8vo.	Ditto.
Proceedings of the Literary and Philosophical Society of Manchester. Nos. 1 to 14. 8vo.	Ditto.
Eight Maps of Hindostan. Nos. 24, 38, 54, 73, 102, 103, 111, and 112.	East India House.
An Account of some Recent Researches near Cairo, undertaken with the view of throwing light upon the Geological History of the Alluvial Land of Egypt. Instituted by Leonard Horner, Esq. 4to.	The Author.
Proceedings of the Zoological Society of London. Nos. 162 to 169. 8vo.	The Society.
Transactions of the Zoological Society of London. Vol. iv. Part 5. 4to.	Ditto.
77 New Charts, 4 Corrected Charts, and 15 Books and Pamphlets.	The Admiralty.
Notice of Two new Maximum and Minimum Thermometers. By the Rev. J. G. Macvicar, D.D., of Moffat.	The Author.

January 3, 1859.

The Lithology of Edinburgh, by Rev. John Fleming, D.D., F.R.S.E. With a Memoir by the Rev. John Duns, Torphichen. 8vo.	The Publisher.
Annales de l'Observatoire Physique Central de Russie. Anna 1855. Nos. 1 and 2. 4to.	The Russian Government.
Medico-Chirurgical Transactions. Vol. xli. 8vo.	The Society.
Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. No. 63. 8vo.	The Highland Society.
Nyt Magazin for Naturvidenskaberne. Udgives af den physiographiske Forenung i Christiania ved M. Sars og Th. Kjerulf. Tiende Binds förte Heft. 8vo.	University of Christiania.
Norges Historie i Kortfattet Udtog af P. A. Münch. Fierde Udgave. 8vo.	Ditto.
Gamle Norske Folkeviser Udg. af Sopus Bugge. 8vo.	Ditto.
Kortfattet Beiledning af M. G. Fletting. 8vo.	Ditto.
Norges Gamle Love, indtil 1387. Ved R. Keyser og P. A. Münch 1, 2, and 3 Binds. Folio.	The Royal Society of Drontheim.
Det Norske Sprogs vaesentligste Ordforrand Sammenlignet nud Sanskrit, &c. Af Chr. A. Holmboc. 8vo.	Ditto.

January 17, 1859.

On the Currents of the Ocean. By James D. Dana. 8vo.	The Author.
Review of Marcou's Geology of North America. By James D. Dana. 8vo.	Ditto.
Francesca da Rimini, her Lament and Vindication. By H. C. Barlow, M.D. 8vo.	The Author.
Nyt Magazin for Naturvidenskaberne, ved M. Sars og Th. Kjerulf. 10de Binds, 2 det og, 3 die Hefte. 8vo.	Roy. Univ. Norw., Christiania.
Physikalske Meddelelser ved Adam Arndtsen. 4to.	Ditto.
Om Piperviken og Ruselókbakken. Ved Gilert Sundt. 8vo.	Ditto.

DONATIONS.	DONORS.
Ueber das Vorkommen von Quellengebilden in Begleitung des Basaltes der Werra-und Fulda-Gegendender. Von Joh. F. L. Hausmann. 4to.	The Author.
Ueber den Einfluss der Beschaffenheiten du Gesteine auf die Architektur. Von J. F. L. Hausmann. 4to.	Ditto.
Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger. Aaret 1857. 8vo.	The Society.
Nachrichten von der Georg-Augusts-Universität und der Königl. Gesellschaft der Wissenschaften zu Göttingen. 1857. 8vo.	The Royal Society of Gottingen.
Acta Academiæ C. L. C. Naturæ Curiosorum. Vol. xxiii., Suppl.; Vol. xxvi. Part 1. 4to.	The Academy.
Kongliga Svenska Vetenskaps-Akademiens Hanlingar. Första Bandet, Andra Häftet, 1856. 4to.	Ditto.
Ofversigt af Köngl. Vetenskaps-Akademiens Forhandlingar. 1857. 8vo.	Ditto.
Berättelse om Framstegen i Fysik under är 1852. Af E. Edlund. 8vo.	Ditto.
Kongliga Svenska Fregatten Eugenies Resa Omkring Jorden under befäl af C. A. Virgin. Aren, 1851–1853. Häft 1–5. 4to.	Ditto.
Journal of the Royal Dublin Society, Nos. 9–11. 8vo.	The Society.
The Assurance Magazine and Journal of the Institute of Actuaries. No. 34.	The Institute.
Meteorologische Beobachtungen aufgezeichnet an der Königl. Sternwarte bei Munchen in den Jahren, 1825–37. 8vo.	Royal Observatory of Munich.
Annalen der Königl. Sternwarte bei Munchen. Band. x. 8vo.	Ditto.
Astronomische Beobachtungen auf der Königl. Universitäts-Sternwarte zu Königsberg. 33 Abtheilung. Folio.	The University.
Observations on British Zoophytes, Descriptions of New Protozoa and of two Tubicolar Animals. By Dr T. Strethill Wright. 7 Pamphlets. 8vo.	The Author.

February 7, 1859.

Bulletin la Société Vaudoise des Sciences Naturelles. Tome vi. Bulletin No. 43. 8vo.	The Society.
Catalogue de la Bibliothèque de la Société Vaudoise. 8vo.	Ditto.
Almanaque Nautico para 1860, calculado de ōrden de S. M. en el Observatorio de Marina de la Ciudad de San Fernando. 8vo.	The Observatory.
Mémoire sur la Relation des Sources Thermales de Plombières, avec les Filons Metalliferes, et sur la Formation Contemporaire des Zéolithes. Par M. Daubrée. 8vo.	The Author.
Recherches Experimentales sur le Striage des Roches du au Phénomène Erratique. Par M. Daubrée. 8vo.	Ditto.
Observations sur le Métamorphisme. Par M. Daubrée. 8vo.	Ditto.
Journal of the Proceedings of the Linnean Society. Vol. iii. No. 11. 8vo.	The Society.
Transactions of the Linnean Society. Vol. xxii. Part 3. 4to.	Ditto.
Transactions of the Historic Society of Lancashire and Cheshire. Vol. x. 8vo.	Ditto.
Transactions of the Botanical Society of Edinburgh. Vol. vi. Part 1. 8vo.	Ditto.
Atlantis; a Register of Literature and Science conducted by the Members of the Catholic University of Ireland. No. 3. 8vo.	The Editors.
Siluria. By Sir R. I. Murchison. 3d Edition. 8vo.	The Author.
The Canadian Journal of Industry, Science, and Art. Nov. 1858. 8vo.	Canadian Inst.
The Statistics of Marriage in England. By S. M. Drach. 8vo.	The Author.
Horæ Subsecivæ. Locke and Sydenham, with other Occasional Papers. By John Brown, M.D. 8vo.	Ditto.
Proceedings of the Berwickshire Naturalists' Club. Vol. iv. No. 2. 8vo.	The Club.

March 7, 1859.

Anniversary Address to the Geological Society of London. By Major-General Portlock, R.E. 8vo.	The Author.

DONATIONS.	DONORS.
The Quarterly Journal of the Geological Society. February 1859. 8vo.	The Society.
The American Journal of Science and Arts. January 1859. 8vo.	The Editors.
Proceedings of the Royal Geographical Society of London. Vol. iii. No. 1. 8vo.	The Society.
Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. No. 64. (March 1859). 8vo.	Ditto.
Quarterly Journal of the Chemical Society. January 1859. 8vo.	Ditto.
Journal of the Statistical Society of London. Vol. xxii. Part 1. 8vo.	Ditto.
A Catalogue of the Graduates in the Faculties of Arts, Divinity, and Law, of the University of Edinburgh since its Foundation. 8vo.	The University.
Comets: their Constitution and Phases. By Christopher Kemplay. 8vo.	Leeds Phil. and Lit. Soc.
Report on the Teneriffe Astronomical Experiment of 1856. Addressed to the Lords Commissioners of the Admiralty. By Professor C. P. Smyth. 4to.	The Author.
Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. 1857–58. 8vo.	The Society.
China and its Trade. By John Craufurd, F.R.S. 8vo.	Phil. and Lit. Soc., Leeds.
Sensorial Vision. By Sir J. F. W. Herschel, Bart. 8vo.	Ditto.
Annual Report of the Leeds Philosophical and Literary Society for 1857–58. 8vo.	The Society.
On the Structure of Lecidia lugubris. By W. Lauder Lindsay, M.D. 8vo.	The Author.
Atti dell' imp. Reg. Istituto Veneto de Scienze, Lettere ed Arti. Dal Novembre 1858 all' Ottobre 1859. Tomo iv. Dispensa Terza. 8vo.	The Institute.
Transactions of the Botanical Society of Edinburgh. Vol. i. Part 3. Vols. ii., iii., iv., and v. Proceedings for 1856. Sixth, Seventh, and Eighth Annual Reports and Proceedings for 1841-44. 8vo.	The Society.

Donation to the Museum—

Geological Specimens from the Peak of Teneriffe. By Professor C. Piazzi Smyth.

March 21, 1859.

Note sur la Comète de Donati. Par M. E. Plantamour. 8vo.	The Author.
Résumé Météorologique de l'Années 1855, 1856, et 1857, pour Genève et le Grand Saint-Bernard. Par M. E. Plantamour. 8vo.	Ditto.
Observations Astronomiques faites a l'Observatoire de Genève, dans les Années 1851 et 1852. Par M. E. Plantamour. 4to.	Ditto.
De la Temperature a Genève d'apres vingt années d'Observations 1836 á 1855. Par M. E. Plantamour. 4to.	Ditto.
Sketch of the Civil Engineering of North America. By David Stevenson, F.R.S.E. 8vo.	Ditto.
Mémoires de la Société Impériale des Sciences Naturelles de Cherbourg. Tome v., 1857. 8vo.	The Society.
Transactions of the Royal Society of Literature. Vols. i., ii., iii., iv., v., and Part 1, Vol. vi. 8vo.	Ditto.
Occasional Papers on the Theory of Glaciers, with a Prefatory Note on the Recent Progress and Present Aspect of the Theory. By James D. Forbes, D.C.L., F.R.S., &c. 8vo.	The Author.
Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome iv. Cahier 3. 8vo.	The Society.
Bulletin de la Société de Geographie. Tome xvi. 8vo.	Ditto.
Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xiv., 2e partie. 4to.	Ditto.
Untersuchungen über die Rechtung und Stärke dis Erdmagnetismus an verschiedenen puncten des Südwestlichen Europa. Von Dr J. Lamont. 4to.	King of Bavaria.
Abhandlungen der Königlich Bayerischen Akademie der Wissenschaften. Philos.-philologischen Classe, Vol. viii. Abth. 3. Math.-physicalischen Classe, Vol. viii. Abth. 2. Historischen Classe, Vol. viii. Abth. 2. 4to.	The Academy.

DONATIONS.	DONORS.
Gelehrte Anzeigen. Vols. xlvi. and xlvii. 4to.	Acad. Roy. Bav.
Uber die geschichtlichen Vorstufen du neuern Rechtsphilosophie. Von Prof. Dr Carl Prantl. 4to.	Ditto.
Uber Neuaufgefundene Dichtungen. Francesco Petrarca's. Von Prof. Dr G. M. Thomas. 4to.	Ditto.
Uber Johannes Muller und sein Verhaltnis zum jetzigen. Standtpunkt der Physiologie. Von Dr Th. L. W. Bischoff. 4to.	Ditto.
Catalogus Codicum Manu Scriptorum BibliothecæRegiæ Monacensis. Tomus vii. 8vo.	Ditto.
Lighthouse Illumination: being a Description of the Holophotal system, and of Azimuthal-condensing and Apparent Lights, with other Improvements. By Thomas Stevenson, F.R.S.E. 8vo.	The Author.

April 4, 1859.

Eroffnungorede der 43 sten Versammlung, Schweizerischen Naturforscher in Bern durch den Presidenten. Prof. Dr B. Studer. 1858. 8vo.	The Author.
Atti del' imp. Reg. Istituto Veneto di Scienze, Lettere ed Arti. Dal. Novembre 1858 all' Ottobre 1859. Tomo iv. Dispensa 4to. 8vo.	The Institute.
Die Fortschritte der Physik im Jahre 1856. Dargestellt von der Physikalischen Gesellschaft zu Berlin. xii. Jahrgang, 1 Abth. 8vo.	The Society.
Proceedings of the Academy of Natural Sciences of Philadelphia. 1858. Nos. 10-20. 8vo.	The Academy.
The Mosaic Account of the Creation. By James C. Fisher, M.D. 8vo.	The Author.
Review of Marcou's "Geology of North America." By James D. Dana. 8vo.	Ditto.
On Marcou's "Geology of North America." By Prof. Agassiz. 8vo.	Prof. Dana.
Notes on the Currents of the Ocean. By James D. Dana. 8vo.	The Author.
Observations on the Genus Unio. By Isaac Lea, LL.D., Vol. vi. Part 2. 4to.	Ditto.
Papers from the Proceedings of the Academy of Natural Sciences of Philadelphia. By Isaac Lea, LL.D. 8vo.	Ditto.
Account of the Remains of a Fossil Extinct Reptile recently discovered at Haddonfield, New Jersey. 8vo.	Dr I. Lea.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. iii. Part 1. 8vo.	The Society.
Journal of the Asiatic Society of Bengal. No. 269. 8vo.	Ditto.

April 18, 1859.

Proceedings of the Natural History Society of Dublin for the Session 1857-58. Vol. i. Part 2. 8vo.	The Society.
Einleitung in das Studium der Physik und Elemente der Mechanik von B. Studer, Professor, Bern. 8vo.	The Author.
The Assurance Magazine and Journal of the Institute of Actuaries. No. 35. 8vo.	The Institute.
Astronomical and Meteorological Observations, made at the Radcliffe Observatory, Oxford, in the year 1857. 8vo.	The Radcliffe Trustees.
Journal of the Proceedings of the Linnean Society. Vol. iii. No. 12. 8vo.	The Society.
The American Journal of Science and Arts. Conducted by Professors Silliman and Dana. March 1859. 8vo.	The Editors.
Englischer Liederschatz von Karl Elze. 32mo.	M. K. Elze.
Westward, Ho! Britisch and Amerikanische Gedichte übersetzt von Karl Elze. 32mo.	Ditto.
Shakespeare's Hamlet. Herausgegeben von Karl Elze. 8vo.	Ditto.
Atlantis: Zeitschrift fur Leben und Literatur in England and Amerika. Herausgegeben von Karl Elze. Vols. i. and ii. 8vo.	Ditto.
Results of the Astronomical Observations made at the Royal Observatory, Greenwich, 1857. 4to.	The Royal Society, London.

DONATIONS.	DONORS.
Jahrbuch du Kaiserlich-Koniglichen Geologischen Reichsanstalt. 1858. Nos. 1 and 2. 8vo.	The Society.
Catalogues of Zoology. Published by the Trustees of the British Museum. 113 publications.	The Museum Trustees.

December 5, 1859.

The United States Naval Astronomical Expedition to the Southern Hemisphere. 1849–52. Vol. iii. 4to.	U. S. Government.
Army Meteorological Register for 1826–30, and for 1831–42. 8vo.	Ditto.
Statistical Reports of the Sickness and Mortality of the Army of the United States, from January 1819 to January 1839. 8vo.	Ditto.
Maury's Wind and Current Charts. Gales in the Atlantic. 4to.	Ditto.
Observations on the Physical Geography and Geology of the Coast of California. By W. E. Blake. 4to.	Ditto.
Report of the Commissioner of Patents for 1856. Arts and Manufactures, 3 vols.; Agriculture, 1 vol. 8vo.	Ditto.
Report of the Superintendent of the Coast Survey, showing the Progress of the Survey during 1856. 4to.	Ditto.
Army Meteorological Register, from 1843 to 1854. 4to.	Ditto.
Statistical Reports of the Sickness and Mortality in the U. S. Army, from January 1839 to January 1855.	Ditto.
Geological Survey of Missouri. First and Second Annual Reports. By G. C. Swallow. 8vo.	Missouri Legislature.
Report (Eleventh) of the Board of Agriculture of the State of Ohio, for 1856. 8vo.	Ohio State Board of Agriculture.
Tables, Meteorological and Physical, prepared for the Smithsonian Institution. By A. Guyot. 8vo.	The Institution.
Proceedings of the American Association for the Advancement of Science. Vols. x. and xi. 8vo.	The Association.
Meteorology in its Connection with Agriculture. By Prof. Joseph Henry. 8vo.	The Author.
Transactions of the Academy of Science of St Louis. Vol. i. Part 2. 8vo.	The Academy.
Proceedings of the American Philosophical Society. Vol. vi. Nos. 57 and 58. 8vo.	The Society.
Proceedings of the American Academy of Arts and Sciences. Vol. iii. Nos. 32–52; Vol. iv. No. 1. 8vo.	The Academy.
Catalogue of North American Mammals, chiefly contained in the Museum of the Smithsonian Institution. By Spencer F. Baird. 4to.	The Institution.
Map of Chicago Harbour and Bar.	Lieut.-Col. J. D. Graham.
The Canadian Journal. Nos. 20 and 21. 8vo.	Canadian Inst.
Journal of the Proceedings of the Linnean Society. Supplement to Botany. No. 2. 8vo.	The Society.
Temperature of the Sea around the Coasts of Scotland during 1857–58. By James Stark, M.D. 8vo.	The Author.
Catalogue of the Admiralty Library. 8vo.	The Admiralty.
Memoirs of the Geological Survey of India. Vol. i. Part 2. 8vo.	Gov.-General.
Recherches Experimentales sur les Effets du Courant Electrique appliqué au Nerf Grand-sympathetique. Par MM. Philippe Comte Linati et Prince Caggiati. 8vo.	The Authors.
Report of the Teneriffe Astronomical Experiment of 1856. Addressed to the Lords Commissioners of the Admiralty. By Professor C. P. Smyth. 4to.	Lords Commissioners.
A Treatise on Problems of Maxima and Minima, solved by Algebra. By Ramchudra; edited by Aug. De Morgan. 8vo.	Secretary of State for India.
Monatsbericht der Königlichen Preuss. Akad. der Wissenschaften zu Berlin. July to Dec. 1858. 8vo.	The Academy.

DONATIONS.	DONORS.
Uëbersicht der Witterung im Nördlichen Deutschland nach den Beobachtungen des Meterologischen Instituts zu Berlin. 1855, 1856, 1857, and 1858. 4to.	The Institute.
Quarterly Journal of the Chemical Society. No. 45. 8vo.	The Society.
Philosophical Transactions of the Royal Society of London. Vol. cxlvii. Part 3, 1857; Vol. cxlviii. Parts 1 and 2, 1858. 4to.	Ditto.
Astronomical, Magnetical, and Meteorological Observations, made at the Royal Observatory, Greenwich, in the year 1857. 4to. 1859.	Ditto.
Report of the Joint Committee of the Royal Society and the British Association, for procuring a Continuance of the Magnetic and Meteorological Observations. 8vo.	Ditto.
Atti dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. 1. Fasc. 10. ed 11. Folio.	The Institute.
Memorie dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. vii. Fasc. 5, 6, 7, ed 8. Folio.	Ditto.
Monumenta Sæcularia der Kön. Bayer. Akademie der Wissenschaften, 28 März 1859. 4to.	The Academy.
Rede bei der Hundertjæhrigen Stiftungsfeier der Kön. Bayer. Akademie der Wissenschaften, Am 28 März 1859. Gehalten von G. L. von Maurer. 4to.	Ditto.
Rede zur Vorfeier des Geburtsfestes Seiner Majestät des Konigs Maximilian II. Gehalten von Geheim-Rath Fr. v. Thiersch. 4to.	Ditto.
Erinnerung an Mitglieder der Math.-physik. Classe der Kön. Bayer. Akademie der Wissenschaften. Von Dr C. F. Ph. von Martius. 4to.	Ditto.
Almanach der Kön. Bayer. Akademie der Wissenschaften für das Jahre 1859. 32mo.	Ditto.
The Atlantis: a Register of Literature and Science, conducted by Members of the Catholic University of Ireland. No. 4. July 1859. 8vo.	The University.
Journal of the Royal Dublin Society. July 1859. 8vo.	The Society.
Proceedings of the Royal Geographical Society of London. Vol. iii. No. 4. 8vo.	Ditto.
Transactions of the Royal Scottish Society of Arts. Vol. v. Part 2. 8vo.	Ditto.
Mittheilungen der Naturforschenden Gesellschaft in Bern. 1856–57. 8vo.	Ditto.
Verhandlungen der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. August 1857.	Ditto.
Neue Denkschriften der Allgemeinen Schweizerischen Gesellschaft für die gesammten Naturwissenschaften. Band xvi. 4to.	Ditto.
The Quarterly Journal of the Geological Society. Vol. xv. Part 3. 8vo.	Ditto.
Die Fortschritte der Physik in Jahre 1856. Dargestelt von der Physikalischen Gesellschaft zu Berlin. 8vo.	Ditto.
Transactions of the Royal Society of Literature. Vol. vi. Part 2. 8vo.	Ditto.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. iii. No. 2. 8vo.	Ditto.
Report of the Proceedings of the Geological and Polytechnic Society of the West Riding of Yorkshire. 1858–59. 8vo.	Ditto.
Annual Report of the Leeds Philosophical and Literary Society. 1858–59. 8vo.	Ditto.
Proceedings of the Royal Geographical Society. Vol. iii. No. 5. 8vo.	Ditto.
The Canadian Journal. July 1859. 8vo.	The Editors.
The Quarterly Journal of the Chemical Society. No. 46.	The Society.
Proceedings of the Horticultural Society of London. Nos. 1 to 3. 8vo.	Ditto.
Quarterly Return of Births, Deaths, and Marriages. No. 18. 8vo.	Registrar-Gen.
Smithsonian Report for 1857. 8vo.	The Institution.
Smithsonian Contributions to Knowledge. Vol. x. 4to.	Ditto.
Reply to the "Statement of the Trustees" of the Dudley Observatory. By B. A. Gould, jun. 8vo. 1859.	The Author.
Defence of Dr Gould. By the Scientific Council of the Dudley Observatory. 8vo.	The Council.

DONATIONS.	DONORS.
Paper and Resolutions in Advocacy of a Uniform System of Meteorological Observations throughout the American Continent. By Major R. Lachlan. 8vo.	The Author.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. T. xlix. Nos. 4 and 5. 4to.	The Academy.
Report of the British Association for the Advancement of Science. Leeds, 1858. 8vo.	The Association.
On the Chemical Composition of the Granites of Ireland. By Professor Haughton. 8vo.	The Author.
Experimental Researches on the Granites of Ireland. By Professor Haughton. 8vo.	Ditto.
On the Lower Carboniferous Beds of the Peninsula of Hook, County Wexford. By Professor Haughton. 8vo.	Ditto.
On the Evidence afforded by Fossil Plants as to the Boundary-line between the Devonian and Carboniferous Rocks. By Professor Haughton. 8vo.	Ditto.
On the Black Mica of the Granite of Leinster and Donegal. By Professor Haughton. 8vo.	Ditto.
Notes to accompany Figures of some Distorted Fossils from Cleaved Rocks of the South of Ireland. By Professor Haughton. 8vo.	Ditto.
On Serpentines and Soapstones. By Professor Haughton. 8vo.	Ditto.
On some Rocks and Minerals from Central India. By Professor Haughton. 8vo.	Ditto.
Journal of the Geological Society of Dublin. Vol. i. Parts 2–4; Vol. ii. Parts 1–3; Vol. iii. Parts 1–4; Vol. iv. Parts 1 and 2. 8vo.	The Society.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nos. 6 and 7. 4to.	The Academy.
Notes as to the Construction of Breakwaters for Harbours of Refuge. By D. and T. Stevenson. 8vo.	The Authors.
Supplement to Daubeny's "Descriptions of Volcanoes." 8vo.	The Author.
Silliman's American Journal of Science and Arts. Vol. xxviii. No. 82. 8vo.	The Editors.
Bulletin de la Société de Geographie. Tome xvii. 4^{me} Sèr. 8vo.	The Society.
An Account of the Life, Lectures, and Writings of William Cullen, M.D. By Drs John and William Thomson and Dr Craigie. 2 vols. Edinburgh, 1859. 8vo.	Dr Allen Thomson and Dr Craigie.
Monthly Return of Births, Deaths, and Marriages. August 1859.	Registrar-Gen.
Proceedings of the Royal Society of London. Vol. x. No. 36. 8vo.	The Society.
Uber die Hügel bei Sitten im Wallis. By Professor Studer. 4to.	The Author.
Journal of Proceedings of the Linnean Society. Vol. iv. No. 14. 8vo.	The Society.
Memoires de l'Académie Royale des Sciences de Belgique. Tome xxxi. Bruxelles, 1859. 4to.	The Academy.
Memoires Couronnés et Memoires des Savants étrangers, publiés par l'Académie Royale de Belgique. Tome xxix. Bruxelles, 1859. 4to.	Ditto.
Annales de l'Observatoire Royale de Bruxelles. Par A. Quetelet. Bruxelles, 1859. 4to.	The Observatory.
Observations des Phénomènes periodiques.	M. Ad. Quetelet.
Memoires Couronnés et autres Memoires publiés, par l'Académie Royale de Belgique. Tome viii. Bruxelles, 1859. 8vo.	The Academy.
Bulletins de l'Académie Royale de Belgique. 2^{me} Sèr. Tomes iv.–vi. Bruxelles, 1859. 8vo.	Ditto.
Annuaire de l'Académie Royale de Belgique, 1859. Bruxelles, 1859. 12mo.	The Editor.
Annuaire de l'Observatoire Royale de Bruxelles. Par Ad. Quetelet. Bruxelles, 1858. 12mo.	Ditto.
Tables générales et analytiques du Recueil des Bulletins de l'Académie Royale de Belgique. 1re Sér. Tome i.–xxii. 8vo.	The Academy.
Sur les Travaux de l'ancienne Académie de Bruxelles. Discours par A. Quetelet. 8vo.	The Author.

DONATIONS.	DONORS.
Observations des Passages de la Lune et des Etoiles de même culmination. Par Ad. Quetelet. 8vo.	The Author.
Sur le Magnetisme terrestre. Par M. Hansteen. Lettres addressées à M. A. Quetelet. 8vo	Ditto.
Sur la Comète de Donati, visible à l'œil nu. Par M. Ad. Quetelet. 8vo.	Ditto.
Sur la Constance dans le Nombre des Mariages et sur la Statistique morale en générale. Par M. Ad. Quetelet. 8vo.	Ditto.
Rymbybel van Jacob van Maerlaut. Bruxelles, 1859. 8vo.	Ditto.
Transactions of the Architectural Institute of Scotland (Session 1857–58). Edinburgh, 1859. 8vo.	The Institute.
Magnetische Untersuchungen in Nord Deutschland, Belgien, Holland, Dänemark. Von J. Lamont. Munich, 1859. 4to.	Royal Observatory of Munich.
Proceedings of the Royal Astronomical Society. 8vo (Monthly).	The Society.
Journal of the Society of Arts (Weekly). 8vo.	Ditto.
Jahres-Bericht der Münchener Sternwarte für 1858. Munich, 1859. 8vo.	Royal Observatory of Munich.
Monatliche und jährliche Resultate der and der Königlichen Sternwarte bei München von 1825 bis 1856 Angestellten Meteorologischen Beobachtungen.	Ditto.
Atti dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. i. Fasc. 1–9. Milan, 1858.	The Institute.
Memorie dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. vii. Fasc. 1–4.	Ditto.
Mémoires presentées par divers Savants à l'Académie des Sciences de l'Institute Impériale de France. Vol. xv. Paris, 1858. 4to.	The Academy.
Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. No. 66 (New Series). Edinburgh. 8vo.	The Society.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften (Mathematisch-Naturwissenschaftliche Classe). 1858. Parts 1–15, Bände xxiv., xxv. 1, 2; xxvi., xxvii. 1.	The Imperial Academy.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften (Philosophisch-Historische Classe). Bände xxiii. 5; xxiv. 1, 2; xxv. 1, 2, 3; xxvi. 1, 2; xxvii.	The Academy.
Almanach der Kaiserlichen Akademie der Wissenschaften. Vienna, 1858. 8vo.	Ditto.
Festrede bei der Feierlichen Ubernahme des ehemaligen Universitätsgebäudes vom Dr T. G. von Karajan. Vienna. 8vo.	Ditto.
Die Principien der heutigen Physik von Dr Andreas Ritter v. Ettingshausen. Vienna. 8vo.	Ditto.
Jahrbücher der K. K. Central-Anstalt für Meteorologie und Erdmagnetismus. Von Karl Kreil. Band v. Vienna, 1858. 4to.	
Denkschriften der Kaiserlichen Akademie der Wissenschaften. Band xiv. Vienna. 4to.	Ditto.
Memoirs of the Royal Astronomical Society. Vol. xxvii. London, 1859. 4to.	The Society.
Monthly Notices of the Royal Astronomical Society. Vol. xviii. London, 1858. 8vo.	Ditto.
Brockhaus (H.) Die Sage von Nala u. Damaganti.	Roy. Sax. Soc.
Berichte d. Philolog.-Histor. Class, 1858. ii.	Ditto.
Fechner psychophysisches Grundgesetz.	Ditto.
Hankel elehtrische Untersuchungen. No. 4.	Ditto.
Hofmeister Phanerogamen.	Ditto.
Berichte d. Math.-Phys. Classe, 1858. ii. and iii.	Ditto.
Bulletin de la Société Palæontologique de Belgique. Tome i. Parts 1–4.	The Society.
Proceedings of the Literary and Philosophical Society of Liverpool, 1858–59.	Ditto.
Proceedings of Horticultural Society of London. Nos. 4–6.	Ditto.
Registrar-General's Monthly Report (September).	Registrar-Gen.

DONATIONS.	DONORS.
Quarterly Journal of Chemical Society.	The Society.
Notices of Proceedings of Royal Institution of Great Britain.	The Institution.
Proceedings of Royal Institution of Great Britain. Part 9. 1859.	Ditto.
Journal of Royal Geographical Society. 1858.	The Society.
Transactions of Zoological Society. Vol. iv. Part 6.	Ditto.
Proceedings of Zoological Society. Part xxvi., 1858; Parts 1 and 2, 1859.	Ditto.
Notice of Royal Astronomical Society. No. 10.	Ditto.
Annual Report of Royal Cornwall Polytechnic Society. 1858.	Ditto.
Bulletin de la Société Imperiale des naturalistes de Moscou. Nos. 23 and 24. 1858–59.	Ditto.
Registrar-General's Monthly Report (October).	Registrar-Gen.
Reply to Sir David Brewster's Memorial to the Lords Commissioners. By D. and T. Stevenson.	The Authors.
Journal of Royal Dublin Society (October 1859).	The Society.
Proceedings of Royal Geographical Society. No. 6.	Ditto.
Admiralty Charts.	The Admiralty.
Six Plans of the Rise and Fall of the River Indus. 1845–48.	The Indian Govt.
Series of Military and other Maps. By Colonel Jervis.	W. P. Jervis, Esq.
Bulletin de la Société Vaudoise.	The Society.
Places of 5345 Stars observed from 1828–1854 at the Armagh Observatory. By Rev. T. R. Robinson, D.D.	H. M. Govt.

December 19, 1859.

Transactions of the Botanical Society of Edinburgh. Vol. vi. Part 2. 8vo.	The Society.
Monthly Notices of Astronomical Society. Vol. xx. No. 1. 8vo.	Ditto.
Proceedings of the Linnean Society. Vol. iv. No. 15. 8vo.	Ditto.
Canadian Journal. September and November 1859. 8vo.	The Publishers.
Journal of Statistical Society. December 1859. 8vo.	The Society.
Transactions of the Royal Medical and Chirurgical Society of London, 1859. 8vo.	Ditto.
Madras Journal of Literature and Science. April to September 1858. 8vo.	Madras Lit. Soc.
Transactions of Bombay Geographical Society. Vol. xiv. 8vo.	The Society.
Aanteekeningen van het Verhandelde in de Sectie-Vergaderingen van het Provinciaal Utrechtsche Genootschap van Kunsten en Wetenschappen. 1855–59. Utrecht. 8vo.	Ditto.
Verslag van het Verhandelde in de Algemeene Vergadering van het Provinciaal Utrechtsche Genootschap van Kunsten en Wetenschappen. 1856–59. 8vo.	Ditto.
Annales de l'Observatoire physique centrale de Russie. 1856. 4to.	The Observatory.
Compte Rendu Annuel. 1857. 4to.	Acad. of Sciences.
Report on Canadian Graptolites. By James Hall, Esq. Montreal, 1858. 8vo.	The Author.

January 3, 1860.

Nautical Monographs. No. 1. 4to.	The Observatory, Washington.
Silliman's American Journal. No. 84. Second Series. 1859. 8vo.	The Editors.
Journal of Asiatic Society of Bengal. No. 3. 1859. 8vo.	The Society.
Proceedings of the Academy of Natural Sciences of Philadelphia. 1859. 8vo.	The Academy.
Extinct Vertebrata from the Judith River, and Great Lignite Formations of Nebraska. By Joseph Leidy, M.D. Philadelphia, 1859. 4to.	The Author.
A Memoir on the Extinct Sloth Tribe of North America. By Joseph Leidy, M.D. 4to.	Ditto.

DONATIONS.	DONORS.
The Ancient Fauna of Nebraska. By Joseph Leidy, M.D. 4to.	The Author.
Descriptions of some Remains of Fishes from the Carboniferous and Devonian Formations of the United States. By Joseph Leidy, M.D. Philadelphia. 1856. 4to.	The Author.
Journal of the Academy of Natural Sciences of Philadelphia. 1859. 4to.	The Academy.
Observations on the Genus Unio. By Isaac Lea, LL.D. Vol. vii. Part 1. Philadelphia. 4to.	The Author.
Lever's Year-Book and Railway and Mining Almanac. Manchester. 1860. 8vo.	
Proceedings of the Horticultural Society of London. No. 7. 1859. 8vo.	The Society.

January 16, 1860.

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences, Nos. 21–24. 4to.	The Academy.
Transactions of the Pathological Society of London. Vol. x. 1859. 8vo.	The Society.
Monthly Notice of the Astronomical Society. Vol. xx. No. 2. 8vo.	Ditto.
Journal of the Geological Society of Dublin. Vol. viii. Part 2. 1859. 8vo.	Ditto.
Instructions and Chart for Observations of Mars in Right Ascension at the opposition of 1860 for obtaining the Measure of the Sun's Distance. By G. B. Airy, Esq., Astronomer-Royal. 8vo.	Ditto.
Memoirs of the Geological Survey of India. Vol. ii. Part 1. 1859. 8vo.	The Indian Gov.
Atti dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. i. Parts 12–14.	The Institute.
Berättelse om Framstegen i Insekternas, Myriapodernas och Arachnidernas Naturalhistoria för 1855 och 1856, af C. H. Boheman. 1859. 8vo.	Roy. Soc. Sciences, Stockholm.
Berättelse om Framstegen i Fysik under år 1853, af E. Edlund. 1859. 8vo.	Ditto.
Ofversigt af Kongl. Vetenskaps-Akadémiens Förhandlingar. 1858. 8vo.	Ditto.
Kongliga Svenska Fregatten Eugenies resa omkring Jorden under befäl, af C. A. Virgin. Aren., 1851–53. Häft 6. 1859. 4to.	Ditto.
Kongliga Svenska Vetenskaps-Akadémiens Handlingar. Bd. ii. Häft 1. 1857. 4to.	Ditto.
The Assurance Magazine and Journal of the Institute of Actuaries. Jan. 1860. 8vo.	The Institute.
Madras Journal of Literature and Science. New Series. Vol. iv. No. 8. 8vo.	Madras Lit. Soc.
Monthly Return of Births, Deaths, and Marriages. Dec. 1859.	Registrar-Gen.
Beretning om en Zoologisk Reise i Sommeren, 1858, af C. D. Danielssen. 8vo.	The Author.
Diplomatarium Norvegicum. 1858. 8vo.	Univ. Christiania.
Personalier oplœste ved Hans Majestaet Kong Oscar den I's. begravelse i Ridderholmskirken. 1859. 8vo.	Ditto.
Tale Ved det Norske Universitets Mindefest for Kong Oscar, den 22de Sept. 1859, af J. S. Welhaven. 8vo.	Ditto.
Al-Mufassal, opus de re grammatica Arabicum Auctore Abu'l Kasim Mahmûd Bin Omar Zamahsario. Edidit J. P. Broch, Christiania. 1859. 8vo.	Ditto.
Navne-Register. 1858. 8vo.	Ditto.
Det Kongelige Norske Frederiks Universitets Aarsberetninger for 1856–58.	Ditto.
Nyt Magazin for Naturvidenskaberne. 1859. 8vo. 10de Binds, 4de Hefte, and 11te Binds, 1ste Hefte.	Ditto.
Karlamagnus Saga Ok Kappa Hans. Udgivet af C. R. Unger, Christiania. 1859. 8vo.	Ditto.
Forhandlinger i Videnskabs-Selskabet I. Christiania. Aar 1858. 8vo.	Ditto.
Uber die Geometrische Repräsentation der Gleichungen zwischen zwei veranderlichen, reellen oder komplexen Grössen, von C. A. Bjerknes. 1859. 4to.	Ditto.
Proceedings of the Horticultural Society of London, No. 8. Jan. 1860. 8vo.	The Society.

February 6, 1860.

DONATIONS.	DONORS.
On Hypsometrical Measurements by means of the Barometer and the Boiling-Point Thermometer. By J. Burgess, F.E.I.S. Calcutta, 1859. 8vo.	The Author.
Reminiscences of General Sir Thomas Makdougall Brisbane, of Brisbane and Makerstoun, Bart. Printed for private circulation. 4to. 1860.	
Memorial on the New System of Dioptric Lights, invented and introduced by Sir David Brewster, K.H., to the Lords Commissioners of Her Majesty's Treasury. 8vo. 1859.	The Author.
On the Life-Boat, the Lightning-Conductor, and the Light-House. By Sir David Brewster, K.H.	Ditto.
Transactions of the Royal Scottish Society of Arts. Vol. v. Part 3. 8vo. 1860.	The Society.
Schriften der Universität zu Kiel, aus dem Jahre, 1858. 4to.	The University.
Charts and Sailing Directions.	Dépôt de la Marine.

February 20, 1860.

London University Calendar. 1860. 8vo.	The University.
Journal of the Proceedings of the Linnean Society. Vol. iv. No. 16. 8vo.	The Society.
Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome v. Part 1. 1859. 8vo.	Ditto.
Maps of Indian Survey.	Indian Govt.
On a New Method of Measuring Watch-Glasses. By Alexander Bryson, F.R.S.E. 1860. 8vo.	The Author.
Almanaque Nautico para 1861, Calculado de Orden de S. M. en el Observatorio de Marina de la Ciudad de San Fernando. Cadiz, 1859. 8vo.	The Observatory.
The Canadian Journal of Industry, Science, and Art. January 1860. 8vo.	Canad. Institute.
Maps, Sections, and Descriptions of the Geological Survey of Great Britain.	Director-General.
Account of the Illness and Death of Dr William Pulteney Alison. By Patrick Newbigging, M.D., F.R.C.S.	The Author.

March 5, 1860.

Memoires de la Société des Sciences Naturelles de Neuchatel. Tome IV. 1859. 4to.	The Society.
Nederlandsch Kruidkundig Archief. Vol. iv. Part 4. 1859. 8vo.	Ditto.
Gelehrte Anzeigen. Band xlviii. Munich, 1859. 4to.	Roy. Bav. Acad.
Jahrbuch des Kaiserlich, Königlichen Geologischen Reichsanstalt. Nos. 1 and 2. 1859. 8vo.	The Institute.
Silliman's American Journal of Science and Arts. No. 85. January, 1860. 8vo.	The Editors.
Atti dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. i. Fasc. 15 and 16. Milan, 1859.	The Institute.
Memoire dell' I. R. Istituto Lombardo di Scienze, Lettere ed Arti. Vol. viii. Fasc. 1. Milan, 1859.	Ditto.
Ansprache Gehalten am Schlusse des Ersten Decenniums der Kaiserlich Königlichen Geologischen Reichsanstalt in Wien. Von W. Haidinger. 1859. 8vo.	Ditto.
Die Fossilen Mollusken des Tertiær-Bekens von Wien. Von Dr Moritz Höres. Band II.	Ditto.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nos. 25 and 26. 1859–60.	The Academy.
Journal of the Asiatic Society of Bengal. No. 4. 1859. 8vo.	The Society.

DONATIONS.	DONORS.
Quarterly Journal of the Geological Society. Nos. 60* and 61. 1860. 8vo.	The Society.
Preisschriften gekrönt und herausgegeben von der Fürstlich Jablonowskischen Gesellschaft zu Leipzig. No. 7. 1859. 8vo.	Ditto.
Erinnerungen an Johann Georg von Lori. Von Dr Georg T. von Rudhart. Munich, 1859. 4to.	Royal Bavarian Academy.
The Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. No. 68. March, 1860. 8vo.	The Society.
Journal of the Statistical Society of London. Vol. xxiii. Part 1. March, 1860. 8vo.	Ditto.
The Australian and Californian Gold Discoveries, and their Probable Consequences. By Patrick James Stirling, F.R.S.E. Edinburgh, 1853. 8vo.	The Author.
Harmonies of Political Economy. By Frédérick Bastiat. Translated from the French, by Patrick James Stirling, F.R.S.E. London, 1860. 8vo.	The Translator.

March 19, 1860.

Quarterly Return of Births, Deaths, and Marriages registered in Scotland—Quarter ending 31st December 1859. 8vo.	Registrar-Gen.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nos. 9 and 10. 4to.	The Academy.
Monthly Notices of Astronomical Society. Vol. xx. No. 4. 8vo.	The Society.
List of Fellows of the Royal Astronomical Society, February 10, 1860. 8vo.	Ditto.
Journal of Proceedings of Linnean Society. Supplement to Vol. iv.—Botany. 8vo.	Ditto.
Monthly Return of Births, Deaths, and Marriages registered in Scotland—January and February 1860. 8vo.	Registrar-Gen.
Answer to Sir David Brewster's Reply to Messrs Stevenson's Pamphlet on Sir David Brewster's Memorial to the Treasury. By D. and T. Stevenson. Edinburgh, 1860. 8vo.	The Authors.
Descriptions of New Palæozoic Fossils from the Western States. By J. H. M'Chesney. Chicago, 1859. 8vo.	The Author.
Proceedings of the Royal Geographical Society of London. Vol. iv. Part 1. 1860. 8vo.	The Society.
Maury's Sailing Directions. 2 vols. 1858. 4to.	U.S. Government.
Maury's Wind and Current Charts.	Ditto.
Part of a Panoramic View of Kashmir Mountains. Sketched by T. G. Montgomerie, Bengal Engineers, to illustrate G. T. Survey of Cashmir.	Prof. C. P. Smyth.
Fac-simile of an Ancient Manuscript on Parchment in the Record Office, which has been copied and printed by Photo-Zincography at the Ordnance Survey Office.	Colonel James.

April 2, 1860.

Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nos. 11 and 12.	The Academy.
Rectification of Logarithmic Errors in the Measurements of two Sections of the Meridional Arc of India. In a Letter to Professor Stokes, Sec. R.S. By Colonel Everest, F.R.S.	The Author.
Reply to Messrs Stevenson's Pamphlet on Lighthouses. By Sir David Brewster, K.H., D.C.L., F.R.S.	Ditto.
Bulletin de la Société de Géographie. Quatrième Série. Tome xviii. Paris, 1859. 8vo.	The Society.
Observations Astronomiques faites à l'Observatoire de Genève, dans les Années 1853 et 1854. Par E. Plantamour. xiii^{e} et xiv^{e} Série. 1859. 4to.	The Author.

DONATIONS.	DONORS.
Résumé Météorologique de l'Année 1858, pour Genève et le Grand St Bernard. Par E. Plantamour. Geneva, 1859. 8vo.	The Author.
Uber die Natürliche Lage von Bern, von B. Studer. Bern, 1859. 4to.	Ditto.
Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xv. Part 1. Geneva, 1859. 4to.	The Society.
Abhandlungen, herausgegeben von der Senckenbergischen Naturforschenden Gesellschaft. B. iii. Part 1. 1859. 4to.	Ditto.
Biographical Sketch of the late Dr George Wilson. By Professor Balfour.	The Author.
Die Fortschritte der Physik im Jahre, 1857. Dargestellt von der physikalischen Gesellschaft zu Berlin. xiii. Jahrgang, Zweite Abtheilung.	The Society.
Magnetical and Meteorological Observations made at the Honourable East India Company's Observatory, Bombay, in the year 1857, under the superintendence of Lieutenant E. F. T. Fergusson, I.N., F.R.A.S. Bombay, 1858.	Government of India.
Lithograph of the Fossil Trees discovered in the Quarry at Granton.	Robt. Allan, Esq., F.R.S.E.

April 17, 1860.

Second Annual Report of the General Board of Commissioners in Lunacy for Scotland. Edin. 1860. 8vo.	Commissioners.
Journal of the Royal Asiatic Society of Great Britain and Ireland. Vol. xvii. Part 2. 8vo.	The Society.
Canadian Journal. March, 1860. 8vo.	Canad. Institute.
Quarterly Journal of Chemical Society. No. 48.	The Society.
Appendix to Messrs Stevenson's Answer to Sir David Brewster's Reply regarding Dioptric Lights. By D. and T. Stevenson.	The Authors.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Nos. 14 and 15.	The Academy.
Von der Bedeutung der Sanskritstudien für die griechische Philologie. Von Dr W. Christ. 4to.	Royal Bavarian Academy.
Rede in der öffentlichen Sitzung der k. Akademie der Wissenschaften. Am 28. Marz 1860. Gehalten Von Justus F. Von Liebig. 4to.	Ditto.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. iii. No. 3. 1860. 8vo.	The Society.
Proceedings of the Zoological Society of London. Part 3. 1859. 8vo.	Ditto.
Monthly Return of Births, Deaths, and Marriages. March 1860.	Registrar-Gen.

April 30, 1860.

Herring Fisheries of Scotland. 1860.	Board of Fisheries.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. No. 16.	The Academy.
Report and Diagram showing the Rise and Fall of the Irawadi River for the Three Years 1856–58.	Secretary of State for India.
Total Solar Eclipse, 1860, July 18. Revised Path of the Shadow. 8vo.	J. R. Hind, Esq.
The Atlantis. No. 5. January, 1860. 8vo.	Catholic University of Ireland.

December 3, 1860.

Proceedings of the Royal Society of London. Vol. x. No. 38. 8vo.	The Society.
Proceedings of Berwickshire Naturalists' Club. 1859. 8vo.	The Club.
Résumé Météorologique de l'Année 1858, pour Genève et le Grand St Bernard. Par E. Plantamour. Geneva, 1859.	The Author.

DONATIONS.	DONORS.
Silliman's American Journal. March 1860. 8vo.	The Editors.
Additional Notes on the Post-Pliocene Deposits of the St Lawrence Valley. By J. W. Dawson, LL.D. 8vo.	The Author.
On the Vegetable Structures in Coal. By J. W. Dawson, LL.D. 1860. 8vo.	Ditto.
On the Silurian and Devonian Rocks of Nova Scotia. By J. W. Dawson, LL.D. 8vo.	Ditto.
On Fossil Plants from the Devonian Rocks of Canada. By J. W. Dawson, LL.D. 8vo.	Ditto.
Monthly Notices of Royal Astronomical Society. Vol. xx. Nos. 6 and 7. 8vo.	The Society.
Report of the Proceedings of Geological and Polytechnic Society of West Riding of Yorkshire. 1859. 8vo.	Ditto.
Transactions of Royal Society of Literature. 2d Series. Vol. vi. Part 3. 8vo.	Ditto.
The Chronicle of Man and the Sudreys. Edited by P. A. Münch. Christiania, 1860. 8vo.	Ditto.
Bidrag til kundskab om de Sindssyge i Norge. af L. Dahl. Christiania. 8vo.	The Royal Univ. of Christiania.
Nyt Magazin for Naturvidenskaberne. Vol. xi. Part 2. Christiania, 1860. 8vo.	Ditto.
Tabellen und amtliche Nachrichten über den Preussischen Staat Berlin, 1858.	Professor Dove.
Astronomische Beobachtungen auf der K. Universitäts-Sternwarte zu Königsberg. Parts 31 and 32. 1859.	The Society.
Quarterly Journal of the Chemical Society. April. 8vo.	Ditto.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Tome l. Nos. 22–26; Tome li. Nos. 1–21. 4to.	The Academy.
Journal of Statistical Society of London. Vol. xxiii. Part 2. 8vo.	The Society.
La Vérité sur le Cholera-morbus. Par le Docteur Fremaux. Paris, 1860. 8vo.	The Author.
Quarterly Journal of Geological Society of London. Vol. xvi. Part 2. 8vo.	The Society.
Address delivered at the Anniversary Meeting of the Geological Society. By J. Phillips, Esq. London, 1860. 8vo.	The Author.
Transactions of the Philosophical Institute of Victoria. Vol. iv. Part 1. 1859. 8vo.	The Institute.
Fragmenta Phytographiæ Australiæ. By Dr Mueller. Parts 8–10. 8vo.	The Author.
Journal of Proceedings of the Linnean Society. Vol. v. No. 17. 8vo.	The Society.
On the Lower Silurian Rocks in the South-east of Ireland, and on a Human Skeleton in an elevated Sea-margin. By Fort-Major T. Austen, F.G.S. 8vo.	The Author.
Annual Report of the Royal Cornwall Polytechnic Society. 1859. 8vo.	The Society.
Proceedings of the Horticultural Society of London. Vol. i. Parts 10–13. 8vo.	Ditto.
Report of the British Association. 1859. 8vo.	The Association.
Jagttagelser over den Postpliocene eller glaciale formation i en del af det Sydlige Norge. Af Prof. Dr Sars og Lector Th. Kjerulf. 4to. 1860.	Ditto.
Reflexions sur les objections soulevées par Arago contre la Priorité de Galilée pour la Double Découverte des Taches Solaires noires, et de la Rotation uniforme du Globe du Soleil. Par Jean Plana. Turin, 1860. 4to.	The Author.
Mémoire sur la Théorie des Nombres. Par Jean Plana. Turin, 1860. 4to.	Ditto.
Bulletin de l'Académie Impériale des Sciences de St Petersbourg. Tome i. Parts 1–6. 4to.	The Academy.
Mémoires de l'Académie Impériale des Sciences de St Petersbourg vii^e Série. Tome i. Nos. 1–15. 4to.	Ditto.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. Wien, 1859. 8vo.	The Society.
Quarterly Return of Births, Deaths, and Marriages registered in Scotland. No. 21. 8vo.	The Registrar-General.
Mémoires de l'Institut Impérial de France. Tomes xxv., xxvii. Part 2; xxxi. Parts 1 and 2. 4to.	The Institute.
Annuaire de l'Institut Impérial de France. 1860.	Ditto.
Journal of the Asiatic Society of Bengal. New Series. No. 101. 8vo.	The Society.

DONATIONS.	DONORS.
Monatsbericht der K. Preuss. Akad. der Wissenschaften zu Berlin. January to December 1859. 8vo.	The Academy.
Memoirs of Geological Survey of India. Vol. i. Part 3. 8vo.	Govt. of India.
Abhandlungen der K. Akad. der Wissenschaften zu Berlin. 1854 (Zweiter Supplement-Band) and 1859. 4to.	The Academy.
Proceedings of Royal Geographical Society of London. Vol. iv. No. 2. 8vo.	The Society.
Madras Journal of Literature and Science. New Series, Vol. v. No. 9. 8vo.	Madras Lit. Soc.
Journal of Asiatic Society of Bengal, No. 1. 1860. 8vo.	The Society.
Beletin de la Sociedad de Naturalistas Neo-Granadindos, 1868. 8vo.	Ditto.
Silliman's American Journal of Science and Art. May 1860. 8vo.	The Editors.
Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. July 1860. 8vo.	The Society.
Bulletin de la Société Vaudoise. Tome vi. Nos. 45 and 46. 8vo.	Ditto.
Oversigt over det Kongelige danske Videnskabernes Selskabs Forhandlinger, 1858. 8vo.	Acad. of Sciences of Copenhagen.
Det Kongelige danske Videnskabernes Selskabs Skrifter, 1859. 4to.	Ditto.
Denkschriften der Kaiserlichen Akademie der Wissenschaften. Band xvii. 4to.	The Academy.
Description of a Deformed Fragmentary Human Skull, &c. By J. A. Meigs, M.D. 8vo.	The Author.
A Sketch of the Botany of the Great Salt Lake of Utah. By E. Durand. 4to.	Ditto.
Acta Academiæ C. L. C. G. Naturæ Curiosorum. Vol. xxvii. 4to.	The Academy.
Descriptions of New Uniones; and other Papers. By Isaac Lea, LL.D.	The Author.
Observations on the Genus Unio. By Isaac Lea, LL.D. Vol. vii. 4to.	Ditto.
Journal of the Academy of Natural Sciences of Philadelphia. New Series, Vol. iv. Parts 1 and 3. 4to.	The Academy.
Mémoires Couronnés, et autres Mémoires, publiés par l'Académie Royale de Belgique. Tome x. 8vo.	Ditto.
Bulletin de l'Académie Royale de Belgique. Tomes vii. and viii. 8vo. 1859.	Ditto.
Memoirs of the Literary and Philosophical Society of Manchester. Second Series, Vol. xv. Part 2. 8vo.	The Society.
Proceedings of the Literary and Philosophical Society of Manchester. 1858–59, Nos. 1–16; 1859–60, Nos. 1–14. 8vo.	Ditto.
On the Phosphates and Arseniates, Microcosmic Salt, Acids, Bases, and Water, and a new and easy Method of Analysing Sugar. By John Dalton, D.C.L., &c. Manchester, 1840–42. 8vo.	Ditto.
Transactions of the Philosophical Institute of Victoria. Melbourne, 1859. 8vo.	The Institute.
Annual Report of Leeds Philosophical and Literary Society, 1859–60. 8vo.	The Society.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt, 1859. X. Jahrgang, No. 4. 8vo.	Ditto.
Sur la Différence de Longitude des Observatoires de Bruxelles et de Berlin, déterminée par des signaux galvaniques. 4to.	M. Ad. Quetelet.
De la Statistique considérée sous le rapport du Physique, du Moral, et de l'Intelligence de l'Homme. Par M. A. Quetelet. I[er] Memoir. Brussels, 1860.	The Author.
Table de Mortalité d'après le recensement de 1856. Par M. Ad. Quetelet.	Ditto.
Proceedings of the Royal Society of London. Vol. x. No. 39. 8vo.	The Society.
Journal of the Royal Geographical Society. Vol. xxix. 8vo.	Ditto.
Quarterly Journal of the Geological Society. No. 63. 8vo.	Ditto.
The Canadian Journal. July 1860. 8vo.	The Editors.
Journal of the Proceedings of the Linnean Society. Supplemental to Vol. iv. Zoology. 8vo.	The Society.
Philosophical Transactions of the Royal Society of London, for the year 1859. Vol. cxlix. Parts 1 and 2. 1860. 4to.	Ditto.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Math.-Naturwiss. Classe, Bände xxxv. Nos. 10–12; xxxvi., 13–16; xxxvii., 17–21; xxxviii., 23–28. Philos.-Histor. Classe, Bände xxx., Nos. 2 and 3; xxxi., 1–3; xxxii., 1–2. 8vo.	The Academy.
Almanach der Kaiserlichen Akademie der Wissenschaften. 1859. 8vo.	Ditto.

DONATIONS.	DONORS.
Proceedings of the Royal Physical Society of Edinburgh, 1854–58. 8vo.	The Society.
Proceedings of the Royal Geographical Society of London. Vol. iv. No. 3. 8vo.	Ditto.
Monthly Notices of Royal Astronomical Society. Vol. xx. No. 8. 8vo.	Ditto.
Memorials of the Families of De Boteville, Thynne, and Botfield. By Beriah Botfield. 1858. 4to.	B. Botfield, Esq.
Du Raisin considéré comme médicament. Par J. Ch. Harpin. Paris, 1860. 8vo.	The Author.
Journal of the Asiatic Society of Bengal. No. 95. 8vo.	The Society.
On the Tertiary Deposits associated with Trap-Rock in the East Indies. By the Rev. Stephen Hislop. 8vo.	The Author.
Observations des Phénomènes Périodiques. Par Ad. Quetelet. 4to.	Ditto.
Rymbybel van Jacob van Maerlant. Derde Deel. Brussel, 1859. 8vo.	Royal Acad. of Belgium.
Annuaire de l'Académie Royal de Belgique. 1860. 8vo.	Ditto.
Annuaire de l'Observatoire Royal de Bruxelles. Par A. Quetelet. 1859.	The Author.
Patent Office Reports. 1857, 4 vols.; 1858, 4 vols.; 1859, 1 vol. 8vo.	U.S. Government.
Ohio Agricultural Report. 1857. Second Series. 8vo.	Ditto.
Description of New Fossils from the Coal-Measures of Missouri and Kansas. By B. F. Shumard and G. C. Swallow.	The Authors.
The Rocks of Kansas. By G. C. Swallow and F. Hawn. 8vo.	Ditto.
Transactions of the Academy of St Louis. Vol. i. Part 3. 8vo.	The Academy.
Geological Report of the South-west Branch of the Pacific Railroad, State of Missouri. By G. C. Swallow. St Louis, 1859. 8vo.	The Author.
Popular Physical Astronomy. By D. Vaughan. Cincinnati, 1858. 8vo.	Ditto.
Grape Culture in Missouri. By G. C. Swallow. 1858. 8vo.	Ditto.
Smithsonian Report. 1858. 8vo.	Smithsonian Inst.
Report of the Geological Survey of Missouri. By G. C. Swallow. 1855. 8vo.	The Author.
Report of Geological Survey in Kentucky. By D. D. Owen. Vols. i. and ii. 1857. 8vo.	Ditto.
The Passage to the North Pole. By Dr J. J. Hayes. 8vo.	W. Sharswood, Esq.
Proceedings of the American Philosophical Society. Vol. vi. Parts 59–61.	The Society.
Proceedings of the American Academy of Arts and Sciences. Pages 89 to 248.	The Academy.
First Report of the Geological Reconnoissance of the Northern Counties of Arkansas. By D. D. Owen. 1858. 8vo.	The Author.
Report of Geological Survey of Iowa. By James Hall and J. D. Whitney. 2 vols. 4to.	The Authors.
Berichte über die Verhandlungen der K. Sach. Gesellschaft der Wissenschaften zu Leipzig. Philol.-Hist. Classe 1859, Parts 1 and 2; 1860, Parts 1 and 2. Math.-Phys. Classe 1859, Parts 1–4. 8vo.	The Royal Saxon Academy.
Mémoires de l'Académie Impériale des Sciences de St Petersbourg. VII^{e} Série. Tome ii. Nos. 1–3. 4to.	The Academy.
Bulletin de l'Académie Impériale des Sciences de St Petersbourg. Tome i. Parts 1–36. 4to.	Ditto.
Journal of the Asiatic Society of Bengal. New Series. No. 103. 8vo.	The Society.
Librorum in Bibliotheca Speculæ Pulcovensis anno 1858 exeunte contentorum Catalogus Systematicus. Edendum Curavit et Præfatus est Otto Struve. 1860. 8vo.	The Editor.
Recueil de Mémoires des Astronomes de l'Observatoire Central de Russie. Vol. ii. St Petersbourg, 1859. 4to.	The Imperial Academy.
Reduction of Greenwich Lunar Observations, 1831–1851. 4to.	The Observatory.
Mémoire della Reale Accademia della Scienze di Torino. Serie Seconda. Tomo xviii. 4to.	The Academy.
Denkschriften der Kaiserlichen Akadémie der Wissenschaften. Phil.-Hist. Classe, Band x. 1860. 4to. Math.-Naturwis. Classe, Band xviii.	Ditto.
Sitzungsberichte der K. Akademie der Wissenschaften. Phil.-Hist. Classe, Band xxxii. Parts 3 and 4; Band xxxiii. Parts 1 and 2; Band xxxiv. Part 1. Math.-Nat. Classe, Band xxxix. Parts 1–5; Band xl. Parts 7–12. 8vo.	Ditto.

DONATIONS.	DONORS.
Almanach der K. Akademie der Wissenschaften. Band x. 1860. 8vo.	The Academy.
Reports of the Geology, Botany, and Zoology of Northern California and Oregon, made to the War Department. By John S. Newberry, M.D. Washington, 1857. 4to.	Ditto.
Memoirs of the American Academy of Arts and Sciences. New Series. Vol. vi. Part 2. 1859. 4to.	Ditto.
Transactions of the American Philosophical Society. Vol. xii. Part 2. Philadelphia, 1859.	The Society.
Report of the Superintendent of the Coast Survey for 1857. 4to.	Prof. A. D. Bache.
Journal of the Royal Asiatic Society. Vol. xviii. Part 1. 8vo.	The Society.
Proceedings of the Royal Medical and Chirurgical Society of London. Vol. iii. No. 4. 8vo.	Ditto.
Journal of the Statistical Society of London. Vol. xxiii. Part 3. 8vo.	Ditto.
Proceedings of the Literary and Philosophical Society of Liverpool. 1860. 8vo.	Ditto.
The Quarterly Journal of the Chemical Society. No. 50. 8vo.	Ditto.
Proceedings of the Horticultural Society of London. No. 15. 8vo.	Ditto.
Quarterly Return of Births, Deaths, and Marriages. No. 22.	Registrar-Gen.
Scheikundige Verhandelingen en onderzoekingen. Uitgegeven door G. J. Mulder. Vol. iii. Part 1. 8vo.	The Dutch Govt.
Journal of Agriculture, and Transactions of the Highland and Agricultural Society of Scotland. October 1860. 8vo.	The Society.
Proceedings of the Royal Society of London. Vol. x. No. 40. 1860. 8vo.	Ditto.
Of the Nature and Treatment of Diseases of the Heart. By James Wardrop, M.D. 8vo. 1859.	The Author.
Madras Journal of Literature and Science. Vol. v. No. 10. 8vo.	Madras Lit. Soc.
The Assurance Magazine. No. 41. 1860. 8vo.	Inst. of Actuaries.
Reply to Professor Tyndall's Remarks in his Work "On the Glaciers of the Alps," relating to Rendu's "Théorie des Glaciers." By James D. Forbes, D.C.L., &c. Edinburgh, 1860. 8vo.	The Author.
Notices of Proceedings at the Meetings of the Members of the Royal Institution of Great Britain. Part 10. 1860. 8vo.	Royal Institution.
Autobiography of a Seaman. By the Earl of Dundonald. Vol. ii. 1860. 8vo.	The Author.
Quarterly Journal of the Chemical Society. No. 51. 1860. 8vo.	The Society.
Canadian Journal. September 1860. 8vo.	Canadian Inst.
Observations Météorologiques faites à Nijné-Taguilsk. Paris, 1860. 8vo.	
Monthly Notices of Astronomical Society. Vol. xx. No. 9. 8vo.	The Society.
Proceedings of Horticultural Society of London. Nos. 17 and 18. 1860. 8vo.	Ditto.
Papers read at the Royal Institute of British Architects. Session 1859–60. 4to.	The Institute.
Geological Survey of Canada—Report of Progress for 1858. Montreal, 1859. 8vo.	Sir W. E. Logan.
Proceedings of the Zoological Society of London. 1860. Parts 1 and 2. 8vo.	The Society.
Original Sanskrit Texts on the Origin and History of the People of India. By J. Muir, Esq., D.C.L. Part 2. 1860. 8vo.	The Author.
Supplemental Chapter to "Acadian Geology." By J. W. Dawson, LL.D., F.G.S. 1860. 8vo.	Ditto.
On Distance-Measuring in Russia. By Professor C. P. Smyth. 1860. 8vo.	Ditto.
Journal of Proceedings of Linnean Society. Vol. v. No. 18. 8vo.	The Society.
Quarterly Return of Births, Deaths, and Marriages in Scotland. Quarter ending 30th September 1860. 8vo.	Registrar-Gen.
Quarterly Journal of the Geological Society. Vol. xvi. Part 4. 8vo.	The Society.
Nouveaux Mémoires de la Société Impériale des Naturalistes de Moscou. Tomes xi., xii., xiii. 4to.	Ditto.
Bulletin de la Société Impériale des Naturalistes de Moscou. 1859, Parts 2, 3, and 4; 1860, Part 1. 8vo.	Ditto.
Philosophical Experiments and Observations of the late eminent Dr Robert Hooke. London, 1726. 8vo.	Alex. Bryson, Esq.

DONATIONS.	DONORS.
The Posthumous Works of Robert Hooke, M.D., F.R.S., containing his Cutlerian Lectures and other Discourses. London, 1705. 8vo.	Alex. Bryson, Esq.
The Large Blasts at Holyhead. By G. Robertson, C.E. 8vo.	The Author.
A Monograph of the Carboniferous Brachiopoda of Scotland. By Thomas Davidson, Esq., F.R.S. 8vo.	Ditto.

December 17, 1860.

Transactions of the Historic Society of Lancashire and Cheshire. Vol. xii. 1860. 8vo.	The Society.
Transactions of the Medico-Chirurgical Society. Vol. xliii. 8vo.	Ditto.
Atti del R. Istituto Lombardo di Scienze, Lettere ed Arti. Fasc. 17–20. 4to.	The Institute.
Quarterly Journal of Geological Society. Vol. xvi. Part 4.	The Society.
Transactions of the Academy of St Louis. 1859. 8vo.	The Academy.
Journal of the Proceedings of the Linnean Society. Vol. v. No. 18. 8vo.	The Society.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Tom. li. Nos. 22, 23. 4to.	The Academy.
Memoranda on Vegetation. By John Hunter, F.R.S. London, 1860. 4to.	Royal College of Surgeons, London.
Catalogue of Plants and Invertebrata. 1860. 4to.	Ditto.
Catalogue of Fossil Plants. 1855. 4to.	Ditto.
Catalogue of Vertebrata in spirit. 1859. 4to.	Ditto.
Observations on Geology. By John Hunter, F.R.S. 1859. 4to.	Ditto.
Catalogue of Fossil Reptilia and Pisces. 1854. 4to.	Ditto.
Catalogue of the Histological Series. Vol. ii. 1855. 4to.	Ditto.
Journal of Geological Society of Dublin. Vol. viii. Part 3. 8vo.	The Society.
Journal of Statistical Society of London. Vol. xxiii. Part 4. 8vo.	Ditto.
Monthly Notices of Astronomical Society. Vol. xxi. No. 1. 8vo.	Ditto.
A Treatise on Physiology and Anatomy in the Chinese Language. By Benjamin Hobson, M.B.	The Author.
Treatise on Midwifery and Diseases of Infants, in Chinese. By B. Hobson, M.B.	Ditto.
Treatise on the Science and Art of Western Surgery in the Chinese Language. By B. Hobson, M.B.	Ditto.
Treatises on Medicine and Natural Philosophy in the Chinese Language. By B. Hobson, M.B.	Ditto.
A Medical Vocabulary in English and Chinese. By B. Hobson, M.B. 1858.	Ditto.
Transactions of Botanical Society, Edinburgh, 1860. 8vo.	The Society.

January 7, 1861.

Transactions of Royal Scottish Society of Arts. Vol. v. Part 4. 8vo.	The Society.
Proceedings of Royal Society of London. Vol. x. No. 41. 8vo.	Ditto.
Proceedings of the Horticultural Society of London. Vol. i. Nos. 18, 19. 8vo.	Ditto.
Jahresbericht der Chemie, von H. Kopp u. H. Will. Giessen, 1860. 8vo.	The Authors.
Proceedings of the Academy of Natural Sciences of Philadelphia, pp. 81–284. 8vo.	The Academy.
Etudes et Expériences synthétiques sur le Metamorphisme. Par M. Daubrée. Paris. 1860. 4to.	The Author.
Observations Meteorologiques faites à Nijné-Taguilsk. Année 1857. 8vo.	
Sitzungsberichte der Königl. Bayer. Akademie de Wissenschaften zu Munich. 1860. Part 2.	The Academy.
Jahrbuch der Kaiserlich-Königlichen Geologischen Reichsanstalt. 1860. No. 1. 8vo.	The Society.
Bulletin de la Société de Géographie. Quatrième Série. Tome xix. 1860. 8vo.	Ditto.

DONATIONS.	DONORS.
Memorie dell' Accademia delle Scienze dell' Istituto di Bologna. Vols. viii., ix., x., Part 1. 4to.	The Institute.
Rendiconto delle sessioni dell' Accademia delle Scienze dell' Istituto di Bologna. 1858–59. 8vo.	The Society.
Mémoires de l'Académie des Sciences de l'Institut Imperial de France. Tome xxx. 4to.	The Institute.
The Canadian Journal, November 1860. 8vo.	Canadian Inst.
Comptes Rendus hebdomadaires de Séances de l'Académie des Sciences. Tome li. Nos. 24–26. 4to.	The Academy.
Norsk Forfatter-Lexikon 1814–56 af Jens E. Kraft. Parts 1–5. Christiania, 1857. 8vo.	Royal Univ. of Christiania.
Index Scholarum in Universitate Fredericiana. Christiania, 1860. 4to.	Ditto.
De vi logicæ rationis in describenda philosophiæ historia ad Eduardum Zellerum epistola quam scripsit M. J. Monrad. 8vo.	Ditto.
Forhandlinger i Videnskabs-Selskabet i Christiania, aar 1859. 8vo.	Ditto.
Radcliffe Catalogue of Stars for 1845. Oxford, 1860. 8vo.	Radcliffe Trustees.
Catalogus van de Boekerij der Kon. Akad. van Wetenschappen. Amsterdam, 1860. 8vo.	The Academy.
Verslagen en Mededeelingen des Kon. Akad. van Wetenschappen. Amsterdam, 1840. 8vo.	Ditto.
Jaarboek van de Kon. Akad. van Wetenschappen. Voor, 1859. 8vo.	Ditto.
Verslag over den Paalworm. 1860. 8vo.	Ditto.
Transactions of the Bombay Geographical Society. Vol. xv. 8vo.	The Society.
The Assurance Magazine and Journal of the Institute of Actuaries. January 1861. 8vo.	The Institute.
Journal of Agriculture and Transactions of the Highland and Agricultural Society of Scotland. No. 71, New Series. 8vo.	The Society.

January 21, 1861.

Journal of Proceedings of the Linnean Society—Supplement to Vol. v.—Botany. 8vo.	The Society.
Bulletin de la Société des Sciences Naturelles de Neuchatel. Tome v. Part 2. 1860. 8vo.	Ditto.
Quarterly Report of the Meteorological Society of Scotland, for the quarter ending 30th September 1860. 8vo.	Ditto.
Monthly Notices of the Royal Astronomical Society. Vol. xxi. No. 2. 8vo.	Ditto.
Proceedings of the Royal Society of London. Vol. xi. No. 42. 8vo.	Ditto.
Comptes Rendus hebdomadaires des Séances de l'Académie des Sciences. Tome lii. No. 1. 4to.	The Academy.
Monthly Return of Births, Deaths, and Marriages in Scotland. December 1860. 8vo.	Registrar-Gen.
Catalogue of the Edinburgh Medical Society's Library. 2 vols., 1837 and 1845. 8vo.	The Society.

February 4, 1861.

Proceedings of the Royal Horticultural Society. Vol. i. No. 20.	The Society.
The Eruption, in May 1860, of the Kötlugjá Volcano, Iceland. By W. Lauder Lindsay, M.D., F.L.S. 8vo.	The Author.
London University Calendar. 1861. 8vo.	The University.
The Polar Regions. By Sir John Richardson, LL.D. Edinburgh, 1861. 8vo.	The Author.
Illustrations of the Genus Carex. By Francis Boott, M.D., London, 1858. 2 vols. folio.	Sir J. Richardson.
Bombay Magnetical and Meteorological Observations. 1858. Folio.	Indian Govt.

February 18, 1861.

DONATIONS.	DONORS.
On the Causes of Death in the Scottish Widows' Fund Life Assurance Society, from January 1853 to January 1860. By James Begbie, M.D., F.R.S.E. 8vo.	The Author.
Proceedings of the Royal Horticultural Society. Nos. vi., xvi., 1860; xxi., 1861. 8vo.	The Society.
Monthly Notices of Astronomical Society. Vol. xxi. No. 3. 8vo.	Ditto.
Transactions of the Linnean Society. Vol. xxii. Part 4; xxiii. Part 1. 4to.	Ditto.

March 4, 1861.

Quarterly Journal of the Chemical Society. January 1861. 8vo.	The Society.
The Canadian Journal. January 1861. 8vo.	Canadian Inst.
Recherches expérimentales sur l'Electricité des Metaux. Par A. T. Kupffer. Tome I. St Petersbourg, 1860. 4to.	The Academy of St Petersburg.
Annalen der königlichen Sternwarte bei München. Band xii.	Royal Observatory of Munich.
Transactions of the Pathological Society of London. Vol. xi. 8vo.	The Society.
Ofversigt af K. Vetenskaps-Academiens Forhandlingar. Stockholm, 1860. 8vo.	The Academy.
Descriptive Catalogue of the Fossil Remains of Vertebrata in the Museum of the Asiatic Society of Bengal. By Hugh Falconer, M.D. Calcutta, 1859. 8vo.	The Author.
Bulletin de la Société Vaudoise des Sciences Naturelles. Tome vi. No. 47. Lausanne, 1860. 8vo.	The Society.
Sitzungsberichte der K. Bayer. Akademie der Wissenschaften. München, 1860. 8vo.	The Academy.
Mémoires de la Société de Physique et d'Histoire Naturelle de Genève. Tome xv. Part 2. Geneva, 1860. 4to.	The Society.
Kongliga Svenska Vetenskaps-Academiens Handlingar 1858. 4to.	Royal Academy of Stockholm.
Kongliga Svenska Fregatten Eugenies, &c. Stockholm, 1859. 4to.	Ditto.
Meteorologiska Jakttagelser i Sverige af Er. Edlund. 1859. 4to.	Ditto.
Journal of Asiatic Society of Bengal. No. 3. 1860. 8vo.	The Society.
Madras Journal of Literature and Science. October 1859 to March 1860. 8vo.	Ditto.
Abhandlungen der Akademie der Wissenschaften zu Berlin. 1859. 4to.	The Academy.
Annales de l'Observatoire Physique Central de Russie. St Petersbourg, 1860. 4to.	The Observatory.

March 18, 1861.

Proceedings of the Royal Horticultural Society. Vol. i. No. 21. 8vo.	The Society.
Monthly Notices of Astronomical Society. Vol. xxi. No. 4. 8vo.	Ditto.
Journal of Royal Dublin Society. Nos. 18 and 19. 8vo.	Ditto.
Journal of Agriculture, March 1861. 8vo.	Highland Society.
On a new genus of Echinoderms, and Observations on the genus Palæchinus. By Fort-Major Thomas Austin, F.G.S. 8vo.	The Author.
Quarterly Return of Births, Deaths, and Marriages registered in Scotland, for Quarter ending 31st December 1860. 8vo.	Registrar-Gen.
Journal of Royal Geographical Society. Vol. xxx. 1860. 8vo.	The Society.
A Lunar Tidal Wave in Lake Michigan demonstrated. By Brevet Lieut.-Colonel J. D. Graham. 8vo.	The Author.
Fortschritte der Physik in Jahre 1858. Berlin, 1860. 8vo.	Phy. Soc., Berlin.
Les libre Echangistes et les Protectionistes conciliés. Par J. Du Mesnil-Marigny. Paris, 1860.	The Author.

DONATIONS.	DONORS.
The Mathematical Works of Isaac Barrow. Edited by W. Whewell. Cambridge, 1860. 8vo.	The Editor.
On the Structure of the North-Western Highlands. By James Nicol, F.G.S., F.R.S.E. 8vo.	The Author.
Schriften der Universität zu Kiel, 1859.	The University.
Transactions of the Philosophical Institute of Victoria. Vol. iv. Part 2. Melbourne, 1860. 8vo.	The Institute.
Journal of Statistical Society of London, March 1861. 8vo.	The Society.

April 1, 1861.

Original Sanskrit Texts on the Origin and History of the People of India. By J. Muir, D.C.L. Part Third. 8vo, 1861.	The Author.
Résumé Meteorologique de l'Année 1859 pour Genève et le Grand St Bernard. Par E. Plantamour. 8vo.	Ditto.
Observation de l'Eclipse totale de Soleil du 18 Juillet 1860. Par E. Plantamour. 8vo.	Ditto.
Observations Astronomiques faites a l'Observatoire de Genève (1855–56). Par E. Plantamour. 4to.	Ditto.
Mesures Hypsometriques dans les Alpes. Par E. Plantamour. 4to.	Ditto.
Journal of Proceedings of Linnean Society. Vol. v. No. 19. 8vo.	The Society.
Almanaque Náutico para 1862. Cádiz, 1860. 8vo.	Observatory of St Fernando.

April 29, 1861.

Quarterly Report of the Meteorological Society of Scotland for the quarter ending 30th December 1860. 8vo.	The Society.
The Canadian Journal. March 1861. 8vo.	Canadian Inst.
Report of the Yorkshire Philosophical Society—1860. 8vo.	The Society.
Transactions of the Royal Irish Academy. Vol. xxiv. Part 1. 1860. 4to.	Ditto.
Bulletin de la Société de Geographie. 4me Série. Vol. xx. 1860. 8vo.	Ditto.
Silliman's American Journal of Science and Arts. March 1861. 8vo.	The Editors.
Atti dell' Imp. Reg. Istituto Veneto. Vols. v. Parts 6–10; vi. Parts 1–3. 8vo.	The Institute.
Sitzungsberichte der Kaiserlichen Akademie der Wissenschaften. Wien, 1860. 8vo. Math.-Natur. Classe, B. xli. Nos. 13–21; xlii. 22–26. Phil.-Hist. Classe, B. xxxiv. No. 2; xxxv. Nos. 1, 2.	The Academy.
Archiv f. Kunde Osterreichischer Geschichts-Quellen. B. xxiv. Part 2.	
Mémoires de l'Académie des Sciences. Tome xxviii. Paris, 1860. 4to.	The Institute.
Abhandlungen der K. Bayerischen Akademie der Wissenschaften. Math.-Phys. Classe, B. viii. Part 3. Philos.-Philol. Classe, B. ix. Part 1. Historischen Classe, B. viii. Part 3.	Bavarian Acad.
Gelehrte Anzeigen, B. xlix. and l.	Ditto.
Glossarium op Maerlants Rymbybel, door J. David. Brussel, 1861. 8vo.	Royal Academy of Belgium.
Alexander's Geesten, van J. van Maerlant. Brussel, 1860. 8vo.	Ditto.
Mémoires Couronnés de l'Académie Royale des Belgique. Tome x. 1860. 8vo.	Ditto.
Bulletin de l'Académie Royale de Belgique. 2me Sér. T. ix. and x. 1860. 8vo.	Ditto.
Annuaire de l'Observatoire Royale de Bruxelles. Par A. Quetelet. 1861.	Ditto.
Annuaire de l'Académie Royale de Belgique,—1861.	Ditto.
Mémoires de l'Académie Royale de Belgique. Tome xxxii. 1861. 4to.	Ditto.
Phénomènes Periodiques. Par A. Quetelet. 8vo.	The Author.
Sur la Physique du Globe. Par A. Quetelet. 8vo.	Ditto.
Observations des Phénomènes Périodiques. Par M. A. Quetelet. 4to.	Ditto.

DONATIONS.	DONORS.
Sur le Congriès international de Statistique. Par Ad. Quetelet. 4to.	The Author.
Proceedings of the Academy of Natural Sciences of Philadelphia, pp. 285–579. 8vo.	The Academy.
Journal of the Academy of Natural Sciences of Philadelphia. New Series. Vol. iv. Part 4. 1860. 4to.	Ditto.
Observations on the Genus Unio. By Isaac Lea, LL.D. Vol. iii. Part 1. 4to.	The Author.
Smithsonian Contributions to Knowledge. Vol. xi. 1859. 4to.	The Smith. Inst.
Proceedings of American Association for Advancement of Science. 1859. 8vo.	The Association.
Ohio Agricultural Report, 1858. 8vo.	Agric. Board.
Memoires of American Academy of Arts and Sciences. New Series. Vol. vii. 1860. 4to.	The Academy.
Transactions of American Philosophical Society. Vol. xi. Part 3. Philadelphia, 1860. 4to.	The Society.
Proceedings of American Philosophical Society. Vol. vii. No. 63. 8vo.	Ditto.

INDEX TO VOL. XXII.

A

B

C

M

O

P

R

S

T

END OF VOLUME TWENTY-SECOND.

EDINBURGH: PRINTED BY NEILL AND COMPANY.

SUPPLEMENT TO VOLUME XXII.

OF THE

TRANSACTIONS

OF THE

ROYAL SOCIETY OF EDINBURGH,

CONTAINING THE

MAKERSTOUN MAGNETICAL AND METEOROLOGICAL OBSERVATIONS

FROM 1847 TO 1855.

EDINBURGH:
PUBLISHED BY ROBERT GRANT & SON, 82 PRINCES STREET; AND
T. CADELL, STRAND, LONDON.

MDCCCLX.

CONTENTS.

ERRATA.

In the column "Bifilar corrected" for December 11th, 1848, 11 A.M., *instead* of 56·10 *read* 561·0.
In the same column for December 1st, 1848, 11 A.M., *instead* of 56·85 *read* 568·5.

INTRODUCTION.

In April 1857, the Committee of the Royal Society of Edinburgh for the reduction of the Makerstoun Magnetical and Meteorological Observations consulted the late Mr Welsh with regard to the propriety of their continuing the publication of these beyond the year 1846, the period to which it had been already extended in the Transactions of the Royal Society of Edinburgh (vols. xvii.–xix.)

Mr Welsh expressed himself favourably with respect to the value of the observations, indicated the nature of the results which might best be obtained from them, and stated what was in his view the best method of publication.

The Committee thereupon employed Mr B. Stewart to perform, under their superintendence, the reduction of the observations, as far as the end of the year 1855, after which the series was considered to be incomplete.

In performing this task, Mr Stewart has been very much aided by the various members of the Committee; and he would desire also to record his acknowledgment of the valuable advice he received from Mr Welsh, who had a particular acquaintance with these observations, having been at one time himself associated with the previous observer, Mr Broun.

Mr A. Hogg, the observer at Makerstoun, has also very kindly afforded whatever information was necessary. Mr Stewart is also indebted to Mr Cram and to Mr A. H. Burgess for efficient help in the reduction of the Meteorological Observations; and also to Mr C. Chambers of Kew, who has assisted in a very zealous and able manner in deducing the general magnetical results.

Position and Description of the Observatory.

The position and arrangements of the Observatory are described in the Makerstoun Magnetical and Meteorological Observations for 1845 and 1846,* (Introduction, p. ix.)

System of Observation.

During the year 1847, five observations were made daily, viz., at 20^h, 23^h, 2^h, 5^h, 8^h, Göttingen mean time.

From January 1848 to February 1850, there were only two daily observations, viz., at 23^h and 5^h Göttingen mean time; and from February 1850 till the end of 1855, there were four daily observations, viz., at 20^h, 23^h, 2^h, and 5^h, Göttingen mean time.

From the beginning of the year 1851, meteorological observations made at 9 A.M., 9 P.M. (Greenwich time) have appeared regularly in the columns of the Kelso Mail newspaper.

The only advantage here taken of these observations has been in the case of the calculated daily means of atmospheric temperature, and the maximum force of wind.

Declinometer.

A detailed description of this instrument, and of the method of observing it, and also of reducing the scale readings to absolute declination, will be found in the Makerstoun Magnetical and Meteorological Observations for 1845 and 1846.*

In August 1857, the adjustment of the declinometer was examined by Mr Welsh. The following are the results :—

Arc-value of one division of the scale . .	= 0′·6722.
Zero point of the scale . . .	= 257·25 divisions.
Azimuth of the vertical wire of the reading telescope (A + Z)	= 25° 28′ 7″.

These quantities being almost identical with the values given in the Introduction to the Observations for 1845–46, no change has been made in the coefficients.

At the same time, Mr Welsh determined that the arc-value of the scale divisions remained unaltered whether the scale was observed from the position of the transit theodolite, or from that of the fixed reading telescope, showing that the divided glass scale was truly in the focus of the lens with which it forms the collimator.

It is found that the plane of detorsion of the suspending thread is apt to

* Transactions of the Royal Society of Edinburgh, vol. xix. Part I.

vary, so that the removal of torsion at any time does not guarantee that the needle shall always henceforth remain without it. The method adopted to prevent any considerable error arising from this source, is to eliminate the torsion at intervals, the declination needle being frequently compared with another, both before and after the elimination, in order to find the effect produced upon the reading of the former by eliminating the torsion. These comparisons will be found below among other notes regarding the declinometer.

No correction deduced from them has, however, been made upon the daily observations of the declinometer, since the amount of error on account of torsion is always exceedingly small.

NOTES REGARDING THE DECLINOMETER.

1847, May 12^d 5^h. Torsion circle turned from B $221\frac{3}{4}°$ to 236°. A comparison made between the declinometer and another magnet, before and after the elimination, gave the effect of torsion before change = + 1′·32.

May 22^d 6^h. Torsion circle turned from B 236° to $233\frac{1}{2}°$. A similar comparison gave the effect of torsion before change = − 0′·42.

Sept. 3^d 0^h. Torsion examined, circle turned from B $233\frac{1}{2}°$ to 242°. A comparison between the declinometer and another magnet, before and after the elimination, gave the effect of torsion = + 1′·66.

1848, Jan. 6^d 22^h. Torsion removed, circle turned from B 242° to 239°. A comparison as before seemed to show that the effect of torsion before the change was = + 0′·06. Assuming the true effect to have been = − 0′·25 (see Observations for 1845–6, page 298, note), there is left an irregularity = 0′·31.

From January 6th to January 18th, 1848, the needle in the vertical force magnetometer was sometimes in its place, and sometimes away; and on January 18th it was finally arranged in a plane parallel to the magnetic meridian, having previously been in a plane perpendicular to that meridian. Owing to this change of plane, the effect of the balance needle on the declination needle after January 18th, 1848, was different from what it had been previous to that date.

With regard to this effect, the *correction*, applicable to the declinometer scale readings on account of the balance magnet, while it was in a plane perpendicular to the magnetic meridian had been determined carefully (Sept. 4, 1843, and Jan. 25, 1844) to be = − 0·80 scale divisions (see Introduction, 1843, p. xvi.) . . . . After Jan. 18^d 5^h, this correction was + 0·60 scale divisions, as determined Jan. 24, 1848, so that the old tables being used into which the correction − 0·80 entered, a correction of + 1·40 scale divisions has been applied to the readings of the declinometer for every observation after Jan. 18^d 5^h. The observations between Jan. 6^d 22^h and Jan. 18^d 5^h have likewise been suitably corrected.

On Sept. 4^d 23^h, steps, containing iron, were placed near the declinometer, from which they were removed Oct. 4^d 2^h. It was found that the *effect* of the iron bands of the steps upon the instrument was $= -2{\cdot}9$ scale divisions. All the observations of declination between these dates have in consequence been corrected by $+ 2{\cdot}9$ scale divisions.

1849, July $10^d\ 5^h$. Torsion removed, circle reading changed from 341° to $343\frac{1}{2}$°. Comparisons made before and after seemed to show that no torsion had been taken out.

Sept. $25^d\ 2^h$. Torsion removed, circle turned from $343\frac{1}{2}$° to $327\frac{1}{2}$°.

Sept. 28^d. Thread wound up about half an inch, and allowed to hang with a brass bar until Oct. $0^d\ 22^h$ (another magnet being used in the interval), when the circle reading (left) was $281\frac{1}{2}$°. The height of the magnet above the marble slab was measured, and the mean of the upper and lower edges (mean of north and south ends) was found to be 2·175 inches. Comparisons made between the declinometer and another magnet before and after change, gave the effect of change $+ = 1'{\cdot}69$.

Oct. $28^d\ 23^h$. Torsion tried, circle not altered, torsion less than 2°.

1850, July $25^d\ 5^h$. Observed height of declination magnet above marble slab. Mean of upper and lower edges (mean of north and south ends) = 2·155 inch. In Oct. 0^d, 1849, it was 2·175 inch, so that the thread has only stretched 0·02 inch. Torsion circle, left reading B 307° ; previously 288°.

1854, Oct. 10^d. Torsion removed, circle turned from 307° to 262°.

BIFILAR OR HORIZONTAL FORCE MAGNETOMETER.

A detailed description of this instrument, of the method of observing it, and of reducing the observations, will be found in the Introduction 1845–46, p. xxv.

It is not the object of the instrument to furnish absolute values of the horizontal component of the earth's magnetic force, but merely to measure the variations of this element. To accomplish this, a magnet is forced into a position at right angles to the magnetic meridian, and is there kept in equilibrium, by two forces, viz., the horizontal component of the earth's magnetic intensity acting on the free magnetism of the bar, and the centre of gravity of the bar itself endeavouring to attain the lowest position (see Introduction 1845–46, Art. 29).

Let us suppose that the magnet has been forced into this position. Were the horizontal component of the earth's magnetism, and the free magnetism of the bar both invariable, the position of the magnet would remain unaltered.

But both of these being variable quantities, there are consequently two independent circumstances which may cause a change in the position of the magnet.

1°, An increase of temperature, which would diminish the magnetic power of the bar, or a diminution of temperature, which would increase it.

2°, Or a change may take place in the horizontal component of the earth's magnetic intensity.

As it is this latter change which we wish to measure, the effect of temperature on the bar must be eliminated by means of temperature corrections applied to the observations.

Our object will therefore be to ascertain—1°, The value of one scale division; and, 2°, The total temperature correction for 1° F.; both of these in parts of force, that is to say, assuming the whole horizontal component of the earth's magnetic force as equal to unity.

The following were the values of these coefficients at the beginning of 1847 :—

Value of one scale division in parts of force . $= k = 0{\cdot}000135$. (Intr. 1845–46, p. xxxi.);
Total Temperature correction for 1° F. in parts of force $= q = 0{\cdot}000266$. (Intr. 1845–46, p. xlvi.);

and consequently the temperature correction in scale divisions

$$= q' = \frac{q}{k} = 1{\cdot}975.$$

This state of things remained until a change was made in the plane of the vertical force magnetometer, in January 1848.

When the magnet of this instrument was in a plane perpendicular to the magnetic meridian before the change, its effect upon the bifilar was ascertained on July 30, 1841, to be $= -3{\cdot}15$ scale divisions $= -0{\cdot}000517$ in parts of force, and from observations, September 4, 1843, it was found $= -4{\cdot}03$ scale divisions $=$ $-0{\cdot}000524$ in parts of force; the mean of the two is $-0{\cdot}000520$. No correction on this account had been applied to the bifilar readings (Introd. 1843, p. xxxiv.).

The effect of the balance needle in its new position in the magnetic meridian was found on January 24, 1848, to be $= -1{\cdot}58$ scale divisions $= -0{\cdot}000213$ in parts of force. Consequently, in order to make the observations after January 18, 1848, comparable with those before that date, a correction of $-0{\cdot}000307$ parts of force $= -2{\cdot}3$ scale divisions, must be applied; and accordingly this has been done to all the observations after January 18, 1848, and before July 8, 1851. After July 8, 1851, the value of a scale division of the bifilar became less in the proportion of 23 to 25 nearly; consequently, the correction on account of the balance magnet, which was $= -2{\cdot}3$ scale divisions before that date, became $= -2{\cdot}5$ scale divisions after it. This amount has accordingly been deducted from all the observations of the bifilar after July 8, 1851.

On July 8, 1851, at $23^h\ 54^m$ Göttingen mean time, a change was made upon the bifilar magnetometer, the torsion circle being turned.

The readings of the torsion circle before being turned were, A 109° 31′, B 289° 33′. After being turned they were, A 107° 59′, B 288° 0′. The mean amount of turning was therefore 1° 32′·5.

Before the change

$$v = 69°\ 3'{\cdot}5 \quad . \quad \text{(Introduction, 1845–46, p. xxxii.)}$$

hence, after the change

$$v = 70°\ 36'.$$

Now,

$$k = 1·08 \times a \cot v, \quad . \quad . \quad . \quad \text{(Introduction, 1845–46, p. xxxi.)},$$
$$= 1·08 \times 0·00032675 \times \cot 70° 36' = 0·0001243,$$

which therefore represents the value of one scale division in parts of force after the change.

Hence, also,

$$q' = \frac{q}{k} = \frac{266}{124·3} = 2·14,$$

which therefore represents the temperature correction for 1° Fahr. in scale divisions after the change.

In order to make the reading 500 represent the same value of force after the change as before it, a process similar to that given (Introduction, 1845–46, p. xxxii.) must be adopted.

Thus we have reading before change corrected for temperature + 340 = 595·4.
Reading after change corrected for temperature + 340 = 516·9.

Hence

$$(595·4 - 500)\ 0·000135 = (516·9 - z)\ 0·0001243,$$

whence

$$z = 413·2,$$

the difference between which and 500 is 86·8. Adding 86·8 to 340·0, we obtain 426·8.

If, therefore, we use 426·8 after the change to replace 340 before it, the same zero, 500, will be applicable both before and after, and consequently the temperature tables after the change will be formed thus:—

Let N denote the observed reading,
t the temperature Fahr.,
n the reading corrected by means of the temperature tables;

then

$$n = N + 426·8 + (t - 26°)\ 2·14. \quad \text{(See Introduction, 1845–46, p. xxxiii.)}$$

Also the means f in parts of the whole horizontal force, given in the abstracts of results, are obtained after the change by the formula

$$f = (n - 500)\ 0·0001243,$$

the corresponding formula before the change being

$$f = (n - 500)\ 0·000135. \quad . \quad . \quad \text{(Introduction, 1845–46, p. xxxiii.)}$$

BALANCE OR VERTICAL FORCE MAGNETOMETER.

A detailed description of this instrument, and of the method of observing it, and reducing the observations, will be found in the Introduction, 1845–46, p. xxxiii.

The object of the instrument is to measure the variations of the vertical component of the earth's magnetic force. It consists of a magnetic needle balanced horizontally, having a knife-edged axle which rests upon agate planes, the tendency of the earth's magnetism to depress the one end being counterbalanced by an excess of weight tending to depress the other.

The variations of the vertical component of the earth's magnetic force will therefore cause changes in theposition of the magnet, and may be measured by these changes, as observed by a micrometer, the correction for temperature being applied.

The following were the values of the instrumental coefficients at the beginning of 1847 :—

Value of one scale division in parts of force $= k = 0\cdot0000100$ (Introduction, 1845–46, p. xlii.) ;
Temperature correction for 1° F. in parts of force $= q = 0\cdot000079$ (Introduction,1845–46, p. xlviii.) ;

and consequently the temperature correction in scale divisions

$$= q' = \frac{q}{k} = 7\cdot90.$$

On January 18, 1848, the balance magnet was changed from a plane perpendicular to the magnetic meridian into the plane of the meridian.

After this change the following observations were made on Jan. 25, 1848, to determine the value of k, the scale coefficient, by the method of deflections.

The deflections were made with Professor FORBES' bar placed N. and S. of the balance magnet, and the following are the results :—

Distance of Bar in Feet.	Deflection of Balance Magnet in adjustment in mic. divisions.	Deflection of Balance Magnet suspended horizontally.	Value of k from the formula $k = \frac{\tan u}{n \tan \text{dip}}$. (See Introduction, 1845–6, p. xli.)
	(n)	(u)	
1·9	409·1	88′ 21″	0·00002123
2·0	341·5	73′ 36″	·00002118
2·2	245·6	53′ 2″	·00002122
2·4	182·6	39′ 28″	·00002124
2·6	140·5	30′ 18″	·00002120
3·0	88·7	19′ 5″	·00002115

Mean value of $k = 0\cdot00002120$

hence $q' = \frac{q}{k} = \frac{\cdot0000790}{\cdot0000212} = 3\cdot72.$

1848, Aug. 28^d 5^h.—The vertical-force box was removed for 20 minutes.

„ Nov. 3^d 23^h.—The cover was placed on the balance magnet—off since the instrument was placed in the meridian.

1850, July 29.—Time of vibration for small arc = 7·36.

In August 1857 observations were made by Mr WELSH to determine the value of k, the scale coefficient of the balance magnet, by the method of deflections.

The deflections were made with a 3·65-inch magnet, in a manner precisely similar to that described in the Introduction, 1845–46, pp. xl. and xli. The following are the results :—

Distance of Bar in Feet.	Deflection of Balance Magnet in adjustment in mic. divisions.	Deflection of Balance Magnet suspended horizontally.	Value of k from the formula $k=\frac{\tan u}{n \tan \text{dip}}$. (See Introduction, 1845–46, p. xli.)
	(n)	(u)	
2·5	212·7	47′ 37″	0·0000226
3·0	116·7	26′ 16″	0·0000228

As the value of k, thus obtained, does not differ much from that obtained by Mr BROUN in 1848, the original value has been adopted in the reductions.

The tabular corrected readings of the balance needle, before its change of plane, are found thus :—

Let n denote the observed reading (generally negative),
t the temperature Fahr.,
R the reading corrected by means of the temperature tables;

then,

$$R = 124 + 7{\cdot}90\,(t - 26^\circ) + n. \quad . \quad . \qquad \text{(Introduction, 1845–46, p. xliii.)}$$

The quantity R being multiplied by the factor 0·00001, gives the variation in parts of force.

After the change of plane of the balance magnet, the above formula became

$$R = 96{\cdot}7 + 3{\cdot}72\,(t - 26^\circ) + n,$$

at least as far as may be inferred from the temperature tables then prepared and employed.

It would seem, however, that some change in the zero of the instrument took place at the time of its change of plane, which was not embodied in the temperature tables. This change appears, however, to have been recognised in the General Results, p. xlv., in a table which contains the monthly means of the vertical component of the magnetic force from 1842 to 1849, and consequently this table furnishes the means of estimating the change. It would seem that R, or the quantities found in the daily observations under the heading "Balance corrected," require, after the date of change, to be diminished by the quantity 118·0, before being multiplied by their appropriate factor 0·0000212, in order to give forces comparable with those obtained before the change. Hence, before the change—

$$f = R \times 0{\cdot}0000100. \quad . \quad . \quad . \quad . \qquad \text{(Results 1844, p. 373.)}$$

After the change,

$$f = (R - 118{\cdot}0) \times 0{\cdot}0000212.$$

It was thought that by this means the observations, after the change of plane, might be made comparable with those before; nevertheless, Mr WELSH advised that they should be treated as two distinct series.

The following are the monthly means of the observations of the balance magnetometer for the years 1850, 1851, 1852 :—

Month.	1850.	1851.	1852.
January	112·0	69·6	99·8
February	111·2	70·6	108·4
March	104·2	62·1	98·7
April	93·0	59·8	91·5
May	77·4	59·3	81·1
June	93·4	64·8	89·9
July	93·5	108·4	96·8
August	75·6	108·8	91·2
September . . .	79·3	123·3	90·9
October	77·4	115·9	88·3
November . . .	72·3	99·8	80·6
December . . .	69·3	100·2	70·4

It appears from the above table that a marked break in the continuity occurs between June and July 1851. It seems likely that some unrecorded alteration was made on the instrument about that date. (The bifilar was altered July 8, 1851.)

It seems advisable, therefore, to divide the whole body of vertical force observations now published into three distinct series. The first of these will extend from January 1, 1847, to January 18, 1848, the date of the change of plane; the second from January 18, 1848, to June 30, 1851; and the third from June 30, 1851, to December 31, 1855.

BAROMETER.

A detailed description of this instrument is given in the Introduction 1845–6, p. lii.

All the observations are corrected by – 0·012 inch to the mean of the Royal Society's flint and crown-glass barometers; they are also corrected for temperature to 32° Fahr. by Schumacher's Tables, given in the Report of the Committee of Physics of the Royal Society of London. The cistern of the barometer is 213 feet above the mean level of the sea at Berwick-upon-Tweed.

THERMOMETERS.

A description of these instruments will be found in the Introduction, 1845–46, p. liii. In page lv. of the same Introduction we have a table of corrections for the readings of the dry and wet bulb thermometers to the temperature by

Newman's standard. On June 20, 1853, Newman's standard was returned from the Kew Observatory with the following Table of corrections :—

Temperature. Fahr.	Corrections to be applied to the readings of Newman's Standard.	Temperature. Fahr.	Corrections to be applied to the readings of Newman's Standard.
°		°	
32	−0·05	60	−0·52
36	−0·10	63	−0·59
40	−0·15	67	−0·67
45	−0·16	70	−0·74
50	−0·27	76	−0·87
55	−0·40	79	−0·92

On August 11, 1857, the wet and dry bulb thermometers were compared with Newman's standard in the running stream of the Tweed, and the temperatures were as follows :—

Newman's Standard, 64°·3 ; dry bulb, 64°·75 ; wet bulb, 64°·35.

Taking everything into consideration, the following Table of corrections has been drawn out as applicable to the readings of the wet and dry bulb thermometers from 1847 to 1855 :—

TABLE of Corrections applicable to the Wet and Dry Bulb Thermometers.

Temperature.	Dry Bulb.	Wet Bulb.	Temperature.	Dry Bulb.	Wet Bulb.
0° F.	−0·5	−0·2	55° F.	−1·1	−0·8
7	−0·6	−0·3	60	−1·2	−0·9
13	−0·7	−0·4	67	−1·1	−0·8
19	−0·8	−0·5	70	−1·0	−0·6
25	−0·9	−0·6	76	−1·0	−0·7
32	−1·0	−0·7	79	−1·1	−0·7

RAIN GAUGE.

The Observatory rain gauge is placed in a space enclosed by a paling on the top of the Observatory hill, with a good exposure on all sides. The funnel-mouth is 6·1 inches in diameter, 8 inches above the soil, and 218 feet above the level of the sea. The quantity of rain is measured at noon by pouring it into a glass tube graduated with reference to the aperture of the funnel.

VANES AND ANEMOMETER.

A detailed description of these instruments will be found in the Introduction 1845–46, p. lviii.

The direction of the wind is indicated in this volume by the *number* of the point of the compass, reckoning N = 0, E = 8, S = 16, W = 24.

The anemometer is observed in the following manner: About 2^m before the observation hour the position of the index is observed, and the pressure shown is registered as the maximum pressure occurring since last observation hour; the index is then put back to zero, and from 7^m to 10^m afterwards the position to which it has again been carried is noted as the present pressure; the index is then set to zero, and a similar double reading made at the next observation hour.

The instrument registers the force of the wind in pounds on the square foot of surface (see Introduction 1845–46, p. lx.).

STATE OF THE SKY.

The extent of sky clouded is estimated; the whole sky covered with clouds being noted as 10, and the complete absence of clouds as zero.

NOTES REGARDING METEOROLOGICAL INSTRUMENTS.

1847, March 28.—New silk put on wet-bulb thermometer.

„ Oct. 29^d 23^h.—New silk put on wet bulb.

„ Dec. 10^d 3^h.—Iron bars put into grate.

„ Dec. 10^d 5^h.—Anemometer repaired.

1848, Nov. 22^d 23^h.—Cord of anemometer found broken at 22^h; a new one put on, but the instrument not adjusted.

1849, July 20^d 23^h.—New silk put on wet-bulb thermometer.

1850, Feb. 8^d 22^h.—Anemometer leaky, the water taken out, a new bottom put on, and a new piece of copper tube put to the under end; 9^d 8^h, placed and filled with water.

1850, Feb. 14^d.—New silk put on vane.

„ April 18^d 5^h.—The index of maximum thermometer is adhering to the mercury.

DESCRIPTION OF THE TABLES OF THE OBSERVATIONS.

Daily Observations of Magnetometers, 1847 *to* 1855 (*pp.* 1–47).

The headings contain the Göttingen mean solar time, astronomically reckoned, of the observations of the declination magnetometer. Göttingen time is 49^m 50^s in advance of Makerstoun time. The first column gives the civil day; the second column gives the absolute westerly declination in degrees, minutes, and decimals of a minute, deduced as already described.

The third column contains the observations of the bifilar magnetometer in scale divisions, corrected for temperature to 26° Fahr. The bifilar is observed 2^m after the declination magnetometer.

The fourth column gives the reading of the balance magnetometer in micrometer divisions, corrected for temperature to 26° Fahr. It is observed 3^m after the declination magnetometer.

During the year 1847, five daily observations of magnetometers were made, viz., at 8 A.M., 11 A.M., 2 P.M., 5 P.M., 8 P.M. Göttingen mean time; these observations extend from page 1 to page 7. As it would have occupied too much space to have given the temperatures of the bifilar and the balance magnetometer separately for each observation hour, the means of the temperatures of both for the hours 8 A.M. and 5 P.M. are given in the last two columns.

From January 1848 to February 1850, only two daily observations of magnetometers were made, viz., at 11 A.M., 5 P.M. Göttingen mean time; these observations extend from page 8 to page 14.

Here the means of the temperatures of the two magnetometers are given for both the observation hours.

From February 1850 to December 1855, there were four daily observations of magnetometers, viz., at 8 A.M., 11 A.M., 2 P.M., and 5 P.M. Göttingen mean time; these extend from page 14 to page 47. Here the mean temperatures of the two magnetometers for all the observation hours are given in the last four columns.

Daily Meteorological Observations, 1847 *to* 1855 (*pp.* 49–101).

The first column contains the civil day; the second gives the calculated daily means of atmospheric temperature which have been obtained in the following manner:—During the years 1844, 1845, hourly observations of temperature were made, and during the years 1843 and 1846 nine observations were made daily. On the basis of these four years' observations, the following Table (similar in principle to Table 75, p. lxxxvi. General Results of the Makerstoun Observations) has been constructed, showing for each month the correction that requires to be applied to an observation made at any hour of the day in order to obtain the mean temperature of the day.

TABLE of Corrections to be applied to Observations of the Temperature of the Air at any Hour, in order to get the Mean of the Day.

Mak. M. T.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
0	−2·4	−3·2	−4·9	−5·9	−5·0	−5·7	−5·2	−6·1	−6·4	−4·7	−3·1	−2·2
1	−3·1	−3·9	−5·3	−6·5	−5·6	−6·4	−5·3	−6·5	−7·3	−5·0	−3·5	−2·5
2	−3·0	−4·0	−5·4	−6·7	−5·6	−6·0	−5·2	−6·8	−7·5	−5·0	−3·3	−2·2
3	−2·2	−3·2	−5·2	−6·5	−5·6	−5·4	−5·1	−6·5	−7·0	−4·3	−2·3	−1·5
4	−1·3	−2·6	−4·1	−5·6	−4·9	−4·8	−4·5	−5·9	−5·8	−2·8	−1·0	−0·4
5	−0·5	−0·9	−2·8	−4·1	−3·8	−4·3	−3·5	−4·4	−4·1	−1·1	−0·0	−0·1
6	+0·1	−0·1	−0·8	−2·5	−1·8	−2·7	−2·4	−2·7	−1·8	−0·0	+0·4	+0·4
7	+0·3	+0·3	+0·3	−0·2	−0·6	−1·3	−0·7	−0·6	−0·0	+0·7	+0·5	+0·4
8	+0·5	+0·7	+1·1	+1·0	+1·6	+0·7	+1·1	+1·1	+1·0	+1·2	+0·7	+0·5
9	+0·5	+1·0	+1·6	+2·3	+2·3	+2·5	+2·2	+2·3	+2·3	+1·8	+0·8	+0·7
10	+0·4	+1·2	+2·1	+3·4	+3·0	+3·7	+3·3	+3·5	+3·1	+1·9	+1·0	+0·8
11	+0·3	+1·5	+2·4	+4·1	+3·8	+4·6	+3·7	+4·2	+3·6	+1·9	+0·9	+0·9
12	+1·2	+1·7	+2·8	+4·5	+4·3	+5·3	+4·5	+4·5	+4·6	+2·2	+1·0	+0·7
13	+1·4	+1·8	+3·1	+5·0	+4·4	+5·7	+5·1	+5·1	+5·1	+2·2	+1·0	+0·5
14	+1·4	+2·1	+3·1	+5·3	+5·1	+6·0	+5·3	+5·5	+5·4	+2·5	+1·3	+0·5
15	+1·4	+2·1	+3·3	+5·4	+5·6	+6·3	+5·7	+5·9	+5·7	+2·6	+1·3	+0·7
16	+1·1	+2·0	+3·7	+5·8	+5·5	+5·8	+5·4	+6·0	+6·0	+2·7	+1·5	+1·0
17	+1·3	+1·7	+4·0	+5·5	+4·5	+4·9	+4·3	+5·8	+6·0	+3·2	+1·4	+1·1
18	+1·2	+1·8	+3·9	+4·2	+2·8	+2·9	+2·4	+4·3	+5·4	+2·9	+1·5	+1·2
19	+1·2	+2·0	+3·0	+2·3	+1·0	+1·1	+0·6	+2·3	+3·2	+2·8	+1·5	+1·0
20	+1·2	+1·7	+1·2	+0·2	−0·7	−1·0	−1·2	+0·0	+0·4	+1·2	+1·5	+0·7
21	+0·7	+0·2	−0·7	−2·1	−2·3	−2·7	−2·4	−2·1	−1·9	−0·7	+0·2	+0·1
22	−0·1	−1·5	−2·5	−4·0	−3·4	−3·9	−3·5	−3·9	−4·3	−2·4	−1·1	−0·8
23	−1·6	−2·5	−4·0	−5·0	−4·6	−5·2	−4·5	−5·1	−5·8	−3·9	−2·2	−1·6

From this Table it is easy to find what correction ought to be applied to the mean temperature of the observation hours in order to obtain the mean of the day.

During the year 1847 there were five observation hours, viz :—20^h, 23^h, 2^h, 5^h, 8^h, Göttingen mean time, or approximately 7 A.M., 10 A.M., 1 P.M., 4 P.M., 7 P.M., Makerstoun mean time. And consequently the following corrections require to be applied to the mean of these observations in order to find the mean temperature of the day :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−0·6	−1·1	−1·7	−2·8	−2·7	−3·1	−2·7	−2·9	−2·8	−1·3	−0·7	−0·5

During the years 1848 and 1849, and January 1850, there were only two hours, viz. 23^h, 5^h, Göttingen mean time, corresponding nearly to 10 A.M. and 4 P.M. Makerstoun mean time, and here the following corrections require to be applied :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−0·7	−2·0	−3·3	−4·8	−4.1	−4·3	−4·0	−4·9	−5·0	−2·6	−1·0	−0·6

From February 1850 till the end of the same year there were four observation hours, at 7 A.M., 10 A.M., 1 P.M., 4 P.M. Makerstoun mean time approximately, and the following are the corrections applicable :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−0·8	−1·5	−2·2	−3·4	−3·2	−3·5	−3·2	−3·5	−3·5	−1·8	−1·0	−0·7

During the years 1851 to 1855, making use of the observations sent to the "Kelso Mail," there are in all six hours, viz., 7 A.M., 9 A.M., 10 A.M., 1 P.M., 4 P.M., 9 P.M., Makerstoun mean time, and the following corrections require to be applied to the mean of these observations :—

Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
−0·3	−0·8	−1·3	−2·3	−2.1	−2·4	−2·1	−2·3	−2·3	−1·0	−0·5	−0·3

The third column contains the calculated daily means of sky clouded, being merely the means of the daily observations, of which (as already mentioned) there were five during 1847, two during 1848 and 1849 and January 1850, and four from February 1850 till the end of 1855. The observations communicated to the "Kelso Mail" were not made use of.

In the 4th, 5th, 6th, and 7th columns, we have the height of the barometer, the temperature of the air, the temperature of evaporation, and the relative humidity for 11 A.M. Göttingen mean time, and in the next four columns we have the same elements for 5 P.M. Göttingen mean time. These columns are continued throughout the whole series of observations. The only remark it is necessary to make regarding these is the following one. The relative humidity was calculated according to APJOHN's formula, viz. :—

$$f''=f'-\frac{d}{87}\times\frac{h}{30}\text{ for temperature of evaporation above 32° Fahr.}$$

And

$$f''=f'-\frac{d}{96}\times\frac{h}{30}\text{ for do. below 32° ,,}$$

where f'' is the elasticity of vapour required to be found, f' the elasticity corresponding to the temperature of the wet thermometer, d the difference between the dry and wet thermometers, and h the height of the barometer. The labour of calculation was abridged by using a sliding-rule adapted to APJOHN's formula invented by the late Mr WELSH.

The 12th and 13th columns contain the readings of the maximum and minimum thermometers on RUTHERFORD's principle. These observations are discontinued after August 1850. Occasionally it will be found that the reading of the minimum thermometer is higher than the calculated daily mean temperature, an instance of which occurs on December 18, 1847. There are two circumstances which may lead to this result.

1°. The calculated daily mean temperature, although on the average of a number of days coming very near the truth, may yet not represent accurately the average temperature of some one particular day.

2°. The minimum thermometer is noted and reset about 10^h A.M., the maximum thermometer about 5^h P.M. Now, although it is probable that the coldest portion of a civil day will have occurred between 12 o'clock of the previous evening and 10 A.M., when the minimum thermometer is read, yet it may not be so, for the weather may grow suddenly colder after 10 A.M., and the mean of the day, as calculated from the temperature observations, may even prove lower than the reading of the minimum thermometer.

The anemometer being an instrument which, by means of an index, registers the greatest force of the wind between two consecutive observation hours, we are thus enabled to find the maximum force of wind for the day, which is given in the 15th column. Here, as the instrument is reset every observation hour, it was necessary to examine the observations contained in the "Kelso Mail" for the years 1851–55.

The mean force of wind noted in the next column is the mean of the present pressures of the wind at the different observation hours, these hours being the same as those for which the direction of the wind is noted in the last column.

General Results of the Magnetical Observations.

Magnetic Declination.

The following Table contains the corrections that have been applied to the means of the observed readings of the declinometer, in order to get the mean of the day. (These corrections have been deduced from hourly observations made during 1844 and 1845):—

Table 1.—Correction for Mean of Observation Hours.

Month.	20^h, 23^h, 2^h, 5^h, 8^h, G. M. T.	23^h, 5^h, G. M. T.	20^h, 23^h, 2^h, 5^h, G. M. T.
January,	−1′·08	−1′·55	−1′·62
February,	−0·96	−1·33	−1·55
March,	−1·35	−1·49	−2 01
April,	−1·26	−1·84	−1·92
May,	−1·14	−2·01	−1·44
June,	−1·07	−1·81	−1·29
July,	−1·10	−1·86	−1·42
August,	−1·41	−2·10	−2·03
September,	−1·24	−1·83	−2·13
October,	−1·39	−1·48	−1·95
November,	−1·01	−1·65	−1·87
December,	−0·83	−0·81	−1·26

If the corrections recorded in the preceding Table be applied to the observations, we obtain the monthly means as follows :—

TABLE 2.—Monthly and Yearly Means of Declination.

Month.	1847. 24°+	1848. 24°+	1849. 24°+	1850. 24°+	1851. 24°+	1852. 24°+	1853. 24°+	1854. 24°+	1855. 24°+
January, .	62′·69	55′·88	47′·90	42′·09	34′·31	27′·10	21′·12	15′·35	8′·60
February, .	62·54	54·67	47·66	42·41	33·65	27·85	20·95	15·32	8·29
March, . .	62·60	54·66	47·35	41·88	33·41	27·16	20·50	14·22	8·25
April, . .	62·07	53·58	46·30	40·41	32·18	27·61	19·92	...	8·41
May, . . .	60·60	53·16	46·20	40·45	32·29	26·51	18·99	...	6·04
June, . .	59·69	51·43	45·85	40·10	32·35	25·53	20·25	...	6·09
July, . . .	59·52	51·44	44·13	39·15	31·26	24·93	19·93	...	4·54
August, . .	59·11	50·56	43·72	37·33	30·21	23·49	16·96	...	...
September, .	57·20	49·10	42·75	37·02	30·56	23·92	17·19	10·10	...
October, . .	56·62	49·33	43·33	36·47	29·24	23·58	16·02	8·00	2·18
November, .	56·79	48·83	43·65	34·88	28·21	22·73	15·77	...	1·33
December, .	55·90	49·22	43·73	35·35	28·37	22·00	16·72	8·45	1·53
Mean Declination,	59·61	51·82	45·21	38·96	31·34	25·20	18·69	[11·82]	[5·25]

If we examine the change of the declination from year to year, we shall find that this increases from 1841 to 1855.

The secular change is not therefore strictly constant.

Let us suppose that it may be represented by the following formula :—

$$\text{Yearly secular change} = x + ny$$

Where x denotes the most probable secular change between 1841 and 1842, and y its yearly increase, so that $x+y$ denotes the change between 1842 and 1843; $x+2y$ that between 1843 and 1844, and so on.

Also let d denote the most probable value of the declination for 1841, then we have, by well-known methods,

$$d = 25^\circ\ 33'{\cdot}78$$
$$x = \quad -5'{\cdot}525$$
$$y = \quad -0'{\cdot}133$$

In the following Table the observed declinations are compared with those calculated according to this formula, and the differences are exhibited :—

TABLE 3.—Observed and Calculated Declinations compared together.

Year.	Declination.		Observed Minus Calculated.*
	Observed.	Calculated.	
	° ′	° ′	′
1841	25 33·68	25 33·78	−0·10
1842	25 28·45	25 28·25	+0·20
1843	25 22·85	25 22·60	+0·25
1844	25 17·06	25 16·80	+0·26
1845	25 11·32	25 10·88	+0·44
1846	25 05·97	25 04·82	+1·15
1847	24 59·61	24 58·63	+0·98
1848	24 51·82	24 52·30	−0·48
1849	24 45·21	24 45·84	−0·63
1850	24 38·96	24 39·25	−0·29
1851	24 31·34	24 32·53	−1·19
1852	24 25·20	24 25·67	−0·47
1853	24 18·69	24 18·68	+0·06
1854	24 11·82	24 11·55	+0·27
1855	24 05·25	24 04·29	+0·96

* Mr Chambers, to whom I am indebted for the calculation of the most probable values of declination given above, has remarked that the residual differences of the last column exhibit some indications of a period in their value.

Having thus obtained the most probable value of the secular change for any year, we may find the annual variation of the declination for a given hour of the day in the following manner :—

From one year's monthly means of declination for that hour eliminate the secular change.

Having thus obtained monthly means for a given hour for that year free from secular change, the annual variation of declination for that hour and year is easily found. If there are several years during which observations at that hour were taken, we may then, in the usual manner, obtain the mean annual variation for these years of declination at the given hour.

The following Table exhibits the annual variation of the declination for the different hours :—

TABLE 4.—Declination—Annual Variation for the Different Hours.

Gött. M. T.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
h.	′	′	′	′	′	′	′	′	′	′	′	′
0	−1·03	−0·61	−0·53	−0·39	−0·12	+0·30	+0·18	+1·51	+2·27	+1·16	−0·87	−1·86
1	−1·98	−1·63	+0·13	+0·92	−0·04	−0·07	+0·23	+2·18	+2·30	+1·00	−0·78	−2·25
2	−2·16	−1·32	+0·93	+1·91	+0·31	+0·95	+1·04	+1·83	+0·75	+0·10	−1·76	−2·58
3	−2·03	−1·31	+0·18	+1·33	+0·35	+0·76	+0·58	+2·18	+1·16	+0·42	−1·26	−2·34
4	−1·32	−1·30	+0·33	+1·18	+0·46	+1·68	+1·42	+1·05	+0·06	+0·25	−1·59	−2·26
5	−0·51	+0·07	+0·47	+1·12	+0·69	+1·53	+1·16	−0·08	−1·18	−0·81	−1·23	−1·21
6	−0·01	−0·24	−1·00	−0·24	+0·22	+1·11	+1·65	+0·25	−0·42	−0·20	−0·38	−0·74
7	+0·40	−0·24	−1·22	−0·54	+0·55	+0·82	+1·52	−0·21	−0·55	+0·16	−0·59	−0·10
8	+0·62	−0·33	+0·08	−0·95	+0·41	+1·44	+1·22	+0·35	−1·24	−0·09	−0·93	−0·60
9	+0·48	−0·41	−0·45	−0·40	+0·27	+1·26	+1·17	+1·14	−0·44	−0·48	−1·28	−0·81
10	+0·17	−0·64	−0·51	−0·37	+0·47	+1·91	+0·97	+0·61	−0·43	−0·29	−1·24	−0·62
11	+0·34	−0·56	−0·37	−0·22	+0·39	+0·92	+0·82	+0·33	+0·72	−0·77	−1·19	−0·37
12	+0·16	+0·43	−0·70	−0·50	−0·21	+0·64	+0·58	+0·88	+0·77	−0·84	−0·72	−0·48
13	+0·77	−0·16	−0·80	−0·12	−1·12	+0·37	+0·16	+0·20	+0·93	−0·15	−0·16	+0·07
14	+0·80	+0·80	−0·38	−1·03	−0·93	+0·01	−0·38	+0·13	+0·44	+0·05	+0·42	+0·04
15	+0·47	+0·66	+0·21	−2·07	−0·62	−0·74	−0·99	+0·37	+0·34	+0·19	+1·45	+0·69
16	+0·71	+0·80	−0·84	−1·52	−0·71	−1·35	−0·37	0·00	−0·44	+1·34	+1·20	+1·18
17	+1·36	+0·64	−0·50	−0·42	−1·08	−2·41	−1·06	−0·95	+0·09	+1·76	+1·03	+1·56
18	+1·52	+0·78	+0·06	−0·88	−1·67	−2·10	−1·39	−0·65	+0·40	+1·81	+0·97	+1·17
19	+2·64	+1·20	+0·39	−1·30	−2·78	−3·86	−2·15	−1·17	+1·22	+2·48	+1·58	+1·73
20	+2·10	+1·36	+0·17	−1·45	−2·15	−2·47	−1·69	−1·44	+0·69	+1·30	+1·57	+2·02
21	+2·48	+1·41	−0·21	−2·65	−2·17	−2·91	−1·59	0·00	+1·61	+0·81	+1·87	+1·34
22	+1·32	+0·99	−0·94	−1·72	−1·47	−1·19	−0·78	+0·36	+1·74	+0·90	+0·47	+0·33
23	+0·09	−0·08	−0·06	−0·67	−0·12	−0·61	−0·56	+0·47	+1·35	+0·27	+0·20	−0·21

In the above Table the variations for some hours represent the means of a greater number of years than those for other hours. The following Table exhibits the years that were made use of, in order to obtain each hour's variation as represented above. Only complete years' observations were used.

TABLE 5.

Hour. G.M.T.	Years Employed.										
0	1843	1844	1845	1846	......	......	......	......	......	......	......
1	......	1844	1845	1846	......	......	......	......	......	......	......
2	1843	1844	1845	1846	1847	......	......	......	1851	1852	1853
3	......	1844	1845	......	......	......	......	......	......	......	......
4	1843	1844	1845	1846	......	......	......	......	......	......	......
5	......	1844	1845	......	1847	1848	1849	1850	1851	1852	1853
6	1843	1844	1845	1846	......	......	......	......	......	......	......
7	......	1844	1845	1846	......	......	......	......	......	......	......
8	1843	1844	1845	1846	1847	......	......	......	......	......	......
9	......	1844	1845	......	......	......	......	......	......	......	......
10	1843	1844	1845	1846	......	......	......	......	......	......	......
11	......	1844	1845	......	......	......	......	......	......	......	......
12	......	1844	1845	......	......	......	......	......	......	......	......
13	......	1844	1845	......	......	......	......	......	......	......	......
14	......	1844	1845	......	......	......	......	......	......	......	......
15	......	1844	1845	......	......	......	......	......	......	......	......
16	......	1844	1845	......	......	......	......	......	......	......	......
17	......	1844	1845	......	......	......	......	......	......	......	......
18	1843	1844	1845	1846	......	......	......	......	......	......	......
19	......	1844	1845	......	......	......	......	......	......	......	......
20	1843	1844	1845	1846	1747	......	......	......	1851	1852	1853
21	......	1844	1845	......	......	......	......	......	......	......	......
22	1843	1844	1845	1846	......	......	......	......	......	......	......
23	......	1844	1845	1846	1847	1848	1849	1850	1851	1852	1853

From this it will be seen that some of the horizontal lines in Table 4 represent the average result of a greater number of years than others. This will undoubtedly diminish to some extent the value of the Table, and prevent the annual variations for the different hours from being so comparable with one another as they would otherwise have been. It is believed, however, that the Table is not without interest.

The following Table represents the annual range for the different hours as deduced from Table 4 :—

TABLE 6.—Declination—Annual Range for the Different Hours.

Hour G. M. T.	0	1	2	3	4	5	6	7	8	9	10	11
Range,	4′·13	4′·55	4′·49	4′·52	3·94	2′·76	2′·65	2′·74	2′·68	2·54	3′·15	2′·11
Hour G. M. T.	12	13	14	15	16	17	18	19	20	21	22	23
Range,	1′·72	1′·89	1′·83	3·52	2′·86	4′·17	3′·91	6′·50	4′·57	5′·39	3′·46	2′·02

On examining Table 6 it is perceived that the ranges of variation for the hours of the day are greater than those for the hours of the night, the ranges for the hours about midnight being especially small. A similar fact has been noticed by General Sabine, for Toronto, Hobarton, the Cape of Good Hope, and St Helena. (See Transactions Royal Society of London, Part II. for 1851.)

Another fact, noticed also by General Sabine for these four stations, has its analogue at Makerstoun.

It will be seen that the months June and July go together, being affected with a minus sign—that is to say, having a less than mean westerly declination, or being east of the mean position from about 14^h to about 23^h G. M. T., or from 1 A.M. to 10 A.M., Makerstoun mean time; while they are affected with a positive sign, or are west of the mean position, during the remaining hours.

Precisely the reverse happens with November and December, which are affected with a positive sign, or are to the west of the mean position from about 1 A.M. to 10 A.M., Makerstoun mean time; while during the remainder of the day they are to the east of the mean, being affected with a negative sign.

HORIZONTAL FORCE.

The following Table contains the corrections that have been applied to the means of the observed readings of the horizontal force magnetometer in order to obtain the mean of the day. These corrections have been deduced from hourly observations made during 1844 and 1845.

TABLE 7.—Horizontal Force—Correction for Mean of Observation Hours in Scale Divisions.

Month.	20h, 23h, 2h, 5h, 8h, G. M. T.	23h, 5h, G. M. T.	20h, 23h, 2h, 5h, G. M. T.	
			Before July 8, 1851.	After July 8, 1851.
January, . . .	−0·68	+0·06	−1·01	−1·10
February, . . .	−0·36	+0·77	−0·05	−0·06
March, . . .	−0·46	+1·82	+0·99	+1·07
April, . . .	+0·57	+3·09	+3·01	+3·27
May, ...	−0·10	+1·40	+2·90	+3·15
June, ...	+0·72	+3·19	+3·53	+3·84
July, ...	+0·65	+3·21	+3·61	+3·92
August, . . .	+0·61	+3·06	+3·30	+3·58
September, . .	+1·39	+4·19	+3·45	+3·75
October, . . .	+0·89	+3·84	+1·98	+2·15
November, . .	+0·53	+2·73	+0·77	+0·84
December, . .	−0·47	+0·75	−0·05	−0·06

If the corrections recorded in this Table be applied to the observations, we obtain the monthly means as follows :—

TABLE 8.—Horizontal Force—Monthly Means in Scale Readings.

Month.	1847	1848	1849	1850	1851	1852	1853	1854	1855
January, .	558·69	557·74	568·61	584·75	593·23	610·54	626·35	638·21	652.35
February, .	556·10	556·59	571·19	584·63	593·77	612·04	626·11	637·95	651·01
March, . .	557·82	559·88	571·36	582·46	597·93	610·26	625·50	640·12	640·77
April, . .	557·26	562·23	574·56	587·58	601·95	615·57	629·26	......	651·10
May, . . .	557·44	567·03	580·20	589·45	600·52	618·03	631·73	......	651·50
June, . .	562·63	568·98	586·84	591·21	603·63	620·99	631·86	......	653·02
July, . .	560·34	568·88	584·10	590·13	*610·56	619·64	632·55	......	649·29
August, . .	559·37	567·49	580·87	589·22	607·90	619·31	634·20	......	......
September, .	558·19	564·29	578·85	588·27	600·13	618·56	630·90	647·32	......
October, .	551·71	568·35	578·04	588·46	602·40	618·41	635·56	659·05	653·29
November, .	556·17	566·85	581·23	592·88	611·17	620·53	637·42	......	657·04
December, .	563·65	566·72	584·78	595·63	611·78	623·68	638·77	628·41	662·06

* After June 1851 the new value of the scale reading commences (see Introduction, page xiv.)

If we obtain the mean scale reading for each year by taking the mean of the months in the above Table, and if we then reduce these yearly means to parts of force and compare consecutive years together, we shall obtain values for the apparent secular change of horizontal force—apparent only, because the lengthening of the thread and loss of magnetism of the magnet will cause gradual change in the readings, which cannot be separated from that due to secular increase of horizontal force alone.

The following Table exhibits the values of apparent secular change thus obtained, making use of the whole series of years:—

TABLE 9.—Apparent Secular Increase of Horizontal Force.

Difference between the mean of			Parts of Force.
1842	and	1843	·003470
1843		1844	·003885
1844		1845	·001435
1845		1846	·001285
1846		1847	·001243
1847		1848	·000852
1848		1849	·001863
1849		1850	·001394
1850		1851	·001335
1851		1852	·001268
1852		1853	·001787
1853		1854	·001339
1854		1855	·001136

The first two values in the above Table are probably erroneous, and the mean of the other eleven gives ·001358, which we may consider to represent the apparent mean yearly increase of horizontal force. While, however, this amount only approximately represents the secular change of horizontal force, it represents actually the mean secular change that takes place year by year upon the readings of the bifilar from a combination of causes, and which must be eliminated from these readings in order that we may obtain the annual variation. This has accordingly been done, and the annual variation of horizontal force so obtained is exhibited in the following Table:—

TABLE 10.—Horizontal Force—Annual Variation for the Different Hours in Parts of Force.

Gött. M. T.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
0	+084	+067	−022	−091	−038	+002	−012	−041	−062	−031	+040	+105
1	+042	+039	−030	−078	−022	+029	+011	−023	−033	−039	+036	+067
2	+016	+012	−017	−021	+003	+039	+014	+015	−007	−051	−016	+013
3	−023	−016	−028	−043	−002	+067	+056	+034	−016	−030	−003	+006
4	−057	−037	−011	−014	+037	+058	+086	+036	−008	−037	−038	−015
5	−070	−053	−025	+040	+099	+094	+086	+033	−024	−060	−077	−044
6	−087	−089	−048	+023	+107	+082	+114	+071	−018	−076	−040	−041
7	−100	−089	−061	+033	+097	+098	+126	+061	−039	−074	−038	−015
8	−080	−068	−014	+013	+098	+111	+104	+061	−043	−092	−066	−024
9	−077	−057	−039	−007	+063	+098	+096	+052	−019	−032	−040	−038
10	−040	−032	−016	−002	+035	+080	+074	+021	−041	−028	−033	−019
11	−067	−065	−057	+010	+032	+086	+061	+047	+006	−011	−021	−023
12	−059	−050	−022	−011	+019	+062	+062	+029	+014	−017	−019	−009
13	−056	−023	−030	−042	+006	+066	+060	+034	−008	−005	+005	−006
14	−051	−029	−078	−033	+006	+058	+053	+017	+012	+008	+021	+016
15	−074	−024	−071	−078	+009	+065	+058	+022	−001	+021	+038	+035
16	−027	−036	−049	−056	−016	+042	+033	+009	−001	+031	+041	+028
17	−009	−028	−055	−055	−031	+029	+014	+008	−003	+029	+051	+051
18	+033	+011	−018	−012	−038	−024	−025	−048	−023	+015	+054	+075
19	+018	+006	−016	−045	−040	−016	−014	−039	−026	+012	+076	+084
20	+093	+050	+033	−011	−051	−033	−049	−078	−097	−012	+064	+092
21	+075	+069	−022	−079	−065	−024	−025	−089	−061	+002	+094	+127
22	+121	+093	+002	−072	−053	−039	−045	−105	−097	−025	+068	+153
23	+105	+060	−017	−054	−027	−005	−039	−046	−103	−050	+052	+122

The years that were made use of in order to obtain each hour's variation, as represented in Table 10, are those exhibited in Table 5, with the exception of the year 1843, which it was thought advisable to leave out.

The following Table exhibits the annual range for the different hours as deduced from Table 10:—

TABLE 11.—Horizontal Force—Annual Range for the Different Hours in Parts of Force.

Hour G. M. T.	0	1	2	3	4	5	6	7	8	9	10	11
	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Range,	196	145	090	110	143	176	203	226	203	175	121	153
Hour G. M. T.	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00	·00
Range,	121	122	136	145	098	106	123	129	190	216	258	225

From this Table we deduce a conclusion similar to that derived from Table 6, viz., that for horizontal force, as well as for declination, the ranges of the annual variation are greater for the hours of the day than for the hours of the night. We may also derive results from Table 10 similar to those derived from Table 5. It will be observed from the former Table that the months June, July, and August comport themselves in the same manner. From between 17^h and 18^h, to about 0^h Göttingen mean time, viz., from between 4 A.M. and 5 A.M. to about 11 A.M. Makerstoun mean time, they are affected with a negative sign, or have a less than average horizontal force, while for the remaining hours they are affected with a positive sign, or have a greater than average horizontal force. Nearly the opposite happens with the two months November and December. From about 13^h to 1^h Göttingen mean time, viz., from about midnight to noon Makerstoun mean time, they are affected with a positive sign, or have a greater than average horizontal force; while during the remainder of the day they are affected with a negative sign, and have a less than average horizontal force. If from Table 10 we deduce the annual variation for the mean of the day, that is to say for the mean of all the hours, we shall obtain a result similar to that deduced by Mr BROUN from part of the series of years used in Table 10, viz., that the horizontal force is a maximum at the solstices and a minimum at the equinoxes.

DAILY OBSERVATIONS

OF

MAGNETOMETERS.

MAKERSTOUN OBSERVATORY,

1847–1855.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Jan. 1	61·78	563·9	237·2	62·69	560·0	240·5	65·11	563·9	238·1	......	......	......	62·23	564·3	259·0	42·1	......
2	60·98	563·3	252·2	65·38	558·5	260·8	69·02	557·6	276·7	......	......	......	61·72	560·8	283·1	41·1	......
4	62·35	565·3	270·5	......	......	......	65·62	557·9	286·7	......	......	......	62·42	561·5	296·0	35·4	......
5	66·50	567·9	252·4	......	......	......	66·53	553·1	279·3	......	......	......	63·11	562·6	274·9	37·9	......
6	62·55	561·4	261·2	63·57	558·4	257·1	67·60	557·1	258·3	62·94	556·2	283·4	61·79	561·0	263·1	41·3	42·9
7	62·28	560·1	246·5	62·62	554·7	252·2	65·99	554·8	254·0	63·04	560·2	258·8	59·07	559·7	266·4	43·3	43·0
8	62·28	564·0	248·2	63·14	557·5	253·0	65·85	555·8	252·6	64·05	558·8	259·0	61·25	559·8	259·3	42·4	42·4
9	60·60	572·7	236·0	63·97	555·1	259·7	64·71	560·4	253·9	64·98	563·5	268·1	64·89	558·9	284·4	39·8	38·2
11	61·70	557·5	278·2	64·35	558·5	282·3	65·82	556·7	284·6	65·90	555·6	306·3	62·99	558·4	297·0	30·5	30·0
12	61·01	558·1	281·8	62·75	555·7	271·1	71·66	552·9	277·9	66·56	557·7	285·0	62·35	538·8	281·0	25·6	24·9
13	62·86	557·7	278·2	65·15	556·2	273·0	67·64	559·5	271·6	62·35	560·7	284·1	59·29	559·1	285·7	24·1	26·9
14	63·94	552·0	274·0	64·48	558·9	276·2	64·64	558·0	277·1	61·81	560·1	283·4	62·62	567·5	272·7	26·9	29·7
15	61·76	562·4	242·0	61·98	557·2	255·0	64·81	561·7	247·5	63·57	560·3	230·0	62·19	561·7	230·2	33·5	37·0
16	61·36	562·6	233·1	62·82	554·1	243·9	66·73	557·2	251·1	64·31	561·5	244·9	63·23	560·6	242·7	35·5	36·2
18	61·75	561·1	244·4	62·86	559·1	249·4	64·08	559·8	254·3	62·99	561·6	249·8	62·48	562·2	245·7	33·2	33·8
19	61·68	561·7	239·9	62·86	557·1	236·5	63·57	560·4	248·2	63·52	562·1	247·4	63·09	561·6	242·7	33·7	34·0
20	61·51	570·1	231·7	64·10	561·2	229·6	68·29	564·8	249·9	63·63	560·7	262·3	62·12	560·3	258·9	33·5	33·3
21	63·65	566·5	233·0	65·55	549·4	235·9	65·58	560·1	250·6	63·63	556·8	298·0	61·88	550·3	271·8	32·2	32·9
22	62·77	559·1	248·3	65·82	552·6	251·2	69·19	554·5	254·1	62·96	562·2	258·3	62·20	558·0	251·5	32·8	34·0
23	62·67	559·2	235·4	65·38	556·7	241·3	64·84	560·2	246·5	63·09	560·0	243·5	62·35	561·9	244·9	34·8	35·4
25	62·10	561·0	228·2	65·05	556·2	237·0	63·02	560.8	239·9	63·16	559·7	230·5	61·75	563·8	227·8	37·7	38·6
26	61·52	562·1	217·7	63·09	557·9	219·4	64·59	561·3	198·1	63·37	561·8	209·6	62·35	564·1	219·4	39·4	42·5
27	62·01	559·6	224·8	63·77	562·3	229·0	64·98	561·8	222·0	63·32	557·6	227·8	62·19	563·2	229·7	40·6	42·1
28	61·14	559·6	228·5	61·98	561·2	228·5	64·05	557·4	228·5	64·10	558·8	235·9	62·28	564·0	232·0	40·5	40·4
29	63·99	558·0	226·6	65·08	558·0	226·1	72·40	560·3	255·1	69·77	558·4	282·8	77·19	560·1	318·8	38·5	39·5
30	62·93	553·1	251·7	63·70	555·5	249·4	66·32	554·0	255·6	55·87	567·8	298·8	66·06	542·9	492·7	38·9	39·2
Feb. 1	65·11	548·6	277·0	68·45	542·7	303·2	65·80	548·7	290·5	62·82	556·8	304·7	62·12	555·6	272·5	34·5	37·5
2	61·36	553·8	272·4	64·01	545·6	275·3	65·03	555·9	283·9	62·13	554·8	279·8	60·98	555·0	268·8	35·1	36·4
3	61·14	558·8	268·2	63·60	545·8	272·5	66·41	551·9	280·6	63·77	559·0	278·7	62·26	559·0	271·0	34·4	35·3
4	64·37	555·8	277·5	64·51	542·8	281·6	66·39	556·9	281·4	62·42	558·1	285·8	62·42	561·3	266·6	31·2	33·1
5	61·68	560·1	268·6	62·94	554·1	259·4	64·82	558·1	261·3	62·82	563·2	251·0	62·72	562·6	240·7	31·8	36·8
6	60·01	569·9	227·6	71·34	551·7	218·8	75·58	553·9	249·9	66·39	560·4	377·8	61·61	560·0	337·0	38·3	40·9
8	62·87	551·9	290·8	63·74	551·7	281·7	69·64	559·0	289·9	64·69	566·7	296·8	62·96	555·9	304·2	28·2	30·2
9	60·40	544·1	258·0	63·13	549·6	264·3	68·79	555·5	276·7	65·92	561·8	302·1	59·98	554·1	297·9	27·2	28·9
10	61·83	556·8	260·1	64·41	558·4	260·0	67·71	560·3	260·7	64·98	562·2	270·4	63·99	560·7	266·3	30·8	33·4
11	60·10	559·7	252·8	62·25	552·7	252·3	69·33	559·4	259·7	64·55	558·5	272·1	61·99	560·5	257·7	33·3	36·4
12	60·40	559·4	253·4	62·89	556·1	251·1	68·05	555·2	261·5	66·56	558·2	271·5	63·30	562·4	262·2	33·9	35·7
13	61·27	557·0	266·3	62·35	555·7	270·8	65·05	556·3	266·9	63·41	556·8	264·3	62·45	561·0	259·3	30·1	32·6
15	60·67	558·2	249·5	63·35	560·4	248·9	63·63	561·7	263·6	62·26	561·1	271·4	62·05	564·3	263·3	39·2	39·0
16	61·56	563·6	243·3	68·52	555·5	259·3	66·77	555·3	282·7	58·96	562·2	295·6	61·29	559·7	263·2	38·5	41·9
17	59·76	558·8	254·8	63·58	552·4	260·8	66·16	561·9	266·4	62·70	557·0	281·4	56·57	560·6	261·5	41·1	42·2
18	61·34	559·3	251·9	64·79	557·2	248·9	67·32	562·9	253·8	66·88	566·8	283·8	60·85	565·8	272·0	45·9	47·6
19	61·68	560·1	253·5	66·81	555·0	249·6	65·09	559·6	270·1	62·82	559·9	268·8	61·88	562·8	261·0	43·3	43·3
20	61·11	559·2	257·6	66·77	552·2	251·5	66·43	558·9	264·6	63·27	560·5	257·3	60·38	563·2	257·6	40·7	42·4
22	60·91	556·5	273·3	68·16	547·6	246·9	73·16	555·4	293·4	71·74	550·3	346·7	60·37	558·3	320·5	42·2	46·3
23	60·15	545·8	256·8	64·78	547·0	271·2	65·72	553·2	291·1	63·18	554·7	294·8	63·72	557·3	292·3	43·5	42·5
24	59·79	560·5	279·6	63·67	552·0	279·0	73·32	561·2	297·1	60·37	553·1	357·0	32·15	547·8	354·1	37·9	39·1
25	61·38	544·2	234·8	63·50	548·3	280·9	66·90	560·2	276·1	67·62	556·5	334·1	55·17	545·7	300·8	34·8	37·2
26	62·50	547·0	210·3	67·15	543·8	276·9	68·55	562·0	289·3	60·57	554·8	295·6	48·03	558·3	269·8	36·3	37·9
27	61·04	550·0	269·1	64.19	549·2	266·6	68·25	558·8	272·7	62·64	561·8	300·2	62·45	558·9	270·3	35·9	38·9

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Mar. 1	60·17	555·9	240·1	62·08	561·7	249·6	74·40	590·1	231·3	71·42	620·1	495·1	92·19	673·3	819·5	38·2	39·9
2	61·43	565·1	292·7	63·77	538·9	294·4	66·91	553·8	316·4	63·23	556·8	298·3	62·45	556·2	284·5	39·4	41·1
3	60·13	556·2	277·5	62·53	543·6	285·6	67·60	558·5	275·2	63·23	561·6	272·7	61·95	562·0	264·7	40·8	42·5
4	59·66	557·7	275·4	61·72	544·4	281·0	67·04	553·9	277·6	64·17	558·5	295·6	62·28	559·0	319·3	40·1	41·1
5	60·27	565·3	249·5	61·98	542·8	269·1	67·07	557·4	273·8	64·58	558·6	272·0	50·56	571·0	275·7	40·8	42·9
6	59·86	560·8	255·5	61·86	552·0	266·9	67·74	559·4	263·5	65·06	559·1	261·3	62·97	569·1	255·7	41·0	42·6
8	66·53	543·4	247·9	67·22	544·9	257·5	68·29	556·2	270·7	66·53	566·8	289·8	62·66	570·8	290·3	42·0	44·3
9	57·02	553·6	229·1	68·18	535·9	254·9	74·68	554·4	293·3	66·12	561·5	325·7	62·01	561·3	294·1	40·6	40·7
10	60·13	555·7	286·1	61·83	550·0	275·8	70·40	552·5	267·8	64·73	559·6	289·4	58·42	550·0	307·7	35·6	38·5
11	59·86	551·0	289·5	63·43	546·6	292·3	69·22	556·3	277·2	65·45	557·9	292·7	62·35	563·0	275·3	31·9	34·2
12	59·71	559·8	268·5	61·75	548·4	269·2	68·68	554·4	262·6	63·97	564·9	259·1	63·18	568·7	250·2	34·6	38·3
13	56·16	565·5	232·6	62·84	551·2	247·1	72·28	561·0	224·0	66·19	566·8	266·6	61·98	567·7	274·2	38·5	44·0
15	59·03	560·3	247·6	62·19	554·4	247·7	71·10	561·4	228·2	65·08	560·4	261·4	62·48	558·5	264·2	42·5	46·5
16	58·92	557·5	263·1	60·98	542·1	254·7	70·33	549·8	237·9	64·37	561·9	242·4	54·86	561·6	259·0	45·1	51·0
17	59·09	562·3	249·9	60·60	542·6	264·6	70·98	548·3	240·3	65·49	562·4	251·9	61·70	570·9	235·9	50·7	52·2
18	59·46	564·1	249·3	63·40	549·0	244·0	71·95	557·1	233·5	64·64	565·8	251·0	60·03	565·8	280·8	50·6	55·3
19	63·81	562·3	202·9	67·40	531·9	267·3	76·45	563·8	347·4	58·40	648·2	541·3	71·21	577·5	641·1	49·5	51·9
20	58·08	535·3	200·3	64·41	542·6	272·5	67·34	559·2	252·4	65·15	557·2	254·0	63·74	561·4	243·5	48·9	51·0
22	60·33	546·2	274·3	61·45	534·1	282·9	69·29	546·2	241·2	64·31	555·5	250·6	62·91	559·2	254·8	46·1	50·5
23	58·58	548·5	289·7	66·86	538·7	261·4	69·91	545·4	248·8	63·20	554·7	290·4	62·94	565·2	272·0	47·1	47·6
	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
25	62·79	551·1	257·9	62·73	540·6	254·5	68·18	553·6	246·2	60·33	558·9	284·4	59·06	558·6	281·7	43·2	44·5
26	60·67	549·2	274·0	63·63	544·4	250·3	69·42	557·0	256·8	63·70	558·9	289·8	53·54	560·6	282·7	42·4	44·1
27	57·98	553·8	259·3	60·74	541·8	261·3	66·90	556·2	246·5	69·80	566·0	260·4	62·69	561·2	254·3	......	......
29	58·70	557·2	288·2	60·91	544·7	276·9	68·95	562·6	255·7	63·23	560·1	268·9	61·43	565·2	258·1	39·8	42·7
30	57·21	558·6	261·1	66·88	538·3	269·0	71·72	565·2	264·8	64·37	555·5	276·1	60·60	565·1	277·4	38·8	41·2
31	57·08	558·6	269·2	62·66	542·3	264·2	69·19	555·5	247·1	63·13	559·2	262·5	61·14	564·6	263·2	37·9	40·4
Apr. 1	57·71	558·4	267·5	61·45	543·1	261·2	70·65	547·8	251·1	63·70	565·4	248·3	61·96	565·0	262·1	37·8	41·4
2	57·39	556·3	260·8	62·28	539·8	253·3	70·41	552·8	232·9	63·97	564·6	250·6	62·28	574·5	245·0	37·8	39·4
3	56·23	558·3	253·7	63·74	527·9	249·1	79·79	567·7	264·1	70·06	589·9	276·6	50·48	547·6	346·4	36·8	40·6
5	58·50	556·8	235·6	61·61	540·9	249·6	71·66	563·0	223·6	63·74	567·9	266·4	53·61	561·6	294·1	42·9	47·2
6	55·49	549·2	278·2	61·39	535·2	233·8	71·27	555·9	273·2	59·01	562·0	265·9	62·12	566·1	252·5	43·7	47·1
7	57·78	555·3	245·8	64·08	534·7	252·2	71·51	554·2	224·0	67·20	573·7	251·0	54·39	586·6	321·7	46·5	50·3
8	77·96	471·8	297·7	74·51	552·6	257·8	70·30	543·0	253·5	61·36	549·2	274·8	60·62	564·6	270·8	47·4	50·4
9	56·92	539·3	266·1	63·27	536·9	284·8	69·96	551·6	271·3	63·06	567·4	289·0	55·78	578·9	277·3	44·0	47·6
10	58·85	546·6	286·7	62·87	548·7	270·5	68·55	551·3	262·5	62·22	562·3	267·9	61·27	564·5	263·5	43·4	47·6
12	56·54	552·0	271·0	61·14	544·6	255·7	67·45	555·8	238·7	63·77	578·3	247·7	63·92	581·3	244·3	48·6	50·9
13	55·70	553·5	271·5	61·68	541·3	274·7	68·21	555·8	259·2	62·22	559·7	261·9	61·14	571·2	257·9	44·5	44·7
14	56·00	552·2	268·5	64·02	540·9	288·0	70·06	557·6	255·4	65·15	570·9	286·9	62·22	561·8	340·2	41·6	42·4
15	56·92	548·1	265·5	65·05	533·9	273·2	69·74	536·6	266·5	64·51	564·4	282·7	60·67	565·2	280·7	40·3	42·3
16	53·64	548·3	254·6	65·83	545·8	238·0	69·62	547·4	238·0	64·07	568·7	246·4	60·15	568·9	252·5	41·4	44·6
17	57·51	547·7	226·2	66·06	546·8	232·6	73·86	576·4	295·5	64·53	564·0	256·7	60·57	557·5	258·3	42·5	43·1
19	56·27	550·8	282·2	62·26	536·6	261·0	68·03	556·3	235·5	62·66	568·4	243·5	61·99	575·8	241·0	42·2	46·6
20	68·25	514·9	269·8	71·62	506·4	253·0	73·83	549·3	432·3	78·16	638·1	590·6	58·29	555·6	474·1	43·8	49·5
21	58·32	547·9	278·3	64·39	545·4	250·6	69·19	582·8	531·7	70·94	602·9	514·0	61·78	550·4	358·2	44·9	51·0
22	59·50	545·4	288·0	64·86	541·1	276·1	69·19	556·7	275·5	57·73	579·3	301·8	57·10	573·5	300·8	46·7	51·9
23	58·65	550·0	277·8	62·48	542·2	276·5	66·54	555·7	256·6	62·91	566·5	274·2	58·80	563·2	279·4	47·4	53·2
24	58·13	546·7	285·3	61·66	545·9	282·5	67·07	547·6	268·6	63·02	560·6	269·2	61·22	565·1	271·1	47·3	50·6
26	55·29	553·5	263·4	60·84	549·7	243·3	66·64	562·2	240·0	62·23	567·8	247·8	61·25	571·4	257·8	49·1	51·0
27	57·48	560·4	262·9	65·52	550·8	248·1	69·69	561·7	248·1	65·55	574·1	276·8	63·16	569·4	302·4	48·0	50·6
28	57·19	553·6	294·1	64·21	550·8	281·2	67·42	564·8	286·3	70·40	586·2	287·7	62·57	570·8	303·1	46·7	50·2
29	54·32	550·8	256·6	65·67	534·9	241·8	67·20	562·1	243·8	62·32	567·4	276·9	57·79	571·2	295·8	47·1	51·6
30	58·55	521·3	265·9	64·88	532·1	256·7	67·76	569·9	350·4	67·00	572·3	289·4	58·67	572·7	299·2	48·3	50·3

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Cor. rected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
May 1	56·82	543·1	272·2	63·14	542·7	256·9	69·96	565·8	256·6	64·64	571·1	276·2	62·42	572·4	263·5	45·3	49·5
3	56·43	551·7	274·6	62·72	544·7	251·6	73·02	560·1	253·9	66·12	569·4	275·5	60·60	568·7	285·4	45·3	47·0
4	55·04	552·8	276·8	62·48	533·7	269·3	71·59	553·7	249·4	63·97	572·8	247·9	59·86	568·8	266·3	45·5	50·9
5	56·35	551·6	270·0	60·77	538·1	257·1	69·06	552·1	240·4	64·10	570·0	256·4	59·93	573·7	258·8	47·9	50·5
6	51·56	559·6	266·8	58·72	545·1	235·3	68·21	548·7	224·8	64·98	563·2	247·3	59·53	571·6	258·0	47·5	50·1
7	54·62	557·7	260·7	59·81	552·8	245·9	67·04	558·8	222·7	65·35	564·3	235·6	60·60	571·9	261·1	46·8	53·3
8	85·63	490·3	−31·1	67·65	500·6	235·8	63·27	567·7	423·7	62·32	562·1	494·2	65·76	553·0	325·7	50·3	50·1
10	62·39	528·7	259·1	64·79	549·5	235·2	68·01	......	241·2	62·73	......	263·8	59·88	568·2	273·6	50·1	56·4
11	54·55	550·4	270·6	62·15	538·6	260·0	66·48	552·1	257·2	60·84	566·7	270·2	61·65	566·4	270·2	51·6	52·8
12	55·56	548·2	296·5	62·62	564·9	264·4	65·11	558·9	249·8	60·53	570·7	259·6	59·17	569·8	263·5	49·2	56·3
13	53·54	545·6	264·2	56·63	541·1	239·0	69·06	559·3	242·9	60·06	574·5	238·5	58·90	569·9	247·1	53·3	58·9
14	54·95	546·5	272·2	62·57	542·7	249·4	66·97	556·3	241·9	60·74	570·6	253·1	59·46	579·4	248·7	54·8	58·9
15	51·72	552·9	264·2	68·82	543·0	210·1	79·28	554·2	244·4	69·03	576·0	295·3	53·17	596·4	394·4	55·2	58·8
17	54·48	537·3	293·6	58·15	533·3	284·8	65·62	551·1	302·7	65·08	578·4	373·4	61·58	574·6	354·3	46·5	47·1
18	57·26	536·3	274·6	62·48	532·9	275·7	67·67	549·5	267·4	65·65	576·3	313·4	60·50	566·4	296·0	45·5	46·8
19	57·61	541·1	271·9	65·25	539·4	242·9	67·64	559·8	240·3	61·34	565·6	260.9	60·77	566·9	256·3	46·1	54·1
20	54·28	543·7	250·5	63·09	537·1	229·7	65·42	553·8	237·8	59·39	566·6	308·1	58·38	582·9	305·2	52·8	57·9
21	55·70	548·8	277·0	60·87	536·1	267·6	65·15	553·1	258·5	60·06	564·1	279·3	54·84	565·3	272·4	52·9	56·6
22	53·74	544·1	275·6	58·87	546·0	262·6	63·97	560·3	262·9	60·53	567·9	269·8	58·92	563·8	277·7	53·4	54·4
24	53·74	555·3	270·4	59·66	544·4	248·1	65·05	583·1	243·6	60·60	564·9	246·9	60·10	568·3	255·3	56·1	60·4
25	52·44	558·7	249·9	58·42	550·0	230·5	65·32	559·4	232·5	61·41	567·6	248·7	60·45	574·8	252·8	55·9	57·9
26	54·35	555·7	238·5	63·90	550·5	231·2	70·43	564·6	233·8	66·53	568·4	284·0	60·00	574·7	284·9	54·7	58·0
27	53·27	556·5	288·2	58·67	549·8	246·0	66·46	562·0	241·8	61·07	564·6	246·2	60·72	592·7	253·2	54·3	62·0
28	51·29	552·3	255·6	61·81	537·8	248·5	68·61	556·9	253·6	60·25	575·5	269·0	59·86	571·6	280·9	58·8	67·3
29	67·31	512·8	241·9	61·72	546·9	233·0	67·51	563·3	256·4	62·60	574·7	359·1	62·25	567·6	264·0	63·3	64·2
31	52·80	555·2	292·1	59·50	545·0	271·0	65·63	555·9	251·9	61·72	587·5	267·7	61·39	574·1	278·0	58·4	67·0
June 1	54·70	551·6	295·0	61·34	543·9	233·9	69·59	564·0	226·1	66·83	577·7	267·7	58·69	572·5	328·8	63·6	71·1
2	56·43	544·6	287·9	61·73	535·9	259·0	65·92	558·4	254·1	62·62	569·5	259·7	59·43	572·6	279·7	65·6	71·7
3	55·31	554·9	285·9	62·96	544·2	259·9	65·65	549·8	248·7	62·32	565·0	249·4	61·05	573·2	266·6	66·2	72·6
4	55·89	551·0	287·3	60·03	538·0	272·0	66·06	553·1	265·0	61·75	561·8	309·3	60·35	569·1	310·9	67·1	65·1
5	55·19	559·3	318·5	60·77	553·7	274·6	63·50	558·0	272·8	63·02	569·8	288·1	60·37	574·2	284·8	59·1	60·9
7	51·76	563·1	271·1	58·08	556·1	267·7	64·31	560·2	270·9	62·72	571·5	298·4	61·01	574·7	294·2	54·5	57·5
8	58·42	553·3	227·8	62·69	548·3	233·0	66·93	558·3	235·8	64·04	560·0	269.7	60·67	576·3	282·9	54·4	56·2
9	56·81	555·6	281·5	62·86	549·7	280·4	65·52	562·4	265·4	61·24	562·6	275·9	61·18	582·3	279·0	52·2	56·9
10	53·17	558·5	280·0	61·86	553·5	253·8	70·56	546·5	262·7	64·88	606·9	360·2	63·06	573·6	294·1	54·9	57·7
11	63·40	533·2	221·4	61·51	540·2	224·1	65·99	561·6	249·7	60·00	588·3	274·3	57·78	581·8	287·3	53·4	57·4
12	49·95	544.3	256·8	60·67	548·3	225·5	67·25	560·7	207·0	65·36	570·7	234·1	61·76	589·8	243·1	53·2	57·2
14	61·07	549·6	179·1	57·17	537·2	219·3	65·32	567·6	262·9	66·29	610·3	330·0	61·76	586·9	277·6	57·0	59·8
15	55·26	547·3	246·8	60·06	535·0	250·2	65·82	562·2	241.9	65·32	566·7	247·8	60·77	569.2	258·3	56·4	58·6
16	52·73	552·4	261·0	59·19	548·7	196·3	64·28	551·7	217·4	62·75	568·3	241·6	59·71	583·2	240·0	54·8	60·1
17	49·14	545·5	250·9	58·72	546·3	236·4	67·13	555·2	235·7	62·37	570·7	252·1	58·25	574·4	253·7	57·1	56·7
18	51·03	556·0	238·2	59·12	548·1	240·9	67·05	556·6	246·2	64·51	573·6	246·8	58·79	589·6	258·2	53·9	55·9
19	50·65	553·1	228·8	55·60	548·8	243·4	61·81	559·4	239·9	61·54	565·3	242·3	59·37	570·9	234·1	55·9	57·9
21	52·10	555·8	233·1	......	......	......	67·84	560·1	190·5	66·17	573·1	211·9	60·17	585·4	204·4	59·2	63·2
22	55·10	562·3	240·1	61·68	542·6	246·6	68·68	555·2	258·0	65·79	565·2	254·9	59·24	571·0	249·8	57·2	58·8
23	53·14	560·1	265·6	56·63	545·4	260·7	64·96	577·2	222·5	62·82	566·7	246·3	59·19	570·4	233·0	55·7	60·7
24	56·03	554·2	252·1	56·37	551·2	228·5	65·36	549·1	225·9	62·25	566·2	222·8	59·76	573·1	223·9	58·9	62·1
25	54·35	558·7	226·5	59·46	549·2	236·8	63·77	558·9	217·8	60·37	570·0	220·1	60·87	570·7	235·0	58·9	60·9
26	52·91	556·4	250·5	63·21	542·8	229·4	66·68	563·1	207·4	61·65	574·4	231·5	58·79	576·7	212·6	57·7	62·7
28	53·67	584·0	264·8	61·31	553·0	240·1	63·94	563·1	229·0	61·88	570·3	230·7	59·37	581·3	251·8	65·5	71·0
29	52·84	550·5	245·0	60·64	544·6	218·5	65·80	567·2	232·1	62·93	585·8	226·9	60·17	573·6	234·3	67·6	72·0
30	53·67	551·1	244·4	60·67	549·5	231·6	64·75	567·1	217·8	60·67	571·4	237·7	61·58	577·3	222·9	67·6	70·7

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
July 1	54·79	545·0	229·6	61·73	538·9	269·9	67·47	573·0	262·7	63·58	571·9	278·1	59·98	571·8	255·4	65·4	66·7
2	51·93	553·3	280·8	56·50	540·5	243·8	66·19	557·4	238·0	63·87	579·0	258·1	60·45	575·9	256·7	62·7	65·2
3	54·55	551·1	283·4	63·27	546·2	267·4	65·42	569·5	247·5	61·98	566·9	247·8	60·42	581·5	244·7	60·2	67·8
5	53·95	550·7	259·6	61·39	543·3	254·0	62·72	567·0	235·1	60·82	562·7	239·3	60·65	571·8	243·1	63·8	68·6
6	52·26	557·3	249·6	60·72	552·0	245·8	65·42	553·5	231·6	61·81	579·1	248·4	62·50	587·3	241·4	65·4	69·3
7	50·56	557·3	244·6	65·72	534·6	230·8	65·06	557·0	231·3	62·72	565·7	287·9	61·70	578·6	256·4	67·0	66·5
8	54·75	552·6	241·4	59·51	545·3	229·9	69·12	554·7	257·1	61·27	563·7	250·6	59·34	572·1	248·8	61·9	67·5
9	55·09	551·5	260·1	57·93	553·9	245·7	62·40	555·9	240·2	61·05	584·7	240·4	55·09	588·5	297·5	62·5	67·5
10	57·78	534·1	112·1	60·99	539·6	264·9	66·66	568·6	252·8	68·14	569·3	260·5	58·43	582·5	288·5	64·4	69·1
12	58·05	536·4	246·3	59·83	542·3	247·5	66·66	552·5	236·1	62·28	580·3	249·0	61·68	572·1	254·4	67·9	72·6
13	59·30	543·0	241·2	58·89	527·6	234·5	68·65	555·5	243·2	64·41	571·4	233·6	57·76	572·7	263·4	69·0	73·5
14	52·48	548·6	259·1	56·97	533·1	253·7	64·78	555·3	232·9	60·98	576·1	219·0	59·79	573·9	252·2	68·4	74·7
15	53·14	543·3	274·7	59·97	532·6	228·2	69·44	553·2	234·6	63·37	570·5	249·1	59·12	565·8	257·9	72·0	74·9
16	51·10	546·5	287·2	59·73	532·8	267·0	68·73	549·5	249·5	64·10	567·9	271·8	59·93	573·1	279·7	67·1	64·0
17	54·08	551·8	315·0	60·24	536·6	247·5	69·66	543·3	234·5	62·40	567·5	265·5	59·07	572·4	251·9	59·4	64·9
19	53·24	548·4	252·8	60·71	539·7	222·8	66·27	559·8	211·7	62·96	568·8	221·5	59·71	578·7	229·7	64·0	69·6
20	52·70	550·6	256·2	62·48	537·6	238·8	66·64	559·5	236·6	61·51	566·0	244·5	59·50	570·7	235·3	65·2	66·3
21	53·88	556·1	258·9	61·48	548·6	241·3	66·73	564·4	226·8	61·38	565·4	238·9	60·27	571·6	236·2	62·8	66·4
22	57·89	554·7	237·6	61·85	552·3	256·0	64·48	571·7	257·0	63·37	571·3	260·9	60·13	577·6	242·1	64·4	66·7
23	53·41	551·9	214·5	61·21	543·6	224·7	67·87	560·0	243·5	63·20	567·2	265·5	61·05	576·0	252·1	60·8	64·2
24	52·92	554·8	251·8	59·76	548·4	233·4	63·77	561·0	219·6	60·80	562·9	221·5	58·85	573·1	228·2	61·1	66·1
26	56·99	553·0	262·1	59·68	545·6	249·4	66·03	557·7	245·5	56·23	600·6	253·4	57·55	578·6	244·2	60·5	66·7
27	55·04	549·5	236·3	62·05	552·2	205·6	66·79	560·4	209·8	60·24	569·9	226·8	59·51	574·2	226·4	63·9	66·9
28	60·92	559·0	208·9	58·13	543·2	228·7	65·08	553·6	224·0	61·01	567·6	240·4	57·81	569·8	240·9	63·5	64·8
29	52·92	551·1	239·4	58·97	549·8	243·8	64·71	565·1	223·0	61·95	575·6	236·1	59·51	565·9	230·9	61·3	67·4
30	56·50	554·6	227·7	65·36	551·4	215·6	65·97	566·5	216·5	61·31	569·9	243·4	59·97	571·6	238·7	64·3	68·6
31	53·74	555·9	231·4	58·56	547·9	222·0	66·26	561·2	219·0	61·27	566·7	243·0	59·41	553·4	229·6	63·7	65·5
Aug. 2	53·61	555·4	239·3	57·17	543·2	231·0	65·74	556·8	212·9	64·04	567·0	219·9	58·33	572·8	227·3	64·8	66·5
3	54·15	542·3	233·3	61·21	555·6	223·0	68·01	553·7	214·7	62·96	567·5	230·2	59·97	576·4	232·6	59·7	63·0
4	54·92	566·6	234·7	58·55	554·4	236·9	69·53	556·4	232·0	62·99	570·3	241·4	59·26	583·3	236·2	58·1	60·5
5	58·65	530·3	139·1	63·35	519·6	204·3	70·06	542·1	243·6	64·81	580·4	248·2	61·21	564·6	263·2	57·6	63·0
6	48·95	541·3	218·7	58·69	539·7	229·5	65·29	562·7	215·7	62·48	582·7	227·8	60·40	578·8	255·7	59·7	64·8
7	56·50	541·1	225·7	59·95	541·4	219·5	68·48	564·4	204·9	63·58	563·6	254·3	55·42	576·5	243·0	62·7	63·9
9	54·92	539·9	212·1	61·93	540·1	221·9	69·71	566·8	227·0	60·15	571·4	239·7	58·83	573·3	232·0	57·1	59·7
10	51·91	551·6	245·7	58·92	545·1	238·7	67·37	561·8	223·1	61·75	575·0	237·4	54·46	573·8	248·2	55·4	58·6
11	54·89	543·9	248·1	59·91	546·1	243·3	65·79	561·8	216·3	62·15	568·2	232·6	58·25	570·9	211·0	55·4	61·7
12	53·20	555·4	219·0	60·92	543·5	209·4	68·58	560·0	210·4	60·62	564·4	212·7	57·79	567·4	197·6	62·0	63·9
13	54·38	551·6	226·9	60·96	543·0	226·6	67·91	552·1	207·8	60·94	564·5	212·0	58·76	570·0	200·9	59·3	63·6
14	51·54	554·6	233·6	57·37	547·2	196·4	70·09	572·2	200·2	63·90	583·3	365·3	62·13	573·6	229·1	58·6	64·7
16	56·30	546·3	201·3	62·42	538·5	232·8	69·87	561·7	208·0	63·70	582·0	243·5	60·78	577·7	219·1	56·8	61·5
17	56·81	553·0	220·3	60·50	548·7	196·4	73·19	574·7	189·7	65·45	583·4	211·6	61·56	595·8	211·4	57·4	62·1
18	51·43	553·0	226·7	58·99	537·2	212·4	67·54	555·3	194·2	61·31	566·4	222·6	58·29	583·0	217·6	59·2	60·3
19	51·39	550·6	235·0	58·83	534·8	229·1	68·36	553·1	198·9	60·71	567·1	198·5	57·91	570·8	229·7	56·8	63·7
20	53·05	550·5	226·4	60·53	538·1	206·4	62·45	556·7	194·6	60·47	574·0	212·0	58·05	568·5	213·5	60·7	64·8
21	50·25	550·4	229·8	57·44	537·8	217·6	66·50	563·2	205·8	60·37	566·2	209·9	58·94	581·6	220·0	60·2	60·9
23	56·34	546·6	231·9	59·06	540·3	236·1	67·74	546·5	222·4	60·37	555·3	247·8	56·37	571·8	240·0	51·9	56·4
24	57·34	539·7	236·9	63·84	543·3	197·9	67·87	559·7	207·5	60·33	561·6	249·7	55·49	566·9	249·3	53·2	57·5
25	63·87	535·6	179·9	66·32	539·2	203·9	65·96	576·6	316·9	55·29	618·2	447·2	58·15	558·1	322·6	56·6	59·5
26	56·57	555·5	165·3	64·37	534·8	195·4	68·68	555·4	253·8	58·65	569·2	238·3	57·21	576·1	207·4	57·6	62·7
27	53·54	549·2	225·4	61·34	538·0	210·2	67·20	552·7	184·5	60·77	567·4	201·3	57·68	572·3	219·3	61·3	66·7
28	48·77	539·6	238·4	65·35	534·2	209·6	70·53	560·9	215·1	63·23	570·7	258·1	58·42	569·1	226·0	63·1	66·7
30	51·25	550·7	231·7	59·59	536·1	214·3	68·45	559·2	224·0	59·23	560·7	270·6	56·43	570·7	253·7	58·8	61·0
31	51·59	557·4	253·0	57·71	543·2	247·5	68·52	556·0	240·1	60·27	565·7	239·2	56·16	571·4	228·6	58·3	63·0

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Sept. 1	51·07	553·0	250·6	57·69	538·3	221·9	69·17	551·7	188·6	60·57	571·2	224·6	55·15	566·5	252·1	58·9	59·1
2	50·67	550·8	246·2	58·72	541·3	232·8	68·83	575·9	216·0	61·93	569·4	238·7	58·85	573·8	228·5	55·0	56·8
3	52·28	554·9	257·9	57·31	538·9	240·3	63·72	556·8	211·1	59·36	577·4	231·1	58·79	572·2	220·5	51·4	54·0
4	52·78	548·6	245·6	58·72	541·7	240·4	67·34	575·6	227·2	55·15	576·2	265·3	58·32	572·7	232·3	49·4	52·3
6	52·08	555·0	217·9	59·19	541·6	210·0	66·54	559·3	207·3	59·76	567·3	233·1	56·40	570·9	216·1	49·6	52·6
7	51·46	546·8	207·4	59·79	537·1	231·3	69·02	561·4	196·8	60·44	572·4	214·9	56·77	572·1	214·1	47·2	51·6
8	53·32	556·0	253·6	58·62	541·3	187·2	64·26	558·7	179·5	59·70	567·8	181·2	57·31	573·0	178·7	53·0	56·4
9	52·46	555·2	194·0	59·48	537·2	184·6	70·33	560·6	187·8	52·57	613·1	271·4	55·93	574·0	274·1	55·8	59·1
10	54·35	546·8	215·3	59·98	535·5	192·3	65·53	558·8	187·8	59·66	568·0	189·8	57·98	573·6	176·8	57·3	60·3
11	53·78	550·8	220·3	60·99	543·5	209·8	67·34	557·5	214·8	59·70	566·1	238·1	57·88	568·6	215·9	53·1	54·5
13	60·00	560·0	169·2	68·66	524·0	190·9	74·67	539·9	290·9	62·35	597·4	459·1	55·36	570·0	332·8	52·2	55·5
14	53·86	550·5	241·8	58·65	533·4	241·5	62·32	544·6	232·9	58·89	571·4	220·3	61·09	576·9	224·4	50·1	53·9
15	54·55	550·2	233·7	57·58	535·9	232·3	65·27	552·4	224·2	59·59	562·7	217·5	57·61	568·3	216·5	48·8	52·6
16	50·42	555·6	220·5	56·52	540·4	202·6	68·34	555·6	190·7	60·60	567·0	200·0	58·32	571·9	192·0	51·7	54·5
17	52·57	550·8	209·2	60·18	527·8	221·8	67·08	551·0	220·3	62·28	579·6	261·6	54·55	568·2	248·0	51·9	54·7
18	55·49	553·4	217·8	55·63	533·5	225·3	65·49	545·1	200·5	59·14	562·0	236·5	56·94	570·0	209·7	49·7	52·4
20	53·20	557·3	201·4	58·22	540·4	219·5	64·01	552·2	215·1	57·64	562·5	230·0	55·67	573·0	219·6	47·0	49·5
21	56·90	561·6	199·0	56·70	543·4	223·1	64·19	555·2	202·1	57·48	551·8	212·6	57·24	568·2	201·1	45·7	51·6
22	56·13	560·7	204·9	59·83	544·7	194·3	64·69	557·8	178·0	55·29	559·3	223·0	55·56	572·7	213·5	52·0	58·3
23	57·95	565·5	176·7	58·18	550·3	177·8	61·68	562·9	230·0	59·09	572·1	361·2	56·38	559·7	260·3	57·3	58·7
24	69·89	524·3	26·2	62·53	527·8	171·2	08·62	830·0?	428·3	44·53	655·1	-358·4	58·49	526·7	304·1	53·8	58·4
25	53·04	513·2	244·1	54·05	510·0	268·9	61·65	519·5	254·7	60·10	533·3	225·8	58·25	543·8	236·6	55·7	60·1
27	52·23	506·6	121·7	48·80	483·0	237·2	55·89	651·4	511·6	61·24	534·7	460·0	56·23	543·1	260·7	45·7	52·1
28	54·79	530·9	256·0	59·46	517·3	274·3	65·89	528·7	262·8	59·26	543·2	255·8	57·05	554·2	250·7	51·1	57·8
29	57·69	541·8	247·2	56·23	527·1	246·8	64·07	548·2	245·4	64·04	582·8	251·4	52·87	541·1	109·9	50·8	54·7
30	54·95	537·1	193·3	58·85	535·2	244·0	62·48	548·4	228·6	59·97	552·4	229·7	55·19	556·1	236·8	49·8	53·3
Oct. 1	54·68	549·8	228·1	55·49	537·2	235·5	62·20	537·8	228·6	61·24	554·7	226·4	59·93	562·2	221·3	50·3	54·0
2	56·03	554·4	215·2	56·84	541·2	211·1	63·09	550·6	206·4	61·21	555·6	231·7	60·58	563·0	238·7	52·0	51·5
4	53·88	558·6	220·5	54·21	541·5	221·0	63·30	571·7	192·8	59·57	559·0	211·2	57·71	566·1	213·1	49·0	49·4
5	52·71	558·1	220·9	54·23	544·7	210·9	64·55	555·0	196·8	60·17	558·8	217·3	60·33	565·5	243·1	47·2	48·7
6	52·91	556·5	228·2	56·90	542·2	209·7	63·06	542·5	200·6	58·32	559·3	219·3	57·32	564·5	214·8	47·6	49·0
7	53·07	559·0	218·9	55·81	533·6	213·9	64·58	547·0	186·8	58·13	563·8	201·5	56·97	569·0	191·2	49·9	51·4
8	49·68	558·8	203·9	59·39	542·4	184·7	66·30	550·8	174·5	62·01	572·0	204·3	58·22	578·7	229·6	46·9	49·9
9	57·07	562·5	208·6	55·67	537·0	209·4	64·71	552·8	200·9	60·78	569·7	192·1	58·11	572·0	190·5	48·6	53·4
11	48·63	556·0	180·9	55·74	537·3	178·1	66·79	553·5	187·4	58·52	565·2	209·5	51·39	562·0	216·2	55·6	59·5
12	51·70	554·3	221·9	58·40	541·2	197·5	66·63	564·3	197·6	59·46	567·4	210·4	45·17	567·4	209·9	55·8	57·0
13	57·07	557·9	160·3	61·56	527·3	195·9	70·03	531·3	289·6	57·05	559·4	517·3	52·10	559·7	364·6	53·9	52·9
14	53·95	545·6	266·9	57·88	520·4	269·4	69·54	537·9	276·6	60·10	553·1	278·5	57·44	557·5	250·9	49·8	49·7
15	56·27	555·5	228·9	61·09	525·0	254·7	69·22	542·3	266·4	60·96	557·7	289·8	55·80	541·6	262·0	47·2	49·5
16	64·44	557·0	165·2	61·27	529·1	250·3	69·32	550·6	254·8	59·16	558·0	282·3	41·81	558·6	270·5	48·9	52·4
18	57·78	556·6	190·6	62·22	534·0	193·2	65·03	536·6	239·2	53·88	567·3	300·4	56·72	561·8	231·0	52·6	54·3
19	54·45	554·0	201·1	57·04	538·2	200·1	67·82	563·8	224·0	61·81	566·7	258·2	56·43	557·6	227·4	53·9	56·4
20	53·20	552·1	221·0	55·33	532·4	219·2	62·48	542·2	255·6	57·91	555·2	215·4	57·04	561·5	224·3	50·7	51·6
21	55·53	551·3	219·3	56·58	538·2	236·1	63·16	541·6	207·8	57·19	557·4	236·2	57·31	565·7	219·8	48·2	48·3
22	53·24	560·1	233·2	54·72	541·0	234·3	66·66	550·3	263·7	58·85	559·2	218·4	56·30	564·4	216·2	47·4	50·8
23	41·20	506·2	179·0	63·20	541·8	28·7	-05·44	556·9	256·0	58·60	702·3	495·2	39·54	530·3	405·2	51·1	51·8
25	99·86	*344·0	138·3	63·81	505·3	290·5	62·72	602·2	479·3	57·14	542·5	551·3	49·10	508·8	110·3	43·1	48·3
26	53·17	535·0	293·8	57·84	519·1	318·3	62·55	531·0	292·3	56·94	542·0	292·2	56·79	549·9	269·3	43·0	44·7
27	52·70	546·3	267·9	56·95	530·2	270·4	63·90	541·3	258·5	58·49	550·1	266·8	57·08	556·7	256·4	49·5	54·0
28	54·92	550·3	259·2	56·95	529·1	272·4	62·55	548·3	269·1	58·11	555·0	257·3	57·05	562·0	249·1	48·5	51·0
29	52·57	558·4	266·3	56·23	537·7	266·0	66·63	597·7	284·5	66·12	587·1	284·2	58·89	566·5	353·8	48·0	50·7
30	53·64	552·7	260·7	57·14	528·3	259·1	60·77	548·2	243·5	58·53	557·6	239·5	56·87	562·8	237·0	47·2	49·3

* Out of field at the lower end.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			8 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Nov. 1	53·67	556·4	230·2	62·66	556·9	207·8	72·15	579·3	245·8	64·91	555·6	344·6	57·79	556·8	293·7	49·1	53·8
2	55·61	540·5	186·0	58·94	532·6	239·0	59·77	542·8	250·8	58·77	552·9	246·7	57·48	559·3	237·5	54·4	56·3
3	56·97	550·6	235·1	59·79	531·8	267·8	66·57	543·5	294·3	59·53	550·3	293·2	57·95	563·2	266·7	46·6	47·0
4	57·28	553·5	221·3	59·53	539·4	248·1	63·97	546·3	253·7	57·89	558·3	246·5	51·93	558·9	243·6	47·0	48·9
5	54·62	552·5	231·2	57·82	542·7	235·5	63·77	547·5	245·9	58·92	559·6	228·3	56·52	564·9	217·1	47·8	50·7
6	54·01	570·3	209·2	58·29	545·5	217·8	63·16	544·0	222·0	59·23	561·7	239·0	57·89	565·7	239·3	51·8	54·4
8	52·57	553·1	205·6	58·60	544·4	217·4	65·58	549·1	247·4	59·39	560·9	257·9	50·72	552·4	275·2	54·8	56·1
9	53·61	558·2	218·4	56·84	543·3	223·3	65·65	551·7	250·4	58·96	559·2	251·0	55·42	562·2	231·8	51·4	52·1
10	54·68	557·1	240·3	56·90	539·4	233·9	65·35	552·7	244·7	59·39	551·1	337·6	53·04	554·5	302·4	47·2	49·8
11	54·55	531·2	216·8	57·34	538·6	229·6	63·02	551·1	239·6	56·32	556·6	246·2	55·71	562·0	230·0	51·1	49·8
12	53·61	559·3	222·0	54·70	540·7	240·8	60·37	544·9	250·5	57·12	558·6	243·4	56·90	568·1	226·8	47·4	47·7
13	56·40	565·6	237·9	54·73	537·9	562·5	64·14	555·8	259·7	41·43	553·5	291·7	56·97	558·0	272·0	43·1	46·3
15	56·67	561·7	205·5	57·49	545·5	215·0	60·53	550·6	222·7	48·53	556·5	252·0	56·79	565·8	228·9	51·9	54·3
16	55·36	564·0	266·0	57·35	539·9	234·0	65·65	555·1	198·3	61·61	567·6	282·1	61·02	548·8	325·6	51·1	48·8
17	54·35	554·4	273·1	56·50	545·3	260·4	59·86	553·3	255·4	57·41	559·4	249·2	56·70	564·6	242·1	42·0	41·4
18	53·61	561·7	232·0	55·70	548·5	239·8	62·93	558·8	242·8	57·84	566·9	235·5	56·37	567·5	229·0	37·3	38·4
19	55·70	561·1	218·3	57·07	551·4	219·3	61·38	561·8	213·8	57·28	568·5	205·0	52·84	569·8	211·9	40·7	45·0
20	52·53	559·6	187·6	56·74	558·1	200·5	63·35	549·4	250·1	62·96	559·5	222·2	57·04	563·4	219·0	45·9	46·6
22	54·52	566·7	203·4	55·36	563·5	206·9	58·02	568·3	212·2	48·80	606·8	214·2	64·29	612·3	472·1	44·8	44·5
23	54·75	537·5	226·7	57·81	529·7	267·5	59·59	548·1	280·7	60·37	555·1	246·3	57·41	546·1	237·7	43·5	44·4
24	55·44	543·3	236·8	56·81	537·5	241·8	59·03	549·8	240·0	56·94	554·5	245·8	54·63	559·6	232·2	42·0	45·1
25	54·48	561·6	191·9	58·65	540·8	201·5	64·17	570·7	235·0	66·39	576·7	269·0	38·67	560·4	236·9	46·2	49·1
26	63·38	535·4	174·9	60·74	550·2	226·7	61·83	580·7	362·6	58·02	548·8	310·4	57·21	553·9	244·6	46·2	44·5
27	56·54	553·8	242·9	57·07	541·8	259·7	61·81	545·4	265·3	56·21	558·2	288·6	60·04	584·3	232·3	40·5	38·7
29	55·15	559·8	234·8	56·84	546·3	236·5	60·84	554·6	228·4	57·34	568·1	229·4	57·37	564·6	232·0	35·9	39·1
30	54·48	562·5	206·7	55·78	556·8	190·4	58·20	556·9	196·5	57·49	565·8	206·4	55·91	563·4	209·9	42·5	47·4
Dec. 1	53·74	560·9	216·3	59·61	552·0	202·3	59·68	561·6	214·6	57·58	570·3	209·7	60·45	578·5	254·6	43·1	43·6
2	54·18	561·5	173·4	55·89	562·3	195·5	59·21	567·4	198·8	57·28	568·6	200·6	58·29	558·3	274·8	44·8	48·3
3	54·39	545·8	179·8	57·51	552·2	211·9	61·01	558·4	209·6	61·09	559·4	285·2	57·71	559·7	231·9	49·8	48·2
4	54·75	559·5	219·2	54·95	556·7	214·7	61·31	539·9	239·5	61·68	558·3	281·5	56·27	560·9	258·9	45·1	45·4
6	56·94	572·4	207·9	54·21	553·0	224·4	59·21	559·0	223·7	57·37	562·5	223·8	56·34	565·6	219·4	38·4	38·9
7	54·28	567·5	206·3	53·56	557·4	210·0	58·42	561·3	197·1	57·05	568·1	207·9	55·86	569·3	207·5	40·0	39·0
8	54·99	576·2	183·4	56·43	554·7	208·5	60·94	556·5	243·1	58·72	565·5	288·0	55·83	566·2	234·0	35·5	35·7
9	56·27	569·9	209·0	57·17	545·9	223·9	62·01	559·1	218·1	56·37	554·6	257·9	54·99	569·7	211·4	35·2	43·1
10	55·80	561·1	243·6	57·48	553·4	199·1	59·74	555·9	209·1	58·92	558·3	245·8	56·97	549·0	294·4	48·0	45·9
11	56·30	562·4	173·2	58·49	541·5	209·6	63·14	550·0	256·0	55·54	562·0	252·0	53·27	562·5	222·1	42·2	42·3
13	55·06	569·3	196·5	55·76	552·3	203·5	60·06	561·3	190·7	51·94	550·7	233·6	55·29	569·0	203·0	43·0	45·8
14	54·82	563·3	192·9	56·77	555·2	194·2	61·70	566·3	200·5	54·05	566·6	227·1	55·07	559·0	220·8	45·0	45·8
15	54·35	568·8	195·1	55·53	559·9	199·6	59·36	562·1	194·0	56·25	569·0	202·7	54·89	569·8	197·5	43·6	45·0
16	55·02	568·3	193·5	54·86	562·1	197·1	57·66	562·9	193·6	55·89	572·9	191·1	56·16	575·4	184·7	43·3	45·7
17	52·15	567·5	174·5	58·70	557·9	196·9	62·23	573·4	186·0	83·24	848·+	977·0	77·09	720·+	445·5	45·0	45·6
18	54·75	543·0	219·5	55·76	549·2	226·0	60·60	527·5	276·4	57·48	553·9	276·4	42·21	532·0	173·3	50·0	48·4
20	69·56	513·9	86·9	16·65	516·6	532·5	60·77	715·8	-181·6	77·15	734·1	389·7	75·47	563·9	-197·6	40·7	......
21	55·98	514·3	237·9	56·57	536·6	229·3	58·92	537·3	236·2	57·34	541·2	242·8	55·22	543·5	228·8	38·7	38·0
22	53·34	548·7	222·9	53·71	548·0	228·1	60·33	552·2	236·6	56·61	553·4	232·9	55·29	554·4	221·8	37·4	37·4
23	53·71	563·8	191·8	56·01	545·2	194·7	56·47	553·9	215·3	58·29	561·3	233·7	55·63	560·6	223·9	36·7	36·9
24	54·52	555·3	210·0	55·73	551·5	186·9	56·81	554·8	200·1	57·81	561·3	209·4	57·64	557·6	221·4	35·9	36·2
25	54·55	561·1	194·7	55·74	549·9	182·6	57·91	555·9	190·8	56·90	560·5	198·0	53·41	561·2	201·9	36·9	38·4
27	54·08	561·1	195·7	57·04	557·5	190·2	59·97	560·0	197·0	56·50	561·2	196·8	54·55	563·9	196·2	36·6	35·2
28	53·24	563·3	193·6	56·00	553·0	187·7	58·72	556·7	194·0	57·04	566·7	203·0	54·01	567·0	190·8	34·2	35·6
29	54·41	567·3	186·8	54·99	564·5	177·2	58·18	563·3	178·6	62·05	562·7	202·7	04·01	618·6	243·0	33·8	35·0
30	54·75	559·4	197·0	55·96	545·6	204·8	59·36	553·3	195·5	56·94	561·4	199·1	57·55	563·7	208·0	35·1	36·2
31	53·64	556·2	205·2	56·47	554·9	182·4	59·24	556·7	186·8	56·75	563·3	187·3	55·63	568·2	193·1	32·5	32·2

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Jan. 1	57·31	557·3	182·7	59·91	557·3	197·3	33·0	33·8
3	54·83	560·3	168·8	57·44	567·6	......	40·6	46·8
4	58·89	562·4	249·2	60·17	556·1	270·3	45·6	46·9
5	56·18	556·1	203·7	56·87	558·9	212·1	44·0	43·2
6	55·68	554·3	228·7	57·31	566·9	......	36·3	37·3
7	57·99	559·8	......	59·91	557·8	......	36·1	36·5
8	53·25	556·8	......	56·78	558·0	......	34·4	32·5
10	57·35	558·7	......	56·68	561·6	......	32·3	32·1
11	56·28	554·3	......	57·39	564·2	......	32·3	33·9
12	59·00	560·4	......	58·70	604·7	......	37·2	40·1
13	58·90	550·1	......	53·45	557·3	......	41·3	42·3
14	57·10	550·2	......	54·82	570·5	......	38·8	39·9
15	58·72	546·5	......	57·68	560·9	......	38·7	39·2
17	57·04	538·4	......	56·70	552·9	......	37·8	38·1
18	54·30	548·2	......	56·73	566·8	......	34·7	35·4
19	53·93	548·0	......	55·63	577·8	......	32·7	34·5
20	56·70	549·5	......	53·38	553·4	......	29·7	31·0
21	58·38	552·1	......	56·30	561·3	......	29·4	30·2
22	53·20	552·8	......	56·30	563·6	......	30·6	31·3
24	61·07	540·6	......	63·84	571·3	......	31·7	32·2
25	57·51	542·1	......	57·91	558·5	......	31·2	32·7
26	57·04	548·1	......	57·91	562·6	......	30·8	32·5
27	56·16	547·4	202·1	58·99	559·1	209·3	32·4	34·0
28	55·96	549·3	176·5	61·21	593·0	182·3	30·8	31·5
29	72·72	540·5	166·0	56·77	551·3	215·8	20·6	21·0
31	55·56	541·6	210·4	57·10	560·3	197·3	30·4	34·5
Feb. 1	54·41	562·5	201·4	56·63	563·9	197·0	29·5	34·3
2	54·62	550·7	190·4	55·70	562·6	196·4	36·0	39·0
3	52·87	560·0	185·6	57·17	568·3	192·7	37·7	40·5
4	54·21	556·3	190·6	56·03	565·0	198·0	43·3	45·6
5	52·40	554·8	188·9	56·10	568·3	193·9	47·8	49·6
7	52·26	551·3	190·0	58·72	563·7	198·6	38·7	40·6
8	56·23	553·5	195·5	53·95	558·4	231·5	40·9	42·0
9	58·32	556·1	190·2	54·62	561·5	243·8	43·8	45·5
10	54·08	550·1	205·5	57·84	564·3	208·9	42·3	43·4
11	52·94	552·8	193·2	57·37	564·3	205·2	38·4	41·6
12	53·61	558·2	194·2	57·78	563·8	199·9	38·2	40·6
14	53·61	554·9	197·3	59·66	574·5	186·3	45·2	46·6
15	55·96	551·0	189·8	59·06	572·3	208·8	42·4	42·8
16	54·62	550·1	195·3	56·37	564·4	203·0	38·8	39·1
17	54·41	551·6	186·6	56·97	568·5	198·1	35·3	39·9
18	52·33	549·9	215·3	56·63	571·2	200·3	37·0	36·5
19	55·09	549·1	192·2	62·35	578·6	211·6	38·7	43·0
21	48·50	456·1	184·9	60·53	542·1	252·6	37·8	39·5
22	49·98	559·9	218·2	61·41	554·9	225·3	36·8	39·5
23	56·70	545·4	219·5	51·99	565·1	246·8	40·8	44·0
24	57·04	516·6	203·1	60·87	616·1	390·1	39·3	39·2
25	61·21	505·0	227·3	57·04	557·6	232·7	38·0	43·4
26	53·41	546·3	202·4	56·63	554·3	215·3	41·7	42·4
28	56·70	553·4	196·3	57·84	558·0	204·5	41·9	46·1
29	59·06	549·7	197·5	56·57	564·2	202·9	41·2	43·0

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Mar. 1	56·50	554·4	201·3	55·36	568·6	209·9	41·1	41·9
2	53·00	522·3	204·6	55·76	564·3	207·6	39·8	40·9
3	53·54	552·5	195·4	56·90	569·6	198·6	39·3	42·9
4	54·62	553·4	211·2	57·31	558·3	207·2	37·5	40·4
6	54·15	554·7	190·9	54·01	561·8	205·4	39·4	40·2
7	54·82	545·3	195·2	58·18	573·5	210·9	39·3	41·5
8	53·54	544·5	186·9	59·86	586·5	231·0	40·8	45·1
9	54·48	538·7	183·6	57·71	571·8	196·5	44·9	48·1
10	52·26	547·0	183·0	57·04	566·7	189·1	42·9	45·6
11	53·07	553·3	228·9	55·42	572·8	188·5	41·8	42·3
13	53·61	526·7	186·2	57·37	573·0	186·9	37·8	42·2
14	52·67	558·0	180·5	58·72	573·0	187·5	37·2	41·9
15	60·13	544·2	189·7	56·50	566·5	265·3	41·9	46·3
16	60·40	550·7	183·0	53·81	569·6	196·6	41·9	42·9
17	62·82	525·5	204·5	59·06	635·4	320·1	41·0	41·4
18	55·89	532·8	204·3	57·58	559·7	203·2	40·5	43·5
20	57·84	537·4	229·1	43·85	658·3	356·8	38·1	42·7
21	56·50	542·0	195·1	60·33	560·9	228·5	38·1	40·3
22	53·61	543·7	196·8	54·82	562·9	198·4	37·2	43·7
23	54·89	539·8	197·8	54·89	567·0	190·2	45·2	48·0
24	59·93	538·6	176·8	58·32	560·8	200·8	46·4	50·4
25	61·21	526·0	190·4	63·09	561·4	286·8	45·6	48·2
27	56·10	538·9	187·4	54·15	568·3	195·4	38·6	47·0
28	54·15	539·5	169·0	56·23	576·6	192·6	45·2	46·3
29	53·95	541·8	180·1	54·35	566·2	185·0	43·5	47·5
30	52·33	539·1	184·7	57·58	573·5	178·0	43·3	49·3
31	55·70	534·6	176·3	62·15	583·0	212·4	48·4	53·9
April 1	55·15	546·5	182·6	55·89	568·2	181·1	46·9	52·7
3	57·84	529·5	198·8	58·58	590·4	253·4	54·5	60·4
4	53·81	536·0	192·4	58·45	587·2	223·8	53·8	57·0
5	50·38	533·8	187·0	57·91	565·3	210·3	50·7	51·3
6	58·11	530·8	199·4	59·53	560·3	230·2	42·8	45·4
7	60·00	511·0	173·0	61·95	576·6	281·3	41·4	46·5
8	56·70	522·5	190·1	56·70	561·1	194·4	41·0	44·1
10	52·40	542·8	188·2	54·89	565·3	192·8	37·7	43·3
11	53·61	547·2	183·5	54·15	569·9	187·6	38·5	44·7
12	51·66	547·1	187·8	57·24	563·0	188·5	40·5	43·7
13	50·72	548·7	181·2	54·01	578·9	173·9	42·4	47·4
14	52·26	551·6	182·5	56·70	572·2	177·7	41·6	45·7
15	51·32	549·5	171·8	58·58	582·6	183·3	39·8	43·7
17	53·61	545·7	179·2	57·04	582·6	187·0	48·7	54·0
18	52·60	545·3	180·9	55·09	567·3	184·4	49·5	53·4
19	54·48	544·8	176·6	57·84	573·2	183·8	48·9	49·7
20	52·13	545·5	183·6	56·37	577·5	168·1	47·5	51·0
21	53·88	553·9	166·2	58·65	599·5	194·1	48·3	49·1
22	54·82	557·5	151·2	59·06	566·2	205·7	48·0	49·0
24	52·94	550·3	183·2	57·44	566·3	190·5	45·0	49·0
25	50·04	549·3	185·9	55·63	569·2	185·5	46·2	48·2
26	53·61	548·5	161·3	54·08	571·8	170·1	43·9	46·3
27	53·67	547·3	166·4	55·09	577·8	166·5	42·5	47·5
28	51·66	555·0	162·6	56·97	575·2	169·2	42·8	45·6
29	57·91	553·3	155·6	58·25	596·5	255·9	42·4	47·8

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
May 1	54·75	550·7	172·6	52·67	579·8	186·4	45·0	53·7
2	52·73	551·6	166·7	55·70	576·9	176·1	49·1	54·5
3	57·98	547·9	153·1	56·57	586·7	205·3	51·5	59·7
4	58·79	559·0	162·8	57·78	597·2	169·2	56·0	63·7
5	53·95	553·3	173·3	54·08	571·5	175·1	58·2	65·0
6	50·38	542·5	157·5	56·70	579·4	166·6	59·0	62·9
8	60·33	545·5	157·9	62·22	601·8	265·7	54·1	58·5
9	53·27	544·8	152·4	53·14	576·6	178·6	52·7	59·6
10	53·74	555·6	145·9	62·42	604·4	173·1	54·7	62·2
11	56·77	545·9	169·1	55·29	571·8	181·5	58·0	65·1
12	52·53	553·6	162·8	56·10	573·0	170·7	59·6	62·4
13	51·05	548·5	160·4	55·76	576·1	170·6	60·4	68·1
15	55·83	562·3	149·9	54·68	578·9	164·1	54·9	58·7
16	53·14	551·4	151·6	53·88	593·9	187·6	57·4	61·9
17	51·99	545·6	153·5	61·07	610·6	177·8	57·9	61·7
18	57·10	543·4	137·9	57·31	568·4	160·6	58·0	60·5
19	53·81	550·1	176·8	55·63	606·2	225·1	54·0	57·8
20	53·47	527·1	186·3	54·21	579·8	197·9	56·1	60·1
22	51·66	540·7	167·0	53·54	580·2	178·8	56·7	64·8
23	51·25	548·7	162·0	56·90	574·1	165·6	61·8	67·9
24	50·72	553·6	157·2	60·27	570·5	164·7	63·6	66·0
25	52·60	548·8	167·0	56·77	565·8	167·5	60·0	65·0
26	51·25	546·0	160·8	54·75	573·4	161·4	58·7	60·6
27	54·01	554·2	135·3	58·11	589·4	236·2	57·4	60·6
29	54·68	545·5	150·8	55·02	579·0	184·6	56·2	59·6
30	53·67	552·1	169·2	54·35	581·5	167·6	56·5	60·2
31	52·20	542·7	158·5	60·80	586·2	178·3	55·8	56·6
June 1	54·41	547·9	168·4	57·17	551·4	184·0	53·3	56·8
2	50·51	545·0	161·1	55·36	579·6	170·7	54·9	58·6
3	51·25	540·9	169·0	57·37	581·1	164·2	55·7	57·7
5	50·11	542·5	172·0	56·63	575·4	169·6	53·5	58·2
6	51·72	550·2	149·9	56·37	579·9	167·3	55·2	58·9
7	51·66	549·8	151·9	55·63	582·1	159·7	55·6	58·9
8	48·36	550·6	156·0	55·15	586·9	158·1	55·0	59·3
9	51·46	553·5	159·2	56·10	582·5	153·9	54·8	57·5
10	57·10	553·9	139·7	54·35	585·6	152·2	54·7	59·2
12	53·20	547·0	143·5	53·74	585·3	158·8	54·1	58·9
13	48·77	555·0	158·3	55·02	578·2	167·8	55·9	56·4
14	49·84	554·4	151·4	56·84	603·8	182·5	54·1	57·7
15	49·77	551·2	161·6	55·29	581·7	176·8	57·0	63·7
16	50·92	546·5	152·9	55·83	582·2	165·0	61·2	65·9
17	51·93	551·9	157·2	54·55	576·1	165·5	61·0	61·8
19	48·56	555·3	145·8	54·68	589·6	162·0	59·8	64·6
20	50·98	553·2	141·8	55·83	579·1	152·4	59·7	67·4
21	53·14	551·2	157·2	57·51	582·7	171·0	65·9	72·4
22	58·85	537·1	154·7	54·28	598·5	190·6	67·6	72·3
23	52·46	549·0	166·5	54·89	574·6	177·6	63·1	65·9
24	45·47	556·8	162·1	53·07	580·3	172·0	60·6	62·0
26	47·42	559·0	165·0	54·62	576·0	160·5	56·3	63·4
27	44·59	547·9	175·0	55·09	583·2	169·0	60·9	63·3
28	49·98	551·9	155·2	54·89	586·2	163·5	61·1	65·3
29	48·97	548·0	157·1	55·49	587·6	163·0	61·4	65·9
30	55·63	548·6	167·7	55·70	573·4	185·6	61·0	63·0

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
July 1	51·52	544·7	168·7	55·36	584·9	190·1	55·0	58·2
3	47·69	548·4	169·1	57·71	597·0	168·9	56·4	61·3
4	51·46	545·1	179·3	56·77	575·8	223·4	56·7	61·4
5	48·36	558·5	167·8	56·37	604·4	211·0	57·6	65·0
6	51·86	543·9	178·2	55·36	569·7	168·1	63·0	65·3
7	47·56	544·6	166·0	54·01	581·0	171·9	64·9	66·7
8	49·71	545·0	172·5	52·94	582·9	173·7	61·4	63·1
10	52·87	559·1	148·3	53·61	579·5	177·6	60·7	64·5
11	72·98	554·2	178·5	57·58	618·0	371·1	61·1	68·5
12	58·65	529·4	200·0	63·16	617·5	286·8	67·5	73·9
13	51·39	532·9	203·7	52·87	616·3	197·0	70·1	76·3
14	50·58	547·0	180·3	58·05	663·9	333·4	69·8	71·1
15	50·51	544·4	213·8	55·42	578·0	188·0	63·3	68·8
17	51·19	547·9	176·5	55·36	580·6	193·9	64·3	65·4
18	50·72	546·8	185·3	56·57	578·5	201·7	62·3	64·1
19	50·25	541·3	165·3	57·84	572·0	195·7	61·4	64·8
20	46·41	545·3	197·6	54·62	567·0	186·8	61·9	64·3
21	50·51	543·2	181·9	56·97	577·4	190·0	56·4	60·7
22	47·82	546·3	180·9	54·01	575·9	175·5	58·0	62·1
24	50·18	533·5	190·7	53·67	574·0	200·4	59·0	63·0
25	47·22	546·9	188·8	52·73	579·9	191·4	60·6	63·9
26	47·89	528·8	198·7	54·28	570·9	191·9	58·9	64·2
27	51·39	545·0	185·4	53·41	569·8	193·7	60·6	63·6
28	50·51	544·2	190·2	54·48	577·6	178·0	59·2	64·2
29	48·03	543·6	178·5	57·78	587·0	218·5	58·9	65·8
31	51·12	545·7	189·3	52·73	579·9	195·7	62·1	66·4
Aug. 1	49·64	539·2	190·7	57·04	586·3	185·8	60·8	64·8
2	53·67	553·6	178·4	56·84	580·4	188·9	59·9	63·5
3	48·43	546·4	181·8	53·81	579·2	189·6	57·5	62·6
4	50·92	546·5	170·7	54·68	582·8	197·5	54·6	59·7
5	56·97	555·6	173·9	55·02	577·3	188·5	55·3	61·2
7	52·67	547·0	177·7	51·99	574·8	181·1	59·1	63·0
8	49·71	542·5	171·5	52·73	602·8	189·5	56·8	60·6
9	56·37	545·3	175·8	52·06	575·4	202·2	56·0	60·0
10	50·92	547·9	182·5	54·08	575·5	187·7	56·6	60·4
11	50·04	543·3	185·3	53·41	584·2	182·0	56·1	60·3
12	55·70	549·8	163·5	52·20	568·8	190·3	56·5	63·1
14	54·62	550·9	180·1	52·06	578·1	182·2	51·4	57·7
15	52·33	547·2	167·9	53·14	575·6	186·6	53·2	57·6
16	50·11	541·4	175·3	53·95	579·8	184·6	54·1	58·5
17	49·91	550·5	169·5	55·09	580·3	173·7	57·2	59·6
18	53·47	541·8	155·7	53·88	584·1	181·3	55·1	62·0
19	49·44	547·2	162·8	54·48	596·8	177·2	59·2	61·8
21	47·08	551·4	168·5	56·50	601·3	172·4	55·1	56·4
22	54·82	556·2	170·4	52·20	593·6	209·2	53·5	55·5
23	49·51	549·1	178·1	51·86	583·5	199·7	53·1	55·9
24	46·88	545·6	181·8	51·66	577·6	184·7	51·4	55·0
25	49·57	548·1	176·6	53·41	572·7	182·6	50·0	57·8
26	54·89	544·2	159·7	49·24	579·4	180·8	55·9	58·5
28	49·98	548·0	166·0	53·41	572·5	201·8	60·1	63·2
29	55·96	529·2	162·3	55·29	588·0	193·0	58·9	62·7
30	52·06	549·8	172·7	51·39	576·8	178·6	56·7	61·6
31	52·67	551·7	168·1	54·01	582·6	171·5	55·6	59·7

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Sept. 1	55·22	552·2	169·8	53·07	576·3	190·0	52·7	57·2
2	51·39	551·2	170·8	55·63	575·6	187·4	56·3	62·0
4	58·45	543·5	169·7	53·54	574·3	216·3	59·9	65·6
5	53·34	543·5	180·0	49·71	566·1	181·4	56·9	65·5
6	54·41	553·0	174·3	49·91	571·8	179·9	62·6	64·3
7	52·13	547·2	178·5	51·59	582·5	192·4	59·6	61·4
8	49·24	562·8	162·5	50·04	579·3	164·5	58·7	62·3
9	54·75	541·4	171·4	49·57	578·4	304·1	56·0	57·6
11	53·47	546·2	176·5	49·84	568·7	173·2	49·6	52·7
12	46·48	548·8	174·7	49·84	568·6	170·7	46·5	52·2
13	50·38	544·9	175·7	49·64	568·2	164·8	48·7	52·3
14	50·72	542·9	165·5	50·65	580·4	165·2	51·8	55·8
15	51·19	540·6	171·9	49·44	579·4	165·5	48·9	57·2
16	51·12	548·0	170·1	49·57	575·2	163·0	59·0	63·0
18	53·54	551·1	164·7	51·66	572·4	203·8	52·0	58·5
19	51·66	524·7	176·2	49·77	570·7	174·4	50·2	56·5
20	50·78	543·4	173·5	51·79	573·9	170·9	54·6	59·9
21	49·17	541·5	171·5	50·04	575·5	174·5	53·3	59·7
22	49·51	550·5	169·6	50·78	569·5	160·1	56·2	60·8
23	47·02	542·4	174·3	50·11	572·5	164·8	56·6	62·0
25	47·22	540·5	172·9	49·57	575·5	171·2	54·5	55·5
26	46·34	547·3	166·3	50·85	571·3	159·6	54·5	57·0
27	54·55	543·0	169·4	50·18	574·7	165·2	54·0	54·5
28	46·14	547·7	166·2	50·92	577·8	160·3	52·7	53·1
29	48·83	554·6	161·2	51·99	570·2	169·8	50·7	52·2
30	50·25	546·6	161·2	51·39	576·6	183·9	53·6	54·8
Oct. 2	46·14	546·5	156·0	53·00	572·7	201·3	53·1	56·2
3	47·42	545·0	163·6	54·35	571·8	167·4	54·6	59·0
4	46·75	553·0	161·8	53·67	573·2	167·8	56·2	59·2
5	48·43	563·3	161·2	52·06	566·8	162·5	57·6	60·5
6	46·55	551·8	157·0	50·51	572·5	169·4	59·3	62·6
7	47·35	550·8	163·7	51·99	575·6	161·8	54·7	59·7
9	47·62	548·3	160·6	51·99	568·8	162·8	53·5	55·6
10	45·34	552·6	170·3	53·14	572·5	160·4	51·9	54·0
11	47·35	559·2	166·6	51·72	571·6	164·1	50·7	52·2
12	53·54	547·8	164·8	49·51	569·1	137·7	48·5	50·5
13	53·20	546·6	171·2	48·56	568·8	180·7	47·6	51·4
14	54·21	550·4	168·5	50·58	567·5	188·7	48·4	51·4
16	45·81	539·9	170·1	53·07	571·7	163·8	48·8	49·2
17	53·07	547·7	168·9	52·40	583·3	185·9	44·7	45·1
18	47·56	531·2	126·9	61·95	612·5	273·2	38·0	39·1
19	42·84	567·2	179·2	57·17	560·4	222·4	38·0	41·4
20	48·77	536·2	192·9	43·65	589·1	210·4	36·5	43·0
21	51·05	547·2	171·5	52·33	564·9	178·6	40·1	43·7
23	51·19	565·0	163·3	55·36	697·4	367·0	43·4	47·0
24	51·59	543·2	188·9	50·38	559·6	208·7	46·4	50·7
25	53·00	555·2	170·3	63·90	585·4	358·9	43·5	45·5
26	57·91	534·9	223·9	51·19	568·9	257·5	42·2	46·9
27	52·33	550·6	187·0	51·46	590·6	225·3	44·9	47·8
28	50·11	544·8	174·8	51·52	563·1	200·1	45·6	49·5
30	48·70	560·7	176·3	49·30	569·9	278·3	41·3	42·8
31	52·26	561·1	163·5	37·39	586·7	222·5	43·4	43·8

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Nov. 1	49·10	545·6	177·6	50·92	569·7	184·1	42·7	45·3
2	49·91	551·7	177·3	50·45	569·6	169·1	42·7	46·3
3	48·90	554·5	171·9	49·64	572·9	168·1	42·2	41·4
4	50·18	560·2	180·6	50·58	575·2	169·9	35·7	36·7
6	49·98	566·7	169·7	49·84	575·5	177·6	38·3	42·4
7	46·55	571·8	167·2	49·84	576·7	164·2	38·6	41·1
8	48·63	565·7	165·4	50·11	578·0	165·4	36·9	37·8
9	49·17	571·3	153·4	54·01	580·5	196·1	35·3	37·8
10	50·18	560·2	163·1	55·36	583·5	184·6	35·2	37·7
11	51·93	559·0	156·9	48·63	570·4	196·7	39·6	41·3
13	52·33	563·5	157·0	50·98	575·5	186·0	35·6	37·9
14	51·86	567·6	159·3	49·64	568·7	198·2	38·7	40·7
15	51·66	558·8	161·1	50·98	569·1	182·0	38·2	40·6
16	48·97	553·6	165·4	50·92	570·1	191·8	40·4	43·9
17	50·18	512·7	163·3	52·26	605·3	349·4	44·3	46·0
18	51·93	536·8	219·5	51·32	561·7	208·1	43·7	44·1
20	56·16	542·2	196·3	49·51	569·1	204·9	45·6	47·7
21	47·82	564·7	180·5	48·97	586·9	191·3	45·1	46·0
22	51·19	571·1	188·9	50·85	559·1	230·8	42·7	43·8
23	48·43	561·8	197·8	46·01	578·8	225·6	41·9	43·5
24	47·62	558·1	187·3	51·93	579·1	186·6	40·1	42·0
25	51·19	561·6	186·9	49·71	566·1	198·3	36·7	37·9
27	60·13	504·6	212·0	51·46	548·9	195·9	45·4	47·8
28	51·39	547·0	191·5	46·28	572·9	203·9	47·1	48·1
29	48·50	560·6	183·8	51·05	570·1	186·4	48·4	48·3
30	48·09	563·0	181·8	51·93	566·7	196·4	44·4	44·9
Dec. 1	50·04	56·85	175·4	52·46	572·2	195·3	40·8	41·6
2	49·24	565·7	163·3	49·03	572·6	195·9	37·7	39·9
4	47·29	569·1	171·9	50·04	571·7	174·9	42·4	43·4
5	46·95	563·3	169·4	49·64	572·9	175·2	40·5	40·8
6	55·09	559·9	171·1	66·93	565·8	241·8	36·9	36·6
7	48·63	560·0	178·1	50·98	569·6	189·1	35·5	35·8
8	53·20	564·2	172·1	60·20	571·5	222·0	35·0	40·9
9	50·98	564·7	185·7	47·96	558·9	201·2	44·5	47·2
11	49·24	56·10	169·9	46·82	570·6	200·6	49·6	50·6
12	50·51	559·8	175·5	48·16	569·0	204·3	47·4	47·7
13	48·23	559·9	172·8	48·30	564·3	184·6	51·1	51·8
14	51·52	564·7	164·3	46·21	573·6	186·3	51·2	50·7
15	46·68	560·2	175·0	49·30	567·4	186·5	46·7	46·3
16	48·56	569·3	174·9	49·71	572·9	179·6	43·5	43·5
18	48·77	551·5	196·6	49·91	563·2	189·1	38·5	39·6
19	47·08	561·3	172·4	55·56	569·7	186·0	41·9	42·7
20	48·23	561·9	179·4	49·10	571·3	179·7	42·1	41·9
21	52·33	555·3	177·2	50·72	556·7	182·9	35·1	35·5
22	48·36	555·6	180·3	49·00	552·5	178·5	30·0	31·0
23	50·85	564·9	174·2	49·91	577·9	175·1	30·5	33·0
25	48·77	569·3	177·9	50·78	591·8	176·6	37·3	39·5
26	52·46	536·4	171·1	53·88	579·3	198·6	41·4	43·4
27	47·62	562·3	177·7	43·85	581·7	183·5	45·9	46·2
28	46·68	557·3	177·5	49·51	576·1	173·8	37·2	37·3
29	48·77	558·5	232·4	49·10	579·7	180·8	31·6	33·5
30	47·42	559·1	177·5	51·32	574·2	183·1	34·0	34·4

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Jan. 1	46·34	564·5	169·6	52·87	575·4	171·9	33·3	34·0
2	47·76	565·4	167·9	49·71	574·0	169·1	31·6	31·8
3	47·35	559·5	177·3	48·83	572·4	177·0	23·7	24·2
4	54·15	555·9	169·1	46·95	576·2	193·2	24·1	26·6
5	50·31	581·7	177·5	48·83	576·2	170·5	29·1	31·8
6	46·95	561·2	176·5	49·24	576·8	169·8	29·4	30·5
8	52·33	566·1	186·5	47·96	581·8	177·2	31·5	33·3
9	50·98	559·7	165·5	47·69	570·4	187·4	35·6	37·9
10	53·61	562·2	157·3	49·51	575·3	184·4	38·2	39·8
11	49·91	565·4	164·7	54·62	575·4	190·0	38·1	37·4
12	48·50	561·2	174·3	56·03	525·5	171·7	34·7	35·3
13	47·69	566·9	163·1	49·84	581·0	166·6	39·4	41·4
15	49·10	555·3	184·1	49·64	584·8	183·3	38·8	40·5
16	48·63	565·1	167·1	55·29	550·7	221·4	41·7	42·8
17	47·96	565·0	176·5	48·63	569·8	186·3	43·4	44·8
18	47·56	561·7	178·9	49·51	573·3	168·7	42·4	45·0
19	45·94	560·6	175·6	48·90	576·0	161·2	45·1	45·4
20	44·93	556·1	179·9	50·25	574·3	169·3	40·5	40·5
22	45·07	570·5?	159·5	49·91	581·1	155·0	42·9	42·9
23	49·24	567·3	164·1	54·28	567·4	177·6	42·6	45·5
24	48·23	566·5	166·7	50·98	572·9	167·3	47·3	48·4
25	46·68	557·7	162·0	51·32	573·3	177·2	49·2	49·6
26	47·56	554·0	177·7	53·41	580·1	189·7	43·2	43·0
27	47·96	557·2	174·6	54·82	573·2	190·5	38·7	38·5
29	47·89	568·4	169·9	49·51	581·2	174·8	36·2	37·5
30	47·22	565·7	167·4	46·48	604·7	203·5	35·7	36·8
31	47·02	565·1	171·5	48·63	572·6	169·3	37·2	40·7
Feb. 1	45·00	546·1	186·8	49·71	580·3	173·2	36·5	36·0
2	47·62	570·8	170·7	50·04	576·2	162·8	38·1	41·2
3	47·29	571·5	158·3	48·43	574·8	162·8	45·0	46·3
5	46·14	568·0	158·2	48·16	579·3	158·5	47·5	48·0
6	44·53	565·3	161·1	49·98	576·1	158·3	46·1	46·5
7	45·34	566·1	170·6	49·84	578·3	160·9	45·1	46·5
8	45·13	565·0	158·3	49·98	577·9	156·4	46·2	46·9
9	41·77	557·1	160·4	49·84	580·3	163·5	42·4	43·3
10	43·99	565·4	152·6	54·28	580·9	162·8	46·4	48·3
12	43·38	559·5	159·7	52·40	589·2	168·7	40·1	41·7
13	45·87	567·7	153·1	50·51	570·9	175·1	41·5	44·6
14	48·36	568·5	158·3	51·86	575·0	165·7	41·2	43·5
15	46·75	561·4	154·8	50·72	578·6	148·8	47·0	49·7
16	46·88	571·3	150·0	49·77	574·8	157·2	46·1	48·2
17	50·25	566·0	141·4	54·48	576·8	165·7	44·6	47·0
19	47·29	565·8	146·7	56·84	597·5	196·5	48·5	50·0
20	46·28	553·8	169·0	51·52	583·1	190·2	42·8	43·1
21	46·34	557·0	174·4	50·45	558·6	200·1	37·5	38·5
22	50·38	556·2	165·4	61·61	601·0	202·9	42·3	44·8
23	45·94	548·7	192·8	49·44	571·6	172·3	39·9	41·8
24	46·61	550·6	172·2	50·58	577·1	173·1	39·0	42·2
26	47·08	554·4	158·7	50·51	577·2	157·3	35·8	39·6
27	46·95	551·9	159·4	59·59	614·2	244·3	33·4	35·8
28	47·56	553·0	176·1	48·63	569·4	207·3	36·7	40·1

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Mar. 1	49·71	551·2	174·7	49·64	567·3	183·5	37·7	40·9
2	46·88	553·7	166·8	51·19	567·2	181·7	41·1	44·7
3	48·30	550·2	166·7	51·59	580·2	161·7	44·5	48·6
5	48·36	558·0	157·8	50·58	580·3	168·3	46·9	48·5
6	48·30	557·3	158·1	48·77	581·8	165·5	44·2	45·2
7	46·28	565·3	151·3	47·96	581·3	153·6	46·5	46·4
8	52·13	567·4	153·1	48·63	569·8	164·8	39·4	40·0
9	49·30	559·7	155·1	49·64	582·1	157·0	33·2	35·0
10	47·82	553·9	154·7	49·64	581·6	159·3	32·6	37·8
12	46·55	559·9	151·8	51·72	588·6	155·8	44·4	47·7
13	46·21	563·7	138·2	51·05	581·8	154·8	48·5	47·5
14	46·21	563·4	147·4	48·70	584·5	150·8	43·3	46·4
15	45·81	563·8	164·4	52·33	586·2	153·3	48·1	53·1
16	46·55	560·4	156·8	50·58	584·8	152·0	46·8	52·8
17	46·61	562·5	145·9	49·44	582·8	149·3	47·5	51·3
19	48·56	566·3	166·3	55·83	585·4	189·0	45·6	48·7
20	49·57	554·0	165·6	46·34	582·2	196·4	44·9	48·4
21	48·36	555·9	151·6	48·90	576·7	168·8	46·0	51 9
22	49·30	547·4	153·3	48·97	578·7	180·4	45·5	48·4
23	48·90	557·8	156·6	49·03	578·7	170·3	44·1	44·0
24	45·94	553·6	150·5	53·61	590·7	175·1	41·8	43·0
26	46·75	553·9	156·1	50·31	592·5	167·0	41·2	45·2
27	46·48	543·3	144·8	50·98	575·0	156·8	42·1	43·4
28	46·08	550·8	143·6	49·17	581·4	167·8	41·4	41·7
29	42·58	560·7	152·8	46·88	585·1	160·0	39·4	39·8
30	50·72	557·0	152·8	50·65	598·3	194·5	38·6	41·2
31	48·30	556·7	153·0	48·83	582·5	139·6	41·3	45·8
Apr. 2	46·55	544·2	152·4	51·12	586·7	181·9	45·8	49·3
3	49·98	549·9	142·7	49·91	579·3	180·4	46·6	47·0
4	49·71	559·6	145·5	51·32	587·4	173·2	44·5	45·9
5	52·53	552·6	141·4	49·24	572·4	157·5	42·7	43·0
6	45·54	553·7	149·3	51·46	590·2	146·0	44·2	50·2
7	46·88	541·4	146·2	50·18	574·8	163·9	47·4	47·3
9	47·56	560·1	148·2	44·93	594·2	212·7	41·1	41·5
10	48·16	553·7	146·9	50·98	579·5	155·5	39·3	41·1
11	45·13	549·3	156·3	49·71	581·2	160·3	39·7	42·2
12	43·92	550·7	140·4	49·30	582·5	141·5	40·3	43·4
13	43·05	554·6	137·1	50·85	592·0	142·4	39·1	43·6
14	51·19	538·3	140·5	54·08	597·0	159·4	41·8	42·9
16	49·24	553·9	131·9	50·78	592·8	157·4	40·5	44·8
17	42·31	556·2	149·7	49·24	583·9	152·8	35·3	36·0
18	45·94	555·0	144·7	48·97	599·6	165·4	35·1	39·3
19	49·77	560·4	140·9	48·83	589·6	152·2	37·7	41·3
20	46·88	555·4	147·9	47·96	592·6	148·6	37·8	41·1
21	41·84	564·4	119·3	51·52	564·1	147·2	36·3	42·7
23	43·72	554·5	96·0	48·23	587·1	134·2	42·1	45·6
24	45·40	556·9	130·2	48·83	593·2	139·2	44·5	48·2
25	41·16	559·8	143·9	50·45	609·1	142·4	46·8	50·3
26	45·74	559·9	127·6	53·14	580·5	178·2	47·2	50·9
27	44·12	561·4	136·8	49·30	595·0	148·0	47·2	50·2
28	44·32	557·5	135·2	49·37	596·7	158·0	48·2	53·6
30	46·75	566·1	133·8	50·18	603·0	142·0	53·4	58·8

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
May 1	46·34	551·8	121·4	47·35	583·5	153·8	......	......
2	46·01	557·2	138·5	48·97	587·8	140·9	......	......
3	43·92	553·8	134·3	46·95	583·2	169·8	50·7	55·2
4	43·38	569·2	137·9	48·50	586·4	134·6	50·1	55·8
5	50·11	553·6	135·2	47·82	584·7	140·5	50·5	51·1
7	54·28	556·9	138·1	47·49	636·0	220·3	45·4	48·9
8	44·53	563·6	146·9	47·15	587·4	143·1	47·3	50·5
9	55·96	557·2	138·6	46·82	589·1	160·4	48·6	50·7
10	......	......	......	......	......	......	......	......
11	47·49	568·2	135·0	48·56	589·3	155·8	46·9	49·4
12	46·95	576·0	120·5	54·82	602·4	182·2	47·9	53·0
14	48·97	562·1	120·7	45·60	593·5	140·1	54·3	55·6
15	58·58	565·0	122·0	44·93	593·5	143·2	53·0	53·8
16	43·79	570·5	107·7	46·82	597·0	150·5	52·3	53·6
17	42·64	570·8	132·6	48·36	597·6	160·7	51·8	54·6
18	50·92	562·1	128·6	49·77	614·5	159·2	54·4	56·4
19	53·54	562·1	145·1	48·30	595·0	145·9	51·1	54·5
21	47·82	556·4	129·2	50·25	590·2	177·9	49·7	56·3
22	......	......	......	......	......	......	......	......
23	50·31	563·9	130·9	49·71	600·2	145·1	56·1	59·7
24	45·34	561·5	129·8	49·03	592·5	145·9	55·8	59·7
25	43·58	562·6	132·0	52·67	587·9	139·3	57·0	59·4
26	46·82	566·7	126·9	49·30	584·4	167·8	55·3	59·0
28	45·54	565·1	133·7	49·37	619·2	160·4	56·3	61·8
29	47·35	564·7	113·1	47·35	591·0	140·0	57·4	62·5
30	49·24	568·3	137·9	47·82	591·1	143·0	58·8	63·3
31	46·28	562·2	125·4	47·69	591·4	130·7	57·7	60·0
June 1	45·94	573·6	109·2	47·22	594·6	133·5	58·1	61·9
2	49·57	573·2	115·0	46·88	596·9	141·3	58·3	61·5
4	44·12	571·7	129·8	49·10	592·0	140·3	58·7	64·4
5	44·93	563·1	120·0	52·46	632·9	151·1	62·1	65·1
6	44·32	557·0	139·3	50·85	615·3	161·7	58·0	62·4
7	50·65	560·4	113·5	53·74	610·2	213·8	57·4	62·4
8	46·75	554·5	142·3	48·90	600·4	161·7	55·7	56·8
9	44·19	558·4	136·7	49·37	592·6	148·6	51·8	55·9
11	44·39	563·1	127·3	52·26	608·2	139·1	50·5	54·5
12	44·53	564·0	136·1	50·45	600·4	153·6	50·3	54·2
13	44·26	560·2	122·0	56·30	670·7	247·5	53·4	58·2
14	46·75	552·3	132·2	50·38	596·1	157·5	55·3	60·0
15	42·31	563·5	140·2	48·63	586·3	150·4	55·5	58·8
16	46·95	564·9	138·1	47·15	589·5	140·9	54·7	58·2
18	43·85	568·2	130·9	46·88	596·2	138·8	57·1	58·9
19	48·43	567·5	133·6	49·30	591·2	147·0	55·5	57·8
20	51·99	580·9	124·1	49·17	600·5	150·6	51·6	57·0
21	45·07	570·6	108·1	51·86	595·3	136·0	56·6	58·8
22	41·30	563·8	134·3	49·24	598·4	144·1	57·2	58·5
23	43·65	559·7	130·6	50·92	592·5	135·3	57·1	59·7
25	48·36	575·6	131·4	48·63	591·6	162·1	58·7	62·5
26	44·73	564·9	126·6	50·65	593·6	141·5	61·6	65·4
27	44·86	571·7	116·4	47·02	618·1	153·1	61·4	62·5
28	47·08	563·8	120·3	51·12	599·0	144·9	57·1	60·4
29	43·72	570·7	133·4	45·34	589·8	141·2	57·3	60·1
30	45·27	567·8	129·9	46·48	592·7	161·0	55·1	59·2

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
July 2	46·95	572·9	114·4	47·29	592·8	127·9	56·8	59·8
3	41·37	568·2	112·4	49·24	634·3	141·9	59·1	61·2
4	45·60	560·6	126·3	49·64	622·3	152·6	57·4	59·1
5	44·46	560·9	126·1	50·45	600·0	145·6	56·9	61·3
6	44·59	563·5	124·8	46·41	607·2	142·2	57·3	61·1
7	42·44	560·7	128·0	47·82	588·7	137·9	61·2	64·2
9	44·39	565·8	117·7	49·24	597·6	131·8	61·4	64·5
10	42·91	557·8	125·4	48·83	586·0	135·9	62·6	67·3
11	43·65	558·1	132·4	50·18	586·8	126·8	66·0	70·9
12	45·40	572·5	125·3	47·22	596·7	186·2	64·9	67·5
13	51·25	571·5	122·2	45·34	615·7	240·9	62·9	66·5
14	44·46	560·0	136·6	42·71	583·9	138·5	61·6	66·2
16	45·87	556·2	131·0	46·82	593·4	137·1	61·7	67·6
17	44·93	564·3	133·4	46·61	583·4	134·0	64·0	66·4
18	46·01	563·5	122·9	48·90	603·5	134·8	60·6	61·8
19	45·47	558·8	124·0	46·82	589·4	143·8	58·9	63·0
20	44·26	556·6	124·6	48·43	600·0	133·4	59·6	64·2
21	44·53	560·1	112·9	48·16	603·3	133·1	60·0	62·4
23	45·13	549·5	131·0	48·43	594·0	134·4	60·9	61·9
24	43·32	570·2	125·7	47·22	606·2	157·6	56·7	61·1
25	43·65	548·9	135·0	47·29	595·1	142·7	57·8	61·5
26	42·24	564·6	132·0	46·95	588·9	136·8	59·7	62·8
27	43·99	564·6	130·5	46·08	603·5	149·5	58·2	62·7
28	44·19	570·4	127·9	45·00	589·1	152·4	58·4	62·1
30	43·25	567·9	130·3	44·06	585·4	141·0	60·1	63·0
31	45·94	567·5	120·1	46·28	623·9	138·1	58·4	61·5
Aug. 1	46·88	555·3	127·8	47·02	587·1	146·3	57·9	62·3
2	43·99	564·9	121·1	47·96	582·0	135·4	58·8	62·4
3	43·32	565·2	122·7	48·16	582·6	136·1	57·5	59·6
4	46·08	563·2	124·5	49·03	591·9	132·6	55·0	58·8
6	44·12	571·3	125·7	46·68	591·4	133·5	61·5	66·3
7	43·45	559·6	122·7	49·57	591·2	128·4	61·2	64·0
8	44·79	566·1	120·4	49·98	602·4	133·8	62·8	68·1
9	41·57	570·9	121·4	50·98	610·6	133·2	65·6	70·3
10	47·69	565·1	121·6	47·15	592·2	158·6	65·2	67·3
11	44·26	563·1	121·2	43·25	599·3	146·6	63·8	65·6
13	41·03	567·1	122·5	48·70	588·4	147·5	62·3	63·4
14	44·26	555·2	126·9	46·61	589·6	139·6	60·0	61·8
15	42·98	566·1	124·8	45·67	595·7	138·4	57·5	61·1
16	44·12	567·4	128·1	45·87	594·3	125·4	57·4	59·6
17	43·65	563·7	123·6	45·27	591·4	127·7	54·9	58·7
18	49·17	564·1	112·9	45·67	583·8	136·8	55·7	59·5
20	46·55	561·2	117·3	49·84	584·4	139·8	59·1	62·0
21	45·27	571·9	117·9	46·34	592·0	125·8	61·0	65·2
22	46·01	561·8	116·8	44·32	588·1	150·6	62·0	64·6
23	46·75	554·8	123·9	44·06	584·3	138·8	57·5	60·8
24	46·55	557·2	131·4	46·48	585·5	135·5	54·0	59·5
25	47·15	567·7	129·0	43·38	582·5	140·9	58·0	61·7
27	46·82	576·8	115·6	50·72	603·8	124·1	58·6	61·5
28	46·08	569·1	114·4	46·01	590·7	131·2	56·2	60·2
29	45·67	567·1	113·4	42·17	588·6	123·5	61·3	67·7
30	43·38	573·1	123·0	43·18	586·5	128·4	63·8	64·2
31	44·39	566·0	123·3	44·32	586·8	124·2	61·2	63·5

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Sept. 1	45·54	566·0	122·9	42·84	585·9	132·2	60·4	64·8
3	48·90	568·4	117·8	43·38	596·0	134·4	60·1	65·7
4	52·73	556·9	119·2	46·68	592·6	161·8	61·2	62·0
5	44·59	559·1	131·5	43·79	589·0	132·7	59·5	63·6
6	44·39	563·3	117·8	45·20	583·1	124·4	59·4	58·9
7	42·10	569·2	118·2	48·43	586·3	121·8	53·6	56·4
8	44·19	565·4	115·1	42·51	596·6	145·0	49·7	56·8
10	42·51	560·4	120·9	48·30	590·4	130·9	53·8	54·7
11	43·65	564·1	120·9	46·34	583·9	125·6	52·6	53·7
12	45·00	569·3	114·1	48·23	588·4	128·9	50·7	57·6
13	44·93	548·5	105·5	38·87	614·6	179·4	54·0	57·0
14	46·41	568·8	123·3	44·59	585·9	142·0	54·5	57·1
15	44·19	561·6	124·7	42·64	578·1	126·6	54·5	57·1
17	42·91	556·1	129·1	39·07	596·4	192·7	50·5	54·7
18	43·25	536·4	135·8	37·59	626·2	186·4	50·4	54·2
19	54·41	546·5	122·1	44·86	582·9	188·2	49·6	54·7
20	42·78	560·3	121·9	42·91	579·2	134·5	53·8	56·5
21	43·65	560·8	122·4	48·70	590·9	132·1	53·6	54·6
22	44·26	571·4	121·8	45·07	584·5	120·2	54·5	55·2
24	43·65	566·4	114·2	49·30	582·5	148·1	55·5	60·0
25	44·59	560·0	125·9	42·91	563·7	156·2	56·4	57·6
26	42·51	567·7	127·7	46·34	584·1	134·6	53·5	56·1
27	43·32	558·6	124·0	43·11	587·8	116·3	55·4	58·0
28	40·49	557·2	128·5	45·94	572·9	141·9	55·9	56·6
29	42·91	566·6	120·3	43·72	582·0	120·3	55·0	56·0
Oct. 1	47·89	566·4	118·7	45·20	587·2	164·8	47·3	49·0
2	44·06	571·6	118·4	45·87	588·3	149·3	42·9	47·5
3	46·08	567·8	125·3	44·06	585·5	129·2	42·3	43·3
4	42·58	565·3	120·5	41·57	585·9	123·9	42·5	45·6
5	41·90	563·2	120·0	45·20	585·7	123·5	40·0	45·0
6	41·63	569·6	113·8	44·32	590·5	120·2	38·4	44·7
8	44·46	564·7	116·4	44·53	580·2	127·5	43·0	45·7
9	43·18	568·4	109·9	45·40	588·5	117·1	42·5	47·3
10	50·38	563·9	108·3	48·63	573·4	140·5	41·2	46·0
11	45·00	558·8	109·5	46·01	583·8	160·7	39·5	44·5
12	44·26	565·9	120·8	42·98	581·0	118·8	42·1	44·8
13	45·13	574·3	115·3	46·48	585·7	141·0	41·2	44·8
15	43·58	565·1	139·4	41·90	582·1	138·7	40·8	46·0
16	44·79	567·7	121·2	46·28	583·4	152·4	43·1	46·0
17	44·26	569·4	117·6	44·12	586·2	120·3	40·3	45·3
18	49·51	558·5	106·1	44·53	587·4	135·6	52·1	54·6
19	41·97	562·4	116·0	44·93	586·9	174·0	54·1	58·1
20	43·72	564·7	115·0	43·92	576·9	147·8	54·9	55·8
22	51·39	561·0	119·5	43·52	600·4	239·9	47·2	48·0
23	45·67	555·5	135·7	43·79	582·4	133·8	61·8	53·5
24	45·67	550·4	130·0	44·12	577·1	166·5	50·0	50·7
25	40·83	565·9	123·2	46·61	580·2	156·9	51·8	54·1
26	48·09	568·5	125·4	40·63	583·4	139·6	54·0	56·1
27	45·20	566·2	131·4	43·92	582·3	140·2	48·8	50·8
29	44·32	560·5	131·4	45·20	582·9	127·9	45·1	47·2
30	44·79	572·6	113·6	45·13	583·4	131·9	51·3	52·7
31	46·01	555·3	123·6	......	572·7	131·7	48·0	49·2

Göttingen Mean Time. Civil Day.	11 A.M. Decln. 24° +	11 A.M. Bifil. Corrected.	11 A.M. Balce. Corrected.	5 P.M. Decln. 24° +	5 P.M. Bifil. Corrected.	5 P.M. Balce. Corrected.	Temperature of Bifilar and Balance. 11 A.M.	Temperature of Bifilar and Balance. 5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Nov. 1	45·47	572·2	125·5	44·46	578·4	132·5	46·1	47·5
2	43·92	568·3	127·5	44·86	586·7	129·2	43·5	44·3
3	47·49	578·0	120·8	45·27	586·9	120·2	44·0	45·1
5	44·73	573·1	117·8	44·19	588·0	131·1	42·6	43·7
6	43·99	575·8	118·4	57·58	587·3	133·0	38·8	39·8
7	43·65	570·1	125·1	43·52	586·4	126·1	34·1	35·1
8	43·72	577·0	115·5	43·85	588·3	116·3	39·0	45·6
9	42·58	576·6	116·2	43·92	588·0	114·3	50·6	52·3
10	42·78	577·8	112·7	47·49	596·4	108·6	52·2	52·9
12	43·99	574·6	112·9	48·09	583·1	128·2	53·1	53·1
13	47·02	568·3	113·2	49·44	579·5	206·1	51·0	51·0
14	44·73	564·1	126·9	45·07	583·4	101·5	44·0	44·4
15	42·37	574·7	126·8	45·07	586·4	120·8	40·3	42·7
16	43·72	579·0	108·4	44·73	578·9	132·1	40·5	42·0
17	44·26	575·1	118·7	45·27	589·4	123·0	37·3	39·1
19	43·72	579·7	114·3	52·53	576·0	165·7	47·9	48·2
20	42·58	575·8	113·0	46·48	583·4	128·2	47·2	48·5
21	43·72	573·3	116·2	44·39	584·5	127·7	46·8	47·0
22	47·49	568·6	122·5	45·94	577·9	143·6	45·4	45·1
23	45·40	571·1	119·5	43·18	586·6	125·3	42·4	43·2
24	45·47	570·8	117·7	41·23	564·7	138·9	39·0	40·5
26	42·78	579·8	111·9	45·81	580·9	149·1	34·4	35·9
27	53·34	558·3	117·3	45·00	585·0	158·7	34·6	34·6
28	52·80	584·8	136·0	47·35	585·7	137·1	30·3	30·9
29	44·46	562·1	124·4	27·11	590·4	186·7	26·9	28·6
30	53·81	568·9	150·3	44·19	582·1	121·1	36·7	40·0
Dec. 1	49·51	554·6	147·9	45·87	599·3	266·1	36·3	36·9
3	43·45	575·1	119·4	43·58	586·1	127·0	40·5	40·1
4	44·06	572·3	122·5	44·93	586·5	121·9	36·1	36·5
5	42·71	580·7	115·7	43·05	586·1	120·9	34·6	34·8
6	42·78	580·4	112·9	43·25	588·3	117·8	36·6	39·0
7	41·90	580·9	112·2	42·91	593·1	113·8	38·9	41·1
8	43·99	581·2	109·5	42·44	589·8	115·8	41·1	41·2
10	43·52	583·8	112·1	44·79	579·9	135·6	41·3	41·4
11	44·32	583·5	103·5	46·88	593·6	117·2	39·1	39·8
12	42·71	582·1	113·2	47·42	595·7	155·1	37·9	38·4
13	42·64	580·1	119·9	44·26	585·2	126·8	37·2	37·8
14	43·18	582·6	115·6	43·25	586·7	119·3	36·9	40·8
15	43·92	583·6	110·3	43·25	588·4	119·8	43·9	44·1
17	42·37	585·5	105·7	43·65	590·9	111·6	45·8	45·9
18	43·45	583·7	109·7	43·85	590·8	106·8	44·9	44·5
19	43·58	583·2	111·4	43·38	590·5	113·6	41·6	42·1
20	43·85	587·5	106·8	58·32	583·7	137·4	38·5	39·2
21	45·81	578·7	109·4	42·58	585·1	125·4	37·0	37·0
22	50·31	575·8	115·0	47·56	583·2	146·8	35·3	35·8
24	45·60	573·4	117·3	42·98	589·4	117·2	35·1	36·9
25	43·18	573·7	115·6	42·84	589·1	113·6	36·5	37·7
26	42·44	580·0	111·1	43·25	591·6	109·8	39·0	40·1
27	44·12	578·2	109·9	44·39	586·9	116·3	38·4	38·0
28	44·59	586·2	107·3	45·40	598·8	109·1	29·3	28·6
29	49·03	570·0	106·3	47·82	588·9	131·5	28·3	31·6
31	43·52	577·7	115·3	43·99	587·8	125·6	31·5	33·1

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Jan. 1	43·11	586·2	106·9	42·24	590·2	118·5	30·5	31·9
2	47·56	574·0	104·3	42·71	589·3	114·8	32·7	34·1
3	45·27	583·1	104·7	43·18	590·5	123·8	37·4	40·1
4	45·07	575·1	106·3	44·46	590·0	113·4	39·4	39·2
5	43·79	574·5	116·9	42·78	592·6	122·7	35·8	36·5
7	43·25	577·6	110·7	44·32	585·9	121·2	29·4	31·4
8	42·64	558·2	108·0	......	......	......	28·2	......
9	43·58	579·4	105·0	43·38	590·1	114·5	26·7	28·3
10	42·10	579·6	105·4	42·64	591·5	108·0	30·2	31·2
11	42·10	580·7	106·3	42·78	592·1	109·5	30·9	31·2
12	42·04	583·8	106·0	43·85	597·9	115·3	31·9	32·5
14	43·32	584·3	98·6	43·72	592·0	111·4	31·4	32·1
15	41·30	581·6	102·8	42·84	592·3	114·5	28·3	30·3
16	40·96	581·8	102·9	45·54	594·0	107·6	30·5	32·0

Göttingen Mean Time.	11 A.M.			5 P.M.			Temperature of Bifilar and Balance.	
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	11 A.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°
Jan. 17	41·57	579·9	100·2	42·98	594·9	106·9	32·4	34·1
18	40·89	578·2	102·8	45·40	589·5	119·0	25·0	25·5
19	46·14	583·4	103·2	44·26	588·0	120·3	30·9	32·5
21	43·79	571·5	118·5	42·84	585·1	116·0	30·5	30·9
22	42·24	579·4	115·3	42·91	593·0	115·9	31·1	33·5
23	44·73	578·5	104.9	47·82	589·3	128·0	37·5	40·4
24	43·65	594·4	112·7	44·59	583·7	116·8	38·7	40·8
25	41·03	599·6	104·9	41·50	598·1	115·0	38·8	39·1
26	43·25	581·9	100·6	45·13	582·5	116·4	39·1	37·7
28	47·02	580·6	92·4	44·79	575·4	167·5	36·8	40·9
29	42·24	570·3	103·4	47·89	584·8	122·4	40·4	40·8
30	41·97	575·1	110·1	42·58	589·2	115·5	34·5	35·0
31	43·05	581·7	103·9	47·62	587·5	119·8	34·1	34·9

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Feb. 1	......	......	......	40·42	573·6	121·9	46·82	581·3	113·8	49·30	583·0	148·0	......	38·8	40·2	41·5
2	43·92	594·3	97·2	48·09	574·7	99·5	56·37	578·0	193·1	57·51	600·4	236·4	42·6	43·0	43·7	44·3
4	38·06	581·3	116·1	43·52	568·4	120·1	48·36	579·1	123·0	41·37	591·0	133·2	40·5	40·1	41·2	42·8
5	39·01	583·0	111·0	44·59	572·6	112·6	49·03	579·1	113·5	43·85	586·1	121·4	40·2	39·4	39·6	40·3
6	45·07	588·7	87·5	43·38	579·3	108·1	51·86	587·0	114·2	53·34	580·4	144·3	38·6	38·4	39·4	40·8
7	40·56	577·1	115·3	42·37	577·6	120·7	46·88	576·5	120·5	43·65	588·5	115·0	36·6	36·1	36·5	38·0
8	38·60	590·3	108·5	40·01	579·6	109·9	50·04	591·2	113·3	43·92	597·9	118·5	36·2	36·1	36·2	37·8
9	41·57	588·9	106·9	41·16	575·8	109·8	47·49	582·1	108·5	44·06	591·2	123·2	43·1	44·2	44·8	44·8
11	39·34	592·8	100·9	41·77	574·5	111·6	46·75	582·9	114·2	43·58	592·8	105·5	38·4	38·5	38·3	38·2
12	39·54	586·1	98·7	42·31	581·5	104·0	48·36	582·7	106·5	46·82	594·9	108·7	34·9	34·8	35·9	37·1
13	38·60	581·2	100·1	41·23	569·8	101·9	46·48	582·7	105·0	43·18	589·8	102·1	33·4	32·7	33·7	36·6
14	38·60	590·3	103·8	42·37	569·0	108·5	49·84	581·2	106·8	45·94	588·2	112·4	36·0	37·0	38·0	39·9
15	39·21	588·0	104·6	41·57	570·9	97·7	49·37	581·2	99·7	46·08	588·1	110·2	45·0	45·4	47·4	48·5
16	37·59	592·9	93·0	41·37	575·2	93·7	48·97	580·9	102·7	43·45	592·4	113·4	46·5	45·7	46·0	45·8
18	37·59	595·7	99·7	40·01	580·7	104·2	47·08	586·9	100·8	44·32	594·0	102·3	46·8	46·8	47·2	47·5
19	41·16	589·6	90·8	41·77	581·3	98·2	48·23	581·7	102·6	44·76	591·0	108·5	46·8	46·9	47·0	47·4
20	38·20	590·3	99·3	40·56	584·4	88·7	47·15	587·3	91·9	43·92	598·2	95·8	47·4	47·1	47·5	48·2
21	38·74	593·3	99·5	39·68	580·8	101·3	47·08	587·6	88·2	44·73	595·3	95·5	44·1	44·2	45·7	47·1
22	41·57	593·2	82·8	43·72	577·4	94·1	46·82	579·1	99·4	48·03	607·4	110.2	47·8	48·0	48·9	50·2
23	36·85	580·8	100·8	40·76	583·3	105·0	44·26	582·7	187·5	50·18	610·0	245·6	46·7	46·5	46·8	47·1
25	41·77	580·3	102·8	40·70	574·2	110·8	47·89	582·5	113·2	43·92	589·1	107·5	43·6	43·2	43·9	45·5
26	38·94	587·5	101·4	40·36	566·9	102·6	50·92	581·4	104·0	45·07	592·0	108·3	44·2	43·6	45·6	47·0
27	38·87	585 6	104·5	41·16	572·0	104·2	51·59	586·8	94·2	44·19	596·1	111·3	46·8	46·8	47·3	48·1
28	38·20	586·0	105·1	42·04	568·4	104·9	48·43	585·5	106·9	42·91	587·9	109·6	45·5	44·6	45·4	46·1

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	37·19	590·0	103·4	41·23	570·0	103·0	53·61	585·2	104·3	49·44	604·7	133·7	45·3	45·5	46·8	48·7
2	36·85	579·5	98·4	40·70	565·4	106·7	47·42	576·9	105·7	42·58	585·5	114·8	47·9	47·8	48·1	48·7
4	39·01	584·3	95·0	45·34	576·9	92·4	51·05	573·5	100·5	48·23	578·5	143·9	41·1	40·0	40·3	41·5
5	40·36	564·8	99·5	42·17	562·4	103·8	48·90	577·8	103·3	43·32	568·8	112·6	39·6	40·0	41·1	42·5
6	38·74	588·8	106·2	39·41	567·5	108·6	49·77	582·7	98·2	44·59	589·2	107·7	45·7	46·7	48·8	50·8
7	38·06	589·1	104·7	40·49	574·3	104·8	50·25	577·7	98·8	46·08	588·7	103·0	49·4	49·3	50·6	52·5
8	37·53	586·3	106·7	39·14	569·4	105·6	49·30	573·0	98·6	45·00	589·4	103·9	48·6	48·0	49·5	53·0
9	51·32	590·8	106·2	40·22	573·0	103·5	52·06	585·5	99·3	49·24	583·8	121·0	49·2	48·3	47·9	48·0
11	42·98	583·4	99·9	45·94	561·4	104·8	55·15	581·8	115·5	50·78	602·2	140·4	42·4	41·7	43·1	45·4
12	35·64	582·6	110·5	40·42	562·4	113·2	46·34	576·7	115·0	49·03	589·0	135·9	40·8	40·0	41·3	44·7
13	38·47	583·0	105·3	40·36	556·8	99·3	50·85	579·3	108·8	44·26	576·3	131·7	42·0	41·5	43·7	46·6
14	48·83	574·7	90·3	40·56	571·6	90·7	49·57	570·6	101·0	44·19	586·1	104·2	46·6	46·5	46·9	47·8
15	38·20	586·4	97·9	40·22	574·3	100·9	50·58	580·2	97·9	45·00	588·9	114·4	45·6	45·3	46·4	48·3
16	35·44	594·6	97·7	42·64	572·2	105·9	52·33	582·9	98·2	49·24	600·7	112·8	46·5	46·4	46·7	47·3
18	37·46	587·5	108·3	41·50	589·1	101·6	48·70	579·1	104·3	43·52	589·3	104·4	38·8	38·6	39·6	41·8
19	37·19	590·6	100·3	40·96	573·1	112·4	48·36	587·8	87·6	44·32	594·0	100·8	43·2	43·6	44·9	46·5
20	37·66	592·8	97·6	40·83	575·1	96·4	47·69	589·5	86·2	43·05	595·8	98·3	44·9	44·8	46·0	47·8
21	36·38	590·0	98·0	40·76	575·4	90·7	50·25	579·2	94·3	40·56	589·2	109·0	44·3	43·9	44·2	44·7
22	37·32	592·9	104·4	40·89	574·9	101·5	51·52	585·2	96·5	45·00	593·7	102·0	42·6	42·8	43·4	45·0
23	36·32	591·0	103·8	39·48	576·8	99·5	50·38	584·9	92·3	46·08	592·5	105·9	41·3	39·9	40·2	41·0
25	39·27	587·5	72·5	52·60	554·4	88·3	52·60	566·6	122·1	44·12	576·7	106·7	31·0	30·7	32·8	36·5
26	36·45	578·8	108·1	42·10	561·8	106·8	48·97	587·5	108·8	44·19	593·2	118·8	35·6	35·7	37·9	41·1
27	35·37	583·3	99·0	40·49	568·8	99·7	53·88	580·9	101·4	42·84	609·5	115·5	37·3	36·9	38·0	39·8
28	34·84	579·9	101·9	40·36	563·8	102·1	50·78	576·9	105·4	45·27	593·6	96·6	34·0	33·4	35·7	40·5
29	35·58	590·4	103·9	39·54	564·7	99·6	48·43	584·0	87·3	47·22	598·1	112·6	35·5	35·3	37·6	40·8
30	36·65	590·0	108·0	39·21	566·0	101·1	47·42	580·7	86·6	45·40	595·0	96·2	38·8	38·7	39·3	40·2
Apr. 1	36·52	580·2	71·4	38·80	561·1	93·6	52·40	568·2	105·2	46·88	601·0	152·8	43·7	44·8	47·0	48·5
2	38·00	588·7	92·7	38·87	568·2	92·2	51·93	581·7	80·8	44·86	598·9	94·9	47·0	46·7	47·3	48·7
3	36·38	581·4	83·4	42·04	573·7	92·3	51·12	584·4	88·4	44·26	594·1	96·7	48·6	49·0	50·0	51·3
4	35·98	588·5	100·8	40·01	575·7	108·6	47·62	581·2	70·4	42·91	590·7	95·0	50·0	50·5	52·1	52·6
5	35·84	590·3	92·2	40·70	572·4	90·4	47·29	586·2	80·5	43·72	597·0	83·3	51·5	51·5	52·3	54·2
6	34·90	588·9	104·3	39·54	577·4	82·7	49·24	593·3	88·6	43·92	605·7	100·8	48·5	46·9	48·1	48·8
8	35·84	580·2	92·5	41·43	567·5	98·9	50·31	570·0	101·5	34·90	625·1	139·1	49·6	50·2	52·2	53·9
9	35·44	578·9	84·6	43·85	568·2	100·2	48·43	580·3	86·4	44·53	591·1	84·5	50·9	50·9	51·8	52·3
10	35·04	580·9	94·0	41·63	580·6	91·2	49·10	573·4	113·8	43·25	599·7	108·5	49·2	49·0	49·7	51·0
11	36·92	580·6	94·4	39·68	567·6	105·0	44·83	582·9	80·1	44·53	605·4	105·4	43·8	42·7	45·4	49·0
12	35·37	589·4	103·2	39·21	560·4	87·0	51·25	576·0	85·7	44·76	605·5	101·2	45·7	45·4	46·3	48·8
13	34·90	591·3	104·5	39·81	567·9	104·0	51·93	580·7	92·8	44·26	600·3	101·3	45·0	44·4	45·7	49·7
15	37·53	593·8	100·5	38·67	565·8	96·4	51·99	578·1	76·9	46·21	604·4	93·1	45·0	44·8	44·8	44·9
16	35·78	587·6	100·1	39·68	564·6	63·9	51·86	578·4	81·6	45·00	598·8	96·1	43·6	44·2	46·1	48·7
17	34·70	588·5	84·1	37·73	568·9	87·9	50·25	580·5	94·4	43·79	591·7	99·5	46·4	46·7	48·7	51·3
18	33·89	586·5	97·7	38·06	569·0	94·5	49·10	582·5	83·2	42·64	596·8	99·0	48·0	48·5	50·7	53·4
19	36·99	592·7	85·1	40·76	572·8	85·9	50·51	590·2	80·8	45·27	600·0	91·2	51·2	51·4	53·0	55·8
20	32·21	589·7	79·6	42·98	569·2	84·5	49·91	579·8	93·7	47·96	597·7	133·3	51·1	50·4	50·3	50·3
22	35·04	585·3	84·6	40·36	571·2	98·2	46·82	581·5	75·0	45·54	590·8	90·6	45·4	45·5	46·5	47·6
23	32·68	586·7	93·3	41·30	566·1	96·3	50·78	580·0	88·9	49·17	595·6	90·3	44·2	44·6	45·9	47·6
24	33·02	583·8	98·0	38·80	569·9	86·1	48·23	583·3	85·6	42·17	598·4	95·0	42·2	42·7	44·5	46·7
25	35·44	588·2	90·7	39·81	577·2	82·6	48·97	577·2	85·9	44·46	593·1	96·2	44·5	44·3	44·6	46·0
26	35·78	589·3	97·1	39·88	573·4	85·9	47·96	580·0	78·2	43·45	596·2	93·4	44·0	44·3	45·3	46·4
27	34·70	594·2	91·3	39·54	579·3	74·5	40·49	592·0	80·0	45·87	603·7	81·6	45·1	46·1	48·5	50·8
29	37·53	582·7	98·4	43·11	579·1	89·3	49·10	589·4	89·3	44·26	598·3	112·2	43·0	43·3	44·4	45·3
30	34·90	590·0	101·7	40·76	575·3	94·1	49·37	582·6	80·9	44·73	600·8	109·7	43·2	43·7	45·3	46·2

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
May 1	34·03	590·0	86·6	39·14	574·4	92·9	46·21	583·8	98·2	44·86	600·0	86·4	45·2	45·3	45·9	47·1
2	35·24	593·2	84·0	41·77	575·6	119·9	49·17	589·2	83·4	38·67	602·0	85·6	42·0	42·3	45·6	48·8
3	38·40	591·8	89·9	41·50	578·6	77·3	52·87	588·4	73·8	50·11	628·0	94·3	45·2	46·0	48·7	51·7
4	38·94	570·4	87·4	46·14	564·6	85.4	51·05	584·8	94·9	43·65	599·1	109·7	46·4	46·5	47·4	48·4
6	33·09	581·8	92·3	41·97	569·2	83·3	45·67	585·3	82·2	39·27	599·4	92·1	40·5	40·9	42·8	45·1
7	34·30	584·4	96·5	41·03	571·9	79·6	50·58	582·3	77·0	45·07	603·5	87·9	40·7	40·9	43·9	47·6
8	32·62	556·4	78·1	46·14	530·7	90·3	52·73	600·9	97·9	44·73	596·9	141·5	44·9	45·0	47·0	49·5
9	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……
10	35·31	587·6	80·3	43·99	577·9	78·2	48·97	588·9	82·9	40·96	607·8	91·3	43·4	44·4	46·7	48·5
11	31·41	576·1	94·9	41·63	565·4	77·0	……	……	……	41·63	599·3	91·1	48·9	49·1	……	52·5
13	31·94	588·1	91·4	43·79	568·0	82·3	……	……	……	43·11	634·2	148·9	48·0	47·9	……	50·1
14	34·16	583·4	94·8	41·37	564·6	76·0	48·16	588·8	71·3	40·22	611·6	108·9	48·2	48·5	49·7	50·7
15	32·41	578·6	82·3	42·51	567·0	64·4	50·98	581·2	73·0	44·32	598·0	83·0	44·6	44·9	46·4	48·0
16	34·84	586·1	79·2	42·51	564·3	68·4	49·24	587·5	64·9	45·34	599·2	85·0	46·5	47·1	49·3	51·2
17	36·25	585·3	66·5	33·42	569·1	71·5	47·56	584·5	67·0	45·20	606·4	75·9	50·9	51·6	54·0	55·8
18	33·70	581·9	80·1	39·61	569·5	78·6	48·36	585·9	75·5	43·32	611·5	85·3	53·1	53·4	54·1	54·7
20	32·41	574·6	67·6	38·06	581·8	70·7	46·21	577·3	78·3	41·63	593·2	83·2	51·2	51·3	51·6	52·0
21	35·31	578·2	77·2	39·61	570·3	64·8	48·30	595·4	69·2	41·30	601·1	81·2	50·0	49·9	52·1	56·2
22	32·41	581·3	93·4	38·94	574·8	83·0	47·49	591·1	74·9	41·97	610·5	87·5	54·1	54·1	55·7	58·4
23	33·76	581·4	82·1	41·37	571·0	68·3	49·30	590·2	65·1	42·57	600·2	80·5	54·9	55·3	58·0	60·1
24	38·40	589·8	81·9	40·89	585·7	—32·5	47·89	595·0	68·7	41·97	604·2	85·2	55·2	55·3	57·0	60·4
25	34·23	583·2	79·9	41·03	578·5	70·6	46·68	586·9	68·8	39·81	601·5	-110·9	56·0	55·4	55·3	55·4
27	29·80	591·5	77·0	39·14	573·6	64·0	50·78	586·3	75·8	45·60	614·0	83·8	54·4	55·1	56·6	59·2
28	39·34	579·6	61·2	42·37	572·8	54·4	51·46	578·6	68·9	44·59	594·9	89·2	57·6	58·2	60·2	61·9
29	34·16	588·1	67·5	39·61	577·1	64·2	47·49	587·8	70·7	45·47	606·7	82·9	57·6	58·1	59·2	60·8
30	34·10	584·9	77·1	42·84	579·9	67·2	48·43	584·4	59·1	43·79	597·3	77·3	57·6	58·3	60·9	63·2
31	32·68	585·5	85·9	41·90	574·0	67·9	46·95	594·9	65·5	42·78	602·9	81·5	57·7	57·5	59·5	62·5
June 1	34·63	580·0	76·0	42·51	582·0	52·9	48·90	594·9	61·7	46·21	608·2	68·7	58·7	59·4	62·6	66·5
3	33·96	574·1	96·0	44·53	575·4	78·0	47·49	589·3	74·3	43·92	622·0	106·0	65·3	66·8	68·1	71·7
4	31·61	569·6	90·9	42·51	588·4	72·1	49·44	584·9	87·2	42·58	594·7	111·7	66·3	66·7	68·7	71·4
5	30·00	576·7	98·4	47·82	577·0	85·4	48·16	586·2	87·9	46·55	593·2	86·9	67·7	66·6	67·0	67·8
6	33·29	564·0	91·2	43·05	578·9	95·1	50·78	607·7	98·7	48·77	634·6	155·5	61·7	62·1	63·2	63·5
7	31·54	579·5	53·8	39·48	572·8	50·4	45·67	587·9	88·5	44·26	605·4	102·4	57·7	58·6	60·4	61·3
8	34·70	584·7	95·1	40·36	567·5	95·6	53·00	575·7	97·4	42·91	602·5	139·8	56·8	57·0	58·1	60·2
10	34·50	584·0	112·3	42·31	569·1	103·5	46·61	584·2	102·7	38·00	610·2	113·7	58·2	58·6	59·5	61·8
11	33·56	579·1	94·3	40·42	561·2	75·9	49·98	580·3	83·4	46·75	605·3	116·7	59·8	60·1	61·8	63·2
12	34·43	584·2	106·5	41·97	568·5	105·3	49·77	584·7	92·5	43·65	606·9	108·6	59·3	58·9	59·0	60·0
13	32·21	587·7	108·7	38·67	577·0	86·3	48·56	589·0	79·7	43·32	627·2	89·4	56·5	56·9	58·3	60·5
14	32·89	575·5	108·4	41·37	567·3	109·4	48·63	593·9	102·9	45·13	615·7	96·0	57·1	57·0	56·8	56·1
15	34·23	570·4	101·7	42·71	568·3	97·7	47·35	580·6	95·0	42·31	602·4	112·8	50·5	50·9	52·4	54·4
17	30·00	583·4	96·6	32·28	577·5	94·0	48·30	588·6	93·4	36·65	602·3	99·3	54·9	55·1	56·2	58·2
18	33·89	591·3	101·3	42·17	567·3	97·7	48·77	597·7	84·3	43·99	601·3	111·7	57·9	58·3	61·2	64·1
19	32·35	580·5	99·9	38·80	574·3	99·6	47·29	591·4	93·7	38·00	595·2	110·0	61·4	62·0	64·3	65·2
20	34·43	581·5	102·2	40·08	572·3	96·0	46·75	583·4	87·6	43·25	594·4	105·8	63·0	63·7	65·7	67·9
21	31·54	580·6	100·0	40.01	578·6	88·4	45·07	591·9	101·1	40·89	595·4	125·4	63·1	63·0	63·7	63·8
22	32·35	579·4	100·9	39·88	571·1	97·3	47·56	594·8	91·4	41·57	604·8	99·6	60·2	61·1	62·3	63·2
24	31·88	584·7	92·0	39·21	580·5	87·3	47·49	592·9	77·1	44·73	601·5	95·0	64·9	65·8	68·4	71·0
25	34·70	579·1	107·1	40·70	568·4	99·1	47·42	588·8	94·6	44·86	597·8	102·8	65·8	65·2	64·9	65·5
26	34·37	588·9	104·1	38·53	578·0	100·9	47·15	593·8	93·3	43·85	602·0	106·0	61·8	62·9	64·6	66·8
27	33·29	590·2	99·0	37·66	600·8	88·3	50·85	598·0	97·8	49·37	614·9	113·3	60·5	60·3	62·3	64·4
28	33·22	581·8	96·6	41·30	575·6	83·4	47·96	593·0	91·1	46·08	601·1	107·6	58·6	58·4	60·8	63·7
29	34·70	584·9	93·3	41·63	580·1	97·9	36·58	590·4	83·1	47·76	591·5	103·4	60·0	59·8	60·5	62·7

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
July 1	33·96	591·7	98·1	37·19	577·0	90·4	46·41	581·2	86·4	43·92	599·7	98·9	60·9	61·8	62·4	63·4
2	32·01	590·7	94·9	37·66	549·8	91·6	50·11	610·1	103·8	41·37	590·1	112·2	58·0	58·1	59·8	62·1
3	33·63	587·2	97·7	43·11	569·4	92·7	44·93	585·5	87·2	43·18	594·5	108·8	58·9	60·0	61·1	61·5
4	33·76	585·3	95·1	41·50	578·8	86·6	48·97	594·8	75·0	43·65	592·7	111·6	57·4	57·9	60·2	62·1
5	39·75	583·2	96·8	41·57	576·3	92·3	46·95	590·0	89·4	36·11	600·9	94·8	58·0	57·8	59·1	60·9
6	33·02	587·8	92·1	40·56	589·2	31·1	50·85	615·4	91·9	49·64	625·9	131·6	56·8	57·1	58·1	58·4
8	……	……	……	39·54	578·4	85·3	49·64	599·4	85·2	42·91	600·4	95·7	……	56·5	57·6	59·2
9	31·74	576·2	101·1	39·21	574·2	75·8	42·31	627·8	89·9	46·68	622·4	125·8	55·7	55·3	56·6	58·1
10	36·18	570·4	73·2	41·03	573·4	79·7	47·35	596·2	87·0	46·34	596·1	101·1	53·5	54·4	56·8	60·0
11	39·01	582·6	57·3	38·00	566·3	78·9	46·14	604·2	114·6	47·15	642·8	123·7	56·8	57·4	59·0	61·0
12	34·70	559·8	80·0	40·56	560·5	88·1	46·08	586·9	142·2	47·62	558·1	240·7	62·1	62·5	64·2	66·3
13	34·43	568·4	96·8	39·95	564·9	103·9	46·68	582·0	84·7	42·91	596·3	107·9	65·2	65·5	67·5	69·8
15	36·85	585·2	99·0	35·51	573·1	91·8	44·86	578·6	98·7	44·19	619·6	119·1	64·0	64·3	66·4	68·7
16	41·84	570·2	65·4	45·40	567·7	92·8	45·20	597·7	121·2	41·57	594·4	147·6	65·4	66·4	68·4	69·8
17	30·67	572·2	114·9	36·65	569·0	107·5	45·87	580·8	100·1	42·84	588·8	105·7	65·2	65·5	67·9	70·0
18	32·48	583·3	105·7	38·06	566·1	98·8	46·21	583·7	95·9	46·21	593·9	102·8	65·5	65·8	67·3	69·3
19	34·57	582·1	106·3	42·24	577·9	96·7	44·26	592·5	99·1	38·94	595·7	105·3	64·7	64·6	64·6	64·7
20	34·43	583·6	104·6	40·56	584·5	96·9	42·44	596·2	94·3	41·30	610·0	112·7	62·9	63·5	65·2	67·9
22	41·63	587·0	96·5	40·01	575·3	94·4	46·14	589·6	93·5	41·50	600·0	98·6	65·4	66·1	68·7	70·0
23	33·42	587·1	90·5	38·20	573·6	77·3	37·86	578·6	72·7	41·03	591·7	96·3	66·3	66·9	69·4	71·4
24	34·16	575·0	85·1	40·29	568·2	77·2	34·84	584·0	78·1	45·94	633·3	79·6	67·8	67·0	66·6	65·8
25	33·83	577·1	84·7	39·95	571·3	74·0	47·15	572·3	80·2	41·84	600·2	92·6	60·4	60·7	63·5	65·6
26	39·34	578·5	75·2	35·17	572·4	76·9	43·92	591·2	77·2	39·75	602·3	87·9	62·3	62·1	62·2	61·7
27	31·81	580·9	90·4	36·32	572·2	73·4	43·72	589·2	67·1	40·56	600·8	87·9	59·0	60·1	61·8	62·6
29	32·35	579·1	63·8	41·84	553·6	82·4	45·34	592·8	65·4	42·71	605·4	95·0	53·9	59·2	61·3	64·9
30	34·63	585·5	76·2	37·79	576·6	81·0	40·49	576·7	77·1	36·92	630·5	90·6	62·8	63·8	66·7	70·2
31	32·82	580·6	85·0	36·45	572·3	81·6	44·12	582·3	65·2	40·56	595·2	89·1	67·8	67·7	68·2	67·8
Aug. 1	29·33	584·9	93·2	35·84	574·6	83·3	43·92	584·3	72·2	42·44	604·2	79·1	59·3	59·0	61·9	65·6
2	29·39	574·0	90·3	38·00	583·1	73·8	43·18	583·9	77·7	41·30	608·4	89·4	62·5	63·0	65·6	67·6
3	41·03	572·0	83·5	35·98	581·3	74·8	45·54	591·8	78·3	42·44	603·2	90·1	61·4	61·6	62·5	63·9
5	30·19	580·4	89·6	38·60	572·6	75·4	47·56	590·3	72·9	40·42	598·4	91·2	61·0	60·9	61·9	63·5
6	33·15	585·9	85·9	43·45	577·7	69·5	49·03	589·2	63·0	39·61	603·8	88·0	59·4	59·9	61·5	63·5
7	33·22	584·0	90·3	40·01	575·2	83·5	46·61	596·8	73·8	38·80	606·8	90·3	58·3	58·2	60·8	64·7
8	30·39	579·9	91·4	37·53	571·6	75·7	46·34	584·1	70·4	39·61	601·6	85·9	62·7	63·5	65·3	66·9
9	31·94	580·6	84·4	39·95	576·5	64·6	47·82	589·3	65·6	41·10	607·4	83·3	63·4	63·4	64·7	65·7
10	30·33	570·0	66·7	43·18	554·8	79·0	49·03	559·2	85·2	40·01	602·0	95·3	62·2	62·5	64·3	67·5
12	38·27	588·3	71·9	41·43	564·2	84·7	48·56	574·0	88·3	39·34	602·9	93·9	60·9	61·5	63·5	65·5
13	35·58	570·0	83·1	40·29	568·8	72·4	43·45	587·4	64·2	38·80	598·4	84·5	60·6	61·0	63·2	67·2
14	31·94	579·0	82·6	38·94	575·3	71·0	44·59	586·1	68·6	44·53	598·9	81·4	62·5	62·3	64·5	67·5
15	32·89	586·5	81·0	39·75	584·2	70·8	45·13	594·4	65·6	40·01	601·8	84·0	62·0	62·4	65·9	69·4
16	33·02	591·1	62·7	35·24	578·4	67·7	42·98	588·2	70·7	41·97	598·2	71·5	67·4	66·5	66·6	67·5
17	34·70	587·0	54·5	39·54	582·2	56·8	44·76	592·6	65·9	39·34	600·2	66·7	64·2	63·6	63·6	64·8
19	33·83	577·7	68·4	37·32	574·8	72·9	44·93	587·4	74·9	39·27	594·9	84·7	57·7	57·4	57·9	58·3
20	29·92	576·6	63·6	38·87	573·1	72·4	46·28	590·0	64·0	40·56	596·3	85·6	53·6	53·7	55·0	56·6
21	34·16	587·9	71·0	39·14	575·3	73·9	42·91	594·7	60·5	39·07	602·6	70·9	51·1	51·5	53·6	56·1
22	33·36	585·2	78·0	40·01	576·3	70·3	45·60	594·7	68·5	36·99	605·4	81·2	49·9	49·8	51·1	52·9
23	29·65	588·6	74·9	40·63	571·7	63·9	46·48	579·5	66·4	40·76	627·4	73·3	48·6	49·0	51·5	53·7
24	33·49	581·3	70·4	41·77	576·1	66·1	44·39	603·1	71·3	38·53	602·4	80·9	51·8	52·4	54·7	57·1
26	33·49	584·3	77·5	39·21	572·2	65·4	44·93	598·9	57·4	38·06	596·9	75·8	58·1	57·8	58·8	60·2
27	32·15	583·8	81·0	41·43	575·5	69·9	47·35	592·4	71·7	39·75	606·4	80·7	53·8	52·9	52·7	52·9
28	30·27	584·8	83·4	37·46	574·7	77·0	44·93	581·7	64·4	39·81	600·2	77·6	50·4	50·6	52·8	55·1
29	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……
30	29·52	582·1	75·5	38 33	576·3	71·9	45·60	591·2	63·7	39·48	603·3	77·0	49·9	49·9	52·2	55·4
31	32·01	586·4	78·8	37·73	576·6	72·3	14·06	581·1	67·0	38·47	601·9	75·7	54·8	55·4	57·5	60·7

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Sept. 2	31·41	578·1	79·8	42·37	578·9	59·4	47·56	599·4	67·4	40·08	583·8	95·2	62·1	62·2	64·0	65·5
3	33·02	579·8	72·7	39·48	572·4	71·9	50·51	598·3	84·1	39·95	585·5	82·6	60·9	60·9	60·2	59·7
4	31·06	585·0	54·0	44·79	578·6	63·4	44·59	585·6	88·2	35·51	597·1	109·4	52·7	52·6	54·0	56·1
5	35·24	587·0	64·3	43·65	560·4	79·3	47·02	588·7	49·5	44·86	520·9	165·2	52·2	52·0	53·8	55·2
6	33·29	574·6	84·1	39·75	577·0	86·6	46·75	600·2	75·4	33·29	612·4	152·3	52·6	52·6	54·1	55·5
7	35·58	580·0	78·5	41·16	558·5	88·0	47·76	579·9	98·0	38·27	589·7	106·9	51·8	51·6	52·2	52·8
9	38·74	582·0	79·1	41·50	573·7	81·1	45·67	587·6	80·7	38·06	598·6	93·7	48·5	48·1	51·2	55·0
10	32·62	581·4	88·4	40·63	562·7	83·6	49·10	588·5	85·6	44·93	625·6	153·8	52·0	51·6	52·4	54·8
11	32·48	582·4	90·6	38·27	570·9	83·3	43·32	582·3	77·8	37·12	596·6	80·3	52·4	52·3	54·4	57·8
12	35·37	584·3	83·4	39·21	564·8	81·3	45·20	585·0	80·7	42·98	600·9	110·3	53·3	52·7	54·9	59·1
13	32·28	581·6	80·2	38·13	575·1	75·4	39·34	598·6	71·3	39·81	606·2	70·3	54·1	53·3	55·5	58·9
14	32·21	586·6	76·6	39·75	575·6	73·6	45·60	585·5	78·2	41·90	601·3	88·8	55·3	54·7	56·3	58·5
16	33·22	583·1	72·0	40·42	572·7	67·9	43·72	583·0	74·7	38·06	599·5	81·6	51·9	50·5	52·3	55·5
17	30·67	579·8	80·0	38·13	576·3	67·3	42·84	589·0	71·0	36·85	596·4	71·8	49·8	48·7	51·3	55·5
18	31·34	583·4	80·2	38·53	576·9	62·8	44·39	594·2	65·4	37·73	598·1	68·9	51·6	50·7	52·6	55·9
19	33·70	582·6	75·4	39·54	577·6	66·8	46·48	591·8	74·4	37·66	598·0	84·2	52·0	51·6	53·5	55·8
20	32·55	589·1	63·6	36·72	574·7	70·8	36·05	585·8	66·6	37·73	599·1	72·4	54·9	55·0	54·3	56·8
21	33·02	587·8	77·4	36·11	577·8	70·8	40·70	588·2	70·4	37·53	597·8	66·7	56·4	56·3	57·0	57·5
23	40·89	585·5	72·4	37·06	575·2	70·6	43·79	588·3	69·2	45·27	597·9	72·0	54·1	54·4	56·2	58·0
24	32·15	577·6	69·6	42·24	567·8	70·2	52·73	580·5	71·1	39·21	606·1	98·0	55·8	55·9	57·7	59·7
25	30·80	587·9	78·1	36·32	564·8	74·1	45·67	579·4	71·0	38·87	597·9	78·5	56·7	56·2	57·9	60·8
26	31·74	589·2	82·6	34·10	570·4	80·7	42·10	579·7	70·5	39·07	596·5	73·9	57·9	57·1	57·4	58·3
27	31·81	589·6	84·3	34·90	577·9	81·4	42·78	584·8	68·8	40·36	599·2	72·3	54·5	54·1	55·3	56·6
28	30·74	591·8	78·9	36·45	573·5	71·9	43·99	574·4	60·6	41·03	591·3	84·3	54·1	53·9	54·8	55·0
30	31·88	590·5	71·0	38·00	574·2	72·8	46·75	584·9	71·4	39·95	592·9	80·0	50·5	49·9	50·5	52·9
Oct. 1	33·76	573·9	26·8	50·18	553·0	66·0	51·52	569·8	166·4	44·32	600·6	171·3	51·8	52·0	52·8	54·0
2	44·59	540·7	51·8	42·98	576·9	90·2	43·45	584·1	89·9	33·22	620·0	139·8	49·7	49·7	51·4	53·1
3	46·41	575·2	34·7	39·21	569·1	82·4	43·58	581·0	101·9	......	......	......	49·3	48·8	50·2	......
4	32·82	582·2	82·5	37·93	570·5	78·1	41·77	586·6	80·6	35·91	587·4	80·0	49·3	49·3	51·1	52·0
5	32·62	582·5	85·3	36·32	567·3	82·0	45·34	587·9	75·6	......	......	......	49·2	48·9	50·9	......
7	33·22	590·4	52·2	37·09	584·1	72·7	42·31	578·9	77·2	39·48	587·3	87·8	50·1	50·2	51·1	51·8
8	36·99	584·2	75·4	38·37	575·4	77·5	43·18	580·3	80·9	37·12	594·1	89·9	50·5	50·6	51·4	52·1
9	41·43	591·6	52·5	36·15	564·5	90·9	42·17	577·9	85·5	34·77	598·7	115·6	47·6	47·3	48·8	50·8
10	34·23	593·3	80·2	35·41	570·8	88·5	43·05	578·2	78·5	38·67	591·1	89·9	46·1	46·7	47·0	48·9
11	33·89	565·8	68·4	38·17	576·1	73·0	42·91	584·8	69·3	37·79	590·8	82·9	44·3	44·4	44·9	46·4
12	32·62	590·7	78·2	34·74	574·8	73·8	40·49	587·6	70·2	38·27	596·5	74·5	41·8	41·5	43·3	45·5
14	34·43	601·8	61·5	38·07	593·9	54·9	42·10	591·2	63·0	35·78	599·2	72·4	49·6	50·1	50·3	51·0
15	34·50	595·1	71·7	38·64	584·0	68·9	44·73	591·2	77·0	41·97	592·7	117·2	42·8	41·9	43·4	45·4
16	32·89	593·1	70·3	37·83	581·0	74·0	42·04	591·8	64·1	37·79	591·8	78·9	47·3	48·4	50·2	51·5
17	32·95	592·0	75·8	36·69	579·2	67·1	40·76	592·2	70·4	36·32	593·8	78·8	50·7	50·7	51·7	52·6
18	34·23	591·1	74·1	37·77	579·0	68·4	42·84	583·8	73·7	37·66	592·3	86·5	52·1	52·1	53·1	53·7
19	33·36	594·3	72·7	36·69	575·4	66·6	40·83	589·0	63·3	36·99	597·9	70·9	54·2	54·0	54·7	55·9
21	33·29	590·2	76·2	35·35	575·4	68·1	41·97	590·1	74·1	35·84	592·3	77·4	46·4	45·9	46·0	45·8
22	33·56	591·7	77·6	37·70	575·3	72·1	41·57	591·3	73·6	36·18	596·1	72·8	42·8	41·8	41·9	42·1
23	33·29	596·6	73·0	35·35	577·6	71·4	41·90	592·8	62·2	37·46	596·9	73·3	42·9	42·7	43·4	44·7
24	32·42	595·9	66·2	43·42	578·0	67·5	42·64	593·0	61·6	38·13	608·4	70·9	38·9	37·7	39·2	40·6
25	33·22	596·3	68·3	39·45	578·2	68·4	44·39	584·2	68·6	42·71	605·0	90·3	40·5	40·6	41·4	42·5
26	33·02	592·8	70·1	37·43	579·5	68·5	34·63	586·6	81·9	39·81	591·8	103·2	40·6	40·4	42·5	44·4
28	34·84	602·4	64·3	36·15	578·7	72·8	41·50	582·9	72·8	36·05	596·7	75·0	39·0	39·1	40·1	41·1
29	34·10	603·9	59·2	35·82	570·8	124·0	43·92	581·8	76·2	37·19	597·3	82·7	37·7	37·1	38·4	41·1
30	41·16	585·6	49·3	36·69	574·2	67·2	43·32	578·0	82·5	35·17	594·3	84·1	38·0	39·0	41·0	43·3
31	34·23	595·8	66·8	40·80	580·8	69·9	45·34	588·6	77·8	......	......	......	45·5	45·5	46·7	......

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Nov. 1	33·89	590·6	73·4	36·52	580·3	74·3	41·97	586·7	77·2	35·51	587·2	91·5	50·6	51·5	52·6	53·5
2	31·94	593·7	70·0	35·51	574·0	75·2	40·01	588·6	69·1	36·25	594·4	70·5	54·0	54·2	54·3	55·3
4	33·42	593·2	64·8	37·12	580·0	67·6	33·76	588·9	67·7	36·11	596·1	72·3	50·5	50·2	49·9	49·2
5	33·22	595·1	74·3	36·18	580·6	71·5	38·80	588·6	74·3	35·98	597·2	72·7	46·1	46·7	48·0	49·2
6	33·42	584·2	72·6	34·77	580·8	74·8	38·87	583·0	71·5	35·10	602·0	74·1	45·9	45·7	47·0	47·9
7	35·17	593·7	70·7	35·98	583·3	76·0	42·58	580·8	76·4	35·44	592·7	87·7	47·6	48·5	48·9	49·5
8	36·72	592·9	69·8	36·58	585·4	69·0	39·21	584·3	72·7	36·85	590·7	85·6	46·1	45·6	46·4	47·6
9	35·04	598·0	72·2	37·39	588·4	75·9	40·42	591·3	75·5	37·26	595·6	80·5	45·0	44·8	44·7	46·0
11	34·16	593·5	71·5	37·12	582·3	75·3	41·97	584·2	84·9	40·63	593·1	99·9	52·9	53·1	53·7	54·3
12	33·56	588·2	71·4	37·26	587·5	71·6	42·84	596·3	75·1	30·86	593·5	119·3	49·9	48·7	48·6	48·6
13	33·83	570·6	71·2	36·72	587·5	63·4	......	......	......	......	......	......	42·7	41·7	......	......
14	33·42	592·4	75·7	37·26	587·2	78·9	38·47	593·2	74·5	37·26	598·0	86·9	37·7	36·8	37·0	39·2
15	33·96	593·6	74·5	36·52	588·4	67·7	40·15	593·3	74·7	36·72	593·1	77·5	34·7	34·2	34·3	34·4
16	34·30	569·5	70·0	37·59	589·6	69·9	39·81	603·1	78·8	35·24	598·0	77·2	36·7	38·2	40·3	42·5
18	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
19	32·55	599·7	64·1	35·24	590·1	63·1	38·06	594·9	66·9	35·98	603·2	69·7	44·7	45·6	47·3	48·0
20	32·82	601·5	61·4	35·84	592·2	61·5	38·00	600·2	65·6	38·80	600·2	76·9	46·3	46·3	46·5	46·8
21	33·56	599·0	61·9	35·64	590·0	66·3	37·32	574·5	72·6	35·84	600·3	72·6	45·1	44·5	45·2	45·8
22	33·96	598·4	65·2	36·32	591·6	64·4	38·74	596·1	67·4	37·46	589·7	60·5	41·1	40·6	41·0	42·2
23	33·15	600·3	55·5	36·65	592·6	63·4	37·12	600·5	66·8	35·51	602·4	69·4	46·3	46·7	47·3	48·1
25	34·30	597·8	67·1	35·04	593·6	62·7	45·54	597·5	65·8	39·34	606·9	67·4	46·4	45·9	46·6	47·0
26	39·61	593·5	54·8	36·92	587·4	63·1	42·37	596·7	68·7	39·01	593·1	82·9	43·9	43·5	43·1	43·3
27	33·96	594·8	71·2	36·79	587·5	70·7	36·45	592·1	73·8	42·98	595·7	72·5	40·1	38·8	38·7	39·0
28	34·57	595·2	66·8	35·10	587·0	68·2	38·20	597·2	69·7	37·79	601·6	75·0	33·3	31·8	32·1	33·7
29	33·83	599·2	67·1	36·11	593·5	71·5	38·20	599·8	69·7	36·11	604·0	65·5	31·6	31·4	32·8	34·3
30	35·31	597·1	58·9	37·73	585·4	72·7	41·10	597·4	88·2	36·92	592·4	94·5	31·4	30·0	30·7	32·4
Dec. 2	34·30	599·3	63·0	35·37	589·3	67·0	38·47	595·5	70·5	35·24	602·4	64·3	33·1	33·6	35·0	36·6
3	34·16	599·9	62·1	43·25	592·1	65·2	38·20	592·3	73·5	35·78	599·1	75·4	42·7	43·1	43·4	44·1
4	36·38	602·5	54·6	38·60	596·0	57·6	32·75	598·1	69·2	35·84	603·9	68·2	44·1	45·0	45·6	47·2
5	32·35	598·4	62·0	34·84	594·3	61·7	36·45	595·3	62·6	35·58	602·0	68·3	45·3	45·1	45·9	47·3
6	33·76	600·1	55·8	34·43	594·9	62·7	44·59	600·7	66·7	35·04	604·2	65·0	49·5	49·2	50·5	50·7
7	34·10	597·9	47·2	36·38	589·0	65·4	38·94	598·1	67·5	37·73	600·3	64·1	44·0	42·5	42·8	44·4
9	35·51	599·9	65·9	36·99	595·6	65·6	38·00	600·8	66·4	35·64	597·7	74·1	35·2	34·1	34·5	36·6
10	33·76	601·6	65·4	36·52	594·4	64·8	38·53	597·6	65·9	37·12	600·6	66·2	32·1	31·0	31·2	32·1
11	37·06	596·5	61·8	36·58	601·4	65·4	39·61	604·5	67·9	38·60	598·5	73·0	33·2	33·1	34·3	35·3
12	35·58	599·2	66·6	36·79	594·4	66·7	37·73	605·3	64·5	34·97	604·8	65·1	40·0	39·9	41·6	43·4
13	34·16	598·3	73·0	35·37	596·1	70·3	36·38	600·9	68·2	33·89	603·0	62·8	41·1	41·8	42·5	43·4
14	33·89	599·2	63·4	36·65	595·9	66·1	37·79	597·4	66·4	34·84	602·1	66·7	41·9	41·0	41·1	42·0
16	34·57	595·3	65·4	33·83	594·8	73·3	36·65	598·0	72·9	34·90	599·3	67·0	39·1	39·2	40·5	41·2
17	46·01	598·4	14·1	45·38	568·3	77·3	36·45	590·3	81·8	42·04	589·3	104·0	39·0	38·8	38·8	39·2
18	33·49	587·6	72·0	37·12	587·1	75·1	37·12	591·4	73·6	36·99	589·8	74·5	36·3	35·3	35·4	36·4
19	33·96	570·9	69·2	36·25	586·7	75·2	37·26	593·3	78·6	35·58	596·1	72·4	31·4	30·7	30·8	32·5
20	33·63	594·4	62·3	36·11	590·6	63·2	35·91	594·5	72·5	35·44	598·7	72·8	32·1	31·6	32·0	32·2
21	37·59	601·7	64·4	37·86	594·0	66·1	36·18	596·9	76·5	34·90	601·2	67·9	34·1	34·3	36·8	38·5
23	34·84	600·4	66·3	37·19	592·2	65·8	36·58	599·5	65·5	34·63	604·5	70·1	41·0	41·1	41·5	42·3
24	34·23	599·9	68·0	35·10	592·3	66·3	35·78	596·8	65·6	54·57	600·3	66·7	43·9	43·9	44·2	44·3
25	40·15	601·9	64·9	36·45	585·3	72·2	39·34	595·8	71·0	35·71	597·4	71·8	42·0	41·2	41·0	41·7
26	33·09	598·9	67·9	35·17	593·2	73·0	46·68	542·4	135·5	39·54	596·6	86·5	40·9	41·8	43·0	44·7
27	33·15	597·4	68·0	35·58	596·5	66·5	37·19	591·0	73·4	32·48	585·9	161·8	43·6	44·1	45·0	46·1
28	34·50	586·9	50·7	36·72	594·5	68·2	35·24	594·7	80·6	34·90	595·1	76·4	42·5	42·1	42·8	43·5
30	33·29	601·2	67·0	......	......	......	......	......	......	......	......	......	44·8	......	......	......
31	33·36	598·9	63·3	36·79	592·1	66·2	38·53	595·3	72·8	35·51	598·3	73·2	44·1	43·6	43·2	43·7

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Jan. 1	33·29	599·9	61·3	34·23	594·7	66·8	41·50	594·5	78·0	40·15	590·5	80·1	48·4	48·6	48·5	48·2
2	33·15	599·1	63·9	34·30	591·4	68·4	35·71	591·7	73·4	34·84	597·3	73·9	49·0	47·9	47·8	47·4
3	32·95	581·2	66·6	33·83	575·1	66·3	36·45	596·2	70·2	34·84	599·6	71·0	40·6	39·1	39·5	40·1
4	33·56	601·4	65·7	35·51	592·2	68·1	36·92	600·3	68·0	34·77	603·4	74·6	34·3	33·3	33·1	33·3
6	40·08	603·3	61·5	35·58	594·8	59·0	37·19	600·0	63·3	34·43	603·0	65·4	38·9	38·6	39·1	40·7
7	32·89	603·2	60·5	34·50	599·4	58·6	37·46	598·5	60·9	34·70	605·0	62·4	37·0	35·9	35·4	35·2
8	33·02	609·4	56·4	34·10	594·9	59·6	37·66	598·3	62·9	35·10	604·5	64·7	34·8	34·3	35·0	35·3
9	32·82	603·7	60·9	35·44	594·5	61·2	38·20	599·8	62·2	35·37	601·6	63·4	36·0	36·0	36·8	38·3
10	32·68	602·5	58·0	35·71	596·5	65·4	39·14	598·5	60·6	35·04	604·4	67·3	36·6	36·9	37·4	38·9
11	33·22	603·4	57·9	35·37	598·7	65·0	37·73	599·8	57·4	34·63	602·3	59·2	46·2	46·6	47·3	47·7
13	32·41	602·5	63·3	34·23	593·7	63·5	36·32	597·1	62·0	35·64	604·5	57·0	43·3	43·4	44·6	45·6
14	32·01	602·4	56·5	34·77	596·8	57·6	38·53	600·5	57·3	37·73	601·0	61·0	45·5	45·4	45·7	46·0
15	32·48	601·4	60·9	33·63	593·8	59·7	38·06	597·4	61·1	34·97	605·3	61·4	44·5	43·6	43·9	43·4
16	31·81	599·0	61·3	34·37	590·8	60·3	35·31	601·9	73·0	39·68	610·1	72·7	43·1	42·1	41·6	41·5
17	40·08	583·0	78·7	34·57	586·1	76·4	39·07	587·3	83·4	36·18	572·2	75·5	44·6	44·1	44·2	44·3
18	31·74	590·2	73·9	34·30	572·6	73·3	40·70	581·3	99·9	35·10	591·9	95·5	41·6	40·6	40·9	41·6
20	43·79	590·4	−11·4	38·60	543·1	66·2	53·47	588·2	121·2	43·18	578·5	130·3	44·3	44·5	44·8	45·1
21	33·11	576·6	79·2	34·23	593·9	77·0	40·15	580·4	82·8	36·65	602·0	114·0	44·0	42·3	43·1	43·6
22	31·14	590·7	64·1	37·86	583·9	66·3	40·83	591·4	88·6	37·93	596·9	100·4	38·6	38·2	39·4	40·5
23	33·15	591·7	71·6	34·63	588·4	76·6	42·58	581·1	84·7	38·80	590·1	87·9	38·7	38·9	39·5	41·4
24	32·75	598·4	75·1	34·63	588·4	74·4	......	......	......	......	......	......	41·6	40·9	......	......
25	33·15	597·8	72·7	32·75	586·5	68·0	39·61	588·0	66·5	34·77	594·9	72·3	40·6	40·1	40·1	40·0
27	32·62	597·4	74·2	34·84	593·5	74·6	38·53	589·3	66·7	38·00	595·2	81·4	38·5	38·5	38·2	39·7
28	33·09	601·1	67·2	35·10	591·0	63·8	38·00	596·3	68·8	35·84	596·3	66·5	38·3	38·0	39·5	40·5
29	34·50	593·1	60·3	34·50	589·2	71·6	39·27	595·3	73·6	35·37	598·1	77·3	40·6	41·6	43·4	45·2
30	32·89	593·5	71·1	33·56	588·5	71·7	37·66	593·0	67·6	35·24	594·5	69·6	41·4	40·6	41·0	42·1
31	32·08	596·1	68·2	32·75	583·0	73·8	37·79	591·9	68·0	34·84	597·6	70·7	38·5	37·7	37·5	38·2
Feb. 1	32·35	608·2	62·6	34·03	596·2	62·8	39·75	601·1	64·7	38·40	602·2	70·3	38·0	37·3	37·6	38·6
3	32·15	602·7	66·0	34·63	591·7	64·6	41·77	586·3	60·7	35·37	593·5	69·5	36·7	36·8	37·0	37·5
4	32·35	597·9	67·2	33·36	590·9	69·4	36·05	596·6	54·9	34·16	599·3	65·1	36·2	36·2	37·0	39·4
5	32·68	601·9	63·3	34·37	590·7	69·5	36·85	595·3	59·7	34·50	603·2	64·6	38·2	38·6	39·8	41·9
6	37·26	592·7	62·5	37·19	580·9	72·3	40·22	582·5	84·8	34·77	590·3	87·3	40·7	40·0	40·2	41·2
7	32·01	596·3	74·5	33·42	582·1	73·8	38·13	589·6	73·5	33·89	595·4	73·5	39·5	40·0	41·6	43·7
8	29·85	597·2	73·7	33·96	605·8	67·2	38·87	572·0	49·6	34·23	599·3	69·0	44·8	44·0	44·2	45·1
10	31·48	597·4	72·7	36·72	589·4	72·7	39·54	590·1	66·9	38·87	599·2	81·7	40·9	41·1	42·0	42·7
11	30·94	595·0	62·5	33·89	588·8	68·4	37·19	599·4	77·6	36·45	597·8	78·4	44·3	44·6	45·3	45·9
12	32·89	594·2	67·6	36·58	594·2	64·9	36·52	595·8	72·6	26·44	602·9	97·1	45·7	45·5	45·5	45·2
13	32·48	595·8	68·3	34·16	593·0	68·0	35·98	580·9	72·1	35·78	598·1	72·4	41·3	40·3	40·5	40·8
14	31·81	598·4	64·2	34·10	592·5	73·4	38·27	595·4	71·0	34·90	603·0	70·1	39·7	39·9	40·3	41·4
15	31·74	599·5	57·2	33·56	598·2	60·8	38·33	600·2	66·5	37·12	600·1	71·9	40·9	41·2	43·1	44·7
17	32·62	603·2	55·7	38·13	593·6	68·9	37·86	599·8	72·6	34·23	598·7	75·9	40·3	39·9	41·1	43·5
18	33·76	601·8	59·7	33·70	591·7	63·7	36·65	599·1	60·5	40·76	618·0	73·2	43·0	43·2	44·2	45·2
19	32·95	574·2	26·6	35·71	576·6	79·9	37·26	596·8	78·2	24·33	608·8	161·2	48·6	49·1	50·5	51·4
20	33·49	583·9	74·3	34·43	574·6	74·6	41·50	603·9	85·3	33·89	613·1	88·3	48·1	47·2	47·1	47·5
21	32·75	588·2	82·8	34·10	579·1	76·9	38·47	586·7	70·7	35·31	595·6	68·1	42·3	41·1	42·5	45·5
22	32·08	592·1	74·3	37·32	581·1	69·8	39·14	579·0	71·7	34·97	599·4	83·3	39·8	38·0	38·4	40·9
24	33·15	599·2	61·9	37·32	576·6	67·5	37·53	583·0	75·3	34·77	599·9	78·2	37·6	37·5	38·6	39·5
25	38·80	595·5	38·9	34·77	586·8	59·1	41·23	594·7	84·2	34·43	595·9	75·9	39·7	39·5	40·5	41·4
26	33·70	593·6	63·1	35·51	585·6	81·1	38·80	595·0	73·9	33·15	593·3	74·1	38·6	38·2	39·1	39·9
27	30·59	594·6	71·6	34·23	580·5	66·9	38·53	587·7	66·5	33·83	593·8	71·7	38·0	37·6	38·4	39·6
28	30·94	596·9	69·2	36·05	585·5	64·1	40·36	598·1	68·3	34·43	590·9	79·5	36·6	36·0	36·6	38·9

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	30·80	583·5	42·7	34·23	582·2	66·6	41·23	594·4	67·3	36·65	599·1	71·3	37·7	37·8	38·6	39·5
3	33·63	597·8	63·1	37·39	595·3	62·6	38·33	599·3	72·4	35·98	590·3	92·4	37·8	38·0	39·8	42·7
4	31·88	594·6	65·7	34·16	592·6	60·8	37·86	597·5	59·0	34·90	596·6	66·7	43·1	43·2	45·3	46·9
5	32·08	595·8	68·1	34·10	608·1	57·4	37·39	596·5	59·7	33·15	600·9	69·7	45·6	45·5	46·2	47·1
6	31·21	599·1	66·5	33·56	590·7	62·7	38·13	597·0	66·3	35·58	602·5	72·5	39·0	38·6	39·2	40·7
7	31·88	603·1	63·2	35·17	590·3	61·9	40·15	593·3	60·1	36·11	604·9	70·3	36·1	35·5	37·2	39·5
8	29·18	601·7	47·1	33·42	582·8	55·0	42·98	593·3	64·3	35·98	607·5	75·2	38·2	38·5	39·6	41·1
10	31·48	599·9	56·1	35·04	589·1	52·0	42·31	600·6	57·6	39·07	613·5	80·1	40·8	40·6	41·1	42·6
11	30·59	595·4	67·8	42·44	575·7	53·4	40·70	597·0	60·5	36·72	597·7	75·6	38·2	37·7	40·1	43·5
12	33·56	595·7	65·5	37·26	588·6	64·4	42·58	596·5	69·9	35·44	604·0	58·0	41·6	41·1	41·2	44·7
13	30·86	596·4	63·6	34·77	584·2	64·1	40·29	595·8	50·6	34·90	601·4	77·7	40·7	40·5	42·5	44·7
14	31·21	601·5	62·7	35·17	591·5	63·3	42·98	601·9	54·0	39·95	605·7	77·5	42·4	41·9	43·4	45·1
15	32·48	589·5	63·0	37·06	580·8	58·4	42·58	602·1	68·3	35·44	601·8	76·8	43·0	42·9	44·7	47·7
17	30·33	601·1	64·4	33·76	586·7	62·8	40·89	595·4	58·9	34·63	606·5	73·4	41·2	40·4	41·0	42·1
18	30·07	600·2	64·0	34·10	588·4	68·8	38·80	597·7	55·1	34·30	598·1	68·5	39·6	39·4	39·7	39·8
19	30·19	600·0	69·1	32·68	585·7	58·4	34·63	597·0	49·5	35·44	604·0	58·0	40·2	41·1	42·8	44·7
20	30·12	610·3	57·4	32·68	598·5	45·1	36·25	604·9	55·9	42·44	595·2	83·2	43·0	43·2	45·1	46·9
21	29·33	595·0	62·6	33·15	583·8	49·0	39·48	604·9	57·4	36·25	614·8	57·0	43·7	43·1	43·5	44·7
22	26·16	601·0	60·6	32·08	587·4	60·5	35·71	598·9	102·6	37·39	603·7	65·7	42·9	42·9	44·4	46·0
24	30·86	602·7	60·8	34·57	591·0	54·1	40·56	597·5	53·7	34·37	606·3	67·4	44·3	44·0	44·3	45·0
25	30·00	601·6	65·2	31·34	606·1	50·7	40·49	598·6	47·5	34·97	593·2	73·0	44·0	43·4	43·8	44·2
26	39·33	599·9	66·0	32·08	583·8	60·0	39·75	594·1	60·1	34·23	605·1	62·8	43·9	43·8	44·2	44·6
27	28·72	605·8	59·4	31·14	589·8	50·3	39·54	595·3	88·1	36·58	605·7	61·5	41·6	41·8	43·3	44·8
28	31·94	596·5	51·4	30·86	608·7	55·0	42·44	586·5	56·5	36·52	600·8	59·3	43·0	43·1	44·5	45·8
29	35·10	602·8	19·0	37·86	569·4	32·9	41·23	601·8	64·9	37·12	603·3	46·3	42·5	42·8	44·8	46·4
31	28·58	596·5	62·9	32·35	583·7	58·2	42·24	594·1	58·1	36·99	605·1	59·2	41·6	41·7	43·0	44·1
April 1	28·92	598·5	62·1	32·55	603·0	58·7	34·63	596·9	53·0	37·46	605·6	67·7	43·4	43·3	44·9	46·7
2	25·83	598·8	58·4	35·04	606·9	50·0	41·90	601·3	48·1	36·79	612·3	54·5	45·2	45·5	46·6	48·3
3	27·91	602·6	64·3	33·56	583·8	47·4	41·16	598·7	48·2	36·65	609·9	60·5	46·3	46·4	48·0	49·5
4	27·71	604·6	46·0	34·43	606·7	38·3	35·71	590·1	50·0	31·81	612·8	71·3	45·8	45·6	46·5	48·7
5	27·64	593·9	59·9	32·28	607·4	48·0	42·24	611·5	49·5	40·29	625·8	81·0	44·9	45·1	46·9	47·7
7	28·58	602·1	50·6	32·82	584·0	55·4	42·04	596·2	46·2	37·93	610·9	74·0	43·4	44·1	46·5	47·6
8	26·03	598·7	51·6	31·54	580·1	58·0	42·17	594·9	59·6	36·79	606·9	60·6	42·0	41·3	41·5	42·0
9	27·64	604·0	60·8	32·48	587·7	51·9	42·17	594·8	48·1	35·24	609·2	52·2	41·0	41·7	43·0	44·8
10	27·11	601·7	58·0	32·62	588·3	51·5	......	......	......	36·92	612·1	70·1	40·7	40·8	......	45·2
11	27·44	603·5	58·6	29·25	588·6	58·6	40·36	594·9	44·3	37·53	605·3	48·8	42·0	41·8	44·3	46·3
12	27·85	604·8	68·5	37·19	590·4	49·6	39·27	593·8	39·8	34·43	604·4	72·6	43·6	44·0	45·8	46·4
14	28·04	604·0	53·0	33·89	585·6	46·4	40·63	587·5	57·9	35·58	602·9	51·5	42·0	42·4	43·6	45·1
15	26·10	600·6	60·7	32·21	589·1	38·4	43·85	588·7	45·3	35·84	606·3	66·9	42·5	42·8	44·3	45·6
16	26·70	600·1	65·5	30·73	579·5	65·1	41·57	594·3	51·6	36·38	612·8	63·9	42·9	43·2	44·9	45·6
17	26·29	602·9	56·4	31·54	580·4	44·0	46·01	602·6	44·9	37·12	617·2	82·5	44·0	43·9	44·0	44·6
18	25·96	598·2	65·8	34·16	599·3	106·0	......	......	......	35·31	603·6	67·2	45·9	47·4	......	50·5
19	26·43	602·4	58·9	32·08	580·9	61·3	40·49	611·4	49·1	34·37	605·2	60·2	46·3	46·4	47·8	50·7
21	38·53	593·2	29·0	35·98	573·5	54·3	39·68	599·0	69·9	33·96	601·4	131·7	52·2	52·2	53·4	55·1
22	29·05	595·9	58·8	35·31	579·9	62·7	40·70	590·2	62·9	36·65	604·6	85·4	51·1	51·2	52·2	54·4
23	26·70	600·9	81·9	31·21	589·0	60·7	39·81	592·1	74·3	34·10	604·9	84·1	50·5	50·0	51·1	52·1
24	28·92	586·5	79·7	33·63	598·2	92·0	38·00	592·4	65·3	31·21	607·8	75·9	47·0	46·7	47·3	48·9
25	29·52	596·6	70·3	31·67	588·1	80·8	38·68	594·7	54·9	36·85	614·3	80·6	46·6	47·0	48·7	50·3
26	25·69	594·5	74·5	31·67	586·4	68·0	39·41	599·5	38·1	36·52	602·3	73·4	46·1	45·4	46·4	47·2
28	28·18	608·7	26·4	31·41	603·0	49·7	38·94	602·8	53·3	35·78	610·1	65·7	39·6	40·8	41·6	43·0
29	26·97	608·2	52·0	31·34	586·4	64·6	38·94	595·2	56·0	34·57	607·8	52·3	40·6	40·9	42·0	43·3
30	26·83	600·2	58·8	28·52	587·2	57·9	35·78	598·9	35·2	34·43	618·2	68·1	42·0	42·0	43·9	46·2

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
May 1	27·91	601·9	58·9	30·19	589·9	54·2	39·68	600·5	42·6	37·59	621·1	65·3	42·5	43·0	45·0	46·5
2	24·75	573·4	36·4	37·93	562·5	52·4	39·54	584·2	143·1	37·59	613·2	92·8	44·6	44·9	46·0	47·1
3	33·09	590·7	44·5	29·66	591·1	63·7	38·53	594·4	73·6	36·05	627·9	97·4	44·1	44·4	45·2	46·1
5	25·69	594·4	52·7	26·43	585·6	41·2	......	......	......	......	......	......	40·9	41·3	......	......
6	27·44	604·5	53·8	29·12	588·2	51·6	38·00	581·7	59·5	36·38	608·9	83·0	41·4	42·1	43·8	45·7
7	30·73	594·5	62·1	30·80	583·3	68·8	42·04	594·2	59·9	35·44	604·1	68·3	45·4	46·1	48·3	50·2
8	33·76	588·9	41·7	39·61	564·2	44·3	......	......	......	39·95	598·0	134·1	47·9	48·6	......	52·5
9	26·36	595·0	63·7	31·41	582·1	67·7	36·05	595·7	74·6	34·23	613·7	62·9	50·4	51·1	52·6	54·1
10	25·96	591·6	65·9	33·63	582·4	57·3	......	......	......	35·44	612·4	61·1	52·5	54·1	......	58·3
12	26·64	596·6	47·8	31·94	587·3	52·4	......	......	......	35·31	612·2	64·0	49·6	50·2	......	53·0
13	26·83	583·5	63·5	33·15	584·8	33·5	39·61	597·4	53·5	34·37	627·3	76·9	47·0	47·4	50·4	53·6
14	29·39	602·7	55·4	32·08	595·5	52·7	39·41	600·5	52·1	36·32	620·4	69·4	49·4	49·9	52·7	56·5
15	27·85	593·9	62·0	31·21	588·6	66·2	38·00	591·0	59·2	34·84	605·9	69·1	51·2	51·2	53·5	56·0
16	27·44	600·2	68·5	30·00	595·2	39·3	41·10	595·8	53·6	39·01	611·5	54·6	54·6	53·8	54·7	56·4
17	39·84	602·3	28·5	39·81	571·3	60·7	43·99	582·1	39·1	35·64	609·0	89·6	53·2	53·8	56·3	58·3
19	27·50	602·5	59·9	30·86	584·2	56·9	36·92	594·8	53·4	32·28	612·8	69·7	51·6	51·6	52·4	53·8
20	26·90	595·1	66·2	35·24	591·8	47·1	37·59	599·7	39·8	35·31	610·4	65·3	49·6	50·4	52·6	55·0
21	28·92	600·9	68·4	34·50	598·1	60·9	36·45	605·1	49·0	33·83	606·6	59·4	54·0	55·8	58·3	59·8
22	24·81	601·7	60·0	32·21	587·7	47·3	35·51	601·4	45·6	34·23	610·5	51·4	58·3	58·2	60·5	60·9
23	28·52	596·1	68·7	32·28	590·1	46·1	37·46	602·9	33·4	33·36	609·5	74·7	54·2	54·6	55·6	56·9
24	22·33	598·6	50·5	35·04	587·7	26·1	44·32	599·1	40·2	41·77	627·9	69·1	53·0	53·6	56·3	58·6
26	25·55	599·1	63·3	28·18	581·6	64·3	39·68	601·2	51·0	35·78	608·7	65·7	52·0	52·4	54·0	54·8
27	27·03	596·6	51·9	35·91	592·0	40·1	39·14	596·7	36·0	35·51	612·7	59·1	50·0	50·9	52·8	54·4
28	24·68	603·0	61·1	32·01	580·6	56·4	38·20	592·9	60·1	33·83	611·6	67·0	53·1	54·1	57·0	60·4
29	23·94	596·0	60·2	34·10	586·3	45·8	39·95	592·8	46·2	34·63	615·9	67·6	58·7	59·0	61·9	64·1
30	25·43	596·3	68·1	32·08	583·0	65·1	37·66	603·6	57·7	34·43	614·4	73·1	59·1	59·6	61·4	63·0
31	23·34	594·8	51·8	31·21	586·0	52·4	40·22	597·4	52·1	35·91	619·3	72·4	55·7	55·9	59·0	63·7
June 2	26·43	600·8	57·7	34·84	583·7	51·7	43·32	601·5	49·1	38·00	613·4	61·3	58·1	59·1	60·8	61·9
3	28·04	604·4	61·9	31·14	600·1	54·9	41·43	596·7	49·4	36·79	612·1	48·2	58·5	58·2	58·4	58·1
4	26·43	592·7	48·0	32·62	593·4	48·9	40·70	608·8	54·0	39·41	611·9	62·9	48·2	48·6	50·4	52·8
5	24·68	603·0	57·4	28·92	591·8	53·9	39·48	599·9	58·7	39·14	642·5	69·8	47·8	48·2	49·6	51·6
6	28·04	580·0	31·8	35·17	573·1	53·4	38·74	594·3	81·7	35·51	631·8	85·3	49·1	49·8	52·0	54·7
7	27·03	587·9	62·4	31·07	578·4	61·2	37·06	605·4	57·6	34·50	606·0	67·8	51·5	52·6	55·6	57·7
9	28·24	593·6	59·0	34·70	592·7	45·0	36·85	610·2	58·8	35·71	622·5	81·3	54·7	54·8	57·0	59·5
10	24·95	593·5	62·6	33·96	588·7	58·9	38·00	598·1	64·8	34·90	602·4	88·4	53·7	53·0	54·4	57·0
11	26·83	613·3	64·4	34·63	582·3	50·8	39·68	597·7	63·8	48·90	604·6	67·4	52·3	53·0	55·0	56·8
12	26·10	595·3	64·8	35·84	584·1	43·3	41·57	602·1	48·7	34·43	609·6	63·8	52·3	51·9	52·5	53·5
13	25·32	592·6	67·0	29·39	590·8	60·0	36·92	601·1	60·5	33·22	613·7	61·6	52·4	52·6	53·9	55·6
14	35·58	587·3	30·0	33·09	569·0	54·0	39·48	616·8	61·4	43·58	616·5	111·0	53·6	54·4	56·8	58·2
16	27·18	593·0	60·3	33·63	580·3	66·1	39·21	597·4	55·1	36·18	611·7	78·7	54·5	54·8	55·9	56·7
17	26·23	588·6	68·0	30·26	574·7	56·4	38·87	596·6	49·5	33·70	615·7	76·4	53·6	54·1	55·4	57·8
18	26·16	589·9	64·0	29·59	582·2	52·8	37·53	600·7	54·3	33·70	613·1	65·7	53·8	54·1	54·7	56·5
19	26·97	597·3	58·7	33·09	581·0	52·0	37·53	600·7	57·3	......	......	......	58·0	59·3	60·7	......
20	25·83	591·0	58·0	32·35	585·9	52·7	37·26	597·4	31·0	34·50	610·7	56·8	55·8	56·4	55·7	59·9
21	30·73	605·1	35·9	31·94	586·0	57·8	41·37	587·7	41·1	35·64	610·8	51·6	58·7	60·0	62·4	64·7
23	26·29	593·5	80·0	32·62	592·5	71·6	36·72	600·6	68·6	34·97	610·4	84·0	57·7	57·0	58·1	59·1
24	24·68	599·2	81·3	31·74	616·8	62·9	35·17	606·7	70·5	35·51	607·7	78·3	55·7	56·5	58·5	60·1
25	24·28	600·5	70·3	32·41	597·1	71·2	37·19	601·1	72·1	34·77	605·8	79·1	59·5	60·9	62·5	64·1
26	24·28	597·2	75·1	30·19	595·1	67·4	36·85	605·9	57·5	36·58	619·7	71·1	60·4	61·0	63·1	65·7
27	24·68	599·2	74·1	32·62	590·8	63·2	39·61	614·3	64·4	38·13	619·1	96·1	62·2	62·9	66·2	69·1
28	27·85	583·7	77·2	37·26	591·8	78·5	39·34	601·3	83·5	33·15	626·5	93·3	64·5	65·6	68·1	72·5
30	22·93	589·0	116·8	31·54	580·2	100·3	40·22	594·8	104·0	36·18	606·4	115·7	70·7	70·9	73·0	75·5

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
July 1	24·40	591·9	115·4	31·40	577·8	117·9	39·34	590·6	110·5	35·51	607·4	115·1	68·9	68·8	71·0	74·1
2	23·80	589·6	111·0	29·04	580·0	104·5	38·53	592·8	105·6	35·37	614·1	114·3	68·6	67·1	66·6	65·3
3	23·80	601·7	105·6	30·72	598·5	25·3	47·62	630·1	104·8	41·16	611·1	140·6	55·4	56·0	57·1	58·2
4	25·14	585·6	114·5	30·86	587·9	115·7	37·93	595·8	110·7	32·48	608·3	140·9	54·5	55·0	58·0	61·6
5	26·02	589·4	69·9	31·06	586·1	108·8	36·85	588·1	118·6	35·44	604·6	115·8	57·6	58·2	60·4	62·6
7	23·73	598·4	107·5	31·20	589·4	112·7	37·46	588·5	100·5	34·70	602·5	108·8	61·8	62·6	64·5	65·1
8	24·74	595·0	92·0	31·47	588·0	101·6	36·25	599·7	96·0	32·82	614·5	103·9	61·6	61·8	61·6	62·5
9	25·48	596·7	115·3	29·39	591·2	92·9	37·53	610·2	101·9	31·81	613·5	124·9	57·5	57·7	58·7	59·6
10	26·15	601·3	126·9	36·45	601·3	96·7	39·88	608·6	53·7	34·57	611·5	107·5	55·2	54·6	55·1	55·9
11	28·64	611·7	108·1	30·86	597·2	108·9	35·44	613·6	107·9	33·49	633·9	113·9	53·4	54·3	55·4	56·4
12	28·71	599·5	105·6	31·06	596·6	96·3	38·00	621·0	94·3	32·95	622·9	119·1	58·2	59·6	61·1	63·6
14	25·34	667·4	97·1	33·63	592·7	103·9	37·12	605·9	95·7	37·46	663·8	151·3	60·6	60·9	62·0	62·4
15	33·63	576·0	70·0	31·74	586·0	116·2	38·27	613·6	110·5	34·84	621·8	118·1	57·2	57·9	59·3	60·7
16	25·81	596·7	87·8	32·28	585·7	95·0	38·13	602·4	103·3	35·78	620·2	102·1	55·6	55·7	56·2	57·8
17	25·95	606·6	114·4	30·32	596·6	97·3	40·42	607·2	98·7	38·80	655·0	125·3	56·6	57·5	59·6	62·4
18	23·58	601·3	95·0	30·86	562·5	101·8	36·25	606·8	115·8	......	......	......	57·9	58·1	60·2	......
19	27·77	579·8	108·4	29·85	590·9	116·2	40·22	603·3	118·8	35·17	631·4	120·6	57·2	57·7	60·3	61·9
21	25·07	602·7	116·9	32·01	595·6	105·9	37·26	603·9	105·9	34·37	619·7	111·1	61·1	60·6	61·2	62·6
22	26·55	600·3	110·9	31·27	598·0	108·5	36·25	610·5	107·0	33·09	623·9	114·6	58·0	58·3	61·2	63·0
23	30·32	601·0	104·1	32·82	596·0	105·1	37·93	598·3	112·8	27·70	611·6	125·3	59·7	60·2	62·4	64·3
24	34·97	601·2	128·3	34·50	601·3	112·4	40·83	605·1	113·0	32·48	613·0	129·9	59·3	59·7	61·2	62·9
25	28·03	595·5	109·1	33·63	601·4	107·6	......	......	......	34·50	611·7	118·4	57·6	57·7	......	59·2
26	28·97	605·5	109·1	33·09	594·6	108·5	34·23	603·0	118·8	33·42	604·0	167·6	56·0	56·5	58·0	59·3
28	25·88	598·1	118·6	28·50	594·0	99·2	35·24	607·7	112·2	31·06	617·1	113·1	60·0	61·6	63·5	65·4
29	23·73	610·9	91·8	31·88	607·2	84·9	40·22	635·4	82·0	36·58	634·9	129·2	62·8	63·7	65·7	66·4
30	26·62	599·9	112·1	30·52	587·7	114·6	41·70	605·6	102·4	33·63	621·7	123·1	59·8	59·5	59·7	60·3
31	26·82	599·1	111·4	28·17	590·3	97·3	37·26	601·4	99·1	33·02	616·8	111·8	57·7	57·9	58·7	60·3
Aug. 1	27·97	603·0	122·6	31·20	594·7	99·5	38·20	614·1	103·6	33·22	613·7	113·8	60·9	61·0	62·0	63·6
2	23·73	602·0	108·5	30·86	595·7	97·3	37·32	609·7	95·6	33·89	617·2	111·6	58·5	58·9	61·2	63·7
4	28·23	593·4	111·4	29·33	593·3	101·9	35·24	611·1	115·9	33·42	610·2	114·9	62·6	62·3	63·7	65·9
5	27·57	599·8	111·9	29·71	599·6	107·6	37·66	602·4	110·1	34·03	623·5	106·8	58·7	59·1	61·5	63·9
6	27·77	595·4	109·7	33·56	592·6	112·5	39·54	613·6	110·6	32·48	611·4	116·4	57·6	57·1	59·3	62·8
7	32·62	578·5	55·1	30·05	573·4	97·4	39·27	622·2	119·9	34·10	612·8	113·6	57·2	57·3	59·7	62·4
8	28·30	598·4	99·8	33·96	591·0	101·9	38·40	612·1	160·9	30·92	607·7	133·4	59·4	59·1	59·6	60·9
9	29·11	608·9	110·1	36·32	597·2	107·9	40·01	620·8	113·1	29·65	609·3	136·1	57·2	57·2	58·2	59·6
11	26·75	601·3	114·5	30·45	585·3	117·2	38·40	602·5	114·8	36·25	648·3	117·3	55·6	56·2	58·0	59·4
12	26·16	604·6	114·4	32·08	599·0	101·4	......	......	......	31·47	610·3	118·3	59·0	60·8	......	67·7
13	26·15	598·2	108·0	32·62	593·3	101·1	36·11	610·0	113·3	30·59	614·6	118·5	66·4	65·9	67·4	69·0
14	27·10	598·7	109·5	34·57	598·4	101·6	41·10	612·5	109·2	32·68	617·0	117·8	64·4	64·6	66·5	67·1
15	24·60	603·1	106·4	33·76	596·4	95·7	37·26	608·4	96·2	31·47	613·6	114·6	60·9	62·1	64·2	66·5
16	27·77	600·0	108·2	29·51	595·0	100·0	37·12	612·6	96·4	32·48	618·0	107·7	62·2	62·6	63·6	64·4
18	27·24	608·2	111·0	30·05	591·8	97·0	36·85	608·0	96·9	32·35	621·5	107·4	54·8	55·4	57·2	59·4
19	24·47	602·2	110·7	31·34	600·2	81·2	38·13	615·9	100·2	31·60	613·9	109·5	56·1	53·8	58·0	60·0
20	26·42	602·1	110·4	31·94	597·4	99·3	37·06	616·1	98·5	32·15	616·8	103·8	60·7	60·9	62·8	64·4
21	26·82	599·1	91·8	34·43	585·9	94·7	42·24	601·9	106·4	30·79	615·1	111·2	61·4	61·8	63·3	66·0
22	27·50	593·9	113·5	32·68	616·7	103·6	38·20	615·2	117·9	30·99	616·7	113·3	63·2	62·9	63·0	63·7
23	25·61	604·5	101·9	34·63	606·0	96·3	39·27	627·4	99·9	32·08	613·9	122·6	59·7	59·8	61·0	63·3
25	25·75	582·7	110·2	33·09	591·5	108·3	29·24	597·8	106·5	35·10	620·1	108·8	52·6	53·4	55·8	58·3
26	25·28	590·8	116·2	32·75	583·1	102·9	37·39	601·0	107·6	25·61	619·2	135·7	56·1	56·2	58·0	59·9
27	25·34	586·2	115·9	32·68	583·9	102·8	36·32	609·1	110·0	30·05	601·8	120·7	57·3	57·9	59·4	60·3
28	25·96	590·1	114·3	32·62	588·9	104·6	35·84	607·9	113·3	29·45	607·4	113·2	55·7	55·1	56·3	57·8
29	27·24	598·0	110·0	33·76	597·9	103·0	39·14	594·7	91·9	31·06	604·4	125·0	53·2	52·9	53·3	54·0
30	26·82	593·0	111·0	32·55	585·9	106·1	39·95	612·5	101·9	33·49	630·7	132·3	52·1	52·1	53·2	55·0

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Sept. 1	29·24	596·3	113·9	33·49	587·0	110·2	35·37	615·1	118·7	30·25	614·3	123·4	58·2	59·4	61·5	62·7
2	30·52	588·0	107·5	35·71	587·6	109·6	37·06	613·1	130·7	32·75	624·3	140·1	61·3	62·6	64·8	67·6
3	25·75	601·0	112·0	34·30	581·5	109·0	38·53	599·7	97·7	17·40	641·7	164·9	65·4	66·0	66·2	70·2
4	53·88	*	4·6	48·97	535·8	118·8	45·74	612·4	241·0	25·54	732·6	306·4	65·1	65·2	65·9	66·1
5	40·42	577·8	81·3	29·18	570·9	129·6	37·32	573·2	138·2	33·02	591·2	132·1	58·9	58·7	59·1	60·2
6	27·37	577·3	121·4	33·83	575·9	125·1	35·78	597·3	116·3	29·11	594·6	120·8	52·5	52·6	54·2	55·9
8	37·53	530·7	81·8	38·87	569·8	122·8	39·14	591·8	134·1	31·47	614·2	156·6	52·1	53·5	55·8	58·5
9	27·97	580·9	101·8	32·41	569·4	117·1	33·83	599·3	123·7	29·11	606·7	125·4	51·1	50·8	52·8	56·0
10	27·03	578·1	133·1	30·39	578·3	126·6	35·04	597·1	123·2	33·36	599·8	122·7	51·0	50·7	53·8	58·1
11	25·95	588·7	130·2	30·66	584·9	121·0	37·26	612·2	111·5	35·78	615·4	131·6	53·6	53·0	56·5	60·5
12	31·06	568·0	118·2	40·08	579·2	110·4	37·73	607·1	114·0	32·15	601·0	123·7	54·7	53·8	56·5	61·1
13	26·16	587·6	131·7	31·81	578·9	125·8	36·65	602·0	118·0	31·88	610·0	170·8	55·1	53·9	56·7	60·7
15	24·80	607·6	106·8	32·82	591·2	107·9	37·66	604·3	111·6	38·13	616·4	129·1	56·4	55·7	58·4	62·6
16	25·01	597·4	122·5	29·51	585·1	120·8	36·58	600·3	119·1	32·55	611·9	127·5	58·5	57·1	59·1	62·0
17	25·61	591·3	127·7	31·13	585·6	120·9	36·72	600·8	120·3	32·15	609·5	134·7	56·6	56·0	56·1	57·2
18	27·37	595·5	127·2	30·86	585·7	122·0	34·84	605·6	118·9	31·20	606·9	120·9	55·6	55·1	56·5	56·9
19	27·44	600·2	123·7	30·92	582·9	119·0	35·91	596·3	114·2	35·51	623·0	133·8	54·3	53·9	54·3	55·5
20	26·55	595·2	118·1	30·66	592·7	113·6	35·04	597·6	114·4	30·12	602·8	124·3	51·9	51·6	54·2	57·8
22	24·47	600·2	119·2	32·55	592·3	116·3	34·77	603·5	104·7	30·59	602·4	119·0	54·2	53·9	55·8	57·3
23	26·69	604·9	118·6	29·78	592·6	113·4	34·03	604·3	110·5	30·59	614·8	117·5	57·6	58·2	59·7	60·7
24	27·37	603·5	116·7	34·16	587·1	108·6	35·98	600·9	106·3	32·21	608·5	127·1	59·2	59·5	60·6	63·6
25	26·28	600·9	115·4	28·50	586·5	111·9	34·70	596·9	105·2	31·27	615·3	113·1	59·1	58·5	57·1	55·2
26	31·06	603·0	106·9	35·84	579·5	105·0	39·34	602·3	112·8	35·58	613·2	141·1	46·5	45·8	45·2	45·8
27	25·68	604·9	108·3	32·08	559·6	120·5	41·30	597·2	126·8	33·70	609·6	159·9	47·3	47·7	48·4	49·0
29	27·24	587·8	116·3	31·47	564·5	121·4	36·32	603·3	134·9	30·94	619·4	161·6	48·3	48·3	49·5	50·6
30	30·59	565·1	140·8	35·64	584·6	105·3	37·32	598·3	142·7	29·33	602·7	145·5	50·2	50·6	51·9	53·5
Oct. 1	25·01	593·2	126·1	27·83	575·4	124·1	34·23	592·7	137·4	30·45	594·7	127·0	52·0	52·1	54·6	52·7
2	24·60	594·7	127·3	13·10	*	138·9	45·94	615·5	139·4	39·41	692·7	301·0	52·7	52·0	53·5	55·6
3	24·54	596·2	132·6	28·37	582·6	121·9	33·15	588·4	122·4	31·20	598·8	120·1	52·0	52·0	53·3	54·0
4	27·30	591·4	125·5	30·25	576·2	128·6	41·16	598·3	118·6	30·18	600·4	117·5	53·0	53·2	54·1	55·7
6	25·95	598·4	117·3	28·84	591·9	109·9	34·63	601·5	110·8	30·12	604·5	113·4	48·7	48·2	49·3	50·6
7	26·28	601·9	111·8	30·45	593·0	114·0	34·70	602·5	112·3	31·54	611·6	114·0	48·7	49·9	51·0	52·1
8	26·22	606·8	109·3	28·30	593·5	113·7	34·97	599·8	111·0	29·78	605·0	121·4	47·0	46·9	49·0	50·8
9	27·03	606·4	110·8	29·38	587·9	110·7	34·03	598·1	109·5	31·67	609·3	114·5	47·4	47·3	47·8	49·4
10	35·17	606·4	91·8	28·30	593·2	106·7	32·62	598·1	104·5	33·29	604·1	127·1	50·1	50·8	52·8	54·4
11	35·91	609·2	95·2	35·17	583·7	112·9	37·73	583·2	118·4	35·31	584·7	139·2	56·1	57·3	58·1	58·6
13	27·70	606·6	105·6	27·50	592·5	112·1	36·38	599·9	102·4	30·79	611·6	112·7	54·1	55·2	56·1	56·7
14	25·68	603·6	107·4	31·54	598·2	98·3	36·58	605·2	109·9	22·32	614·1	147·6	50·0	50·3	51·4	53·1
15	27·17	605·4	114·8	29·45	586·8	103·5	34·90	603·8	102·2	30·86	611·7	102·6	51·6	51·1	51·5	52·3
16	26·75	610·7	104·5	27·44	602·0	104·2	34·84	607·7	101·6	31·06	613·5	103·1	44·7	44·4	46·6	49·2
17	27·70	607·0	109·2	28·64	598·4	105·3	33·15	603·7	51·8	31·88	619·2	102·5	44·7	44·4	47·6	49·8
18	25·28	612·2	105·5	27·24	604·3	100·2	36·99	614·3	98·9	38·47	615·4	124·6	50·5	52·2	53·4	54·4
20	26·22	603·0	117·3	30·86	587·7	112·3	36·85	604·1	113·9	31·34	623·2	115·5	55·0	54·7	55·2	55·4
21	26·75	583·4	99·8	30·86	590·7	113·1	33·56	609·8	116·7	30·52	611·4	115·8	55·4	55·2	56·1	56·8
22	25·28	615·4	108·5	30·59	590·2	115·2	34·84	593·9	117·3	33·15	600·8	126·9	54·8	54·7	55·3	56·5
23	25·61	602·8	109·9	33·02	579·3	106·7	39·68	607·6	111·3	30·99	607·3	137·8	55·0	54·6	54·6	55·5
24	33·36	601·8	83·9	35·24	579·5	105·7	36·99	598·6	127·9	25·28	607·6	154·7	52·4	51·3	52·3	55·0
25	28·97	603·3	101·9	33·56	582·6	111·5	35·37	612·4	121·9	27·03	614·2	133·9	49·1	48·1	49·2	52·4
27	28·17	607·9	93·8	35·51	591·0	104·9	37·06	599·9	120·3	31·27	612·6	121·5	53·1	53·1	54·0	55·4
28	26·49	608·6	107·9	28·85	589·8	113·5	35·17	603·6	110·6	32·82	617·7	104·4	48·8	49·7	51·1	51·1
29	41·30	560·1	95·0	37·86	576·3	125·3	32·89	581·8	129·2	31·34	600·9	125·5	45·0	44·4	44·6	43·7
30	26·49	593·2	119·1	31·60	582·2	127·3	34·16	589·6	127·4	29·85	597·1	122·3	42·9	43·0	44·0	44·6
31	27·17	605·8	113·8	29·85	593·9	115·1	31·20	600·2	116·7	29·04	602·1	111·7	42·0	41·6	42·0	42·7

* Out of field.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Nov. 1	27·83	611·3	100·8	30·59	600·0	108·0	32·41	608·1	107·7	29·33	613·0	104·9	41·7	41·8	43·8	45·6
3	26·35	608·4	102·5	31·74	603·8	101·4	36·11	607·7	114·6	26·55	609·3	122·2	38·4	37·7	39·1	40·6
4	28·03	605·2	96·1	31·34	600·2	104·1	35·91	601·1	108·5	30·92	591·6	94·7	34·7	34·2	35·2	35·6
5	32·08	608·3	95·4	32·95	606·2	94·9	35·78	606·7	101·3	31·13	607·8	107·1	34·9	35·5	37·5	40·0
6	27·57	614·7	94·8	31·47	605·2	101·9	32·35	603·5	105·2	28·44	611·0	105·4	41·8	42·0	42·7	43·7
7	26·96	615·2	103·1	29·04	598·7	103·0	32·48	607·4	100·3	28·50	613·4	104·8	42·3	41·6	42·2	42·6
8	27·17	617·3	94·3	30·72	601·0	103·4	33·63	601·2	100·1	29·38	614·3	102·4	42·4	42·2	42·8	43·8
10	25·54	622·4	78·4	26·42	607·5	86·0	39·01	608·1	102·3	30·12	612·8	107·0	42·4	41·8	42·3	43·3
11	26·42	617·2	91·8	30·18	613·8	87·2	34·23	609·7	93·4	33·15	618·0	102·8	45·0	45·3	46·5	46·9
12	27·50	613·0	95·4	29·33	602·5	94·8	31·13	612·1	97·5	29·45	617·8	99·6	43·6	42·5	43·0	45·2
13	27·70	615·7	93·6	28·78	605·0	95·9	31·13	610·9	99·1	31·67	615·4	106·1	41·8	41·7	42·7	44·2
14	26·75	612·5	97·8	29·78	606·2	96·9	30·92	607·7	98·5	31·74	614·5	110·8	41·4	40·5	40·3	40·1
15	26·02	615·9	92·3	28·91	615·7	91·4	32·55	615·7	95·0	29·85	616·9	101·5	38·0	37·6	38·0	38·7
17	27·77	615·2	93·2	29·58	608·0	96·2	34·63	610·8	101·2	26·44	615·1	112·4	33·5	32·9	33·4	34·3
18	27·70	614·5	95·0	29·51	606·8	94·3	32·21	613·3	99·0	30·39	608·9	101·4	33·1	32·8	33·7	34·5
19	27·90	613·6	96·2	29·18	607·1	94·9	32·15	613·3	95·2	29·51	619·4	96·6	31·9	31·4	32·2	33·1
20	28·50	622·6	88·9	27·90	608·9	95·9	30·12	611·1	89·8	28·78	617·4	93·6	34·3	34·4	34·9	36·3
21	27·37	619·3	88·1	29·11	613·5	86·2	......	......	......	22·79	612·7	112·2	38·2	38·7	......	40·3
22	40·70	614·5	74·9	31·47	601·8	86·0	30·25	604·7	150·0	24·33	615·8	168·5	39·0	38·6	40·0	41·6
24	32·21	598·2	89·8	34·10	594·3	102·3	35·98	598·9	116·4	32·55	604·7	137·1	38·1	37·5	38·6	40·6
25	27·77	607·7	100·9	28·50	602·8	98·4	30·79	609·2	97·8	29·92	617·8	101·2	36·1	34·8	35·1	36·5
26	27·77	614·8	95·0	28·78	606·7	96·7	31·40	611·4	96·3	29·04	616·7	98·7	36·2	36·4	37·7	39·0
27	27·37	614·4	93·4	30·39	609·2	96·0	31·27	612·4	96·8	28·44	619·6	96·4	37·4	37·1	37·3	38·0
28	26·96	606·8	95·5	30·12	607·3	92·1	31·60	612·0	95·8	28·97	612·7	102·3	36·7	36·3	37·0	38·9
29	27·24	613·7	92·7	28·91	606·0	92·7	31·81	618·0	94·4	30·39	621·9	95·6	33·6	32·4	32·6	33·8
Dec. 1	28·03	617·4	94·6	29·45	611·7	95·5	32·01	617·5	98·1	30·66	615·0	102·7	32·5	33·1	34·9	35·5
2	28·17	611·6	89·2	31·20	610·2	94·3	30·12	614·9	96·4	27·03	616·6	99·6	31·9	31·1	31·6	33·3
3	27·03	616·4	91·6	29·04	613·8	94·4	29·98	619·3	92·6	28·50	616·4	97·7	29·9	29·6	29·8	30·7
4	27·24	619·1	83·2	28·91	617·2	91·1	30·27	617·3	84·4	28·10	620·1	95·5	30·6	31·3	31·8	33·7
5	27·03	619·3	91·5	27·57	615·2	93·1	29·65	619·8	93·4	28·10	621·2	92·0	40·2	41·0	42·9	44·8
6	30·59	636·0	72·6	27·97	617·6	80·4	29·92	589·2	95·3	27·77	613·7	91·1	47·8	48·0	48·9	47·9
8	25·88	604·8	93·7	30·86	594·6	102·5	31·47	609·9	112·9	26·82	609·0	125·0	47·3	47·1	46·8	46·6
9	29·38	608·5	100·5	30·86	610·5	99·5	33·89	613·1	105·2	26·49	601·4	117·6	43·9	44·2	45·8	46·8
10	27·57	607·3	96·9	29·85	608·6	100·2	31·20	614·7	108·0	29·18	615·8	103·0	50·8	51·1	51·7	51·7
11	27·90	613·0	99·8	29·71	607·8	101·2	29·78	591·6	113·7	29·18	608·1	115·1	47·5	47·0	47·3	48·1
12	27·70	613·2	98·3	29·45	611·1	100·8	30·32	614·6	100·3	30·92	610·5	105·9	45·4	45·0	45·2	45·8
13	28·97	613·0	92·3	30·99	606·6	95·9	32·08	613·9	104·2	21·78	617·7	125·9	42·5	41·4	41·2	42·0
15	27·23	614·7	100·5	29·04	607·7	96·8	30·92	614·5	96·8	27·83	616·8	104·9	39·9	39·9	40·2	41·2
16	27·90	620·8	92·9	30·72	606·7	95·4	32·41	619·3	96·6	31·20	612·2	110·8	41·0	41·5	42·9	44·1
17	27·30	617·1	96·6	28·50	608·2	96·4	31·47	618·2	93·0	29·11	619·2	98·6	45·8	45·8	45·6	46·7
18	27·83	621·1	95·9	32·48	604·9	96·2	35·10	617·6	98·7	31·20	612·8	108·2	44·3	43·5	43·3	43·9
19	36·05	609·3	84·8	33·56	610·3	97·1	36·65	608·2	107·8	27·24	600·4	123·9	43·5	43·5	43·9	44·6
20	28·78	616·0	91·6	30·92	619·4	94·3	30·12	611·6	94·0	29·65	615·4	94·1	45·6	46·0	46·4	46·9
22	26·75	624·0	80·9	34·23	596·6	92·8	33·29	619·2	97·9	37·86	611·4	143·9	41·7	40·6	39·5	38·3
23	29·11	606·8	82·5	31·74	607·2	92·3	32·62	610·3	107·9	30·86	615·1	112·3	33·5	33·5	34·3	35·7
24	29·85	624·2	80·7	31·67	603·4	85·9	30·25	612·2	93·7	35·78	613·7	108·6	33·6	33·1	32·9	33·0
25	29·18	614·5	89·2	31·88	603·6	101·8	30·45	611·4	109·6	24·13	610·2	119·9	33·1	33·1	33·4	34·5
26	28·50	611·9	96·8	33·15	607·6	97·3	30·39	595·9	105·0	25·21	600·0	131·9	36·7	36·9	37·4	38·0
27	26·75	616·9	92·3	30·18	607·6	100·3	35·04	613·9	103·4	33·42	610·3	124·2	36·5	36·2	36·2	36·6
29	27·17	593·4	105·8	24·74	603·9	106·6	25·07	605·4	119·3	28·17	610·4	152·2	37·5	36·6	37·0	38·6
30	27·44	596·3	71·5	27·77	616·5	112·8	28·97	612·3	104·5	27·63	611·8	106·5	37·8	38·3	40·0	41·7
31	26·83	614·7	99·8	28·50	612·0	100·8	28·30	609·0	98·7	27·17	616·5	100·1	42·3	42·6	43·5	44·3

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Jan. 1	25·89	614·3	102·2	26·29	614·3	101·1	......	......	......	28·45	598·1	98·4	43·0	43·8	......	42·9
2	26·35	614·5	99·1	28·58	610·6	101·7	30·12	612·6	103·4	27·50	615·3	101·6	41·2	41·2	41·5	42·1
3	26·29	614·8	92·9	27·43	609·8	101·4	30·67	618·2	99·9	30·86	620·9	97·4	37·3	36·9	37·1	37·6
5	27·03	611·8	105·3	33·56	589·0	114·9	30·53	613·6	121·3	24·21	615·5	125·9	34·8	35·0	36·0	37·2
6	26·71	613·1	89·0	27·31	608·8	96·0	29·18	609·4	110·7	27·78	618·5	104·8	42·9	44·4	45·0	45·3
7	25·49	614·5	96·4	27·38	605·3	94·9	31·21	612·6	102·2	28·78	612·5	104·7	44·9	44·0	43·4	43·3
8	26·08	612·8	94·8	26·96	607·8	96·0	31·06	615·0	98·9	28·51	620·8	99·2	40·2	39·7	40·1	41·0
9	25·96	615·5	94·4	25·89	608·9	89·3	31·61	613·7	97·1	26·75	610·4	119·7	40·8	39·2	38·3	37·7
10	26·75	613·5	94·2	28·17	611·8	88·8	30·27	617·0	94·7	28·98	......	......	33·6	33·0	33·4	......
12	27·23	614·4	89·7	26·03	608·5	93·1	31·34	609·8	93·3	28·65	619·8	96·0	36·5	37·7	39·1	40·3
13	25·42	619·8	95·0	30·00	598·4	94·4	31·81	610·1	97·3	28·98	617·0	99·0	37·0	35·9	35·5	35·7
14	26·35	615·9	89·7	26·71	608·1	93·1	29·33	605·9	89·6	31·88	617·2	96·0	32·2	31·8	31·9	33·6
15	26·08	620·5	95·9	26·71	613·3	89·8	29·45	611·6	87·7	27·90	620·6	95·8	38·6	39·5	40·1	40·8
16	25·49	623·8	86·7	25·62	610·7	89·2	30·74	611·3	91·4	28·45	620·9	93·2	41·1	40·9	41·3	42·2
17	26·35	625·3	82·1	26·56	616·6	92·7	31·94	619·7	82·0	28·51	622·3	89·4	40·5	40·3	41·0	42·4
19	25·96	619·0	85·6	25·76	612·4	101·5	31·81	615·7	99·9	29·12	623·1	95·6	41·5	41·8	41·9	41·9
20	52·06	586·6	−1·6	29·60	589·8	96·6	36·05	627·7	157·7	34·57	607·0	153·7	42·7	43·3	44·5	45·7
21	27·43	597·7	84·6	28·85	585·8	106·0	35·58	596·0	119·5	29·65	606·3	127·6	42·0	41·5	41·1	40·9
22	25·62	611·5	91·1	27·11	603·2	91·2	32·89	615·1	87·8	16·46	648·6	263·7	41·8	41·0	41·1	40·7
23	26·83	605·6	92·6	26·56	599·7	104·6	35·51	592·5	129·8	35·44	623·8	189·2	39·8	39·6	40·3	41·1
24	27·11	604·6	101·3	27·31	595·8	106·4	31·06	602·6	106·9	28·05	606·4	111·8	40·1	40·3	41·4	43·2
26	26·49	605·8	95·6	28·72	599·8	76·0	31·48	609·9	95·5	22·31	620·7	123·8	38·5	37·9	38·5	40·0
27	27·70	612·5	69·7	30·86	579·2	86·7	34·63	614·6	91·4	27·58	615·0	102·1	42·3	42·5	42·9	43·3
28	25·42	608·0	92·0	27·78	600·2	84·3	31·54	613·7	96·8	27·58	617·2	92·3	39·7	38·8	38·9	40·5
29	25·62	619·1	88·5	27·23	611·0	94·5	29·33	617·5	80·4	27·70	620·0	94·5	36·8	36·8	37·9	40·0
30	25·89	616·7	88·4	28·85	597·8	84·7	37·32	616·8	85·1	......	......	......	43·0	42·3	42·0	......
31	24·01	613·0	75·1	29·52	609·4	83·5	36·25	614·8	100·9	19·56	623·8	126·8	38·6	37·9	38·8	38·4
Feb. 2	27·23	614·7	77·9	31·34	605·8	91·8	31·67	611·9	99·1	30·59	615·8	104·8	43·0	43·8	45·4	46·7
3	26·44	613·9	88·2	25·76	606·0	93·3	29·92	613·3	94·1	24·07	611·2	109·8	44·0	43·0	43·0	43·4
4	20·76	616·8	87·4	25·62	608·2	89·0	32·28	612·1	95·7	30·53	616·5	101·1	39·2	40·2	41·7	44·3
5	25·68	612·0	88·9	26·08	607·3	87·7	34·03	615·8	88·9	30·07	615·6	99·0	43·9	43·3	43·4	43·4
6	25·35	617·7	83·9	30·00	612·6	82·9	33·83	623·9	95·3	28·78	636·3	125·2	42·0	41·6	42·0	43·3
7	25·76	614·8	85·1	28·25	601·8	91·4	36·38	624·8	101·5	33·15	616·6	109·7	40·0	39·8	40·6	42·0
9	27·23	615·8	82·1	26·49	605·7	92·4	33·96	609·9	95·3	28·72	619·9	94·7	43·0	42·0	41·6	41·4
10	25·01	615·7	85·1	26·75	606·1	87·9	32·82	611.2	94·7	29·39	620·0	98·5	39·0	38·4	39·4	40·1
11	24·62	617·5	87·5	25·22	603·5	107·5	31·54	604·9	92·4	28·79	619·7	93·4	35·3	36·2	34·7	36·3
12	24·89	628·4	79·9	25·49	613·7	85·3	29·60	608·7	81·8	29·65	626·0	84·7	39·0	39·6	40·3	41·2
13	24·48	632·8	79·1	25·82	615·1	80·1	33·83	614·1	76·4	31·00	624·3	89·9	39·8	39·0	38·9	39·4
14	24·89	619·9	85·4	27·03	615·1	84·5	32·95	617·3	83·4	29·12	620·8	85·7	37·6	36·9	37·5	38·4
16	35·98	642·3	−13·4	27·84	591·6	132·0	29·60	633·2	157·9	24·54	635·0	190·5	41·5	40·9	41·1	41·6
17	28·72	585·2	114·0	26·03	579·1	140·7	30·86	607·5	153·8	......	......	......	41·2	41·2	42·9	......
18	7·04	*	......	24·01	604·1	114·6	48·03	693·2	206·2	52·53	*	357·1	......	40·8	40·8	41·8
19	32·41	562·5	88·4	25·42	580·4	130·7	39·21	679·1	152·1	29·39	686·6	223·7	36·1	35·0	35·3	35·8
20	28·78	454·8	−45·9	34·50	577·0	163·6	28·85	679·5	201·2	19·09	637·3	188·2	31·1	31·3	31·7	33·8
21	27·31	599·3	99·7	27·16	580·9	117·7	41·50	622·8	133·3	31·81	667·2	219·4	32·6	33·1	35·6	38·9
23	31·74	604·1	100·9	26·08	579·2	113·2	33·29	596·3	118·1	32·08	603·8	145·3	41·5	41·2	42·0	45·1
24	24·54	602·5	106·8	25·96	587·3	101·3	33·76	605·4	108·6	29·85	603·0	116·4	39·7	37·9	38·2	40·9
25	25·01	608·1	105·0	25·68	595·9	104·3	31·00	596·2	102·7	28·72	610·9	57·0	34·8	33·2	33·3	34·7
26	29·65	617·9	89·7	33·83	592·3	99·3	33·83	605·5	99·8	31·26	612·0	114·1	34·9	35·2	36·9	38·1
27	25·15	607·6	106·3	27·43	600·3	107·0	31·06	612·2	102·0	35·78	614·1	147·2	37·4	37·4	39·0	41·2
28	28·05	606·5	99·3	33·15	606·9	102·6	31·14	603·7	107·9	30·33	607·9	135·2	41·3	41·2	41·3	41·9

* Out of field.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	26·16	604·1	96·3	31·74	602·9	54·7	35·24	614·7	117·3	29·25	624·4	110·6	37·3	37·1	38·5	39·9
2	25·62	606·2	97·7	30·80	614·7	100·6	31·81	602·8	111·4	27·43	610·7	112·1	35·2	35·7	36·1	38·4
3	24·69	604·8	94·8	27·31	605·0	93·8	31·14	607·7	97·3	27·70	615·1	113·1	35·2	35·3	37·3	40·4
4	30·33	607·5	91·9	27·50	601·1	101·7	33·15	614·1	105·7	29·92	617·2	104·8	34·0	33·1	35·3	39·1
5	23·94	606·3	92·4	28·58	599·0	106·4	34·43	623·1	100·4	33·96	625·5	112·5	38·6	39·7	41·7	42·8
6	22·31	608·2	87·6	28·58	592·5	90·8	36·58	615·4	100·6	33·89	637·9	150·9	43·0	42·6	44·1	45·4
8	32·21	602·9	111·5	34·63	588·8	107·6	36·05	619·7	127·4	27·70	611·2	129·6	40·0	39·6	40·9	44·0
9	24·01	607·7	86·9	24·48	587·5	94·5	35·98	607·6	90·2	34·57	607·8	119·0	42·0	41·3	42·4	46·0
10	21·52	605·2	96·6	28·85	592·1	101·2	34·77	602·1	115·4	31·48	617·3	118·7	41·5	40·1	40·4	40·8
11	21·99	617·1	101·5	34·90	597·5	88·7	35·58	605·3	94·8	30·12	615·1	100·0	39·5	39·4	40·1	41·1
12	23·94	622·0	85·7	28·58	606·5	86·0	39·54	592·8	96·4	29·45	614·2	145·7	40·2	40·5	42·7	45·5
13	27·16	600·3	91·7	38·60	566·3	103·6	35·51	607·0	99·0	25·42	624·2	128·8	40·6	39·4	39·2	39·4
15	24·75	621·4	86·0	26·49	599·0	102·3	33·76	606·3	104·5	29·39	623·6	100·7	40·4	40·4	42·0	43·8
16	21·78	611·1	95·4	26·44	604·4	94·7	36·79	615·5	91·4	29·33	627·0	109·5	43·4	43·0	43·4	44·4
17	26·35	610·4	82·7	19·70	590·6	100·8	33·02	602·5	115·3	21·78	628·9	144·9	42·6	42·2	42·2	42·9
18	29·72	611·2	65·2	30·00	597·0	86·2	34·63	609·4	101·7	26·75	618·1	105·7	41·7	41·4	42·6	44·5
19	25·68	613·4	95·3	27·58	594·1	95·3	32·21	618·6	108·1	20·43	630·2	118·6	38·9	38·2	38·5	40·0
20	24·27	616·1	83·6	27·03	597·2	100·2	37·39	613·4	95·5	33·15	633·9	125·3	38·9	39·5	42·4	45·6
22	22·31	601·3	87·7	25·68	597·2	81·6	34·43	598·7	97·8	23·86	618·3	108·9	47·1	46·7	46·9	48·6
23	22·11	613·5	92·4	27·31	592·2	82·0	35·51	601·0	84·6	27·98	617·2	96·3	50·2	50·7	53·4	57·2
24	21·72	610·3	97·0	24·21	592·2	95·7	32·82	603·9	89·2	27·70	615·2	96·8	53·0	51·6	49·9	48·8
25	21·84	612·5	92·4	25·15	600·1	89·8	33·49	610·7	87·7	29·12	622·2	91·2	40·9	40·6	40·9	41·1
26	27·31	619·3	86·6	27·11	607·4	81·9	......	......	......	33·83	653·4	74·2	38·1	38·3	......	40·6
27	30·86	597·9	47·1	27·16	589·0	117·2	32·21	613·4	120·8	31·67	618·6	124·2	37·9	38·3	39·6	40·8
29	23·40	607·0	68·5	29·52	601·8	79·0	33·89	612·6	90·6	28·85	623·4	95·0	37·9	38·1	40·0	42·6
30	21·52	603·3	69·4	25·62	604·0	89·0	33·29	603·8	91·7	29·52	631·2	120·8	41·7	42·3	42·5	42·8
31	21·32	610·8	91·4	29·65	591·5	82·9	36·52	600·0	90·3	29·39	617·1	89·0	41·1	41·2	42·3	44·0
Apr. 1	22·11	603·4	73·8	28·85	591·8	100·6	33·42	612·2	133·7	31·26	625·4	96·5	40·7	40·8	43·0	45·8
2	28·11	600·4	89·6	26·29	582·0	103·6	34·50	605·1	93·6	32·55	646·8	132·6	40·9	40·1	42·6	45·7
3	20·96	602·4	74·4	29·52	585·6	82·7	38·87	620·2	90·2	28·11	621·3	116·6	42·6	42·1	44·6	48·0
5	18·62	605·1	74·2	30·86	584·8	77·0	39·27	643·2	100·6	33·09	627·7	152·7	40·6	40·5	43·8	46·3
6	22·19	603·5	83·5	29·60	585·5	87·8	35·84	616·2	86·0	29·60	622·5	101·1	40·3	39·8	42·8	46·8
7	21·17	607·2	91·1	27·16	586·6	81·5	35·84	607·1	79·5	29·92	619·4	87·8	43·9	43·9	46·1	48·8
8	27·78	615·4	89·7	28·31	591·8	90·0	36·25	615·1	62·5	30·39	619·8	88·8	44·1	43·8	44·2	50·0
9	25·29	618·0	78·0	26·83	592·6	71·6	39·14	620·3	85·5	32·21	607·0	138·6	47·5	47·6	49·1	51·5
10	24·89	625·8	66·8	28·51	591·4	77·2	32·01	609·8	88·9	26·71	632·4	97·6	47·4	47·2	49·2	53·2
12	21·72	605·4	97·9	27·58	595·0	91·6	30·59	612·1	132·0	26·83	621·4	86·9	49·3	49·0	52·2	56·7
13	29·05	604·7	88·7	29·18	583·2	88·3	36·92	606·8	88·8	30·19	626·1	117·3	50·7	50·2	53·2	58·1
14	22·59	609·9	86·5	28·85	599·2	79·7	35·10	604·9	85·0	29·18	630·8	94·4	54·0	51·0	54·1	59·3
15	32·82	617·7	82·8	28·45	595·8	85·5	35·84	615·7	89·8	29·25	627·0	99·0	52·6	51·8	53·8	56·8
16	25·29	607·6	77·6	28·45	594·4	77·3	36·85	622·1	89·2	30·47	644·8	118·9	48·9	48·8	49·7	52·3
17	30·53	605·4	88·5	25·89	601·3	86·2	32·95	622·4	80·4	27·84	634·9	94·4	47·0	47·0	50·8	54·3
19	33·70	599·0	71·7	30·39	600·5	75·7	31·54	613·0	90·6	28·45	624·9	103·3	44·0	43·6	46·1	49·7
20	23·86	597·9	75·4	27·38	605·0	78·8	46·88	624·4	85·6	39·27	646·5	209·4	45·6	46·1	48·9	52·0
21	22·66	*	−79·3	33·49	593·1	76·9	37·86	688·5	193·0	32·21	700·3	220·0	49·6	50·3	53·2	56·0
22	22·19	593·2	95·1	27·38	584·1	91·5	35·31	612·9	103·5	31·14	626·5	108·0	49·4	49·6	51·9	53·9
23	28·78	573·4	40·0	31·34	570·8	98·3	32·95	602·4	104·1	28·25	651·1	117·7	48·7	49·4	50·6	52·4
24	28·58	589·7	63·9	24·42	586·8	89·9	32·89	607·8	100·9	26·35	636·6	120·7	47·0	47·1	48·2	49·6
26	22·45	602·6	44·2	27·03	599·3	87·7	35·51	612·6	81·4	24·07	638·2	127·7	44·2	44·5	45·5	47·5
27	21·32	602·0	81·1	28·11	596·2	83·4	33·29	611·6	83·0	28·65	624·3	109·8	46·7	46·5	48·0	50·1
28	19·82	605·2	85·5	27·98	605·8	77·7	34·70	619·7	69·4	27·03	625·6	95·9	45·9	46·2	47·0	48·2
29	......	......	......	25·29	600·3	78·3	33·15	618·1	70·5	28·45	626·5	79·3	......	51·0	53·7	55·6
30	22·25	611·3	80·9	27·43	648·8	79·8	34·16	619·9	76·3	30·47	641·2	85·1	53·6	52·6	51·7	51·0

* Out of field.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
May 1	19·50	611·8	64·6	28·58	591·8	71·3	35·24	609·2	80·3	35·24	647·9	94·1	45·7	46·4	48·1	50·0
3	25·01	597·5	87·9	26·64	593·4	81·4	20·96	617·3	80·6	29·80	635·2	100·0	46·6	46·8	47·9	49·4
4	19·97	614·8	81·5	27·43	592·8	76·0	34·23	619·7	76·6	30·47	630·1	88·4	45·3	46·1	48·6	51·6
5	21·38	613·7	83·7	24·48	602·1	76·9	35·84	617·8	73·0	29·45	621·7	85·0	49·2	49·9	51·1	52·3
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	25·82	604·5	75·7	25·15	611·4	78·5	31·94	616·2	85·0	30·47	642·0	89·2	52·9	52·9	53·9	55·0
8	24·07	612·9	74·0	29·18	603·2	80·1	......	......	......	30·19	611·8	135·5	53·7	54·8	......	57·7
10	22·98	619·9	77·5	24·95	600·5	75·4	......	.....	......	27·43	644·6	100·6	53·7	53·7	......	56·5
11	22·19	617·1	71·5	24·81	601·8	78·8	30·33	615·4	84·5	28·11	623·1	76·8	51·9	51·6	52·2	53·0
12	21·58	612·6	71·0	23·66	607·4	69·3	29·39	611·2	69·1	29·33	645·6	89·2	49·4	49·6	51·1	53·8
13	23·13	612·2	71·4	26·44	617·0	62·6	30·80	621·3	67·4	29·45	628·9	75·1	51·8	53·0	54·7	55·3
14	21·38	606·7	60·5	28·31	607·6	63·0	29·60	621·0	60·0	26·75	626·2	85·1	53·0	52·6	52·6	53·9
15	29·39	611·2	69·1	23·54	616·1	81·0	27·70	612·8	78·6	27·11	629·7	92·5	51·1	49·7	50·5	54·2
17	19·56	618·2	86·5	25·15	604·0	79·7	35·58	614·6	74·6	27·78	626·6	83·3	53·6	54·2	56·2	58·7
18	29·25	612·3	72·0	......	......	......	32·82	613·2	74·9	36·65	639·1	94·9	55·4	......	57·6	57·9
19	20·29	609·5	80·9	24·95	618·0	68·6	32·21	632·6	63·9	35·17	639·6	85·5	52·0	52·0	52·4	51·9
20	22·19	607·1	25·9	27·84	593·7	65·2	35·64	590·4	147·6	34·70	649·4	128·4	50·0	50·6	52·8	55·2
21	33·42	591·3	59·3	27·78	587·7	81·1	28·78	612·7	103·4	26·75	637·4	103·3	51·9	51·9	52·2	52·2
22	22·86	612·0	46·9	26·29	592·4	74·4	31·48	616·4	82·5	27·43	635·3	99·2	48·7	49·1	50·6	51·5
24	26·29	603·5	82·6	28·51	599·9	67·5	27·50	624·2	85·2	26·03	644·1	84·5	50·8	51·1	53·8	56·2
25	34·50	611·1	62·2	26·16	602·1	67·6	29·85	611·6	67·7	27·03	643·1	88·0	53·1	53·7	55·6	58·5
26	21·58	612·8	80·3	26·83	601·1	70·7	30·67	619·5	66·8	27·16	643·5	87·5	52·3	51·6	52·0	52·3
27	28·51	578·1	72·2	31·00	571·8	72·7	33·49	623·2	81·3	35·98	666·0	118·0	50·2	50·3	51·1	52·1
28	22·78	606·3	81·4	28·92	576·4	86·6	37·73	609·5	133·1	30·53	618·2	108·8	50·3	50·6	51·0	53·8
29	19·30	597·4	83·5	25·89	600·9	74·1	29·65	615·6	73·2	26·29	626·2	89·7	49·8	50·0	50·8	51·4
31	19·56	612·7	80·7	28·25	607·0	71·2	33·42	614·2	91·8	28·17	634·7	107·7	48·6	49·1	51·1	53·0
June 1	22·78	616·3	93·5	27·31	605·7	97·7	33·09	608·8	97·7	26·35	627·3	105·2	48·5	49·2	51·1	52·9
2	19·97	614·7	104·7	26·29	606·6	92·3	34·37	616·6	97·6	29·72	629·6	100·6	49·8	50·4	51·9	52·6
3	18·74	619·5	98·0	22·45	604·2	88·1	35·17	617·4	82·6	30·74	630·3	95·6	50·9	51·4	53·0	54·2
4	20·64	614·7	100·7	26·03	611·5	94·9	33·56	616·5	95·0	34·90	643·2	113·5	50·6	52·0	55·1	57·7
5	19·36	617·1	96·7	23·46	607·7	85·5	31·54	632·5	84·7	29·33	636·7	109·8	54·3	54·3	57·3	60·0
7	19·90	612·0	87·0	27·03	605·8	82·6	32·62	629·0	77·5	28·92	627·7	95·4	54·9	55·2	56·6	58·0
8	20·70	622·7	86·0	24·75	618·8	86·0	27·03	622·9	84·8	26·49	627·0	110·8	55·6	55·7	55·8	56·3
9	22·31	612·6	87·2	27·98	604·5	83·4	29·72	618·7	75·7	26·56	632·4	83·6	54·1	54·2	54·2	54·6
10	19·90	617·9	94·8	26·22	611·1	77·1	30·53	627·6	70·1	27·90	629·5	82·4	53·4	52·6	53·5	53·8
11	21·11	622·1	76·1	28·37	608·2	61·2	35·10	625·5	84·3	30·00	662·1	116·7	49·7	49·6	51·1	52·5
12	23·34	593·5	21·7	28·65	586·5	89·8	32·75	646·6	89·7	27·50	635·5	145·4	51·6	52·2	54·2	54·3
14	16·93	608·9	87·6	23·86	597·7	85·3	29·60	612·5	82·1	26·64	627·3	92·8	54·8	54·5	55·3	56·3
15	17·01	602·0	91·2	25·62	608·4	81·6	33·29	622·6	79·2	28·45	635·3	86·4	53·5	55·2	57·8	59·5
16	16·34	598·9	39·5	32·95	592·3	69·4	26·71	647·6	137·8	32·48	641·8	144·3	55·6	56·1	56·6	56·6
17	33·96	583·8	71·2	22·45	602·6	81·9	30·80	619·4	108·7	28·65	626·6	118·7	54·3	55·6	57·3	59·1
18	18·15	599·7	96·1	25·42	591·6	95·0	29·25	611·2	88·9	29·25	632·5	98·9	56·0	57·1	58·6	60·2
19	22·45	606·0	74·8	24·01	598·1	80·9	32·21	633·1	86·9	30·67	636·1	128·0	58·0	59·2	60·2	61·7
21	17·60	615·3	98·7	22·45	595·5	89·9	33·70	613·0	74·6	29·12	625·7	94·7	65·8	63·8	65·1	66·9
22	18·62	615·7	92·7	23·74	599·2	86·7	32·15	610·8	83·6	28·72	630·3	86·1	61·4	61·2	61·8	62·2
23	28·05	611·1	59·5	32·68	601·8	85·1	32·75	605·9	97·3	26·75	629·5	110·6	57·3	58·0	59·9	62·0
24	......	......	......	23·54	595·9	80·3	31·88	616·0	78·2	29·33	641·4	92·3	......	58·2	60·1	61·8
25	16·61	621·8	84·5	24·69	608·6	80·3	30·07	629·0	76·6	28·37	624·7	107·4	60·2	60·2	61·3	62·7
26	28·92	609·2	94·8	23·94	603·1	80·8	29·80	617·8	73·4	27·90	628·1	93·2	60·3	60·3	60·5	61·4
28	17·74	616·5	89·2	23·80	605·5	81·4	31·26	628·0	81·7	28·72	640·4	102·2	59·2	59·4	60·9	62·8
29	22·86	584·3	85·4	27·58	625·4	72·8	30·53	614·2	81·8	27·11	634·9	98·2	58·8	59·5	61·6	62·9
30	17·54	624·7	83·5	28·05	602·2	73·7	34·97	598·2	99·3	29·05	635·8	132·2	59·6	59·1	61·6	63·4

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
July 1	22·98	620·1	74·2	25·68	607·5	68·4	29·12	612·5	78·6	26·22	633·3	102·4	59·9	60·2	61·9	62·9
2	19·36	614·1	85·5	22·92	611·2	81·2	30·47	621·0	75·3	28·31	634·0	90·5	60·9	60·8	61·5	63·6
3	15·32	610·9	87·7	26·96	593·2	80·5	30·39	627·9	88·0	......	......	......	59·4	60·2	63·2	......
5	26·03	604·3	85·5	23·46	596·9	93·0	30·80	609·7	100·8	26·96	628·5	118·4	70·5	71·5	73·7	74·5
6	18·88	609·9	86·6	27·43	600·1	93·9	30·47	616·2	101·2	27·70	640·0	100·2	71·5	71·6	72·6	73·1
7	18·15	609·3	102·1	23·74	602·7	105·0	29·33	632·4	107·1	30·94	631·7	131·3	68·3	68·1	69·2	71·0
8	32·08	556·2	46·4	37·12	577·1	94·1	31·74	617·6	104·9	27·38	622·0	115·2	67·2	68·2	70·3	72·5
9	17·40	606·8	100·8	23·13	606·6	104·2	30·80	617·6	89·9	30·00	624·7	96·4	68·3	68·9	71·7	73·9
10	35·84	589·4	8·3	25·08	606·8	73·1	37·06	635·5	120·4	28·78	677·4	191·1	68·6	67·9	68·1	69·4
12	19·97	589·3	97·6	22·66	604·1	98·1	30·07	617·1	85·4	28·45	646·5	103·3	63·4	64·4	67·3	70·9
13	20·23	599·6	79·5	25·35	586·6	108·8	30·74	622·4	94·4	29·12	632·4	115·3	65·0	65·1	67·3	70·6
14	20·49	607·4	92·6	25·01	609·6	99·7	32·68	621·0	99·5	26·71	640·0	124·9	66·4	66·4	69·3	73·1
15	22·92	611·9	78·5	26·16	605·1	89·9	28·05	622·4	98·7	27·78	625·6	104·9	69·8	68·7	69·3	69·7
16	16·54	601·6	87·5	27·03	604·8	89·2	31·14	632·3	118·4	28·37	632·7	110·2	66·2	66·7	69·4	72·2
17	18·94	611·5	94·6	24·54	599·5	90·4	28·72	616·0	95·4	25·15	629·3	113·4	68·4	68·9	70·1	70·4
19	18·74	609·4	103·0	24·48	601·2	94·1	30·39	611·4	96·3	27·16	631·7	112·6	65·5	65·8	67·6	69·3
20	17·80	611·8	101·8	24·07	600·1	98·6	31·14	611·1	92·7	25·01	630·1	106·4	65·3	65·9	67·3	68·8
21	18·01	612·0	96·5	21·38	601·7	88·4	30·74	615·8	85·0	28·11	628·5	91·5	66·0	66·6	68·1	69·0
22	16·93	616·3	98·6	23·80	605·2	72·0	31·48	615·8	78·4	27·50	637·0	92·9	65·7	66·0	67·1	68·7
23	14·91	609·0	148·9	24·13	608·7	91·6	33·09	629·3	80·4	28·58	636·3	97·7	62·6	62·9	65·5	68·6
24	27·31	612·2	100·9	24·01	607·3	90·8	34·84	621·8	86·7	27·98	632·1	92·8	65·2	65·5	67·7	70·4
26	18·62	606·8	104·0	24·33	607·2	94·0	33·29	641·0	91·5	26·16	631·6	104·6	66·7	66·1	65·6	65·5
27	20·64	615·9	92·5	24·21	612·4	94·5	28·78	634·8	87·3	24·62	648·8	108·0	62·7	63·0	65·0	66·8
28	28·51	614·6	42·9	30·00	585·2	85·1	32·35	607·2	96·8	28·17	631·4	120·1	64·2	64·1	66·4	69·9
29	20·96	608·4	99·6	28·45	617·5	80·4	33·49	616·6	109·8	28·78	627·1	122·0	65·1	64·7	66·3	69·2
30	22·66	602·3	81·7	19·70	587·9	97·7	31·81	606·3	110·9	23·13	646·8	162·2	67·9	68·9	71·2	73·7
31	26·75	609·4	87·1	27·16	601·9	83·7	29·80	616·5	102·8	29·33	616·1	130·8	67·3	67·2	68·6	70·8
Aug. 2	20·76	605·4	93·1	24·75	605·0	90·9	31·41	621·4	92·1	26·56	622·4	102·7	63·4	63·4	65·0	66·9
3	16·40	610·5	93·3	23·74	599·9	81·6	30·07	614·1	85·3	27·16	638·7	95·1	63·7	63·5	63·1	63·0
4	18·27	608·3	94·4	22·86	608·4	82·6	30·00	624·1	88·6	27·38	632·8	103·4	57·6	58·3	61·2	63·2
5	29·05	617·6	89·6	24·01	610·0	91·1	30·59	621·7	80·5	29·39	637·1	90·5	58·9	59·1	62·7	64·8
6	20·90	604·8	88·6	23·74	609·2	92·5	31·41	620·5	76·6	26·71	632·9	94·8	60·3	60·6	63·1	65·3
7	25·01	615·3	65·2	25·55	598·3	91·4	26·44	616·8	102·9	25·42	634·2	101·1	60·5	61·3	63·3	64·6
9	18·41	612·3	90·5	24·27	597·9	87·7	30·74	614·5	78·4	26·49	630·1	93·0	59·1	59·8	61·9	63·4
10	18·41	620·0	88·8	23·60	609·4	81·8	30·59	632·6	75·1	24·62	625·1	91·4	59·1	59·8	62·1	63·8
11	17·21	601·4	94·7	......	......	......	30·12	623·3	88·1	24·95	631·5	98·6	58·8	......	61·4	63·5
12	18·74	597·5	83·2	24·54	605·9	87·6	29·80	626·8	83·5	27·43	640·4	127·7	60·3	60·2	60·3	60·8
13	18·94	607·4	93·2	26·56	610·3	89·7	31·21	614·4	92·1	22·98	627·0	104·8	56·9	57·5	60·3	62·3
14	15·19	606·0	81·7	29·72	597·9	84·2	31·94	645·4	87·6	32·62	622·2	107·4	58·9	59·2	61·9	65·1
16	14·71	610·6	87·6	25·42	606·4	89·9	30·19	622·5	85·0	22·98	624·8	98·6	58·5	58·7	60·3	60·9
17	18·82	603·7	91·1	25·89	607·4	83·7	31·61	627·2	93·0	24·81	628·2	97·9	61·9	62·6	64·7	66·0
18	17·74	610·8	89·1	25·22	598·4	79·1	32·08	601·9	78·7	25·22	632·5	95·0	62·9	62·9	64·6	66·6
19	17·28	618·2	91·0	23·19	600·3	86·9	32·35	613·9	75·0	28·05	636·5	91·1	61·9	62·2	62·7	63·9
20	16·54	616·5	94·2	21·72	599·2	90·5	30·94	621·0	81·3	25·82	627·7	93·0	60·8	61·4	64·0	67·5
21	15·52	614·7	94·4	25·55	600·3	80·2	31·67	615·2	80·5	25·01	633·0	91·6	63·5	63·0	64·7	67·8
23	21·11	610·0	94·4	31·67	613·9	87·4	35·04	627·9	94·8	25·29	608·6	86·5	61·8	62·1	64·6	63·9
24	34·43	608·8	56·7	28·11	613·9	76·4	35·04	619·9	109·5	31·41	627·3	166·8	61·9	62·2	64·1	66·4
25	18·88	594·1	92·5	28·98	598·8	82·7	32·62	595·6	108·5	28·17	645·4	130·7	63·4	62·6	62·4	63·2
26	18·35	604·8	70·9	25·68	607·8	81·8	28·25	605·4	94·3	15·26	652·7	137·3	57·6	57·8	60·9	64·5
27	21·84	610·0	77·0	29·18	602·0	76·5	33·70	611·1	100·2	26·16	627·0	119·7	60·3	60·7	63·7	67·2
28	22·72	609·9	79·1	27·43	603·9	86·5	21·99	617·9	107·1	23·34	615·1	110·2	63·9	63·6	66·4	69·1
30	18·27	614·0	88·8	24·13	602·3	81·3	31·00	620·1	80·4	26·49	625·6	103·3	63·3	62·8	63·8	64·5
31	20·09	613·4	89·7	24·42	601·1	81·8	30·94	616·5	79·1	23·60	627·6	90·8	59·5	59·4	61·1	63·2

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Sept. 1	18·94	617·9	102·9	26·08	607·8	80·0	37·59	646·2	73·0	31·06	649·1	98·2	62·2	59·1	61·0	62·8
2	18·62	615·5	86·1	25·29	604·1	85·9	29·80	622·3	77·8	26·56	631·8	92·1	62·3	63·0	65·5	67·2
3	19·15	617·2	55·3	24·75	599·4	74·3	31·41	621·6	83·9	25·55	632·1	93·9	61·6	61·5	64·2	67·1
4	34·03	621·0	31·0	30·94	596·9	64·9	40·01	605·5	99·9	25·55	630·2	123·2	62·8	62·5	63·4	65·9
6	19·23	610·4	95·1	24·48	601·7	83·6	32·28	615·4	86·4	14·52	640·9	74·7	62·7	63·0	63·5	63·5
7	18·88	614·0	80·2	25·01	609·5	88·2	28·17	620·1	91·6	21·11	635·8	112·9	60·4	61·0	63·0	64·7
8	17·01	609·2	89·0	24·81	590·1	84·6	28·98	611·8	91·7	21·25	619·7	127·5	63·4	63·8	65·3	65·9
9	20·96	604·8	73·5	28·65	595·4	73·7	31·06	634·0	76·1	31·41	650·6	117·6	62·7	62·6	63·7	64·6
10	28·25	596·3	13·8	29·92	593·1	92·8	26·96	617·3	101·6	21·17	621·6	118·2	61·1	61·0	61·3	61·4
11	30·39	592·0	74·8	31·00	584·8	78·9	27·70	623·5	91·5	19·76	619·4	124·0	56·4	56·5	57·6	61·1
13	21·05	606·5	76·5	24·27	605·1	74·6	29·33	614·1	87·8	27·70	618·6	96·3	55·0	54·6	56·5	57·1
14	20·76	611·2	91·0	26·44	607·7	82·4	28·72	624·9	81·5	25·89	624·7	88·1	50·4	50·0	50·9	52·6
15	21·38	616·4	86·0	25·35	600·8	86·0	27·84	616·7	87·0	22·78	623.3	87·1	48·4	48·0	50·8	53·3
16	20·70	613·6	88·0	25·22	596·2	80·7	31·88	630·0	77·4	22·92	630·1	94·1	45·8	45·4	47·7	50·7
17	28·85	627·2	72·2	29·85	605·9	83·6	35·84	628·9	98·4	18·01	661·3	223·5	50·0	50·0	52·0	54·6
18	19·15	612·0	93·0	22·51	605·1	83·0	27·84	610·3	81·2	24·81	627·4	85·9	48·2	48·1	50·8	55·0
20	38·60	607·3	53·7	32·35	591·7	89·7	33·09	607·4	122·5	30·00	620·7	160·5	47·7	47·8	48·4	49·6
21	18·41	612·4	85·3	24·69	591·6	91·6	30·39	627·3	97·2	26·16	633·4	161·2	48·6	48·7	50·2	51·4
22	30·74	597·7	36·6	29·33	596·2	92·4	29·18	596·1	126·6	20·37	621·6	129·6	46·5	46·7	49·0	52·6
23	24·33	629·3	53·8	23·19	601·8	90·4	28·65	618·7	109·7	21·78	621·9	122·8	54·2	54·5	56·1	57·6
24	24·07	615·7	81·3	......	......	......	28·37	614·7	112·9	27·11	618·2	102·2	54·4	......	56·1	58·7
25	25·01	611·6	81·9	24·33	604·1	88·2	21·05	608·9	91·0	23·07	620·3	96·5	54·4	53·8	57·1	60·0
27	20·03	617·0	83·1	23·66	603·8	78·1	26·71	614·5	76·2	24·89	623·2	94·8	49·7	49·7	50·5	52·6
28	20·84	620·9	83·8	......	......	......	......	......	......	......	......	......	46·6	......	......	......
29	21·25	623·7	84·3	26·16	614·5	84·8	29·05	627·4	81·1	24·81	629·3	81·5	47·5	47·2	47·5	48·1
30	23·66	615·6	77·5	34·16	580·4	86·1	26·83	593·5	134·1	27·70	614·4	110·7	46·9	47·0	47·6	47·6
Oct. 1	24·33	612·4	82·8	28·45	604·0	88·9	12·77	612·2	92·2	23·86	632·4	108·4	44·5	44·3	46·2	47·3
2	21·72	614·9	82·3	24·42	599·3	79·1	35·10	616·7	86·2	28·31	625·4	109·7	43·9	43·7	44·8	46·1
4	25·08	611·7	77·0	31·88	579·2	98·7	29·25	610·2	83·5	25·08	623·0	93·4	45·8	45·5	47·3	48·8
5	24·21	627·5	80·0	22·59	612·7	79·4	38·74	614·6	100·1	24·95	625·7	99·5	48·3	48·1	48·4	48·6
6	24·75	617·3	79·8	22·39	605·8	83·1	28·11	616·0	81·6	24·21	628·0	108·7	46·1	45·8	47·7	49·7
7	21·64	616·0	83·7	24·81	601·0	83·6	29·52	614·0	88·8	19·62	631·6	123·3	44·5	43·8	44·6	45·2
8	21·05	613·2	84·3	25·76	610·1	79·8	33·49	628·8	82·1	18·41	638·3	115·3	41·1	40·9	41·8	43·7
9	20·76	611·2	87·2	23·80	608·5	81·2	28·45	623·8	79·4	22·66	628·7	83·0	40·7	40·9	42·5	44·5
11	21·17	621·6	83·7	25·42	598·8	72·8	30·47	627·4	77·6	24·81	618·6	98·6	47·2	47·1	48·4	49·8
12	23·07	618·9	77·6	28·98	601·2	68·1	30·53	617·7	79·6	24·69	626·6	92·5	45·0	44·0	45·9	48·5
13	21·38	624·0	60·6	23·13	607·2	68·9	26·56	617·1	76·7	25·35	619·0	92·6	47·8	47·7	48·5	49·6
14	21·17	621·2	129·3	24·48	605·8	77·2	20·76	616·4	82·5	24·27	624·6	86·7	48·4	48·3	49·6	50·5
15	21·52	621·8	79·8	23·54	610·3	77·6	28·17	620·9	70·1	25·96	626·5	79·6	45·8	45·2	45·6	46·3
16	21·05	621·3	74·8	26·08	612·3	64·1	27·84	610·6	91·2	27·03	620·3	98·3	46·2	45·3	47·1	47·6
18	25·76	612·3	76·8	31·41	597·9	75·1	30·67	620·4	89·2	50·72	668·3	148·8	43·1	42·5	45·5	49·0
19	24·13	621·1	80·0	25·15	606·0	87·7	27·64	618·5	89·7	22·11	625·8	104·5	48·0	48·4	49·8	51·6
20	25·55	610·9	80·0	31·26	593·5	103·0	34·23	615·0	116·8	28·58	597·4	171·1	50·1	49·6	50·8	52·9
21	28·05	599·8	82·9	28·65	585·9	95·0	28·51	612·3	97·7	21·44	610·1	125·6	51·0	50·8	51·2	51·9
22	21·05	606·9	91·9	24·27	602·9	98·1	29·65	612·6	97·5	27·50	618·6	93·5	50·3	50·4	51·5	52·7
23	19·42	616·4	90·5	23·60	601·7	88·2	27·38	610·5	136·8	23·07	621·2	87·6	53·9	53·4	53·8	53·8
25	21·11	617·8	80·1	20·90	607·0	78·7	28·37	619·1	79·2	22·92	627·0	78·4	45·6	44·5	45·1	47·5
26	20·76	621·5	75·6	23·46	611·7	72·6	26·83	624·1	77·4	23·66	638·0	81·5	42·4	41·2	41·0	41·8
27	19·70	625·4	78·1	24·07	611·3	79·5	27·58	625·0	79·5	27·84	621·2	93·1	44·7	45·0	45·5	56·3
28	20·76	624·0	79·8	22·31	608·2	83·3	27·03	620·6	80·2	24·13	631·2	79·4	44·6	44·2	43·8	43·7
29	20·64	630·1	74·5	26·75	612·0	80·0	29·05	621·0	77·3	26·49	632·9	79·9	41·4	41·5	42·7	43·6
30	25·62	603·8	83·7	26·96	605·9	80·3	27·11	619·8	87·7	24·07	622·4	106·3	44·7	44·4	44·9	45·4

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Nov. 1	26·64	609·0	66·8	27·43	597·7	78·1	32·48	611·9	90·8	25·08	623·6	119·5	49·5	49·8	51·2	52·4
2	23·86	618·5	68·5	24·69	600·2	77·0	31·61	620·7	85·4	24·42	624·8	85·6	52·6	52·5	54·0	55·4
3	21·84	619·6	75·9	25·82	605·6	79·4	26·35	612·3	78·8	24·42	635·6	81·2	52·0	51·7	52·4	52·9
4	21·17	612·6	71·9	22·78	608·2	81·7	29·80	617·5	84·5	22·39	623·2	86·4	46·4	46·6	48·0	50·0
5	24·01	617·9	72·2	28·92	609·6	76·1	31·00	611·6	87·8	24·54	619·7	94·5	47·1	47·2	48·1	49·7
6	25·29	619·1	70·1	24·27	599·8	80·4	28·37	612·7	81·9	25·68	626·4	87·2	48·4	47·9	48·5	49·0
8	21·44	622·3	76·4	22·05	605·9	83·3	26·83	615·6	93·2	23·86	623·9	79·2	52·9	52·8	53·1	53·0
9	21·78	623·2	73·7	23·46	609·5	80·9	27·11	617·2	78·2	23·27	624·8	80·6	48·3	47·7	48·1	47·8
10	23·40	626·2	63·2	25·01	613·9	68·4	29·52	627·3	74·4	24·81	624·8	82·5	44·0	43·0	43·1	44·3
11	27·64	636·7	62·8	23·40	617·4	71·8	27·43	622·1	73·7	28·58	638·7	76·4	40·8	40·5	40·8	41·1
12	29·85	577·4	70·8	25·01	594·8	82·0	31·74	618·9	91·3	28·72	631·5	125·8	40·4	39·9	41·0	41·9
13	23·60	621·0	71·3	26·83	570·5	110·6	30·12	610·5	112·5	3·55	609·2	167·0	39·5	39·2	39·7	40·1
15	21·44	613·7	80·7	22·51	613·5	83·3	25·76	618·7	87·2	22·59	627·2	93·2	39·2	39·3	40·0	40·6
16	22·11	623·7	78·4	23·66	611·9	80·3	25·35	622·0	81·0	24·48	626·0	83·9	42·7	43·5	44·4	45·5
17	21·99	616·6	82·0	23·54	596·8	91·0	25·42	610·3	97·8	......	......	......	45·2	45·3	47·0	......
18	25·76	626·2	75·9	30·07	610·1	84·0	31·48	610·6	103·8	26·03	622·8	116·6	45·0	44·8	44·9	45·3
19	22·31	622·2	82·2	24·01	613·7	85·5	25·01	623·2	86·2	22·39	622·8	88·6	41·7	41·2	42·1	42·7
20	22·78	630·5	74·4	21·99	617·7	80·5	24·27	616·3	79·8	22·78	626·1	81·0	43·4	43·3	43·5	43·8
22	21·11	627·2	73·2	23·13	618·4	80·4	24·54	628·5	81·0	22·66	629·7	77·4	39·7	39·4	40·7	41·4
23	20·90	628·7	68·9	24·07	621·4	77·0	25·29	631·9	74·7	26·49	627·2	84·6	38·1	37·6	38·7	40·4
24	20·96	630·9	68·5	22·11	617·7	69·3	25·49	625·8	72·7	24·27	631·7	76·4	36·6	36·0	36·3	36·9
25	21·32	625·2	66·8	22·31	621·3	69·5	26·03	630·8	65·3	23·40	632·2	69·8	34·1	33·2	33·6	34·1
26	24·13	623·5	65·8	22·66	623·3	68·2	24·21	625·5	70·4	25·49	644·7	71·9	37·6	39·0	41·4	43·2
27	22·45	618·7	62·3	22·51	617·8	68·3	28·91	628·4	79·8	24·07	626·6	83·6	41·8	41·2	42·2	43·5
29	21·38	628·6	67·7	21·84	618·2	66·7	25·55	625·0	73·9	23·13	631·7	75·8	36·5	36·0	36·1	36·7
30	21·78	634·4	71·0	22·51	620·9	70·9	26·03	625·9	67·9	24·42	634·4	71·5	32·9	30·9	30·6	31·6
Dec. 1	27·31	643·7	25·7	26·44	605·0	58·0	30·12	614·8	99·4	23·34	629·5	85·2	33·4	34·8	36·5	38·7
2	23·94	626·4	62·7	26·08	611·7	69·2	25·01	610·5	79·7	26·96	619·3	78·2	38·1	38·5	39·3	39·5
3	21·99	607·9	48·0	29·18	617·6	79·7	30·59	608·1	97·8	22·78	630·0	81·7	38·0	38·1	38·7	39·9
4	28·65	628·8	65·2	28·72	625·8	66·1	24·69	625·5	62·4	23·40	630·9	72·3	38·5	39·7	42·2	44·6
6	21·92	636·8	65·7	21·72	620·9	62·5	30·12	656·5	56·5	26·29	647·5	67·7	44·8	44·6	45·3	46·0
7	29·45	625·3	66·3	23·80	612·7	70·2	26·35	624·4	74·1	22·98	622·0	82·7	43·7	42·9	43·1	44·4
8	28·92	624·1	69·8	22·78	622·7	65·3	26·83	630·2	71·7	23·60	630·4	70·9	39·8	39·3	40·1	40·2
9	23·40	626·0	65·4	24·89	618·2	68·3	27·84	622·6	76·9	24·21	629·0	79·9	41·4	40·8	41·8	42·5
10	24·27	625·6	55·5	23·80	610·2	68·9	30·07	593·0	147·0	23·13	631·2	84·5	43·5	44·3	45·7	46·6
11	23·94	621·1	63·7	24·95	614·7	69·9	25·22	623·4	89·4	15·38	632·4	103·0	47·6	48·2	49·4	49·7
13	26·08	629·9	52·1	22·98	615·4	20·7	24·81	622·6	83·4	1·73?	648·4	64·2	44·8	43·4	42·6	42·6
14	19·76	630·0	49·5	19·03	605·8	80·3	24·01	600·4	93·1	20·29	627·7	100·6	41·2	41·2	41·3	41·6
15	21·38	629·1	66·8	19·62	614·9	66·8	24·01	620·1	67·2	21·44	630·6	73·7	42·4	42·5	42·6	43·5
16	20·76	625·5	65·4	20·03	617·4	67·4	23·19	620·3	71·2	21·44	626·5	68·6	42·0	41·6	41·9	41·8
17	21·17	636·7	64·9	20·96	624·7	64·9	23·80	623·2	62·4	23·19	634·1	67·0	42·8	42·9	43·2	43·2
18	19·70	626·2	54·5	24·69	620·3	58·5	......	......	......	20·09	619·4	94·1	39·8	38·9	......	38·3
20	20·64	627·3	67·0	21·32	626·8	64·9	24·48	628·7	67·5	22·11	629·5	67·3	49·0	49·4	50·0	49·7
21	21·17	626·6	66·8	21·78	623·7	61·9	24·07	625·9	67·4	22·31	631·6	66·3	43·1	42·0	41·9	42·3
22	20·64	629·9	62·2	22·39	626·2	58·2	24·07	645·9	60·6	22·51	630·6	62·9	38·1	37·4	37·0	36·9
23	21·58	628·8	58·8	27·90	627·3	63·6	24·62	626·1	65·4	25·35	624·4	75·4	36·6	36·7	37·6	38·9
24	19·62	620·4	60·6	25·01	623·8	62·7	24·42	617·2	73·3	21·78	631·0	79·9	39·4	40·1	41·4	42·6
25	20·64	625·4	66·2	21·92	619·6	66·1	23·94	629·5	72·0	15·73	617·9	86·5	42·6	42·3	42·7	43·5
27	20·64	627·2	63·1	20·84	619·7	63·0	23·74	624·5	62·8	21·58	629·5	66·4	44·1	44·5	44·7	45·0
28	22·45	631·5	56·3	21·17	615·8	64·3	26·08	618·8	71·1	21·72	624·2	85·9	41·6	41·1	41·3	42·6
29	28·85	617·9	40·6	21·52	619·1	44·6	26·83	612·9	77·5	19·70	629·7	145·3	39·8	39·4	39·4	40·0
30	21·52	622 3	68·1	22·05	613·4	72·4	22·86	610·1	75·0	20·43	621·7	75·2	44·3	44·6	45·1	45·4
31	20·09	624·0	91·6	21·32	615·4	73·0	23·34	620·0	71·4	21·11	625·8	73·4	43·1	43·5	44·5	45·2

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Jan. 1	19·03	630·8	63·4	20·90	623·1	63·3	24·62	620·0	65·3	21·58	626·4	74·4	46·3	46·3	45·6	46·3
3	21·78	626·3	51·6	22·78	619·8	65·1	22·98	627·1	60·6	21·17	627·3	72·3	42·3	41·9	42·5	43·1
4	19·90	629·7	68·6	22·78	630·2	58·4	23·19	643·0	68·5	20·90	633·2	67·6	42·5	43·5	45·3	46·5
5	19·76	626·0	65·1	21·78	620·8	67·7	23·40	621·6	68·7	21·44	629·7	65·3	44·2	43·1	43·2	43·6
6	21·32	632·7	55·3	20·23	619·1	65·5	29·18	627·0	68·2	22·72	629·6	90·8	39·7	38·6	38·5	38·9
7	25·15	635·0	53·4	25·55	626·4	58·3	23·86	626·4	63·9	20·64	631·8	74·4	37·2	37·1	37·6	38·9
8	23·13	629·7	56·1	25·22	615·8	68·1	22·19	625·9	104·5	28·17	645·1	105·6	38·1	38·7	40·0	41·2
10	22·78	627·8	48·1	24·01	620·0	67·8	21·17	618·9	78·5	30·39	618·0	85·7	40·9	41·0	41·0	41·5
11	20·49	627·9	61·4	18·35	619·1	61·5	21·64	624·8	68·5	20·29	630·2	71·0	42·9	42·6	42·6	42·9
12	20·37	629·6	62·1	20·09	623·2	60·9	22·92	631·2	61·2	22·51	633·6	62·3	39·2	38·9	39·1	39·3
13	21·44	634·9	57·8	20·96	614·3	61·1	25·76	620·2	77·5	25·35	631·3	107·4	36·8	36·5	36·6	36·9
14	21·38	629·2	64·0	20·57	622·0	60·1	23·66	631·9	62·3	23·46	635·5	78·2	35·4	35·0	35·2	36·3
15	21·25	637·0	53·0	20·70	625·0	55·1	24·62	621·3	61·8	22·25	634·2	68·3	33·5	33·7	34·1	34·8
17	20·90	634·7	56·6	21·17	626·2	57·2	26·16	629·3	55·5	24·89	635·2	78·7	35·0	35·0	35·3	36·1
18	20·64	630·1	73·0	21·64	634·1	54·1	25·35	634·2	54·9	28·85	635·0	72·1	32·7	31·6	31·9	33·3
19	28·72	623·1	38·1	27·11	633·9	61·2	23·80	614·1	67·4	26·44	615·0	87·4	35·6	36·1	37·0	38·8
20	19·56	627·5	63·4	21·99	623·4	63·2	24·21	624·6	61·6	21·58	625·3	63·0	45·6	45·7	45·8	46·2
21	19·90	630·9	55·3	20·64	611·7	61·4	27·64	623·1	66·0	23·27	625·8	69·5	41·4	41·3	42·1	42·6
22	20·37	629·3	57·7	26·83	624·1	59·9	22·98	625·8	61·8	21·99	631·9	65·4	38·2	37·4	37·9	38·8
24	20·17	634·0	54·1	21·25	626·5	54·6	24·54	631·1	55·5	22·72	630·9	54·0	35·4	35·2	35·8	35·9
25	20·29	636·6	40·3	20·09	621·1	54·6	27·23	625·8	59·4	24·69	630·4	68·5	35·9	35·7	36·3	37·1
26	19·62	635·6	51·1	19·15	626·0	52·2	24·27	628·2	59·1	21·92	628·2	65·7	36·6	36·2	36·5	37·9
27	19·56	638·6	52·1	19·09	621·5	54·7	24·01	627·0	55·9	22·45	630·7	62·3	37·0	37·0	37·9	38·4
28	20·37	633·5	48·0	19·82	611·7	59·9	31·00	627·5	61·4	28·72	623·9	81·2	36·9	36·6	36·5	36·8
29	19·97	630·0	57·2	21·32	622·7	55·6	26·03	631·8	60·7	22·05	634·6	63·0	33·0	32·3	32·5	34·2
31	19·62	624·9	58·9	19·76	620·6	52·3	24·54	621·2	65·8	22·45	631·6	60·4	36·9	36·7	38·4	41·5
Feb. 1	21·11	633·6	54·2	21·52	627·5	46·9	24·54	607·4	55·3	24·27	634·8	66·1	40·3	39·6	40·4	42·2
2	20·57	623·5	53·3	22·31	618·6	60·2	25·82	615·6	71·1	19·62	632·1	128·7	40·0	39·3	39·2	40·1
3	19·76	629·4	44·0	21·78	626·8	52·6	24·13	620·9	61·5	21·58	626·4	65·8	39·7	38·9	38·9	39·2
4	23·80	626·4	50·9	23·80	625·8	54·2	24·27	626·2	57·7	27·84	625·6	72·7	36·9	36·6	36·8	37·3
5	19·62	628·6	56·5	20·70	624·9	56·2	22·25	623·6	59·2	19·97	619·6	67·7	36·6	36·4	37·0	37·4
7	19·70	633·3	51·4	28·17	633·2	49·0	22·78	628·1	54·0	20·84	631·2	59·3	36·8	36·3	37·1	39·5
8	20·76	627·1	50·8	22·98	614·3	49·5	25·68	627·0	58·9	21·72	631·2	59·3	35·4	34·8	34·6	34·5
9	19·70	637·0	50·6	21·17	625·7	48·8	22·78	629·7	47·9	21·78	637·1	53·7	33·7	33·9	34·5	35·1
10	18·88	638·4	48·1	19·50	628·1	54·6	23·07	633·7	49·8	21·99	638·5	52·4	35·2	35·2	35·7	36·4
11	19·23	628·8	50·8	19·82	621·9	52·3	24·21	627·7	57·2	21·44	629·3	71·2	32·0	31·3	31·7	32·8
12	20·03	630·5	55·9	21·78	626·9	52·6	24·01	627·2	55·5	23·80	633·7	61·7	30·3	29·5	29·9	31·4
14	17·60	640·8	37·4	24·62	620·3	47·1	31·61	624·4	74·8	35·78	632·3	112·2	31·0	31·2	32·4	34·4
15	20·43	620·7	46·7	24·48	613·4	63·7	25·62	614·9	65·9	21·78	624·3	64·5	31·3	31·2	32·6	34·4
16	19·70	626·5	58·9	21·64	595·3	62·4	26·16	620·4	65·9	22·92	633·4	64·8	33·2	32·9	33·7	34·6
17	19·09	640·5	34·0	23·46	617·3	67·1	28·51	630·4	66·0	21·99	624·9	95·0	32·1	32·2	33·2	34·3
18	19·42	623·6	58·6	22·78	618·5	54·7	22·72	622·0	60·2	21·32	626·5	69·3	30·0	29·7	30·9	33·0
19	19·09	631·5	58·3	20·43	618·4	61·1	23·40	626·0	55·6	20·49	628·3	58·5	30·6	30·8	32·7	35·5
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	17·95	621·8	57·8	21·72	608·7	66·3	28·85	622·2	64·9	25·96	627·6	94·6	34·4	35·1	36·4	39·3
23	21·17	626·5	54·9	25·15	610·7	62·2	26·29	616·0	74·6	15·05	636·2	126·3	36·9	36·6	37·4	37·4
24	18·68	628·8	59·5	19·42	614·1	62·5	24·13	624·8	60·7	21·32	633·2	60·1	32·5	32·6	34·3	36·5
25	18·15	627·9	52·5	22·51	614·7	50·4	27·38	631·7	54·7	24·54	630·8	70·6	36·0	35·6	36·7	37·9
26	18·88	633·4	53·6	20·76	625·6	56·7	25·49	633·6	55·1	22·66	635·8	58·3	36·8	36·7	36·8	36·8
28	21·44	621·6	50·6	25·76	636·5	39·0	23·80	620·8	55·6	22·78	633·2	73·4	30·6	30·1	31·9	33·9

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	19·97	631·5	53·8	22·31	626·5	52·8	25·62	641·8	61·5	20·37	628·8	65·5	34·5	35·1	37·2	39·7
2	18·68	631·8	48·1	25·42	622·4	45·6	24·27	635·5	49·5	21·44	633·8	59·0	37·6	37·3	37·7	38·6
3	19·15	630·0	46·6	26·29	621·3	43·2	28·17	628·1	61·7	20·09	630·7	69·1	36·0	35·9	37·0	39·0
4	19·76	627·5	51·2	25·68	630·6	39·9	29·45	624·2	61·5	20·64	630·4	64·2	34·8	34·1	35·9	39·8
5	18·47	631·4	47·4	22·45	620·2	47·5	23·54	612·1	57·8	19·36	626·9	59·4	39·4	39·5	40·9	42·7
7	18·15	627·5	48·9	20·43	625·6	41·0	23·74	627·1	44·8	26·75	649·3	62·0	41·4	40·8	42·8	46·4
8	20·17	612·7	50·3	27·50	592·6	52·0	28·78	619·6	87·3	26·83	646·4	145·3	41·8	40·9	41·0	43·7
9	18·74	612·6	39·0	24·48	610·9	51·9	21·52	623·7	91·6	22·39	634·0	121·7	43·0	42·3	42·9	43·3
10	26·35	610·2	23·1	22·92	611·6	38·5	21·78	634·5	55·2	13·65	642·5	90·5	44·5	45·2	46·7	48·9
11	20·49	615·0	55·3	22·31	599·9	57·0	29·25	644·6	78·6	21·32	652·8	123·7	43·9	43·2	44·4	46·6
12	20·49	597·0	46·9	30·59	601·9	61·0	25·82	621·5	73·1	21·38	633·8	107·5	42·1	41·4	41·6	42·6
14	20·23	622·0	53·4	28·11	613·8	52·3	26·64	623·8	47·8	28·11	630·4	56·0	40·8	40·8	41·0	41·3
15	16·46	630·8	43·0	18·68	615·7	50·9	29·80	630·7	51·5	24·33	629·0	70·4	39·5	39·1	39·0	39·2
16	18·41	629·8	59·3	19·42	618·4	48·9	......	......	......	22·92	633·9	62·4	38·2	38·1	......	38·4
17	17·88	634·4	53·9	19·23	624·0	47·0	27·43	635·9	46·8	28·11	658·7	61·7	34·7	34·8	35·3	36·5
18	17·74	624·0	53·5	18·62	609·2	48·6	30·80	619·3	71·6	20·84	633·5	78·7	32·7	32·3	33·2	35·4
19	18·27	624·9	59·2	18·88	614·1	54·6	25·82	622·3	45·8	22·31	633·0	44·3	31·3	31·2	32·7	35·6
21	15·67	620·4	57·6	17·68	611·2	46·6	27·78	619·7	44·6	21·92	634·4	48·6	35·7	35·9	37·9	39·6
22	15·67	628·6	55·0	18·62	616·3	43·2	24·75	623·2	46·7	22·19	634·2	46·6	35·2	35·0	36·4	37·9
23	15·32	628·3	53·3	19·09	616·6	42·2	26·75	628·2	41·8	21·78	630·4	57·3	34·8	34·7	36·7	40·7
24	14·99	631·7	42·7	20·49	620·3	37·4	28·17	619·7	46·6	24·42	638·1	77·9	33·9	33·5	35·7	38·1
25	15·38	625·3	40·1	19·82	616·4	41·4	28·05	632·8	41·5	25·08	571·8	70·2	32·3	32·2	34·1	38·0
26	15·94	619·8	52·0	21·38	615·8	41·0	......	......	......	28·78	631·0	92·5	34·2	34·2	......	40·9
28	15·38	628·6	60·5	23·13	595·7	55·0	27·03	624·0	60·8	22·72	619·6	89·5	42·4	42·1	44·6	44·6
29	16·40	627·0	45·9	18·21	614·0	55·7	25·76	628·5	62·9	23·66	627·4	57·9	42·0	41·4	43·9	47·5
30	16·14	627·3	53·9	21·58	615·0	53·1	31·48	606·4	61·8	22·72	638·5	59·7	41·4	40·8	42·3	45·5
31	16·54	627·3	50·5	20·17	616·2	44·5	29·33	615·7	55·9	31·61	637·4	106·1	39·5	38·6	39·6	42·6
April 1	19·56	624·5	59·9	24·33	602·7	45·6	27·70	629·2	44·4	22·51	631·7	66·2	43·0	44·7	45·2	45·2
2	20·96	623·7	32·6	21·38	611·9	36·6	25·22	622·9	41·3	19·76	634·2	53·5	43·5	44·2	45·4	46·8
4	19·42	631·7	49·8	23·40	613·7	52·3	27·84	622·1	44·8	24·01	638·0	44·3	46·1	46·3	48·7	50·1
5	16·26	631·8	48·9	21·38	626·8	34·1	34·37	607·9	32·1	25·15	634·7	57·8	46·8	47·3	49·0	50·8
6	20·23	619·7	37·6	24·07	608·4	49·7	33·89	644·7	117·3	25·82	639·0	108·4	50·1	50·8	52·5	54·3
7	20·03	576·6	4·4	28·51	576·6	51·1	28·58	629·3	64·5	24·62	635·5	67·8	48·9	48·7	49·4	50·9
8	13·04	622·8	50·2	19·97	601·1	46·6	29·72	642·4	68·5	26·03	655·7	111·6	45·6	44·7	45·0	46·0
9	16·26	612·3	35·4	20·29	606·3	36·4	31·00	636·0	52·5	25·35	637·5	107·2	40·0	39·9	41·8	44·6
11	20·29	618·2	23·6	21·32	595·8	51·2	29·18	612·6	51·8	26·16	656·7	111·0	49·1	49·6	51·8	54·1
12	12·22	615·0	18·9	21·05	608·0	32·4	29·65	614·2	44·3	25·08	629·3	79·1	47·1	46·7	47·3	47·6
13	13·92	624·5	52·7	17·60	611·1	47·7	29·18	624·2	50·6	24·81	649·8	61·7	42·8	42·8	44·1	45·6
14	12·10	627·6	52·2	14·99	609·7	47·0	24·21	617·5	46·9	22·72	639·7	64·6	43·9	44·4	45·5	46·6
15	12·77	630·3	65·6	15·67	614·8	44·0	24·21	618·3	30·1	22·11	637·1	44·4	44·9	45·5	46·5	47·4
16	13·65	636·4	47·6	16·54	620·7	23·7	25·22	624·3	48·5	21·64	640·5	48·3	46·7	47·3	49·1	51·2
18	12·69	633·1	41·9	19·09	613·2	44·7	28·05	624·5	42·9	21·11	646·4	52·1	49·8	50·6	53·9	57·0
19	19·62	626·6	47·5	18·01	615·8	56·9	27·31	625·8	42·4	24·89	642·3	43·7	53·4	52·9	52·9	52·9
20	10·75	626·0	64·4	19·30	615·3	32·1	31·34	622·7	39·2	23·66	641·8	59·8	47·1	46·7	48·1	50·7
21	12·42	630·9	43·2	19·70	610·7	32·4	30·80	620·6	39·6	25·22	641·9	45·8	46·1	45·9	47·3	49·2
22	14·65	625·7	49·2	20·64	615·0	37·8	29·25	653·3	22·5	22·59	636·8	58·3	43·4	43·7	45·2	47·3
23	21·58	635·1	6·4	27·23	606·1	45·7	29·12	622·4	60·2	22·51	638·4	68·2	42·8	44·2	46·2	47·5
25	15·11	626·1	37·9	19·09	608·9	54·0	25·08	625·5	29·1	21·72	636·7	52·3	41·0	41·2	41·9	42·5
26	14·65	632·2	44·2	18·47	612·5	46·4	25·55	626·0	37·2	22·72	646·0	47·8	39·8	40·2	42·1	43·8
27	15·19	633·2	59·0	18·15	613·9	34·0	25·01	627·5	31·4	22·19	643·3	47·2	40·9	41·6	43·9	45·8
28	15·05	639·7	53·3	16·00	621·8	58·2	24·48	627·4	39·4	23·19	643·2	49·8	42·7	43·7	46·6	49·1
29	18·15	634·1	44·6	16·34	620·4	40·3	23·86	630·4	39·2	22·59	651·7	40·9	44·7	44·9	47·0	50·0
30	16·40	625·6	50·7	20·29	608·8	40·7	23·66	636·8	47·9	20·37	653·6	50·1	45·8	45·5	46·1	47·5

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
May 2	18·01	630·7	32·5	19·30	623·3	31·2	24·33	618·3	39·0	24·95	652·6	47·6	49·8	49·9	50·8	52·2
3	20·37	581·6	−23·7	23·27	604·1	32·2	32·35	659·5	63·7	23·13	642·2	133·9	48·8	48·8	49·3	49·7
4	17·88	610·3	39·5	22·25	603·0	45·1	24·75	637·5	82·2	23·60	642·2	85·4	48·0	48·4	50·0	52·5
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	12·16	608·1	35·6	22·45	592·3	54·3	25·96	622·0	45·6	21·25	639·3	66·7	53·5	52·6	52·8	52·8
7	17·80	611·7	44·8	18·01	610·9	49·1	......	......	......	23·94	644·0	67·8	45·6	44·7	......	45·6
9	13·31	623·8	45·8	16·00	614·8	55·4	23·66	627·6	44·3	21·38	641·5	64·7	41·6	42·0	43·0	44·5
10	13·77	632·3	37·5	18·35	612·4	39·1	24·33	626·0	32·3	23·19	641·4	39·4	41·7	42·4	43·8	45·5
11	12·89	628·7	52·2	16·61	618·4	36·4	23·74	627·7	30·5	20·70	641·8	47·9	41·6	41·8	43·1	45·1
12	14·32	637·7	36·0	17·34	615·2	37·3	24·42	633·6	37·6	20·43	654·1	46·5	45·5	46·5	48·4	50·2
13	14·44	631·0	44·8	18·88	643·6	26·6	25·29	642·6	34·0	21·38	649·0	40·7	46·7	47·2	49·1	51·4
14	13·85	630·5	42·3	16·81	618·4	37·3	22·39	625·0	39·3	19·90	644·9	46·9	48·1	48·4	50·0	51·7
16	14·18	632·8	37·0	20·37	622·0	30·7	24·42	623·5	40·2	19·70	645·3	8·3	49·0	49·7	51·9	......
17	13·71	617·6	37·2	17·54	622·7	30·9	23·34	625·0	34·7	20·84	655·2	44·3	48·9	49·5	51·9	54·5
18	9·00	629·7	25·5	18·94	618·3	33·4	24·81	629·1	31·0	19·76	644·3	47·4	49·3	49·8	52·4	56·3
19	11·02	624·1	44·5	19·42	627·9	28·5	25·49	631·5	41·3	21·58	680·1	110·2	53·7	54·2	56·8	59·3
20	14·91	626·9	45·7	22·72	626·4	33·4	24·69	642·8	53·6	19·36	649·6	58·1	53·0	53·0	56·1	59·6
21	12·50	624·2	48·4	23·80	614·2	44·9	24·69	644·1	41·9	18·01	622·0	74·6	55·0	55·1	57·5	60·6
23	17·95	624·0	34·5	22·98	620·2	22·0	22·31	630·5	38·5	27·58	661·1	79·4	53·6	53·3	56·2	59·0
24	14·99	622·6	45·6	......	......	......	28·05	639·4	42·6	25·42	686·6	57·3	54·2	......	58·2	61·3
25	10·61	530·0	−20·3	23·60	613·2	43·5	27·84	611·0	79·1	24·33	653·7	103·0	57·0	57·8	60·3	62·8
26	13·37	610·7	58·4	16·67	607·7	52·0	......	......	......	......	......	......	56·1	56·4	......	......
27	34·10	619·4	55·1	19·36	612·8	54·0	22·25	630·2	53·9	21·25	636·5	62·9	60·3	60·5	61·0	61·5
28	12·98	596·9	41·2	26·16	618·1	41·3	24·75	624·9	57·7	22·31	656·7	80·4	56·9	56·8	59·1	59·9
30	17·40	601·5	30·1	18·21	616·8	40·5	22·39	625·2	48·3	19·03	665·9	80·8	56·3	56·1	56·0	56·5
31	9·61	610·9	27·0	20·76	615·8	43·6	24·69	637·3	51·2	22·86	674·1	61·4	53·2	53·3	55·0	57·3
June 1	13·37	616·9	58·4	20·23	623·3	44·6	25·42	655·1	34·4	23·86	655·2	70·2	55·8	56·5	59·6	62·7
2	28·51	585·4	−72·9	20·49	617·3	74·4	33·83	680·1	115·7	30·86	657·8	97·4	57·7	56·9	56·7	57·3
3	15·46	599·7	43·7	16·61	614·5	52·9	22·66	620·9	54·4	20·03	628·1	57·2	52·6	52·7	55·0	57·4
4	11·83	623·5	45·8	17·60	617·7	40·4	24·69	639·0	57·1	21·72	634·2	74·3	55·6	56·4	58·1	59·9
6	8·94	621·9	48·0	15·94	624·1	42·9	24·69	633·3	39·5	27·38	640·7	49·5	56·4	57·7	60·2	61·9
7	17·95	631·7	26·4	20·64	613·7	17·2	26·44	632·6	24·7	22·98	640·7	46·2	56·8	57·2	60·8	64·0
8	13·71	622·5	50·4	23·27	616·4	35·9	31·06	616·0	34·8	24·07	643·8	49·7	58·9	59·4	62·5	66·1
9	13·92	622·0	53·8	28·17	612·4	45·5	31·06	641·5	29·0	30·67	644·8	47·5	63·9	64·4	65·1	66·0
10	15·46	618·3	18·9	22·78	618·7	47·2	26·03	629·8	57·0	22·11	640·3	57·2	61·4	61·8	64·0	65·3
11	13·57	626·8	56·6	18·35	614·0	49·8	26·83	623·2	46·3	24·13	642·2	48·4	62·6	62·3	62·1	62·4
13	13·04	626·1	56·2	28·45	620·5	41·3	25·82	631·6	38·7	22·72	647·6	67·6	55·1	56·2	57·8	60·4
14	13·92	626·0	50·4	28·51	583·3	35·7	24·69	666·9	67·4	26·75	673·3	123·1	57·7	58·3	61·7	64·4
15	13·51	631·4	53·2	21·25	622·0	52·0	25·68	633·8	72·0	21·58	643·6	67·7	63·4	63·3	63·9	65·1
16	13·71	619·4	51·7	20·90	607·3	46·8	27·50	632·1	27·3	24·81	632·0	51·9	60·7	61·1	62·5	65·0
17	10·67	618·0	55·5	19·15	617·5	41·3	28·05	635·5	37·8	25·15	639·7	55·2	60·7	61·0	62·4	64·5
18	18·35	627·4	48·4	18·15	623·1	48·5	30·39	623·0	41·4	24·07	637·9	40·4	61·2	61·0	62·9	63·7
20	9·88	617·8	47·0	20·37	611·3	37·8	31·06	641·9	27·5	26·29	671·6	57·7	57·7	58·0	58·8	60·4
21	......	......	......	18·15	606·3	30·6	24·89	622·2	132·9	22·98	612·9	72·2	......	61·1	63·5	65·3
22	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
23	12·98	612·8	51·2	18·15	609·9	38·4	27·38	625·6	37·0	24·75	633·3	46·7	61·2	61·7	65·2	68·2
24	16·34	619·9	44·4	20·70	610·5	46·9	26·16	630·8	33·1	21·44	639·3	51·2	62·3	61·5	60·4	59·3
25	14·18	626·0	51·7	18·15	620·9	27·5	31·14	636·3	37·3	25·08	647·5	48·2	56·4	56·7	58·7	60·6
27	16·06	624·0	23·0	18·94	610·5	31·9	27·50	631·2	38·7	23·74	654·8	80·4	60·3	61·1	62·6	64·1
28	14·24	616·4	22·4	25·15	600·0	39·6	23·80	624·6	45·3	22·05	639·8	75·5	61·1	61·5	63·2	65·4
29	14·79	611·5	38·6	17·74	614·5	43·6	24·42	628·1	37·8	22·05	647·9	56·4	61·0	61·1	60·7	61·4
30	13·77	618·4	50·4	18·62	619·4	47·6	21·99	629·6	45·4	20·70	656·0	52·3	58·6	59·3	60·7	62·1

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
July 1	13·10	624·7	41·5	18·82	609·7	39·4	......	......	......	30·33	655·3	50·4	58·0	58·7	......	61·0
2	11·63	620·4	37·0	18·55	607·5	45·3	26·56	642·3	37·1	25·22	668·3	63·3	58·0	58·1	58·5	59·4
4	14·38	621·9	54·2	21·05	617·5	44·9	24·33	630·2	43·0	29·05	641·9	50·0	61·1	61·5	62·4	63·1
5	12·89	631·3	43·2	......	......	......	......	......	......	......	......	......	60·8	......	......	......
6	12·63	621·8	26·2	18·94	621·3	22·1	26·83	636·4	28·9	23·34	642·8	36·0	59·8	60·6	62·0	63·2
7	11·90	630·0	40·9	18·55	624·5	27·5	24·48	641·6	29·9	22·92	651·6	36·0	60·1	61·3	63·0	64·4
8	11·96	628·9	35·8	18·74	629·7	31·7	28·58	633·0	34·6	29·85	642·6	64·2	59·5	60·1	62·0	65·5
9	17·80	634·7	26·2	16·81	617·3	27·3	27·38	632·2	27·6	21·44	648·1	33·9	61·6	62·0	63·1	63·8
11	11·96	624·6	41·1	23·07	612·7	39·4	29·60	634·9	38·0	29·25	653·9	53·7	60·7	62·0	63·2	64·2
12	22·78	616·7	34·5	23·94	616·0	39·2	33·36	657·4	53·6	27·84	679·6	87·7	60·7	61·5	63·4	64·8
13	14·99	581·6	48·1	18·35	597·6	69·8	25·89	623·7	59·8	20·43	641·4	72·1	60·0	60·4	62·7	64·8
14	14·85	623·0	57·2	20·76	603·0	53·1	26·83	617·9	49·3	19·62	634·9	66·2	61·6	60·8	60·0	60·0
15	......	......	......	......	......	......	29·80	637·3	33·6	20·03	655·0	99·1	......	......	57·2	57·9
16	10·40	619·9	49·0	19·15	616·2	37·3	24·95	623·4	40·5	20·37	644·9	60·9	57·3	58·0	59·1	60·1
18	25·55	612·8	45·1	20·64	629·3	30·2	28·58	619·0	37·7	21·38	635·0	44·9	57·7	59·5	60·7	62·0
19	13·18	624·7	48·3	18·35	619·8	41·7	22·72	628·1	42·4	18·47	637·7	41·9	59·7	59·5	60·5	62·8
20	15·26	622·3	42·5	20·49	613·9	40·3	25·29	629·7	36·9	27·31	636·3	54·3	60·1	60·5	62·8	63·8
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
23	13·45	617·8	43·4	23·86	616·7	29·3	30·94	643·6	28·9	......	......	......	58·5	59·1	61·2	......
25	......	......	......	......	......	......	......	......	......	23·40	635·0	42·6	......	......	......	62·8
26	16·40	623·3	50·6	16·40	619·0	40·4	29·18	622·0	34·2	20·96	642·8	52·3	60·0	60·3	61·2	62·4
27	22·78	611·9	41·6	20·17	606·8	39·7	20·29	617·4	36·5	22·92	647·1	50·2	58·2	58·8	59·7	60·5
28	21·05	619·0	32·9	18·62	613·7	32·1	23·46	620·8	49·3	22·19	641·8	49·1	57·6	59·2	60·8	62·1
29	15·94	621·6	34·1	17·88	619·6	32·3	25·01	643·3	37·5	23·13	646·4	54·0	59·2	59·4	59·3	60·2
30	16·00	615·0	20·4	18·94	618·0	30·0	22·86	631·2	29·5	......	......	......	56·6	57·1	58·0	......
Aug. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
2	......	......	......	16·20	619·4	45·7	24·89	628·6	40·0	20·37	646·0	30·8	......	57·3	60·5	62·6
3	14·32	621·9	30·6	19·42	645·9	40·0	25·89	640·8	39·0	......	......	......	58·2	58·9	59·5	......
4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
9	......	......	......	17·48	625·2	20·1	31·06	622·8	26·7	23·07	635·6	52·7	......	64·2	65·0	66·2
10	19·97	624·4	39·2	15·58	619·1	38·2	22·98	625·4	35·9	18·47	648·3	47·7	60·7	60·8	62·9	66·7
11	13·37	623·6	43·6	16·46	614·7	34·9	25·76	632·3	35·9	20·64	643·3	37·6	59·4	59·6	62·7	66·1
12	10·61	628·6	43·8	15·73	620·7	37·3	24·81	640·4	36·7	19·36	643·8	15·6	63·3	63·5	65·5	66·8
13	13·92	624·4	38·8	16·06	618·2	34·5	21·84	639·2	37·8	20·49	647·9	40·0	60·5	60·2	60·6	62·0
15	20·49	626·0	40·5	19·03	613·4	30·1	23·34	631·1	27·8	17·80	641·5	33·9	57·1	56·2	59·5	60·8
16	11·63	628·9	33·3	18·74	630·1	21·6	22·78	638·0	21·3	......	......	......	57·8	57·7	60·5	......
17	13·45	630·1	31·6	20·29	629·0	25·2	27·38	632·3	36·1	20·70	650·3	41·3	58·7	59·0	60·2	61·3
18	14·91	626·3	44·2	18·74	626·6	39·9	22·59	644·2	32·0	18·35	650·6	48·9	56·7	57·1	59·0	61·3
19	12·50	629·2	26·5	21·99	620·1	57·6	24·48	651·0	29·6	23·74	656·4	41·6	60·2	61·2	63·7	65·4
20	14·12	603·5	37·6	21·11	611·1	34·3	25·89	639·2	32·0	19·42	639·4	47·1	61·6	62·0	64·0	65·9
22	10·61	620·3	31·3	19·36	616·6	33·3	27·03	638·7	40·1	20·09	635·9	61·0	62·1	62·4	64·2	65·5
23	12·36	615·2	40·3	18·01	613·4	30·2	25·89	636·1	31·1	22·59	648·3	59·4	57·3	57·3	59·6	62·2
24	11·96	618·5	30·9	16·73	611·5	32·2	......	......	......	20·09	641·3	50·3	55·2	55·5	......	62·1
25	12·36	616·4	31·0	20·76	607·4	32·1	24·69	639·4	12·4	19·62	635·2	51·7	54·9	56·8	57·9	58·4
26	9·33	629·6	18·0	17·74	619·8	24·2	28·31	635·7	33·9	8·07	664·6	56·4	58·6	60·1	62·2	62·9
27	11·02	614·1	30·1	21·64	591·3	37·2	26·16	628·8	29·3	16·87	635·5	58·5	58·7	58·4	59·2	61·0
29	12·57	621·6	......	17·40	618·9	32·3	24·07	634·0	24·3	18·27	643·5	39·3	58·5	58·5	59·7	61·0
30	12·83	628·4	......	18·68	622·5	28·7	26·16	642·6	19·7	15·79	638·5	51·3	55·5	55·8	58·4	59·8
31	11·43	625·8	34·0	19·70	617·1	28·9	22·92	642·1	20·1	18·55	645·9	29·5	53·6	54·1	57·2	59·2

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Sept. 1	9·61	624·0	39·5	19·70	616·1	24·9	25·29	636·8	31·1	16·67	638·9	43·0	52·6	53·2	56·9	58·8
2	38·47	617·3	−74·2	23·80	599·2	57·8	15·32	617·1	5·6	23·94	679·3	184·9	53·6	54·0	54·8	55·8
3	17·95	546·4	−56·8	21·99	612·5	94·7	26·96	649·0	98·4	20·76	629·8	76·1	51·5	52·2	53·9	55·7
5	14·18	611·5	38·3	20·03	615·1	35·1	22·98	638·1	34·5	17·68	639·8	41·8	49·0	48·8	53·3	58·5
6	12·98	625·4	40·9	21·05	605·1	29·6	41·10	606·3	61·2	26·56	660·7	106·7	52·6	52·5	56·0	61·0
7	11·83	614·5	42·7	17·54	619·2	42·6	......	......	......	......	......	......	53·3	53·6	......	......
8	12·42	625·4	43·6	17·68	609·5	43·1	27·84	620·8	37·4	17·07	633·2	46·9	57·6	58·0	58·7	59·5
9	......	......	......	16·67	606·5	38·7	24·89	630·8	47·3	18·21	635·5	47·8	......	57·4	59·0	59·7
10	13·57	625·1	41·5	19·42	618·1	39·8	21·32	635·4	37·9	16·40	634·9	38·0	56·8	57·6	60·5	62·6
12	12·57	627·0	26·5	22·31	622·0	23·5	22·51	634·9	25·8	17·13	643·6	28·2	60·8	61·4	63·9	65·2
13	12·77	625·9	38·5	20·37	619.1	30·6	21·92	633·7	32·1	15·73	636·9	34·3	58·5	57·5	57·9	59·1
14	12·10	627·3	11·8	18·94	619·5	29·0	22·92	634·1	26·2	17·07	627·3	48·6	52·2	51·7	54·2	56·7
15	15·26	632·3	22·6	21·84	623·9	30·8	23·40	646·4	21·2	24·48	636·5	51·3	53·4	53·5	55·6	57·7
16	13·98	623·1	36·0	20·76	621·5	29·1	24·13	647·3	30·1	17·34	640·9	37·8	53·4	53·1	55·0	58·1
17	14·12	632·9	33·0	17·40	625·1	26·2	26·16	635·0	31·9	15·38	640·3	29·5	55·0	54·8	58·6	61·0
19	15·38	621·5	22·9	17·95	612·5	41·5	21·25	624·4	40·1	16·67	639·4	52·3	57·0	57·4	59·5	61·4
20	13·57	628·5	30·7	21·38	614·6	36·9	24·54	640·3	65·1	18·35	651·4	72·1	56·7	57·6	59·0	60·2
21	13·37	617·3	36·0	21·78	617·3	27·5	23·34	628·5	33·7	17·40	639·5	39·1	58·1	58·2	60·0	61·4
22	12·36	623·2	32·5	15·46	616·0	28·5	22·72	628·8	31·8	19·36	637·7	32·3	58·0	58·2	59·3	59·5
23	12·98	630·2	31·0	17·95	619·9	23·5	25·76	638·6	21·4	19·42	640·1	33·4	51·6	52·0	53·4	54·5
24	12·63	632·0	34·7	16·61	621·9	26·8	21·92	635·5	24·5	18·62	644·1	27·6	48·8	49·4	52·8	54·8
26	15·32	629·7	22·5	22·66	605·8	30·2	24·69	637·9	49·0	17·74	629·0	46·0	46·6	46·7	48·7	50·4
27	11·96	633·6	33·2	16·06	619·4	28·9	19·76	619·6	29·5	16·87	640·2	37·1	46·0	46·6	48·9	51·6
28	19·62	594·6	74·0	30·00	585·7	40·7	25·96	639·4	126·5	21·11	631·0	76·3	54·0	54·8	57·1	57·3
29	14·85	620·7	22·7	16·54	617·4	33·0	......	......	......	16·81	633·3	37·7	52·3	51·8	......	55·1
30	13·31	632·4	31·8	18·01	621·8	30·7	22·39	630·0	33·8	21·05	638·6	30·4	50·2	49·9	52·3	54·8
Oct. 1	19·36	623·0	23·1	22·86	627·9	20·2	29·12	629·1	36·5	15·38	628·4	59·7	50·3	49·9	50·6	51·6
3	13·65	632·5	29·8	16·54	622·4	34·2	23·07	634·2	30·2	18·01	642·0	34·1	41·3	41·5	45·8	49·6
4	13·37	634·1	33·6	17·40	621·5	35·9	20·90	634·6	23·6	17·28	640·5	34·6	46·1	47·6	50·5	53·0
5	14·59	632·2	27·3	......	......	......	......	......	......	......	......	......	52·5	......	......	......
6	13·25	638·2	27·2	16·61	641·5	27·8	23·34	633·3	20·9	17·95	641·5	31·3	53·6	53·7	53·4	52·7
7	14·18	638·8	25·7	14·91	622·4	25·9	21·52	633·3	21·7	18·01	644·7	26·5	50·8	51·1	52·1	52·5
8	12·98	638·6	24·4	14·24	622·6	16·7	20·70	633·8	20·3	17·80	642·0	27·5	51·0	51·5	53·1	53·4
10	14·59	637·8	20·1	17·13	630·5	16·8	20·70	632·8	29·5	18·62	636·4	35·1	54·3	54·1	54·3	53·7
11	14·18	630·3	35·7	21·84	624·7	37·9	19·82	629·6	43·9	17·01	639·0	55·1	51·3	50·9	51·5	52·2
12	12·10	643·5	41·2	14·04	621·0	37·9	19·42	633·9	27·2	16·93	637·2	34·4	50·0	50·6	52·2	53·7
13	12·30	643·4	22·6	16·93	624·6	29·4	21·38	629·9	34·3	16·61	640·0	35·4	49·0	49·1	50·1	50·6
14	14·32	644·0	31·6	17·54	626·2	25·9	22·05	639·3	18·9	20·76	644·2	37·3	49·0	49·4	51·5	52·5
15	11·96	626·9	35·5	......	......	......	22·05	631·4	30·1	19·36	643·4	38·0	50·0	......	50·9	52·2
17	......	......	......	18·55	626·8	23·2	26·75	634·2	30·6	18·15	639·5	45·6	......	44·3	47·4	50·2
18	14·71	625·8	24·0	17·54	625·1	23·6	27·98	628·4	42·4	17·80	637·6	38·3	43·7	43·4	46·7	49·9
19	14·79	631·9	22·6	16·40	620·7	23·6	21·99	626·5	27·2	17·21	618·9	37·8	43·0	42·2	43·5	45·3
20	15·94	627·5	28·3	18·07	627·4	28·0	23·19	635·2	28·8	18·07	640·0	38·4	45·2	45·9	48·7	51·1
21	14·12	627·3	22·2	21·38	629·4	20·6	26·08	633·6	31·5	18·07	614·7	72·0	47·3	47·9	50·1	52·5
22	13·18	637·7	33·0	16·93	619·4	32·1	20·96	649·1	29·4	16·40	638·5	34·7	51·0	51·6	53·8	55·0
24	13·18	640·1	27·1	20·57	621·3	37·1	26·16	633·5	50·9	20·96	642·3	58·2	52·9	53·6	55·9	56·5
25	17·28	634·9	23·5	19·97	626·8	32·1	28·85	656·3	37·7	−12·95	641·4	112·2	53·9	54·3	55·5	56·7
26	15·94	628·1	35·1	17·07	619·8	38·8	19·76	623·9	35·4	16·73	635·7	28·2	49·5	48·2	48·1	48·5
27	15·11	639·6	27·4	20·23	619·0	33·4	......	......	......	......	......	......	48·1	47·6	......	......
28	14·59	639·4	34·4	17·68	623·0	31·0	21·72	632·0	28·3	17·34	638·7	29·3	49·5	49·2	49·2	49·1
29	13·65	638·6	23·9	15·19	626·3	22·8	21·05	634·9	22·9	19·03	640·3	19·9	48·0	47·6	49·7	50·7
31	13·98	641·6	20·0	16·87	638·9	16·7	25·49	658·6	24·2	21·72	649·1	103·6	45·2	45·4	47·1	48·0

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Nov. 1	14·18	623·6	38·7	18·82	616·1	36·1	20·17	628·0	50·3	17·34	629·0	59·5	51·4	51·6	53·7	54·3
2	17·01	629·1	28·6	18·07	623·6	29·0	20·03	632·5	33·1	16·61	631·4	34·2	50·8	50·9	52·3	52·2
3	13·71	631·2	23·5	17·60	624·9	28·1	18·62	633·3	29·0	16·54	637·8	36·0	47·0	45·7	47·1	49·3
4	14·52	637·4	24·8	17·13	623·7	30·5	22·39	625·3	39·4	18·47	640·8	42·0	47·4	47·7	50·1	53·1
5	14·32	637·2	19·8	17·07	625·4	24·4	19·30	633·6	33·0	15·94	639·7	29·9	47·6	47·6	48·1	48·1
7	18·68	645·7	17·9	16·73	617·7	21·0	21·11	629·9	30·0	17·01	639·2	30·2	48·3	48·5	50·1	51·6
8	16·73	646·7	17·9	18·15	634·9	26·5	24·54	656·8	21·9	24·01	639·1	35·9	48·4	48·8	49·6	49·7
9	14·65	637·9	26·8	17·95	631·3	21·3	28·37	633·9	38·1	17·28	613·5	99·1	43·2	43·2	45·3	46·6
10	21·64	613·7	−29·0	16·34	628·1	19·7	......	......	......	......	......	......	44·9	45·3	......	......
11	14·99	635·1	25·5	16·00	623·4	32·7	19·76	631·4	33·8	18·01	642·4	34·3	47·1	46·7	47·8	48·6
12	13·31	635·8	27·9	16·67	628·5	29·3	20·76	638·1	34·5	15·52	640·9	35·0	41·0	40·2	42·4	44·6
14	15·46	635·8	16·2	12·57	637·8	36·0	17·01	643·2	32·7	15·67	643·2	22·2	36·6	37·2	39·1	41·0
15	14·18	643·3	14·8	17·60	643·9	14·4	19·09	648·4	20·1	15·67	656·7	25·4	38·2	38·5	40·8	42·6
16	15·58	623·8	3·6	20·84	630·6	9·7	21·17	640·9	35·6	17·60	642·3	37·7	37·9	37·6	38·0	38·8
17	16·00	630·8	17·7	19·70	624·0	22·1	19·30	626·4	37·9	16·06	639·6	36·9	37·0	36·0	37·2	40·0
18	16·67	644·7	16·4	18·55	635·7	20·0	19·36	639·7	28·0	19·09	635·3	49·4	35·0	36·0	37·8	40·5
19	16·06	651·1	19·8	17·40	634·7	24·3	19·76	638·7	28·0	17·13	643·8	40·2	43·0	44·3	45·1	46·6
21	15·67	644·0	22·8	14·91	638·8	25·0	......	......	......	15·46	638·4	37·7	40·6	39·2	......	41·7
22	15·58	645·6	13·7	18·68	635·2	20·0	20·84	639·5	27·5	18·47	642·3	33·3	37·1	36·7	38·2	40·9
23	17·68	637·5	17·7	15·58	630·4	17·1	19·42	630·7	21·6	19·56	641·1	31·6	35·5	34·7	35·2	36·3
24	14·38	646·7	22·4	16·67	635·5	24·6	20·37	634·9	29·8	17·13	644·5	24·4	34·7	35·1	35·5	36·1
25	15·05	643·9	18·4	19·62	618·6	28·5	20·37	643·9	19·5	16·61	647·7	3·7	36·1	35·8	36·5	37·3
26	16·06	634·8	8·2	16·40	636·4	8·2	18·68	642·7	9·2	15·58	648·7	13·9	37·9	37·0	37·6	39·4
28	14·85	643·8	13·6	17·60	640·5	15·7	20·43	646·8	16·0	16·14	642·6	23·0	37·3	37·9	39·8	42·2
29	16·40	643·0	20·2	17·48	639·4	23·1	......	......	......	17·13	645·2	24·3	39·6	41·3	......	43·9
30	15·32	645·1	14·9	15·19	637·8	5·6	17·01	644·0	25·5	16·34	640·4	19·2	44·3	43·6	45·3	46·7
Dec. 1	14·59	642·6	8·1	17·07	639·7	11·3	19·76	646·7	9·6	17·28	647·6	16·9	39·2	38·8	41·7	44·6
2	26·22	658·3	−9·2	18·47	637·6	6·8	21·58	632·3	13·4	16·34	642·2	9·8	44·0	43·7	43·3	43·1
3	17·74	644·4	−8·2	19·70	631·0	6·7	......	......	......	19·23	636·0	20·6	38·2	37·0	......	39·2
5	22·86	650·6	1·5	22·11	659·8	11·3	21·11	631·6	37·9	15·52	644·0	41·0	39·8	39·5	40·5	41·2
6	17·48	644·9	16·9	18·21	642·5	9·3	29·65	629·8	78·3	13·45	*	320·4	36·1	34·7	34·9	37·0
7	14·59	621·0	45·2	19·03	627·2	41·7	18·01	630·6	47·2	20·64	630·9	44·3	35·0	34·7	35·1	35·9
8	16·34	631·2	29·5	18·74	628·1	28·7	19·90	634·3	30·3	17·80	637·3	31·8	37·8	38·5	39·7	40·1
9	15·87	630·6	21·6	17·68	632·8	21·7	19·62	639·2	19·7	16·81	642·8	21·4	33·8	33·3	33·6	35·6
10	15·73	633·5	9·4	16·61	637·5	6·6	18·21	610·4	21·1	15·87	643·2	14·5	31·1	30·2	31·0	32·8
12	15·73	644·0	9·8	16·54	639·5	7·1	18·21	641·5	12·6	17·40	641·8	7·5	36·1	35·8	35·5	35·0
13	14·32	642·3	13·6	21·92	641·7	4·0	33·15	630·2	51·1	23·34	629·5	61·5	34·8	31·7	31·5	31·7
14	20·43	638·2	9·5	16·06	632·8	20·4	20·03	637·6	12·8	17·68	638·9	18·8	36·8	38·1	39·3	39·6
15	18·35	644·7	10·3	21·72	631·7	10·0	19·42	635·7	11·5	16·73	636·0	22·5	39·7	38·2	38·3	38·9
16	17·01	647·5	6·4	18·94	627·3	15·8	24·13	639·9	25·4	17·40	638·6	26·2	37·9	39·0	38·3	38·6
17	16·61	639·6	−2·1	17·68	623·2	11·1	26·49	641·0	27·3	16·61	612·6	55·2	37·0	36·7	36·8	37·0
19	16·73	641·1	20·8	17·80	638·0	12·0	18·41	638·4	19·5	16·34	643·9	20·1	33·4	32·9	33·7	34·0
20	15·79	646·0	9·3	16·40	633·5	6·8	19·03	640·0	11·8	14·04	626·0	38·0	35·6	36·4	37·2	37·8
21	16·00	653·1	1·8	17·28	638·0	5·7	25·01	636·4	18·3	6·52	651·6	78·1	39·0	39·0	38·8	38·9
22	16·93	635·6	16·6	18·35	628·2	20·7	18·68	644·2	16·9	14·32	635·7	25·2	37·6	37·7	37·2	38·1
23	15·11	641·6	11·2	16·93	643·1	18·0	20·23	644·8	17·8	17·68	640·3	34·9	37·3	38·4	38·9	39·4
24	15·67	640·0	11·6	17·40	638·4	10·3	19·15	642·4	15·9	11·29	628·1	39·8	38·5	37·8	37·7	38·7
26	15·58	643·7	8·1	17·34	641·2	10·6	18·27	644·7	15·6	18·07	638·2	17·2	37·4	37·2	37·2	37·2
27	15·73	642·6	10·5	16·34	641·8	12·6	17·88	642·6	13·4	15·67	643·9	12·1	31·7	30·9	31·1	31·3
28	14·99	645·1	8·4	15·19	649·6	9·8	17·60	646·6	13·0	18·07	641·8	19·4	29·5	30·1	31·6	33·0
29	17·74	646·6	−7·4	16·67	641·5	11·0	17·74	639·4	13·6	19·62	632·0	24·3	32·7	31·3	31·2	31·7
30	15·67	649·8	1·3	16·61	647·4	1·9	16·20	644·3	5·9	15·38	644·4	8·1	33·6	33·4	33·3	33·3
31	17·68	635·9	13·7	17·01	640·7	1·7	17·01	638·9	12·6	16·40	639·0	15·2	28·9	28·2	28·3	29·0

* Out of field.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Jan. 2	14·99	647·2	6·2	17·13	644·7	0·1	25·82	628·9	25·8	26·44	620·0	211·3	22·9	21·8	23·1	25·4
3	......	......	......	19·36	626·3	21·4	16·40	633·6	33·2	19·62	624·5	44·8	......	19·6	19·6	20·5
4	16·00	637·2	14·6	18·15	639·0	14·2	......	......	......	......	......	......	18·6	20·5	......	......
5	16·26	638·5	10·8	19·09	630·1	14·9	16·67	639·4	9·2	12·89	640·2	22·5	30·3	30·8	31·7	32·5
6	14·24	642·4	8·0	17·60	639·1	9·7	17·80	646·3	25·6	16·00	645·3	10·7	32·1	32·1	34·7	33·1
7	14·65	642·1	7·2	17·28	642·6	7·0	17·74	647·3	11·5	17·95	644·7	10·8	30·5	29·3	29·3	30·9
9	14·12	637·5	4·8	15·58	627·1	14·3	16·81	635·1	12·0	19·15	636·8	4·3	36·2	36·1	36·6	36·0
10	13·77	633·1	5·4	16·93	633·1	20·8	16·14	642·2	18·2	14·79	642·7	11·8	33·2	34·4	35·0	35·1
11	13·04	648·0	3·8	15·94	637·5	15·4	20·17	642·7	20·3	16·06	641·0	14·5	33·0	32·5	32·9	33·4
12	23·40	640·8	−17·4	18·74	635·2	− 4·2	20·64	632·3	10·3	14·65	643·0	8·0	28·3	27·4	27·6	31·5
13	......	......	......	19·15	635·0	5·4	22·59	640·8	21·4	16·00	639·5	25·3	......	31·9	33·0	34·0
14	14·24	644·9	3·3	20·23	640·9	8·8	16·67	635·0	7·9	16·26	638·9	17·7	32·7	33·1	34·5	36·3
16	15·11	648·3	− 5·7	18·01	640·5	8·6	18·15	644·2	10·1	18·01	649·1	17·1	31·1	30·6	31·6	33·0
17	22·11	645·4	−10·1	22·39	633·9	− 1·5	20·76	635·3	11·7	14·99	642·9	6·1	36·2	36·8	39·9	42·4
18	12·69	651·4	1·0	15·73	634·3	7·6	17·68	628·5	14·0	13·98	638·0	27·7	45·0	45·6	46·0	46·7
19	13·98	643·2	1·4	18·94	627·4	3·0	19·42	635·8	9·0	5·49	628·5	69·1	45·4	45·6	46·4	46·9
20	16·81	643·8	− 0·7	21·78	626·0	9·5	18·94	634·9	15·3	15·94	639·2	45·4	43·6	43·7	44·5	44·9
21	15·26	645·9	3·8	17·60	629·5	12·2	19·36	651·0	17·1	16·61	632·1	39·7	42·6	42·2	42·2	42·6
23	14·99	638·1	10·9	16·26	642·9	− 3·7	18·68	645·9	8·5	18·68	647·2	15·6	43·9	43·2	44·1	45·5
24	16·06	639·5	− 6·8	17·40	636·2	8·5	21·38	639·4	11·9	16·54	637·3	20·9	46·3	46·2	45·9	46·0
25	14·38	640·6	8·2	15·58	638·1	11·0	16·93	644·6	10·3	14·59	645·0	12·4	39·8	38·9	39·2	39·6
26	11·90	651·1	0·0	16·34	644·8	8·2	19·15	647·1	24·6	14·38	644·3	5·6	38·3	37·9	38·2	39·7
27	14·04	643·3	−17·0	15·32	642·6	−10·7	18·68	645·7	0·5	14·99	645·6	6·3	37·9	40·5	43·0	45·0
28	14·24	649·5	3·4	14·65	642·8	5·3	17·01	642·8	10·9	16·34	650·3	4·8	43·9	42·7	43·2	44·5
30	14·59	645·2	− 6·9	18·62	619·5	12·9	16·93	640·9	26·9	19·50	640·7	27·6	43·3	44·4	45·9	47·8
31	15·19	632·9	0·7	17·68	632·2	9·3	14·85	614·5	16·6	17·34	641·5	27·3	46·4	45·7	46·2	46·8
Feb. 1	14·59	643·7	− 0·2	14·04	637·3	18·9	18·55	641·5	8·1	15·79	637·3	10·8	45·8	44·9	44·7	44·3
2	14·85	642·5	2·7	15·73	638·2	3·9	......	......	......	14·59	643·0	15·0	38·8	38·5	......	43·4
3	13·77	641·8	7·2	14·99	633·3	11·5	16·93	643·0	12·5	15·73	649·2	8·9	39·2	38·2	40·1	42·0
4	14·99	656·8	− 9·6	15·26	637·0	5·6	21·64	620·2	22·6	16·93	651·3	26·3	37·6	36·7	37·1	38·7
6	14·32	643·0	3·0	15·32	629·2	14·8	18·68	637·7	4·6	15·73	623·8	19·4	46·9	47·5	48·8	49·3
7	12·77	639·1	11·7	16·00	630·0	15·5	19·70	636·7	12·1	16·67	643·0	5·4	46·7	45·4	45·2	45·1
8	20·29	639·7	−17·5	13·04	632·4	11·7	20·09	634·5	20·2	16·34	640·9	20·5	38·8	38·2	39·2	40·5
9	15·05	647·2	11·4	15·19	637·4	−10·0	18·35	637·6	14·5	15·79	643·3	4·5	39·3	39·5	40·8	41·1
10	13·45	647·0	− 1·4	29·05	610·4	4·4	23·34	633·3	19·4	22·72	633·7	79·9	36·6	36·4	36·7	37·2
11	17·28	626·9	22·8	25·08	608·2	30·2	28·45	630·5	7·0	21·52	645·8	115·8	36·2	35·0	35·2	36·5
13	15·52	643·6	6·2	13·71	629·5	17·5	24·48	635·4	23·8	19·09	637·8	34·1	38·3	37·8	39·3	41·4
14	13·31	656·9	28·6	14·65	640·2	9·2	......	......	......	......	......	......	41·6	41·2	......	......
15	13·51	638·9	11·0	19·36	632·4	17·0	19·23	630·3	46·6	9·61	666·1	126·2	43·0	41·7	41·2	40·5
16	16·81	621·0	8·5	16·54	625·6	18·8	21·92	648·6	20·0	21·72	604·7	61·8	36·1	35·7	36·2	38·4
17	13·92	644·2	13·3	18·88	619·7	29·3	16·67	640·5	11·6	14·12	634·2	53·0	42·1	42·6	43·0	42·6
18	13·71	637·8	− 5·9	13·71	623·8	−10·8	19·03	634·9	20·1	16·14	629·8	26·7	34·5	34·3	35·1	36·1
20	14·44	638·2	17·9	16·26	635·4	10·8	17·01	638·2	7·6	14·99	643·0	15·4	38·7	40·2	42·6	44·4
21	12·02	644·2	− 3·4	12·10	632·9	8·4	17·88	639·9	10·7	16·14	648·6	15·3	38·1	37·2	38·7	40·2
22	13·31	645·4	− 1·8	14·24	644·9	− 3·3	19·70	651·6	− 6·1	16·87	649·3	7·1	41·9	42·6	44·1	45·4
23	12·77	645·5	3·5	16·73	637·0	6·2	17·74	642·0	− 4·6	14·12	648·6	− 4·5	40·8	40·6	41·7	44·0
24	12·22	653·1	1·1	14·59	644·3	− 3·0	18·07	646·5	− 2·6	23·60	676·8	22·8	42·2	42·2	43·3	44·6
25	13·77	629·6	18·6	14·12	599·0	24·7	20·09	654·8	35·4	21·99	630·5	67·7	42·6	42·3	43·1	44·2
27	13·65	633·3	−14·2	13·71	628·7	11·4	19·70	640·9	10·8	19·03	654·3	24·2	45·5	46·1	46·8	47·4
28	14·24	636·6	0·4	14·59	622·0	11·4	17·95	638·6	4·9	17·13	631·9	28·8	46·5	45·1	45·6	46·8

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	12·63	646·4	−10·9	14·52	627·8	−2·8	19·03	639·1	4·3	15·94	641·0	14·5	43·6	44·4	45·6	49·1
2	12·10	638·1	12·2	13·77	634·4	−2·5	19·90	645·2	5·8	16·26	646·5	18·2	41·2	41·5	43·1	45·9
3	13·85	650·0	−7·7	14·32	628·1	5·4	20·23	637·3	10·7	21·17	652·8	39·6	43·6	44·1	46·6	49·1
4	15·94	642·1	−17·3	15·11	633·0	12·7	21·25	637·0	17·2	16·67	634·4	32·5	42·9	41·5	43·7	48·3
6	18·07	653·4	−9·6	13·77	628·4	1·8	20·49	639·5	−1·1	17·34	649·5	12·8	39·9	38·4	41·0	44·4
7	13·31	647·4	−1·1	16·73	612·3	11·0	19·90	624·1	24·3	14·12	648·5	50·9	41·9	41·7	43·5	45·7
8	11·63	641·7	1·8	13·77	634·1	−10·9	18·35	640·3	−8·6	15·26	642·1	1·4	46·4	47·8	50·2	52·6
9	13·71	647·2	−7·2	13·31	630·4	8·4	21·84	649·5	10·8	14·18	639·3	10·7	51·2	52·0	53·7	53·7
10	11·83	641·9	4·0	13·18	632·9	10·3	19·30	639·4	−4·9	13·92	646·3	18·3	50·8	50·6	50·7	52·1
11	12·57	647·8	−0·1	14·79	633·3	6·4	20·43	636·3	6·6	15·79	647·5	15·9	47·9	48·7	50·2	50·9
13	10·28	638·9	11·4	13·04	637·1	8·9	20·37	642·8	−3·5	18·15	652·2	15·3	45·3	46·1	48·5	49·7
14	23·07	643·5	−9·9	17·34	624·2	0·0	22·45	647·3	3·4	16·67	645·1	29·2	50·0	49·8	50·2	50·9
15	9·27	641·6	1·5	12·89	628·1	11·9	21·05	641·5	−1·0	17·95	651·8	15·8	45·8	46·1	48·0	50·9
16	17·01	628·3	−9·1	15·19	626·5	20·3	20·03	612·5	87·6	14·18	644·7	55·4	50·1	50·2	51·0	51·4
17	15·79	629·2	−20·7	……	……	……							42·2			
18	12·30	643·6	4·4	13·71	633·9	9·1	19·15	636·6	11·7	15·46	652·5	19·5	45·3	45·3	46·6	47·8
20	12·22	627·4	17·4	11·02	630·2	28·9	18·74	635·8	−0·5	17·07	647·0	5·9	39·2	39·7	41·4	42·6
21	11·69	643·5	2·5	15·26	630·9	14·9	19·82	644·8	−1·2	19·70	644·4	25·3	41·1	41·4	42·7	44·7
22	9·00	642·6	5·7	12·36	636·9	4·6	17·28	642·9	3·7	17·74	644·0	14·1	40·9	40·6	45·0	48·7
23	10·40	638·8	15·8	14·59	624·9	−4·1	19·76	629·4	−3·1	17·01	646·6	13·8	41·5	41·1	51·0	52·0
24	11·55	633·8	14·3	14·52	633·4	9·9	17·07	642·4	3·3	15·32	647·1	6·1	45·8	45·4	48·5	52·3
25	9·27	636·0	14·7	14·44	635·7	−3·0	23·80	632·9	1·0	22·72	646·2	18·1	44·7	45·0	46·8	48·7
27	11·29	627·6	+7·3	16·34	628·0	20·3	24·54	650·0	3·8	18·15	648·5	16·7	43·7	44·5	46·7	49·1
28	7·45	596·0	−76·9	20·03	586·2	77·3	16·34	689·4	137·5	11·16	693·8	161·1	47·2	48·3	50·9	53·0
29	9·81	626·4	18·6	14·91	619·8	21·6	23·54	637·8	25·5	34·50	679·1	93·7	51·3	51·2	51·5	51·7
30	11·16	635·8	12·6	14·65	624·6	19·5	22·05	652·8	23·5	17·40	639·0	38·8	49·6	49·6	50·3	50·8
31	16·73	650·4	16·3	18·55	620·5	9·7	21·78	647·1	27·8	12·02	641·6	28·5	45·3	45·3	48·5	48·6
April 1	10·67	636·9	10·6	12·42	625·1	14·7	20·17	635·8	35·4	15·11	645·8	22·2	48·2	49·0	51·7	52·3
3	7·87	627·3	15·1	13·37	632·7	9·7	19·56	628·9	15·0	17·07	639·1	41·3	47·2	46·9	48·5	49·7
4	10·20	636·3	12·2	12·69	627·3	14·2	20·70	633·5	3·8	16·14	647·9	15·7	46·0	46·1	47·5	50·8
5	9·67	639·7	7·3	12·02	628·9	6·1	22·25	628·7	12·4	17·40	651·0	18·6	47·8	48·9	51·0	53·8
6	10·34	641·8	7·1	14·32	628·8	10·1	21·72	637·9	−1·1	15·73	644·0	12·0	49·0	50·1	51·7	52·1
7	16·54	632·6	2·9	12·89	632·4	−0·7	17·68	636·5	−1·0	14·32	647·4	8·5	49·5	49·2	51·4	53·9
8	11·96	642·5	−14·4	14·79	621·1	3·2	19·09	635·9	−1·6	15·05	648·7	4·2	50·8	50·9	52·8	54·5
10	8·80	640·6	−1·6	13·31	624·7	7·8	20·43	645·4	−4·6	14·59	649·3	17·2	46·9	47·1	51·3	54·8
11	−0·89	584·6	−9·1	26·08	592·7	2·0	31·14	677·2	−14·8	22·86	626·8	46·8	47·5	47·6	49·9	52·1
12	8·66	624·3	4·1	13·04	613·0	16·1	16·14	629·8	11·7	14·59	638·2	6·4	47·0	47·3	50·5	53·1
13	9·88	629·4	8·6	14·24	621·6	7·3	20·23	640·3	−2·7	16·73	649·3	9·8	44·0	44·3	48·5	53·6
14	8·19	639·7	6·8	11·63	630·7	7·6	14·65	650·5	−5·5	25·35	672·4	21·2	46·7	47·2	50·6	55·1
15	8·54	629·1	11·0	14·99	617·5	−0·3	25·79	642·3	24·1	26·08	637·4	107·9	45·3	45·4	50·2	55·0
*																

* No Observations from 15th April to 6th September.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Sept. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
2	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	6·25	637·4	23·5	13·37	637·5	14·4	16·67	658·3	15·0	......	......	......	60·2	61·2	65·2	......
7	6·98	637·4	21·0	14·99	632·9	9·5	16·00	651·7	21·7	9·88	653·8	24·1	62·9	63·1	66·0	67·9
8	7·39	641·9	21·9	13·92	642·1	11·3	14·24	661·5	11·9	9·00	655·8	21·8	62·0	61·1	62·2	64·3
9	10·61	636·6	12·5	12·98	629·0	8·9	19·09	654·0	16·5	......	......	......	53·7	54·0	58·7	......
11	7·87	654·8	−3·1	17·01	633·8	0·1	......	......	......	......	......	......	57·7	58·0	......	......
12	5·97	632·9	30·1	10·67	619·5	34·9	14·38	639·8	19·8	13·31	646·9	29·8	57·5	57·9	62·7	63·6
13	7·66	633·1	19·4	11·90	630·4	16·9	14·59	643·8	13·5	11·43	656·6	20·0	62·4	61·9	64·3	65·5
14	7·66	636·6	2·7	13·65	628·6	13·3	15·67	647·5	15·4	16·67	646·3	15·2	60·0	60·1	63·0	64·9
15	8·19	645·8	8·8	......	......	......	18·07	646·1	11·5	13·25	655·2	25·7	57·8	......	61·0	63·1
16	7·12	637·0	21·8	12·57	635·2	15·7	13·92	647·3	20·9	9·67	645·3	24·8	59·3	61·7	66·0	67·0
18	9·88	645·3	16·8	18·82	632·6	21·3	14·38	645·2	11·3	11·02	651·1	17·9	56·8	57·4	58·1	58·0
19	6·17	645·4	19·8	11·69	641·0	17·5	15·11	647·6	13·3	10·40	643·0	21·2	54·5	54·9	57·5	58·2
20	6·37	645·2	15·1	10·28	638·9	10·9	13·65	643·5	12·3	10·28	648·8	18·2	56·4	57·0	59·8	60·8
21	3·94	646·6	7·5	10·28	636·4	9·8	15·38	652·0	9·9	12·63	643·2	3·3	53·3	53·7	55·8	54·5
22	6·92	646·6	1·9	12·69	628·5	12·1	......	......	......	......	......	......	48·8	48·6	......	......
23	9·00	639·3	12·2	13·25	636·2	10·4	14·79	652·9	10·3	10·40	646·9	22·0	53·2	54·6	56·3	57·0
25	8·27	645·3	5·5	16·61	632·0	10·1	22·19	650·7	18·3	16·00	655·0	45·6	50·3	50·5	52·1	54·5
26	......	......	......	10·61	651·5	7·8	16·20	644·3	2·7	12·77	663·4	12·5	......	55·3	57·7	61·0
27	16·00	638·0	7·8	19·42	622·0	9·3	15·94	644·8	22·0	12·10	651·9	35·2	55·7	56·0	58·0	60·1
28	9·73	625·7	12·9	11·96	632·2	14·4	16·40	652·5	17·5	13·77	648·7	21·7	53·2	52·3	54·8	58·1
29	6·92	640·1	15·6	10·08	630·0	22·2	14·44	662·8	10·0	11·69	654·1	18·0	51·7	51·4	55·3	59·1
30	7·25	645·0	16·6	13·25	624·6	13·0	13·65	645·7	9·4	10·48	649·2	18·7	56·1	56·5	58·3	60·1
Oct. 2	6·78	644·3	14·1	......	......	......	15·19	647·3	13·7	10·55	646·1	17·1	55·7	......	58·9	60·1
3	6·64	642·2	12·9	10·81	636·4	12·8	......	......	......	9·94	651·5	15·5	56·1	54·9	......	55·4
4	......	......	......	8·47	642·1	14·5	......	......	......	......	......	......	......	47·4	......	......
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
9	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	5·58	646·2	18·4	6·92	635·1	19·8	11·63	636·2	11·1	9·61	646·9	22·0	54·5	54·3	55·6	56·5
12	5·58	643·9	15·3	9·61	641·0	13·3	12·69	645·5	10·1	14·52	638·0	33·8	46·8	46·3	50·1	53·1
13	10·08	645·4	−4·8	5·64	637·6	16·5	10·34	639·7	24·3	8·13	652·2	29·2	48·1	48·6	50·8	52·1
14	5·43	647·6	25·5	9·27	638·2	27·4	11·90	645·1	21·3	8·19	647·8	24·9	53·0	54·2	55·4	56·6
16	7·99	646·5	17·6	10·55	640·4	18·3	12·02	650·3	20·8	8·54	649·2	23·6	46·2	46·2	47·0	47·7
17	6·11	651·4	14·4	11·29	637·8	20·3	13·25	650·7	14·8	8·27	652·4	16·7	44·3	44·0	45·5	47·0
18	8·19	632·3	9·7	10·28	641·9	12·9	14·91	653·5	14·3	17·34	639·3	−15·1	44·3	43·9	43·6	43·5
19	7·31	647·8	9·0	10·96	638·2	20·2	13·31	648·6	17·5	9·88	651·5	17·2	40·6	40·6	42·0	43·1
20	7·19	648·0	13·4	10·20	640·6	8·5	12·57	650·3	14·2	8·66	646·5	22·8	46·3	46·4	48·7	50·2
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
23	6·58	648·0	9·7	9·00	640·9	10·0	11·29	653·6	15·1	......	......	......	44·5	44·4	45·1	......
24	5·91	655·7	0·3	10·28	643·3	25·2	15·32	635·6	15·6	19·36	642·5	13·0	40·5	42·8	43·9	46·6
25	12·57	660·9	2·1	10·55	632·8	−31·4	13·04	639·7	24·2	10·55	647·5	35·9	40·4	40·2	43·0	45·4
26	8·27	645·3	10·3	10·28	634·9	12·6	12·50	655·7	13·9	1·39	642·4	39·2	38·1	37·7	40·8	44·0
27	7·25	653·3	6·8	9·21	644·4	19·3	14·65	648·4	17·0	10·40	648·1	27·1	38·3	39·0	42·7	45·5
28	7·87	657·9	11·6	7·93	647·8	12·4	10·55	644·7	10·2	9·00	651·8	15·4	47·5	50·0	50·6	51·5
30	7·25	659·0	5·4	9·47	649·5	4·7	12·36	653·5	13·9	9·47	658·9	10·6	47·3	46·7	49·1	51·4
31	7·12	654·4	5·7	9·33	645·4	7·8	13·37	653·9	7·0	9·06	655·7	12·5	52·2	52·6	54·7	54·7

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Nov. 1	7·25	653·1	−0·7	10·87	655·5	3·3	......	......	......	......	......	......	48·6	49·7	......	......
2	7·31	650·8	8·6	13·04	643·2	16·7	14·18	640·3	25·6	......	......	......	52·9	53·1	54·7	......
3	8·27	644·9	−2·6	11·90	644·3	11·0	13·57	638·4	19·4	7·39	645·5	21·7	47·2	46·5	47·6	48·6
4	8·33	657·0	10·0	9·61	648·9	8·1	11·29	647·9	17·1	10·00	656·0	16·9	44·2	44·2	46·4	48·4
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
9	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
14	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
15	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
16	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
17	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
18	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
20	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
23	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
24	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
25	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
27	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
28	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
29	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
30	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
Dec. 1	8·19	659·6	−1·2	8·94	654·5	−1·1	12·69	654·0	3·4	8·80	643·5	15·8	38·4	37·5	37·4	36·9
2	17·68	632·5	−19·5	14·38	642·3	−3·5	8·19	640·3	37·6	−5·07	633·2	56·6	36·0	35·7	35·4	36·2
4	7·60	656·1	−3·7	5·23	646·8	−1·4	10·08	643·2	2·6	8·80	645·1	6·8	42·6	42·0	42·5	43·7
5	7·66	655·1	−10·1	9·00	652·0	−6·6	10·75	642·1	6·4	14·91	644·5	1·7	45·0	44·6	44·8	43·5
6	8·27	656·7	−2·5	15·05	647·9	1·8	10·75	650·6	5·1	8·33	654·4	9·3	41·8	41·4	42·0	42·7
7	7·51	654·4	−4·0	8·19	651·1	−6·3	11·08	653·8	−1·1	8·54	657·3	4·5	38·5	37·5	37·4	37·6
8	7·60	661·4	−3·8	8·33	654·7	−10·0	11·35	655·8	0·0	9·00	656·6	5·9	42·0	44·2	46·2	46·7
9	6·37	653·5	−9·8	8·13	648·2	−4·7	10·81	652·7	2·9	9·94	652·3	3·9	41·5	40·6	40·3	40·4
11	8·66	647·0	−4·0	9·94	652·1	−3·6	10·34	654·1	−2·4	8·33	657·9	−0·7	35·1	36·6	38·5	40·7
12	7·25	659·4	−7·3	12·63	653·5	−5·4	10·40	660·7	−3·3	8·47	663·3	−6·3	39·3	39·1	39·9	41·2
13	7·51	656·8	−8·4	9·14	658·8	−5·7	11·23	665·8	−10·8	14·91	663·9	−4·3	41·0	40·7	42·5	44·3
14	......	......	......	8·86	654·5	−8·1	6·64	649·7	−5·2	11·08	647·8	−0·6	......	42·7	43·2	44·0
15	7·25	655·9	−4·9	8·19	654·6	−4·5	9·53	652·1	−6·9	7·66	655·3	−6·6	47·3	48·3	48·2	47·8
16	6·98	657·9	−11·2	8·39	658·1	−11·8	13·37	658·7	−10·5	8·47	657·2	−8·3	42·4	41·0	40·7	40·6
18	6·58	656·1	−10·2	10·55	651·1	−11·1	10·55	657·7	−3·9	9·53	658·5	−2·7	37·0	36·1	36·1	36·3
19	7·80	651·9	−11·5	6·84	651·7	−8·3	11·90	655·0	−3·1	8·94	656·8	−2·1	34·0	33·3	33·5	34·0
20	7·72	658·8	−8·6	9·67	655·3	−8·3	12·02	660·3	0·3	11·35	655·4	13·9	37·0	37·5	38·8	39·7
21	9·53	656·7	−7·7	8·27	656·0	−3·0	10·28	650·3	−1·5	10·67	651·2	4·4	36·8	37·7	39·9	42·4
22	15·32	657·3	−9·4	9·21	652·2	−9·1	9·61	656·2	−10·8	8·94	658·6	−5·8	47·7	48·8	49·5	50·5
23	8·19	649·8	......	11·02	649·9	−10·3	11·43	657·8	−6·5	13·10	657·1	−3·7	42·7	41·9	41·9	42·3
25	8·86	659·1	−9·7	10·48	659·1	−7·8	......	......	......	......	......	......	42·5	42·2	......	......
26	8·13	656·4	−8·4	......	......	......	......	......	......	......	......	......	37·3	......	......	......
27	8·13	656·9	−14·2	9·41	651·6	−11·1	11·35	643·4	−2·3	9·06	661·6	−13·5	35·3	34·6	35·5	36·0
28	8·07	658·5	−13·7	9·94	647·0	−9·8	17·48	659·6	−1·7	12·77	653·5	3·1	31·9	31·0	31·6	32·8
29	8·74	657·7	−9·6	11·23	645·1	−2·8	13·77	651·6	−7·5	11·43	651·4	28·1	35·1	36·7	39·4	42·2
30	8·94	651·1	−5·9	9·33	644·4	3·6	12·77	654·7	3·0	9·61	654·4	1·8	44·3	44·1	45·1	44·5

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Jan. 1	8·54	654·7	−3·6	9·00	651·3	−2·0	10·55	655·2	−0·5	8·66	653·9	−0·4	47·3	46·7	45·9	45·0
2	10·34	664·7	−12·8	10·61	649·1	−4·8	13·31	655·9	−1·6	10·67	650·9	11·0	42·1	42·2	42·2	42·6
3	7·87	655·2	−5·3	10·14	656·8	−5·5	11·23	662·3	−7·0	4·70	640·7	5·8	44·3	44·5	45·9	46·9
4	7·80	655·3	−2·6	8·66	651·0	−1·8	11·29	656·2	−3·0	8·27	655·7	−3·7	45·2	45·7	45·5	45·8
5	9·61	648·8	−7·3	11·55	654·0	−8·3	12·63	657·0	−5·4	13·57	655·2	9·1	46·1	46·3	47·0	47·2
6	8·94	661·5	−8·7	9·61	644·1	1·7	10·67	655·0	−6·1	8·86	653·3	4·4	45·9	45·9	46·2	46·5
8	8·94	656·0	−4·4	9·47	646·8	4·4	11·55	654·1	−4·0	6·45	657·0	−1·7	46·6	46·8	46·5	46·5
9	7·93	656·8	−9·7	8·74	633·1	0·2	14·24	655·1	−3·4	9·00	660·6	−3·0	45·7	44·6	44·2	44·5
10	8·19	654·6	−9·3	9·41	647·1	0·1	13·98	655·8	−5·1	11·29	659·8	2·4	36·2	35·3	34·7	35·4
11	8·80	659·3	−4·2	8·60	652·9	−2·9	12·30	654·3	−3·7	9·81	656·4	0·8	37·3	37·8	40·6	42·5
12	7·99	658·0	−23·4	9·53	643·6	−7·4	14·71	659·6	−2·2	9·14	655·2	4·8	38·3	38·3	38·7	39·7
13	8·07	655·0	−5·9	10·00	651·9	−3·0	15·26	660·5	−0·3	8·80	662·2	2·7	38·6	37·9	37·7	38·6
15	7·99	646·9	−9·0	8·94	649·5	0·0	15·67	654·9	−3·7	10·34	658·3	2·5	35·5	34·9	34·7	35·2
16	7·72	654·2	−4·5	8·07	646·7	−0·1	12·57	654·0	−2·3	8·39	659·7	−2·3	36·6	36·8	37·1	37·8
17	6·92	656·4	−4·5	8·66	651·3	1·7	12·89	663·5	1·1	11·02	658·6	2·9	36·4	35·8	36·0	36·5
18	6·72	645·5	−7·7	8·66	649·3	−0·2	12·77	655·3	4·8	8·60	658·8	4·1	32·2	31·7	32·1	33·1
19	7·31	659·4	−5·6	8·60	651·2	−0·4	13·25	658·5	−4·4	8·74	660·5	2·2	35·4	35·5	37·1	38·4
20	6·72	659·5	−9·8	9·00	653·4	−10·9	11·90	659·1	−5·9	16·34	658·0	−3·5	37·4	37·1	36·7	36·4
22	8·27	650·8	−16·3	7·51	637·1	−10·2	15·26	654·8	4·6	13·25	646·7	19·7	34·5	34·6	35·2	35·7
23	7·93	660·6	−16·2	11·63	641·9	−10·2	14·44	657·2	−2·8	10·00	656·4	2·0	32·9	32·3	32·6	33·6
24	8·07	662·5	−4·9	7·31	649·4	−2·8	11·55	652·1	−6·3	9·67	640·9	−1·3	33·3	33·2	33·9	34·9
25	13·37	646·4	−14·5	10·61	646·0	−2·5	......	......	......	......	......	......	34·2	34·5	......	......
26	8·13	659·0	−7·7	8·33	646·8	−3·4	7·93	641·2	5·3	9·14	658·9	3·1	33·4	33·2	33·5	34·4
27	8·19	658·4	−8·2	11·55	648·0	−6·1	13·25	639·3	0·6	13·25	656·5	9·0	30·2	33·4	34·5	35·6
29	6·05	657·7	−19·6	9·88	642·6	−3·6	11·90	652·1	−3·0	10·55	658·9	8·1	29·0	29·3	30·1	32·0
30	7·87	655·6	−14·4	10·00	641·7	−4·8	14·12	642·2	0·1	9·33	660·8	−2·3	26·8	25·7	26·2	27·6
31	10·61	668·3	−22·5	16·61	658·0	−14·8	16·93	650·1	−4·3	12·16	657·7	17·9	27·1	27·7	28·0	28·5
Feb. 1	8·86	657·3	−13·4	8·39	653·2	−10·3	......	......	......	8·94	649·3	5·8	28·7	29·1	......	32·5
2	9·61	667·9	−18·6	7·31	648·4	−14·8	11·35	656·2	−6·4	8·60	659·9	−3·2	28·6	28·0	26·5	30·9
3	7·39	665·4	−12·4	7·72	654·3	−17·3	11·63	657·0	−10·8	9·14	658·6	2·5	33·2	33·1	35·2	35·5
5	6·92	652·5	−8·5	6·98	654·5	−10·2	9·27	617·9	−7·7	7·45	658·5	−0·3	36·6	35·5	36·5	36·5
6	7·31	661·2	−8·6	6·11	646·8	−6·4	10·20	655·9	−2·9	8·27	657·5	0·6	35·0	35·2	36·1	37·0
7	6·52	662·0	−10·4	6·45	657·7	−10·1	8·94	658·5	−6·6	14·59	651·0	−4·8	35·1	35·0	36·1	36·9
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
9	8·07	652·7	−9·6	10·28	642·8	−3·7	13·65	653·8	−92·4	8·94	641·1	44·7	29·5	29·9	31·0	31·5
10	8·60	650·6	−2·4	14·99	656·5	−1·7	10·67	653·6	−0·1	10·00	660·8	10·0	29·6	29·8	31·7	33·7
12	7·31	656·8	−17·2	8·94	647·1	−9·0	14·65	660·0	−4·3	10·28	665·3	12·3	30·7	31·0	31·4	34·3
13	9·61	657·6	−14·0	......	......	......	......	......	......	......	......	......	......	......	......	......
14	5·49	658·6	−16·0	6·92	649·0	−5·3	14·85	655·9	−3·6	10·61	655·3	1·2	28·4	28·7	31·1	31·7
15	5·29	650·2	−6·7	4·08	644·9	−9·9	12·16	650·6	−3·8	7·72	656·7	2·3	25·0	22·9	23·0	26·4
16	5·91	653·2	−3·7	6·37	645·4	6·6	9·94	651·9	−5·7	9·53	652·0	2·4	18·2	16·8	17·8	20·8
17	5·64	653·8	4·3	6·84	641·8	−7·1	11·96	640·5	−13·6	11·23	655·1	−9·6	14·6	13·0	13·0	18·6
19	11·90	650·2	−30·2	8·27	644·4	−19·7	12·98	642·3	1·1	9·81	653·8	3·6	25·3	23·8	26·5	29·8
20	8·19	651·9	−13·8	11·90	633·6	−9·1	11·96	649·2	0·9	10·08	661·0	2·1	28·2	27·6	30·1	32·3
21	8·86	651·8	−26·2	12·63	635·1	−10·2	14·44	647·3	0·3	10·34	654·9	4·9	26·0	25·6	27·2	30·7
22	12·57	641·2	−23·0	11·96	641·7	−9·7	......	......	......	9·94	651·4	−0·7	27·1	26·6	......	32·5
23	6·17	648·7	−23·7	7·99	645·9	−5·9	13·57	641·2	−9·8	11·29	655·7	0·8	25·4	25·9	27·7	32·0
24	8·33	652·7	−16·7	11·69	645·4	−8·5	12·98	651·9	−6·1	7·87	648·5	0·4	27·7	28·2	31·7	34·0
26	6·45	650·4	−10·6	9·88	642·7	−7·6	10·40	651·8	−6·2	14·59	650·2	−2·0	33·6	33·9	36·0	38·3
27	7·31	649·5	−8·7	13·65	646·8	−8·0	16·34	649·8	2·2	8·86	651·7	3·7	33·4	33·2	35·1	37·5
28	19·70	657·8	−29·0	10·61	629·3	−10·1	7·99	652·8	4·1	10·96	641·0	67·4	36·4	36·1	38·9	40·6

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Mar. 1	7·19	640·2	−3·0	15·58	638·7	0·3	14·18	633·3	1·2	7·25	650·1	12·8	38·7	39·7	41·6	42·4
2	9·67	646·2	−8·0	6·92	631·2	−10·8	12·98	647·5	1·0	6·72	647·8	17·8	39·8	40·4	43·0	45·4
3	4·82	655·6	−7·9	7·99	635·3	−5·1	12·57	648·4	−3·2	7·39	654·0	4·1	40·5	39·7	40·5	41·3
5	5·91	653·9	−9·8	9·06	646·5	−1·1	13·77	651·3	−3·7	9·27	653·9	3·1	39·8	40·7	41·2	43·2
6	4·76	648·4	−3·3	8·54	638·6	5·6	12·02	653·7	−1·1	8·27	657·5	10·2	37·9	37·6	40·9	45·5
7	4·90	655·5	−6·6	8·27	633·2	−3·9	12·22	652·6	1·5	8·27	658·5	14·1	38·1	37·5	38·1	41·3
8	5·02	571·7	−1·0	6·52	633·1	−0·8	13·04	647·1	1·4	......	......	......	37·7	37·7	40·0	......
9	1·53	656·2	−10·7	5·91	638·9	−9·4	14·71	642·8	−2·1	23·34	666·2	33·0	37·1	35·9	37·0	38·5
10	5·64	646·0	−12·0	9·00	633·3	−3·8	17·80	643·8	−4·9	10·28	653·6	10·2	35·1	34·7	34·6	34·7
12	3·82	655·7	−6·0	11·49	645·3	−22·2	22·51	657·8	−17·6	......	......	......	33·2	34·7	39·1	......
13	1·73	638·8	−10·7	6·17	634·5	12·1	12·36	645·8	9·0	11·75	657·5	28·6	39·4	38·9	39·1	39·5
14	7·60	647·0	−14·1	11·83	636·7	2·6	12·42	652·4	0·5	7·04	651·5	17·9	36·8	37·2	40·8	41·9
15	5·85	644·5	−0·5	10·40	638·4	−6·8	16·40	644·2	10·3	12·36	649·8	19·1	35·8	35·2	36·5	37·6
16	4·96	654·3	−3·7	14·99	632·2	−2·2	......	......	......	......	......	......	36·1	36·7	......	......
17	5·85	648·8	−4·6	7·66	640·5	−1·4	9·14	645·8	−0·7	14·32	670·8	−1·1	37·5	37·5	39·4	41·1
19	13·04	644·2	−10·4	12·83	635·1	−9·5	16·61	642·4	5·7	10·96	656·6	15·8	38·7	39·0	41·3	42·9
20	10·08	641·9	−12·0	8·94	624·9	−11·5	16·46	645·5	−3·0	12·63	649·5	21·0	38·2	37·9	38·0	38·4
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	6·31	651·7	−3·4	10·61	640·4	−9·9	15·94	643·4	−11·3	11·63	660·6	0·7	36·3	37·0	38·5	38·7
23	6·84	654·2	−7·5	7·99	643·5	−6·7	16·40	649·8	−9·2	12·36	657·0	1·4	34·3	34·7	36·0	37·1
24	6·25	650·7	−12·2	12·98	643·3	−11·0	19·70	656·5	−18·1	14·04	663·4	7·6	32·7	32·6	36·1	38·7
26	5·29	649·3	−7·1	6·98	639·6	15·2	16·34	644·3	−11·6	6·98	645·8	16·8	36·1	39·2	39·7	42·9
27	6·17	646·6	−1·2	8·54	638·5	−7·5	15·11	647·3	−5·3	10·28	659·6	−3·0	39·1	39·0	40·6	41·4
28	6·98	649·5	−7·5	11·69	633·1	−13·2	13·77	649·5	−21·1	8·27	650·1	14·3	37·8	38·4	39·6	41·4
29	3·94	645·9	−6·6	9·21	633·9	−11·4	15·58	647·7	−18·5	9·88	656·7	−9·1	35·5	35·5	39·4	43·2
30	4·62	651·3	−11·8	9·41	638·8	−12·7	17·34	642·6	−14·0	12·16	652·9	6·8	38·1	38·1	40·3	42·0
31	8·07	653·2	−18·4	9·27	637·8	−11·6	14·44	645·3	−27·1	16·67	654·1	−19·6	38·2	39·1	42·6	45·1
April 2	3·67	651·5	−12·6	7·12	636·2	−20·6	15·05	649·1	−26·6	10·00	659·8	−8·9	37·5	36·9	40·3	43·7
3	4·14	656·1	−24·1	8·74	642·6	−25·7	18·68	652·0	−27·4	14·99	669·6	−13·7	38·5	39·1	40·3	42·0
4	8·47	631·1	−35·7	10·00	643·3	−33·5	16·46	656·6	−27·4	20·17	660·0	−7·7	36·6	36·0	40·0	45·4
5	7·72	639·9	−27·5	13·92	619·6	−3·5	17·40	644·5	3·1	14·71	663·7	20·0	41·3	42·4	47·0	51·2
6	6·78	642·1	−8·5	11·75	625·3	−4·2	14·71	649·8	4·9	11·75	646·1	29·1	48·3	49·1	53·7	55·1
7	4·96	643·9	−9·5	9·06	635·7	−7·8	15·05	646·1	−10·8	11·08	656·0	6·9	50·1	49·8	50·5	51·3
9	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
12	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
14	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
16	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
17	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
18	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
19	4·14	650·2	−3·8	9·61	635·4	0·5	15·38	656·1	−5·2	12·50	654·2	14·3	49·1	50·3	53·9	56·2
20	5·10	646·8	−3·8	8·13	638·1	−4·1	14·71	646·4	−7·6	10·28	658·9	0·4	47·6	47·9	49·6	50·6
21	......	......	......	6·25	637·0	−9·4	14·99	645·0	−13·7	11·75	658·7	−2·6	......	42·3	44·0	47·6
23	3·67	651·1	−4·7	8·74	637·2	1·0	13·77	649·8	−14·5	12·10	655·7	−6·8	44·8	45·7	51·3	56·9
24	3·47	642·9	−7·0	8·66	638·7	−9·5	14·04	650·1	−12·9	10·28	653·9	−6·3	48·0	48·3	53·5	55·7
25	6·17	648·3	−6·7	10·14	643·8	−14·8	15·73	648·3	−12·8	11·16	667·1	45·2	50·5	50·4	50·9	51·4
26	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
27	3·55	648·7	−5·1	8·60	639·8	−11·5	14·71	654·4	−24·0	7·87	659·8	46·0	43·3	44·2	50·6	54·3
28	2·12	647·8	−0·2	6·25	634·5	−7·4	14·24	647·5	−7·5	10·34	659·5	−4·1	48·8	49·1	50·5	52·3
30	3·15	641·5	−2·7	8·94	639·1	−1·2	15·32	662·4	−8·9	12·69	654·7	8·0	44·6	46·8	50·5	51·5

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
May 1	7·51	643·6	5·7	12·02	644·2	−17·4	13·25	656·0	1·6	10·55	660·0	4·3	46·0	45·7	46·3	47·0
2	4·76	645·8	−13·9	11·23	634·5	−7·8	15·38	655·1	−11·1	11·29	657·8	10·6	43·7	45·4	49·8	54·0
3	4·23	634·7	−13·4	8·13	628·8	−12·5	14·38	649·2	0·4	9·00	653·5	9·8	48·2	46·9	46·8	46·9
4	5·58	646·1	−18·8	6·11	633·4	−16·0	12·36	639·7	−12·7	11·02	659·3	1·8	39·3	38·8	40·7	42·3
5	1·53	647·3	−2·9	4·29	636·6	−6·8	13·37	660·5	−15·7	12·16	671·1	6·4	37·6	40·1	42·8	44·4
7	0·19	644·2	−10·9	4·90	643·9	−13·0	8·74	648·1	−15·8	5·85	661·1	−4·8	43·9	43·9	44·6	44·9
8	0·98	645·3	−11·8	6·98	641·6	29·2	14·24	655·1	39·2	13·31	679·5	32·8	40·8	42·0	44·3	45·7
9	2·06	646·2	−3·2	10·14	634·6	−5·4	......	......	......	7·99	655·6	13·4	40·4	42·5	......	42·9
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	0·58	645·5	−13·7	11·69	631·6	−17·2	12·10	648·7	−10·8	8·33	661·1	2·4	41·1	41·6	42·3	43·1
12	1·19	593·6	−7·7	7·25	640·3	−13·6	13·45	658·5	−16·0	9·21	663·5	−5·0	40·6	41·4	44·5	45·7
14	1·13	643·0	−1·2	6·92	633·0	−4·1	11·23	666·7	6·6	5·85	666·6	10·1	42·9	43·8	45·8	47·8
15	3·15	648·6	−11·9	6·11	637·4	−11·7	11·63	640·7	−9·2	−4·72	693·6	19·6	43·7	44·2	45·6	46·5
16	0·52	645·2	−10·2	4·62	631·2	−11·6	17·34	666·5	−11·0	5·23	664·4	−9·7	44·1	44·9	46·9	49·7
17	6·37	642·0	−3·3	8·19	628·3	−4·0	12·10	660·5	−5·4	7·04	671·0	9·1	47·3	47·2	49·6	52·8
18	2·39	651·4	−13·1	7·93	635·1	−9·3	9·33	641·1	−3·3	9·81	661·7	1·0	47·5	48·1	52·1	55·2
19	0·52	645·6	40·4	6·92	631·6	−13·2	10·34	651·2	−13·0	6·92	666·1	0·3	51·5	53·5	56·8	59·9
21	2·88	646·8	−6·7	5·23	638·9	11·9	12·98	657·3	−18·0	7·51	659·8	−6·1	51·6	54·7	52·6	53·1
22	−0·09	648·8	−6·4	6·52	635·5	−12·9	......	......	......	......	......	......	47·8	48·0	......	......
23	3·21	648·9	−8·0	9·21	638·6	−20·8	9·88	647·2	−9·6	6·45	658·6	−5·1	49·2	49·0	53·2	55·4
24	1·86	650·7	−4·0	8·94	640·9	−15·8	10·96	646·6	−10·2	6·25	655·0	−5·9	53·5	54·4	56·8	57·6
25	−1·83	654·2	−13·6	3·27	637·9	−23·3	11·35	648·6	−5·7	7·31	656·0	−2·4	56·6	59·1	63·6	65·1
26	0·92	650·4	−3·2	6·92	634·8	−61·4	11·23	645·7	−7·1	8·19	667·3	−7·4	58·2	58·7	62·9	65·4
28	17·34	608·5	−52·2	9·33	632·4	−25·4	11·75	654·3	−8·0	8·47	659·8	14·6	51·6	51·5	52·7	54·0
29	1·33	636·1	−19·1	6·78	634·8	−9·9	8·66	653·5	12·3	7·19	658·3	3·2	47·5	47·7	48·9	49·3
30	0·78	640·4	−7·0	4·56	631·9	−3·6	10·61	646·9	−6·8	7·72	667·6	−6·8	46·3	47·3	48·0	50·1
31	3·82	639·5	−3·1	3·08	640·5	0·2	12·57	648·6	−1·6	8·54	661·8	5·7	45·4	45·8	47·8	50·0
June 1	3·41	642·0	−1·0	6·92	645·0	−10·2	11·08	662·7	−3·6	16·54	660·3	−0·5	45·9	45·9	46·2	46·2
2	2·58	655·8	−9·1	7·99	646·8	−6·9	11·49	661·0	−14·6	14·91	659·4	−3·2	46·1	47·4	49·0	50·5
4	0·58	653·5	−6·8	7·31	634·0	−9·5	13·92	658·5	−10·8	9·67	664·0	4·9	45·4	56·0	57·8	60·6
5	1·06	647·5	−9·2	5·64	642·1	−14·5	6·78	650·4	−6·0	7·87	656·0	2·1	56·7	56·8	59·1	61·5
6	0·66	651·2	2·0	5·17	644·6	−8·8	5·02	651·3	−7·7	17·01	684·8	−7·4	59·7	61·0	63·2	64·3
7	4·14	653·1	−9·2	13·57	632·5	−3·4	12·98	636·2	−0·2	8·60	667·2	18·5	59·8	60·4	61·9	64·1
8	1·53	648·3	−1·9	7·51	636·7	−3·3	10·28	634·9	5·8	8·07	645·6	13·8	56·9	57·9	60·6	61·2
9	2·52	644·1	−8·1	6·31	644·2	−5·0	8·54	656·2	−4·9	6·52	662·1	14·0	57·1	58·2	59·2	61·0
11	−0·48	637·3	−19·7	......	......	......	......	......	......	......	......	......	57·7	......	......	......
12	1·19	643·1	−1·8	6·11	644·8	−5·6	12·63	648·7	0·9	8·86	654·5	7·4	58·5	59·6	62·5	65·3
13	0·52	650·7	−13·0	6·25	635·9	−6·6	12·57	657·4	1·1	9·73	665·0	15·9	58·9	60·4	64·3	66·8
14	2·06	645·8	−2·9	7·60	633·5	1·8	9·47	653·9	1·7	7·93	655·7	7·6	59·8	58·8	58·3	59·7
15	−1·24	641·6	−0·6	5·78	642·6	−9·0	10·67	657·5	−10·3	14·79	661·6	−2·3	55·1	55·0	56·3	57·5
16	1·13	643·7	2·8	3·94	642·0	−22·9	12·02	660·0	−13·1	6·25	661·6	6·3	53·9	53·3	53·0	53·2
18	0·31	648·6	−1·5	......	......	......	10·20	656·5	−14·4	9·27	659·8	−1·1	50·3	......	52·1	53·9
19	0·86	643·2	−6·1	7·25	645·4	−14·3	......	......	......	......	......	......	47·7	47·7	......	......
20	0·86	647·4	−1·7	3·41	642·1	−14·5	......	......	......	7·39	665·5	−6·4	50·9	53·5	......	61·6
21	2·06	646·3	5·3	2·52	642·1	−13·5	10·55	653·1	−8·2	10·61	663·0	−6·0	59·6	62·3	65·7	68·4
22	1·45	645·0	0·0	4·62	637·8	−9·1	11·69	656·7	−9·9	15·58	672·6	−7·9	66·0	65·7	67·2	67·4
23	11·75	628·6	−18·8	7·25	627·7	−2·3	11·29	645·1	12·3	8·39	659·5	9·6	64·2	63·0	63·9	65·4
25	−0·82	640·2	5·6	5·49	635·6	1·2	11·43	645·9	2·6	8·86	655·3	8·1	57·6	58·0	60·1	61·3
26	0·52	635·7	8·3	5·64	633·0	−2·6	9·00	646·9	−8·9	5·97	660·5	7·2	60·5	60·9	62·9	64·7
27	7·93	635·9	−1·3	5·91	646·6	−12·7	8·86	653·2	−10·8	5·97	658·0	−1·3	63·3	64·4	66·9	68·4
28	0·66	635·7	−9·9	8·33	640·2	−3·7	12·16	659·7	−7·0	8·60	660·1	20·4	61·7	61·8	67·1	72·0
29	0·78	640·7	9·9	7·93	642·0	7·6	14·91	662·5	23·4	......	......	......	67·7	68·1	69·8	......
30	13·77	597·6	13·4	6·11	641·3	8·8	13·25	650·5	17·1	10·00	659·3	27·8	63·3	64·8	66·4	67·4

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24°+	Bifil. Corrected.	Balce. Corrected.	Decln. 24°+	Bifil. Corrected.	Balce. Corrected.	Decln. 24°+	Bifil. Corrected.	Balce. Corrected.	Decln. 24°+	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
July 2	0·92	643·7	16·9	7·60	631·5	21·0	13·77	647·5	7·8	9·41	663·1	17·2	62·1	63·8	66·2	67·3
3	3·82	643·8	−17·4	1·33	635·2	3·1	8·94	635·6	10·9	7·60	653·6	24·7	62·4	62·5	64·8	64·9
4	2·88	641·0	20·0	5·49	635·3	21·9	9·53	630·0	22·1	9·53	671·2	18·6	62·5	62·5	64·5	66·5
5	11·49	624·4	−4·5	6·11	630·9	4·3	14·04	652·7	28·5	8·60	653·5	35·1	59·8	59·6	59·5	61·5
6	−0·36	636·7	22·5	6·17	638·2	22·5	12·89	643·7	12·2	7·93	656·2	25·8	57·5	58·2	62·1	66·5
7	−1·44	646·7	19·9	3·41	637·6	24·2	9·00	650·8	17·5	7·87	659·7	22·7	61·7	62·9	67·0	69·9
9	0·52	642·1	24·4	4·62	630·9	22·8	......	......	......	......	......	......	63·4	64·5	......	......
10	0·58	636·0	16·7	4·90	637·4	15·7	12·98	651·5	11·6	8·60	668·3	16·8	62·6	61·9	62·6	62·2
11	0·86	644·3	17·3	4·50	631·7	26·1	9·21	654·7	20·3	4·82	660·4	33·4	59·5	60·8	63·0	66·0
12	0·19	648·4	15·4	4·70	633·4	18·5	10·61	651·5	13·0	6·84	663·6	27·9	62·2	63·9	67·1	70·6
13	0·05	647·4	24·6	4·50	637·2	18·9	11·43	647·5	23·6	5·29	657·3	31·9	64·3	65·6	69·4	71·3
14	5·91	641·4	20·1	3·08	633·6	19·0	9·61	645·7	21·6	7·66	659·6	23·4	66·5	65·7	66·5	68·7
16	−1·77	642·1	15·4	2·94	636·0	12·7	10·75	653·0	18·2	4·76	660·5	23·6	64·0	63·6	64·2	64·9
17	−0·82	641·7	20·6	......	......	......	9·21	654·1	17·2	5·64	654·5	25·0	60·4	......	61·1	62·1
18	−0·76	651·2	19·2	3·35	640·6	−22·0	8·39	653·9	15·9	5·78	661·8	23·0	60·9	61·7	64·8	66·8
19	−3·85	657·8	17·7	5·23	642·5	11·0	......	......	......	......	......	......	62·1	62·0	......	......
20	6·78	619·7	27·9	6·98	623·8	31·1	10·28	656·3	78·8	14·71	657·1	41·8	60·4	61·5	62·9	63·9
21	−1·44	637·3	28·7	3·08	629·7	28·9	11·43	636·8	25·2	6·92	656·7	43·0	61·1	61·3	65·0	68·1
23	4·23	616·2	25·3	5·58	639·3	17·6	8·66	656·8	21·8	5·64	646·7	27·4	68·3	68·5	72·6	73·8
24	0·31	631·3	28·8	5·58	636·1	26·0	8·66	649.9	24·2	2·88	651·3	24·9	67·4	66·5	67·6	67·7
25	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
26	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
27	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
28	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
30	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
31	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
* Sept. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
12	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
13	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
14	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
15	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
17	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
18	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
19	1·33	647·0	1·8	4·70	639·1	1·0	7·31	656·8	−7·3	3·55	664·3	5·4	54·3	55·0	57·9	60·7
20	4·02	649·4	−4·7	2·88	642·2	1·7	3·94	646·5	−5·3	4·14	660·9	4·7	58·8	60·3	62·1	64·5
21	−0·76	645·4	1·6	4·82	646·7	−3·0	12·57	650·8	−1·8	5·58	645·3	23·2	60·0	61·2	63·4	66·5
22	0·78	648·7	2·5	6·25	644·6	2·5	8·13	648·8	−3·1	3·67	644·8	10·8	62·3	63·0	65·0	63·7
24	−1·50	647·8	0·8	3·61	641·3	−0·2	9·94	650·4	2·3	......	......	......	53·2	53·3	55·6	......
25	−0·56	649·4	−9·7	7·66	639·6	−9·8	10·34	661·8	−3·7	3·15	651·2	25·4	49·0	48·6	51·7	55·0
26	−0·62	651·9	2·2	4·23	644·9	−3·4	6·58	656·7	1·2	4·08	662·1	2·6	50·5	50·9	52·5	54·8
27	−0·09	650·5	−1·5	3·47	641·9	7·0	7·45	653·4	−1·7	......	......	......	53·6	54·2	55·7	......
28	13·04	644·0	−9·9	11·90	631·3	1·1	......	......	......	1·53	654·9	30·4	51·3	52·1	......	55·1
29	2·94	644·0	−10·9	3·88	640·3	2·0	7·99	649·9	5·1	4·08	656·3	15·5	55·0	55·1	57·9	61·9

* No Observations during August.

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Oct. 1	1·06	652·6	9·0	2·88	643·2	4·7	8·66	647·4	8·4	−0·01	650·7	17·3	58·0	57·9	58·2	59·0
2	1·86	650·0	2·8	4·29	647·5	3·1	5·37	656·4	4·7	......	......	......	54·1	54·0	54·3	......
3	3·00	661·2	−8·7	6·84	649·3	−4·5	11·69	641·1	16·9	......	......	......	53·6	53·5	54·5	......
4	−1·44	646·2	12·4	2·12	641·2	4·5	8·66	644·3	5·2	......	653·4	10·8	53·6	55·0	57·1	58·5
5	6·11	644·8	−12·4	3·55	637·7	8·4	8·07	646·0	4·0	2·52	649·9	13·7	55·0	54·8	55·4	56·7
6	−0·09	650·7	6·5	1·80	639·0	14·2	7·39	644·3	11·9	2·12	654·2	6·1	50·6	51·3	53·9	55·1
8	−0·28	651·0	9·1	3·61	636·5	3·3	6·78	650·3	2·5	2·80	655·8	4·2	48·8	48·2	50·5	53·7
9	0·46	660·2	2·8	2·19	646·6	2·1	10·48	648·1	2·0	6·78	661·8	−1·1	52·3	52·3	52·7	52·5
10	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
11	0·39	637·9	−6·5	5·58	643·4	0·6	11·08	664·6	−1·2	2·88	661·7	4·4	48·5	48·9	49·6	49·8
12	3·61	647·3	−2·8	2·12	646·1	5·5	8·54	660·5	1·8	2·80	659·9	11·5	46·7	47·0	49·7	51·4
13	0·72	649·8	−3·9	3·41	640·5	0·7	7·72	651·7	−3·7	2·12	659·9	10·6	45·8	46·2	47·5	48·8
15	−0·01	644·0	−2·6	3·47	644·5	−2·5	7·45	654·6	−0·6	2·12	661·5	2·9	42·0	41·2	43·7	47·4
16	0·86	653·4	2·2	2·19	645·3	0·7	......	......	......	......	......	......	42·2	43·3	......	......
17	0·05	652·5	−0·4	2·52	640·7	−0·6	7·99	651·0	−3·0	3·08	657·7	5·3	41·3	40·7	43·6	46·9
18	0·46	665·6	−3·3	1·86	650·6	−0·5	9·21	648·9	−4·2	9·47	644·9	62·5	46·3	47·1	50·1	52·5
19	3·15	638·7	−0·3	0·58	638·1	13·1	6·98	647·5	11·1	3·75	651·4	13·8	48·2	48·5	50·4	51·5
20	5·37	650·1	−15·9	16·73	640·1	−6·4	8·74	641·0	16·7	2·31	662·6	16·4	49·6	49·1	52·0	53·2
22	0·05	653·3	1·9	3·27	640·3	5·7	9·53	651·0	8·9	1·80	653·8	8·5	52·6	52·6	53·9	54·6
23	13·92	656·8	0·0	1·86	647·4	3·8	6·58	654·3	−3·9	4·23	654·0	8·2	54·3	55·1	54·5	54·8
24	4·14	654·3	−8·0	0·92	645·1	5·0	6·58	647·8	3·0	2·31	656·9	10·0	45·6	44·5	45·4	46·3
25	0·66	655·1	4·2	2·46	640·9	8·5	8·47	656·6	9·0	3·47	657·9	4·8	42·1	43·7	46·5	47·9
26	0·11	659·3	−1·0	2·25	646·5	−1·7	7·12	654·3	1·4	1·92	659·1	−0·7	49·8	49·2	50·4	50·2
27	−0·62	656·7	−1·0	2·72	645·9	−6·0	4·82	657·0	−1·6	......	......	......	40·9	39·7	41·3	......
29	−0·15	660·1	−5·1	3·94	643·5	−5·2	8·39	655·0	−7·4	6·05	656·1	2·6	34·4	34·4	35·4	37·9
30	5·37	661·6	−3·0	2·88	647·0	−2·5	7·39	656·5	−14·7	3·88	661·6	1·0	42·6	42·8	41·7	43·5
31	0·52	661·8	3·8	2·58	653·6	0·0	6·25	656·7	−4·7	1·80	654·4	5·8	45·0	44·1	44·5	44·6
Nov. 1	0·05	658·9	−7·3	2·72	650·9	−10·8	7·51	652·9	−1·3	4·90	657·5	0·6	39·3	38·5	40·0	40·8
2	0·31	660·1	−2·5	1·86	652·1	−5·4	7·72	661·6	−8·3	8·54	654·1	7·6	39·3	39·8	42·1	43·6
3	−0·42	657·7	−1·6	2·12	648·5	−4·2	5·49	647·1	−5·2	......	......	......	44·0	44·4	45·8	......
5	0·19	657·0	−7·5	2·25	646·7	1·0	5·23	661·5	−2·3	1·45	665·9	−7·9	39·2	40·2	41·5	42·9
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	0·25	658·3	−6·9	2·06	653·1	−8·7	3·00	653·3	−12·1	7·99	643·8	9·1	43·5	43·3	43·2	44·5
8	−0·15	655·1	−7·5	2·46	651·0	−15·3	6·78	654·9	−3·3	4·62	663·6	6·2	44·7	44·3	45·0	46·1
9	−0·48	656·3	−3·7	2·80	644·5	−6·4	7·25	653·1	3·2	−4·13	648·2	28·6	39·9	38·5	40·4	41·5
10	1·39	657·4	−9·8	1·86	651·7	0·8	5·64	653·0	10·2	3·15	662·7	4·4	39·7	39·6	42·1	45·5
12	1·53	657·6	−1·6	2·12	649·3	−4·4	4·29	658·2	1.3	2·12	661·1	2·7	50·2	50·2	50·7	51·1
13	−0·09	659·8	−10·6	......	......	......	4·76	652·4	−11·0	1·53	659·8	−0·5	48·9	......	48·1	48·1
14	0·52	659·3	−0·7	2·39	647·8	−6·8	5·91	654·0	−3·5	2·12	660·5	−0·3	45·6	44·9	44·9	45·0
15	0·46	661·3	−13·9	......	......	......	3·82	660·0	−0·5	1·80	663·5	−6·6	42·3	......	43·0	43·4
16	0·31	664·0	−4·8	2·12	654·1	−13·6	5·17	658·4	−5·2	6·17	656·7	5·5	38·7	37·5	38·7	41·8
17	0·46	661·8	−12·8	2·88	653·0	−11·3	9·33	653·9	4·8	1·53	662·3	10·2	34·9	34·2	35·0	36·7
19	0·58	662·1	−3·9	3·27	677·6	−11·6	6·25	651·5	−1·9	2·52	655·2	−3·1	42·4	42·4	42·8	43·1
20	1·13	662·4	−10·8	4·14	653·3	−10·7	6·72	658·8	−7·3	2·72	656·7	−2·6	42·2	42·2	42·4	42·8
21	3·47	658·1	−15·0	5·23	652·1	−1·3	9·33	646·9	13·0	6·64	650·8	23·3	42·4	42·2	43·1	43·2
22	1·13	658·3	−8·0	4·35	646·8	−0·2	6·37	656·9	20·1	1·92	658·5	7·9	42·3	42·3	44·7	43·0
23	0·66	663·9	−6·1	2·06	657·7	−5·6	10·87	653·5	2·7	......	......	......	42·0	42·2	42·3	......
24	1·25	657·6	−13·9	2·19	653·6	−5·2	4·62	659·3	1·0	1·80	662·3	0·1	40·5	40·5	41·1	41·3
26	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
27	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
28	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
29	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
30	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......

Göttingen Mean Time.	8 A.M.			11 A.M.			2 P.M.			5 P.M.			Temperature of Bifilar and Balance.			
Civil Day.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	Decln. 24° +	Bifil. Corrected.	Balce. Corrected.	8 A.M.	11 A.M.	2 P.M.	5 P.M.
	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	′	sc. div.	mic. div	°	°	°	°
Dec. 1	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
3	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
4	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
5	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
6	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
7	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
8	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
10	1·73	660·1	−15·4	2·88	662·2	−14·7	2·94	662·4	−8·2	1·59	663·7	−8·8	32·2	31·8	32·7	33·2
11	1·39	655·4	−15·5	3·27	669·8	−22·9	3·67	668·3	−16·1	2·25	666·0	−12·0	29·0	28·7	30·6	31·1
12	4·08	664·2	−22·2	5·10	652·3	−22·5	5·64	659·2	−8·3	4·23	656·9	−7·1	28·3	27·9	28·2	28·7
13	2·00	663·9	−19·3	3·35	659·9	−21·0	3·88	667·3	−12·3	1·53	665·5	−12·3	25·8	25·4	26·6	27·5
14	1·86	666·8	−66·6	3·88	665·3	−17·3	......	......	......	2·52	665·3	−7·1	33·3	35·0	......	41·8
15	3·67	663·8	−14·2	4·62	666·7	−12·9	3·61	663·7	−5·3	......	......	......	43·2	43·6	44·5	......
17	1·73	664·4	−17·0	9·00	650·0	−13·6	6·31	666·4	−9·2	5·91	666·9	0·6	37·0	36·2	36·0	36·0
18	2·80	667·5	−14·4	5·23	657·7	−9·5	6·84	651·0	−6·3	1·45	651·9	−11·3	36·4	36·3	37·0	37·2
19	3·27	649·2	−17·4	4·14	643·9	−16·5	4·29	653·9	−10·6	......	......	......	33·1	31·9	31·9	......
20	1·65	660·0	−18·5	3·08	656·7	−11·1	4·02	663·6	−6·5	2·19	661·8	−8·3	28·4	28·0	29·8	30·1
21	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......
22	0·86	665·6	−26·8	3·61	663·2	−20·3	2·80	664·7	−13·6	1·06	665·0	−15·9	25·3	24·7	24·6	26·7
24	0·66	665·7	−16·9	2·94	651·1	−20·4	3·27	663·7	−13·4	1·53	664·4	−8·4	35·7	36·3	37·8	39·5
25	0·52	669·4	−18·8	3·00	666·8	−21·6	4·62	660·8	−15·4	4·14	677·3	−5·1	40·8	40·9	42·1	43·2
26	0·78	664·3	−18·7	1·45	661·3	−13·9	2·19	664·1	−13·0	0·58	664·4	−12·7	40·9	41·0	41·2	41·4
27	−0·15	667·1	−11·9	1·53	667·1	−15·3	4·82	636·5	−10·8	0·52	666·2	−11·9	42·2	42·6	43·1	43·7
28	0·46	664·5	−16·2	2·80	660·9	−18·8	1·59	664·6	−15·8	0·78	664·2	−12·4	40·8	40·6	40·4	41·3
29	−0·21	668·2	−15·2	2·00	662·8	−15·4	3·55	668·4	−13·0	1·73	664·2	−10·0	43·3	43·3	44·1	44·8
31	0·58	662·6	−15·6	2·19	655·7	−9·0	2·94	660·2	−6·3	......	......	......	44·4	45·0	46·6	......

DAILY

METEOROLOGICAL OBSERVATIONS.

MAKERSTOUN OBSERVATORY,

1847–1855.

Civil Day.	Calculated Daily Means.*		11 A.M., Gottingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Gottingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h, 8h.
	°			°	°			°	°		°	°				
Jan. 1	37·8	......	......	......	......	......	......	......	......	......	36·5	40·6	......	......	......	....
2	37·2	......	......	......	......	......	......	......	......	......	36·7	38·8	......	......	......	....
4	36·2	......	......	......	......	......	......	......	......	......	32·9	38·8	......	......	......	....
5	39·7	......	......	......	......	......	......	......	......	......	36·6	42·0	......	......	......	....
6	41·7	......	29·817	42·2	41·5	95	29·845	42·1	41·9	98	40·4	45·6	......	......	......	....
7	41·1	......	29·884	41·0	40·1	93	29·852	41·6	40·5	91	40·3	43·0	......	......	......	....
8	39·6	......	29·958	41·9	40·2	87	30·003	39·0	36·9	83	39·8	42·4	......	......	......	....
9	33·0	......	30·157	34·2	32·5	85	30·136	32·4	31·2	89	33·5	35·1	......	......	......	....
11	20·2	1·2	29·949	20·4	20·7	100	29·882	21·7	22·4	100	19·1	26·1		0·1	0·0	— — 28, 30, —
12	15·3	3·6	29·869	16·9	17·2	100	29·814	15·1	15·6	100	12·0	19·6		0·0	0·0	....
13	26·7	9·7	29·707	26·7	26·8	100	29·697	28·7	28·9	100	14·4	30·8		0·0	0·0	20, 14, 22, 30, —
14	28·7	7·1	29·766	27·1	27·2	100	29·789	30·9	30·7	98	17·8	31·6		0·0	0·0	— — 28, 18, —
15	35·3	0·5	29·793	37·0	35·0	83	29·750	35·0	31·9	75	30·9	41·2		......	0·3	18, 14, 16, 18, 28
16	31·3	6·6	29·884	33·7	33·6	100	29·941	30·8	30·4	95	31·4	36·6	·070	0·3	0·0	14, 0, 24, 16, 18
18	31·3	10·0	29·966	31·6	31·4	98	29·973	32·0	31·6	96	30·8	34·1		0·1	0·0	4, 7, 12, 31, 17
19	30·6	10·0	29·992	31·2	31·0	98	29·947	31·3	30·4	92	29·9	33·4		0·2	0·0	2, 0, 20, — 18
20	29·0	7·0	29·831	29·9	29·8	99	29·777	30·1	......	......	25·6	34·6		0·1	0·0	— 18, 18, 17, —
21	28·3	7·3	29·707	25·4	25·7	100	29·643	32·6	30·9	86	24·7	34·6		0·2	0·0	8, 6, — 12, 8
22	33·6	9·9	29·589	34·9	32·8	82	29·535	34·9	32·9	83	30·3	36·3		2·2	0·8	14, 14, 14, 14, 14
23	34·1	10·0	29·458	34·1	33·3	93	29·356	35·5	34·5	91	33·7	36·1		2·2	0·2	15, 12, 14, 6, 14
25	37·7	9·0	28·790	37·5	35·7	85	28·741	38·6	37·6	93	34·4	40·8		6·6	0·5	6, 16, 19, 18, 17
26	41·7	7·7	28·878	44·0	42·3	88	28·888	41·0	38·9	85	37·7	45·8	·040	5·2	1·5	18, 19, 22, 16, 16
27	39·6	6·9	28·732	41·0	39·6	90	28·873	40·5	38·1	82	33·5	44·4	·084	6·0	1·2	20, 18, 19, 20, 8
28	37·7	10·0	28·611	36·7	36·5	99	28·721	39·4	38·2	91	34·9	42·2	·041	0·6	0·1	18, 20, 26, 24, 24
29	37·5	7·1	28·957	38·5	37·5	92	29·026	38·9	37·3	88	31·5	43·3		0·9	0·2	18, 17, 22, 20, 16
30	36·3	8·4	29·318	36·3	35·5	93	29·403	37·9	36·7	90	31·9	40·6		1·5	0·6	28, 28, 30, 31, 0
Feb. 1	32·4	6·7	29·634	34·0	33·9	99	29·716	34·0	31·7	82	31·2	39·6	·280	2·0	0·2	2, 2, 3, 2, 2
2	31·5	6·1	29·843	33·7	32·1	86	29·830	32·4	31·3	91	25·5	38·3	·057	0·8	0·3	28, 31, 2, 0, 4
3	29·7	8·4	29·899	32·2	31·9	97	29·910	32·7	32·5	98	22·6	37·8	·138	0·5	0·1	18, 21, 18, 16, 24
4	25·7	3·9	29·968	28·3	28·6	100	29·980	31·0	31·5	100	13·6	36·8		0·1	0·0	— 20, 24, 18, 20
5	38·6	8·2	29·768	40·3	38·1	83	29·658	40·7	37·5	76	19·1	42·8		1·2	0·4	22, 17, 20, 19, 22
6	38·3	4·2	29·208	42·4	39·3	78	29·234	36·7	32·9	70	36·5	44·2		6·1	2·3	22, 26, 29, 28, 28
8	24·6	1·7	29·324	25·5	25·4	100	29·203	28·4	25·9	77	18·7	30·1		1·3	0·1	26, 23, 26, 28, 24
9	26·4	7·0	29·098	27·8	25·9	82	29·100	31·2	29·4	84	18·6	34·0		4·0	1·5	22, 29, 29, 28, 29
10	30·6	2·8	29·340	30·1	29·4	94	29·334	34·0	31·6	81	27·1	35·1		5·0	1·0	28, 28, 28, 29, 30
11	31·2	6·6	29·589	29·8	28·4	87	29·598	34·0	31·5	80	27·2	38·5		......	0·1	28, 18, 26, 26, 24
12	25·6	3·1	29·610	26·8	26·1	93	29·610	31·8	31·2	95	16·1	36·2		......	0·0	18, — 28, — 18
13	29·1	7·2	29·711	28·6	27·9	94	29·556	35·1	33·2	84	15·5	37·2		3·2	0·5	— 20, 18, 20, 20
15	36·8	6·9	29·032	37·9	37·0	93	28·868	39·8	37 9	86	34·1	44·8	·100	4·1	0·7	20, 16, 18, 22, 23
16	40·2	6·4	29·263	40·8	38·4	82	29·204	42 3	40·0	83	34·7	44·6	·032	5·6	1·4	22, 20, 18, 20, 22
17	42·3	9·6	29·333	41·6	40·6	93	29·303	45·8	44·6	92	34·8	46·4	·065	4·2	0·9	18, 18, 18, 20, 20
18	44·5	7·2	29·252	47·4	44·3	80	29·238	43·0	41·2	87	......	49·7	·021	11·1	3·4	20, 20, 20, 19, —
19	39·5	6·4	29·370	40·2	36·9	75	29·558	42 0	37·9	70	36·8	44·9		6·3	2·3	22, 22, 26, 20, 24
20	41·6	10·0	29·837	41·6	39·9	87	29·750	45·5	43·0	83	34·0	47·6		2·1	0·7	18, 16, 18, 20, —
22	41·4	3·4	30·065	41·4	40·5	93	30·071	46·9	44·9	86	31·7	50·0		0·6	0·1	21, 20, 22, 20, 0
23	35·0	6·6	30·103	35·4	35·5	100	30·060	39·9	37·7	83	30·5	44·4	·058	0·8	0·1	8, 4, 16, 12, 20
24	32·4	5·2	30·049	32·5	31·3	90	30·006	39·5	35·4	68	26·6	43·1		0·7	0·2	24, 28, 16, 14, —
25	28·7	0·3	29·998	27·5	27·2	97	29·963	36·3	32·9	72	19·6	37·6		0·3	0·1	— 24, 8, 2, 0
26	34·0	9·7	30·045	36·1	32·3	68	30·047	35·9	33·0	75	27·3	39·8		0·9	0·4	4, 8, 8, 10, 8
27	33·2	7·4	30·069	33·4	32·9	95	30·033	36·5	33·6	76	28·9	39·3		0·5	0·2	12, 2, 0, 1, 0

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky Clouded.	11 A.M., Gottingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Gottingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h, 8h.
Mar. 1	35·9	9·6	30·292	39·8	38·2	87	30·322	38·3	37·8	96	31·8	41·0	·013	1·0	0·4	27, 3, 2, 2, 2
2	37·8	10·0	30·421	39·0	36·6	81	30·423	42·0	38·3	73	34·2	44·3		0·8	0·2	30, 20, 0, 30, 28
3	38·1	10·0	30·452	41·0	38·7	83	30·422	40·4	37·4	77	38·4	43·4		0·6	0·2	31, 2, 3, 4, 28
4	37·3	10·0	30·376	39·6	37·3	82	30·334	41·2	37·6	73	32·6	43·5		0·6	0·1	18, 10, 0, 0, 30
5	39·2	9·6	30·304	42·2	38·9	76	30·260	41·1	38·9	83	37·9	44·7		2·2	0·9	0, 1, 1, 2, 2
6	38·9	8·9	30·136	41·0	37·0	70	30·048	41·0	38·3	79	35·2	45·2		1·3	0·6	1, 0, 4, 28, 2
8	40·8	6·8	29·978	43·2	39·9	76	29·878	45·2	39·5	61	37·0	48·9	·084	2·2	0·8	23, 30, 28, 31, 31
9	32·1	6·4	29·876	34·3	32·1	81	29·855	34·4	31·6	77	31·3	39·0		5·1	0·7	31, 31, 30, 30, 30
10	27·8	4·9	29·883	31·3	30·4	91	29·942	32·4	30·7	85	25·1	37·1	·056	1·4	0·2	4, 26, 0, 6, 24
11	31·9	7·5	29·794	34·6	31·5	74	29·621	34·3	34·0	98	16·8	39·5		3·8	1·0	19, 19, 21, 20, 25
12	35·6	7·2	29·921	37·8	34·9	76	29·930	40·0	35·3	64	30·8	42·1		1·1	0·2	28, 30, 30, 0, 17
13	42·5	9·1	29·912	45·0	42·3	81	29·934	46·8	42·9	74	33·2	49·7		1·8	0·7	26, 24, 24, 20, 28
15	47·4	7·3	29·682	48·2	40·8	54	29·561	57·6	44·9	35	33·3	58·1		11·0	0·8	— 17, 17, 18, 8
16	52·3	8·0	29·441	54·3	47·4	61	29·339	56·6	49·0	59	37·9	64·8		5·0	1·4	17, 17, 18, 15, 17
17	50·8	10·0	29·431	53·8	49·5	75	29·438	54·5	50·8	79	45·7	58·1	·025	12·7	0·3	17, 16, 17, 18, 24
18	52·3	2·3	29·554	56·0	48·1	57	29·501	60·3	48·5	42	39·7	64·7		2·0	0·5	16, 17, 16, 24, 20
19	46·6	2·8	29·390	47·3	44·6	82	29·244	56·1	46·9	51	31·1	60·1		2·4	0·7	— 8, 14, 12, 16
20	47·4	7·6	29·091	50·7	46·7	76	29·140	51·3	45·5	66	40·0	56·0		4·8	1·1	17, 16, 18, 18, 14
22	43·5	4·7	29·616	44·8	42·6	85	29·607	51·0	44·9	63	31·3	54·0		0·3	0·1	18, 17, 2, 6, 4
23	43·2	9·4	29·492	43·9	41·6	84	29·410	46·8	44·7	86	32·9	51·7		1·0	0·3	28, 6, 16, 12, 15
24	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……
25	40·7	9·0	29·812	42·0	41·5	96	29·801	45·4	41·9	76	39·8	46·9	·068	0·6	0·1	4, 6, 8, 12, 5
26	40·9	10·0	29·828	42·3	41·3	92	29·784	44·4	42·3	85	35·9	49·0		0·8	0·1	10, 10, 14, 6, 7
27	46·0	8·2	29·749	47·3	45·4	87	29·687	53·7	46·4	59	38·8	57·2		0·2	0·0	20, 25, 18, 3, 2
29	37·0	8·7	29·556	41·8	38·3	74	29·526	38·8	37·1	86	30·5	46·1		3·3	1·2	30, 31, 0, 2, 30
30	35·8	8·3	29·495	38·3	34·5	71	29·423	41·0	35·4	59	30·5	42·6	·042	1·2	0·4	29, 28, 30, 31, 25
31	34·6	6·2	29·326	38·7	34·3	66	29·236	37·3	34·5	78	29·0	42·8		1·1	0·2	28, 31, 29, 28, 20
April 1	31·9	5·2	29·165	35·2	31·6	72	29·108	37·7	34·3	74	28·0	44·5	·055	0·7	0·1	26, 28, 28, 29, 0
2	32·7	6·8	29·153	35·3	33·6	86	29·205	38·2	34·1	68	28·1	40·7	·054	4·2	2·0	30, 0, 0, 0, 0
3	34·7	4·2	29·296	37·8	34·6	75	29·357	40·2	35·8	67	30·8	42·6	·103	5·2	1·9	0, 0, 0, 1, 2
5	42·8	3·8	29·295	46·5	40·4	60	29·310	49·0	41·6	55	36·8	52·3		6·2	2·4	24, 24, 25, 25, 20
6	44·4	6·6	29·517	46·7	39·9	56	29·502	49·8	43·0	58	30·5	51·4		1·2	0·4	18, 27, 23, 22, 18
7	45·3	8·6	29·425	48·7	43·2	65	29·423	49·9	43·3	60	41·2	54·6		8·0	1·2	22, 25, 22, 24, 21
8	42·3	6·7	28·896	49·3	44·0	67	28·871	41·0	38·3	80	39·2	51·5	·230	10·8	4·5	20, 21, 20, 23, 24
9	41·2	2·2	29·156	47·0	40·3	57	29·276	43·0	39·3	74	37·6	50·0		9·8	3·3	26, 26, 26, 22, 26
10	42·4	3·8	29·581	46·9	39·5	53	29·603	49·5	41·3	50	32·9	52·3		2·2	0·1	26, 27, 26, 28, 22
12	45·1	9·4	29·399	52·6	48·4	75	29·514	44·2	41·3	80	42·3	59·1		2·0	0·2	— 20, 7, 2, 4
13	37·1	8·5	29·776	40·6	36·5	69	29·816	41·4	36·6	64	32·5	43·9	·014	2·8	0·8	1, 31, 0, 2, 1
14	36·1	10·0	29·938	39·5	35·0	65	29·889	40·1	35·3	64	33·5	42·6		2·4	0·8	0, 2, 2, 2, 0
15	37·3	10·0	29·861	43·0	39·0	71	29·870	39·8	38·7	92	34·8	44·2	·010	0·5	0·1	26, 1, 8, 14, 16
16	40·0	10·0	29·778	42·0	40·4	88	29·686	46·6	42·5	73	35·4	51·5	·046	0·8	0·4	22, 19, 18, 20, 20
17	36·3	10·0	29·556	38·6	37·3	90	29·575	41·0	39·3	87	35·2	42·4	·087	0·6	0·1	16, 24, 25, 24, —
19	40·6	8·1	29·505	47·1	41·7	65	29·474	45·5	40·4	66	26·8	52·0	·017	1·1	0·0	16, — 0, 4, 8
20	41·8	6·1	29·636	45·6	40·7	67	29·661	45·2	40·3	67	27·4	56·7		0·7	0·1	24, — 28, 6, 14
21	45·5	6·7	29·782	49·5	45·1	72	29·775	53·0	46·7	63	29·3	57·2		0·5	0·2	— 1, 16, 16, 17
22	45·2	4·7	29·860	48·5	44·0	71	29·816	50·7	46·3	72	31·9	57·8		0·5	0·2	20, — 4, 16, 20
23	46·5	3·8	29·760	50·2	45·3	69	29·704	54·9	47·3	58	29·6	59·6		1·0	0·1	25, 28, 20, 12, 16
24	45·1	5·9	29·709	50·9	44·8	63	29·691	49·5	46·6	82	28·2	58·3		0·7	0·0	25, 28, 24, 12, 18
26	45·5	7·8	29·161	48·8	45·5	79	29·249	50·0	44·7	67	40·0	53·4	·133	5·5	1·6	18, 21, 21, 20, 22
27	43·9	6·7	28·916	49·0	44·3	71	28·853	47·2	42·6	70	39·6	51·4	·139	10·6	4·6	20, 20, 20, 20, 20
28	44·2	9·3	28·962	48·0	44·6	78	29·020	47·2	44·8	84	40·1	53·3	·103	9·9	2·8	20, 20, 19, 21, 24
29	46·1	7·9	29·196	50·0	43·5	61	29·271	51·8	44·6	58	38·6	57·9	·013	1·1	0·2	24, 30, 31, 7, 14
30	41·0	6·6	29·363	47·8	42·3	65	29·367	46·0	41·3	69	36·7	54·1	·230	1·2	0·2	19, 24, 22, 20, 18

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.		11 A.M., Gottingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Gottingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h, 8h.
May 1	43·0	5·3	29·478	47·8	42·3	65	29·439	49·0	43·3	65	32·3	53·4	·022	0·7	0·2	— 30, 6, 4, 14
3	40·9	9·9	29·636	43·0	41·7	91	29·688	44·4	41·6	80	37·4	47·1	·078	3·0	1·2	0, 1, 2, 2, 2
4	46·1	5·5	29·751	48·0	45·5	83	29·683	54·4	49·0	69	40·8	57·3	·003	0·7	0·2	2, 6, 8, 14, 10
5	43·4	9·4	29·663	50·8	47·3	78	29·589	46·0	44·2	88	36·5	52·6		2·4	0·9	4, 3, 6, 5, 3
6	42·3	9·4	29·541	49·3	45·9	78	29·481	44·0	43·1	93	39·1	54·7		1·2	0·5	5, 8, 8, 5, 8
7	49·9	9·2	29·486	57·8	51·0	63	29·433	53·6	49·5	76	39·0	62·0	·358	1·8	0·6	12, 16, 10, 6, 12
8	41·9	10·0	29·384	44·6	44·3	98	29·278	46·7	46·0	95	42·2	50·1	·037 ·597	1·2	0·4	4, 4, 4, 4, 2
10	53·0	6·5	29·609	58·7	53·3	71	29·595	57·2	52·4	74	41·1	64·5	·096	2·4	0·2	8, 3, 14, 12, 12
11	46·2	10·0	29·463	51·2	49·1	87	29·399	47·9	47·1	95	39·4	53·2		0·4	0·1	4, 4, 8, 3, 4
12	50·7	7·1	29·388	57·9	53·5	76	29·365	50·5	49·8	96	35·5	64·4		1·8	0·1	— 18, 19, 30, 4
13	52·8	6·4	29·445	57·6	52·9	74	29·416	59·4	54·2	73	47·5	63·4	·354	1·7	0·3	21, 20, 18, 30, 19
14	52·6	6·0	29·467	56·9	53·0	78	29·457	57·9	51·9	68	44·8	61·1	·140	1·7	0·8	14, 19, 18, 19, 19
15	53·4	4·1	29·560	57·5	50·9	65	29·583	57·9	51·6	66	43·8	61·7		2·5	0·8	19, 18, 18, 18, 20
17	39·2	10·0	29·519	40·7	40·0	95	29·660	42·6	41·6	93	39·2	45·7	1·320	2·6	0·3	2, 3, 5, 6, 4
18	41·0	10·0	29·816	44·0	41·5	82	29·739	44·3	42·6	88	39·6	47·0		0·7	0·4	6, 8, 6, 7, 3
19	51·2	9·2	29·485	56·7	52·3	75	29·452	57·4	53·3	77	41·9	63·6	·634	1·3	0·5	10, 1, 18, 18, 20
20	52·4	8·9	29·444	56·6	52·2	75	29·523	56·5	51·1	70	45·4	60·7	·192	2·3	0·7	22, 28, 24, 28, 20
21	52·2	9·2	29·735	56·1	50·7	70	29·747	53·7	50·6	81	44·9	60·3		2·3	1·1	21, 21, 20, 20, 20
22	49·8	8·3	29·582	52·8	49·3	79	29·619	53·9	50·7	81	46·9	57·6		2·7	1·1	20, 19, 20, 22, 25
24	55·8	6·2	29·458	58·1	53·3	74	29·412	61·4	54·3	64	49·2	64·2	·012	3·6	1·3	— 20, 20, 20, 20
25	51·8	8·6	29·611	54·2	47·7	63	29·723	56·1	50·7	70	44·9	59·7	·028	3·8	1·9	22, 19, 24, 20, 18
26	52·2	7·4	29·808	55·8	50·6	70	29·835	51·7	49·5	86	47·7	60·9		3·9	1·5	22, 20, 20, 20, 18
27	59·4	4·5	29·882	59·1	52·5	65	29·782	67·1	59·1	63	42·0	72·3		1·2	0·3	21, 21, 12, 12, 12
28	66·8	4·3	29·669	68·3	61·3	68	29·631	75·0	65·3	60	45·2	80·3		1·2	0·1	8, 8, 12, 24, 16
29	56·2	9·1	29·533	60·6	59·3	93	29·586	62·0	57·2	76	47·2	67·7	·486	1·4	0·3	16, — 20, 18, 18
31	63·9	3·8	30·261	66·8	60·4	70	30·255	69·3	60·1	59	46·9	73·3		2·4	0·4	16, 18, 20, 20, 20
June 1	65·3	5·2	30·302	68·6	61·1	66	30·253	70·2	62·9	67	47·0	78·0		0·4	0·1	— 22, 8, 4, 4
2	64·2	6·1	30·256	71·1	63·0	64	30·231	67·9	60·3	65	47·1	76·0		0·4	0·1	30, — 0, 4, 2
3	64·7	1·8	30·187	70·7	63·6	68	30·149	69·8	61·9	64	51·2	73·7		0·4	0·1	— 6, 6, 2, 4
4	52·3	10·0	30·183	56·5	55·0	91	30·182	54·2	50·8	80	51·6	60·0		0·4	0·2	2, 6, 4, 3, 4
5	52·1	7·8	30·062	55·5	47·5	56	29·947	59·8	49·4	47	44·8	62·4		0·9	0·3	28, 0, 28, 0, 2
7	50·0	9·9	29·799	54·2	49·2	71	29·713	52·9	48·6	74	36·1	59·6		1·9	0·3	— 24, 24, 24, 24
8	46·6	5·8	29·444	52·7	46·1	61	29·506	50·4	45·5	70	42·0	56·9	·080	4·0	0·9	26, 30, 30, 30, 31
9	50·0	10·0	29·677	53·9	48·1	67	29·564	57·2	52·0	72	36·0	65·5		0·8	0·1	30, 0, 10, 18, 20
10	48·0	8·4	29·463	53·9	48·3	68	29·520	55·6	49·6	66	46·4	59·7	·326	2·0	0·6	30, 28, 30, 28, 26
11	51·1	8·4	29·699	56·9	50·3	64	29·719	54·7	49·3	69	38·0	60·6	·022	1·2	0·3	24, 28, 22, 20, 24
12	53·4	9·9	29·665	57·3	51·6	69	29·655	57·6	50·9	64	37·0	64·3		1·0	0·3	20, 18, 18, 18, 18
14	54·1	8·7	29·185	54·9	51·4	80	29·168	61·6	54·2	63	49·0	64·9	·228	2·5	0·2	20, 18, 19, 22, 16
15	49·9	9·8	29·117	57·3	52·6	74	29·175	51·6	48·2	80	41·7	63·6	·152	0·9	0·2	20, 20, 18, 20, 18
16	55·0	6·2	29·392	58·4	50·9	61	29·325	58·2	53·3	74	39·9	66·9		0·7	0·2	22, 21, 6, 10, 8
17	47·3	10·0	29·379	50·7	49·7	94	29·429	50·3	49·7	96	47·8	53·2	·100	1·7	0·8	4, 2, 3, 0, 31
18	50·8	9·2	29·549	52·3	50·1	87	29·574	57·2	52·6	75	47·7	60·1		0·7	0·5	0, 0, 0, 2, 1
19	55·3	9·9	29·659	56·7	52·6	77	29·660	62·4	55·6	66	51·2	68·0		1·1	0·2	30, 31, 0, 31, 22
21	54·6	8·8	29·334	60·0	54·5	71	29·325	60·6	50·7	51	51·9	65·3		1·3	0·7	23, 20, 22, 20, 22
22	50·8	8·2	29·284	55·5	51·9	78	29·218	55·7	51·1	74	42·0	60·2	·450	3·1	1·2	21, 18, 19, 20, 18
23	57·5	4·1	29·288	59·9	52·9	64	29·279	63·2	53·8	55	43·4	66·6		1·2	0·4	18, 18, 21, 20, 20
24	55·7	8·1	29·204	58·8	54·7	78	29·169	63·4	55·2	61	43·8	66·3	·098	0·7	0·2	22, 16, 18, 18, 20
25	54·4	8·1	29·296	61·0	56·2	75	29·359	58·1	54·3	80	45·3	63·7	·200	1·0	0·3	18, 18, 18, 20, 24
26	56·9	6·9	29·710	59·9	52·7	62	29·784	63·5	54·2	55	43·3	67·8	·314	1·1	0·3	22, 23, 21, 20, 20
28	66·4	2·2	30·097	69·3	63·5	73	30·105	74·0	65·3	63	51·8	76·0		1·1	0·2	20, 0, 31, 28, 23
29	63·4	1·6	30·174	66·9	61·7	75	30·162	69·3	61·1	63	47·4	73·5		0·4	0·1	2, 4, 6, 7, 8
30	58·6	4·9	30·186	63·7	59·1	77	30·156	65·9	59·8	71	52·2	67·3		0·4	0·2	6, 4, 7, 6, 6

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h, 8h.
July 1	56°·5	6·9	30·176	56°·3	54°·3	88	30·139	60°·8	56°·6	78	51°·0	68°·2		0·4	0·2	4, 6, 8, 8, 6
2	54·6	4·3	30·136	57·9	53·8	77	30·076	58·6	54·5	78	49·7	65·8		0·4	0·1	6, 6, 4, 4, 2
3	64·0	0·7	29·922	64·0	57·9	70	29·859	75·2	62·8	50	38·7	76·2		0·5	0·1	22, 16, 16, 20, 18
5	60·5	6·7	29.701	62·9	60·0	85	29·665	66·9	63·3	83	50·9	78·8		0·7	0·1	15, 12, 18, 2, 2
6	63·9	9·6	29·656	64·5	62·4	90	29·608	72·0	65·2	70	53·4	77·1		0·2	0·0	— — 22, 14, 18
7	56·0	10·0	29·532	57·6	56·6	94	29·474	59·5	59·5	100	53·5	67·0	·176	0·2	0·1	1, 2, 3, 1, —
8	59·8	8·4	29·613	69·9	63·1	69	29·607	58·9	58·9	100	45·4	74·5	1·026	1·0	0·1	12, 20, 8, — 4
9	60·6	6·0	29·666	64·8	59·1	72	29·697	64·3	58·1	70	46·4	69·1	·760	1·3	0·6	18, 22, 22, 19, 16
10	63·4	9·6	29·789	64·5	62·8	91	29·797	70·0	63·2	69	54·0	75·9		1·2	0·3	20, 24, 20, 18, 20
12	65·8	4·6	29·901	69·6	65·4	80	29·908	71·5	66·4	77	58·8	76·4		1·1	0·3	22, 18, 18, 18, 20
13	65·6	6·8	29·973	71·0	65·5	75	29·953	70·5	64·9	74	53·7	75·6		0·5	0·2	22, 16, 23, 19, 20
14	69·5	4·8	29·999	72·2	65·3	69	29·961	77·0	70·0	71	50·4	84·4		0·2	0·0	21, 14, 19, 22, 22
15	64·0	8·5	29·937	75·8	68·7	70	29·913	63·0	61·3	91	55·8	83·2		0·8	0·2	28, 16, 2, 2, 2
16	52·5	10·0	29·909	55·1	53·2	89	29·907	56·6	53·9	84	51·5	58·5	·046	0·9	0·3	0, 1, 2, 2, 2
17	57·7	3·0	29·917	61·8	56·6	73	29·877	62·4	54·2	59	42·9	67·6		0·3	0·1	9, 10, 8, 10, 2
19	62·3	9·0	29·749	64·0	58·2	71	29·695	66·2	61·3	76	51·7	76·1		0·4	0·1	26, 26, 12, 4
20	56·4	9·9	29·726	59·2	55·5	80	29·711	61·0	56·8	78	52·9	67·1		0·4	0·1	1, 0, 6, 6, 4
21	58·4	9·6	29·617	60·6	57·1	81	29·547	63·0	59·7	83	47·8	73·0		0·7	0·1	12, — 21, 2, 0
22	58·4	9·4	29·547	60·2	58·7	92	29·595	62·7	57·6	74	54·0	69·3	·975	3·4	1·8	18, 18, 22, 22, 20
23	57·6	7·3	29·934	60·6	54·3	67	29·967	62·8	55·1	62	50·1	68·6		4·2	0·5	23, 23, 29, 24, 20
24	57·6	6·9	29·903	63·5	56·2	64	29·848	59·0	54·4	75	45·5	71·2		0·9	0·0	18, 20, 20, 2, 6
26	62·6	7·7	29·738	64·8	59·9	76	29·738	68·7	57·9	52	41·5	72·5	·152	0·5	0·1	— 24, 28, 28, 24
27	60·1	8·6	29·796	65·2	58·6	68	29·719	63·6	57·9	72	45·4	70·0		2·8	0·9	21, 28, 16, 20, 20
28	57·0	9·9	29·658	60·0	56·1	79	29·680	60·6	55·2	72	55·3	65·5		3·2	1·2	22, 22, 22, 24, 24
29	61·3	6·3	29·793	63·2	59·2	79	29·785	69·0	58·8	55	51·8	71·6	·010	1·7	0·5	20, 22, 24, 22, 30
30	61·3	4·6	29·680	64·0	57·5	68	29·628	64·7	58·6	70	51·0	69·8		2·4	1·0	18, 20, 22, 20, 20
31	58·3	7·2	29·727	63·2	55·7	63	29·677	60·2	56·5	80	49·2	66·0		3·0	1·0	21, 20, 16, 19, 18
Aug. 2	57·0	8·4	29·663	60·1	56·7	82	29·653	62·6	54·1	59	50·6	67·4	·187	2·3	0·2	20, 22, 28, 26, 26
3	55·8	4·4	29·696	58·3	51·6	64	29·688	61·4	52·5	56	37·5	63·8		1·8	0·4	18, 24, 24, 24, 24
4	54·2	9·8	29·562	59·0	53·6	71	29·451	58·3	51·5	64	36·8	63·6		1·6	0·5	18, 20, 18, 16, 17
5	57·0	9·8	29·247	63·6	58·8	76	29·209	60·3	56·8	82	48·5	66·3	·184	1·2	0·4	22, 18, 19, 18, 20
6	58·6	6·7	29·373	61·6	58·0	81	29·443	64·3	58·2	70	46·3	67·2	·038	0·4	0·1	23, 4, 0, 4, 4
7	56·8	8·9	29·304	62·2	58·1	79	29·269	63·9	56·6	65	49·0	67·3	·016	1·7	0·6	20, 18, 25, 22, 21
9	52·9	9·4	29·465	55·9	51·0	72	29·486	56·4	53·0	81	47·7	63·0	·198	1·6	0·2	26, 0, 31, 6, 30
10	54·6	10·0	29·460	58·5	54·4	78	29·403	62·2	58·1	79	38·2	64·6		1·4	0·5	30, 14, 18, 16, 16
11	57·5	6·3	29·745	62·0	56·5	72	29·734	62·4	55·3	65	40·8	68·7		2·3	0·5	18, 18, 20, 17, 16
12	57·8	9·6	29·650	59·5	58·4	94	29·708	62·7	58·2	77	54·7	66·5	·230	1·1	0·5	18, 20, 19, 20, 20
13	58·6	3·4	30·022	61·1	55·3	70	30·074	64·3	57·5	67	43·0	67·9	·050	0·8	0·3	22, 26, 22, 0, —
14	56·8	1·9	30·212	59·8	55·2	75	30·175	66·9	59·5	65	35·8	70·0		0·5	0·1	26, — 6, 10, 20
16	54·6	5·2	30·084	58·5	53·6	73	30·002	63·4	58·5	75	35·1	66·0		0·2	0·0	21, 0, 2, 2, 0
17	54·1	7·8	30·008	60·5	56·3	77	30·020	58·5	56·2	87	38·6	65·2		0·9	0·3	— 0, 2, 0, 2
18	53·5	9·6	30·106	55·9	54·2	90	30·064	59·8	56·6	82	50·4	64·3		0·7	0·1	2, 2, 4, 4, 4
19	58·6	3·3	29·985	59·3	56·0	82	29·873	70·6	63·6	69	42·0	71·8		0·2	0·1	22, 18, 18, 24, 22
20	59·3	7·0	29·694	65·5	59·3	70	29·617	65·6	60·8	77	39·8	69·8		1·2	0·4	16, 20, 22, — 20
21	54·4	10·0	29·600	60·3	56·0	77	....	57·0	55·2	89	48·0	63·2		1·1	0·4	16, 20, 20, — 16
23	49·0	4·2	29·844	51·6	49·0	84	29·894	57·2	54·3	83	......	......	·132	0·7	0·3	30, 0, 30, 31, —
24	53·4	8·3	29·956	59·5	57·3	88	29·910	58·2	56·9	92	......	......		0·4	0·2	16, 22, 22, 20, 18
25	54·5	10·0	29·835	58·8	54·2	75	29·845	60·5	55·3	72	......	......		0·1	0·1	22, 20, — — 24
26	56·6	8·0	29·974	60·4	56·5	79	29·957	63·8	61·1	86	......	......		0·3	0·0	16, 22, 16, 20, —
27	51·5	8·7	29·967	66·7	62·1	78	29·940	65·9	61·8	80	......	......		1·2	0·5	18, 18, 20, 22, 20
28	59·0	5·5	30·036	63·2	62·7	97	29·963	67·6	59·3	62	......	......		0·3	0·0	16, 12, 26, 22, 24
30	54·6	8·8	29·693	58·8	55·3	81	29·605	59·5	55·3	78	......	......		0·9	0·5	18, 18, 24, 20, 22
31	55·4	6·8	29·727	59·0	53·5	71	29·686	60·8	53·5	63	......	......		0·6	0·2	21, 20, 20, 20, 22

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20ʰ, 23ʰ, 2ʰ, 5ʰ, 8ʰ.
	°			°	°			°	°		°	°				
Sept. 1	50·7	7·2	29·313	55·2	50·0	71	29·233	53·9	48·9	71				4·5	2·3	20, 20, 20, 24, 22
2	49·5	4·9	29·583	53·8	46·9	61	29·678	53·9	46·7	59	47·4	57·6	·070	5·2	2·1	27, 28, 30, 30, 30
3	47·3	9·3	29·551	53·7	49·6	76	29·519	51·3	46·3	70	......	57·8		0·6	0·1	16, 22, 18, 2, 24
4	44·8	5·1	29·618	49·6	44·3	67	29·611	50·1	45·4	71	32·8	54·9		2·1	0·6	28, 28, 28, 25, 20
6	47·0	8·9	29·631	49·3	45·0	73	29·658	52·9	47·0	66	40·8	56·1		1·6	0·3	28, 30, 30, 28, 20
7	49·3	9·9	29·610	55·4	51·4	77	29·526	55·0	51·8	81	26·8	60·4		1·4	0·2	— 20, 18, 18, 16
8	51·6	7·2	29·656	51·7	51·4	98	29·672	60·0	56·0	79	47·2	......	·088	0·5	0·1	31, 4, 7, — 18
9	55·8	10·0	29·604	60·4	57·7	85	29·634	61·7	59·0	86	47·0	63·2		2·9	1·2	20, 20, 20, 20, 20
10	50·8	4·0	29·810	54·4	49·3	70	29·830	56·3	49·2	61	48·0	61·2	·030	0·9	0·2	24, 24, 20, 25, 24
11	47·2	7·6	29·784	50·7	46·3	73	29·515	51·7	50·6	93	45·0	57·3		8·2	1·4	18, 21, 20, 18, 20
13	46·6	5·7	29·515	55·3	49·7	69	29·524	49·6	48·5	93	36·8	61·8		2·6	0·1	— 28, — 20, 20
14	45·7	5·1	29·542	51·0	47·1	76	29·544	50·2	47·5	82	34·0	57·2	·175	1·0	0·1	— — 26, 16, 20
15	46·1	8·3	29·553	51·3	47·9	79	29·409	50·1	46·6	78	32·3	57·8		2·1	0·4	20, 22, 18, 20, 16
16	47·8	6·8	28·591	50·7	49·4	92	28·733	49·2	48·0	92	42·3	58·6	·202	8·2	2·2	20, 20, 25, 26, 22
17	47·3	9·3	29·048	51·2	47·4	77	29·001	51·7	47·3	74	46·2	58·8		10·3	0·3	21, 22, 23, 26, 20
18	44·8	4·3	29·124	48·2	43·3	69	29·242	49·6	46·9	83	32·6	55·4	·279	2·4	0·5	22, 20, 28, 30, 20
20	42·5	3·8	29·362	45·3	42·7	82	29·513	48·3	43·2	68	32·0	52·8		2·9	0·6	21, 24, 24, 20, 18
21	46·6	7·6	29·761	50·5	46·0	72	29·691	51·8	47·5	74	35·2	58·4		0·8	0·3	22, 21, 18, 18, —
22	56·9	9·1	29·625	61·2	58·9	88	29·641	59·8	58·0	90	45·5	67·0	·330	1·6	0·5	21, 20, 22, 19, 18
23	53·2	8·4	29·401	59·1	56·5	86	29·503	55·4	50·8	76	52·8	61·2	·020	9·2	1·5	20, 20, 20, 22, 20
24	50·1	7·9	29·882	53·3	48·3	70	29·929	54·1	49·0	70	46·0	60·5		1·6	0·2	10, 26, — 18, 18
25	53·0	6·3	29·517	59·8	56·1	80	29·640	56·9	53·3	80	50·0	61·2	·173	5·0	1·0	20, 20, 23, 23, 1
27	42·3	0·3	30·093	44·2	41·6	81	30·044	55·1	48·3	61	25·0	56·8	·008	0·5	0·0	— 14, 14, 14, —
28	48·9	2·2	30·142	55·1	50·1	71	30·122	55·5	50·5	71	39·0	62·8		0·3	0·1	— 4, 12, 13, —
29	48·6	5·9	30·209	53·2	49·3	77	30·163	53·0	49·3	78	35·0	60·3		1·1	0·2	14, 16, 14, 12, —
30	47·6	8·1	30·187	52·3	47·9	73	30·127	51·6	47·3	74	32·2	55·3		1·0	0·3	4, 6, 5, 7, 4
Oct. 1	50·6	5·6	30·072	54·2	52·1	87	30·063	54·6	51·6	82	38·7	58·2		2·2	0·7	8, 4, 3, 3, —
2	46·8	10·0	30·062	48·0	45·9	86	30·017	48·8	47·4	91	45·7	51·0		1·6	0·5	2, 1, 0, 30, 0
4	43·4	9·9	29·918	45·7	44·0	88	29·831	45·0	44·1	93	†43·6	48·4		1·1	0·1	0, 30, 30, 0, 2
5	43·2	10·0	29·634	47·7	44·5	79	29·567	43·0	42·9	99	39·2	49·8		0·9	0·4	3, 2, 2, 2, 2
6	46·1	10·0	29·550	48·0	46·9	93	29·475	47·8	47·0	95	41·2	50·7	·348	2·4	1·2	10, 6, 8, 8, 8
7	48·2	9·2	29·234	51·6	50·6	94	29·260	50·9	49·5	91	46·2	53·2	·452	10·2	0·7	11, 10, 14, 18, 20
8	46·8	8·1	29·364	47·8	47·1	95	29·426	50·4	48·3	87	33·5	56·3	·300	0·3	0·1	4, 4, 14, 16, 18
9	47·1	5·1	29·665	48·8	47·5	92	29·597	50·8	48·3	84	37·5	55·9	·010	0·4	0·1	— 4, 16, 8, 12
11	55·9	5·8	29·616	59·3	57·1	88	29·624	58·3	56·2	89	54·3	62·8	·140	1·2	0·3	14, 14, 15, 12, 0
12	50·1	8·6	29·715	53·0	52·4	96	29·713	52·0	51·9	99	45·2	58·9	·010	0·4	0·1	— 2, 2, 2, 2
13	46·7	10·0	29·893	48·6	48·3	98	29·884	48·1	47·3	94	46·0	50·5	·038	0·6	0·2	2, 4, 4, 6, 8
14	43·2	9·5	29·780	45·4	43·3	85	29·720	44·6	42·8	87	42·0	49·1		0·4	0·1	10, 8, 6, 8, 8
15	46·5	9·9	29·764	49·7	47·3	84	29·762	49·2	46·9	85	39·8	53·3		0·5	0·1	4, 7, 8, 4, —
16	46·5	5·3	29·866	50·1	46·3	76	29·817	50·2	47·3	81	43·2	55·8	·015	0·1	0·0	— — 11, 4, 18
18	51·8	9·8	29·317	53·9	51·5	86	29·222	53·9	51·9	88	49·2	57·0		2·0	0·7	18, 22, 20, 20, 18
19	52·3	8·3	29·015	56·4	54·5	89	28·927	54·8	53·9	95	49·6	60·3		2·1	0·5	16, 17, 18, 16, 18
20	45·2	6·4	29·353	44·7	43·5	92	29·369	49·1	47·1	87	37·2	53·2	·150	2·2	0·5	20, 18, 20, 22, 18
21	43·6	4·0	29·406	43·6	42·6	93	29·548	45·5	43·1	84	34·0	50·0	·230	0·8	0·2	— 18, 20, 24, 20
22	50·8	9·8	29·496	52·6	51·3	92	29·356	52·0	50·5	91	36·2	55·5		8·9	2·9	20, 18, 20, 20, 18
23	44·4	7·7	29·208	49·7	47·7	87	29·176	44·2	42·3	87	44·0	49·8	·160	11·7	0·4	21, 20, 21, 20, 20
25	42·1	2·1	29·691	45·6	43·5	86	29·849	45·8	43·7	86	34·2	51·4	·065	1·7	0·2	20, 22, 24, 22, 24
26	45·0	9·7	30·012	42·8	42·1	94	29·922	51·3	49·9	91	28·9	52·9		1·2	0·3	28, 4, 18, 18, 18
27	50·2	4·4	29·813	55·3	54·2	93	29·933	51·0	49·2	89	48·8	57·2	·115	2·4	0·9	18, 18, 18, 18, 24
28	44·4	1·9	30·083	48·3	47·4	93	30·025	48·3	47·3	93	35·4	53·7		0·8	0·1	— 20, 20, 22, —
29	47·3	5·6	29·838	51·0	49·9	93	29·872	48·0	46·5	90	38·0	53·7		1·3	0·6	18, 20, 24, 24, 21
30	46·0	8·5	29·896	48·5	46·1	84	29·747	47·9	44·9	80	40·0	53·4		1·8	0·6	21, 18, 20, 20, —

* See Introduction for a description of the methods by which these means have been obtained.
† Spirits adjusted, a bubble being found near the top of tube.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20ʰ, 23ʰ, 2ʰ, 5ʰ, 8ʰ.
Nov. 1	° 51·9	9·0	29·853	° 55·2	° 53·3	88	29·796	° 53·6	° 50·2	80	° 45·7	° 58·0	·745	4·7	1·7	18, 19, 18, 16, 20
2	48·1	2·9	29·972	52·7	46·9	66	30·097	46·2	42·4	74	51·0	54·0		11·5	0·5	20, 24, 24, 18, 20
3	38·8	4·9	30·192	36·0	35·6	96	30·097	43·4	41·6	87	27·1	48·6		0·1	0·0	18, 24, 0, 24, 6
4	46·8	8·8	29·933	47·6	46·8	94	29·846	49·1	47·7	91	40·3	53·2		0·2	0·0	— — 18, 18, —
5	47·0	8·6	29·667	47·7	46·4	91	29·506	47·6	44·7	81	39·7	56·3		1·1	0·2	— — 6, 18, 16
6	52·4	8·4	29·600	54·0	51·5	85	29·538	53·0	51·2	89	43·9	56·9	·020	3·0	0·8	19, 20, 29, 19, 16
8	53·7	7·7	29·040	55·5	54·2	93	28·962	55·7	52·3	81	51·9	59·3	·210	11·4	1·4	17, 18, 16, 18, 16
9	46·3	2·6	29·424	49·8	46·0	76	29·724	47·4	43·3	73	45·4	50·9		10·7	1·0	19, 22, 28, 18, 20
10	50·2	9·8	29·732	52·0	48·1	76	29·631	51·6	48·7	82	34·0	53·9		11·0	4·0	18, 20, 20, 19, 18
11	42·6	9·9	29·852	44·3	44·0	97	29·851	43·0	42·7	98	42·0	45·1	·356	2·2	0·0	20, 20, — — 4
12	40·2	5·2	29·980	43·2	41·9	90	29·982	39·4	38·5	92	39·7	46·0	·240	1·5	0·2	2, 0, 0, 26, —
13	45·2	6·2	29·870	48·3	47·0	91	29·915	46·6	43·8	81	30·6	52·7		0·6	0·2	9, 18, 23, 18, 20
15	55·0	9·8	29·777	56·3	54·7	91	29·684	56·1	54·2	89	51·4	59·4	·088	3·2	1·1	20, 20, 18, 20, 20
16	39·4	1·0	29·872	42·9	39·1	72	29·849	40·1	35·9	68	36·8	45·0		3·6	0·5	22, 24, 24, 22, 18
17	36·0	1·6	29·994	37·3	35·4	84	30·130	36·6	33·1	71	33·0	40·9		5·6	1·8	28, 30, 29, 28, 28
18	36·0	5·8	30·193	33·0	30·1	76	30·100	38·0	35·3	78	26·9	41·9		0·9	0·1	22, 22, 24, 16, 18
19	44·7	7·6	30·040	46·1	44·2	87	30·006	46·3	44·6	88	37·0	50·1		2·5	0·5	20, 20, 20, 18, 18
20	44·7	8·6	29·894	46·6	44·3	84	29·757	45·9	43·6	84	38·9	48·1		1·5	0·4	19, 19, 18, 20, 18
22	41·2	10·0	29·271	42·0	40·3	88	29·123	41·9	39·0	79	40·0	45·0		4·3	0·7	20, 22, 17, 16, 16
23	39·0	2·2	29·184	40·7	38·3	82	29·244	37·9	36·9	92	36·0	44·8	·045	3·7	0·9	18, 18, 20, 20, 20
24	45·2	8·5	29·447	44·3	43·2	93	29·489	47·2	44·8	84	35·2	49·1	·472	3·0	0·9	22, 20, 18, 18, 18
25	50·5	10·0	29·449	50·1	48·0	87	29·280	53·0	51·2	89	39·0	55·0	·178	8·7	1·7	18, 16, 20, 20, 20
26	37·0	6·4	29·468	39·0	37·8	91	29·426	38·0	37·3	94	32·0	42·6	·138	1·6	0·1	20, 18, 22, 20, 26
27	30·6	10·0	29·207	31·4	31·4	100	29·147	31·3	31·4	100	26·2	34·8		0·1	0·0	— — — — —
29	36·5	2·9	28·998	37·5	36·3	90	29·166	35·4	33·9	88	29·3	41·9	·052	0·7	0·1	23, 25, 24, 20, 20
30	47·8	6·7	29·194	50·9	48·6	86	29·304	47·2	43·9	78	33·7	53·0		2·6	1·0	22, 20, 21, 24, 22
Dec. 1	42·2	6·1	29·796	41·8	36·9	64	29·802	42·0	39·5	81	32·0	45·6	·040	5·7	1·7	20, 22, 18, 20, 24
2	51·0	10·0	29·736	50·4	48·8	90	29·672	53·0	51·4	90	38·0	54·8		4·0	1·5	18, 20, 19, 18, 16
3	41·8	4·8	29·710	43·3	40·9	83	29·624	42·0	39·5	82	40·6	46·1		2·3	0·9	20, 20, 20, 20, 20
4	44·2	6·5	29·324	43·6	41·3	84	28·927	44·3	44·3	100	38·3	49·1	·024	8·5	2·0	20, 20, 19, 17, 20
6	36·8	8·4	28·242	38·0	37·3	95	28·061	38·4	38·1	98	30·5	39·7	·404	1·5	0·1	4, 2, 2, 2, 2
7	36·0	8·4	28·685	38·2	34·7	73	28·885	36·3	32·6	70	35·0	41·2	·342	9·5	2·4	31, 28, 30, 28, 28
8	29·9	2·9	29·212	31·0	29·4	89	29·278	30·5	29·9	95	26·2	35·3	·012	2·2	0·3	— 20, 21, 18, 22
9	48·8	8·6	28·831	50·9	49·7	93	28·850	52·8	50·9	88	26·0	54·8	·052	9·5	4·3	20, 20, 20, 18, 19
10	39·8	10·0	29·492	41·0	39·2	87	29·537	38·0	36·9	91	40·0	43·8		9·9	0·1	20, 16, 22, 20 —
11	37·5	6·5	29·256	40·2	40·3	100	29·409	35·0	34·3	94	34·2	42·6	·402	1·4	0·1	— 24, 19, 17, 18
13	45·5	6·8	29·620	47·2	45·5	89	29·655	45·2	44·0	92	40·0	50·8	·368	2·8	0·8	18, 18, 16, 15, 18
14	41·1	1·0	29·745	41·8	40·5	91	29·745	39·0	38·9	99	38·8	45·8		2·8	0·6	18, 22, 16, 14, 16
15	44·5	7·8	29·560	45·7	43·7	86	29·550	45·5	44·7	95	37·2	48·5		6·4	1·9	16, 14, 16, 14, 16
16	47·5	6·9	29·446	48·2	46·5	89	29·288	49·4	47·5	88	37·0	51·2		4·1	1·3	16, 16, 16, 16, 17
17	47·3	9·0	29·230	46·8	43·2	77	29·024	49·4	47·5	88	39·0	49·0	1·105 }	11·3	4·5	16, 18, 18, 14, 16
18	41·0	10·0	29·100	45·8	45·9	100	29·162	38·2	38·4	100	44·0	54·1	1·267 }	14·9	0·1	18, 28, 18, 18, 28
20	35·6	9·2	29·676	36·8	35·8	91	29·649	36·0	34·3	86	32·2	41·8		0·7	0·1	2, 8, 2, — —
21	34·8	9·9	29·524	36·5	34·3	82	29·466	35·5	33·3	82	30·2	38·0		0·6	0·2	8, 8, 12, 12, 4
22	32·4	10·0	29·666	33·3	32·0	89	29·775	32·8	32·0	92	32·0	34·2	·030	0·1	0·0	14, 2, 4, 2, —
23	33·7	10·0	29·667	33·4	33·3	99	29·532	35·0	33·9	91	31·3	37·1		0·2	0·0	0, 28, — — 12
24	33·3	10·0	29·843	33·2	32·1	90	29·947	34·4	33·6	93	27·0	35·5		0·8	0·0	2, 22, 28, — —
25	36·0	10·0	30·183	35·2	35·3	100	30·163	38·0	37·5	96	31·0	39·2		0·1	0·0	18, — 2, 20. —
27	27·5	5·8	30·115	28·8	28·4	96	30·088	27·1	27·4	100	23·8	40·5		0·5	0·0	— — 28, — —
28	27·1	3·3	30·126	27·3	26·7	94	30·053	26·1	26·9	100	24·2	31·8		0·1	0·0	— 22, 24, — —
29	33·0	10·0	29·680	34·7	33·0	85	29·448	32·0	30·5	87	22·2	36·2		2·7	1·0	16, 14, 14, 15, 17
30	33·1	7·4	29·578	35·1	32·9	81	29·687	31·8	31·3	96	31·2	37·2		1·9	0·0	24, 24, 20, — —
31	26·6	6·5	29·776	24·0	24·3	100	29·684	30·6	30·2	97	18·8	31·5		0·2	0·0	— 20, 22, — —

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Sky clouded.	11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Thermometer. Min.	Max.	Rain in Inches.	Force of Wind. Max.	Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23ʰ.	5ʰ.
Jan. 1	31·8	9·9	29·606	32·2	31·7	96	29·573	32·8	31·5	89	26·2	34·0		1·2	0·6	16,	14
3	48·9	9·7	29·379	48·8	47·1	89	20·334	50·5	47·5	81	34·0	51·6		9·2	1·4	18,	16
4	44·0	3·0	29·585	45·8	44·5	91	29·472	43·7	41·8	86	41·6	47·3		9·6	1·5	16,	16
5	38·0	9·7	29·204	39·2	38·5	95	29·185	38·3	37·9	97	37·0	40·3		10·0	0·7	16,	18
6	27·3	0·5	29·618	27·8	27·6	98	29·606	28·3	28·4	100	23·5	32·5		0·3	0·0	24,	16
7	33·6	8·9	29·189	33·8	33·5	98	29·226	34·7	34·3	97	26·0	32·5		2·3	0·0	—	20
8	28·0	6·2	29·453	26·9	27·2	100	29·603	30·6	30·9	100	25·5	32·2		0·1	0·0	—	0
10	29·5	9·4	30·045	29·8	29·2	95	29·991	30·7	……	……	22·0	32·9		1·0	0·3	22,	18
11	30·7	4·0	30·248	29·8	29·7	99	30·292	33·0	32·0	91	25·4	36·0		1·7	0·1	24,	18
12	41·8	5·9	30·153	43·0	41·5	89	30·163	42·0	40·9	92	28·2	46·2		1·2	0·2	21,	26
13	38·3	6·0	30·229	41·8	41·0	94	30·204	37·2	36·9	97	36·6	46·6		0·8	0·0	24,	18
14	38·3	8·5	29·975	39·0	38·7	97	29·752	39·1	38·4	94	28·6	42·6		0·8	0·2	16,	16
15	33·0	2·2	29·766	33·0	30·8	82	29·731	34·4	33·1	88	28·8	39·9		2·6	0·1	17,	24
17	31·6	10·0	29·139	33·7	33·4	97	29·136	31·0	30·3	94	31·9	35·6	·438	12·2	0·1	16,	22
18	27·0	0·8	29·141	26·9	26·6	97	29·102	28·5	27·4	90	25·0	33·7		0·5	0·1	16,	17
19	27·7	4·7	29·387	30·5	30·4	99	29·481	26·3	27·2	100	22·8	36·0		1·1	0·0	4,	18
20	23·8	0·5	29·741	23·4	23·5	100	29·818	25·6	25·2	97	17·0	30·0		0·1	0·0	24,	28
21	28·8	9·0	30·033	28·7	28·2	96	30·007	30·3	30·0	97	19·2	33·0		0·1	0·0	15,	16
22	30·3	9·2	29·889	31·5	31·1	97	29·808	30·6	30·5	99	21·8	33·0		0·5	0·6	14,	16
24	27·6	6·7	30·367	25·9	25·9	100	30·361	30·8	30·8	100	21·2	33·2		……	0·0	24,	2
25	22·7	1·7	30·384	21·7	22·0	100	30·311	25·1	25·4	100	18·2	30·1		……	0·0	22,	16
26	32·8	8·4	30·147	33·0	31·8	90	30·069	34·0	32·3	85	18·2	36·6		……	0·3	4,	8
27	32·2	7·0	30·081	34·2	34·3	100	30·076	31·7	31·4	97	28·2	36·2		……	0·5	10,	12
28	24·6	8·5	29·775	27·1	25·9	88	29·612	23·6	23·5	99	……	28·8		……	2·0	8,	10
29	18·8	9·5	29·735	9·9	10·0	100	29·548	29·1	28·4	93	1·0	30·0		……	0·3	20,	14
31	26·7	0·5	29·050	27·1	27·6	100	29·137	27·7	26·6	89	15·2	32·4	·520	0·1	……	10,	28
Feb. 1	34·0	4·7	29·465	34·2	34·1	99	29·527	37·9	36·5	88	18·2	40·4		……	0·6	22,	22
2	34·8	6·2	29·831	36·9	36·3	95	29·859	36·8	36·3	95	31·8	43·2		……	0·2	—	20
3	39·5	10·0	29·806	40·0	38·9	92	29·659	43·1	41·3	87	34·2	44·7		……	3·0	20,	20
4	44·8	10·0	29·540	46·5	45·6	93	29·529	47·2	47·0	98	42·0	50·0		14·2	2·0	22,	20
5	45·0	9·0	29·550	52·5	50·7	89	29·619	41·6	41·6	100	45·3	54·6	·042	2·9	1·0	20,	6
7	40·7	10·0	29·584	39·8	39·7	99	29·505	45·6	45·6	100	36·8	46·9	·828	0·4	0·0	30,	22
8	40·4	10·0	29·462	39·6	39·3	98	29·198	45·3	44·7	96	32·2	47·4	·176	2·0	0·7	—	18
9	41·8	9·7	28·438	45·0	44·3	95	28·316	42·6	42·0	96	42·5	52·0		2·3	0·1	24,	22
10	38·1	7·0	28·391	41·3	38·9	82	28·423	39·0	37·2	86	36·8	44·1	·540	3·0	1·1	18,	20
11	39·8	6·4	28·916	39·3	38·6	95	29·081	44·4	40·9	76	27·5	46·6		0·8	0·2	20,	22
12	40·3	9·4	29·378	39·5	38·3	91	29·173	45·2	44·2	93	31·0	46·2		8·8	3·9	18,	18
14	41·4	8·5	29·338	43·8	41·3	82	29·335	42·9	40·5	83	39·2	47·8	·186	8·5	2·0	18,	20
15	34·9	9·9	29·254	39·2	39·1	99	29·189	34·6	34·3	98	33·2	45·6		1·5	0·0	14,	18
16	35·2	10·0	29·513	37·5	34·9	79	29·698	36·9	35·9	91	31·6	39·0	·320	2·2	0·7	26,	30
17	32·7	4·6	30·195	32·6	31·8	93	30·221	36·9	35·1	85	27·2	37·3		1·2	0·1	28,	2
18	35·0	10·0	30·128	35·2	34·0	89	29·717	38·9	36·3	80	23·0	40·2		3·4	1·6	20,	18
19	41·9	8·5	29·309	44·6	41·9	81	29·205	43·3	40·9	83	34·8	46·3	·045	6·0	0·7	20,	18
21	35·7	9·0	29·466	37·5	34·3	74	29·343	38·0	36·3	86	29·8	42·3		1·6	0·3	25,	20
22	38·2	5·2	28·818	37·5	37·3	98	28·566	43·0	39·5	76	30·0	49·3	·196	4·5	1·6	16,	22
23	40·9	2·5	28·478	44·3	40·9	77	28·673	41·6	39·2	82	……	46·9	·130	8·2	2·7	24,	26
24	32·1	10·0	28·877	36·0	34·9	91	28·851	32·2	32·5	100	……	37·3		2·9	0·0	—	4
25	42·2	7·5	28·497	43·3	43·3	100	28·581	45·2	44·3	94	31·2	51·0	·810	1·7	0·4	19,	20
26	37·8	10·0	28·550	41·5	41·5	100	28·749	38·2	38·0	99	33·0	43·1	·070	1·3	0·6	4,	1
28	40·8	5·5	28·657	46·1	42·6	77	28·758	39·6	38·8	94	38·0	50·2	·302	5·7	1·1	22,	20
29	38·9	8·0	28·785	40·3	39·1	91	28·753	41·6	39·8	87	34·8	46·7	·135	3·0	0·6	18,	18

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.	
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	23h,	5h.
Mar. 1	36·0	10·0	28·563	40·0	38·9	90	28·639	38·7	37·9	94	32·2	42·0		1·7	0·6	1,	0
2	36·1	10·0	29·068	39·9	38·3	88	29·304	39·0	37·9	91	35·0	41·0		3·1	0·6	31,	31
3	36·0	2·5	29·803	39·3	36·6	79	29·830	39·3	36·4	77	34·1	43·0	·107	1·7	0·3	30,	28
4	36·9	10·0	29·854	38·2	36·3	84	29·750	42·3	39·5	80	24·5	46·7		0·6	0·0	20,	18
6	35·1	10·0	29·663	37·9	37·6	98	29·581	39·0	38·3	95	32·3	42·0		0·4	0·0	4,	12
7	37·9	10·0	29·723	39·8	39·3	96	29·820	42·6	40·9	87	35·8	46·2		0·4	0·1	15,	20
8	42·5	5·5	29·768	42·8	41·1	87	29·825	48·9	44·4	71	34·8	52·4	·485	4·4	1·1	20,	20
9	46·3	7·0	29·611	49·8	47·1	83	29·534	49·4	47·5	87	39·0	54·0		1·3	0·5	18,	19
10	37·3	3·0	28·996	38·8	38·6	99	29·001	42·4	40·7	88	30·0	47·4	·149	2·3	0·2	18,	20
11	35·2	10·0	28·326	41·5	39·9	88	28·286	35·6	35·8	100	31·8	43·0	·273	2·8	0·8	24,	26
13	37·4	4·0	29·179	39·7	39·3	97	29·300	41·7	37·0	66	32·0	43·7	·460	3·9	1·3	30,	1
14	38·9	9·4	29·606	40·5	38·3	83	29·640	43·9	39·0	66	23·8	47·3		1·2	0·3	16,	20
15	41·1	5·7	29·350	43·6	40·3	77	29·253	45·3	43·0	84	33·3	48·3		3·3	0·9	20,	17
16	38·8	10·0	29·536	43·8	40·7	78	29·529	40·5	39·2	90	32·0	46·3		3·8	1·2	2,	2
17	35·4	10·0	29·396	38·2	38·0	98	29·420	39·2	38·3	93	35·0	40·0		4·5	2·5	2,	2
18	37·3	8·0	29·338	41·0	39·3	88	29·196	40·2	39·0	91	36·0	45·7	·618	3·4	0·0	2,	12
20	37·0	8·5	28·632	39·7	37·5	83	28·601	40·9	37·5	75	38·8	46·2	·100	1·5	0·3	18,	16
21	33·9	10·0	28·832	35·3	35·0	98	28·944	39·2	37·5	87	26·0	44·6		0·2	0·0	—	12
22	38·7	9·5	29·294	39·5	36·9	80	29·249	44·6	40·2	70	25·6	49·3		1·0	0·5	22,	16
23	45·0	10·0	29·078	49·0	46·7	85	29·211	47·6	45·5	87	38·3	52·6	·528	2·5	0·8	20,	24
24	44·7	1·0	29·781	46·8	41·6	66	29·878	49·2	43·8	66	40·4	50·9		1·3	0·7	0,	1
25	43·0	9·7	29·947	43·7	41·1	81	29·824	49·0	45·0	74	35·3	52·5		0·4	0·0	—	12
27	40·1	5·5	29·542	40·3	39·4	93	29·500	46·5	42·7	75	27·8	49·1	·420	0·5	0·1	6,	7
28	40·8	9·8	29·429	43·1	43·0	99	29·518	45·2	43·5	88	40·5	48·4	·210	2·1	0·3	4,	17
29	42·7	7·0	29·603	44·0	42·1	86	29·518	48·1	42·3	63	32·5	53·0		1·4	0·4	16,	18
30	50·0	7·0	29·466	51·0	46·8	75	29·483	55·6	49·9	68	30·8	57·7		1·7	0·8	16,	22
31	47·7	3·1	29·735	51·0	46·0	70	29·750	51·0	48·1	82	40·2	53·3		0·4	0·2	20,	2
April 1	49·2	4·5	29·794	50·8	44·5	62	29·763	57·2	50·4	63	30·2	58·2		1·5	0·7	20,	18
3	56·4	5·5	29·718	59·6	55·0	76	29·672	62·9	56·9	70	47·0	65·6		2·0	0·4	20,	20
4	48·3	8·5	29·726	53·6	47·5	64	29·658	52·7	49·7	82	45·0	......		3·6	2·1	20,	18
5	40·3	9·9	29·573	47·0	42·9	73	29·479	43·1	40·5	81	42·0	50·8	·005	4·6	1·0	25,	24
6	36·8	9·5	29·520	42·0	39·5	82	29·508	41·2	37·7	74	27·0	48·4		1·5	0·4	31,	0
7	34·6	7·5	29·429	38·2	35·0	75	29·320	40·6	36·5	70	26·0	47·6		1·1	0·1	0,	10
8	36·6	7·4	29·446	40·6	35·3	61	29·468	42·3	37·1	63	30·8	45·1	·084	2·2	1·1	4,	2
10	36·8	6·0	29·202	42·3	37·6	67	29·168	40·9	36·9	71	24·3	47·8		1·7	0·8	10,	8
11	38·1	6·5	29·447	39·0	36·3	79	29·426	46·8	38·3	46	24·5	50·3		1·3	0·2	24,	24
12	37·6	10·0	29·178	42·8	40·1	80	29·200	42·1	40·1	86	26·0	47·3		0·4	0·1	8,	4
13	41·3	6·0	29·427	43·2	37·3	59	29·421	49·0	40·5	48	29·8	51·0		0·7	0·2	30,	28
14	39·4	7·0	29·620	44·4	38·9	62	29·744	44·1	38·5	61	28·2	49·3		1·9	0·4	30,	1
15	40·7	9·9	29·732	46·0	41·1	67	29·658	45·1	40·9	71	21·5	49·7		1·3	0·6	14,	12
17	47·0	7·5	29·246	52·5	49·1	80	29·241	51·2	47·3	76	45·2	57·7		1·5	0·4	20,	20
18	47·2	9·9	29·284	52·0	47·1	71	29·175	52·1	46·6	68	39·0	57·6		1·5	0·6	6,	12
19	40·5	10·0	29·096	44·5	44·3	99	29·084	46·2	45·3	94	43·5	49·1	·372	1·8	0·2	4,	4
20	42·4	7·5	29·322	43·8	43·6	99	29·369	50·6	46·2	73	39·8	54·0	·065	0·7	0·3	8,	4
21	41·1	10·0	29·435	46·0	45·3	95	29·486	45·9	44·8	92	40·8	48·0		0·9	0·3	2,	2
22	41·1	10·0	29·567	46·3	46·0	98	29·596	45·5	44·8	95	42·7	49·8	·100	1·7	0·7	2,	2
24	41·2	8·0	29·762	46·0	41·8	72	29·751	46·1	41·9	72	40·8	50·0		2·2	0·5	3,	2
25	41·2	9·9	29·707	47·4	43·7	75	29·695	44·7	41·3	76	39·2	48·7		1·0	0·3	31,	4
26	37·1	6·5	29·704	42·3	37·8	67	29·684	41·6	39·2	82	31·8	46·3	·064	2·1	0·3	30,	0
27	41·4	8·2	29·550	43·8	38·5	64	29·424	48·7	42·0	58	27·2	50·5		3·0	1·0	20,	20
28	38·7	9·9	29·300	41·0	38·5	81	29·379	46·0	41·6	71	31·2	47·6	·248	2·1	0·4	26,	30
29	40·2	4·0	29·663	44·7	40·3	70	29·692	45·4	40·3	66	30·0	49·0	·090	2·4	0·7	23,	26

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.	
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	23h,	5h.
May 1	50·6	1·6	29·955	50·2	44·3	63	29·878	59·2	50·3	54	29·0	60·8		0·4	0·0	17,	20
2	51·9	7·5	29·885	53·4	47·3	64	29·833	58·6	51·1	60	31·0	62·0		0·6	0·2	18,	20
3	58·8	3·5	29·815	61·0	54·5	66	29·789	64·9	57·1	62	38·2	66·8		1·1	0·7	20,	20
4	62·6	0·7	29·912	64·5	59·4	74	29·895	69·0	57·8	51	38·0	70·0		0·8	0·3	17,	20
5	63·4	6·9	29·922	67·1	58·2	59	29·861	67·9	58·8	59	39·2	71·8		1·5	0·4	18,	18
6	53·2	1·5	29·876	54·7	49·0	67	29·810	59·9	53·0	66	43·2	62·7		1·0	0·5	26,	20
8	51·4	4·5	29·692	53·7	49·6	76	29·795	57·4	50·8	64	46·5	60·8	·040	3·5	0·8	20,	24
9	55·5	8·0	30·011	56·8	50·7	66	29·947	62·4	54·7	61	34·7	67·6		1·4	0·5	24,	20
10	59·7	2·7	30·021	60·3	55·2	73	30·011	67·4	58·6	59	36·0	69·6		1·1	0·4	22,	28
11	60·9	5·2	30·001	65·4	57·8	63	29·932	64·7	58·2	68	37·3	70·3		3·1	1·1	21,	18
12	57·3	9·9	29·878	60·0	56·4	80	29·897	62·8	58·2	76	51·7	66·2		1·4	0·8	20,	21
13	65·4	4·0	29·941	67·1	59·3	63	29·885	72·0	63·1	61	45·0	76·6		0·7	0·7	19,	20
15	57·1	10·0	29·604	64·0	59·9	80	29·447	58·5	55·7	84	34·8	64·7		1·9	1·3	22,	22
16	54·6	7·5	29·165	56·1	54·1	89	29·162	61·4	56·2	73	50·6	64·1		3·8	1·3	20,	20
17	54·4	8·4	29·088	56·9	54·9	89	29·057	60·2	53·6	66	47·1	66·8	·032	1·1	0·2	—	20
18	51·4	7·5	28·984	58·4	54·2	77	29·085	52·6	48·1	74	45·0	62·1	·053	2·1	1·0	20,	24
19	52·2	8·5	29·376	58·6	53·0	70	29·390	54·1	52·9	93	36·0	64·6		2·2	0·8	16,	12
20	54·1	9·9	29·671	59·1	55·2	79	29·789	57·4	54·2	82	44 0	63·0		1·1	0·2	26,	0
22	57·0	6·5	30·114	58·5	55·2	82	30·084	63·7	59·0	76	40·2	72·3	·030	0·7	0·2	4,	0
23	63·7	6·5	30·118	68·7	59·6	59	30·092	66·9	59·7	66	46·2	74·0		0·5	0·0	—	8
24	60·3	8·7	30·070	68·0	62·2	73	30·053	60·8	59·1	90	46·8	71·9		0·9	0·0	12,	18
25	54·7	8·5	30·071	58·8	56·2	86	29·973	58·9	56·5	86	41·8	66·5	·095	0·6	0·3	4,	4
26	49·8	10·0	29·913	54·1	52·7	91	29·874	53·8	53·2	96	45·2	60·9		0·5	0·1	2,	4
27	58·2	5·5	29·905	57·7	55·2	86	29·865	66·9	61·2	72	49·3	70·9		0·3	0·1	18,	8
29	55·8	10·0	29·731	62·8	63·1	100	29·710	57·0	56·0	94	46·0	66·5		0·6	0·0	4,	22
30	51·2	8·5	29·841	55·9	52·1	78	29·850	54·7	54·0	95	42·5	64·8		0·5	0·1	—	28
31	50·3	9·7	29·509	54·4	53·2	92	29·388	54·4	52·0	86	41·0	57·9	·040	2·1	0·5	18,	18
June 1	48·4	10·0	29·375	54·2	49·5	73	29·291	51·2	49·3	88	44·2	58·0	·060	3·2	0·6	26,	20
2	48·1	10·0	29·040	53·0	51·9	93	29·023	51·8	49·8	88	46·3	60·4	·296	0·5	0·1	20,	2
3	51·0	8·5	29·046	55·1	51·8	81	29·041	55·5	52·0	80	39·8	57·9	·100	1·8	0·4	2,	8
5	54·0	8·5	29·312	59·3	53·7	70	29·338	57·2	51·9	71	37·0	65·5	·387	0·4	0·2	22,	20
6	53·0	8·9	29·424	59·4	51·5	59	29·416	55·2	49·5	68	38·2	61·0		1·1	0·9	20,	20
7	49·3	9·0	29·393	54·2	50·3	78	29·404	53·1	48·7	74	45·0	60·7	·015	2·7	0·4	20,	24
8	51·4	9·9	29·406	56·9	50·3	64	29·393	54·6	50·0	74	40·2	63·9		1·0	0·3	19,	21
9	51·7	10·0	29·436	55·1	51·7	80	29·412	56·9	52·1	73	36·0	60·4	·191	1·3	0·4	18,	18
10	50·5	9·9	29·322	54·3	49·3	71	29·368	55·3	50·9	75	45·0	62·8	·145	0·7	0·2	30,	4
12	52·6	6·5	29·570	56·8	53·0	79	29·525	57·0	54·7	87	35·3	61·6	·355	0·6	0·3	2,	2
13	49·1	10·0	29·183	51·0	51·3	100	29·095	55·8	55·2	96	47·2	58·6	·590	0·6	0·3	2,	20
14	52·2	8·4	29·441	55·9	49·5	65	29·537	57·1	49·4	59	45·0	61·0	·270	4·8	1·8	20,	17
15	61·8	6·7	29·661	65·9	59·0	67	29·703	66·2	56·3	54	47·2	71·7	·024	2·1	0·4	15,	12
16	57·4	9·7	29·769	61·9	57·9	79	29·730	61·5	58·8	85	63·0	67·7		0·7	0·3	3,	4
17	52·9	10·0	29·598	58·5	56·4	88	29·649	55·9	56·0	100	52·0	60·4		0·4	0·2	5,	4
19	52·6	6·0	29·961	57·4	54·2	82	29·959	56·5	54·0	86	46·2	66·0	·618	1·0	0·2	12,	8
20	59·4	0·5	29·958	59·2	54·5	74	29·884	68·2	61·9	70	42·0	70·8		0·4	0·1	12,	4
21	66·0	4·0	29·826	69·8	62·3	66	29·797	70·8	64·4	71	47·0	75·4		0·6	0·2	10,	4
22	61·2	9·9	29·792	70·8	62·1	62	29·748	60·3	59·6	96	55·0	75·2		0·5	0·1	12,	2
23	52·5	9·9	29·706	58·6	55·2	81	29·635	55·0	51·6	80	50·2	63·0	·048	1·5	0·8	8,	6
24	52·3	9·5	29·384	57·9	52·6	71	29·325	55·1	54·4	96	60·7	62·7		1·6	0·8	6,	2
26	54·9	5·5	29·771	56·4	51·6	73	29·707	62·0	56·9	74	36·2	66·0		0·4	0·1	10,	2
27	56·1	9·7	29·408	59·1	56·4	85	29·287	61·8	58·0	81	50·5	67·0	·190	2·5	1·0	14,	22
28	57·8	7·0	29·289	60·8	55·8	74	29·321	63·4	56·4	66	52·8	66·7		3·5	1·8	22,	24
29	53·6	9·9	29·260	59·8	56·4	82	29·273	56·0	53·6	86	51·2	68·7		2·4	0·6	24,	30
30	48·6	9·9	29·228	56·9	53·3	80	29·252	49·0	48·0	94	47·3	62·1	·112	1·3	0·4	8,	4

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h,	5h.
July 1	48°·4	7·0	29·424	53°·8	46°·5	59	29·437	51°·0	47°·3	77	44°·0	59°·8	·495	1·3	0·3	30,	22
3	54·1	5·5	29·449	55·9	50·0	67	29·469	60·3	51·2	54	39·8	63·0	·175	1·7	0·5	28,	26
4	54·2	5·5	29·681	56·2	49·5	63	29·773	60·3	52·0	57	37·0	63·6		1·7	0·9	27,	26
5	58·9	5·0	29·932	59·8	53·3	66	29·892	66·0	55·2	50	37·0	69·4		1·2	0·3	12,	22
6	59·5	10·0	29·776	64·0	60·3	81	29·774	63·0	59·6	82	49·0	68·8		1·2	0·3	22,	21
7	60·9	8·5	29·510	66·1	61·9	80	29·434	63·8	60·9	85	48·8	77·0		1·2	0·5	20,	20
8	54·4	9·0	29·449	56·4	52·9	80	29·474	60·4	54·9	71	50·2	65·5	·112	2·6	1·3	19,	20
10	56·0	8·7	29·886	62·3	56·4	70	30·024	57·8	53·3	75	46·0	66·1		0·6	0·3	0,	6
11	65·4	9·9	30·151	69·2	63·1	72	30·146	69·6	64·0	74	48·2	76·3		0·4	0·3	18,	22
12	70·4	4·2	30·236	72·2	64·4	66	30·223	76·6	67·1	61	51·2	78·8		0·7	0·5	20,	20
13	70·2	7·0	30·243	72·9	65·3	67	30·160	75·6	68·6	70	50·5	82·0		0·3	0·2	24,	28
14	56·0	9·9	30·150	62·0	57·7	78	30·117	58·0	54·9	83	53·0	68·3		0·5	0·2	6,	4
15	61·6	6·5	30·096	64·4	58·4	70	30·029	66·9	58·2	59	48·7	71·9		0·3	0·0	—	2
17	57·1	9·0	29·922	60·5	55·5	74	29·871	61·8	56·1	70	57·0	65·1		1·4	0·6	20,	24
18	57·2	8·9	29·725	61·0	55·2	70	29·618	61·4	56·8	76	48·0	65·2		1·5	0·4	24,	26
19	57·0	10·0	29·141	59·8	57·9	90	29·001	62·2	59·7	87	50·1	67·0	·275	2·5	1·0	22,	18
20	57·4	8·7	28·794	60·8	57·2	81	28·718	62·1	59·1	85	51·2	67·0	·253	2·5	1·3	19,	18
21	51·4	7·0	29·233	55·4	50·8	74	29·255	55·4	52·1	81	40·3	63·5	·040	4·3	1·4	20,	20
22	56·5	9·9	29·376	61·5	57·6	80	29·392	59·5	55·2	77	42·8	65·8	·085	2·1	0·8	20,	18
24	56·3	9·5	29·482	60·3	54·3	69	29·476	60·3	55·7	76	40·2	65·5	·022	2·4	0·9	23,	20
25	56·4	8·5	29·271	62·1	58·0	79	29·218	58·8	53·9	74	47·9	67·6		1·9	0·4	18,	22
26	57·1	7·0	29·332	60·6	54·2	67	29·292	61·6	55·3	68	44·0	68·9	·112	1·1	0·7	20,	18
27	54·9	5·5	29·240	58·4	52·5	69	29·344	59·4	53·0	66	48·8	64·0		5·1	2·7	20,	24
28	57·1	9·9	29·683	60·0	54·5	71	29·741	62·2	54·6	62	45·0	65·9		3·6	0·4	26,	22
29	56·6	6·2	29·860	59·0	54·4	75	29·802	62·2	57·6	76	36·0	66·8		0·8	0·3	12,	4
31	57·7	3·5	29·186	62·1	56·4	71	29·148	61·4	56·0	73	51·2	67·8	·220	1·8	0·3	20,	18
Aug. 1	56·0	9·9	29·063	62·6	51·4	47	29·137	59·3	56·7	86	41·0	......		0·6	0·1	—	24
2	55·0	9·2	29·485	60·0	55·2	75	29·533	59·8	52·2	61	46·0	64·0	·125	2·0	0·7	26,	21
3	52·5	6·2	29·485	57·5	51·2	66	29·437	57·3	52·2	72	37·2	65·0	·026	1·2	0·4	20,	20
4	52·4	7·5	29·387	56·6	52·3	76	29·360	58·0	53·1	73	33·2	67·1	·292	0·7	0·2	6,	20
5	53·9	6·4	29·223	57·7	53·1	75	29·123	59·9	55·0	74	33·6	67·0	·443	0·5	0·2	4,	8
7	54·7	4·2	29·558	58·5	52·5	68	29·598	60·8	56·0	75	......	64·2	·180	1·2	0·6	26,	20
8	53·0	9·9	29·620	62·3	56·4	70	29·586	53·5	52·3	92	37·2	66·0	·086	1·8	0·2	22,	16
9	51·4	9·9	29·530	58·8	54·2	75	29·549	53·9	52·3	90	40·9	63·2	·010 ·162	0·3	0·2	5,	6
10	51·5	9·9	29·669	59·5	54·0	71	29·689	53·4	52·8	96	39·0	64·4	·270	0·4	0·0	25,	0
11	52·3	9·5	29·803	56·6	51·7	72	29·798	57·8	52·9	73	41·5	63·8		0·2	0·0	2,	10
12	55·6	3·2	29·780	57·7	52·5	71	29·734	63·4	55·7	63	38·0	67·3	·010	0·4	0·2	12,	26
14	49·6	3·0	29·824	54·2	48·3	66	29·756	54·8	48·3	63	26·8	58·0		1·4	0·6	8,	7
15	51·0	9·9	29·793	56·6	50·2	65	29·780	55·9	49·4	64	33·1	61·1		0·9	0·4	6,	8
16	53·3	9·9	29·687	58·7	53·1	70	29·656	57·8	53·8	78	38·0	64·2		0·5	0·1	6,	12
17	52·8	8·0	29·432	55·9	54·4	91	29·496	59·5	51·3	58	48·8	63·4	·110	1·4	0·3	20,	25
18	53·8	6·5	29·769	57·9	52·5	70	29·653	59·5	54·1	71	36·2	67·6		1·0	0·3	19,	10
19	53·1	6·0	29·209	58·2	53·5	75	29·274	57·8	52·5	72	48·2	63·2	·356	4·9	1·8	20,	21
21	47·0	10·0	29·232	54·4	51·1	81	29·052	49·5	48·9	96	39·2	59·0	·050	2·2	0·3	10,	3
22	47·6	9·9	29·156	51·4	50·5	94	29·157	53·7	51·0	84	44·2	57·0	·488	0·6	0·1	28,	26
23	47·8	7·5	29·384	48·5	47·0	90	29·435	57·0	51·3	69	40·8	59·0	·085	0·5	0·2	2,	24
24	51·1	6·2	29·621	56·1	51·8	76	29·668	56·0	51·9	77	35·0	60·0	·116	1·8	0·1	25,	18
25	52·4	4·0	29·762	55·4	51·3	77	29·714	59·3	53·2	68	29·2	63·8		0·6	0·2	16,	18
26	54·8	10·0	29·406	56·9	55·2	90	29·294	62·5	60·8	91	43·8	64·7	·095	1·2	0·7	16,	18
28	55·8	6·0	29·326	60·6	56·8	80	29·421	60·8	54·7	69	46·0	64·0	·287	3·1	1·4	20,	21
29	54·7	5·7	29·558	59·8	54·2	70	29·532	59·4	53·5	69	47·2	63·7	·010	4·3	1·4	18,	20
30	53·7	6·0	29·658	57·4	53·1	76	29·680	59·8	53·7	68	41·7	63·0	·022	3·2	1·0	22,	20
31	50·6	6·0	29·911	55·1	51·3	78	29·906	55·9	49·6	64	37·0	62·6		0·8	0·0	7,	4

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum, Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Thermometers. Min.	Thermometers. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h,	5h.
Sept. 1	° 52·2	9·9	29·926	° 57·1	° 53·1	77	29·918	° 57·4	° 54·2	82	° 31·2	° 63·3		0·8	0·5	24,	21
2	55·9	6·0	30·035	61·5	56·2	73	30·040	60·4	54·8	70	45·1	64·6		1·6	0·6	22,	22
4	57·5	0·6	29·821	59·6	54·4	72	29·755	65·5	56·9	59	46·7	66·7		1·6	0·7	20,	18
5	61·4	7·0	29·478	63·1	57·9	74	29·409	69·7	62·8	69	37·0	73·8		0·6	0·2	18,	16
6	54·4	9·0	29·334	59·5	56·0	81	29·453	59·3	54·8	76	49·0	64·2	·126	3·8	2·2	18,	20
7	52·8	10·0	29·577	57·3	55·2	88	29·601	58·3	55·2	83	52·2	......		2·9	1·5	20,	20
8	52·7	7·0	29·415	58·5	56·5	89	29·331	56·9	52·2	74	52·8	63·1	·038	2·5	2·0	18,	18
9	51·0	8·4	29·433	54·1	50·1	77	29·380	58·0	53·6	76	45·0	59·9	·035	3·0	1·2	20,	18
11	45·3	4·0	29·816	49·7	44·5	68	29·899	51·0	44·1	58	32·0	54·9	·015	2·3	0·8	30,	30
12	44·6	4·0	30·084	47·0	41·6	64	30·093	52·3	45·3	59	31·0	55·0		0·9	0·1	30,	28
13	47·0	10·0	30·038	50·0	45·8	73	29·910	54·0	48·7	69	33·6	57·9		1·4	0·5	18,	20
14	50·7	5·5	30·005	55·7	48·8	61	30·031	55·8	50·0	67	37·3	59·4		1·2	0·2	28,	30
15	51·2	1·1	30·143	53·7	51·1	84	30·088	58·8	54·4	76	28·7	61·5		1·1	0·2	21,	18
16	56·4	9·0	30·081	61·8	59·1	86	30·062	61·1	56·5	76	51·2	67·0		2·1	0·4	19,	17
18	48·5	4·7	30·072	50·6	47·3	79	29·959	56·4	50·3	66	31·0	61·0		0·9	0·0	—	20
19	51·8	1·2	29·613	53·7	49·9	78	29·460	60·0	54·2	70	30·2	62·6		1·6	0·4	18,	18
20	52·0	8·0	29·384	60·2	53·6	66	29·429	53·9	53·3	96	42·0	66·1		1·4	0·7	18,	20
21	50·3	1·5	29·627	53·2	51·1	87	29·609	57·5	51·5	68	34·8	62·6	·215	0·5	0·2	6,	8
22	53·0	9·7	29·629	57·2	54·6	85	29·633	58·8	56·9	89	43·0	65·0		0·4	0·1	2,	4
23	51·7	2·5	29·505	55·9	54·9	94	29·377	57·6	54·5	83	44·2	65·4		0·9	0·2	6,	12
25	47·7	9·9	29·421	52·2	51·9	98	29·418	53·2	50·3	82	49·1	56·0	·415	4·7	0·6	6,	4
26	49·9	9·7	29·558	55·4	52·9	85	29·597	54·5	51·8	84	49·0	59·4		0·6	0·3	5,	4
27	46·4	10·0	29·691	51·2	49·0	86	29·698	51·6	48·0	78	48·2	54·0		0·8	0·4	2,	2
28	44·8	10·0	29·812	50·0	50·1	100	29·843	49·6	47·8	88	48·2	52·6		2·6	1·6	2,	2
29	47·0	10·0	29·666	50·3	48·6	89	29·596	53·8	52·6	92	44·8	54·8	·113	2·3	0·4	1,	2
30	48·7	10·0	29·540	53·8	52·8	94	29·438	53·7	53·7	100	50·0	55·0	·225	0·6	0·3	2,	2
Oct. 2	51·8	9·9	29·402	53·8	51·7	87	29·360	55·1	51·7	80	42·5	61·0	·240	0·7	0·0	2,	14
3	53·2	1·7	29·397	56·1	51·8	76	29·417	55·5	50·7	73	46·2	61·8	·083	0·5	0·5	16,	16
4	54·9	10·0	29·251	59·1	58·6	97	29·377	56·0	53·5	86	46·0	64·1		2·7	0·8	18,	20
5	57·5	9·9	29·642	60·8	58·2	86	29·661	59·5	59·2	98	51·0	64·0	·416	1·4	0·5	20,	20
6	56·7	5·0	29·638	60·0	56·0	79	29·789	58·6	53·0	70	53·8	63·0		4·8	2·2	22,	20
7	56·0	4·2	29·819	55·4	53·3	88	29·800	61·9	58·9	84	39·8	65·4		0·4	0·1	—	22
9	51·7	9·8	29·502	55·0	50·5	75	29·345	53·6	50·7	83	45·6	57·3	·045	2·3	0·6	18,	22
10	49·3	5·7	29·428	52·5	49·5	82	29·586	51·4	48·6	83	42·0	55·4		3·4	1·1	30,	0
11	47·5	9·4	29·772	50·7	46·7	75	29·772	49·5	45·7	76	44·0	53·5	·075	1·1	0·2	0	30
12	45·9	10·0	29·837	48·0	45·8	85	29·773	49·0	46·3	82	38·0	53·6		0·4	0·1	4,	4
13	45·8	5·5	30·100	51·0	47·9	81	30·122	45·8	44·8	92	35·8	53·9	·176	0·7	0·2	8,	4
14	46·5	5·7	30·141	50·2	45·3	69	30·095	48·0	44·1	74	41·0	54·0		1·4	0·7	2,	1
16	43·3	10·0	29·748	46·4	44·5	87	29·731	45·4	42·5	80	43·8	49·4	·596	1·4	0·5	4,	1
17	36·2	4·5	29·850	41·0	36·3	65	29·807	36·6	32·3	66	36·5	42·7	·134	3·5	1·5	31,	0
18	32·1	6·0	29·673	33·8	32·5	89	29·663	35·6	32·6	75	30·0	39·4	·190	4·2	1·6	0,	0
19	35·0	5·0	29·744	39·0	38·0	92	29·772	36·2	34·5	85	30·0	43·0	·284	3·9	0·1	7,	0
20	35·1	4·5	29·895	33·7	31·8	84	29·862	41·7	38·6	76	22·0	43·6		0·3	0·0	16,	8
21	40·6	8·4	29·747	40·7	39·1	88	29·678	45·8	44·1	88	27·2	50·0	·056	0·2	0·0	16,	8
23	43·2	5·0	29·278	45·2	43·3	87	29·260	46·4	44·5	87	34·2	52·0		1·5	0·1	20,	14
24	44·9	5·0	28·961	48·0	44·8	79	29·093	47·0	44·9	86	37·1	52·0	·580	2·4	0·4	20,	20
25	40·3	9·7	29·131	41·0	40·4	96	29·171	44·8	42·9	87	31·0	48·3		0·4	0·1	17,	26
26	44·1	8·5	29·510	45·7	44·3	90	29·526	47·7	45·3	84	30·1	53·2		1·0	0·1	17,	16
27	47·5	10·0	29·213	50·3	48·3	87	28·985	50·0	49·6	98	34·0	53·8	·105	2·2	0·6	14,	2
28	45·5	6·0	29·006	49·0	45·8	80	29·017	47·1	43·5	77	35·0	52·5	·122	1·7	0·4	16,	16
30	37·5	9·0	29·301	37·3	37·6	100	29·388	42·9	42·6	98	29·6	44·4		0·2	0·0	19,	6
31	37·9	10·0	29·414	41·3	41·3	100	29·424	39·7	39·4	98	39·5	42·8	·470	1·2	0·5	1,	2

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Thermometer. Min.	Max	Rain in Inches.	Force of Wind. Max.	Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h,	5h.
Nov. 1	39·5°	9·9	29·393	40·0°	39·3°	95	29·345	41·0°	37·4	74	38·0°	46·2°	·580	0·7	0·2	25,	20
2	42·5	7·9	29·465	43·5	40·9	81	29·419	43·6	40·8	80	31·7	49·6		0·4	0·2	24,	22
3	34·6	10·0	29·358	36·2	35·8	97	29·455	35·0	33·9	91	29·8	40·0	1·060	3·0	1·8	0,	0
4	30·7	5·5	29·499	31·0	30·7	97	29·511	32·4	32·3	99	27·2	36·4	·015	2·6	0·5	30,	2
6	43·1	4·5	29·208	45·8	41·9	74	29·090	42·5	38·9	74	35·0	49·2		1·9	0·8	20,	24
7	36·4	4·0	29·326	37·3	35·3	84	29·482	37·6	33·7	69	32·7	44·0		1·7	0·5	28,	30
8	34·7	9·2	29·877	36·2	33·1	74	29·870	35·2	31·9	74	28·0	38·1		0·6	0·2	30,	28
9	35·3	8·5	30·204	36·7	34·3	79	30·215	36·0	33·2	76	26·8	40·2		0·9	0·1	28,	30
10	38·1	7·5	30·248	37·8	36·5	89	30·283	40·4	38·9	88	24·2	45·0		0·4	0·0	24,	28
11	41·5	10·0	30·322	42·0	40·0	85	30·302	43·0	40·6	82	31·4	45·2		0·6	0·2	1,	30
13	39·4	8·5	30·263	37·2	35·3	84	30·154	43·6	41·4	84	22·0	44·4		0·7	0·1	23,	20
14	37·6	5·5	30·160	38·3	35·6	78	30·151	38·9	34·9	69	32·6	43·7		1·3	0·1	28,	24
15	35·6	5·0	30·258	36·2	35·6	95	30·161	37·0	34·9	82	28·6	41·8		0·4	0·1	20,	22
16	43·8	9·0	29·935	46·8	44·1	82	29·956	42·9	41·9	92	33·4	50·0		0·6	0·4	24,	4
17	44·3	5·0	29·513	47·2	42·5	69	29·393	43·5	39·9	75	34·0	49·1		2·9	1·1	28,	20
18	40·1	8·5	29·093	43·8	41·5	84	29·107	38·5	36·4	84	......	45·2	·075	4·2	0·3	20,	20
20	49·8	10·0	29·002	50·8	49·3	91	28·755	50·8	48·9	89	34·0	52·0		10·2	6·8	20,	18
21	42·0	5·5	29·094	44·8	41·5	78	29·204	41·2	40·5	94	39·8	46·2	·248	9·7	1·9	19,	20
22	42·9	10·0	28·914	41·2	41·4	100	28·773	46·7	46·0	95	36·0	47·8	·452	1·1	0·4	4,	14
23	35·6	3·7	28·907	35·8	35·9	100	28·967	37·5	37·5	100	29·5	46·0	·153	1·9	0·1	28,	—
24	34·6	0·2	29·488	36·2	33·9	81	29·637	35·0	32·8	81	29·8	40·2		0·6	0·0	22,	—
25	38·8	10·0	29·687	38·8	36·5	82	29·475	40·8	40·0	94	24·8	41·2	·052	1·5	0·4	16,	16
27	46·0	5·7	29·487	47·2	44·4	82	29·645	46·8	43·5	78	42·0	50·0	·092	3·1	0·2	22,	24
28	48·2	8·2	29·443	47·7	47·5	98	29·289	50·7	48·3	85	41·6	54·2		3·9	2·4	20,	18
29	45·2	8·0	29·417	46·3	43·6	82	29·362	46·2	42·8	77	43·0	48·8		8·0	1·1	20,	20
30	39·2	8·0	29·462	40·8	38·3	81	29·473	39·7	36·8	78	37·2	42·8		2·2	0·6	25,	20
Dec. 1	41·5	6·5	29·307	36·0	35·4	95	29·017	48·2	46·7	90	31·4	42·0		1·7	0·4	16,	14
2	36·6	7·2	28·707	37·7	35·8	85	28·833	36·7	34·3	80	31·2	39·2	·058	5·2	1·6	20,	—
4	40·9	7·5	28·672	44·6	43·1	90	28·593	38·5	37·3	91	34·8	46·0	·280	3·2	0·2	18,	16
5	36·3	4·8	28·508	38·1	36·4	86	28·690	35·7	34·0	86	33·9	39·8	·285	4·3	0·3	28,	23
6	34·4	9·2	28·821	35·0	34·3	94	28·775	35·0	34·5	96	28·5	39·0		1·0	0·3	22,	4
7	33·1	9·5	29·191	33·3	32·4	92	29·276	34·2	33·5	94	27·9	36·8		0·5	0·0	26,	24
8	46·0	9·4	29·272	47·6	46·9	95	29·435	45·6	43·5	86	25·5	50·6	·360	3·2	0·8	18,	20
9	51·5	10·0	29·600	51·6	50·6	93	29·607	52·7	51·1	90	43·1	54·5	·223	5·5	1·2	18,	20
11	48·9	5·7	29·642	50·9	48·3	84	29·704	48·2	46·5	89	46·1	53·0	·015	4·5	0·8	20,	20
12	46·3	10·0	29·783	44·4	43·7	95	29·642	49·5	49·5	100	38·8	52·0		1·7	0·2	18,	18
13	50·5	6·0	29·477	50·9	50·7	99	29·507	51·2	49·1	87	49·0	54·6	·247	4·5	1·0	18,	18
14	46·8	6·2	29·380	49·3	46·2	80	29·249	45·5	43·9	89	47·0	50·2		2·3	1·0	17,	16
15	47·5	8·0	29·355	44·2	42·3	87	28·910	52·0	48·6	80	45·8	53·0		6·8	1·7	13,	18
16	37·3	5·5	29·490	38·8	36·8	84	29·637	37·0	35·3	86	34·9	41·8	·130	11·6	0·4	18,	15
18	36·2	6·5	29·520	36·0	34·6	88	29·469	37·7	36·6	91	34·0	39·2		2·8	0·4	16,	16
19	39·6	8·0	29·726	39·2	39·3	100	29·846	41·3	39·8	89	36·2	43·8		0·9	0·0	18,	16
20	37·6	9·9	30·116	39·8	38·6	90	30·160	36·7	35·0	85	37·8	40·5	·029	1·4	0·6	15,	14
21	27·8	0·2	30·240	29·1	28·5	95	30·212	27·8	27·8	100	25·9	31·5		1·2	0·0	—	—
22	21·6	0·0	30·310	20·6	20·6	100	30·316	23·8	24·3	100	16·0	29·0		1·8	......	—	—
23	34·8	9·4	30·325	34·9	33·3	86	30·242	36·0	34·3	85	19·5	38·2		†	......	14,	12
25	39·8	9·9	29·714	40·7	38·9	86	29·759	40·2	38·9	90	33·4	42·5		2·0	0·4	11,	12
26	45·1	6·5	29·496	44·5	43·4	92	29·344	47·0	46·3	95	38·6	48·5		6·3	2·9	16,	16
27	41·1	3·1	29·654	44·7	41·9	80	29·802	38·7	36·7	83	44·0	45·5		4·5	1·0	21,	18
28	26·6	0·1	29·996	27·4	27·3	99	30·014	27·0	27·3	100	22·1	31·9		0·5	0·0	16,	—
29	28·4	6·2	30·073	27·0	26·8	98	30·050	31·0	31·0	100	19·1	32·0		0·0	0·0	—	28‡
30	33·1	10·0	30·014	33·6	32·5	90	29·974	33·8	32·3	86	25·0	35·2		0·2	0·0	4,	6

* See Introduction for a description of the methods by which these means have been obtained.
† Anemometer frozen. ‡ Found by observing smoke.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. =100.	5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. =100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23ʰ,	5ʰ.
Jan. 1	31°·8	9·8	30·091	32°·2	32°·1	99	30·097	32°·8	31°·3	87	29°·9	35°·8		0·4	0·0	‡24,	10
2	22·8	2·0	29·964	25·8	26·1	100	29·795	21·2	20·7	94	19·9	27·0		1·8	0·6	16,	15
3	14·1	0·0	29·668	13·3	13·4	100	29·635	16·3	16·6	100	8·2	20·8		†	......	‡20,	—
4	28·6	9·9	29·717	28·4	28·4	100	29·702	30·3	30·6	100	11·0	32·4		†	......	20,	4
5	31·8	9·7	29·739	32·5	32·7	100	29·772	32·6	31·7	93	23·0	36·2		†	......	4,	31
6	28·2	8·0	29·850	25·9	25·7	98	29·779	32·0	32·1	100	18·2	34·8		†	......	—	20
8	34·8	10·0	29·315	35·2	34·5	94	29·281	35·8	35·5	97	26·2	37·2		†	0·1	17,	17
9	35·9	1·0	29·231	38·0	36·9	91	29·208	35·2	34·5	94	32·4	41·2		†	0·1	22,	20
10	38·9	10·0	28·313	41·0	40·5	96	28·488	38·2	37·0	91	30·7	46·0		†	0·2	18,	28
11	31·3	10·0	29·349	32·0	31·9	99	29·668	32·0	31·3	94	31·6	34·0	·690	†	0·2	2,	—
12	33·5	10·2	29·618	34·7	33·7	91	29·333	33·8	34·1	100	26·0	40·0		†	0·8	20,	18
13	42·7	7·5	29·258	42·3	41·4	94	29·187	44·5	43·3	92	37·2	45·8	·053	0·5	0·6	20,	18
15	42·2	9·7	29·446	42·2	40·1	84	29·451	43·6	40·3	77	33·3	46·0		3·0	1·1	20,	20
16	41·0	9·9	29·543	42·4	40·9	89	29·406	41·0	40·1	93	37·9	45·2		3·3	0·4	22,	20
17	42·1	8·5	29·225	45·0	41·8	78	29·464	40·6	37·5	77	37·8	45·8	·144	2·6	0·2	26,	20
18	47·2	10·0	29·221	48·4	46·0	85	29·225	47·5	46·8	95	32·0	50·2		8·0	5·9	20,	18
19	43·1	9·0	29·528	43·8	41·3	82	29·584	43·8	41·1	81	38·4	48·0		3·8	0·3	19,	18
20	33·1	5·5	29·936	30·6	30·4	98	29·906	37·0	36·9	99	25·8	37·2	·072	0·4	0·1	20,	18
22	43·9	8·0	29·402	41·0	38·0	77	29·487	48·3	46·8	90	33·5	44·5	·628	7·4	2·3	23,	20
23	48·8	6·5	29·684	50·0	47·2	82	29·787	49·0	45·5	77	34·9	51·9		8·9	4·8	26,	20
24	48·9	9·9	29·624	50·0	46·8	80	29·519	49·2	46·9	85	47·2	52·0		7·3	2·9	20,	22,
25	46·7	10·0	29·368	48·8	47·8	93	29·334	46·1	44·2	88	46·8	51·7		6·7	1·4	20,	20
26	36·8	6·0	29·231	37·3	36·9	97	29·222	37·8	37·8	100	34·2	41·5	·342	4·7	2·5	20,	20
27	34·9	10·0	29·568	33·8	33·6	98	29·378	37·5	36·7	93	28·8	39·3	·084	3·5	0·0	20,	14
29	34·0	6·0	29·768	35·5	31·3	67	29·846	33·9	31·9	82	30·5	38·3	·700	4·5	0·2	1,	6
30	39·3	9·7	29·546	35·4	34·3	91	29·347	44·6	43·6	93	27·0	47·2		2·8	0·7	18,	24
31	38·1	1·1	29·795	39·7	36·3	74	29·893	38·0	35·5	80	32·1	43·0	·062	2·3	0·4	20,	18
Feb. 1	30·2	9·7	29·928	29·6	29·4	98	29·967	34·9	34·0	92	24·0	37·4		0·3	0·0	—	—
2	43·0	9·7	29·962	44·0	43·1	93	29·924	46·0	45·3	95	34·0	48·8		1·6	0·6	20,	22
3	45·1	10·0	29·950	47·3	46·5	94	29·943	47·0	46·0	93	44·3	50·7	·010	2·3	0·5	21,	18
5	45·5	10·0	30·102	46·6	44·3	84	30·094	48·5	46·5	87	43·8	52·1		1·8	0·3	18,	20
6	42·8	9·7	30·090	45·7	43·1	82	30·042	44·0	42·3	88	40·6	46·7		2·4	0·7	22,	20
7	43·7	9·7	29·980	45·8	43·5	84	29·842	45·5	42·5	79	40·0	49·0		2·3	0·7	24,	20
8	40·2	2·7	29·580	44·2	43·3	94	29·680	40·2	37·1	76	42·5	45·8		6·5	0·4	24,	22
9	40·5	9·0	30·000	42·3	40·6	87	29·776	42·7	41·3	89	32·2	45·1		3·8	1·5	20,	20
10	43·9	5·1	29·821	47·2	42·5	69	29·973	44·7	41·2	75	42·0	49·8	·130	7·2	0·8	20,	18
12	37·0	8·2	30·443	38·8	37·6	90	30·321	39·2	36·9	82	30·1	43·9		1·4	0·4	20,	18
13	43·4	7·9	30·172	45·7	43·4	84	30·238	45·1	40·8	70	35·8	50·1		2·7	0·7	18,	24
14	41·2	9·7	30·213	41·0	38·6	81	30·009	45·5	42·4	78	31·2	49·7		5·5	2·0	20,	20
15	47·0	4·5	30·120	50·3	47·0	79	30·174	47·7	44·5	79	44·7	52·6		5·2	2·4	24,	20
16	40·7	5·0	30·153	42·2	40·1	84	30·088	43·2	41·0	84	38·0	46·7		2·6	1·3	20,	18
17	39·7	6·0	30·233	41·2	39·1	84	30·092	42·3	40·3	85	36·8	49·4		4·8	1·3	16,	20
19	46·8	7·9	29·284	51·0	47·1	76	29·338	46·7	42·7	74	43·8	53·0		10·0	4·3	20,	26
20	38·0	9·7	29·417	40·0	38·3	87	29·280	40·1	38·3	86	34·4	47·3		4·8	0·6	22,	24
21	35·2	9·7	29·640	37·4	35·3	83	29·421	37·1	36·9	98	28·6	42·6		1·8	0·2	20,	18
22	41·3	6·9	29·165	44·5	40·3	71	29·166	42·2	38·3	72	36·0	45·6		6·5	2·3	26,	28
23	37·5	8·5	29·610	38·2	36·0	82	29·556	40·9	30·7	31	28·2	44·9		3·5	0·2	19,	22
24	32·4	2·1	29·293	31·7	32·0	100	29·333	37·2	34·6	79	29·8	41·8	·585	2·0	0·6	22,	18
26	33·1	0·6	29·496	33·8	32·1	85	29·579	36·4	32·7	70	25·0	38·9		0·9	0·2	28,	30
27	33·0	8·5	29·760	31·8	32·1	100	29·671	38·3	35·4	77	19·8	43·3		1·1	0·2	20,	19
28	35·1	6·0	29·847	37·2	37·3	100	29·809	37·0	32·7	65	31·3	42·0		4·8	1·8	20,	20

* See Introduction for a description of the methods by which these means have been obtained.

† Anemometer frozen. ‡ Found by observing smoke.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10^h 10^m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4^h 10^m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.	
	Tem. of Air.	Sky Clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	23^h,	5^h.
Mar. 1	36°·1	6·5	29·411	39°·2	34°·8	66	29·469	39°·7	37°·9	86	31°·8	44°·2	·580	6·8	0·5	26,	20
2	42·4	6·7	29·610	45·4	41·7	74	29·707	46·0	42·3	75	37·6	50·4		3·9	1·6	20,	20
3	43·9	5·0	30·017	47·8	43·1	69	30·015	46·6	42·8	74	40·4	51·2		3·0	1·4	20,	22
5	42·3	9·6	30·077	46·2	41·9	71	30·160	45·1	39·4	61	41·5	49·9		3·7	1·0	23,	24
6	41·8	7·7	30·129	46·2	42·6	75	29·819	44·0	41·5	82	35·7	47·4		5·3	3·4	20,	20
7	38·6	6·5	29·411	42·0	39·3	81	29·424	41·9	37·0	65	41·0	49·3		8·9	1·4	24,	22
8	30·8	1·5	29·657	34·8	31·1	71	29·616	33·4	31·5	84	25·8	......		3·1	0·7	30,	28
9	30·7	9·7	29·714	33·6	31·1	78	29·780	34·5	31·8	78	24·8	37·7		5·3	2·7	28,	30
10	35·0	5·0	30·130	35·3	31·5	70	30·083	41·4	37·0	67	23·8	43·0	·160	4·6	0·4	26,	26
12	47·9	5·9	29·748	50·8	47·0	77	29·875	51·7	47·2	73	42·0	53·8		4·6	0·3	24,	24
13	36·3	10·0	29·917	39·7	39·3	97	30·041	39·6	36·9	79	39·0	42·8		2·2	0·2	3,	4
14	45·1	10·0	29·982	46·0	43·0	79	29·983	50·9	48·4	84	36·0	53·9		0·4	0·0	24,	24
15	51·7	9·8	30·056	56·1	52·5	79	30·053	53·9	49·8	76	44·5	59·1		0·7	0·1	24,	24
16	48·3	2·0	30·111	47·7	44·6	79	30·065	55·5	49·9	68	30·0	56·3		0·3	0·0	—	18
17	44·7	7·5	30·059	49·5	46·1	78	30·005	46·5	44·2	84	30·7	54·4	·017	1·0	0·1	20,	18
19	43·8	5·5	29·789	41·2	40·8	97	29·736	53·1	48·9	75	32·8	53·6		0·1	0·0	16,	—
20	45·6	10·0	29·918	47·8	45·1	82	29·929	50·0	46·3	77	29·8	54·5		0·4	0·1	20,	18
21	48·9	9·9	30·055	50·7	47·5	80	30·011	53·7	47·7	65	33·0	59·2		0·3	0·0	—	—
22	39·0	10·0	29·986	42·7	42·0	94	29·933	42·0	41·5	96	28·8	49·0		9·3	0·0	20,	4
23	36·1	10·0	29·962	39·2	38·8	97	29·907	39·7	38·5	90	34·0	42·8		0·2	0·0	8,	2
24	35·3	10·0	29·888	39·3	37·3	84	29·888	38·0	34·9	75	34·8	45·4	·020	0·3	0·1	8,	12
26	41·5	5·1	29·768	43·8	39·5	70	29·692	45·8	40·3	63	35·2	49·5	·027	0·4	0·0	28,	—
27	36·9	9·0	29·287	41·2	36·5	66	29·248	39·2	37·3	85	30·0	46·6		1·3	0·5	12,	12
28	34·6	10·0	29·344	38·3	38·3	100	29·388	37·4	36·9	96	35·8	40·2		3·0	2·0	4,	4
29	32·3	10·0	29·301	37·0	36·3	94	29·183	34·3	33·9	97	32·8	39·1		2·3	0·6	4,	3
30	39·7	8·7	29·135	44·0	41·8	85	29·126	42·1	40·0	85	31·8	46·0	·690	1·5	0·6	10,	8
31	43·6	9·9	29·254	43·8	42·1	88	29·232	50·0	46·0	75	36·6	56·6	·015	1·6	0·4	16,	16
April 2	44·6	4·0	29·169	49·2	44·5	70	29·176	49·7	45·2	72	40·0	54·4	·130	1·8	0·3	16,	12
3	40·1	10·0	29·361	44·3	44·1	99	29·379	45·6	44·2	90	40·8	47·5		1·0	0·2	8,	12
4	39·3	10·0	29·408	42·2	41·1	91	29·353	46·1	43·3	82	35·2	51·1		0·7	0·4	2,	10
5	37·3	10·0	29·368	42·2	40·3	86	29·318	42·0	41·2	94	33·2	43·3		1·7	0·5	7,	6
6	47·5	2·5	29·283	50·8	44·5	62	29·250	53·9	46·1	56	37·2	57·1	·070	1·7	1·2	14,	14
7	39·4	10·0	29·303	47·2	45·5	89	29·353	41·3	40·4	93	40·2	47·7	·095	2·0	1·0	8,	6
9	33·1	10·0	29·594	38·8	37·6	90	29·643	37·0	35·4	87	37·5	42·0	1·050	2·6	0·7	4,	4
10	35·5	9·9	29·686	41·0	37·1	71	29·710	39·7	36·8	77	34·0	43·1		1·9	1·0	4,	3
11	35·2	8·5	29·652	38·5	36·8	86	29·655	41·6	37·0	66	32·0	44·2		2·3	0·8	2,	2
12	38·2	10·0	29·434	44·2	39·3	67	29·213	41·9	39·3	81	32·0	47·6		3·0	0·9	20,	20
13	38·3	8·0	29·027	43·0	39·5	76	29·017	43·3	40·2	78	25·0	49·1	·120	1·7	0·1	18,	4
14	36·6	10·0	29·242	41·4	41·4	100	29·376	41·4	39·9	89	31·2	43·4	·548	4·1	1·9	6,	6
16	35·6	9·9	29·475	47·8	42·8	68	29·478	33·0	32·3	94	29·8	51·4		3·2	0·7	26,	2
17	27·5	7·5	29·538	32·7	28·8	68	29·543	32·0	31·3	94	22·0	35·2		3·9	1·6	28,	30
18	33·3	10·0	29·594	37·2	33·6	71	29·366	39·0	35·2	71	27·2	43·6		5·1	0·1	28,	18
19	32·8	9·0	29·411	36·3	33·5	77	29·447	38·9	36·4	80	29·8	44·8	·295	3·0	1·0	0,	2
20	33·5	8·0	29·597	37·7	34·1	74	29·615	39·0	34·9	69	29·7	42·0		3·0	1·3	0,	27
21	35·7	5·0	29·658	39·0	34·5	65	29·510	42·1	37·4	67	19·8	48·8		0·4	0·1	12,	8
23	39·8	10·0	29·399	44·5	43·1	90	29·419	44·8	42·4	83	34·5	51·7	·150	0·0	0·0	24,	6
24	44·4	8·5	29·457	47·8	44·5	78	29·411	50·7	45·0	66	37·2	55·1		0·8	0·2	20,	18
25	45·7	6·7	29·398	49·3	44·8	72	29·407	41·7	......	......	36·8	53·5		1·7	0·8	23,	20
26	43·3	6·5	29·425	51·0	45·1	65	29·432	45·2	42·6	82	35·7	54·4	·022	1·9	1·6	20,	22
27	46·5	9·0	29·406	50·3	45·6	71	29·287	42·3	......	......	32·5	56·4		2·4	1·0	18,	16
28	48·1	5·5	29·387	51·2	45·3	65	29·477	54·7	48·2	63	35·9	58·8		2·5	0·2	20,	20
30	56·0	1·9	30·066	60·6	53·3	62	30·047	61·1	53·2	60	45·8	64·9		1·7	1·2	16,	12

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.	
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	23h,	5h.
May 1	° 44·9	6·0	30·088	° 45·0	° 44·0	92	29·986	° 53·0	° 49·3	78	° 29·0	° 53·9		1·7	0·4	12,	2
2	44·9	10·0	29·889	48·3	45·3	80	29·858	49·7	47·7	86	38·0	55·0	·025	0·3	0·2	6,	6
3	48·9	1·0	29·882	52·2	49·5	83	29·858	53·8	47·3	62	41·0	48·0		1·5	0·5	7,	4
4	52·6	3·0	29·847	56·9	51·8	71	29·809	56·5	51·3	71	31·2	61·0		1·4	0·7	2,	5
5	41·6	8·5	29·845	45·5	42·3	78	29·822	46·0	42·1	73	40·2	50·0		1·7	1·1	0,	2
7	43·6	8·0	29·960	48·0	46·5	90	29·975	47·5	43·3	72	35·2	51·9		1·9	0·5	6,	2
8	42·2	1·5	30·043	44·8	44·3	96	29·997	47·9	41·1	56	37·3	......		1·4	0·6	3,	6
9	42·4	8·4	29·870	46·2	41·6	69	29·824	46·9	41·3	63	38·8	50·6	·035	0·9	0·4	0,	4
10	......	....	....	......	......	......	....	......	......	......	34·1	50·0		......	......	—	—
11	41·9	10·0	29·803	45·0	40·8	71	29·842	47·0	40·6	58	39·5	51·5		0·8	0·2	5,	2
12	47·1	9·5	29·983	50·8	44·0	58	29·932	51·6	45·6	64	40·2	59·1	·005	0·3	0·2	28,	8
14	47·3	10·0	29·350	50·2	50·3	100	29·222	52·6	51·2	92	46·2	57·6	·958	0·9	0·0	3,	4
15	46·8	10·0	29·235	50·2	48·9	92	29·264	51·7	50·0	90	45·7	54·1	·160	0·0	0·0	2,	7
16	49·6	10·0	29·130	54·5	50·9	79	29·062	52·9	52·1	95	42·5	56·4	·188	0·6	0·1	12,	8
17	51·7	8·5	28·914	55·7	54·1	91	28·913	55·9	53·4	86	42·8	59·6	·190	0·3	0·0	—	4
18	51·2	9·0	29·129	55·9	51·3	75	29·304	54·8	49·0	67	44·8	61·8	·087	0·8	0·1	—	29
19	46·3	9·7	29·721	51·0	44·0	58	29·762	49·8	44·7	68	38·8	56·4		1·0	0·1	0,	6
21	59·6	8·4	29·554	61·6	56·2	72	29·528	65·8	56·2	56	43·0	68·1	·818	0·7	0·4	18,	16
22	......	....	....	......	......	......	....	......	......	......	47·6	62·0		......	......	—	—
23	54·5	8·0	29·636	56·2	50·4	68	29·696	61·0	53·3	61	47·0	63·6	·278	2·2	0·7	21,	24
24	58·5	10·0	29·868	62·8	55·2	62	29·764	62·4	53·3	55	38·5	67·5		1·6	0·9	18,	18
25	53·9	6·0	29·616	56·7	52·1	75	29·624	59·4	52·1	62	47·0	63·6		2·0	0·5	18,	22
26	53·6	7·4	29·572	54·6	52·0	85	29·649	60·9	52·0	55	47·0	63·7	·040	1·8	0·2	20,	22
28	58·8	3·2	30·038	59·6	52·3	62	30·020	66·3	57·3	58	35·0	69·0		1·2	0·2	10,	12
29	57·1	8·5	29·974	60·0	51·8	57	29·883	62·4	53·6	56	......	68·3		0·9	0·5	21,	20
30	55·9	3·7	29·874	58·2	51·6	64	29·868	61·8	55·4	67	49·1	64·9		1·0	0·4	18,	19
31	56·7	6·5	29·718	59·5	53·7	69	29·602	62·2	55·3	66	39·6	65·5		1·0	0·3	23,	20
June 1	53·5	2·0	29·726	56·8	47·5	50	29·783	58·9	52·0	63	47·5	64·0	·047	2·6	1·2	21,	20
2	53·4	9·4	29·810	60·5	52·7	60	29·861	55·5	50·9	74	46·0	63·2		2·0	0·9	18,	18
4	62·4	2·6	29·878	64·3	56·4	61	29·775	69·2	55·9	43	38·2	71·5		1·2	0·4	18,	22
5	52·6	10·0	29·696	63·6	56·4	65	29·607	50·2	49·5	95	46·2	73·1		0·6	0·0	6,	4
6	55·2	2·2	29·906	56·6	49·5	61	29·926	62·4	52·1	50	43·3	65·2		0·7	0·3	26,	25
7	56·4	0·0	29·972	57·7	49·5	56	29·911	63·8	53·5	51	33·6	64·9	·200	1·1	0·2	29,	22
8	45·5	6·0	29·901	46·0	45·0	93	29·856	53·7	48·1	67	37·0	56·4		0·5	0·2	3,	3
9	50·3	4·0	29·725	52·3	45·8	62	29·600	56·9	48·8	57	30·5	60·3		0·6	0·5	2,	30
11	45·7	9·9	29·662	53·0	46·6	63	29·632	47·0	45·3	88	34·0	58·7		2·6	0·1	24,	0
12	46·4	3·5	29·674	48·0	41·3	57	29·673	53·5	45·2	53	35·7	57·8		0·4	0·1	28,	29
13	50·9	6·0	29·877	51·4	44·1	56	29·854	59·0	49·6	51	36·5	62·6	·495	0·4	0·0	28,	24
14	52·1	2·1	29·873	54·6	46·1	52	29·837	58·2	50·3	58	33·1	64·0		0·4	0·0	24,	28
15	51·6	10·0	29·790	56·9	50·9	67	29·735	54·9	52·3	84	35·2	62·6		0·4	0·1	8,	28
16	53·4	9·0	29·681	60·0	55·2	75	29·666	55·4	51·1	76	35·3	66·5	·773	0·9	0·0	—	10
18	53·4	10·0	29·737	59·6	52·3	62	29·678	55·8	51·2	74	44·4	62·1		1·1	0·5	20,	20
19	49·7	10·0	29·274	54·8	53·3	91	29·424	53·2	50·1	81	46·8	60·9		2·7	0·6	22,	30
20	50·5	5·0	29·836	53·7	47·4	63	29·776	56·0	50·4	69	32·7	62·4	·272	2·7	0·7	22,	18
21	53·4	6·0	29·665	55·9	49·6	65	29·712	59·6	52·9	65	49·5	60·7		3·4	1·6	22,	24
22	50·2	10·0	29·825	57·1	50·6	64	29·701	52·0	50·8	92	45·2	61·7		2·7	0·5	20,	22
23	55·1	7·4	29·552	58·1	52·1	68	29·553	60·7	51·6	54	49·0	62·1	·200	2·7	0·8	24,	22
25	57·4	10·0	29·661	62·5	57·5	75	29·595	61·0	57·0	79	43·9	72·6		0·4	0·0	18,	20
26	57·5	7·0	29·596	62·1	56·2	70	29·628	61·6	55·9	71	49·8	66·7		1·7	0·7	24,	20
27	53·2	6·7	29·581	56·4	49·7	63	29·545	58·7	52·1	65	50·8	61·9		3·0	1·5	26,	22
28	51·9	5·7	29·786	53·7	48·1	68	29·830	58·8	51·0	59	45·7	63·0		3·0	0·1	—	6
29	50·9	10·0	29·776	59·4	53·9	70	29·725	51·1	50·1	94	36·5	67·2	·247	0·4	0·0	27,	6
30	52·9	5·9	29·922	53·0	46·6	62	29·907	61·5	54·1	62	39·8	62·1	·192	0·3	0·0	3,	22

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h.	5h.
July 2	53·8°	7·0	29·605	57·3°	51·8°	70	29·632	58·4°	51·6°	64	46·2°	63·2°		2·3	0·7	24,	22
3	54·3	8·5	29·080	57·2	54·9	87	29·122	59·4	54·1	72	49·9	63·4	·332	3·2	1·1	20,	21
4	50·3	9·0	29·326	56·0	50·4	69	29·363	52·7	51·0	89	46·3	63·0		3·4	0·1	26,	10
5	53·9	8·0	29·560	58·0	51·1	63	29·609	57·9	52·7	72	40·7	63·3	·160	1·7	0·1	26,	26
6	54·9	10·0	29·676	58·0	53·3	74	29·646	59·8	57·7	89	42·6	66·6		5·0	1·2	18,	18
7	58·1	9·0	29·619	59·8	58·8	94	29·593	64·5	60·7	81	55·4	72·4	·120	2·7	0·8	19,	19
9	57·5	5·0	29·979	59·5	52·0	61	30·034	63·5	54·2	55	45·4	65·2	·080	2·5	0·4	22,	24
10	63·3	6·0	30·098	65·1	57·8	65	30·072	69·6	61·6	64	48·5	73·9		0·8	0·6	20,	22
11	65·0	8·2	30·154	69·0	62·1	68	30·121	69·0	62·4	70	51·7	77·4		0·9	0·0	18,	2
12	57·0	5·2	30·202	59·6	57·1	86	30·170	62·5	57·2	73	44·5	67·1		0·5	0·2	4,	6
13	56·2	4·5	30·134	60·3	56·8	81	30·095	60·1	56·5	81	50·7	63·2		0·5	0·2	4,	6
14	56·9	0·5	30·069	57·4	54·3	82	30·008	64·4	58·2	69	50·0	67·2		0·6	0·1	6,	8
16	64·9	3·5	29·887	65·2	59·5	72	29·724	72·6	62·1	56	40·0	74·5		0·6	0·1	14,	23
17	57·7	7·5	29·482	60·6	54·0	66	29·494	62·8	53·4	55	52·3	66·7	·210	1·8	1·0	28,	24
18	48·9	10·0	29·337	52·8	51·3	91	29·232	53·0	52·6	97	45·3	64·5	·122	0·9	0·0	18,	10
19	55·3	7·5	29·212	59·2	52·7	66	29·229	59·4	53·6	69	46·7	65·6		0·8	0·1	22,	20
20	56·9	8·0	29·326	60·2	53·9	67	29·351	61·7	55·4	68	44·2	68·3	·500	0·3	0·0	23,	8
21	55·5	9·0	29·583	55·6	†54·3	92	29·604	63·5	55·2	60	48·1	67·3	·088	0·0	0·0	10,	25
23	51·8	10·0	29·341	57·1	54·5	86	29·267	54·6	53·5	94	52·7	66·6		1·4	0·0	20,	20
24	55·2	8·0	29·244	60·4	54·2	68	29·184	58·1	52·1	68	39·7	65·0	·405	1·0	0·2	8,	8
25	55·9	8·0	29·139	57·0	53·3	79	29·146	62·8	55·8	66	42·7	66·1		0·9	0·0	2,	8
26	54·3	9·7	29·250	59·4	54·2	73	29·319	57·3	54·0	82	46·8	68·7	·023	0·2	0·1	3,	8
27	56·6	8·2	29·588	60·6	53·6	64	29·608	60·7	55·0	70	41·0	66·8		0·6	0·1	26,	22
28	56·9	8·5	29·658	62·5	56·2	69	29·545	59·4	55·9	81	39·4	68·9	·053	1·6	0·5	20,	16
30	53·6	6·5	29·234	58·4	55·3	83	29·211	56·9	53·5	81	45·3	64·0		1·7	0·3	19,	22
31	52·1	8·7	29·450	57·9	52·5	71	29·554	54·3	51·9	85	47·6	66·0		1·9	0·4	0,	24
Aug. 1	54·4	5·2	29·793	59·2	53·5	70	29·837	59·4	54·4	73	44·0	68·2	·290	0·9	0·3	27,	7
2	52·0	9·5	29·878	58·9	53·9	73	29·846	55·0	51·5	79	42·9	63·8		0·6	0·2	8,	2
3	49·9	7·0	29·846	54·7	48·8	66	29·848	54·9	49·1	67	45·9	58·7		0·7	0·3	0,	1
4	51·0	9·9	29·788	53·9	50·3	78	29·760	57·9	52·2	69	39·0	64·4		0·5	0·0	30,	6
6	56·9	5·0	29·836	60·2	57·4	84	29·819	63·5	60·3	83	......	72·5		0·4	0·0	4,	2
7	55·3	10·0	29·802	57·9	56·6	92	29·723	62·5	60·8	91	48·6	69·7		0·1	0·0	3,	12
8	64·8	3·7	29·626	67·6	64·2	83	29·590	71·8	65·4	71	53·0	75·0	·190	0·4	0·0	24,	24
9	63·6	8·4	29·512	70·8	64·7	73	29·467	66·3	63·1	84	46·7	74·6		0·3	0·0	24,	—
10	58·9	9·9	29·499	62·8	61·4	93	29·524	64·8	63·1	91	51·3	69·6		0·0	0·0	0,	6
11	59·9	8·2	29·521	59·7	59·2	97	29·473	70·0	66·4	83	51·7	74·0	·500	0·7	0·3	8,	20
13	54·1	9·9	29·006	58·3	57·0	93	28·960	59·9	57·5	87	50·0	65·0	·330	4·4	1·7	20,	18
14	54·2	6·5	29·130	59·0	55·9	83	29·241	59·2	52·8	66	51·9	62·9		3·6	2·0	21,	22
15	51·3	7·5	29·383	56·0	52·4	80	29·414	56·4	52·4	77	42·7	63·7		3·1	0·6	22,	22
16	50·8	9·5	29·322	57·0	52·4	75	29·357	54·5	51·1	80	46·0	61·9	·232	1·4	0·3	20,	28
17	50·8	7·5	29·564	56·4	51·3	72	29·667	55·1	51·3	78	37·8	62·5		0·8	0·1	28,	3
18	50·3	7·0	29·759	55·2	50·1	71	29·740	55·2	51·3	77	42·7	63·0	·370	1·5	0·4	22,	30
20	55·8	10·0	29·987	59·9	56·7	82	29·981	61·5	58·4	83	51·6	66·0		1·7	0·6	16,	22
21	60·0	10·0	29·994	64·8	62·2	87	29·947	65·0	61·6	83	51·4	73·0		1·4	0·1	20,	18
22	57·0	8·0	29·817	62·9	58·1	75	29·793	61·0	58·4	86	50·3	69·3	·015	2·4	1·1	20,	26
23	52·8	8·9	29·924	57·9	52·3	69	29·919	57·6	53·2	76	40·1	63·3		0·6	0·0	24,	20
24	54·8	8·9	29·960	60·2	54·5	69	29·900	59·2	53·3	68	31·8	65·8		0·1	0·0	28,	20
25	57·5	10·0	29·765	62·4	58·3	79	29·773	62·5	58·5	79	46·3	67·7		0·9	0·1	22,	24
27	53·5	6·4	29·588	57·9	53·2	74	29·630	59·0	53·5	71	44·8	63·1		2·7	0·6	24,	20
28	54·8	9·0	29·635	58·9	53·6	71	29·596	60·5	58·0	86	37·1	62·5		0·9	0·3	21,	21
29	63·2	6·0	29·639	67·0	62·8	80	29·655	69·3	64·1	76	51·4	73·6		0·8	0·1	24,	25
30	55·6	10·0	29·620	61·1	59·8	93	29·561	59·9	59·0	95	51·8	65·7		0·1	0·1	18,	16
31	55·7	8·9	29·613	63·2	59·1	80	29·643	58·1	56·8	93	46·9	67·2	·822	0·4	0·0	26,	2

* See Introduction for a description of the methods by which these means have been obtained.
† July 21—New silk put on wet bulb thermometer.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h,	5h.
Sept. 1	58·9°	8·5	29·630	65·1°	59·8°	74	29·601	62·7°	59·2°	82	48·3°	70·8°		0·6	0·1	12,	8
3	61·2	2·5	29·743	62·9	61·4	92	29·800	69·5	63·5	72	42·1	72·4	·194	0·5	0·0	0,	14
4	52·9	10·0	30·042	56·7	56·2	97	30·052	59·1	57·7	92	44·3	62·8		0·1	0·0	2,	6
5	57·7	8·5	30·082	59·4	56·8	85	30·029	66·1	59·8	70	49·4	67·6		0·1	0·0	14,	—
6	48·7	10·0	30·070	54·5	54·3	98	30·078	53·0	50·1	82	42·5	56·9	·020	0·6	0·2	2,	2
7	48·0	5·1	30·124	53·8	49·6	75	30·103	52·2	48·5	77	37·4	58·3		0·7	0·2	4,	2
8	52·4	1·0	29·982	54·1	51·3	83	29·464	60·8	56·4	77	28·1	64·2		0·8	0·2	18,	20
10	46·8	10·0	29·155	52·4	51·3	93	29·099	51·2	51·2	100	39·2	54·8		0·8	0·0	6,	4
11	45·8	10·0	28·856	51·9	51·2	95	28·825	49·8	49·8	100	40·4	54·8		0·2	0·0	2,	—
12	51·2	4·0	28·826	54·1	52·0	88	28·855	58·4	54·1	77	34·5	63·8	·622	0·1	0·0	16,	28
13	49·2	4·0	29·257	54·5	49·1	69	29·430	54·0	47·9	65	37·0	58·5		1·8	1·4	28,	28
14	52·3	7·5	29·667	57·7	53·9	79	29·747	56·9	53·3	80	45·3	61·2		1·7	0·7	22,	21
15	52·4	9·5	29·800	57·0	54·1	83	29·758	57·9	55·2	85	41·2	62·4		2·2	0·8	18,	18
17	50·4	2·0	30·203	53·6	48·6	71	30·191	57·2	50·1	61	31·6	59·8		0·6	0·1	30,	0
18	47·7	4·5	30·233	51·2	46·9	74	30·220	54·2	48·3	66	33·0	58·0		0·7	0·2	2,	0
19	53·5	7·0	30·283	56·5	54·3	87	30·263	60·5	55·8	75	32·6	65·1		0·4	0·0	22,	4
20	49·9	10·0	30·337	56·1	55·1	94	30·311	53·7	53·7	100	39·8	60·5		0·7	0·0	8,	4
21	48·2	10·0	30·325	53·6	52·5	93	30·278	52·9	52·6	98	42·8	55·8	·162	1·3	0·6	2,	5
22	49·0	10·0	30·163	55·0	53·7	92	30·084	53·0	53·0	100	47·2	58·2	·033	1·7	0·2	4,	6
24	52·5	7·4	29·779	57·8	55·9	89	29·739	57·2	55·5	90	48·3	62·2		0·6	0·1	7,	6
25	49·4	4·2	29·733	55·0	51·5	80	29·727	53·8	51·5	86	43·8	57·6		0·2	0·1	6,	5
26	48·7	8·9	29·801	53·9	51·3	84	29·764	53·5	53·2	98	39·7	59·0		1·3	0·2	4,	3
27	51·8	9·7	29·766	57·5	53·9	80	29·753	56·1	53·1	83	48·8	61·8	·232	1·2	0·4	8,	10
28	50·6	10·0	29·653	57·0	53·9	83	29·563	54·3	54·5	100	49·3	58·8		1·3	0·1	8,	4
29	48·0	10·0	29·437	54·0	52·8	92	29·364	52·0	51·7	98	46·0	56·7	·392	0·2	0·1	4,	2
Oct. 1	44·1	9·7	29·384	46·7	43·3	77	29·441	46·8	43·3	77	37·3	48·6	·318	3·7	0·4	2,	0
2	43·7	1·5	29·491	45·0	41·7	77	29·453	47·7	42·5	67	22·8	49·6		0·4	0·0	—	22
3	36·9	9·7	29·271	40·2	39·3	93	29·100	38·8	38·7	99	25·7	43·6		0·1	0·1	—	4
4	39·7	3·6	29·072	43·0	40·6	83	29·158	41·7	37·6	71	31·3	46·0	·387	0·8	0·2	1,	—
5	40·0	2·2	29·345	42·8	39·5	76	29·371	42·5	39·6	79	22·3	49·8		0·6	0·1	24,	20
6	39·4	0·7	29·528	39·3	37·9	89	29·520	44·7	40·0	68	18·3	47·8	·010	0·1	0·0	—	28
8	41·4	6·2	29·668	44·0	41·7	84	29·715	44·0	41·1	79	34·7	47·9		2·9	0·5	0,	30
9	45·5	4·5	29·703	48·3	45·2	79	29·656	48·0	43·5	71	25·9	52·4	·115	1·1	0·3	18,	22
10	39·4	0·3	29·692	39·0	37·6	89	29·632	45·0	41·3	75	22·2	48·8		0·1	0·0	24,	4
11	39·4	5·2	29·561	38·7	38·0	94	29·552	45·3	42·1	78	19·8	50·2	·020	1·7	0·0	9,	8
12	38·3	3·7	29·660	41·8	41·3	96	29·678	40·1	39·1	92	26·8	46·2		2·2	0·2	4,	2
13	39·3	7·7	29·851	43·3	40·4	79	29·902	40·5	39·7	93	28·6	46·1	·332	2·7	1·2	2,	1
15	39·5	4·6	30·099	38·7	36·8	84	30·038	45·5	42·6	80	26·5	48·6		0·8	0·0	—	—
16	42·4	5·9	29·881	45·2	41·1	71	29·766	44·8	41·6	78	27·8	50·6		0·3	0·0	—	—
17	50·1	9·2	29·440	51·7	49·0	83	29·379	53·8	50·8	82	22·8	56·8		2·2	0·8	19,	20
18	53·7	7·0	29·634	56·6	54·0	85	29·708	56·1	52·9	82	45·8	61·0		4·3	3·4	20,	18
19	57·8	6·0	29·653	60·3	55·0	73	29·587	60·6	56·0	76	44·4	65·0		6·3	0·2	19,	19
20	47·4	5·7	29·516	50·5	47·4	81	29·533	49·6	46·4	80	40·4	57·4	·188	3·0	0·6	20,	18
22	44·5	10·0	29·746	45·6	44·3	91	29·555	48·7	47·3	90	30·7	54·1		1·2	0·0	24,	16
23	49·5	9·7	29·674	54·9	51·4	80	29·672	49·3	45·3	75	43·4	56·0		5·2	0·4	24,	24
24	46·0	10·0	29·691	48·6	48·3	98	29·736	48·7	48·6	99	40·0	51·7	·958	0·2	0·0	2,	4
25	53·3	9·9	29·486	56·2	55·6	97	29·417	55·6	54·3	92	44·0	58·6	·344	1·2	0·6	20,	20
26	47·4	2·5	29·383	51·0	46·7	74	29·407	49·0	45·3	76	44·2	54·7		1·4	0·2	20,	20
27	49·9	8·5	29·548	49·4	48·5	94	29·611	55·7	54·0	90	31·4	59·8		0·4	0·0	16,	16
29	48·5	9·7	30·280	48·8	46·1	82	30·164	53·2	50·3	82	27·2	54·6		3·0	0·4	20,	—
30	50·4	10·0	29·756	52·1	49·1	81	29·572	53·9	51·5	86	45·2	57·3		5·9	1·6	18,	17
31	44·3	10·0	29·350	49·2	46·4	82	29·265	44·7	43·6	93	34·5	51·8		2·1	0·1	20,	17

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 23h,	5h.
Nov. 1	44°·7	5·9	29·373	46°·0	45°·3	95	29·421	45°·4	44°·0	90	35°·2	50°·3	·063	0·1	0·1	6,	3
2	44·0	7·4	29·411	43·2	43·1	99	29·352	46·8	41·3	64	27·8	49·4		0·0	0·0	18,	—
3	43·9	10·0	29·307	45·2	43·5	88	29·186	44·7	44·0	95	32·2	48·5	·044	0·1	0·0	20,	18
5	38·7	1·5	28·437	41·2	38·3	79	28·614	38·3	36·3	84	31·0	45·2	·182	2·2	1·1	25,	18
6	31·9	3·0	29·167	34·0	31·8	82	29·100	31·8	30·7	91	23·5	41·0	·037	2·2	0·8	18,	18
7	33·2	10·0	29·667	33·4	32·3	90	29·609	35·0	34·3	94	23·2	37·0		3·9	0·0	—	—
8	53·3	10·0	29·800	55·4	54·3	93	29·801	53·2	51·7	90	30·8	56·8		3·0	0·6	20,	20
9	53·0	10·0	29·854	54·4	52·7	90	29·839	53·7	52·3	91	36·5	56·0	·018	4·8	0·9	20,	20
10	53·1	10·0	29·832	54·5	51·5	82	29·765	53·7	50·9	83	47·8	55·5	·065	2·1	0·6	20,	18
12	50·9	10·0	29·700	52·4	50·9	90	29·638	51·5	50·5	94	47·2	54·2	·005	3·6	1·3	18,	20
13	46·1	6·5	29·378	50·2	47·4	82	29·353	44·0	41·7	84	39·8	53·2		3·0	0·6	18,	20
14	38·9	4·7	29·187	42·3	41·1	91	29·182	37·5	35·7	86	30·2	44·5	·154	0·8	0·1	17,	—
15	40·0	1·8	29·339	40·0	36·7	75	29·475	42·0	41·1	93	28·2	46·0		1·8	0·2	26,	30
16	39·6	5·0	29·857	42·2	38·9	76	29·901	39·0	36·3	78	32·0	44·6		0·8	0·1	28,	28
17	39·0	9·7	30·008	38·8	37·3	88	29·928	41·2	41·1	99	22·8	44·6	·027	0·2	0·0	—	—
19	45·2	10·0	29·838	46·0	44·8	91	29·836	46·4	45·4	93	39·8	55·7		1·3	0·0	—	—
20	44·7	10·0	29·866	46·2	46·2	100	29·850	45·2	45·2	100	41·2	48·0	·132	0·1	0·0	4,	—
21	42·6	2·5	29·802	43·0	42·3	95	29·777	44·3	43·1	91	38·0	47·8		0·2	0·1	17,	15
22	41·5	10·0	29·586	41·9	41·3	96	29·456	43·1	43·0	99	36·0	45·4		0·5	0·0	14,	—
23	42·0	9·9	29·161	43·8	42·3	90	29·019	42·2	41·6	96	28·9	45·8	·155	2·2	0·4	17,	18
24	36·1	5·5	29·092	36·2	36·2	100	29·066	38·0	37·3	94	25·8	42·4	·150	0·4	0·1	20,	—
26	33·1	8·0	29·724	33·2	33·1	99	29·840	35·0	34·6	96	20·6	38·7		0·1	0·0	8,	—
27	29·6	8·5	30·022	30·1	30·1	100	29·985	31·1	30·8	97	19·8	34·0		0·1	0·0	26,	—
28	22·1	1·0	29·830	23·0	22·7	97	29·730	23·3	23·8	100	12·6	27·0		0·1	0·0	—	—
29	32·8	10·0	29·537	30·3	29·4	92	29·430	37·3	36·3	91	11·5	43·8		†	0·1	—	20
30	38·3	0·2	29·520	41·0	40·6	97	29·633	37·7	37·3	97	......	45·0	·340	0·1	......	22,	20
Dec. 1	36·5	8·7	29·792	34·7	34·7	100	29·708	39·6	39·3	98	24·5	40·8		0·2	0·1	20,	16
3	35·9	8·0	29·598	38·4	35·3	75	29·634	34·6	33·3	89	34·0	39·8	·046	2·9	0·5	9,	4
4	31·3	9·0	29·451	30·7	30·4	97	29·271	33·2	33·1	99	24·0	36·6		0·6	0·0	4,	4
5	28·3	5·1	29·214	24·9	25·4	100	29·107	33·0	33·3	100	18·8	37·0		0·4	0·1	—	4
6	39·9	5·2	29·249	38·8	37·9	93	29·386	42·2	40·3	86	29·2	44·6	·245	3·8	1·7	16,	17
7	43·7	10·0	29·468	43·7	40·5	77	29·401	45·0	42·3	81	30·0	46·8		2·4	1·4	12,	12
8	39·8	10·0	29·350	39·8	39·3	96	29·376	41·0	40·7	98	35·8	43·0	·017	3·1	0·4	8,	9
10	38·8	10·0	29·977	39·7	39·7	100	30·032	39·2	39·1	99	34·0	41·5		2·0	0·0	‡0,	4
11	37·1	6·2	30·131	37·6	36·3	89	30·088	37·8	36·5	89	29·0	41·2		0·2	0·1	6,	4
12	36·1	6·0	29·982	38·2	35·3	76	29·892	35·2	33·3	83	29·0	40·2	·138	0·5	0·2	8,	8
13	34·8	9·9	29·666	37·0	36·3	94	29·563	33·8	32·8	91	29·8	39·6		1·3	0·4	10,	14
14	43·3	5·1	29·427	44·0	42·6	90	29·435	43·8	42·8	93	27·2	51·0	·313	2·0	0·4	20,	20
15	44·0	10·0	29·494	43·4	42·5	93	29·525	45·8	44·1	88	38·4	46·8		7·2	0·1	—	19
17	42·7	6·0	29·177	41·9	41·4	97	29·310	44·8	42·5	84	37·6	48·5	·428	3·8	0·1	—	22
18	40·6	10·0	29·202	42·2	42·4	100	29·178	40·2	40·1	99	37·5	46·5	·130	1·2	0·2	4,	0
19	37·7	0·6	29·864	39·4	35·3	68	29·958	37·2	35·3	84	32·9	42·5	·113	4·3	0·3	30,	26
20	35·1	3·2	30·208	36·2	33·5	77	30·348	35·2	34·3	92	28·2	40·2	·046	1·7	0·2	30,	—
21	33·3	8·7	30·484	34·0	32·6	87	30·530	33·8	31·5	81	27·2	36·8		0·7	0·1	0,	4
22	30·9	5·7	30·617	33·0	29·8	73	30·618	30·1	30·4	100	27·7	34·8		0·5	0·0	5,	4
24	37·4	7·0	30·378	38·8	38·6	98	30·409	37·2	36·3	92	26·6	41·0		1·2	0·1	1,	2
25	35·9	7·5	30·407	35·8	34·5	89	30·246	37·3	35·5	85	29·7	41·0		0·7	0·0	24,	20
26	41·3	9·4	29·869	41·7	39·5	83	29·620	42·2	40·0	83	31·2	44·2	·192	1·0	0·5	24,	23
27	33·1	3·0	29·283	35·4	35·0	97	29·266	32·0	31·7	97	30·7	36·8		4·5	2·7	30,	30
28	22·1	1·0	29·259	21·4	19·5	79	29·303	24·0	23·0	90	17·5	26·0		5·8	2·3	30,	30
29	35·5	9·2	29·408	36·0	33·3	77	29·585	36·3	34·6	86	19·8	39·0		4·0?	1·7?	30,	30
31	29·3	1·6	30·139	30·6	30·7	100	30·117	29·3	28·6	94	18·0	33·5	·332	†	0·0	—	—

* See Introduction for a description of the method[8] by which these means have been obtained.
† Anemometer frozen.
‡ Found by observing smoke.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Thermometer. Min.	Thermometer. Max.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h
Jan. 1	32·7	6·9	30·046	33·0	31·9	91	30·007	33·8	32·7	90	19·6	37·0		†	0·0	— ‡16, — —
2	36·7	10·0	29·976	37·2	36·3	92	29·962	37·6	37·3	97	22·8	39·5		†	0·1	— 24, — 24
3	42·3	10·0	29·749	42·9	42·3	95	29·655	43·2	42·9	98	33·2	45·2		0·5	0·2	— 22, — 20
4	36·4	3·0	29·217	37·4	35·8	87	28·936	36·8	35·3	88	28·3	40·0	·014	1·3	0·3	— 18, — 20
5	30·9	3·6	28·921	33·6	31·7	84	29·061	29·7	28·4	89	27·0	35·5		1·9	0·1	— 21, — 20
7	31·2	7·2	29·773	30·1	30·2	100	29·913	33·8	31·9	84	16·7	35·0		0·7	0·1	— 28, — —
8	......	0·1	30·136	24·6	23·5	89	....	......	......	......	15·0	31·6		†	0·0	— — — —
9	26·5	5·0	30·025	24·4	24·1	96	30·011	30·1	30·0	99	12·8	30·5		†	0·0	— — — —
10	29·9	9·9	29·782	30·3	......	......	29·638	30·9	31·0	100	25·0	34·0		†	0·0	— 16, — 24
11	29·3	10·0	29·634	29·7	29·6	99	29·689	30·3	30·4	100	23·6	32·5		†	0·1	— 16, — 4
12	32·2	10·0	29·895	33·6	32·1	87	29·914	32·3	32·3	100	26·0	34·2		†	0·3	— 4, — 6
14	27·5	7·2	29·789	26·4	25·9	95	29·735	30·1	27·9	80	22·3	33·2		†	0·1	— 4, — 8
15	24·2	7·0	29·568	23·7	23·5	98	29·458	26·1	25·9	98	15·8	31·5		†	0·1	— 8, — 6
16	31·2	10·0	29·383	31·8	31·3	96	29·440	32·0	31·8	98	20·2	34·3	·590	†	0·1	— 4, — 8
17	25·5	7·5	29·702	31·3	30·8	96	29·742	21·2	21·5	100	25·0	29·0		†	0·0	— 20, — —
18	24·8	10·0	29·675	19·8	19·9	100	29·531	31·3	30·4	92	1·2	32·6		†	0·2	— 16, — 12
19	31·4	10·0	29·363	32·6	32·6	100	29·552	31·6	31·6	100	27·8	35·5		†	1·0	— 6, — 6
21	27·0	10·0	30·079	27·1	27·2	100	30·104	28·4	28·4	100	22·2	32·0	·298	†	0·1	— 14, — 17
22	34·8	10·0	30·143	34·8	34·1	93	30·127	36·3	36·1	97	21·2	38·0		†	0·6	— 18, — 22
23	42·5	7·0	30·138	44·2	42·3	86	30·115	42·2	40·8	89	32·2	49·0		†	0·3	— 19, — 18
24	40·1	7·0	30·024	41·1	39·3	86	29·924	40·5	38·7	85	31·2	45·5		†	0·2	— 20, — 21
25	38·2	9·5	29·478	37·4	37·3	99	29·418	40·4	38·9	88	32·2	42·1		†	0·1	— 18, — 26
26	30·0	5·1	29·269	32·8	33·1	100	29·640	28·7	28·4	97	28·8	34·2		5·2	1·0	— 31, — 31
28	45·3	9·2	29·370	45·0	44·0	93	29·255	47·0	43·1	75	24·6	49·9	·717	5·2	1·2	— 18, — 22
29	33·2	3·0	29·789	35·0	32·3	77	29·856	32·8	30·7	82	28·8	49·0		0·5	0·0	— 26, — —
30	32·7	9·5	30·000	31·5	30·4	90	30·005	35·4	33·3	81	22·2	39·0		0·1	0·0	— 24, — 25
31	34·7	10·0	29·807	33·6	33·3	97	29·581	37·3	36·3	91	23·8	39·0		0·2	0·0	— — — —
Feb. 1	44·2	7·3	29·206	46·5	45·8	95	29·082	46·0	42·3	75	33·0	49·2	·212	2·5	0·6	— 18, 18, 18
2	44·3	8·9	29·284	45·6	43·5	86	29·097	44·3	43·6	96	40·2	49·0		4·8	0·7	20, 20, 22, 19
4	38·0	8·7	29·561	39·8	37·7	84	29·475	39·2	37·5	86	30·8	44·8		2·3	0·2	20, 21, 18, 17
5	36·1	8·0	29·146	36·2	34·3	84	28·466	42·0	41·9	99	28·0	42·8	·244	6·6	1·3	18, 18, 18, 17
6	37·1	3·7	28·436	40·2	37·3	78	28·703	37·0	34·6	81	29·8	43·0	·430	7·2	2·9	24, 27, 27, 27
7	35·2	0·4	29·068	35·6	32·5	75	29·159	37·5	33·5	69	28·8	40·8		2·4	0·7	24, 24, 25, 25
8	37·7	10·0	29·122	33·3	33·1	98	29·075	44·2	44·2	100	28·2	47·0	·188	2·1	0·1	17, 16, 17, 21
9	42·7	7·2	28·717	45·0	43·3	88	28·564	40·4	37·7	80	40·2	49·2	·436	10·0?	5·1?	18, ‡19, 22, 20
11	34·6	10·0	28·274	39·0	37·8	91	28·656	32·0	32·1	100	30·0	40·2	·265	2·2	0·3	20, 16, 12, 2
12	31·4	6·7	28·925	33·6	32·7	92	28·971	33·0	32·5	96	22·4	39·5	·485	2·6	0·2	21, 22, 23, 26
13	28·6	1·6	29·776	29·3	27·9	87	29·870	30·9	30·4	95	23·2	34·0		3·8	0·2	28, 26, 22, —
14	40·8	10·0	29·464	39·5	38·9	95	29·458	46·6	45·5	92	25·6	48·6		2·4	0·5	18, 18, 20, 18
15	49·7	8·6	29·462	53·2	49·9	81	29·425	49·9	48·5	91	42·8	55·8		3·0	1·4	19, 22, 19, 20
16	39·5	1·4	29·539	40·3	36·8	73	29·761	40·6	38·2	82	33·8	44·8	·190	5·0	1·7	26, 25, 26, 25
18	45·8	10·0	29·702	47·6	45·6	86	29·706	47·0	45·5	89	40·0	49·8		3·5	1·9	29, 19, 20, 19
19	42·9	8·8	29·558	46·0	44·8	92	29·438	36·6	36·8	100	42·0	50·9		4·1	1·7	19, 18, 17, 18
20	42·3	2·6	29·573	45·0	40·9	72	29·668	40·2	38·1	83	40·2	47·2		4·5	1·0	20, 22, 24, 21
21	46·1	7·0	29·450	47·5	42·7	69	29·446	49·2	44·6	71	33·3	51·0	·197	11·4	7·3	22, 26, 26, 26
22	48·5	6·4	29·905	50·0	46·6	79	29·981	49·2	45·5	76	44·0	53·6		10·5	1·6	25, 24, 26, 22
23	44·1	9·8	29·929	46·0	42·7	77	29·902	45·2	41·5	74	35·2	48·4		2·3	1·0	20, 20, 23, 20
25	41·0	7·3	30·076	42·6	39·8	79	30·053	44·6	43·3	91	33·2	47·0		1·1	0·2	— 24, 20, 20
26	42·7	1·2	30·057	45·0	42·3	81	29·989	46·5	42·5	73	29·8	40·0		2·8	0·7	20, 20, 17, 20
27	46·0	9·4	29·955	47·0	44·7	84	29·933	48·4	46·1	84	40·0	52·0		4·2	0·3	24, 22, 19, 24
28	43·5	10·0	29·919	44·8	43·1	88	29·889	46·0	43·6	83	33·0	49·5		0·7	1·1	— — 20, 20

* See Introduction for a description of the methods by which these means have been obtained.

† Anemometer frozen. ‡ Found by observing smoke.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h.
Mar. 1	47·0°	7·2	29·806	49·6°	45·3°	73	29·890	51·0°	46·5°	72	38·2°	54·0°		3·2	1·5	19, 21, 22, 19
2	44·3	10·0	29·793	46·3	45·1	91	29·665	45·8	44·5	91	39·8	49·8		3·2	1·2	20, 19, 20, 22
4	33·1	2·8	29·905	34·2	33·9	97	30·035	38·5	33·3	59	25·3	40·2	·108	3·5	0·4	— 30, 29, 28
5	40·9	10·0	30·080	42·7	41·1	88	30·065	45·2	43·9	91	28·0	48·8	·032	3·1	0·9	19, 18, 20, 17
6	50·0	7·9	30·161	53·0	49·3	78	30·168	52·5	49·6	82	35·3	57·0		3·5	1·4	19, 20, 20, 20
7	48·9	3·4	30·233	51·3	47·5	76	30·193	52·6	47·9	72	42·3	56·8		1·9	0·3	20, 23, 24, 24
8	46·9	2·7	30·184	47·7	45·3	84	30·121	54·0	48·7	69	34·2	59·8		1·0	0·1	21, 16, 20, 20
9	42·0	10·0	29·880	44·2	42·1	85	29·800	44·1	42·3	87	34·2	46·8		1·9	0·5	20, 18, 20, 19
11	40·0	3·5	30·277	42·3	37·2	63	30·286	45·6	39·6	59	27·3	48·7		1·8	0·2	25, 29, 30, 30
12	39·9	2·5	30·338	42·8	40·1	80	30·322	48·6	44·1	70	21·8	50·8		0·5	0·1	— 23, 28, 25
13	42·5	3·5	30·305	46·2	42·3	73	30·280	52·0	46·3	65	25·2	54·6		0·3	0·1	18, 29, 14, —
14	43·9	10·0	30·356	46·6	44·3	84	30·348	46·4	44·3	85	37·8	48·2		0·2	0·0	— — — 6
15	43·7	9·9	30·317	46·3	43·5	81	30·245	47·8	43·3	70	35·8	54·0		0·2	0·1	4, — 18, 6
16	41·1	7·6	30·140	44·0	41·1	79	30·135	42·2	38·0	69	37·6	47·4		1·3	0·4	30, 1, 4, 3
18	40·9	10·0	30·096	40·0	38·3	86	30·023	48·4	43·3	67	29·2	51·2		0·4	0·1	— 17, 23, 28
19	44·3	9·2	29·991	47·0	45·3	88	29·985	47·8	42·5	65	38·0	51·0		1·0	0·2	30, 31, 0, 4
20	45·3	9·4	30·026	47·0	42·9	72	29·982	51·0	44·3	59	36·4	52·2		0·4	0·2	28, 30, 30, 30
21	38·4	9·8	30·097	40·4	37·3	76	30·100	43·0	38·5	68	32·4	44·6		1·8	0·5	30, 1, 1, 1
22	44·3	9·8	29·768	45·3	40·6	67	29·543	48·8	44·5	73	32·8	50·5		1·9	0·6	25, 26, 24, 25
23	33·1	3·6	29·314	36·8	35·8	92	29·329	35·8	33·5	81	25·2	41·5		4·5	2·2	26, 28, 0, 29
25	30·9	1·1	29·524	32·0	30·9	91	29·440	38·0	31·9	56	15·3	41·8		2·5	0·2	25, 22, 26, 26
26	34·6	1·6	29·552	37·0	31·9	62	29·614	40·2	33·9	53	15·3	42·0		0·7	0·2	— 4, 7, 4
27	33·8	3·5	29·659	36·2	31·9	67	29·667	38·8	32·6	53	20·2	43·0		0·6	0·2	— 29, 30, 0
28	33·5	2·7	29·826	35·3	32·3	74	29·819	41·2	33·3	42	14·5	42·5		0·9	0·1	— 20, 4, 5
29	38·8	6·5	29·854	40·6	35·3	62	29·805	45·0	37·7	51	12·0	51·8		1·2	0·4	— — 18, 16
30	37·2	10·0	29·718	39·8	34·5	62	29·609	39·2	34·6	67	30·3	44·0		5·2	2·0	13, 12, 14, 12
April 1	47·9	9·8	29·318	53·7	49·6	76	29·230	51·6	48·8	83	37·8	57·0	·062	3·7	0·5	14, 15, 14, 12
2	44·7	10·0	28·928	45·0	44·1	94	28·888	54·5	51·8	84	37·5	56·8	·042	0·6	0·1	4, 2, 6, 14
3	47·8	10·0	28·947	50·3	48·1	86	28·888	52·2	47·1	70	40·3	57·8	·134	1·1	0·2	18. 17, 18, 16
4	51·2	9·9	28·548	56·2	52·8	81	28·568	55·0	52·6	86	42·8	60·6	·148	2·2	0·2	16, 15, 20, —
5	47·8	5·1	29·163	49·7	46·5	80	29·350	51·0	46·8	75	44·3	55·8	·038	4·0	1·5	25, 25, 26, 22
6	42·2	9·2	29·332	47·5	44·3	79	29·274	47·0	44·3	82	30·2	49·0		1·8	0·1	17, 24, 20, 21
8	51·4	9·6	29·208	56·9	47·5	50	29·092	51·8	50·5	92	35·5	63·0	·146	0·8	0·1	12, 12, 14, 4
9	49·3	8·9	28·951	49·5	46·2	79	28·928	51·7	48·4	80	41·2	55·9	·404	2·0	0·6	14, 14, 14, 14
10	44·5	9·1	29·054	50·3	47·3	81	29·144	47·8	42·3	65	37·8	52·8	·012	2·6	0·6	18, 18, 19, 17
11	43·9	5·6	29·265	47·2	43·3	74	29·295	51·2	46·3	70	23·6	58·2		0·8	0·1	24, — 16, 14
12	42·3	6·5	29·567	42·0	40·3	87	29·581	49·3	44·3	69	31·7	50·2		0·9	0·1	6, 4, 6, 8
13	41·9	7·2	29·653	40·8	40·5	98	29·584	53·4	46·7	61	24·2	54·2		0·4	0·1	12, 6, 8, 12
15	38·0	10·0	29·272	42·6	40·6	85	29·056	41·0	39·7	91	36·2	45·0		2·7	0·7	10, 6, 8, 8
16	44·0	8·7	28·832	46·8	45·5	91	28·802	47·8	45·3	84	34·2	49·6	·106	1·3	0·1	— — 12, 6
17	48·1	5·7	29·052	52·2	47·5	72	29·169	53·2	45·6	57	30·4	58·0	·032	1·9	0·8	18, 20, 24, 20
18	48·3	6·4	29·570	52·6	45·3	58	29·620	52·6	47·3	69	34·2	······		2·1	0·8	18, 22, 20, 20
19	51·6	4·5	29·470	55·7	52·3	80	29·464	57·6	50·7	63	39·5	59·8	·174	3·4	1·2	18, 20, 20, 20
20	43·1	10·0	29·098	47·8	46·6	92	29·108	48·2	46·5	89	35·5	50·0		1·7	0·1	— — 28, 26
22	41·6	6·1	29·754	44·4	39·1	63	29·794	46·9	40·5	58	32·6	48·8	·253	2·9	1·4	30, 0, 0, 0
23	40·6	7·2	29·832	47·0	40·3	56	29·821	43·3	39·1	70	30·2	48·2	·006	1·5	0·3	30, 3, 4, 6
24	41·8	9·7	29·884	45·0	37·8	54	29·877	47·8	40·5	53	28·2	51·8		0·4	0·2	30, 29, 0, 6
25	39·7	10·0	29·809	44·0	40·6	76	29·822	43·3	40·1	76	29·8	47·6		0·7	0·5	14, 8, 11, 6
26	40·5	10·0	30·097	44·5	41·7	80	30·092	44·0	42·5	89	29·8	48·0	·016	0·8	0·2	8, 2, 2, 8
27	44·2	3·1	30·155	48·9	41·6	54	30·157	48·3	42·6	63	35·0	······		0·7	0·3	6, 8, 6, 5
29	39·6	10·0	30·272	42·8	38·9	72	30·243	43·8	39·3	68	28·0	47·2		1·1	0·3	1, 2, 2, 2
30	40·4	6·6	30·148	43·8	40·3	75	30·104	45·0	39·1	59	31·5	47·6		0·8	0·2	4, 4, 2, 1

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h.
May 1	°40·8	6·5	29·994	°43·4	°38·5	65	29·978	°45·5	°39·1	57	°35·0	°······	·035	2·3	0·6	1, 1, 0, 2
2	45·2	3·7	30·048	47·0	42·7	71	29·990	51·9	44·9	58	20·2	53·8?		0·6	0·1	17, — 23, 26
3	47·8	4·2	29·843	51·7	45·6	63	29·763	51·7	45·9	65	······	······		3·2	1·6	24, 22, 26, 28
4	42·0	7·0	29·624	47·0	41·3	63	29·529	44·0	39·1	66	29·0	49·8?	·028	2·4	0·2	27, 30, 8, 30
6	39·0	5·1	29·614	42·0	37·3	66	29·586	45·8	41·5	71	25·2	†	1·084	1·7	0·1	0, 2, 8, 14
7	41·0	3·2	29·552	44·4	38·9	62	29·473	46·8	41·1	63	29·8	······	·015	0·4	0·1	— 4, 12, 14
8	44·1	10·0	29·205	46·8	41·6	66	29·146	50·8	43·5	57	33·0	······		0·3	0·1	— 12, 24, 30
9	······	······	······	······	······	······	······	······	······	······	······	······	·148	······	······	— — — —
10	46·3	7·6	29·370	49·3	47·3	87	29·359	55·9	48·9	62	30·2	······	·083	3·5	0·8	17, 20, 20, 21
11	47·3	9·8	29·509	50·4	45·5	70	29·496	50·6	41·1	44	38·3	······	·090	2·6	0·9	20, 26, — 22
13	44·9	6·2	29·968	45·4	38·1	54	29·917	50·6	42·3	50	30·0	······		1·5	0·2	28, 31, — 20
14	43·9	7·1	29·718	48·7	41·2	53	29·751	45·0	39·7	64	37·0	······		1·8	0·9	25, 0, 2, 2
15	41·9	6·5	29·826	45·5	38·3	51	29·798	46·8	39·5	53	25·5	······		1·6	0·4	29, 0, 1, 2
16	53·5	9·9	29·651	······	······	······	29·619	56·9	49·7	61	33·2	······		0·3	0·1	25, 22, 18, 26
17	51·4	9·9	29·694	56·6	51·0	69	29·626	57·7	54·1	80	38·9	66·0		0·6	0·1	— 18, 18, 16
18	48·9	10·0	29·475	53·2	49·3	77	29·463	52·0	48·7	80	39·0	57·6	·150	0·3	0·2	21, 18, 17, 18
20	44·0	10·0	29·703	44·8	44·8	100	29·610	48·6	47·7	94	37·1	50·9	·042	1·7	0·4	3, 2, 2, 3
21	49·7	6·7	29·655	51·8	49·6	86	29·573	57·6	54·3	82	40·0	61·4	·093	0·6	0·1	— 12, 12, 8
22	51·3	5·4	29·377	52·4	50·7	89	29·297	59·9	55·5	77	34·8	61·5		0·3	0·1	8, — 6, 4
23	53·2	8·6	29·345	56·9	53·3	80	29·354	54·3	43·5	41	40·2	68·2		0·3	0·0	— — 7, 2
24	54·1	7·9	29·312	56·9	54·6	87	29·260	60·0	54·6	72	39·0	65·6	·208	0·2	0·0	— — — 6
25	46·6	10·0	29·127	50·0	49·3	95	29·072	50·0	49·9	99	41·8	51·8	·531	0·5	0·1	4, 28, 4, 21
27	54·5	6·1	29·339	56·1	52·6	80	29·371	63·1	54·8	60	45·8	67·0	·442	1·5	0·7	20, 20, 20, 19
28	57·0	8·8	29·578	65·4	56·7	59	29·707	56·4	53·3	82	44·6	64·6	·251	1·4	0·3	26, 20, 17, 20
29	56·7	9·8	29·888	58·2	53·6	75	29·873	63·1	57·5	72	42·2	66·6	·047	1·1	0·4	22, 20, 18, 17
30	60·6	4·2	29·848	65·8	57·5	61	29·829	65·9	59·4	69	38·0	70·9		1·2	0·2	— 19, 16, 16
31	55·2	7·4	29·981	55·1	53·1	88	29·975	64·6	57·4	65	37·8	73·1	·048	0·5	0·1	— 7, 12, 15
June 1	61·9	3·7	30·099	64·6	59·4	74	30·059	66·4	58·6	63	39·6	73·5		0·5	0·1	— — — 20
3	68·6	6·2	30·114	73·2	63·7	60	30·050	73·6	62·9	55	48·6	68·8		0·3	0·0	— — — 20
4	65·8	7·9	29·949	71·3	59·4	49	29·869	74·0	61·9	51	43·6	77·4		0·2	0·1	8, 20, — —
5	59·0	8·2	29·653	59·7	57·0	85	29·564	62·1	56·2	70	50·0	71·0		1·2	0·2	— 6, 23, 21
6	58·1	8·1	29·262	63·0	55·4	63	29·116	59·6	56·3	83	41·8	68·2		1·2	0·1	— 18, 18, 18
7	54·1	9·5	29·044	59·1	55·4	80	29·176	56·7	51·8	73	38·8	64·2	·318	1·0	0·2	— 30, 28, 0
8	53·1	6·5	29·566	54·4	50·7	79	29·626	58·1	50·9	62	38·3	63·5	·115	2·2	0·6	28, 22, 26, 26
10	56·5	4·9	29·781	60·3	55·8	76	29·695	63·6	55·7	61	······	64·4		2·2	0·7	21, 20, 20, 21
11	56·0	5·5	29·466	61·4	58·0	82	29·525	60·2	51·5	56	41·8	65·4	·030	3·3	0·7	21, 20, 24, 26
12	52·6	8·7	29·308	54·0	54·3	100	29·131	60·8	56·2	76	45·0	62·4	·298	2·7	0·9	20, 20, 20, 20
13	52·3	6·6	29·096	53·3	49·7	79	29·169	58·4	53·3	73	44·8	62·6	·002	3·1	1·3	22, 26, 24, 24
14	47·6	10·0	29·299	57·9	57·9	100	29·245	46·8	46·7	99	42·2	54·1		2·3	0·4	— 8, 8, 5
15	47·1	6·6	29·495	49·6	45·1	72	29·579	52·2	45·3	59	35·8	55·6	·275	2·5	1·0	1, 1, 4, 2
17	54·6	9·6	29·811	58·9	55·4	81	29·812	61·6	54·3	63	40·8	64·6	·155	0·8	0·1	— 20, — 22
18	56·2	7·3	29·986	61·1	55·5	71	30·011	58·8	54·6	77	40·0	67·9	·296	0·6	0·1	— 10, 26, 2
19	61·1	8·9	30·083	64·4	59·9	77	30·049	67·4	62·1	75	44·8	70·0		0·7	0·3	20, 23, 22, 20
20	61·3	6·7	29·957	64·6	60·1	78	29·924	63·4	58·8	77	······	71·0	·010	1·6	0·5	23, 22, 20, 22
21	56·2	9·6	29·757	61·0	54·5	67	29·713	60·0	56·8	82	49·6	66·8		3·4	1·7	22, 22, 20, 20
22	57·4	9·0	29·746	62·3	58·7	81	29·772	62·1	57·8	78	48·8	65·8	·018	2·8	1·9	20, 20, 21, 21
24	66·8	7·5	29·987	71·8	64·3	67	29·931	71·2	64·1	68	43·0	77·2		1·3	0·3	23, 23, 24, 19
25	54·9	9·8	29·982	55·4	54·4	94	29·904	59·7	56·3	81	46·2	64·1		0·7	0·2	20, 4, 6, 2
26	58·4	4·2	29·755	61·6	51·7	51	29·729	63·1	55·0	60	44·2	67·9		0·4	0·1	— 0, 26, 0
27	55·4	2·4	29·927	57·5	49·7	58	29·883	64·6	55·2	55	31·6	66·3		1·6	0·1	— — 7, 14
28	57·2	2·6	29·625	58·9	50·9	58	29·502	64·2	55·2	57	33·2	68·8		0·3	0·1	20, 19, 28, 20
29	53·2	3·4	29·385	56·5	48·5	57	29·397	58·7	51·3	61	33·2	61·3	·005	2·7	0·7	21, 23, 23, 26

* See Introduction for a description of the methods by which these means have been obtained. † Sent to be repaired.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Thermometer.		Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Min.	Max.		Max.	Mean.*	20h, 23h, 2h, 5h.
July 1	56·6	6·5	29·336	60·4	52·1	58	29·314	57·4	50·5	63	50·0	63·2	·155	2·6	1·1	23, 22, 20, 20
2	56·1	6·9	29·413	59·1	51·5	61	29·443	60·6	52·3	58	39·8	64·6	·017	2·2	0·7	23, 22, 26, 23
3	54·5	5·6	29·002	58·9	55·2	80	29·306	55·2	51·3	78	42·8	62·7	·225	6·6	3·0	22, 22, 20, 22
4	54·0	7·2	29·407	59·1	52·3	64	29·367	51·0	50·8	99	38·8	66·6		3·6	0·2	20, 18, 22, 16
5	52·0	4·8	29·656	55·7	49·8	67	29·764	60·4	53·3	63	40·0	63·3	·257	1·5	0·3	18, 22, 26, 25
6	50·4	10·0	29·817	56·1	52·3	78	29·726	52·2	49·7	84	34·2	……	·016	0·8	0·0	— — — —
8	52·4	5·0	29·799	54·0	46·5	57	29·757	59·9	50·8	53	37·6	63·0	·422	1·5	0·2	— 1, 0, 28
9	50·8	8·7	29·732	53·6	50·8	83	29·758	54·4	48·9	68	38·8	62·5		0·6	0·1	— — 16, 4
10	57·5	6·4	29·818	59·1	51·3	59	29·776	64·4	55·2	56	29·0	66·9	·050	0·7	0·0	— — 4, —
11	58·3	10·0	29·816	62·1	59·0	84	29·817	67·7	60·7	67	36·8	71·4		0·2	0·0	— — 17, 24
12	65·4	9·7	29·880	67·3	60·7	69	29·833	70·5	62·1	63	49·2	75·4		0·2	0·1	20, — — 20
13	63·2	7·8	29·879	66·9	59·5	65	29·882	68·2	59·3	59	51·8	72·6		0·4	0·1	— 4, 8, 9
15	63·0	9·1	29·900	65·6	59·0	68	29·850	69·1	59·7	58	43·8	76·9		0·3	0·1	4, — 8, 12
16	64·6	5·9	29·804	70·5	60·9	58	29·774	64·8	59·6	74	42·8	73·9		0·4	0·1	— 9, 12, 6
17	62·8	6·1	29·726	67·4	61·1	70	29·681	67·5	60·1	66	47·2	……		0·3	0·1	— 4, 8, 6
18	62·2	8·1	29·734	63·8	59·9	80	29·727	60·6	57·7	84	……	70·8	·093	0·3	0·2	— 4, 6, 8
19	57·1	9·7	29·753	59·4	57·2	88	29·754	62·4	59·8	86	49·8	67·1		0·2	0·1	8, — 4, 4
20	62·0	8·1	29·728	64·4	59·4	75	29·679	70·2	61·3	61	46·6	75·2		0·1	0·0	— — — —
22	66·4	7·7	29·701	69·2	59·8	58	29·696	70·6	69·9	97	49·2	79·7		1·1	0·4	18, 18, 20, 12
23	64·2	3·4	29·718	68·9	62·1	69	29·644	69·7	62·9	69	47·2	72·9		2·1	0·6	12, 10, 14, 10
24	54·2	10·0	29·579	58·2	58·2	100	29·586	56·9	57·0	100	50·2	68·3	·415	0·8	0·1	— 24, 20, 22
25	60·7	5·3	29·577	61·8	56·6	73	29·496	65·6	58·4	66	39·0	68·3	·463	0·3	0·1	28, — 8, 12
26	52·9	10·0	29·471	58·7	55·4	82	29·474	53·8	53·1	96	42·8	59·4	·056	0·6	0·1	2, 2, 1, 2
27	56·1	9·9	29·601	60·0	58·4	91	29·726	58·7	57·5	93	46·0	65·5	·316	1·9	0·7	4, 3, 4, 6
29	58·7	5·0	29·995	59·5	57·2	87	29·946	68·4	62·9	74	43·8	71·4		0·3	0·0	2, — — —
30	67·2	6·1	29·949	70·0	61·7	63	29·901	73·2	65·7	67	42·5	79·3		0·4	0·1	22, 24, 20, 20
31	61·4	9·3	29·873	68·5	64·1	79	29·968	59·7	55·8	79	52·6	71·3		1·3	0·1	20, 30, 6, 8
Aug. 1	58·6	4·6	30·001	61·0	55·4	71	29·901	70·0	60·9	60	33·6	74·1		0·4	0·0	— — — 23
2	63·6	7·3	29·749	67·5	62·4	76	29·732	67·9	60·6	66	40·5	72·2		1·4	0·5	18, 20, 23, 24
3	57·2	6·9	29·756	60·3	54·3	68	29·727	62·8	54·9	61	37·2	66·8	·125	1·3	0·2	28, 22, 24, 26
5	56·7	10·0	29·428	61·0	57·5	82	29·410	59·7	57·4	87	45·6	70·1	·045	1·1	0·1	20, 18, 22, —
6	58·0	8·9	29·460	63·1	58·8	78	29·480	59·6	58·4	93	37·6	69·0	·233	0·7	0·1	16, 20, 14, 18
7	57·9	2·3	29·606	59·5	54·1	71	29·537	69·2	61·9	67	33·0	71·8	·272	0·2	0·1	— 22, 14, 20
8	62·2	9·4	29·342	67·3	62·6	78	29·305	64·5	59·4	75	33·0	70·9	·034	0·7	0·2	20, 21, 22, 22
9	58·5	7·4	29·127	63·3	58·5	76	29·155	63·0	57·4	72	43·8	67·9	·062	0·8	0·2	23, 24, 24, 26
10	61·0	4·5	29·450	64·9	58·5	69	29·468	63·2	58·2	75	48·8	……	·118	1·4	0·5	23, 28, 24, 22
12	57·4	5·2	29·614	61·8	57·5	78	29·677	62·4	57·8	77	44·2	67·0	·024	0·8	0·2	— 6, 5, 8
13	58·3	3·2	29·708	60·6	56·2	77	29·663	65·1	60·3	77	36·8	72·2		0·6	0·0	— — — —
14	59·9	3·6	29·878	62·6	56·5	69	29·877	67·5	60·7	68	40·7	71·9		0·1	0·0	— — — 16
15	67·2	6·2	29·863	69·4	65·1	80	29·819	73·2	65·5	67	37·2	78·8		0·3	0·1	— 6, 19, 23
16	57·8	10·0	29·809	57·6	56·3	93	29·755	64·0	60·6	83	37·2	71·7		0·3	0·0	— 4, 0, —
17	54·1	8·2	29·765	57·7	56·2	91	29·786	57·5	54·8	84	47·0	64·7	·330	0·2	0·1	2, 6, 2, 14
													·118			
19	51·2	9·6	29·118	54·8	48·9	67	29·157	55·9	50·5	70	42·0	57·8	·012	7·0	4·1	30, 22, 22, 24
20	48·8	6·7	29·287	52·3	46·9	68	29·305	52·4	48·5	77	35·2	58·2	·040	4·7	0·3	28, 24, 0, 1
21	48·8	5·8	29·333	50·8	45·6	69	29·306	54·3	46·7	57	29·2	……	·060	0·3	0·1	22, 26, 31, 24
22	45·3	9·8	29·339	47·2	46·1	92	29·320	52·0	49·2	83	32·2	57·7	·150	0·9	0·2	0, 18, 18, 18
23	48·1	5·2	29·556	52·5	47·5	71	29·588	53·5	49·3	75	29·8	59·6	·182	1·7	0·6	22, 20, 24, 22
24	52·2	7·6	29·698	55·9	52·4	80	29·677	57·9	53·9	78	34·2	63·6	·170	1·0	0·1	— 20, 28, 24
													·100			
26	53·1	1·4	29·460	56·5	49·5	62	29·684	56·1	49·6	64	44·4	61·2		4·8	3·0	28, 31, 24, 24
27	45·5	10·0	29·709	48·8	48·1	95	29·292	51·8	49·5	86	32·0	51·8	·616	2·6	0·0	— — 14, 2
28	48·2	2·5	29·750	50·8	45·5	68	29·747	54·3	46·3	55	33·8	58·4		3·1	0·6	28, 26, 24, 30
29	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……	……
30	48·8	4·0	29·975	52·6	46·7	65	29·981	56·3	50·6	68	25·6	59·9		1·8	0·1	— 24, 26, —
31	55·0	7·8	29·977	57·1	52·1	72	29·967	61·0	55·2	70	41·2	65·8		1·0	0·4	24, 28, 23, 26

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum, Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20ʰ, 23ʰ, 2ʰ, 5ʰ.
Sept. 2	°57·4	4·6	30·057	°61·0	°56·2	75	30·013	°61·4	°55·8	71	·025	2·3	0·5	18, 26, 26, 28
3	49·0	10·0	29·968	52·3	51·3	93	30·041	50·6	48·9	89		1·4	0·2	25, 28, 6, 4
4	48·9	7·0	30·181	52·6	46·9	66	30·160	53·2	48·1	70		0·2	0·1	4, 6, 1, —
5	46·4	7·4	30·128	54·2	50·3	77	30·128	51·2	46·5	71		0·2	0·1	— 15, 4, 7
6	48·2	6·6	30·194	52·2	47·3	70	30·214	53·0	45·9	58	·018	0 7	0·2	2, 4, 4, 4
7	45·8	10·0	30·290	51·0	46·9	75	30·290	50·6	46·5	75		0·2	0·0	— — 2, —
9	47·7	3·2	30·184	53·6	50·6	82	30·134	56·4	52·6	78		0·1	0·0	— — 10, —
10	46·9	6·0	30·129	48·2	47·3	93	30·068	57·9	54·3	80		0·3	0·0	— — — —
11	51·3	5·7	30·072	53·9	51·1	83	30·018	62·4	56·8	71		0·2	0·0	— — — 18
12	50·0	1·9	30·083	51·0	50·5	97	30·051	61·8	57·2	76		0·2	0·0	— — — 28
13	50·9	2·9	30·139	53·3	51·7	90	30·096	61·0	54·3	65		0·2	0·0	— — 8, 4
14	49·2	9·8	30·147	51·6	50·0	90	30·118	56·9	50·6	65		0·1	0·0	— — — —
16	47·7	1·6	30·210	51·7	49·1	84	30·163	59·1	53·3	69		0·2	0·0	— — — —
17	51·3	2·8	30·152	52·0	49·9	87	30·056	61·0	54·6	67		0·1	0·0	— — — —
18	48·8	5·7	29·830	54·2	50·3	77	29·690	58·7	53·5	72		0·5	0·2	— 24, 18, 16
19	52·1	9·9	29·592	58·7	53·6	73	29·538	57·5	54·3	82		0·7	0·2	— 16, 16, 16
20	53·0	10·0	29·440	56·4	54·7	90	29·419	58·1	55·2	84		0·8	0·2	15, 18, 18, 16
21	49·9	10·0	29·042	57·5	56·9	97	29·160	53·6	51·9	90	·760	2·3	0·5	8, 4, 20, 22
											·040			
23	54·7	8·0	29·657	59·7	55·8	79	29·609	59·9	54·3	70		1·4	0·0	— — — —
24	57·0	6·9	29·572	57·9	54·4	81	29·515	60·0	54·7	72		0·1	0·0	— — — —
25	50·8	7·5	29·517	53·7	51·3	85	29·469	58·9	53·6	71		0·5	0·0	— — 18, 18
26	51·8	7·5	29·396	54·9	51·8	82	29·376	56·0	52·3	79	·112	1·6	0·3	— 16, 18, 16
27	51·1	6·6	29·354	56·9	51·9	73	29·323	55·1	52·3	84		1·5	0·2	20, 19, 24, —
28	47·6	5·7	29·226	51·6	47·7	77	29·296	54·1	47·6	63	·432	4·2	0·8	22, 20, 25, 22
30	46·3	5·9	28·997	49·3	45·9	78	28·922	53·2	49·4	78	·524	0·9	0·2	30, 28, 18, 20
Oct. 1	50·6	5·0	29·265	51·4	50·3	93	29·399	53·3	51·9	92	·140	3·2	1·0	2, 2, 2, 0
2	49·5	10·0	29·616	52·6	50·3	86	29·602	51·8	50·8	94		0·5	0·0	— — 4, —
3	47·4	7·8	29·630	54·2	51·9	87	………	……	……	……		0·3	0·1	— 20, 20, —
4	49·9	9·2	29·581	54·9	51·1	78	29·521	50·6	49·3	92		0·5	0·1	— 20, 20, 20
5	45·0	1·0	29·435	48·0	45·3	82	………	……	……	……	·418	3·1	0·1	— 20, 18, —
7	48·2	9·7	28·646	51·2	49·1	87	28·686	49·8	46·6	79	·302	3·1	0·3	24, — 24, 22
8	48·7	9·0	29·281	51·0	46·9	75	29·411	50·6	46·3	74	·025	0·8	0·2	30, 0, 0, 28
9	44·5	2·9	29·708	47·2	43·3	74	29·781	48·2	42·8	65		0·3	0·1	— 2, 2, —
10	43·7	8·3	29·809	46·6	42·7	74	29·710	46·6	44·5	86	·148	1·6	0·5	24, 30, 28, 0
11	38·2	5·9	30·011	40·0	39·1	92	30·094	43·2	40·3	78		6·7	1·1	0, 1, 2, 4
12	40·4	5·9	30·203	43·7	39·1	68	30·145	45·8	43·3	83		0·7	0·0	— — 26, 24
14	47·6	7·2	29·538	50·6	48·5	87	29·513	46·3	42·6	75	·018	2·6	0·8	23, 22, 28, 26
15	40·1	8·4	29·740	43·6	39·1	68	29·697	45·3	41·3	73		1·4	0·4	20, 28, 22, 22
16	50·9	8·4	29·603	54·4	48·9	68	29·641	52·3	48·3	76		2·5	1·4	26, 22, 24, 20
17	50·3	7·6	29·556	52·2	50·4	89	29·607	53·8	50·3	79	·026	2·4	0·5	20, 22, 24, 24
18	52·3	10·0	29·718	52·8	51·1	89	29·621	56·0	53·3	84		1·9	0·8	23, 20, 22, 22
19	51·2	5·6	29·572	53·8	53·5	98	29·580	53·3	50·3	82	·194	2·1	0·4	26, 28, 24, 24
21	38·7	4·6	29·974	38·6	38·3	97	30·030	43·3	40·1	76	·612	3·0	0·8	1, 1, 4, 3
22	36·7	9·2	29·851	40·0	37·3	79	29·491	42·2	40·9	90	·120	2·2	0·3	— 22, 23, 22
23	39·2	5·5	29·107	42·0	38·5	75	29·091	39·5	35·8	72		5·0	0·1	— 31, 0, 31
24	38·1	9·0	29·238	42·5	40·3	84	29·392	42·3	38·0	69	{·118 ·040	3·0	0·4	— 10, 10, 10
25	39·6	8·4	29·475	41·6	40·1	88	29·484	41·4	38·6	79	·110	3·5	0·1	4, 4, 8, 7
26	37·6	3·4	29·614	38·8	37·6	90	29·640	40·5	37·3	76		0·3	0·0	— 14, 2, —
28	38·7	6·6	29·094	42·0	40·8	91	29·067	39·0	37·3	87	·066	0·2	0·0	24, 27, — —
29	36·2	2·3	29·270	40·0	38·3	87	29·354	38·8	36·5	82		0·2	0·0	— — 4, 24
30	46·0	7·9	29·162	47·3	45·9	91	29·231	49·6	45·8	76	·044	3·1	0·4	20, 22, 22, 24
31	47·5	6·3	29·535	50·0	48·1	88	………	……	……	……		3·2	0·1	26, 23, 24, —

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Sky Clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Nov. 1	53·6	10·0	29·466	56·1	54·3	89	29·467	53·1	53·0	99	·023	2·4	0·5	20, 16, 22, 23
2	51·7	6·4	29·448	52·2	48·7	79	29·449	50·0	48·3	89		2·5	0·4	— 22, 25, 22
4	41·1	6·1	29·168	43·4	40·6	81	29·291	42·6	38·9	74		7·0	1·9	26, 22, 22, 24
5	49·0	5·5	29·312	51·0	47·6	79	29·392	48·2	43·9	72		4·8	2·1	23, 25, 26, 24
6	46·0	6·2	29·631	47·4	44·7	82	29·680	47·0	45·5	90		3·8	0·6	22, 22, 24, 22
7	49·0	9·5	29·494	50·3	49·3	94	29·259	49·0	47·8	92		6·8	2·3	20, 20, 20, 19
8	44·1	0·7	29·451	45·5	41·1	70	29·664	44·8	40·9	73	·150	5·5	2·3	24, 24, 26, 24
9	45·4	9·5	29·933	41·2	40·9	97	29·838	54·0	52·1	88	·050	0·9	0·2	— — 20, 20
11	53·5	9·4	29·624	56·1	53·3	84	29·619	53·4	49·5	77		1·5	0·3	22, 22, 23, 25
12	43·1	5·5	29·781	43·8	41·5	83	29·821	43·2	41·3	86		2·2	0·1	28, 28, 28, 20
13	......	6·5	29·811	39·2	38·3	92	....	......	......	......		0·1	0·0	— — — —
14	30·5	0·7	30·054	30·7	29·4	89	30·059	31·1	30·2	92		0·4	0·0	— — — —
15	31·8	10·0	29·971	32·2	31·4	93	29·898	34·8	34·6	97		0·1	0·0	— — — —
16	44·6	6·7	29·644	47·0	46·8	99	29·656	42·6	40·9	88	·120	0·6	0·1	— 20, 24, 20
18	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
19	47·8	8·9	28·445	51·5	48·7	83	28·286	46·2	44·5	89	·282	2·7	0·4	17, 18, 16, 14
20	44·3	10·0	28·706	46·6	45·6	93	28·956	44·0	42·9	92	·276	3·3	0·9	6, 4, 4, 2
21	38·2	7·7	29·404	40·3	39·5	94	29·412	35·2	35·1	99		1·2	0·0	— — 22, —
22	41·4	9·6	29·284	42·2	41·3	94	29·114	46·2	44·3	87		0·3	0·0	— — 20, 20
23	45·6	6·9	28·937	47·0	43·6	78	28·983	44·2	42·1	85	·042	1·8	0·3	20, 22, 20, 20
25	43·5	5·4	28·500	45·0	41·7	77	28·553	43·8	42·3	89	·336	4·2	0·5	24, 20, 22, —
26	39·4	10·0	29·035	40·5	39·9	95	29·282	39·8	38·7	92		1·2	0·3	18, 30, 2, 4
27	32·6	1·4	29·696	34·8	32·1	77	29·794	32·2	29·9	80	·196	1·4	0·2	0, 0, 1, 0
28	23·9	0·5	30·065	23·8	23·5	97	30·068	27·6	......	......		0·3	0·0	— — — —
29	32·2	8·7	30·070	34·0	32·0	82	30·040	34·2	32·5	84		0·4	0·1	— — 18, 20
30	23·6	0·1	29·977	24·2	23·8	96	29·952	24·8	24·7	98		0·2	0·0	— — — —
Dec. 2	42·7	10·0	29·860	39·0	38·1	92	29·798	47·2	46·5	95		0·5	0·1	16, — — 17
3	43·5	9·5	29·807	44·8	44·1	95	29·728	42·2	41·3	93	·142	0·2	0·0	26, 22, 20, —
4	46·3	6·5	29·652	47·2	47·2	100	29·784	45·0	44·1	93	·016	0·7	0·0	— 20, — —
5	49·3	10·0	29·856	48·5	48·3	98	29·903	53·0	52·1	94		2·7	0·2	20, 19, 20, 20
6	47·3	1·0	30·128	46·9	44·5	83	30·127	47·2	45·9	91		0·9	0·0	— 20, 20, —
7	37·5	0·2	30·107	36·2	35·9	97	30·068	40·5	39·5	92		0·2	0·0	— — — —
9	29·0	0·0	30·151	29·9	29·4	95	30·114	29·5	29·4	99		0·0	0·0	— — — —
10	27·4	3·5	29·935	27·3	26·4	91	29·844	30·7	30·0	94		0·0	0·0	— — — —
11	36·9	7·5	29·582	35·5	33·9	87	29·497	41·8	40·9	93		1·0	0·0	— — — 20
12	42·0	1·6	29·538	44·0	42·3	88	29·532	41·2	39·9	90		1·7	0·6	20, 22, 20, 20
13	43·3	9·2	29·384	43·6	41·8	87	29·255	44·2	42·5	88		2·3	0·6	20, 19, 20, 18
14	38·3	6·3	29·168	37·2	35·8	89	28·758	41·0	40·3	95	·028	5·1	0·6	— 16, 18, 20
											·190			
16	39·2	3·5	28·669	39·8	38·1	87	28·634	37·6	36·3	90	·015	3·8	0·7	22, 20, 22, 24
17	34·7	8·1	28·706	35·6	35·3	98	28·753	33·0	32·5	95		0·8	0·1	24, 18, — —
18	28·7	0·4	29·181	29·1	27·8	89	29·134	26·4	26·4	100		0·8	0·0	— — — —
19	29·5	1·5	29·405	28·1	28·0	99	29·561	32·8	31·2	87		0·0	0·0	— — — —
20	27·9	5·2	29·962	27·7	26·9	92	29·969	29·8	29·0	92		0·0	0·0	— — — —
21	41·2	8·4	29·765	42·5	40·3	83	29·856	41·0	39·1	85		0·9	0·4	— 20, 20, 24
23	43·4	9·1	30·229	43·4	41·6	87	30·206	44·0	42·9	92		2·5	0·5	22, 22, 20, 23
24	43·6	10·0	30·042	44·6	43·6	93	29·803	42·8	40·7	84		3·0	0·5	22, 22, 24, 22
25	41·1	2·6	29·506	41·8	37·6	70	29·624	44·6	41·7	80	·055	5·3	2·5	26, 26, 28, 26
26	46·2	8·9	29·796	49·2	47·3	87	29·876	44·8	43·1	88	·016	1·6	0·4	— 24, 24, 28
27	46·5	5·4	29·779	47·7	46·3	90	29·803	45·5	41·3	71		3·1	0·6	24, 18, 24, 26
28	42·3	0·6	29·775	43·6	39·7	72	29·831	42·2	38·5	72		5·0	2·7	24, 30, 28, 28
30	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
31	43·2	8·5	29·311	39·2	38·1	91	29·109	49·2	49·1	99	·158	4·2	0·2	20, — 18, 20

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Jan. 1	49·0	9·4	29·127	49·0	47·1	88	29·121	48·2	46·3	88	·200	4·0	0·8	20, 20, 20, 19
2	41·0	5·7	29·299	42·6	40·5	85	29·469	39·2	38·3	93	·406	6·9	0·1	22, 18, — —
3	30·3	0·0	29·818	31·7	31·4	97	29·797	31·8	31·4	97		0·1	0·0	— — — —
4	31·0	7·1	29·598	28·9	29·0	100	29·464	37·2	36·5	94	·190	0·4	0·0	— — — —
6	35·9	8·2	29·422	36·7	35·8	92	29·411	37·2	36·7	96	·054	0·1	0·0	— — — —
7	29·0	10·0	29·269	26·1	26·4	100	29·141	31·1	31·2	100		0·0	0·0	— — — —
8	34·4	9·9	29·219	34·2	34·2	100	29·140	36·6	35·5	91	·407	0·2	0·0	— — — —
9	35·6	4·0	29·439	36·2	33·8	80	29·625	33·6	32·6	91	·493	4·3	0·7	30, 26, 29, —
10	42·7	7·8	29·534	37·8	37·8	100	29·558	47·8	47·1	95	·225	0·3	0·0	— — 26, 20
11	49·0	10·0	29·638	49·0	47·9	93	29·592	48·2	48·1	99		2·5	0·4	18, 22, 20, 18
13	47·9	9·8	29·240	49·0	46·5	84	29·132	47·5	45·8	89	·172	2·7	1·2	18, 18, 20, 18
14	45·7	10·0	29·107	47·0	45·3	88	29·042	47·0	45·1	87	·132	2·2	0·8	18, 16, 18, 17
15	42·1	10·0	28·870	40·6	38·9	87	28·805	44·6	42·5	86		3·2	0·5	15, 16, 18, 16
16	40·5	6·2	29·232	39·0	36·8	83	28·876	45·0	43·3	88		5·0	2·0	— 18, 20, 20
17	41·1	4·0	29·047	41·8	38·8	78	29·122	41·0	38·1	78	·212	4·2	0·7	22, 22, 20, 20
18	37·2	6·1	29·578	36·7	35·8	92	29·671	39·2	37·5	86		2·0	0·1	— 22, 20, —
20	45·7	10·0	29·228	45·3	43·9	90	28·957	46·5	44·9	89	·112	4·3	2·6	18, 18, 20, 19
21	36·3	3·4	29·045	37·8	35·8	84	29·076	35·5	33·8	86	·326	4·4	0·3	— 20, 22, 18
22	37·7	5·0	29·316	39·0	36·5	81	29·562	37·2	35·8	88		3·2	0·9	24, 22, 22, 20
23	39·2	5·0	29·999	38·5	37·5	92	30·005	41·3	40·1	90		1·1	0·1	— 20, 19, 20
24	38·9	5·0	29·907	40·8	38·8	84	....	......	......	......		1·1	0·1	20, 19, — —
25	36·8	10·0	29·619	37·0	36·3	94	29·562	37·0	36·3	94	·192	1·1	0·2	18, 18, 18, 18
27	36·9	7·7	29·436	36·8	36·3	96	29·568	36·0	34·9	91		1·8	0·0	— 20, 20, —
28	39·4	6·1	29·443	40·8	39·5	91	29·358	38·5	37·3	90	·020	2·5	0·1	18, 20, 20, 20
29	46·3	9·7	29·075	48·6	47·3	92	28·957	46·5	44·3	86	·042	3·7	1·5	18, 18, 20, 20
30	35·4	4·9	29·038	37·4	35·3	83	28·988	34·0	32·9	91	·025	1·6	0·5	20, 18, 24, —
31	32·6	6·4	28·927	33·4	32·2	90	29·005	36·7	35·3	89	·154	0·4	0·1	— 30, 30, 1
Feb. 1	37·5	6·9	29·423	35·2	34·8	97	29·407	37·0	35·8	90	·292	1·7	0·4	0, 2, 2, 2
3	36·0	9·8	29·094	36·2	35·3	92	29·111	39·5	38·3	91	·155	1·8	0·2	18, 20, 20, 20
4	34·7	1·0	29·550	36·3	35·3	92	29·598	38·0	35·6	81		0·3	0·0	— — 21, 20
5	43·6	9·6	29·101	45·0	44·3	95	28·894	48·5	46·8	89	·068	3·3	0·3	20, 20, 19, 20
6	39·4	2·0	29·355	39·2	35·6	72	29·645	39·2	34·9	67	·030	3·7	0·9	28, 26, 25, 24
7	35·9	9·4	29·445	46·6	44·8	88	29·352	48·6	46·9	88	·008	5·0	1·5	23, 23, 20, 22
8	41·3	0·7	29·590	43·0	39·3	74	29·795	43·5	40·9	81		4·3	1·1	26, 26, 30, 28
10	43·5	10·0	30·069	44·4	43·3	92	30·005	45·0	43·8	91		1·1	0·1	— — 22, 24
11	45·6	8·5	29·861	46·7	46·1	96	29·872	46·3	46·1	98		1·2	0·1	20, 21, 20, 20
12	39·7	10·0	29·804	44·0	42·1	86	29·777	37·2	36·9	97	·115	1·0	0·0	— — — —
13	35·7	4·5	29·879	36·2	33·6	79	29·856	38·0	35·1	77	·310	0·1	0·0	— — 12, —
14	41·6	10·0	29·910	42·9	41·7	90	29·906	44·6	43·5	92		0·7	0·1	— — 21, 20
15	44·0	8·8	29·928	45·3	43·1	84	29·925	46·5	43·6	80		2·7	0·3	20, 20, 24, 20
17	41·1	6·2	29·634	41·3	40·5	94	29·635	45·7	42·3	77		1·6	0·3	18, 19, 24, 21
18	47·0	10·0	29·341	46·3	45·8	97	29·270	50·3	48·3	87		5·2	2·1	20, 20, 22, 20
19	49·8	8·5	29·246	53·3	50·8	85	29·201	51·0	48·7	86		5·0	2·4	20, 22, 22, 22
20	40·5	4·0	29·392	42·8	38·9	72	29·425	44·0	38·8	64		3·8	0·6	23, 24, 28, 25
21	37·7	0·5	29·663	40·6	37·8	79	29·696	44·2	39·6	69		0·9	0·0	20, — — 24
22	32·3	2·9	29·801	30·4	30·0	95	29·740	42·2	38·1	70		0·1	0·0	— — — —
24	33·4	10·0	29·670	37·2	35·9	89	29·640	41·8	40·3	89		0·3	0·0	— — — 7
25	38·3	9·7	29·834	41·0	37·3	72	29·907	39·2	36·5	78		1·8	0·6	6, 8, 6, 5
26	36·4	9·2	30·246	38·5	34·9	72	30·267	38·6	35·3	74		1·5	0·3	4, 4, 2, 2
27	34·3	6·6	30·279	38·0	35·3	78	30·257	37·6	35·5	83		0·9	0·3	0, 0, 1, 1
28	35·0	8·1	30·245	34·8	32·5	80	30·112	40·2	35·9	68		1·7	0·2	28, 30, 30, 28

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Mar. 1	36°·3	9·4	30·077	37°·6	33°·9	70	30·055	39°·5	35°·5	69		2·3	0·8	1, 30, 0, 2
3	40·9	4·2	29·884	43·0	40·1	78	29·822	46·0	42·8	78		0·5	0·1	24, 24, 24, 24
4	43·2	6·5	29·737	46·3	41·7	69	29·639	45·6	42·2	77		1·4	0·4	20, 22, 20, 22
5	42·2	6·6	29·417	49·0	45·2	76	29·437	42·0	36·3	59	·046	2·2	0·4	— 0, 0, 31
6	37·0	6·7	29·660	40·0	35·9	69	29·716	40·5	35·9	67		3·4	0·8	28, 0, 0, 0
7	33·6	6·9	29·720	36·0	32·7	72	29·632	41·0	37·3	72		0·9	0·1	— — 20, 18
8	40·9	10·0	29·752	40·6	39·5	91	29·719	42·8	41·5	90		0·4	0·1	20, 20, — 20
10	37·5	10·0	29·432	39·8	36·7	76	29·498	42·8	37·5	62	·117	3·2	0·2	— 30, 0, 30
11	36·3	1·8	29·789	38·0	35·8	82	29·681	43·6	39·3	70		0·3	0·1	— — 20, 20
12	38·1	10·0	29·370	38·0	37·9	99	29·182	43·2	41·4	87	·380	0·4	0·0	— 18, — 8
13	39·2	7·6	29·432	41·8	40·3	89	29·414	44·8	40·9	73		0·4	0·1	— — 20, 22
14	38·8	5·0	29·476	41·5	39·9	88	29·456	43·0	39·5	75		1·2	0·2	— 20, 20, 20
15	42·8	8·4	29·527	45·0	42·5	83	29·547	47·0	43·9	80	·050	0·6	0·0	16, — — —
											·100			
17	36·2	9·8	29·520	38·4	37·1	89	29·476	42·2	38·5	73		0·4	0·1	— — 12, 14
18	37·1	10·0	29·348	38·8	36·6	83	29·074	39·6	38·3	90		2·7	0·9	16, 15, 20, 18
19	42·4	9·4	29·199	45·8	42·6	78	29·182	43·2	41·3	87	·090	1·4	0·5	22, 24, 28, 8
20	42·7	5·9	29·078	46·8	44·1	82	29·054	44·8	42·5	84	·110	1·1	0·2	— 4, — 8
21	39·3	8·7	28·920	42·0	40·9	92	28·836	46·2	43·9	85	·100	0·9	0·4	— 16, 16, 17
22	43·0	6·5	28·802	45·0	41·9	78	28·782	46·0	43·3	82	·132	2·2	0·2	20, 18, 14, 14
											·268			
24	40·7	10·0	29·277	42·2	41·3	93	29·397	43·5	42·1	90	·137	2·5	0·6	2, 2, 2, 2
25	40·8	10·0	29·484	41·6	40·5	92	29·418	44·4	42·3	85	·153	1·2	0·2	8, 9, 14, 14
26	40·0	10·0	29·071	42·4	42·1	98	28·838	40·2	39·5	94	·564	1·2	0·2	6, 4, 4, 22
27	43·4	7·1	29·066	44·6	42·6	87	28·971	51·2	45·8	68	·270	3·4	0·6	25, 28, 20, 22
28	41·5	6·4	29·212	45·0	39·1	60	29·284	44·6	39·3	64		5·6	1·7	24, 24, 26, 24
29	42·1	5·5	29·106	46·3	41·3	67	29·067	45·6	39·1	57	·022	2·7	1·1	20, 22, 28, 28
											·015			
31	42·3	9·4	29·849	......	......	......	29·761	47·0	42·5	70		3·1	0·5	28, 30, 28, 28
April 1	42·0	9·9	29·851	45·2	41·9	76	29·774	46·8	41·3	64	·036	1·2	0·2	24, — 20, 24
2	43·2	8·7	29·654	45·7	40·9	68	29·650	48·4	44·1	72		1·3	0·4	20, 22, 24, 20
3	44·0	3·6	29·878	48·0	41·9	60	29·906	50·4	43·3	56		0·9	0·2	28, 0, 30, 31
4	42·9	7·5	29·993	44·3	40·8	75	29·895	48·0	42·1	61	·065	0·6	0·2	— 0, 4, 4
5	38·4	7·7	29·837	43·0	38·5	68	29·833	42·2	37·6	66		0·4	0·2	12, 12, 8, 6
7	42·8	9·0	29·908	49·5	44·8	70	29·916	46·6	43·3	78		0·1	0·0	— — — —
8	36·6	9·2	30·006	38·0	35·9	82	29·944	41·6	39·6	85		0·3	0·1	— — 4, 4
9	39·1	8·4	29·781	42·0	39·5	81	29·741	43·8	40·0	73		0·8	0·3	4, 4, 4, 4
10	40·5	3·2	29·832	44·4	39·9	68	29·874	46·5	45·3	91		0·8	0·2	1, 2, — 4
11	40·5	5·6	29·855	46·8	42·9	74	29·809	46·6	41·5	66		0·3	0·0	— — 4, —
12	40·6	9·4	29·796	44·8	40·9	72	29·794	44·6	40·5	71	·036	1·6	0·3	0, 4, 4, 8
14	39·9	9·9	29·843	43·2	38·3	65	29·811	44·0	38·3	60		0·4	0·2	1, 3, 4, 4
15	39·6	8·7	29·670	42·8	38·5	70	29·680	44·4	40·3	71		0·6	0·3	— 4, 4, 6
16	40·6	10·0	29·691	44·3	40·9	76	29·678	44·4	41·5	80		0·4	0·2	8, 8, 8, 6
17	41·4	10·0	29·520	42·0	40·7	90	29·495	48·0	41·1	56	·095	0·5	0·1	8, 10, 16, 6
18	48·6	7·6	29·462	51·2	48·1	81	29·411	51·2	48·1	81		2·3	0·5	20, 20, — 20
19	45·6	3·7	29·591	47·8	43·3	71	29·547	50·8	45·9	70	·250	4·3	0·9	20, 20, 20, 20
21	47·6	5·5	29·102	50·5	46·8	77	29·090	52·0	46·5	68	·404	2·8	0·5	22, 20, 20, 20
22	47·6	4·0	29·056	51·7	47·6	75	29·177	52·8	46·5	64	·060	2·0	0·4	20, 20, 22, 24
23	43·2	8·5	29·391	44·8	43·3	89	29·438	48·3	44·6	76	·166	1·2	0·4	— 4, 4, 8
24	41·9	9·6	29·619	45·8	44·3	89	29·634	49·5	45·3	73		0·2	0·0	— — — —
25	44·3	9·1	29·719	47·6	44·3	78	29·653	48·3	43·6	70		0·3	0·0	24, 28, — —
26	38·3	8·4	29·586	39·5	37·3	82	29·533	43·3	38·5	66	·462	1·1	0·4	2, 1, 1, 2
											·188			
28	37·2	10·0	29·314	40·2	38·3	86	29·314	39·5	38·3	90	·038	2·0	0·4	30, 30, 2, 0
29	37·0	7·5	29·328	38·4	36·8	87	29·319	44·6	40·3	71	·352	1·9	0·2	2, 0, 2, 4
30	39·6	6·0	29·430	44·8	42·1	81	29·496	45·0	39·5	63	·260	1·4	0·4	20, 8, 6, 8

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M, Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
May 1	44·0°	6·9	29·406	48·2°	41·9°	60	29·410	46·8°	42·7°	73		1·5	0·3	24, 24, 28, 0
2	40·5	9·2	29·602	45·4	39·5	60	29·639	44·5	40·1	69	·110	2·7	1·2	4, 4, 4, 4
3	37·8	8·5	29·627	42·8	37·8	64	29·639	41·6	36·5	63	·020	3·1	1·1	2, 2, 4, 2
5	39·2	10·0	29·646	41·7	40·3	89	....	......	......	......	·420	4·6	1·6	4, 4, — —
6	43·3	9·5	29·663	44·5	40·9	75	29·629	48·5	43·5	68	·100	1·8	0·4	2, 30, 2, 4
7	46·2	9·6	29·505	49·5	43·5	63	29·468	49·6	46·6	81		0·4	0·1	20, 30, 30, 20
8	50·2	9·3	29·384	53·2	47·8	68	29·345	54·9	47·5	59		1·5	0·4	16, 18, — 17
9	52·4	9·9	29·423	55·6	49·1	64	29·416	57·4	50·3	62		1·9	0·7	18, 14, 14, 14
10	52·5	4·0	29·559	59·5	56·4	83	29·575	54·1	47·6	63		2·2	0·7	4, 16, — 14
12	46·4	9·8	29·902	50·6	45·0	66	29·962	48·8	44·5	72		0·4	0·1	— 6, — 8
13	48·1	2·0	30·139	52·0	45·5	61	30·122	56·4	48·1	55		0·3	0·1	— 10, 4, 14
14	52·6	0·4	30·183	56·1	48·8	59	30·094	61·8	50·3	44		0·4	0·1	— 22, 20, 20
15	51·8	3·5	29·972	55·3	47·8	58	29·899	56·2	46·9	50		1·7	0·4	— 20, 20, 20
16	51·7	9·7	29·768	53·8	50·5	80	29·734	55·2	50·5	73		1·0	0·2	20, 20, 22, —
17	53·8	9·4	29·667	56·9	51·9	73	29·605	59·8	53·3	66		0·7	0·1	— — 20, 20
19	47·6	4·2	29·397	50·6	44·1	61	29·515	52·6	49·6	82	·095	4·2	2·2	25, 25, 28, 30
20	50·1	6·7	29·874	54·4	48·1	64	29·924	52·8	47·3	68		2·9	0·6	26, 30, 26, 26
21	56·8	8·6	29·889	61·6	55·2	67	29·936	59·1	55·0	78	·056	1·3	0·6	28, 28, 30, 24
22	54·1	6·6	29·875	60·6	53·3	62	29·889	56·4	52·9	80		2·6	1·3	26, 25, 28, 28
23	50·7	7·5	30·043	53·9	47·1	61	30·024	56·5	47·5	51		2·5	0·2	— 25, 30, 24
24	53·6	6·0	30·073	56·2	46·9	49	29·987	54·6	50·0	73		1·5	0·2	— — 16, 22
26	47·6	9·1	29·723	52·8	46·3	62	29·795	50·0	44·6	66		1·9	0·5	0, 31, 4, 4
27	51·0	8·2	29·782	55·7	49·3	64	29·794	58·7	52·8	68		0·6	0·2	28, 24, 31, 8
28	56·8	4·7	29·978	60·0	53·1	64	29·981	65·3	55·2	53		1·5	0·2	23, 28, 31, 26
29	59·5	6·9	30·154	60·6	54·7	69	30·137	65·0	58·0	66		1·2	0·1	28, 30, 20, 28
30	54·3	4·1	30·204	60·8	54·2	66	30·231	56·1	50·3	67		1·2	0·3	27, 26, 4, 8
31	57·9	0·9	30·265	59·3	56·5	84	30·167	68·3	54·8	41		0·3	0·0	— — 24, 0
June 2	56·6	9·9	29·828	59·5	55·0	76	29·744	58·6	54·6	78		2·6	0·7	22, 22, 22, 20
3	48·0	10·0	29·347	53·9	51·5	86	29·330	41·6	41·0	96		3·6	1·4	22, 22, 23, 4
4	45·1	4·2	29·528	47·2	42·1	67	29·548	53·4	43·9	47	·549	1·8	0·2	24, 28, 25, 28
5	45·7	7·5	29·321	48·6	46·8	88	29·333	49·2	45·1	74		1·8	0·3	12, 20, 24, 24
6	49·0	5·7	29·394	53·0	45·3	56	29·481	54·9	47·9	61	·100	2·4	0·4	20, 24, 24, 20
7	43·3	9·4	29·642	57·1	55·4	90	29·555	55·9	50·5	70	·048	1·2	0·1	24, 22, 24, 17
											·310			
9	52·1	7·4	29·585	56·1	49·5	64	29·585	55·7	49·9	68		5·7	0·3	28, 28, 26, 12
10	46·6	9·9	29·465	50·5	45·3	68	29·450	52·8	47·1	66	·158	2·5	0·1	2, 4, 24, 28
11	49·9	8·0	29·602	56·3	49·5	63	29·610	54·7	50·9	78	·085	2·2	0·5	28, 24, 31, 26
12	46·5	10·0	29·266	49·0	49·1	100	29·239	52·5	52·6	100	·668	1·6	0·1	12, 6, 4, 4
13	49·5	10·0	29·528	50·6	47·5	81	29·657	57·4	56·4	94	·372	0·3	0·1	2, 4, 2, —
14	52·1	8·2	29·738	57·3	50·5	63	29·751	54·9	52·5	86		0·9	0·2	— 26, 24, 20
16	50·8	6·5	29·298	53·9	51·1	83	29·428	53·9	49·5	75	·420	5·7	2·5	24, 24, 24, 22
17	51·0	3·6	29·877	50·0	47·3	82	30·016	57·1	48·1	52		4·0	1·0	28, 29, 28, 0
18	52·0	10·0	30·008	50·2	48·6	89	29·820	60·6	57·0	81	·030	1·8	0·7	20, 22, 25, 26
19	55·9	9·7	29·640	58·1	51·6	65	....	......	......	......		3·8	2·7	28, 24, 28, —
20	54·9	10·0	29·797	58·2	54·0	77	29·786	60·0	56·4	81	·090	3·7	0·1	28, 18, — 20
21	61·4	9·9	29·599	64·8	59·0	72	29·484	68·4	61·3	67	·183	0·6	0·2	22, 20, 20, 20
23	51·7	8·2	29·899	55·1	48·7	64	29·934	55·7	49·6	65		1·7	0·6	27, 0, 31, 0
24	55·4	9·0	29·922	59·3	54·4	74	29·892	58·2	55·3	83		0·7	0·3	22, 24, 24, 23
25	58·0	10·0	29·859	61·6	57·4	78	29·870	60·6	58·2	87		1·0	0·4	28, 0, 26, 22
26	59·0	7·2	29·887	62·3	56·8	72	29·894	64·4	58·4	70		2·2	0·8	24, 26, 22, 23
27	64·2	0·2	29·977	69·3	62·7	70	29·930	70·0	62·3	65		0·6	0·1	24, — — 2
28	69·2	4·0	29·927	70·0	63·1	68	29·871	81·9	71·9	62		0·1	0·0	— — — —
30	70·0	1·7	29·928	75·2	61·1	44	29·890	77·0	64·1	49		0·4	0·1	— — 16, 17

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
July 1	68·2	7·0	29·832	71·6	61·1	55	29·753	76·3	65·3	56		0·2	0·0	— — — 15
2	51·4	10·0	29·927	56·7	53·5	81	29·979	52·2	50·6	89		1·6	0·6	2, 2, 1, 2
3	49·8	3·8	30·018	53·9	48·4	68	29·981	54·4	48·1	63		1·8	0·4	1, 2, 2, 4
4	55·4	0·5	29·854	58·2	50·9	61	29·767	63·4	56·2	65		0·5	0·1	— 8, 2, 2
5	56·7	6·7	29·742	60·0	52·5	61	29·721	63·1	55·5	62		0·2	0·1	— — 0, 22
7	58·7	9·8	29·687	63·8	59·0	76	29·635	59·6	58·5	94		0·4	0·1	26, 27, 28, 24
8	53·2	7·2	29·526	55·2	52·6	85	29·589	57·9	53·3	75	·358	1·2	0·4	30, 2, 1, 4
9	50·9	10·0	29·508	56·1	51·3	73	29·422	53·8	50·5	81		0·6	0·0	— — — —
10	47·4	8·2	29·537	50·0	45·8	73	29·616	54·3	47·3	60	·397	0·5	0·1	4, 4, 0, 2
11	54·0	10·0	29·764	56·1	50·7	70	29·700	57·5	56·0	91		2·0	0·4	— 20, 20, —
12	58·0	10·0	29·622	61·2	56·5	76	29·492	61·8	60·4	92		1·5	0·6	22, 20, 20, 25
14	54·8	9·9	28·700	59·1	55·4	80	28·830	56·2	52·9	81	·182	4·0	1·2	20, 22, 20, 20
15	53·1	7·1	29·262	57·4	51·9	70	29·318	57·2	50·5	64		4·0	0·5	23, 24, 20, 20
16	52·4	9·6	29·476	55·6	52·1	80	29·525	58·7	51·9	64		1·3	0·0	— — — —
17	54·6	5·9	29·629	59·1	52·3	64	29·632	60·3	54·2	68	·040	0·2	0·0	— — — 15
18	54·0	3·1	29·641	58·1	51·6	65	....	......	......	......		0·3	0·0	— — 30, —
19	56·0	7·7	29·649	62·4	53·9	58	29·566	58·7	53·9	74		0·4	0·0	— — — 14
											·552			
21	55·2	8·6	29·529	57·6	53·0	75	29·616	60·6	53·5	64	·450	2·0	1·2	22, 23, 20, 26
22	53·8	5·6	29·814	60·6	54·2	67	29·773	59·4	55·4	78		1·2	0·0	— — — —
23	57·5	10·0	29·601	63·3	55·4	62	29·532	57·5	52·8	74		0·4	0·1	— — 10, 4
24	54·3	4·2	29·423	57·7	51·5	66	29·405	57·4	50·0	60		0·6	0·2	4, 4, 4, 4
25	52·4	9·8	29·345	54·3	50·7	79	29·347	55·9	51·7	76		0·9	0·5	4, 4, — 2
26	55·1	8·2	29·382	57·7	52·3	70	29·407	61·9	58·6	83		0·2	0·1	— — 20, —
28	59·2	7·7	29·362	64·4	60·6	81	29·374	64·4	60·3	80	·420	1·6	0·3	18, 20, 20, 18
29	57·5	9·4	29·486	63·8	60·1	81	29·558	56·1	55·7	98		1·8	0·0	— — — 2
30	52·6	10·0	29·820	55·4	54·2	92	29·822	55·2	54·6	96	·250	1·1	0·1	4, 4, — 6
31	57·6	10·0	29·530	58·7	58·0	96	29·475	63·5	61·6	90	·122	0·4	0·1	18, 20, 19, 24
Aug. 1	56·4	9·0	29·539	60·8	54·7	68	29·536	61·1	55·2	70		0·3	0·0	— — 18, 26
2	58·2	6·9	29·714	62·1	56·9	74	29·713	62·3	56·8	72		0·8	0·0	— — 20, 20
4	57·3	1·7	29·919	61·0	52·9	59	29·991	64·6	55·9	58	·468	0·1	0·0	— — — —
5	56·3	4·2	30·168	60·3	55·5	74	30·121	66·1	59·4	68		0·2	0·0	— — 6, —
6	54·6	4·2	30·148	56·2	53·3	83	30·093	70·3	59·6	53		0·1	0·0	— — 2, —
7	54·6	3·2	30·090	60·0	54·6	71	30·047	58·7	54·9	79		0·4	0·1	— 8, 6, 6
8	52·2	8·0	30·009	54·6	52·3	86	29·954	59·8	55·6	77		0·2	0·0	— — 4, —
9	52·5	10·0	29·904	55·3	52·3	82	29·880	57·0	52·8	76		0·1	0·0	— — — —
11	56·1	10·0	29·863	61·8	57·2	76	29·808	61·3	58·2	83		0·1	0·0	— — — 12
12	63·6	7·8	29·784	66·4	62·6	82	29·738	71·5	65·2	72	·280	0·2	0·0	— — — —
13	60·9	9·7	29·640	64·3	61·9	88	29·591	66·7	62·3	79	·435	0·4	0·1	— — 21, 14
14	58·4	9·2	29·482	66·2	61·7	78	29·437	57·9	57·2	96		0·4	0·0	18, — — 24
15	59·9	5·1	29·580	64·8	60·7	80	29·599	67·2	60·7	69	1·121	0·3	0·1	22, 25, 24, 25
16	54·6	8·6	29·761	58·0	55·1	83	29·729	59·9	56·0	79		0·6	0·0	— 4, 4, —
											1·519			
18	50·6	8·4	29·983	54·2	49·2	71	30·013	57·1	50·8	65	·028	0·2	0·0	— — — —
19	57·6	8·4	30·010	59·9	57·7	88	29·949	63·3	59·2	79		1·8	0·1	— 20, 20, 20
20	58·2	9·9	29·943	62·5	57·6	75	29·890	63·8	59·2	77		2·2	0·0	— — — —
21	60·5	8·1	29·611	63·4	61·2	88	29·524	68·6	63·4	76		2·7	0·8	20, 20, 20, 18
22	59·0	9·9	29·585	62·0	58·0	79	29·492	63·4	60·8	87		1·3	0·2	20, 18, 18, 20
23	55·4	7·7	29·460	60·8	56·2	76	29·461	54·4	52·5	89		2·6	0·1	20, 20, 20, 22
25	52·8	5·7	29·712	57·5	51·4	66	29·788	57·0	50·4	64	·870	1·0	0·2	26, 18, 23, 20
26	54·4	10·0	29·466	58·8	56·1	85	29·354	60·6	58·7	90	·140	2·5	0·2	16, 16, 16, 20
27	55·1	8·7	29·491	60·0	54·7	72	29·504	57·7	53·2	75	·058	2·8	0·2	26, 20, 21, 22
28	51·3	4·6	29·435	55·1	49·0	66	29·457	57·7	50·0	59		2·8	0·1	22, 28, 26, 28
29	48·5	7·7	29·563	49·8	45·1	70	29·708	53·1	48·0	70		3·3	0·1	30, 30, 0, 0
30	49·6	7·8	29·969	52·1	46·7	67	29·974	56·6	50·2	64		0·8	0·0	— 30, — —

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h
	°			°	°			°	°					
Sep. 1	57·7	10·0	29·884	62·3	59·9	87	29·832	62·2	60·3	90		1·1	0·0	18, 20, 20, 20
2	63·7	5·9	29·859	65·6	61·4	79	29·849	71·5	65·2	72	·023	0·3	0·0	— — 24, 26
3	64·4	5·1	29·939	68·9	63·5	75	29·926	67·2	62·5	77		0·3	0·0	— — 26, —
4	54·1	8·3	29·943	59·1	55·1	79	29·918	56·6	52·3	76		0·2	0·0	— — — —
5	48·7	3·9	30·092	53·3	49·2	75	30·114	53·9	48·8	70		0·8	0·1	5, 2, 4, 4
6	48·0	4·4	30·255	51·8	47·0	71	30·273	52·3	47·2	69		0·2	0·0	— 4, — —
8	50·7	7·2	30·383	56·8	50·9	67	30·354	55·2	50·0	70		0·2	0·0	— — 8, 8
9	48·8	3·2	30·295	52·1	51·9	98	30·237	58·3	57·3	94		0·2	0·0	— — — —
10	51·1	3·7	30·277	57·0	52·4	74	30·238	62·2	55·0	64		0·0	0·0	— — — —
11	52·1	0·6	30·241	57·2	52·4	73	30·185	64·8	56·1	58		0·0	0·0	— — — —
12	51·7	0·6	30·183	57·2	54·0	81	30·118	65·8	58·7	66		0·0	0·0	— — — —
13	52·4	0·5	30·112	57·1	51·9	71	30·089	64·5	58·4	70		0·1	0·0	— — — —
15	54·3	5·2	30·361	57·6	54·5	83	30·371	62·1	57·3	75		0·2	0·0	— — — —
16	50·0	2·7	30·416	52·6	50·8	89	30·377	60·3	56·3	78		0·1	0·0	— — — —
17	47·7	9·9	30·385	50·2	48·5	89	30·321	54·9	52·2	84		0·0	0·0	— — — —
18	50·3	9·8	30·171	53·2	50·2	82	30·083	54·5	50·9	79		0·0	0·0	— — — —
19	49·2	8·0	29·941	51·4	48·7	83	29·860	54·5	51·0	79		0·0	0·0	— — — —
20	52·6	5·4	29·912	54·2	......	......	29·880	60·6	54·5	68		0·0	0·0	— — — —
22	53·2	7·2	29·765	59·6	56·7	84	29·756	59·4	57·8	91		0·5	0·1	— 18, 20, 20
23	57·2	9·0	29·931	60·3	56·7	81	29·962	58·9	57·9	95		0·1	0·0	— — — —
24	55·3	8·6	29·866	59·9	57·4	86	29·738	57·6	55·5	88	·060	0·2	0·0	— — 20, 20
25	44·5	10·0	29·458	46·3	45·2	92	29·491	42·5	42·3	98	·503	3·0	1·5	— 4, 2, 0
26	40·7	10·0	29·335	43·8	42·5	91	29·316	42·8	42·9	100	1·040	8·7	3·3	30, 30, 0, 30
27	44·5	10·0	29·371	47·0	45·8	91	29·486	48·4	46·4	87	·355	4·5	0·3	31, — 31, —
29	47·6	8·7	29·481	53·6	47·6	66	29·336	51·2	47·5	77		0·5	0·1	— 20, 18, —
30	50·8	9·3	29·016	52·5	50·3	87	28·944	56·4	54·0	86		4·2	1·0	14, 14, 16, 17
Oct. 1	50·9	3·7	28·873	53·5	49·0	74	28·895	49·2	42·2	57		4·2	0·3	— 16, 15, 16
2	49·6	4·7	28·932	53·8	49·1	73	29·038	56·1	50·2	68		2·4	0·1	— 16, 16, 14
3	51·0	9·7	29·215	52·9	50·8	87	29·204	55·7	51·8	78		0·2	0·1	14, 18, 18, —
4	49·7	5·7	29·060	53·8	51·8	88	29·096	51·4	46·5	71	·172	1·0	0·1	— 22, 20, 19
6	45·7	5·5	29·264	48·3	45·1	79	29·345	47·5	44·2	79		1·7	0·5	20, 22, 20, 20
7	47·7	6·7	29·064	50·2	48·8	91	29·146	49·2	44·9	73		5·0	1·1	18, 20, 20, 20
8	47·3	3·5	29·467	50·6	45·3	69	29·536	50·6	45·5	69	·238	3·0	0·4	22, 24, 26, 20
9	46·6	10·0	29·550	46·7	44·7	86	29·494	52·4	49·5	82		0·4	0·0	— — — —
10	53·0	9·0	29·669	55·9	52·0	78	29·740	55·4	50·2	70		0·8	0·1	— — 24, 24
11	56·0	8·1	29·708	59·1	56·2	84	29·650	57·7	54·7	83		3·8	1·5	20, 18, 20, 18
13	52·3	7·0	29·514	57·5	54·5	83	29·592	52·4	46·2	63	·076	3·0	0·9	18, — 20, 20
14	49·4	4·9	29·525	52·7	48·9	77	29·520	50·6	46·5	74		1·7	0·5	22, 22, 20, —
15	45·5	3·4	28·943	47·8	45·3	84	28·951	46·0	41·5	71	·118	3·6	0·4	18, 20, 20, 20
16	42·3	1·7	29·126	45·2	42·5	81	29·219	46·2	42·6	76		1·0	0·0	— — — —
17	44·8	4·0	29·523	46·2	43·3	80	29·543	49·0	44·3	70		0·3	0·0	— — — —
18	52·5	10·0	29·415	55·8	53·9	89	29·423	56·6	54·4	87		3·1	0·8	22, 21, 20, 20
											·178			
20	52·1	10·0	29·806	52·8	51·4	91	29·760	56·1	55·3	95	·040	0·2	0·0	— — — —
21	54·3	10·0	29·784	56·1	54·7	92	29·730	56·1	53·2	83		0·2	0·0	— — — —
22	53·9	10·0	29·799	53·6	51·8	89	29·843	56·7	54·0	84		0·0	0·0	— — — —
23	52·1	10·0	30·070	54·6	53·1	91	30·074	55·6	53·5	88		0·0	0·0	— — — —
24	45·4	1·1	30·204	45·8	45·7	99	30·178	52·3	50·3	87		0·0	0·0	— — — —
25	47·4	4·7	30·164	47·0	46·8	98	30·124	50·4	49·3	93		0·2	0·0	— — 20, —
27	47·6	1·6	29·916	52·0	47·5	72	29·964	47·2	45·8	90		2·2	0·3	— 30, 0, —
28	47·9	8·9	29·562	53·3	48·8	73	29·297	47·0	43·3	76		3·0	0·7	— 22, 20, 24
29	39·3	8·7	29·182	38·0	37·9	99	29·171	40·8	37·6	76	·130	4·2	1·1	28, 0, 0, 30
30	39·2	7·5	29·609	41·2	40·6	95	29·633	40·0	37·9	84	·410	5·5	0·3	0, 4, 0, —
31	39·4	8·9	29·387	41·2	39·5	87	29·246	43·4	42·4	93		0·3	0·0	— — — 22

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
Nov. 1	39°·2	2·3	29·178	42°·0	39°·5	82	29·152	41°·2	37°·8	75	·025	0·4	0·0	— — 20, —
3	34·2	1·2	29·584	37·2	36·3	92	29·617	35·0	31·3	71	·100	2·2	0·1	25, 30, 28, —
4	32·3	1·6	29·766	34·4	32·3	82	29·837	34·0	31·1	76		0·2	0·1	— 28, 28, 28
5	42·5	9·7	29·748	41·6	38·3	76	29·666	46·8	44·5	85		1·3	0·2	24, 25, 24, —
6	41·3	9·7	29·748	44·0	40·3	74	29·775	41·8	39·0	79		2·2	0·2	— 30, 28, 28
7	40·0	10·0	29·789	41·3	39·6	87	29·754	40·6	40·1	96		2·1	0·0	— — — —
8	42·6	10·0	29·645	43·4	43·3	99	29·587	45·0	44·9	99	·128	0·0	0·0	— — — —
10	40·1	8·8	29·460	40·8	39·9	93	29·565	41·8	41·9	100	·118	0·2	0·0	— — — —
11	44·7	8·1	29·954	47·8	46·1	88	29·989	45·0	44·3	95	·060	0·4	0·1	— 0, 0, —
12	35·4	4·1	30·110	35·0	35·2	100	30·113	38·6	38·3	98		0·1	0·0	— — — —
13	42·5	7·3	30·167	44·0	43·3	95	30·113	43·8	41·6	84	·060	0·4	0·0	— 28, — —
14	34·8	7·2	30·285	36·3	33·5	77	30·103	35·0	31·9	75		1·8	0·1	— 28, 28, —
15	35·5	9·2	29·795	35·7	35·3	96	29·762	37·8	36·9	92		0·2	0·0	— — — —
17	30·7	2·1	29·683	32·8	32·7	99	29·670	32·8	32·6	99		5·2	1·3	30, 30, 30, 30
18	32·0	5·5	29·731	34·0	32·1	83	29·680	32·3	32·3	100		1·6	0·0	— — — —
19	31·5	10·0	29·567	32·6	31·5	91	29·439	33·0	32·8	98		0·1	0·0	— — — —
20	33·3	7·4	29·834	34·0	33·9	99	29·841	35·8	34·3	87	·145	0·1	0·0	— — — —
21	......	4·0	29·692	40·6	37·8	79	29·812	38·6	36·1	81		4·5	0·1	30, — — 28
22	36·7	1·4	29·998	39·0	37·3	86	30·025	36·6	35·1	87		4·0	0·1	28, 28, — —
24	33·0	0·7	29·193	35·6	34·6	91	29·186	34·2	31·9	81		0·0	0·0	— — — —
25	28·4	3·5	29·238	28·7	27·9	92	29·238	28·1	28·0	99		0·0	0·0	— — — —
26	36·4	7·7	29·551	36·2	36·1	99	29·593	36·2	34·7	87	·216	0·2	0·1	— — 30, 28
27	37·9	9·5	29·686	36·0	34·5	87	29·704	38·0	35·9	83		0·2	0·0	— — — —
28	33·7	2·7	29·858	35·8	33·3	79	29·876	36·6	34·3	81		0·0	0·0	— — — —
29	25·2	1·8	29·933	26·7	26·3	96	29·932	27·4	27·4	100		0·0	0·0	— — — —
Dec. 1	33·9	3·6	30·168	36·3	34·3	83	30·125	29·7	30·0	100		0·0	0·0	— — — —
2	25·5	0·4	30·090	25·7	25·4	97	30·058	28·4	28·2	98		0·0	0·0	— — — —
3	29·2	8·9	30·072	29·6	29·4	99	30·027	32·0	31·4	95		0·0	0·0	— — — —
4	37·2	10·0	29·972	35·5	35·1	96	29·918	40·7	39·6	92		0·2	0·0	— — — —
5	47·7	9·3	29·777	47·2	46·3	93	29·822	51·2	48·6	83		0·5	0·2	18, 20, 20, 20
6	47·3	10·0	29·757	47·3	44·9	84	29·703	47·6	45·5	86	·257	2·7	0·8	20, 20, 20, 20
8	44·6	6·6	29·244	45·8	41·5	71	29·659	44·0	43·7	98		11·0	4·5	20, 22, 20, 19
9	49·4	10·0	29·596	46·8	45·6	92	29·518	53·8	51·3	85	·024	4·2	1·7	18, 18, 20, 20
10	50·4	10·0	29·398	52·8	51·5	92	29·429	50·2	48·1	87	·110	8·5	1·6	20, 18, 19, 18
11	47·0	7·1	30·044	48·0	44·3	76	30·128	45·3	43·9	90	·130	1·5	0·2	22, 22, 18, 20
12	43·0	7·9	30·229	45·0	43·9	92	30·205	43·8	41·9	86		1·2	0·8	20, — 20, —
13	32·5	6·9	30·309	32·0	31·3	94	30·330	31·3	31·0	97		0·2	0·0	— — — —
15	39·3	10·0	30·183	40·0	38·5	88	30·093	39·6	37·9	87		0·0	0·0	— — — —
16	46·7	10·0	29·993	47·6	46·7	94	30·008	48·3	47·3	93		1·2	0·2	20, 20, 21, 20
17	44·9	9·6	30·040	45·6	44·5	92	29·987	44·8	43·9	93		0·4	0·0	— — — —
18	41·2	10·0	29·770	41·0	39·1	86	29·712	42·0	40·9	92		0·5	0·0	18, — — —
19	46·5	10·0	29·767	44·4	43·3	92	29·716	46·2	45·1	92	·015	0·7	0·0	— — — —
20	47·9	10·0	29·608	47·5	45·8	89	29·517	48·8	47·9	94	·015	2·0	0·3	18, 18, 20, 20
22	28·3	5·7	29·460	28·9	29·2	100	29·601	29·9	30·0	100	·010	0·5	0·0	— — — —
23	30·2	2·9	29·995	29·7	29·4	97	30·024	29·9	30·2	100		0·0	0·0	— — — —
24	27·3	6·5	30·062	26·9	26·8	99	30·033	25·9	25·9	100		0·0	0·0	— — — —
25	34·0	10·0	30·078	34·0	33·3	93	30·110	37·1	36·9	98		0·0	0·0	— — — —
26	35·6	10·0	30·311	36·6	36·6	100	30·354	36·2	36·1	99		0·0	0·0	— — — —
27	35·1	10·0	30·342	33·8	33·7	99	30·315	37·5	37·1	96		......	......	— — — —
29	33·6	0·3	30·289	33·5	32·5	91	30·235	34·8	33·1	85		0·2	0·0	— — — 20
30	42·6	8·1	30·189	43·0	41·6	89	30·089	43·3	41·1	83		1·0	0·1	20, 20, 20, 18
31	43·9	8·6	29·898	45·3	42·9	83	29·824	44·8	42·9	86		2·0	0·5	20, 19, 18, 18

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
Jan. 1	° 40·2	9·8	29·593	° 42·0	° 40·9	92	29·478	° 39·3	° 37·6	86		0·4	0·0	20, — — —
2	38·3	6·0	29·233	39·3	36·6	79	29·225	36·8	35·6	90		2·4	0·4	20, 22, 20, 20
3	37·1	10·0	29·200	37·0	35·8	90	28·937	41·8	41·1	95		2·2	0·4	— 16, 18, 18
											·290			
5	40·2	10·0	29·607	36·5	34·9	87	29·461	46·0	45·6	97		4·0	0·6	20, 20, 18, 20
6	46·4	9·3	29·344	47·0	43·3	76	29·203	45·6	40·5	66	·030	9·0	1·7	18, 20, 18, 18
7	38·7	8·2	28·846	39·0	36·9	84	28·981	40·6	37·6	78		11·0	2·5	20, 20, 20, 22
8	39·2	10·0	29·144	36·9	36·9	100	28·679	43·6	42·6	93	·408	11·4	1·2	— 17, 16, 18
9	34·1	8·7	28·609	31·3	30·3	92	28·820	33·6	32·8	93	·358	11·4	3·4	28, 28, 28, 27
10	29·4	1·9	29·362	38·3	37·6	95	29·389	25·7	24·3	86		4·0	0·0	— — — —
12	40·6	5·9	28·663	41·6	39·9	88	28·669	39·0	36·9	84	·255	6·0	0·9	20, 20, 20, 20
13	28·0	3·7	29·376	28·8	28·1	94	29·430	28·4	28·1	97		2·0	0·0	— — — —
14	33·8	10·0	29·511	30·1	29·5	95	29·439	39·0	37·9	91		2·0	0·1	— — 16, 18
15	42·5	9·6	29·019	42·5	41·3	91	29·074	44·6	41·6	80	·158	1·0	0·1	20, — — 20
16	41·3	5·4	29·226	43·2	41·3	87	29·395	42·0	39·3	81	·120	2·2	0·5	20, 20, 20, 20
17	39·3	2·7	29·663	40·8	38·5	83	29·794	38·2	37·1	91	·414	2·5	0·1	20, 24, 22, —
19	41·8	10·0	29·711	42·6	39·6	78	29·599	42·2	40·5	87		2·8	0·1	— 18, 18, 18
20	45·9	9·8	29·294	47·6	46·3	92	29·262	43·2	42·5	95		1·0	0·1	17, — 18, —
21	38·9	7·8	29·338	38·0	35·9	84	28·861	42·4	41·1	90	·116	4·5	1·0	— — 17, 17
22	38·8	7·0	28·602	39·3	36·7	80	28·554	41·0	37·9	77	·390	4·2	1·7	18, 21, 18, 20
23	37·7	4·4	29·023	37·8	35·9	85	29·169	39·8	39·1	95		5·2	1·2	18, 18, 19, 18
24	43·6	9·7	28·883	44·0	42·8	92	28·872	45·2	42·9	85	·078	10·0	1·7	18, 17, 18, 20
											·192			
26	40·3	6·2	29·548	39·6	37·6	84	29·469	43·6	42·3	90	·130	2·2	0·1	20, 16, — 16
27	41·7	9·4	29·049	44·8	42·1	82	29·112	40·6	38·3	83		8·5	1·9	16, 16, 16, 16
28	33·2	1·9	29·589	33·0	32·3	94	29·680	36·4	35·0	88	·038	0·4	0·0	— — — —
29	42·4	10·0	29·537	41·0	39·5	88	29·479	46·6	45·5	93		3·8	0·4	18, 17, 20, 20
30	38·7	5·4	29·061	40·2	38·3	86	....	......	......	......	·383	7·5	0·5	20, 20, 22, —
31	38·4	10·0	29·442	39·0	37·9	91	29·225	37·6	36·7	93	·010	1·0	0·0	— — — 16
											·267			
Feb. 2	46·5	10·0	29·386	49·2	49·0	99	29·337	44·8	44·3	97	·128	3·4	0·7	18, 18, 19, 18
3	37·9	2·9	29·497	41·0	37·8	76	29·527	38·3	34·9	73	·580	3·0	0·9	18, 20, 18, 20
4	45·3	10·0	29·217	46·5	45·3	92	29·142	50·2	49·6	96	·160	6·8	1·1	20, 20, 17, 18
5	41·8	9·9	29·297	42·8	40·3	82	29·171	42·2	40·4	87	·385	7·8	0·0	— 22, — —
6	38·5	4·7	29·388	39·6	37·6	85	29·591	41·0	37·3	72	·056	2·2	0·2	28, 24, 28, —
7	41·1	9·1	29·701	40·3	40·3	100	29·624	44·0	41·3	81		1·7	0·1	— 18, 20, 22
											·060			
9	37·3	6·2	29·008	38·3	35·3	77	29·075	36·0	32·3	70	·090	3·0	0·7	30, 30, 28, 25
10	36·2	3·7	29·750	38·3	35·1	74	29·847	37·8	33·5	66	·028	3·7	0·6	29, 30, 30, 1
11	34·6	8·2	29·832	35·3	33·3	83	29·751	41·0	38·9	84		0·8	0·1	— — 22, 20
12	40·4	10·0	29·515	42·2	40·5	87	29·412	41·8	40·2	88	·028	1·7	0·2	17, 20, 20, 20
13	35·0	8·5	29·346	35·0	33·9	91	29·426	38·0	36·3	86	·038	0·5	0·0	— — — —
14	37·9	9·2	29·788	37·6	36·5	91	29·758	42·4	39·9	81		3·0	0·3	— — 20, 20
16	37·9	9·2	29·587	38·0	37·1	93	29·494	41·0	39·3	87	·215	3·3	0·4	24, 25, 24, 20
17	46·5	9·6	29·382	49·3	47·3	87	....	......	......	......		6·0	1·4	24, 24, 25, —
18	34·2	3·3	29·310	37·2	32·5	63	29·407	36·0	31·9	69		3·7	1·6	28, 30, 28, 28
19	29·8	3·5	29·746	31·8	29·5	81	29·858	32·2	31·3	92		3·0	1·1	28, 30, 30, 30
20	28·5	4·4	30·014	29·8	27·8	82	29·962	33·8	30·6	74		1·6	0·2	28, 28, 28, —
21	38·0	3·6	29·988	40·3	37·3	77	30·081	41·8	38·6	76		0·4	0·0	— — 28, —
23	39·4	8·2	30·526	41·0	39·6	89	30·514	45·2	43·3	86		0·0	0·0	— — — —
24	30·5	0·5	30·520	31·3	31·1	98	30·413	38·0	34·9	75		0·0	0·0	— — — —
25	28·4	4·9	30·371	26·1	25·5	94	30·368	36·2	33·3	76	·020	0·1	0·0	— — — —
26	35·2	9·8	30·370	37·3	34·5	77	30·234	36·5	33·9	78		1·2	0·1	2, 2, 31, —
27	40·3	4·7	29·977	41·0	38·6	81	29·826	44·8	41·3	75		0·2	0·0	— 28, 22, —
28	38·3	7·4	29·487	40·6	36·5	70	29·450	37·8	32·7	60		4·6	0·9	— 28, 28, 30

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum, Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean *	20h, 23h, 2h, 5h.
Mar. 1	32°·6	6·2	29·451	34°·8	32°·5	80	29·464	36°·8	32°·1	62		0·6	0·0	— — 28, 28
2	32·5	0·9	29·657	35·2	34·3	92	29·691	38·0	34·0	68		0·6	0·2	28, 28, 0, 31
3	33·0	4·9	29·915	34·8	33·3	87	29·919	38·6	33·7	62		0·6	0·1	2, — — —
4	34·0	4·0	30·060	35·6	32·3	72	30·104	42·6	38·5	70		0·4	0·0	— 20, — —
5	42·8	9·5	30·344	45·8	40·1	61	30·414	43·8	42·5	90		2·2	0·4	— 18, 19, 20
6	43·4	10·0	30·547	45·2	43·1	85	30·538	48·0	45·1	81		0·3	0·0	— 20, — —
8	38·7	5·7	30·474	40·5	39·3	91	30·399	43·5	41·3	84		0·4	0·1	— — — 3
9	35·3	3·1	30·344	33·8	32·9	91	30·278	51·8	46·1	65		0·2	0·0	— — — —
10	32·8	7·6	30·264	33·2	33·3	100	30·326	38·2	38·0	98		0·2	0·0	— — — —
11	38·4	10·0	30·161	40·6	38·1	81	30·149	41·2	38·3	78		0·2	0·0	— — — —
12	40·5	2·8	30·252	40·8	37·7	77	30·193	48·0	41·8	60		0·1	0·0	— — — —
13	34·8	9·9	30·318	36·5	35·3	89	30·320	39·6	37·3	82		0·0	0·0	— — — —
15	42·6	10·0	30·318	45·5	42·7	80	30·303	47·8	42·3	64		0·2	0·0	— — — —
16	42·1	10·0	30·279	45·3	39·6	61	30·213	45·1	40·0	65		0·0	0·0	— — — —
17	39·6	10·0	30·193	41·1	39·5	88	30·152	44·6	40·9	74		0·0	0·0	— — — —
18	39·3	8·5	30·127	42·6	40·1	81	30·074	45·0	40·3	68		0·2	0·0	— — — —
19	36·7	8·5	30·054	37·5	36·6	92	29·985	44·6	40·6	72		0·7	0·1	— — 12, 12
20	41·2	3·4	29·900	42·6	39·5	77	29·807	51·0	42·9	52		3·4	1·0	15, 14, 16, 16
22	46·2	10·0	29·804	43·6	43·3	98	29·745	53·0	51·6	91	·070	0·8	0·0	— — — —
23	55·0	7·2	29·819	57·4	54·5	83	29·749	63·4	59·0	78		0·2	0·0	20, — — 20
24	37·2	10·0	29·870	40·0	38·9	91	29·869	39·3	34·6	63	·136	0·7	0·1	— 4, 4, 4
25	36·5	9·8	29·906	39·6	35·6	69	29·856	37·8	35·5	81		1·0	0·2	— 0, 31, 0
26	36·1	6·6	29·698	38·6	34·9	71	29·594	39·5	36·1	74		0·7	0·1	28, 30, — —
27	34·2	9·2	29·397	38·1	34·7	74	29·377	38·6	34·3	67		0·4	0·0	0, 0, — —
29	39·9	8·4	29·391	42·6	38·1	68	29·314	44·8	40·5	71		1·0	0·3	17, 12, 14, 12
30	38·8	10·0	29·139	40·5	39·5	93	29·144	40·6	39·9	95	·028	1·5	0·8	6, 5, 6, 6
31	39·6	7·9	29·498	41·6	38·3	76	29·624	43·0	38·6	69	·150	0·8	0·1	— 4, 4, 4
April 1	38·4	6·0	29·907	41·8	37·8	70	29·915	47·6	42·3	65		0·2	0·0	— 0, — 16
2	40·9	9·5	30·095	44·6	41·9	81	30·054	51·8	44·9	59		0·2	0·0	— — 16, 16
3	38·9	0·2	30·166	44·5	40·9	74	30·155	48·8	42·7	61		0·2	0·0	— — — 12
											·022			
5	38·3	3·0	30·034	43·5	39·5	71	29·978	47·0	42·5	70		2·2	0·0	— — 16, —
6	40·8	6·9	29·997	46·0	41·9	72	29·988	50·0	43·6	60		0·2	0·0	— — — —
7	41·8	6·6	30·107	46·8	45·3	89	30·114	48·0	42·1	62		1·5	0·1	— 6, 8, 8
8	43·5	3·6	30·150	45·5	42·1	76	30·094	51·5	44·3	56		0·2	0·0	— — — 4
9	47·5	8·2	30·161	51·2	47·1	75	30·123	54·9	48·5	63		0·2	0·0	20, — — —
10	44·9	1·6	29·958	50·0	45·3	70	29·984	53·3	45·3	54		0·2	0·0	— — — 2
12	52·5	1·0	30·008	56·4	50·1	64	29·975	66·6	54·5	46		0·2	0·0	— — — 20
13	52·7	0·8	30·040	60·3	51·3	54	30·015	67·1	53·6	40		0·2	0·1	— 18, 18, 18
14	54·0	0·0	30·050	60·8	51·3	52	29·994	66·2	51·7	36		0·2	0·0	— — — —
15	46·4	0·1	30·000	53·2	48·1	69	29·961	52·6	48·3	74		0·3	0·1	— 4, 4, 4
16	42·4	7·1	29·942	44·8	42·6	84	29·882	53·0	48·3	72		0·1	0·0	— — — —
17	50·2	2·6	29·783	51·8	46·9	70	29·667	60·6	49·9	47		0·2	0·1	— — 30, 30
19	41·2	1·5	29·853	44·6	40·1	69	29·764	51·6	45·9	66		0·3	0·1	— 16, 20, 20
20	48·6	5·7	29·745	51·4	46·3	69	29·752	57·9	49·1	53		0·5	0·2	18, 20, 24, 24
21	50·0	5·5	29·822	53·9	48·9	70	29·738	58·8	49·5	52		0·3	0·1	— 16, 16, 14
22	47·3	9·2	29·715	53·6	45·1	52	29·715	52·2	44·9	57		2·4	0·5	8, 14, 12, 12
23	45·2	5·1	29·765	49·2	45·6	77	29·886	50·6	45·6	69		2·5	1·2	6, 8, 12, 12
24	40·8	5·6	30·040	45·4	40·0	63	29·996	44·0	39·3	67		2·7	1·4	8, 6, 6, 6
26	41·2	7·7	29·946	44·0	39·6	69	30·023	47·8	41·8	61		0·5	0·1	— 2, 6, 6
27	44·1	7·9	29·980	46·5	45·7	94	29·953	55·5	52·2	81		0·3	0·0	— — — 14
28	45·8	9·2	29·736	48·0	46·3	89	29·615	50·4	48·8	90	·173	1·8	0·1	18, 18, 20, 18
29	51·1	9·9	29·468	57·7	54·1	80	29·406	58·8	54·2	75	·062	0·5	0·0	— — 23, —
30	41·2	10·0	29·373	42·8	42·9	100	29·433	44·2	42·5	88	·645	0·4	0·1	— 4, 4, 4

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
May 1	44·7	3·9	29·626	47·4	40·7	57	29·653	51·6	44·9	60		0·7	0·0	— 2, 4, —
3	43·1	8·5	29·948	46·3	45·5	94	29·990	48·2	46·1	86	·060	0·7	0·1	— 4, 4. —
4	44·9	7·1	30·060	48·2	44·1	73	30·037	51·0	46·1	70		0·2	0·0	4, — 6, —
5	46·6	9·6	30·094	49·2	44·9	73	30·077	52·2	46·1	63		0·2	0·0	— — 0, —
6	51·6	....	....	......	......	......	....	......	......	......		0·1	......	— — — —
7	50·7	10·0	29·759	53·9	51·3	84	29·698	58·0	52·6	71		0·9	0·2	20, 17, 20, 20
8	54·0	9·6	29·654	58·2	55·8	87	29·632	56·2	53·5	84	·040	2·0	0·2	— 20, — 20
											·018			
10	51·6	7·3	29·354	54·7	53·1	90	29·264	55·9	50·1	68	·282	5·0	0·8	18, 16, — 18
11	45·2	9·7	29·272	47·0	44·6	84	29·299	50·0	46·9	80		5·0	0·8	18, 20, 20, 20
12	47·4	7·7	29·228	49·7	46·8	82	29·245	55·5	49·5	67	·318	3·3	0·0	— — 28, 20
13	50·7	9·9	29·271	56·9	52·9	78	29·163	50·0	50·3	100		0·7	0·1	22, 20, 17, 20
14	45·1	8·2	29·165	47·6	46·9	95	29·320	49·3	46·5	82	·375	2·0	0·7	30, 0, 28, 25
15	49·2	7·0	29·668	50·6	47·3	79	29·617	53·4	49·1	75		1·7	0·2	— 20, 20, 18
											·217			
17	53·2	8·4	29·505	55·4	51·3	77	29·513	59·6	53·3	67		1·2	0·2	20, 20, 20, 20
18	51·0	9·1	....	......	......	......	29·677	50·0	47·7	85		1·5	0·5	4, — 4. 4
19	44·8	10·0	29·701	49·6	46·1	78	29·675	44·3	44·1	98	·062	2·1	0·4	4, 4, 2, 4
20	47·3	10·0	29·866	50·4	49·0	90	29·868	51·8	49·3	85	·182	0·6	0·1	4, — — 6
21	44·3	10·0	29·858	47·8	46·9	94	29·868	47·2	43·1	72		0·4	0·2	4, 4, 3, 4
22	44·6	10·0	29·960	47·5	43·6	74	29·979	48·0	45·5	83		0·4	0·2	3, 2, 6, 4
24	50·7	2·2	29·940	52·6	48·7	76	29·892	60·0	51·9	58		0·2	0·0	— — — —
25	48·3	7·0	29·919	51·4	48·3	80	29·907	50·0	48·7	91		0·2	0·0	— — 8, 8
26	45·0	10·0	29·894	48·0	48·0	100	29·874	48·0	48·3	100		2·9	0·3	4, 4, 4, 2
27	46·4	9·9	29·866	48·2	48·3	100	29·828	50·6	50·5	99		1·4	0·1	0, 4, 2, 2
28	47·7	9·9	29·724	50·6	49·1	90	29·676	52·0	51·3	96		0·9	0·1	2, 0, 4, 4
29	43·1	7·4	29·560	48·1	47·7	97	29·509	49·2	48·8	97		1·1	0·0	30, 28, 30, 28
31	45·7	8·1	29·473	49·2	43·4	64	29·476	47·0	43·1	74	·038	0·5	0·1	30, — 30, —
June 1	47·3	7·9	29·530	51·0	45·1	64	29·506	53·3	47·1	64	·110	0·4	0·1	— — 22, 18
2	47·3	9·7	29·416	50·8	47·9	82	29·414	49·0	47·1	87	·038	0·4	0·2	18, 18, 18, 16
3	47·6	7·5	29·295	54·9	50·1	73	29·297	53·2	48·8	74	·318	0·8	0·2	18, — 16, 20
4	54·0	4·4	29·448	58·5	51·5	63	29·490	57·9	51·3	64		0·9	0·0	16, — — 20
5	55·6	6·7	29·704	58·5	52·5	68	29·684	61·9	54·8	64		0·2	0·0	— 16, — —
7	50·2	8·2	29·609	54·2	51·5	84	29·596	54·0	51·1	83	·032	1·2	0·3	4, 4, 7, 4
8	50·0	10·0	29·597	53·5	52·8	96	29·585	52·0	51·6	98		1·0	0·3	4, 4, 4, 4
9	48·4	10·0	29·579	51·2	50·1	93	29·549	51·0	49·3	89	·056	0·5	0·2	4, 2, 2, 2
10	47·8	9·9	29·352	54·3	48·5	67	29·284	49·4	46·6	83		2·4	0·5	30, 30, 30, 30
11	47·6	9·9	29·253	49·3	45·3	75	29·268	54·0	48·5	69	·683	4·0	1·4	30, 31, 31, 28
12	48·2	10·0	29·434	54·0	50·3	78	29·459	49·4	49·3	99	·056	2·0	0·0	0, — — —
											·128			
14	48·6	10·0	28·992	53·6	49·5	76	29·037	51·8	50·9	94	·020	0·3	0·0	— — — 6
15	52·6	6·4	29·266	56·9	51·8	72	29·299	54·8	52·9	89	·024	0·2	0·0	4, — — 6
16	50·7	10·0	29·123	56·1	51·8	76	28·980	52·5	52·1	98		2·5	0·7	6, 6, 9, 10
17	56·8	8·1	29·111	59·8	53·9	69	29·124	63·1	55·4	63	·120	1·2	0·5	14, 16, 16, 16
18	55·3	9·6	29·276	59·5	54·3	72	29·302	59·9	54·9	74	·025	0·4	0·1	— 12, 8, 12
19	56·3	6·9	29·475	59·9	57·2	85	29·494	64·2	57·5	67		0·3	0·0	— — 10, —
21	60·3	8·7	29·276	62·0	57·0	75	29·220	64·6	57·0	64	·043	0·3	0·1	17, 18, 16, 22
22	54·2	8·5	29·190	57·7	53·9	79	28·953	55·2	54·3	94	·026	0·9	0·2	— 20, 20, 16
23	56·1	4·5	29·330	62·1	55·0	65	29·383	58·9	54·9	79	·240	1·5	0·3	20, 20, 20, 19
24	57·1	5·0	29·624	60·0	54·9	73	29·681	61·1	55·6	72	·080	1·6	0·4	— 20, 20, 20
25	58·3	9·9	29·694	60·1	54·3	70	29·586	62·1	55·5	67		1·1	0·2	18, 18, 18, 18
26	56·2	10·0	29·407	58·7	57·2	92	29·389	61·0	59·2	91	·410	0·6	0·1	16, 16, 15, —
											·187			
28	56·1	9·6	29·373	59·9	55·2	75	29·396	62·1	57·5	77		1·7	0·2	— 20, 22, 20
29	56·5	9·8	29·346	61·4	57·5	80	29·238	58·9	57·0	89	·010	1·7	0·1	— 18, 20, —
30	56·8	7·0	29·234	60·1	55·2	75	29·338	63·1	56·0	65	·200	4·0	1·5	20, 20, 20, 23

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
July 1	57·3	7·9	29·593	58·7	52·5	67	29·645	62·6	55·8	66		2·6	0·8	23, 22, 20, —
2	56·1	6·8	29·518	56·2	54·6	90	29·628	63·4	53·9	54	·082	3·4	1·7	20, 22, 24, 22
3	61·1	5·3	29·804	64·8	57·7	66	....	......	......	......		2·4	0·1	20, — 22, —
5	72·9	7·2	29·653	78·7	69·1	62	29·659	75·4	69·5	75		0·3	0·0	16, — — 8
6	65·6	9·8	29·710	70·0	66·2	82	29·750	70·0	66·8	85		0·2	0·0	— — 6, 4
7	64·6	10·0	29·819	64·3	62·4	90	29·812	70·0	66·2	82	·125	0·2	0·0	— — — 4
8	64·2	8·3	29·873	66·8	60·8	71	29·814	70·0	64·3	74	·020	0·3	0·1	— 6, 4, 4
9	70·0	4·0	29·723	75·7	66·2	61	29·694	74·8	65·3	61		1·8	0·3	— 16, 16, 18
10	59·4	3·7	29·902	62·0	54·5	62	29·931	66·5	65·7	96		0·7	0·1	23, 28, 24, 24
12	64·6	0·0	29·903	66·9	60·1	68	29·888	73·5	65·4	65		0·4	0·0	— — — 16
13	53·3	0·9	29·891	64·6	58·8	71	29·827	73·6	65·5	65		0·4	0·1	8, 8, 9, 12
14	66·3	4·7	29·780	68·2	63·1	76	29·736	76·6	65·5	56		0·6	0·1	— — 14, 15
15	63·0	9·8	29·675	68·9	63·9	77	29·661	65·1	63·1	90	·040	0·4	0·1	— 12, 10, —
16	65·8	8·4	29·669	68·9	63·7	76	29·621	69·2	65·4	82		0·3	0·0	— — — 7
17	63·3	9·1	29·482	68·5	65·3	85	29·459	67·4	64·7	87	·255	0·5	0·1	6, 4, — 20
											·060			
19	62·2	6·7	29·619	67·4	61·9	74	29·639	68·9	61·7	67	·015	0·7	0·1	— 20, 22, 21
20	65·7	7·8	29·627	69·1	64·3	78	29·667	71·5	62·3	61	·030	1·6	0·5	— 18, 20, —
21	63·2	7·2	29·670	66·1	59·2	67	29·672	67·9	62·1	73		1·3	0·2	— 18, 20, 20
22	60·8	7·7	29·736	60·8	57·6	83	29·816	66·1	56·5	55		1·5	0·5	— 24, 26, 24
23	62·8	0·9	29·936	65·3	57·6	63	29·860	70·1	60·1	56		0·9	0·1	20, 14, — 18
24	66·3	5·0	29·749	70·2	63·1	68	29·679	73·9	64·6	61		0·4	0·1	— 18, — 16
26	56·9	10·0	29·646	58·7	58·4	98	29·714	60·3	59·7	97	·083	1·5	1·0	0, 3, 4, 2
27	58·9	6·7	29·916	63·9	60·2	81	29·928	64·0	59·9	79	·024	1·2	0·3	4, 4, 4, 4
28	61·7	4·4	29·941	63·6	59·7	80	29·863	74·2	65·3	62		0·2	0·0	— — — —
29	60·8	9·1	29·903	63·1	59·9	83	29·873	69·3	61·6	65		0·0	0·0	— — — —
30	68·4	8·9	29·849	72·8	66·7	73	29·840	70·2	64·5	74		0·3	0·0	— — 28, —
31	63·6	6·4	29·825	66·7	60·4	70	29·789	69·2	60·4	60		0·4	0·0	26, — — —
Aug. 2	60·3	9·3	29·597	64·0	57·2	67	29·429	64·8	55·2	55		0·5	0·0	— — 20, —
3	55·6	10·0	29·063	58·8	55·5	82	28·932	59·4	57·1	87	·200	1·5	0·2	15, 16, 16, —
4	56·2	2·6	28·987	60·3	55·0	73	29·013	62·1	55·6	68	·510	1·0	0·1	— 20, 20, 20
5	58·7	5·6	29·101	61·8	57·0	76	29·109	67·2	58·6	61		0·4	0·0	— — 18, —
6	56·3	5·0	29·069	64·0	57·5	68	29·002	53·8	53·3	97		0·8	0·0	— — 16, —
7	56·7	5·9	28·919	63·4	57·2	69	28·923	57·3	54·9	87	·175	0·7	0·2	— 18, 18, 18
											·265			
9	57·5	7·4	29·171	61·0	56·8	80	29·170	64·2	57·6	68	·180	1·2	0·0	— — — —
10	57·3	8·6	29·260	62·8	55·8	65	29·262	61·1	57·0	79	·050	0·6	0·1	— 20, 18, 18
11	56·8	6·3	....	......	......	......	29·136	60·2	56·2	79	·146	0·6	0·1	20, — 4, 4
12	54·3	10·0	29·073	56·2	54·8	92	29·151	58·9	55·5	82	1·890	2·9	0·8	1, 31, 0, 0
13	57·1	5·0	29·339	61·0	53·9	64	29·354	64·8	54·5	52	·042	0·8	0·2	24, 4, 0, 30
14	58·6	3·2	29·430	61·8	55·4	68	29·425	66·1	58·2	63		0·4	0·0	— 16, — 6
											·080			
16	57·3	9·8	29·643	63·4	58·6	76	29·557	60·8	58·0	85		1·4	0·1	— 16, 14, 12
17	62·1	9·8	29·491	69·1	62·7	71	29·444	67·1	62·5	79		2·5	0·4	0, 0, 0, 18
18	58·4	5·2	29·483	62·8	56·4	68	29·570	66·1	58·8	66	·256	1·2	0·2	20, 20, 20, 20
19	56·2	10·0	29·821	59·5	56·2	82	29·809	59·5	55·2	77		0·4	0·0	— — 2, —
20	60·2	4·2	29·830	61·4	56·7	75	29·827	67·9	59·7	62		0·2	0·0	— — — —
21	58·6	5·0	30·030	62·6	59·2	82	30·047	67·1	61·1	71		0·2	0·0	— — 4, 6
23	58·9	8·2	30·060	66·9	62·6	79	30·042	60·6	59·0	91		0·1	0·0	— — — —
24	60·6	9·7	29·864	64·0	60·0	80	29·752	67·9	59·8	63	·086	0·2	0·0	— — — 20
25	55·2	8·2	29·546	55·1	53·9	93	29·627	61·1	53·9	63	·794	1·7	0·2	— 0, 30, 1
26	57·3	1·8	29·758	61·8	56·9	75	29·775	66·4	57·8	60		0·4	0·1	— — 15, 20
27	61·6	6·6	29·919	66·0	59·8	70	29·909	71·0	63·9	68		0·3	0·0	— — 20, 18
28	61·2	6·9	29·868	64·4	60·7	81	29·780	67·9	62·7	76		0·3	0·1	— — 16, 16
											·040			
30	56·0	6·0	29·675	61·6	55·9	71	29·642	55·5	53·3	87	·065	0·7	0·3	18, 17, 17, 18
31	54·0	5·9	29·646	58·7	53·1	70	29·654	61·0	54·3	66	·262	1·6	0·3	— 22, 18, 20

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = $10^h\ 10^m$ A.M., Makerstoun Mean Time.				5 P.M., Göttingen = $4^h\ 10^m$ P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20^h, 23^h, 2^h, 5^h.
Sept. 1	57·1	9·5	29·707	60·1	56·0	78	29·743	61·4	57·4	79	·035	2·1	0·4	— 17, 18, 18
2	61·5	9·1	29·968	65·0	59·2	71	29·974	65·4	59·4	70		1·3	0·1	— 20, 21, 20
3	60·5	6·1	29·993	65·1	60·3	76	29·938	68·9	62·3	70		0·3	0·1	— — — 10
4	58·1	4·9	29·941	61·1	58·5	86	29·918	66·5	61·3	75		0·4	0·0	4, — — 14
6	56·6	9·7	29·771	62·0	59·8	89	29·766	57·2	56·4	95		0·1	0·0	— — — —
7	59·0	9·0	29·862	62·0	59·6	87	29·948	63·4	61·9	92	·368	1·0	0·3	— 6, 6, 2
8	59·8	4·1	30·099	63·8	60·7	84	30·092	63·4	60·1	83		1·4	0·6	6, 0, 4, 2
9	57·3	8·2	30·062	60·4	57·4	83	30·007	60·1	57·5	86		0·8	0·3	— 4, 4, 0
10	53·3	9·8	29·906	57·3	54·8	85	29·814	57·2	54·5	84		0·8	0·2	2, 0, 4, —
11	52·6	6·0	29·652	56·2	49·5	63	29·590	56·9	51·8	72		1·6	0·2	— 2, 28, —
											·025			
13	47·1	2·4	29·678	50·3	44·5	64	29·661	55·7	47·1	53	·070	0·8	0·3	31, 30, 30, 25
14	46·0	5·0	29·652	49·0	45·5	78	29·572	50·6	45·7	70		0·5	0·1	— 24, 24, 28
15	41·9	2·8	29·412	48·0	42·9	68	29·341	48·3	44·3	75		0·3	0·0	— — — 4
16	46·2	4·9	29·500	49·3	46·6	83	29·524	56·3	48·7	58		0·5	0·0	— — — —
17	46·2	3·4	29·614	50·5	47·6	82	29·575	55·9	48·5	59		0·3	0·0	— — — —
18	48·0	6·3	29·424	52·0	48·3	77	29·225	57·7	51·3	66		0·1	0·0	— — — —
											·030			
20	45·7	9·2	29·193	51·3	49·1	86	29·146	50·8	49·5	92	·304	0·2	0·1	16, 16, — —
21	41·5	7·4	29·545	48·8	45·3	78	29·775	51·0	43·9	57	·376	4·8	1·5	0, 30, 30, 30
22	50·4	8·9	29·952	52·6	50·3	86	29·986	59·4	55·2	77	·010	1·8	0·4	— 20, 20, 20
23	52·5	9·0	30·109	56·4	54·1	86	30·104	55·7	52·3	80		1·8	0·3	— 20, 22, 20
24	51·2	1·3	....	......	......	......	30·108	57·5	52·5	72		1·5	0·2	— — 20, 20
25	55·5	3·0	29·937	59·8	56·2	81	29·827	60·5	55·8	75		0·8	0·1	— 18, 20, 20
27	42·1	6·4	29·803	46·0	44·3	88	29·718	48·6	44·9	76	·276	0·2	0·0	— — 6, 4
28	50·1	....	....	......	......	......	....	......	......	......	......	4·5	......	— — — —
29	44·3	10·0	28·938	46·3	44·9	91	28·957	47·8	45·9	87	1·025	7·5	1·3	0, 31, 0, 30
30	44·0	10·0	29·061	48·8	45·3	78	29·193	45·8	42·3	76	·420	3·0	0·9	25, 28, 28, 28
Oct. 1	41·4	7·2	29·110	46·3	43·6	82	29·082	42·6	41·9	95	·128	0·5	0·2	20, 20, 20, 20
2	40·5	7·2	29·061	43·5	41·8	88	29·103	44·6	43·1	90	·158	0·8	0·1	— 31, 28, 28
											·150			
4	43·4	5·9	29·386	45·8	43·3	83	29·042	47·0	45·3	89	·070	4·0	0·0	— — — —
5	45·3	10·0	28·739	47·3	45·5	88	28·934	46·3	44·5	88	·610	4·8	0·8	0, 0, 30, 30
6	44·3	6·0	29·348	47·6	43·5	73	29·344	48·4	43·3	68	·020	0·6	0·1	18, — 20, 26
7	40·2	3·0	29·544	43·2	37·5	60	29·659	42·0	37·6	68		3·5	1·0	24, 28, 30, 30
8	39·1	2·2	29·686	40·0	34·9	62	29·684	44·8	39·5	64		1·7	0·5	28, 28, 30, 28
9	42·7	10·0	29·755	45·3	39·6	61	29·624	44·5	42·6	87		0·5	0·0	— — — 18
											·145			
11	45·8	6·9	29·951	49·0	45·3	76	30·032	49·5	46·1	78		0·5	0·1	— — 0, 2
12	42·6	4·9	30·192	44·0	42·3	88	30·172	50·2	47·5	82		0·1	0·0	— — — —
13	46·8	10·0	30·169	49·6	47·6	87	30·144	49·6	46·3	79		0·0	0·0	— — — —
14	45·5	8·9	30·154	48·6	46·1	84	30·135	48·8	46·1	82		0·0	0·0	— — — —
15	43·2	10·0	30·184	44·4	42·3	84	30·137	47·6	45·3	84		0·0	0·0	— — — —
16	46·2	10·0	30·123	48·2	46·3	87	30·112	48·0	45·6	84		0·0	0·0	— — — —
18	43·8	3·7	30·052	48·6	46·8	88	30·060	51·2	48·2	81		0·0	0·0	— — — —
19	50·9	9·6	30·120	52·6	50·3	86	30·060	53·2	49·5	78		1·6	0·2	— 20, 20, 20
20	49·3	5·1	29·941	51·2	47·1	74	29·876	52·2	48·3	76		1·8	0·2	20, 20, 18, —
21	48·0	10·0	29·733	50·8	49·3	90	29·649	50·0	49·1	94		0·5	0·0	— — — —
22	52·6	9·8	29·432	52·0	51·1	94	29·290	57·9	56·2	90	·100	0·2	0·0	— — — 14
23	46·3	7·1	29·381	50·0	47·6	85	29·347	46·3	44·3	86	·056	1·0	0·0	— — — —
											·030			
25	40·2	5·0	29·182	43·3	42·5	94	29·167	45·5	42·3	78		0·0	0·0	— — — —
26	36·0	6·9	29·066	33·4	31·7	86	28·918	43·0	42·9	99		3·5	0·1	— — — 4
27	43·7	10·0	28·938	43·8	42·9	94	29·139	45·6	44·1	90	·484	6·0	2·1	4, 4, 3, 3
38	38·2	9·2	29·530	40·8	38·9	86	29·577	38·2	37·1	91	·430	5·5	1·1	2, 2, 4, 4
29	41·9	9·7	29·578	44·6	41·9	81	29·446	43·0	43·1	100	·330	3·5	0·4	6, 6, 6, 6
30	41·0	7·7	29·359	43·0	42·5	96	29·336	44·3	44·3	100	·326	1·0	0·1	4, 4, — —
											·162			

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky Clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Nov. 1	52·8	10·0	29·299	52·5	50·3	87	29·156	56·1	54·5	91	·032	1·2	0·2	16, 18, 16, —
2	50·9	6·4	29·223	53·3	50·8	85	29·160	52·2	51·6	96		0·7	0·1	18, 20, 20, 16
3	45·8	5·0	29·272	48·2	46·3	87	29·317	46·4	44·3	86	·150	1·0	0·2	22, 20, 22, —
4	42·5	2·3	29·482	46·2	44·9	91	29·503	46·5	43·7	81	·050	0·4	0·0	— — 20, 19
5	49·3	8·2	29·097	48·5	48·3	98	28·959	53·8	52·1	90	·236	4·0	0·6	8, 8, 16, 14
6	44·6	5·0	29·256	47·8	44·3	77	29·329	45·0	42·9	85	·258	4·0	0·5	18, 18, 18, 18
											·030			
8	40·6	9·7	29·391	52·3	52·1	99	29·548	49·2	45·6	77	·118	8·5	0·1	20, — 22, 24
9	44·1	9·9	29·894	45·0	43·3	88	29·870	45·0	41·9	78	·054	1·5	0·0	— — — —
10	35·4	1·9	29·901	37·3	34·8	79	29·850	38·0	36·1	84		0·2	0·0	— — — —
11	37·4	10·0	29·572	38·3	36·9	88	29·435	39·8	37·5	82	·010	1·5	0·1	— — 4, 4
12	37·8	5·5	29·631	40·0	38·3	87	29·647	38·0	34·1	69	·122	2·5	0·3	4, — 6, 8
13	33·7	10·0	29·472	38·6	38·3	97	29·408	46·6	46·1	97	·070	0·7	0·0	— — — —
											·286			
15	40·5	10·0	29·001	40·6	39·9	95	28·908	42·8	42·6	99	·350	3·0	0·4	4, 4, 5, 4
16	44·3	10·0	28·610	46·3	46·3	100	28·615	46·8	46·7	99	·336	0·5	0·1	2, 2, — —
17	45·5	9·0	28·737	49·0	47·3	89	....	......	......	......	·264	0·4	0·1	— — 18, 18
18	41·9	7·9	28·882	42·6	39·7	80	28·855	43·2	39·9	76		3·7	0·3	20 20, 20, 22
19	40·3	6·7	29·372	39·3	38·6	94	29·305	40·6	38·9	87		1·5	0·1	— — 18, 16
20	38·6	8·2	29·221	40·0	38·9	92	29·173	39·0	38·1	93	·066	3·0	0·1	— 18, 20, —
22	34·9	7·0	28·977	35·0	34·3	94	29·045	36·8	35·3	88		0·0	0·0	— — — —
23	34·1	3·9	29·169	36·5	35·3	91	29·091	34·5	34·3	98		0·0	0·0	— — — —
24	32·0	9·0	29·411	33·8	32·7	90	29·532	33·0	32·6	97		0·2	0·0	— — — —
25	29·7	5·0	29·754	27·7	27·7	100	29·675	33·0	32·3	94		1·0	0·0	— — — —
26	45·6	10·0	28·844	49·8	49·7	100	28·844	46·2	44·3	87	·388	7·0	0·7	18, 16, 20, 20
27	35·6	1·7	29·305	39·8	38·3	88	29·290	40·5	38·3	83	·040	2·0	0·4	20, 18, 20, 20
											·190			
29	35·1	5·4	29·468	35·3	32·3	75	29·566	35·6	31·0	65		0·8	0·2	28, 30, 28, 28
30	26·5	4·9	29·752	24·1	25·4	100	29·691	32·3	......	......		0·2	0·0	— — — —
Dec. 1	39·5	5·7	29·390	41·6	39·8	87	29·469	38·6	37·7	93	·072	1·0	0·3	20, 20, 20, —
2	38·0	3·7	29·470	39·0	36·6	81	29·490	38·2	......	......		0·5	0·1	20, — 20, —
3	36·7	2·2	29·682	38·0	35·7	81	29·698	38·8	36·6	82		0·4	0·1	20, — 20, 20
4	50·0	9·1	29·318	51·0	50·1	94	29·363	51·6	50·5	93	·298	1·0	0·3	22, 22, 24, 20
6	44·2	1·2	29·319	45·6	43·5	86	29·315	45·0	43·1	87	·110	3·8	0·9	19, 18, 20, 22
7	36·9	1·0	29·354	36·8	36·9	100	29·331	37·8	37·3	96		2·7	0·0	— — — —
8	40·5	10·0	29·087	42·6	41·3	91	28·997	40·0	39·9	99	·010	0·6	0·0	— — — —
9	38·4	7·6	29·254	39·3	38·6	94	29·281	40·5	39·9	96	·490	0·2	0·0	— — — —
10	49·0	7·0	28·973	50·6	49·1	91	29·022	46·8	44·1	82	·096	3·8	1·3	18, 20, 22, 22
11	52·8	8·2	29·009	52·4	50·5	88	28·981	57·3	56·3	94	·015	8·0	3·3	22, 20, 21, 20
											·415			
13	34·4	9·6	29·321	32·0	31·9	99	29·260	37·0	36·6	97	·485	0·2	0·0	— — — —
14	40·4	10·0	28·986	40·0	39·9	99	28·860	42·0	41·8	98	·671	2·4	0·2	4, 4, 4, —
15	41·8	10·0	28·675	42·2	42·1	99	28·590	43·0	43·1	100	·698	3·2	0·2	— 6, 4, 4
16	38·7	8·6	29·106	38·8	37·7	92	29·973	39·3	37·9	89	·445	3·2	0·0	— — — —
17	41·6	10·0	28·587	44·8	44·3	97	28·906	39·8	38·3	89	·304	3·5	0·9	— 2, 4, 4
18	33·4	5·2	29·967	32·8	31·6	89	29·983	31·2	30·9	97	·148	3·5	0·0	— — — —
											·060			
20	47·2	9·6	29·163	52·3	51·1	93	29·336	41·0	39·9	92	·020	6·0	1·7	22, 20, 22, 30
21	34·8	1·3	29·751	36·6	35·3	89	29·753	34·2	32·5	85	·100	2·1	0·0	— — — —
22	31·7	8·0	29·671	31·0	30·4	95	29·621	33·2	31·3	84		0·3	0·0	— — — 4
23	37·4	7·2	29·520	37·2	35·8	88	29·466	37·8	36·1	86		2·5	0·3	20, 20, 20, 16
24	43·5	7·1	29·198	43·6	40·9	81	29·211	43·8	41·9	86	·155	3·6	1·9	18, 20, 20, 20
25	39·9	5·2	29·103	41·6	38·5	78	29·227	38·0	36·9	91	·218	9·0	2·1	24, 24, 20, 20
											·200			
27	43·9	9·4	27·887	44·6	43·3	91	28·520	43·2	40·1	78	·725	13·0	5·7	20, 22, 22. 22
28	39·1	0·3	29·061	40·3	37·9	82	29·194	39·2	36·6	80	·012	7·0	1·8	22, 20, 22, 24
29	41·4	9·4	29·291	39·0	36·6	81	28·996	47·8	45·6	86		4·8	1·7	— 18, 18, 16
30	44·7	6·0	29·199	46·2	44·3	87	29·326	44·8	42·5	84	·378	7·5	3·5	20, 20, 22, 22
31	47·3	9·9	29·538	47·8	45·8	86	29·448	48·8	47·3	90		8·0	2·3	20, 20, 20, 22

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
Jan. 1	44°·8	7·4	29·530	43°·6	42°·3	90	29·438	45°·5	43°·5	86	·040	9·0	1·1	20, 20, 20, 20
											·570			
3	39·5	4·6	29·234	39·8	38·1	87	29·331	38·6	36·5	84	·083	3·5	0·5	22, 22, 22, 20
4	48·6	9·1	28·948	50·8	49·3	91	28·868	50·6	49·3	92	·130	6·0	2·2	22, 20, 20, 19
5	39·5	2·7	29·088	41·0	38·5	81	29·204	39·5	37·1	82	·355	3·5	1·5	22, 22, 22, 20
6	36·3	10·0	29·148	36·6	35·3	90	28·836	40·0	39·3	95	·064	3·5	0·5	— 18, 16, 22
7	38·2	6·6	28·588	38·2	36·9	90	28·785	39·4	36·1	74	·070	8·0	1·6	18, 18, 22, 20
8	39·9	6·6	28·901	42·6	41·1	90	28·926	37·8	36·5	89	·048	3·3	0·9	20, 22, 20, 22
10	41·1	10·0	29·272	41·2	39·9	90	29·103	43·0	42·1	93		0·5	0·0	— — — —
11	39·5	6·7	28·815	39·0	37·5	88	28·909	39·8	35·3	67	·270	4·2	1·7	20, 22, 22, 22
12	35·8	7·4	28·914	36·0	36·1	100	29·041	36·6	35·8	94	·130	2·4	0·0	— — — —
13	34·9	10·0	28·885	35·2	35·3	100	28·966	38·4	36·9	88	·182	0·0	0·0	— — — —
14	32·8	4·1	29·465	36·0	33·9	83	29·546	32·8	31·5	88		1·0	0·0	— 28, — —
15	33·7	10·0	29·188	35·0	34·9	99	28·953	33·6	33·6	100	·036	0·4	0·2	12, 16, 10, 10
17	32·6	7·4	29·216	33·2	32·9	97	29·348	31·2	30·4	93	·300	1·5	0·4	4, 2, 2, —
18	30·0	2·6	29·667	25·1	24·6	95	29·600	31·8	31·3	96		0·7	0·0	— — — —
19	41·3	9·0	29·555	40·2	39·7	96	29·307	46·0	44·6	90	·020	4·6	0·3	— 20, 20, 18
20	43·8	7·2	28·907	47·5	47·6	100	29·285	41·8	37·3	68	·648	7·5	1·9	18, 21, 24, 22
21	39·7	6·7	28·978	42·0	40·3	88	28·941	37·8	35·3	80	·042	1·5	0·2	— 22, 26, 22
22	37·0	4·0	29·337	38·2	34·3	69	29·552	38·8	35·5	74		2·5	0·7	30, 30, 30, 2
24	35·0	9·2	30·073	31·6	31·9	79	29·962	36·6	34·3	81		0·3	0·1	— — 18, 18
25	35·8	9·9	29·638	36·8	35·7	91	29·563	36·8	35·9	92		0·8	0·2	15, 16, 15, 8
26	35·4	9·9	29·587	35·3	35·1	98	29·615	37·8	36·9	92		0·2	0·0	— — — —
27	36·2	9·9	29·677	37·3	36·7	95	29·659	38·0	37·3	94	·142	0·2	0·1	4, — 0, —
28	29·0	10·0	29·779	29·1	29·2	100	29·779	29·6	29·6	100		0·0	0·0	— — — —
29	31·0	2·4	29·685	27·9	27·7	97	29·579	34·0	33·3	94	·018	0·3	0·1	— 20, — 20
31	38·6	2·8	29·846	38·2	36·6	86	29·911	42·0	40·3	87		0·2	0·1	22, 22, — 20
Feb. 1	36·2	3·7	29·920	37·0	35·3	85	29·883	37·6	36·3	89		0·7	0·1	4, 24, 20, —
2	37·1	10·0	29·854	37·8	36·5	89	29·745	39·6	37·9	87		0·7	0·1	— — — 18
3	36·7	10·0	29·452	36·8	35·9	92	29·400	34·2	33·5	94	·040	1·0	0·2	— 18, 18, 17
4	34·2	9·9	29·611	35·7	35·3	97	29·657	35·2	34·1	91	·070	1·3	0·2	— — 2, 4
5	35·8	9·4	29·804	37·2	35·1	83	29·779	37·0	35·3	86	·033	1·7	0·2	4, 4, 29, 2
7	32·2	1·5	29·209	32·6	31·3	89	29·158	33·5	32·3	90		0·7	0·1	— 25, 20, 20
8	27·7	10·0	29·080	28·4	28·4	100	29·016	29·1	29·2	100		0·2	0·0	— — — —
9	32·7	10·0	29·029	33·0	32·9	99	28·960	34·0	33·9	99		0·6	0·0	4, 4, 5, 6
10	32·7	10·0	29·258	35·0	33·8	90	29·324	32·2	32·3	100	·480	4·0	0·5	4, 4, 4, 4
11	25·5	7·2	29·404	26·3	26·2	99	29·480	27·1	27·0	99		4·0	0·1	— — 30, 4
12	20·4	4·2	29·459	22·0	22·0	100	29·499	25·7	25·7	100	1·020	0·6	0·2	4, 4, 4, 4
14	28·9	9·9	29·727	31·6	31·6	100	29·703	31·0	31·2	100	·155	0·2	0·0	— — — —
15	31·2	6·5	29·651	31·8	31·8	100	29·682	33·0	32·5	96	·045	1·5	0·3	4, — 2, 2
16	28·8	5·2	29·780	29·4	29·4	100	29·762	32·8	32·1	94		4·2	0·4	17, — 0, 0
17	29·7	4·6	29·627	31·6	31·1	96	29·511	28·1	28·1	100	·438	4·0	1·7	0, 0, 0, 31
18	27·6	6·0	29·482	29·7	27·6	81	29·418	31·0	30·4	94		3·0	0·2	31, 0, 31, —
19	31·1	4·4	29·465	34·3	32·3	83	29·620	31·0	30·4	94		3·5	0·9	4, 4, 0, 0
21	32·6	....	....	......	......	......	....	......	......	......	·621	1·0	......	— — — —
22	35·6	9·2	29·739	37·8	35·3	80	29·750	37·2	34·9	81		1·0	0·0	— — 0, —
23	31·7	7·4	29·335	36·6	33·6	75	29·350	29·1	28·2	92		6·5	2·0	— 0, 1, 0
24	34·7	9·5	29·563	35·0	35·1	100	29·257	37·2	35·3	85		4·2	0·1	30, 28, 25, —
25	32·5	8·1	29·529	33·8	32·3	87	29·525	35·6	33·6	84	·158	3·0	0·5	31, 0, 28, 26
26	31·6	10·0	28·926	32·6	32·7	100	29·113	33·0	32·1	93	·288	9·6	3·8	28, 2, 2, 1
28	29·2	5·7	29·652	33·0	30·2	77	29·578	34·2	32·3	84	·426	0·3	0·1	— — 26, 24

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Mar. 1	34·6	9·4	29·475	36·5	34·6	84	29·473	37·0	36·1	92		0·5	0·1	31, 4, — —
2	34·2	9·7	29·212	37·6	37·1	96	29·326	34·0	33·3	94		4·7	2·2	30, 30, 30, 0
3	31·6	9·3	29·816	33·0	30·4	78	29·807	35·6	32·3	72	·088	1·3	0·0	— — 26, —
4	34·4	9·0	29·754	36·0	32·1	68	29·679	41·0	37·5	74		0·5	0·1	— 23, 26, 22
5	37·2	10·0	29·545	38·6	36·8	86	29·586	41·6	39·3	83		0·3	0·0	— — — —
7	38·5	1·1	29·727	41·2	38·5	79	29·710	46·0	41·3	68		0·2	0·0	17, 20, — 20
8	39·8	6·9	29·577	40·2	37·9	82	29·652	48·2	43·1	68		1·0	0·5	— 20, 22, 24
9	42·3	10·0	29·764	43·0	41·3	87	29·726	46·6	44·3	84	·015	2·5	0·3	21, 20, 20, 20
10	44·4	5·0	29·745	46·5	42·9	76	29·902	51·5	45·3	62		3·2	0·7	22, 22, 22, —
11	42·1	5·7	30·009	45·0	43·1	86	29·960	48·8	44·6	73		1·7	0·1	— — 18, 14
12	34·5	7·0	29·872	35·3	34·1	89	29·779	41·6	38·5	77		0·6	0·1	— — 18, 17
14	37·9	10·0	29·426	40·0	39·9	99	29·389	39·6	39·1	96	·020	1·5	0·2	4, 4, 6, 8
15	35·2	10·0	29·391	36·0	35·6	96	29·393	38·0	37·9	99		1·5	0·4	4, 5, 4, 4
16	33·3	10·0	29·602	35·2	34·7	96	29·659	32·8	32·5	97		1·5	0·2	8, — — 9
17	27·9	8·1	29·802	29·4	28·7	93	29·774	30·9	30·4	95		0·4	0·1	— 4, 6, 12
18	27·3	3·2	29·981	29·4	29·2	98	30·030	32·0	31·3	94		0·5	0·2	— 7, 8, 9
19	32·7	2·7	30·017	34·8	31·5	74	29·951	39·0	34·3	63		0·6	0·2	— 29, 0, 27
21	31·8	6·9	29·715	33·8	31·9	84	29·772	34·6	31·6	76	·150	3·0	1·1	4, 2, 6, 4
22	29·9	6·6	29·865	32·0	31·2	93	29·848	33·0	31·8	89	·020	2·5	0·3	0, 0, 2, 6
23	29·4	1·0	29·854	35·3	30·0	59	29·786	33·6	31·3	82		1·7	0·2	1, 1, 1, —
24	27·5	4·5	29·707	31·6	30·4	89	29·672	30·7	30·4	97	·035	2·0	0·2	2, 2, 2, 2
25	28·4	2·4	29·787	29·1	27·4	85	29·733	37·0	33·5	71		0·2	0·0	— — 16, —
26	36·4	5·5	29·749	35·3	31·5	70	29·689	42·0	35·3	53		0·5	0·0	— — — —
28	42·0	5·9	29·966	44·4	41·3	78	29·955	48·0	43·5	71		0·2	0·0	— — — —
29	42·7	0·4	29·960	44·0	40·3	73	29·842	50·6	44·6	63		0·2	0·1	24, — 20, 18
30	37·2	1·4	29·662	41·2	36·2	64	29·552	44·8	40·3	69		1·0	0·1	— — 18, 12
31	38·7	8·2	29·430	39·2	37·5	86	29·306	48·6	44·3	73		0·5	0·1	— — 16, 17
April 1	41·9	9·6	28·603	45·0	42·9	86	28·588	43·6	41·3	84	·020	5·0	2·2	18, 18, 20, 20
2	44·0	9·7	29·063	48·2	44·1	74	29·197	48·5	44·5	75	·010	5·0	2·2	20, 26, 26, 23
4	46·4	9·8	29·396	51·0	47·3	78	29·355	49·3	46·1	80		1·3	0·2	— 20, 22, 20
5	47·5	1·9	29·405	51·6	45·3	63	29·503	54·5	48·1	64		2·5	0·7	— 26, 22, 22
6	48·1	6·5	29·283	52·3	50·2	87	29·318	53·9	49·3	73		5·7	2·8	24, 22, 23, 24
7	43·0	8·9	29·154	47·6	44·6	81	29·299	43·8	43·1	95		4·0	0·8	22, 23, 28, 1
8	38·5	7·7	29·684	41·0	39·1	85	29·810	42·0	39·1	78	·020	3·3	0·9	1, 1, 2, 2
9	39·3	5·4	30·061	40·3	37·3	77	29·923	42·6	42·3	97		2·0	0·2	— 31, — 24
11	47·9	4·5	29·807	53·0	50·9	87	29·811	52·0	50·3	89		3·2	1·7	26, 24, 30, 30
12	41·2	9·1	29·789	44·8	42·3	82	29·758	45·0	43·3	88		2·0	0·8	0, 31, 0, 2
13	40·1	7·5	29·952	42·3	40·6	87	29·920	47·0	43·7	77		4·0	0·7	4, 4, 3, 2
14	42·3	9·7	29·836	48·0	46·1	87	29·870	43·6	41·6	85		1·6	0·4	30, 31, — 4
15	45·1	10·0	29·890	48·6	44·7	75	29·850	48·6	47·1	90		0·5	0·0	— 4, — —
16	47·0	10·0	29·823	50·8	48·1	82	29·754	52·0	49·3	83		1·0	0·2	25, — 24, 24
18	52·0	8·6	29·769	56·9	53·3	80	29·752	53·8	50·6	81		2·3	0·3	22, 22, 22, 20
19	45·9	10·0	29·546	50·8	47·6	80	29·448	48·2	45·5	82		2·0	0·9	22, 20, 20, 21
20	43·0	2·4	29·562	46·0	40·7	65	29·504	51·2	43·1	52		1·2	0·3	31, 0, 0, 3
21	38·9	4·2	29·385	44·0	39·9	71	29·374	42·0	38·9	77		0·6	0·3	10, 8, 8, 9
22	38·8	7·6	29·363	42·6	38·3	69	29·395	43·8	38·5	64		0·7	0·3	6, 6, 6, 8
23	42·5	10·0	29·481	47·6	43·3	72	29·456	47·0	41·3	63		1·3	0·6	20, 20, 23, 28
25	36·0	8·7	29·310	38·0	37·3	94	29·412	40·8	39·3	88	·010	1·8	0·4	4, 5, 4, 4
26	38·2	9·1	29·536	42·8	39·6	77	29·555	43·8	39·7	71	·020	2·2	0·9	0, 2, 2, 2
27	39·8	8·5	29·569	43·2	39·6	75	29·557	43·6	40·3	77		1·5	0·2	— 22, 20, —
28	43·6	7·3	29·636	48·8	45·1	76	29·636	46·8	43·3	77		1·0	0·1	— — 22, 12
29	42·2	5·2	29·586	50·8	43·1	54	29·526	47·4	41·3	61	·006	2·0	0·4	24, 12, 14, 12
30	42·2	9·3	29·470	45·2	41·6	75	29·477	52·2	46·6	67		0·8	0·0	14, — — 12

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
May 2	44·2	9·3	29·784	45·8	44·5	91	29·770	47·6	46·3	91		1·6	0·8	6, 6, 12, 8
3	43·5	10·0	29·809	46·0	45·6	97	29·880	46·0	45·3	95		2·8	0·5	10, 10, 10, 10
4	48·7	7·3	30·083	50·3	48·5	88	30·094	58·1	49·9	57		0·6	0·2	— 10, 10, 15
5	50·4	....	....	......	......	......	....	......	......	......		0·5	0·5	— — — —
6	43·5	10·0	29·887	48·0	44·1	74	29·825	45·0	41·3	74		1·2	0·5	6, 6, 4, 6
7	36·8	6·0	29·513	40·6	35·1	60	29·481	39·4	36·7	79		6·0	1·7	2, 2, — 2
9	36·4	7·6	29·451	39·0	37·3	87	29·483	43·0	38·9	71		1·7	0·5	— 4, 4, 4
10	39·6	7·1	29·684	42·8	36·6	56	29·731	44·0	39·6	69		1·5	0·3	4, 2, 2, 4
11	41·8	9·7	29·754	41·5	39·5	85	29·736	51·6	47·1	73		2·7	0·7	— 22, 24, 24
12	43·5	5·1	29·970	47·0	42·5	70	29·994	46·3	41·3	66		1·3	0·3	6, 8, 10, 10
13	43·7	6·2	30·106	46·8	42·3	70	30·072	49·0	44·3	70		2·0	0·7	8, 8, 8, 9
14	47·4	7·9	29·988	50·8	46·9	76	29·961	51·5	47·3	74		1·8	0·2	6, 8, 12, 14
16	47·6	8·0	29·747	56·2	46·7	49	29·726	50·0	46·1	75		1·9	1·0	10, 10, 12, 10
17	48·1	2·6	29·717	53·6	49·1	73	29·765	53·8	47·1	61		1·2	0·4	7, 9, 14, 10
18	49·4	3·2	29·787	49·9	46·6	79	29·728	61·6	52·5	55		1·4	0·0	— — 2, —
19	53·0	1·0	29·767	58·1	50·5	60	29·755	57·7	49·1	54		0·4	0·2	— 8, 6, 6
20	50·7	4·6	29·870	51·8	45·6	63	29·832	64·4	55·6	58		0·3	0·0	— — — —
21	54·8	0·6	29·896	60·6	51·3	52	29·888	62·2	52·9	54		1·0	0·1	— — 12, 12
23	52·7	0·0	30·047	55·9	48·9	61	29·988	61·0	56·2	75		0·5	0·1	— — 4, 4
24	56·0	0·0	....	......	......	......	29·904	65·9	54·6	48		0·5	0·3	— — 7, 12
25	56·5	3·6	29·685	61·0	53·6	62	29·585	64·7	53·5	46		1·6	0·4	— 10, 10, 11
26	55·5	9·9	29·417	60·4	54·8	71	....	......	......	......		0·2	0·0	— — — —
27	55·1	10·0	29·494	56·5	51·7	73	29·479	57·7	53·9	79		0·4	0·0	— 8, — 6
28	52·5	8·0	29·374	57·7	51·7	68	29·384	51·6	50·6	94		0·4	0·1	22, 22, 20, —
											·001			
30	49·3	10·0	29·916	50·5	49·6	94	29·950	54·3	51·6	84		0·6	0·2	2, 4, 2, —
31	48·9	5·6	29·979	51·3	49·7	90	29·917	56·3	52·7	80		0·6	0·1	— — 6, 2
June 1	53·5	4·2	29·878	57·2	53·3	78	29·851	62·1	53·6	58		0·5	0·1	— — 8, 6
2	47·3	10·0	30·040	50·6	47·1	78	30·040	53·8	47·3	62		1·0	0·4	4, 4, 4, 5
3	52·2	9·0	30·039	54·1	48·3	66	29·927	58·8	51·6	61		0·4	0·1	— — — 4
4	50·6	7·4	29·879	53·8	48·5	69	29·808	55·3	49·5	67		0·7	0·2	1, 8, 4, 6
6	57·7	9·9	29·655	64·8	58·4	69	29·692	60·3	55·8	76		0·3	0·0	— — — 20
7	58·6	3·4	29·795	62·6	55·2	63	29·783	65·4	57·5	62		0·3	0·0	— — — 8
8	65·2	1·1	29·809	67·9	57·2	52	29·729	74·6	60·7	45		1·0	0·2	— 16, 20, 20
9	60·0	10·0	29·759	63·1	60·1	85	29·733	63·8	61·1	86		0·6	0·1	14, 12, 14, —
10	59·4	9·6	29·743	64·8	60·1	77	29·698	66·2	......	......		0·0	0·0	— — — —
11	55·9	10·0	29·581	59·6	56·4	83	29·577	55·9	54·8	94	·202	0·5	0·1	1, — — 24
											·570			
13	53·5	7·4	29·662	55·7	54·1	90	29·699	59·6	55·4	78		0·9	0·3	4, 7, 6, 6
14	61·4	1·6	29·708	64·8	58·7	70	29·628	70·6	59·0	50		0·6	0·1	— 22, 24, 24
15	57·8	9·4	29·703	59·8	55·4	77	29·739	57·7	54·7	83		0·5	0·1	— — 7, 6
16	58·4	7·4	29·793	62·0	51·3	48	29·772	65·0	55·6	56		0·6	0·1	— 18, 22, 22
17	57·7	8·1	29·724	57·5	55·2	87	29·682	64·8	57·5	65		1·4	0·4	20, 16, 20, 18
18	57·4	9·8	29·544	60·8	51·7	55	29·511	65·0	58·1	67		2·6	1·3	20, 20, 18, 18
20	53·8	10·0	29·377	57·7	55·2	86	29·412	54·3	53·1	92	·235	1·2	0·1	— — — 1
21	48·5	8·8	29·589	62·6	57·8	76	29·610	64·0	60·3	81		2·3	0·8	— 3, 2, 4
22	56·0	....	....	......	......	......	....	......	......	......	......	1·5	0·2	— — — —
23	63·7	5·6	29·621	69·1	62·7	71	29·588	68·5	68·3	99		0·6	0·2	— — 1, 4
24	50·9	10·0	29·516	50·6	50·1	97	29·500	50·6	49·6	93	·258	1·0	0·1	— 2, 2, —
25	54·3	7·1	29·427	57·4	50·1	61	29·377	62·8	55·4	64	·230	0·4	0·2	28, 25, 0, —
27	57·1	9·6	29·125	62·0	56·2	71	29·135	60·8	56·4	77	·405	2·6	0·7	20, 22, 21, 20
28	58·8	7·2	29·278	62·4	57·0	73	29·170	62·0	58·4	82		1·5	0·4	22, 20, 22, 28
29	55·4	7·4	29·048	57·1	54·5	86	29·161	59·7	56·5	83	·410	7·8	1·8	21, 19, 18, 20
30	56·6	8·1	29·312	59·6	55·4	78	29·276	62·1	56·4	71		3·2	0·7	18, 19, 16, 24

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
July 1	54·2°	9·2	29·319	56·9°	52·3°	75	29·369	57·5°	54·3°	82	·355	2·2	0·6	20, 21, — 24
2	52·8	9·7	29·724	56·1	51·7	75	29·806	57·9	51·5	65	·030	0·8	0·5	24, 25, 28, 24
4	57·2	10·0	29·685	59·9	58·5	92	29·635	59·9	57·7	88	·010	3·0	0·9	18, 20, 20, 18
5	59·9	10·0	....	......	......	......	....	......	......	......	·038	3·8	0·2	— 18, — —
6	58·7	8·1	29·567	63·0	58·8	79	29·556	61·6	57·8	80	·098	1·3	0·4	20, 20, 18, 20
7	59·4	9·2	29·623	64·1	59·5	77	29·651	63·8	57·4	69		1·3	0·7	20, 18, 21, 26
8	56·2	8·8	29·864	58·5	56·2	87	29·877	62·6	59·4	83		0·9	0·3	6, 6, 8, 9
9	57·0	10·0	29·871	61·1	59·2	90	29·824	57·9	54·1	79	·020	0·8	0·4	8, 8, 14, 16
											·178			
11	58·9	9·4	29·620	65·0	58·8	70	29·649	62·0	58·0	80		1·2	0·7	20, 18, 24, 18
12	57·3	9·9	29·745	63·1	55·2	61	29·734	58·9	56·2	85	·080	0·5	0·0	22, — — —
13	58·3	7·5	29·649	60·8	55·4	72	29·567	62·8	57·1	72	·150	0·7	0·1	— 8, 8, 6
14	51·6	10·0	29·242	52·7	51·5	93	28·978	54·9	54·5	97	·770	5·8	1·5	4, 0, 0, 2
15	53·0	10·0	....	......	......	......	28·957	57·8	55·3	86	·060	1·7	0·2	— — 10, 20
16	54·6	8·1	29·183	55·6	51·5	77	29·204	58·9	54·2	75	·180	3·3	0·7	16, 20, 16, 16
											·170			
18	55·9	9·1	29·452	57·4	56·4	94	29·470	57·8	56·1	90	·292	1·4	0·2	20, 20, — —
19	57·2	9·0	29·672	57·6	54·4	82	29·697	66·2	59·8	69		0·0	0·0	— — — —
20	58·2	7·6	29·582	61·4	56·9	77	29·520	59·9	57·3	86		2·9	0·4	20, 20, 20, 20
21	58·7	....	....	......	......	......	....	......	......	......		1·6	......	— — — —
22	55·9	....	....	......	......	......	....	......	......	......		0·4	......	— — — —
23	57·8	5·8	29·643	59·9	55·1	75	....	......	......	......		1·4	0·4	22, 20, 16, —
											·175			
25	55·6	....	....	......	......	......	29·306	57·6	55·4	88		3·0	......	— — — 22
26	55·2	8·5	29·296	58·5	54·3	76	29·352	56·4	53·8	85	·210	3·2	0·7	20, 20, 22, 22
27	54·7	9·4	29·509	56·3	54·3	88	29·534	60·3	56·3	79	·022	2·6	0·6	20, 20, 20, 20
28	56·4	9·4	29·545	58·4	55·0	82	29·521	62·4	57·1	73		1·2	0·1	26, 26, 24, 22
29	53·9	10·0	29·455	56·2	54·2	88	29·316	57·4	55·3	88		3·4	0·4	— 18, 16, 18
30	53·2	10·0	29·285	56·5	53·2	82	....	......	......	......	·038	2·6	0·7	22, 22, 22, —
Aug. 1	......	....	....	......	......	......	....	......	......	......	·108	0·8	......	— — — —
2	55·5	7·6	29·662	58·2	52·9	71	29·707	65·0	60·0	75		0·7	0·0	— — — —
3	54·5	9·2	29·777	58·7	53·0	69	....	......	......	......		0·6	0·0	— — — —
4	......	....	....	......	......	......	....	......	......	......		0·5	......	— — — —
5	......	....	....	......	......	......	....	......	......	......		0·6	......	— — — —
6	......	....	....	......	......	......	....	......	......	......		0·6	......	— — — —
8	......	....	....	......	......	......	....	......	......	......		0·2	......	— — — —
9	60·0	9·2	29·903	63·8	60·9	85	30·010	64·8	62·1	86		0·8	0·0	20, — — —
10	57·8	2·7	30·121	61·0	56·6	77	30·080	64·8	61·1	81		0·0	0·0	— — — —
11	58·0	5·4	30·112	62·4	58·8	81	30·052	65·4	62·9	87		0·7	0·0	— — 4, —
12	57·1	9·0	30·109	61·3	56·5	75	30·081	61·0	57·8	83		0·5	0·0	— — — 4
13	53·2	10·0	30·071	55·3	52·9	85	30·029	55·9	54·6	92		0·5	0·1	— — 6, 6
15	54·9	10·0	29·810	59·4	57·2	87	29·759	58·8	57·4	92		0·2	0·0	— 21, 8, —
16	56·6	9·5	29·512	61·4	58·4	84	....	......	......	......		0·2	0·1	— 12, 11, —
17	52·4	6·3	29·502	54·6	52·3	87	29·541	56·9	53·9	83	·050	0·9	0·4	4, 2, 2, 2
18	55·8	9·8	29·630	57·9	54·9	83	29·598	63·0	59·7	83		0·5	0·0	— — — 19
19	59·8	6·1	29·572	64·1	61·1	85	29·544	63·3	60·9	87	·015	2·5	0·4	19, 20, 20, 18
20	59·5	5·7	29·469	63·0	61·3	91	29·475	64·1	61·4	86		2·5	0·9	— 20, 18, 18
22	56·5	5·7	29·581	62·8	59·6	84	29·592	61·4	59·3	89		1·1	0·6	18, 20, 24, 18
23	53·6	3·6	29·575	57·9	54·3	80	29·513	62·3	58·0	78		0·7	0·1	— 26, — 22
24	53·6	1·8	29·587	57·1	55·0	88	29·530	62·4	59·0	82		0·7	0·1	— 27, — 28
25	53·3	10·0	29·415	57·4	56·4	94	29·314	59·4	57·2	88	·042	1·7	0·3	— 13, 16, 16
26	56·9	6·1	28·891	62·2	58·8	83	28·706	60·0	58·2	90	·420	1·6	0·6	— 15, 18, 10
27	54·7	9·0	28·745	55·2	54·8	97	28·825	62·4	56·2	69	·697	1·3	0·3	26, 28, 30, —
											·102			
29	53·9	8·9	29·463	56·8	55·0	90	29·497	56·0	52·7	81	·490	0·6	0·2	— — 16, 20
30	52·6	6·7	29·625	59·1	54·2	74	29·562	56·9	53·1	79		1·1	0·0	20, 20, 20, 20
31	50·4	6·6	29·485	55·8	51·3	74	29·501	57·3	52·2	72	·268	0·2	0·0	22, 18, 28, 28

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10^h 10^m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4^h 10^m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20^h, 23^h, 2^h, 5^h.
Sept. 1	° 51·4	7·7	29·584	° 57·3	° 53·9	81	29·575	° 54·9	° 52·5	86		0·8	0·1	20, 6, 6, 6
2	48·4	7·0	29·711	52·3	......	......	29·755	52·2	47·5	71	·270	2·9	1·5	0, 0, 0, 0
3	50·2	9·2	29·989	53·6	49·0	73	30·079	55·3	49·8	69		1·7	0·6	30, 30, 0, 0
5	48·6	0·9	30·289	54·0	49·6	74	30·252	59·5	52·9	65		0·3	0·0	20, 20, 20, 20
6	51·5	2·7	30·230	58·3	53·2	72	30·147	62·2	55·4	65		0·0	0·0	20, 24, 18, 18
7	50·6	2·2	30·064	55·0	52·7	86	....	......	......	......		0·0	0·0	20, 12, — —
8	52·2	7·9	29·810	56·9	53·9	83	29·765	54·8	52·8	88		0·5	0·2	2, 0, 2, 2
9	53·1	10·0	29·658	56·7	53·3	81	29·612	57·7	55·6	88	·055	0·2	0·1	— — 7, 9
10	56·7	7·8	29·625	60·9	57·3	81	29·630	61·8	52·3	53	·020	7·0	0·3	13, 7, 12, 8
12	55·9	8·2	29·715	56·5	54·5	88	29·733	60·2	51·9	57		1·5	0·3	18, 18, 18, 15
13	49·8	9·4	29·741	50·6	49·6	93	29·754	57·5	53·3	76	·686	0·7	0·1	— 20, 24, 24
14	50·0	9·4	29·780	56·6	53·3	81	29·739	56·5	53·3	82		0·7	0·1	— 16, 16, —
15	52·2	7·8	29·891	55·9	53·6	86	29·913	56·9	54·6	86	·030	0·3	0·0	— — — 4
16	49·8	9·7	29·898	52·3	50·0	86	29·819	58·7	56·4	87		0·0	0·0	— — — —
17	55·5	7·2	29·830	60·3	55·4	74	29·839	60·3	57·2	83		1·8	0·1	— 19, 18, —
19	53·4	4·5	29·827	56·9	53·9	83	29·775	56·2	53·5	84		4·0	1·6	20, 18, 16, 20
20	55·9	9·6	29·696	59·9	56·8	83	29·680	60·9	57·5	82		2·8	0·2	20, 20, 19, 18
21	54·4	8·7	29·584	59·7	56·2	81	29·555	56·5	55·2	93		1·8	0·5	— 20, 19, 22
22	53·4	9·9	29·277	59·2	56·0	82	29·256	52·4	51·3	93		3·5	1·1	22, 20, 22, 21
23	45·5	2·5	29·230	51·5	47·1	73	29·191	46·0	43·6	84	·042	4·6	1·9	20, 18, 20, 20
24	46·3	2·2	29·315	51·8	46·5	69	29·358	51·0	45·5	67		3·7	0·5	22, 28, 25, 25
											·150			
26	46·1	2·8	29·370	47·6	42·9	70	29·499	48·6	44·6	75	·510	6·5	1·4	28, 0, 30, —
27	49·3	9·7	29·542	50·7	50·3	97	29·527	54·0	50·5	80		0·8	0·2	— — 23, 22
28	52·7	9·5	29·183	57·3	55·9	92	29·209	54·9	50·5	75		6·8	3·1	22, 20, 22, 20
29	48·8	5·6	29·485	51·6	47·9	78	29·483	51·8	46·7	69	·136	4·8	0·6	26, 21, — 26
30	47·1	3·3	29·595	51·6	46·6	70	29·570	52·2	46·9	69		2·4	0·7	20, 22, 24, 26
Oct. 1	43·4	9·1	29·253	46·0	44·5	90	29·245	45·3	43·1	85	·242	3·8	0·0	— — 22, —
											·024			
3	40·8	1·6	29·744	45·0	42·6	83	29·720	47·3	44·1	79		1·7	0·1	— — 23, 22
4	51·1	9·2	29·116	51·0	49·9	93	29·144	55·3	53·1	87	·022	5·8	1·1	18, 18, 18, 20
5	52·9	....	....	......	......	......	....	.... .	......	......	·020	0·7	......	— — — —
6	48·1	10·0	29·388	49·8	49·8	100	29·373	48·0	47·6	97	·448	2·8	0·6	4, 3, 4, 4
7	50·0	10·0	29·201	51·8	50·8	94	29·216	51·0	50·7	98	·691	2·7	0·1	6, 6, — 8
8	49·6	8·4	29·357	42·2	41·8	97	29·347	51·6	51·3	98	·142	0·4	0·1	— — 4, 4
											·100			
10	49·3	10·0	29·714	51·0	50·9	99	29·792	50·2	49·3	94	·337	0·4	0·1	4, 6, 6, 4
11	47·5	10·0	29·645	49·4	49·1	98	29·641	49·0	48·3	95	·170	0·6	0·2	4, 4, 3, 4
12	46·4	7·7	29·649	50·0	48·9	93	29·645	49·0	47·5	90	·200	0·4	0·0	— — — —
13	46·8	10·0	29·701	48·0	47·7	97	29·700	48·5	46·5	87	·180	0·4	0·2	4, 4, 4, 4
14	47·6	9·4	29·601	49·2	47·3	88	29·461	49·6	47·5	87	·020	0·2	0·1	— 16, 16, 16
15	47·4	8·8	....	......	......	......	29·085	50·5	47·1	79	·070	2·0	0·8	16, — 20, 22
17	41·6	2·3	28·943	45·0	42·3	81	28·910	45·4	42·6	81		1·0	0·1	— 24, — 24
18	39·7	1·9	29·222	42·4	40·3	84	29·199	45·2	42·3	80		0·2	0·0	— — — —
19	40·2	9·6	29·171	44·6	43·6	93	29·112	45·0	45·1	100		0·2	0·1	— — 6, —
20	43·1	1·9	29·278	44·5	42·3	84	29·358	47·0	42·9	73	·135	0·4	0·1	22, 24, 25, 25
21	50·7	10·0	29·129	51·6	49·5	87	29·026	57·2	55·7	92	·040	10·0	1·9	23, 23, 16, 18
22	52·5	4·7	29·185	55·7	52·1	80	29·343	53·6	50·7	83	·302	10·0	3·7	18, 18, 18, 20
											·112			
24	55·2	8·7	29·611	57·3	56·2	94	29·530	57·1	54·8	87	·360	2·1	0·6	16, 16, 16, 16
25	53·7	6·2	29·513	56·7	54·4	87	29·286	56·9	54·5	86	·010	1·1	0·2	18, — 6, 14
26	44·9	10·0	29·557	44·3	44·2	99	29·416	48·8	48·5	98	·185	5·5	0·1	— 14, 4, 4
27	43·9	4·0	29·422	45·3	45·1	99	....	......	......	......	·012	0·8	0·0	— — — —
28	46·6	10·0	29·308	48·2	48·1	99	29·181	48·0	48·1	100	·040	0·2	0·0	— — — —
29	44·0	3·3	29·544	46·3	43·9	84	29·599	46·8	43·5	78	·758	0·8	0·1	— 20, 20, 18
31	48·4	10·0	29·444	49·2	45·7	78	29·436	51·0	47·5	79		5·5	1·5	18, 17, 16, 16

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
Nov. 1	53·7	10·0	29·464	56·2	53·1	82	29·471	53·3	50·4	83	·020	5·2	1·3	17, 17, 20, 16
2	48·6	4·1	29·339	53·3	48·7	73	29·605	48·0	45·3	82		8·5	2·2	14, 18, 20, 20
3	39·7	2·7	29·960	40·3	39·9	96	29·929	45·6	44·5	92		1·0	0·0	— 0, — —
4	47·8	5·5	29·796	50·2	49·3	94	29·749	50·0	47·5	84	·068	0·0	0·0	— — — —
5	45·5	10·0	29·688	47·0	45·3	88	29·636	46·9	45·5	90		0·9	0·2	20, 12, 13, 14
7	49·2	8·4	29·994	50·3	48·3	87	30·022	50·2	46·9	79	·010	0·5	0·1	— — 22, 22
8	46·3	6·0	29·814	51·6	50·5	93	30·016	42·6	39·3	76	·030	4·8	1·7	18, 19, 22, 24
9	44·7	7·8	30·212	47·6	42·6	67	30·155	44·6	42·3	83		1·7	0·3	20, 20, 20, 20
10	46·8	10·0	30·034	47·5	45·3	85	....	......	......	......		2·0	0·5	22, 21, — —
11	41·4	4·7	30·084	45·2	42·7	82	30·122	41·2	38·9	82		1·2	0·1	— 22, 22, —
12	36·1	1·9	30·131	39·0	38·1	92	29·979	39·2	38·9	97		0·4	0·0	— — 20, —
14	34·9	7·6	29·550	36·8	36·3	96	29·507	36·6	36·1	96		0·0	0·0	— — — —
15	33·5	3·2	29·459	35·2	34·3	92	29·455	34·6	33·5	90		0·0	0·0	— — — —
16	35·3	10·0	29·506	36·5	36·1	96	29·464	38·2	37·9	97	·164	0·0	0·0	— — — —
17	29·3	0·2	29·605	31·2	31·0	98	29·624	30·7	30·4	97		0·0	0·0	— — — —
18	40·4	8·3	29·584	40·6	39·5	91	29·610	41·8	40·7	92		1·8	0·2	18, 17, — —
19	48·0	9·5	29·536	48·3	46·6	88	29·456	50·2	47·9	85		4·5	1·8	18, 19, 18, 18
											·120			
21	30·5	3·2	30·130	30·7	31·6	100	30·131	35·8	35·5	97		0·0	0·0	— — — —
22	32·7	3·2	30·086	33·6	32·3	88	29·993	35·3	34·1	89		0·0	0·0	— — — —
23	29·6	3·0	29·976	30·5	30·4	99	29·957	31·8	31·2	94		0·0	0·0	— — — —
24	34·6	10·0	29·673	36·0	34·7	89	29·708	35·9	34·9	91	·040	3·2	0·3	18, 16, 18, 18
25	35·4	9·6	29·734	35·2	34·3	92	29·570	37·9	36·3	87	·310	3·7	0·7	— — 17, 18
26	32·2	3·5	29·740	33·0	32·1	92	29·835	33·2	33·1	99	·042	3·6	0·0	— — — —
28	38·7	5·2	29·803	42·3	41·5	94	29·834	37·8	37·3	96		0·4	0·0	— — 18, —
29	46·3	10·0	29·452	46·8	45·3	90	29·458	47·6	47·1	97	·090	4·2	1·3	16, 17, — 19
30	38·3	2·1	29·777	40·3	39·3	92	29·875	38·6	36·9	86		1·0	0·1	16, 18, — —
Dec. 1	45·2	9·3	29·729	49·0	47·9	92	29·732	49·3	47·1	86		1·5	0·2	— 16, 20, 20
2	36·7	10·0	29·744	38·9	38·9	100	29·703	36·8	36·9	100		0·0	0·0	— — — —
3	33·5	3·8	29·732	32·6	32·1	95	29·718	39·5	39·1	97		0·0	0·0	— — — —
5	39·1	10·0	29·660	39·8	39·3	96	29·679	40·6	39·6	92		0·5	0·1	18, 18, 20, 22
6	28·3	0·4	29·920	27·7	27·8	100	29·941	29·9	30·0	100		0·0	0·0	— — — —
7	30·2	7·2	29·914	27·1	27·4	100	29·857	34·8	33·9	91		0·0	0·0	— — — —
8	36·0	6·8	29·962	40·6	40·3	97	30·063	33·0	32·3	93		0·0	0·0	— — — —
9	28·8	0·3	30·305	28·3	28·2	99	30·308	29·3	29·4	100		0·0	0·0	— — — —
10	28·0	2·2	30·278	25·4	25·4	100	30·286	38·8	38·9	100		0·1	0·0	— — — —
12	31·7	10·0	29·729	32·0	31·0	91	29·669	31·1	30·4	94		1·3	0·2	14, 12, 14, —
13	28·9	7·6	29·555	26·8	26·6	97	29·411	32·0	31·9	99		0·3	0·0	16, — — 16
14	40·4	10·0	29·330	41·6	40·3	90	29·370	39·8	38·9	93	·222	1·8	0·3	6, — 5, 4
15	38·6	9·9	29·425	38·6	36·3	82	29·387	39·0	36·1	77		3·0	0·6	2, 4, 3, 2
16	36·5	9·9	29·313	37·7	37·5	98	29·355	35·8	35·6	98	·142	1·8	0·2	2, 6, 1, 30
17	33·4	10·0	29·567	34·0	34·1	100	29·564	34·6	34·5	99	·168	0·2	0·0	— — — —
19	34·4	9·8	29·520	36·6	35·1	88	29·594	36·2	34·9	89		0·5	0·1	4, 6, 8, 4
20	38·5	9·7	29·800	38·8	38·3	96	29·840	38·8	38·3	95		1·7	0·4	4, 4, 2, 4
21	38·1	9·6	30·068	38·3	36·4	84	30·086	36·5	35·9	95	·330	2·1	0·5	4, 4, 4, 2
22	35·4	9·2	30·208	33·0	32·3	93	30·164	36·8	35·6	89	·108	1·2	0·1	— 1, 1, —
23	39·0	9·0	29·867	40·1	38·9	90	29·879	38·8	37·5	89	·100	3·0	0·6	29, 0, 2, 0
24	36·9	10·0	30·126	35·7	35·5	98	30·127	39·0	37·7	89	·122	3·0	0·1	— 16, 20, 20
26	32·7	6·2	30·001	34·8	33·1	84	30·029	32·6	30·6	83	·072	2·0	0·2	— 28, 28, 28
27	28·4	4·1	29·802	28·9	28·6	97	29·864	28·2	28·2	100		3·1	1·3	28, 2, 29, 1
28	31·4	6·0	30·015	30·7	30·6	99	30·072	33·6	33·3	98		3·3	0·7	28, 30, 1, 4
29	24·2	3·0	30·060	20·6	20·5	99	29·813	28·3	27·6	94	·250	0·5	0·2	16, 16, 17, 20
30	29·7	2·3	29·455	29·1	28·0	90	29·461	29·1	28·7	96		2·5	0·8	31, 28, 28, 28
31	23·7	0·8	29·369	26·7	26·0	93	29·288	24·8	24·7	99		1·2	0·2	20, 28, 28, 28

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10^h 10^m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4^h 10^m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20^h, 23^h, 2^h, 5^h.
Jan. 2	17·3	3·4	29·009	19·0	18·2	91	29·019	19·8	19·5	96		2·0	0·0	— — — —
3	9·6	0·6	29·267	8·2	7·7	93	29·306	12·2	12·3	100		0·0	0·0	— — — —
4	34·1	5·0	29·230	34·2	31·9	81	....	......	......	......		0·2	......	— — — —
5	31·0	10·0	28·899	31·3	31·0	97	28·868	31·1	31·4	100		5·0	2·9	6, 6, 6, 6
6	31·1	10·0	28·880	32·1	32·0	99	28·888	31·1	31·4	100		2·0	0·3	6, 4, — 6
7	28·3	10·0	28·898	22·5	22·8	100	28·703	36·0	35·3	94		0·0	0·0	— — 6, 6
9	33·6	10·0	29·135	34·8	34·5	97	29·184	33·3	......	......	1·670	2·2	0·2	4, 4, 4, 2
10	32·1	10·0	29·550	32·6	32·0	95	29·660	33·6	32·1	87		3·0	0·9	2, 4, 2, 2
11	25·1	9·0	29·821	28·3	27·4	92	29·780	26·3	......	......		1·6	0·1	16, — 20, 18
12	25·6	6·2	29·524	23·2	......	......	29·315	32·6	32·3	97	·378	0·5	0·1	16, — 16, —
13	31·5	6·2	29·334	31·1	30·7	97	29·302	32·8	31·9	93		0·6	0·1	— — 16, 16
14	30·5	2·7	29·354	32·0	31·9	99	29·415	30·1	......	......		0·6	0·0	— — — —
16	31·2	7·5	29·551	27·3	27·4	100	29·462	35·6	34·1	87		0·4	0·3	12, — — 16
17	42·7	3·2	29·400	42·5	40·6	86	29·548	43·3	41·9	90	·090	3·8	1·0	24, 18, 20, 23
18	45·3	10·0	29·684	48·3	47·6	95	29·722	36·3	36·3	100		3·2	1·0	19, 20, 17, 18
19	43·6	3·4	29·686	45·0	43·3	88	29·554	45·0	41·5	76		2·0	0·4	15, 18, 16, 16
20	45·2	6·7	29·494	44·8	43·1	88	29·418	......	......	......		3·0	0·5	16, 17, 16, 15
21	43·6	9·7	29·879	41·3	40·5	94	29·687	47·0	45·9	92	·173	3·2	0·8	16, 14, 15, 15
23	41·9	5·2	29·717	40·2	38·5	86	29·536	43·3	41·9	90		3·3	0·4	— 16, 17, 16
24	41·3	7·5	29·054	43·6	42·3	91	29·153	39·0	36·6	81	·320	5·5	1·0	16, 17, 18, 19
25	43·9	9·5	29·543	38·0	35·3	78	29·326	46·0	45·8	98		5·5	1·7	18, 17, 17, 18
26	37·3	6·5	29·729	38·8	36·0	77	30·007	36·5	33·5	75	·290	4·0	1·2	18, 18, 22, 22
27	47·2	10·0	29·774	47·6	46·3	91	29·643	47·8	46·1	89	·042	5·0	3·7	17, 18, 20, 18
28	37·9	4·1	29·737	39·9	38·2	86	29·784	38·2	35·6	79		5·2	0·2	18, 18, 22, 21
											·180			
30	50·0	9·7	29·575	50·0	47·3	83	29·544	53·3	49·3	77		7·2	2·3	17, 23, 20, 20
31	44·1	6·2	29·736	44·6	41·6	79	29·659	42·6	40·9	87		4·5	1·0	18, 18, 23, 18
Feb. 1	39·0	9·4	29·634	45·6	37·5	47	29·684	37·6	34·3	74	·100	3·8	0·3	— 24, 28, 33
2	36·6	0·2	29·987	38·7	36·0	78	30·041	......	......	......		1·9	0·1	— 20, — 20
3	35·2	3·0	30·125	36·0	35·3	93	30·063	38·2	37·3	92		0·7	0·0	— — — —
4	34·8	7·0	29·696	35·6	33·5	82	29·436	38·0	34·9	75		2·7	0·3	— 18, 16, 16
6	50·6	7·4	29·464	51·8	46·6	69	29·454	52·8	48·6	75	·040	7·0	2·7	23, 23, 22, 22
7	36·6	0·7	29·586	39·8	35·8	69	29·605	38·0	35·1	77	·110	4·2	0·8	20, 20, 20, 25
8	36·8	0·7	29·676	36·6	33·6	75	29·761	39·3	35·3	69	·092	3·2	1·6	24, 25, 28, 26
9	37·1	4·5	29·878	38·6	33·3	61	30·017	37·6	33·3	67		3·8	1·4	28, 27, 26, 31
10	35·4	9·9	30·193	37·0	33·6	73	30·189	36·6	33·6	75		1·3	0·2	28, 28, 28, 28
11	32·3	8·2	30·047	32·3	31·4	92	29·967	37·2	35·8	88		0·2	0·1	— 20, 18, 18
											·040			
13	37·5	9·4	30·334	38·0	36·3	86	30·319	41·8	38·9	78		0·2	0·1	20, 20, 20, 22
14	42·8	10·0	30·184	42·2	40·3	85	....	......	......	......		2·6	0·3	20, 19, — —
15	34·6	7·2	29·832	34·3	29·7	63	29·826	34·0	29·7	65		2·5	0·4	31, 0, 30, 28
16	36·6	9·2	29·734	33·0	31·9	91	29·598	44·8	42·3	83		1·3	0·2	— 20, 17, 20
17	37·6	6·5	28·950	42·2	39·5	80	28·830	32·6	31·4	90		6·4	1·2	18, 20, 24, 20
18	32·0	1·1	29·301	32·0	30·2	85	29·466	34·3	31·5	78		7·0	4·2	29, 28, 28, 28
20	44·3	8·9	29·541	48·2	46·3	87	29·710	46·2	42·1	73		1·8	0·6	22, — 28, 30
21	35·9	6·5	30 058	36·5	34·3	81	29·944	41·8	39·3	81		1·6	0·2	— — 16, 20
22	44·3	10·0	29·569	46·0	45·3	95	29·392	48·0	46·5	90	·082	4·0	1·3	16, 16, 19, 20
23	40·2	1·1	30·026	42·0	38·9	77	30·165	44·6	39·5	64	·030	3·0	0·8	20, 25, 24, 23
24	43·9	9·6	29·821	44·6	42·3	84	29·708	51·0	46·5	72		4·8	1·0	20, 22, 18, 18
25	42·0	4·7	30·016	43·6	38·5	64	30·128	45·2	39·3	60		5·0	2·4	24, 28, 26, 23
27	45·6	10·0	29·924	46·8	45·3	89	29·848	46·8	45·1	88		4·0	1·6	20, 18, 20, 18
28	40·2	1·6	29·937	40·8	37·6	75	30·130	43·0	39·5	74	·016	3·5	1·2	22, 26, 20, 22

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10^h 10^m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4^h 10^m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20^h, 23^h, 2^h, 5^h.
Mar. 1	42°·6	3·9	30·324	47°·0	41°·3	62	30·336	45°·0	43°·2	87		2·0	0·8	22, 17, 19, 18
2	39·9	2·7	30·338	43·0	39·9	77	30·287	46·0	41·9	72		1·5	0·3	— — 18, 20
3	44·3	7·9	30·341	45·2	43·6	88	30·375	48·0	46·5	90		1·5	0·4	— — 18, 20
4	35·8	0·1	30·701	36·5	36·1	96	30·626	48·6	43·3	66		0·2	0·1	— — 16, 17
6	35·1	5·1	30·263	33·9	32·3	86	30·174	45·6	43·6	86		0·3	0·1	— — 22, 22
7	41·7	10·0	30·058	43·6	42·7	93	29·998	46·6	45·3	91	·020	1·2	0·4	— 20, 22, 20
8	49·5	8·4	29·778	53·0	48·9	76	29·846	52·0	46·3	65		4·2	1·4	20, 21, 24, 22
9	51·2	9·9	29·709	53·1	51·3	89	29·680	51·0	48·9	87		3·6	1·3	20, 20, 19, 18
10	43·9	5·5	29·492	47·6	43·5	73	29·616	42·2	39·6	81	·035	4·2	0·9	17, 23, 22, 20
11	48·5	9·3	29·549	50·8	48·5	85	29·661	49·3	46·8	84	·023	3·0	1·4	19, 18, 20, 20
13	48·7	9·2	29·530	48·6	45·3	79	29·358	54·0	49·3	73		3·8	1·2	— 18, 16, 16
14	44·7	6·8	29·456	48·0	46·1	87	29·618	48·6	43·8	70	·040	4·3	0·3	— 20, 20, 18
15	47·0	5·1	29·785	51·0	47·7	80	29·736	53·6	49·3	75		1·9	0·6	— 15, 16, 17
16	44·7	8·5	29·609	48·6	46·3	85	29·787	45·6	41·6	73	·025	3·0	0·5	— 19, 24, 22
17	38·4	....	....	......	......	......	....	......	......	......		2·1	......	20, — — —
18	41·8	5·9	29·795	45·5	42·3	78	29·760	46·6	40·3	59	·030	1·6	0·3	— 23, 26, 27
											·180			
20	39·5	10·0	30·299	41·6	39·1	81	30·338	42·3	39·6	80	·030	1·6	0·8	— 2, 4, 2
21	39·9	9·4	30·356	42·0	39·9	84	30·366	42·8	41·3	89		2·5	1·3	2, 2, 2, 3
22	39·1	0·6	30·393	41·6	38·3	75	30·297	48·2	44·6	76		1·3	0·0	— — 9, 10
23	45·1	0·1	30·264	45·8	41·3	69	30·260	59·7	49·9	50		0·0	0·0	— — — —
24	44·1	1·8	30·176	46·3	41·3	66	30·027	52·6	46·9	66		0·8	0·2	— 30, 7, 20
25	44·1	10·0	29·717	46·2	43·3	80	29·629	48·6	44·9	77		1·6	0·5	23, 23, 22, 25
											·212			
27	46·9	8·9	29·860	47·6	43·6	73	29·773	50·2	47·5	83		3·1	0·9	— 18, 22, 20
28	50·3	8·9	30·036	52·6	47·6	70	29·995	53·9	50·2	78		2·2	0·7	20, 22, 18, 20
29	47·6	10·0	29·930	50·0	48·3	89	29·879	50·0	48·1	87		3·0	1·2	20, 20, 20, 20
30	45·6	8·6	29·800	49·0	48·3	95	29·618	49·0	44·9	75	·030	5·5	1·2	— 20, 22, 20
31	44·9	5·8	30·056	47·8	42·9	68	29·928	48·0	44·1	74	·032	4·2	0·6	18, 22, 18, 20
Apr. 1	47·3	7·2	29·793	51·6	48·5	81	29·812	55·5	50·6	72		5·8	1·3	22, 20, 20, 20
3	42·5	4·0	30·274	46·5	41·1	64	30·272	47·0	41·9	66		1·4	0·8	24, 28, 28, 25
4	45·4	4·7	30·142	47·6	42·3	65	30·054	50·8	44·1	59		2·6	0·8	20, 20, 20, 21
5	47·2	6·4	29·972	51·6	46·9	72	30·054	54·2	44·5	46		3·7	0·6	20, 20, 26, 28
6	47·7	9·9	29·960	50·3	46·6	77	29·971	50·8	46·6	74		2·6	0·8	18, 21, 20, 20
7	46·5	9·2	30·101	48·0	44·3	76	30·077	52·5	46·9	66		1·3	0·1	— 24, 22, 21
8	48·4	9·3	29·890	52·3	49·3	81	29·793	51·5	45·3	63		1·4	0·4	20, 16, 21, 22
10	46·6	5·4	30·011	50·8	45·3	66	29·932	54·9	48·3	62		0·2	0·0	— — 23, —
11	44·4	8·9	30·083	48·4	44·6	75	30·123	49·0	45·5	77		0·9	0·2	— 4, 4, 5
12	42·8	2·4	30·312	45·6	41·5	72	30·259	51·2	42·9	50		0·9	0·3	10, 10, 10, 12
13	44·7	7·1	30·263	49·3	44·9	72	30·279	54·9	46·9	55		0·7	0·1	— — 15, 18
14	44·5	3·1	30·056	47·0	41·5	63	29·947	54·7	47·3	58		0·6	0·1	— 4, — 6
15	45·5	0·1	29·907	48·5	41·3	54	29·875	57·8	45·3	37		0·3	0·0	— — 7, 6
17	......	....	....	......	......	......	....	......	......	......		1·0	......	— — — —
18	......	....	....	......	......	......	....	......	......	......		0·9	......	— — — —
19	......	....	....	......	......	......	....	......	......	......		0·8	......	— — — —
20	......	....	....	......	......	......	....	......	......	......		2·5	......	— — — —
21	......	....	....	......	......	......	....	......	......	......		0·8	......	— — — —
22	......	....	....	......	......	......	....	......	......	......		1·3	......	— — — —
24	......	....	....	......	......	......	....	......	......	......		0·3	......	— — — —
25	......	....	....	......	......	......	....	......	......	......		0·0	......	— — — —
26	......	....	....	......	......	......	....	......	......	......		0·1	......	— — — —
27	......	....	....	......	......	......	....	......	......	......	·008	0·5	......	— — — —
28	......	....	....	......	......	......	....	......	......	......		0·3	......	— — — —
29	......	....	....	......	......	......	....	......	......	......	·009	0·5	......	— — — —
											·020			

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
	°			°	°			°	°					
Sept. 1	......	......	......	......	......	......	......	......	......	......		1·5	......	— — — —
2	......	......	......	......	......	......	......	......	......	......		0·9	......	— — — —
4	......	......	......	......	......	......	......	......	......	......		1·0	......	— — — —
5	......	......	......	......	......	......	......	......	......	......		0·2	......	— — — —
6	60·4	0·5	30·113	64·8	59·4	73	......	......	......	......		0·9	0·2	— 23, 20, —
7	58·8	7·9	30·098	65·9	61·1	76	30·078	60·0	58·0	89		0·4	0·1	— — — —
8	53·1	6·2	30·110	55·6	53·3	86	30·092	58·1	52·7	70		0·3	0·2	4, 4, 4, —
9	53·2	0·0	30·000	56·2	51·3	72	......	......	......	......		0·2	0·0	— — 20, —
11	57·2	0·1	29·848	62·1	57·6	77	......	......	......	......		1·5	0·3	17, 20, — —
12	59·0	2·2	29·648	62·3	56·2	69	29·505	67·4	59·2	62		1·0	0·5	20, 18, 18, 19
13	55·7	5·9	29·531	58·9	55·2	80	29·474	61·8	57·2	76	·070	1·4	0·3	20, 18, 18, 19
14	55·3	3·1	29·326	59·9	55·0	74	29·323	58·8	53·5	72	·020	1·8	0·5	18, 18, 18, 18
15	54·7	4·8	......	......	......	......	29·535	59·6	54·6	74		2·2	0·5	20, — 20, 20
16	59·5	7·2	29·364	63·6	61·9	91	29·339	64·3	61·1	84	·120	1·8	0·4	18, 18, 16, 17
											·020			
18	52·1	8·0	29·563	57·3	53·9	81	29·370	56·2	56·2	100	·052	4·0	1·4	18, 18, 18, 16
19	52·6	8·7	29·649	58·5	53·2	72	29·627	54·0	51·6	86	·086	2·2	0·2	20, 22, 20, 20
20	52·1	3·4	29·524	58·7	53·3	71	29·518	51·0	48·9	87	·146	2·8	0·4	22, 22, 20, 21
21	49·5	3·9	29·751	55·0	49·6	69	29·895	53·8	47·7	64	·038	2·8	0·7	21, 28, 28, —
22	48·0	7·5	30·069	52·6	47·3	68	......	......	......	......		0·7	0·1	— 26, — —
23	53·9	10·0	29·867	58·1	54·3	79	29·751	56·7	54·3	86		1·7	0·6	21, 20, 22, 18
											·180			
25	50·3	7·5	29·989	52·6	48·3	74	30·037	54·9	51·3	79	·050	1·6	0·3	22, 25, 24, 22
26	53·2	3·7	30·024	57·5	52·9	74	30·008	58·0	53·9	77		1·5	0·5	— 18, 20, 21
27	52·8	4·6	30·056	55·9	52·9	82	30·015	59·9	56·5	81		1·6	0·3	17, 17, 18, 18
28	50·3	7·2	29·936	53·8	51·9	88	29·872	62·8	55·8	65		0·2	0·0	— — — —
29	51·4	2·9	29·880	56·3	53·3	83	29·889	57·5	54·1	81		0·6	0·1	— 22, 22, 20
30	53·7	6·6	29·886	57·9	54·3	80	29·907	59·5	55·6	79		1·3	0·6	20, 20, 21, 22
Oct. 2	55·0	9·6	......	......	......	......	29·570	55·9	52·3	79		1·3	0·4	22, — 18, 20
3	49·1	1·2	29·508	50·6	44·9	66	29·628	48·0	41·3	58	·035	3·8	1·1	28, 27, 29, 26
4	......	......	......	48·0	43·5	......	......	......	......	......		1·9	......	— — — —
5	......	......	......	......	......	......	......	......	......	......	·268	2·4	......	— — — —
6	......	......	......	......	......	......	......	......	......	......	·165	1·2	......	— — — —
7	......	......	......	......	......	......	......	......	......	......	·095	0·7	......	— — — —
9	......	......	......	......	......	......	......	......	......	......	·020	0·4	......	— — — —
10	......	......	......	......	......	......	......	......	......	......	......	2·0	......	— — — —
11	46·1	2·1	29·848	51·4	46·3	69	29·977	49·6	45·5	74	·160	2·0	0·1	— 23, 22, 24
12	43·4	2·2	30·298	47·0	44·1	80	30·240	49·0	47·3	89		3·0	0·1	— — 19, —
13	51·7	10·0	30·098	53·2	51·3	88	30·050	55·0	53·3	90		0·8	0·2	— 17, 20, 20
14	54·9	9·2	29·944	56·9	55·2	90	29·921	55·9	53·3	85		0·8	0·2	— 16, 18, 18
16	43·4	8·7	29·726	46·0	43·9	85	29·530	44·6	43·3	91		0·3	0·0	— — 20, —
17	41·6	7·6	29·353	44·2	43·6	96	29·366	41·0	40·9	99		5·5	0·9	6, 6, 0, 1
18	40·6	8·9	29·516	42·0	38·3	73	29·502	40·8	37·1	72	·870	7·0	2·6	0, 30, 31, 31
19	42·6	10·0	29·398	42·3	40·6	88	29·200	46·6	44·9	89	·052	2·1	0·4	— 18, 14, 18
20	47·9	6·6	30·024	50·3	47·1	79	30·084	52·3	46·1	63		2·5	0·2	— 26, 28, 25
21	44·5	......	......	......	......	......	......	......	......	......		0·7	......	— — — —
											·402			
23	39·8	4·5	28·923	43·5	41·7	87	......	......	......	......		0·3	0·1	— 20, 20, —
24	40·7	2·4	28·844	42·0	39·9	85	28·879	41·2	38·7	82		1·2	0·2	18, 18, 18, 18
25	37·2	6·1	28·880	38·8	37·5	90	28·874	41·0	39·1	86		0·4	0·1	— 22, 16, —
26	35·5	3·0	29·289	40·0	37·9	84	29·467	42·6	39·3	77		0·3	0·1	— — 20, 18
27	39·6	4·9	29·910	40·3	38·9	89	29·911	45·0	43·3	87		1·0	0·1	— 18, 16, 15
28	51·8	10·0	29·738	53·8	50·6	81	29·742	52·8	50·8	88	·060	3·4	1·8	17, 16, 16, 16
											·158			
30	47·3	6·1	29·846	47·0	45·6	90	29·748	53·8	51·3	85		0·5	0·1	— — 18, 18
31	49·1	6·1	29·679	53·0	50·5	85	29·749	48·8	48·1	95		2·0	0·2	— 19, 20, 16

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
	°			°	°			°	°					
Nov. 1	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
2	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
3	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
4	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
6	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
7	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
8	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
9	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
10	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
11	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
13	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
14	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
15	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
16	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
17	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
18	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
20	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
21	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
22	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
23	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
24	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
25	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
27	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
28	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
29	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
30	......	....	....	......	......	......	....	......	......	......	......	......	......	— — — —
Dec. 1	34·4	7·9	29·186	33·0	30·0	75	29·305	32·0	29·7	81		1·7	0·4	28, 28, 28, 27
2	34·0	8·9	29·523	32·8	29·6	74	29·610	36·6	34·5	83		1·5	0·4	26, 19, 20, —
4	42·7	5·0	29·577	41·6	38·1	74	29·531	43·0	41·5	89	·090	7·0	1·0	26, 18, 21, 20
5	41·6	6·7	28·872	41·6	38·3	76	28·529	40·5	39·7	94	·100	4·0	2·1	19, 20, 18, 18
6	43·1	6·3	29·048	42·6	38·6	72	29·282	41·0	37·9	77	·058	3·5	0·8	25, 26, 26, 26
7	34·2	7·7	29·930	34·2	31·2	75	29·876	33·0	32·3	93		1·8	0·2	26, 22, 22, 20
8	47·5	6·1	29·320	51·5	48·1	79	29·260	45·0	40·9	72	·170	3·3	0·7	20, 23, 19, 20
9	36·6	4·9	29·149	38·0	35·1	78	29·354	36·5	33·9	79	·020	2·4	0·5	24, 25, 28, 28
11	41·6	10·0	29·394	42·0	41·3	95	29·277	45·5	45·3	99		2·8	1·1	18, 17, 17, 17
12	38·8	3·1	29·615	38·0	35·7	82	29·504	41·6	39·9	87		3·7	1·3	18, 20, 20, 18
13	45·6	10·0	29·495	46·3	45·6	95	29·316	47·3	47·3	100	·110	4·0	1·5	20, 19, 20, 17
14	44·0	8·3	29·470	42·6	41·6	93	29·486	46·5	43·3	78	·125	3·2	0·4	— 18, 20, 24
15	46·2	9·2	29·434	48·0	44·1	75	29·489	42·0	39·6	82	·030	5·1	0·9	26, 22, 22, —
16	34·1	2·4	29·510	35·5	33·5	83	29·582	32·7	31·3	88		1·0	0·1	— 22, 23, —
18	32·9	0·4	29·103	31·8	28·8	74	29·255	35·0	34·3	94	·090	3·0	1·1	2, 28, 28, —
19	32·5	9·2	29·441	32·0	29·4	78	29·127	34·8	33·5	89		1·5	0·1	20, — 16, 16
20	37·4	1·9	29·399	39·3	36·6	79	29·674	35·2	32·9	80	·070	2·2	0·2	— 28, 27, 26
21	45·1	10·0	29·571	45·0	43·7	91	29·567	49·3	47·6	89	·115	1·8	0·6	22, 20, 16, 18
22	51·2	10·0	29·233	54·5	52·3	86	29·022	53·0	51·5	91		5·8	2·0	20, 20, 20, 21
23	36·3	6·4	29·580	37·2	35·7	87	29·522	38·0	37·3	94	·088	6·0	0·1	— 20, 22, 20
25	38·6	....	29·025	39·3	37·1	83	....	......	......	......	·060	6·3	0·6	20, 18, — —
26	34·9	....	....	......	......	......	....	......	......	......	·620	3·2	......	20, — — —
27	30·8	1·3	29·448	32·2	31·2	91	29·608	29·1	29·2	100		2·0	0·3	22, 20, 22, 26
28	28·3	1·1	30·185	26·9	26·7	98	30·164	27·9	28·0	100		0·5	0·0	— — 20, 20
29	44·4	5·1	30·002	45·0	42·3	81	30·020	44·3	43·3	92		2·8	0·8	20, 21, 20, 18
30	43·3	5·2	29·764	43·6	42·3	91	29·925	41·2	37·5	72	·020	5·0	1·6	18, 18, 23, 20

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
Jan. 1	43·5	4·1	29·408	42·6	39·5	78	29·529	41·6	36·9	66		11·0	5·6	28, 28, 28, 26
2	43·0	10·0	29·835	42·2	39·1	77	29·796	44·8	43·5	91		2·6	0·0	— — — —
3	45·7	6·0	29·886	47·3	……	……	29·878	46·8	44·6	85		0·7	0·2	21, 24, 24, 23
4	45·4	10·0	29·764	46·0	43·1	80	29·688	44·8	42·1	81		2·7	1·0	20, 19, 20, 19
5	46·5	9·9	29·524	47·0	46·3	95	29·439	48·2	47·1	92		3·5	1·3	18, 20, 18, 18
6	45·6	9·0	29·923	47·0	44·1	80	30·101	45·2	43·9	91		2·6	0·1	— 18, 18, 18
8	45·6	9·5	29·960	46·2	43·7	82	29·899	45·6	44·1	90		3·0	1·8	18, 20, 20, 20
9	37·3	2·7	30·047	36·6	35·3	89	30·216	37·3	36·3	91		5·0	0·0	— — 30, 0
10	27·3	2·6	30·329	24·7	24·9	100	30·270	29·1	29·6	100		0·1	0·0	— — — —
11	38·6	5·0	30·275	37·8	36·7	91	30·261	40·0	38·9	91		0·1	0·0	18, — — —
12	37·0	10·0	30·458	36·6	36·3	97	30·457	39·2	38·7	95		0·0	0·0	— — — —
13	33·8	5·8	30·435	32·8	32·0	92	30·377	37·0	36·3	94		0·0	0·0	— — — —
15	33·6	7·5	30·250	32·0	31·7	97	30·139	36·5	33·6	75		0·7	0·0	18, — — —
16	35·1	9·9	30·015	35·8	34·9	92	30·030	35·2	34·1	90		1·0	0·2	28, 30, 31, 4
17	30·6	6·7	30·219	30·3	29·2	90	30·211	31·7	30·6	91		0·3	0·1	— 4, 4, 2
18	31·6	9·6	30·011	30·7	30·4	97	29·912	34·6	34·5	99		0·9	0·2	— 28, 29, 0
19	38·1	10·0	29·858	40·0	39·9	99	29·810	39·6	38·6	92	·228	1·5	0·3	— 1, 0, 31
20	32·0	8·2	29·958	32·6	31·4	90	29·910	32·2	31·8	96	·110	0·6	0·1	— 6, 1, 4
22	31·9	10·0	29·671	33·0	33·1	100	29·665	31·7	31·7	100	·148	0·5	0·1	— 2, 7, —
23	27·9	7·5	29·828	27·1	26·8	97	29·866	31·1	30·5	95		0·2	0·0	— — 24, —
24	31·7	9·2	30·028	31·7	31·0	94	30·030	32·6	31·6	92		0·2	0·0	— — 20, —
25	34·6	10·0	30·013	35·2	33·7	87	………	……	……	……	·100	0·6	0·1	— 30, — —
26	33·1	9·4	29·706	33·0	32·5	95	29·717	31·9	32·1	100		1·5	0·1	— — 28, 2
27	33·0	9·9	29·896	34·2	32·5	85	29·964	32·6	32·3	97	·170	2·0	0·6	2, 2, 2, 2
29	25·2	4·9	29·585	28·4	27·7	93	29·536	28·1	27·7	96		0·3	0·0	— — — 20
30	24·7	9·2	29·706	24·2	24·5	100	29·733	27·7	27·6	99		0·0	0·0	— — — 8
31	27·2	10·0	29·653	27·5	27·6	100	29·630	28·9	28·1	93		0·6	0·3	8, 8, 6, 5
Feb. 1	31·1	9·9	29·885	32·6	32·5	99	29·967	33·6	33·3	97		0·3	0·2	4, 4, — 6
2	24·2	10·0	30·036	29·7	29·6	99	29·974	34·8	33·3	87		0·2	0·0	— — — 6
3	33·0	10·0	29·646	33·6	32·6	91	29·455	35·0	33·8	89		1·5	0·3	6, 6, 6, 5
5	34·1	10·0	29·325	34·2	33·9	97	29·343	35·4	33·6	85	·294	1·0	0·3	— 2, 1, 2
6	33·5	3·4	29·486	35·2	32·9	80	29·571	34·0	32·1	84	·150	1·4	0·3	4, 2, 2, —
7	32·6	7·2	29·775	33·8	33·5	97	29·760	34·2	32·8	87	·200	1·6	0·4	2, 1, 1, 2
8	29·7	………	………	……	……	……	………	……	……	……		3·2	……	— — — —
9	38·1	10·0	30·027	29·4	29·4	100	30·013	28·7	28·7	100		3·0	1·0	7, 7, 7, 7
10	32·3	9·1	29·837	31·7	31·9	100	29·830	29·1	27·8	88		1·0	0·0	— — — —
											·122			
12	24·5	6·8	29·494	24·6	24·9	100	29·450	30·7	30·2	95		1·0	0·1	8, — — 2
13	27·5	………	………	……	……	……	………	……	……	……		1·0	……	4, — — —
14	24·6	6·7	29·309	25·7	25·7	100	29·322	25·6	25·6	100		2·0	……	2, — — —
15	7·4	4·7	29·635	13·0	13·3	100	29·739	16·3	16·6	100		†	……	— — — —
16	6·0	0·1	29·868	6·1	……	……	29·818	11·4	……	……		†	……	— — — —
17	10·2	0·5	29·816	5·7	……	……	29·783	18·6	……	……		†	……	— — — —
19	18·6	5·3	29·875	18·1	……	……	29·821	29·3	29·0	97	·680	†	……	— — — —
20	24·5	8·0	29·736	26·7	26·0	92	29·697	28·6	28·6	100		†	……	— — — —
21	22·4	6·3	29·733	20·0	……	……	29·731	26·1	26·2	100		†	……	— — — —
22	15·9	5·6	29·791	21·0	……	……	29·785	22·8	22·5	97		†	……	— — — —
23	27·2	8·7	29·067	29·1	……	……	29·676	33·4	33·5	100		†	……	— — — —
24	32·2	6·7	29·531	33·2	31·6	86	29·346	36·0	35·6	97		2·0	1·1	20, 18, 18, 20
26	32·3	7·9	29·405	36·2	34·9	89	29·465	35·2	31·6	72	·220	†	……	— — — 20
27	31·6	8·2	29·511	31·1	30·0	90	29·510	36·6	34·6	84		†	……	— — — 12
28	37·1	7·6	29·444	38·0	36·3	86	29·470	40·2	37·5	79	·288	†	……	18, 24, 25, 18

* See Introduction for a description of the methods by which these means have been obtained. † Anemometer frozen.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = $10^h\ 10^m$ A.M., Makerstoun Mean Time.				5 P.M., Göttingen = $4^h\ 10^m$ P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky Clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.		Max.	Mean.*	20^h, 23^h, 2^h, 5^h.
Mar. 1	° 39·1	7·8	28·920	° 41·4	° 38·5	79	28·982	° 42·3	° 38·9	76	·110	4·0	1·1	20, 18, 20, —
2	40·5	6·2	28·768	42·5	40·9	88	28·568	44·4	40·5	73	·030	5·0	1·2	— 18, 18, 16
3	36·1	6·4	28·518	36·0	35·5	96	28·700	40·6	35·9	65	·184	5·0	1·4	16, — 25, 25
5	39·0	6·3	29·365	41·0	38·6	82	29·434	43·8	40·6	77		1·0	0·3	20, 18, 18, —
6	36·2	0·3	29·665	38·8	37·3	88	29·672	43·8	40·1	74	·200	1·0	0·1	— — 18, 17
7	33·0	9·2	29·736	32·0	......	......	29·766	40·3	37·5	79		0·2	0·0	— — — 6
8	35·8	7·9	30·015	39·6	36·6	77	....	......	......	......		0·0	0·0	— — — —
9	33·6	6·7	29·822	32·0	30·9	91	29·722	37·2	33·5	70		0·4	0·1	— — — 14
10	28·9	10·0	29·611	30·1	29·7	97	29·497	31·3	31·0	97		0·2	0·0	— — — —
12	37·2	9·6	28·558	39·0	37·6	89	....	......	......	......	·200	2·5	0·0	— — — —
13	34·2	10·0	28·969	35·0	33·7	89	29·137	35·8	34·5	89	·070	0·3	0·0	28, — — —
14	37·0	9·5	29·346	41·0	38·6	82	29·383	42·6	37·8	66		0·0	0·0	— — — —
15	32·9	8·4	29·510	34·8	33·3	87	29·357	37·0	34·7	82		4·5	0·5	— — 14, 14
16	37·5	10·0	29·139	41·0	39·6	89	....	......	......	......		4·0	......	— — — —
17	38·7	10·0	29·156	41·3	40·9	97	29·061	42·8	38·7	71		2·4	0·0	— — 24, —
											·020			
19	36·1	6·2	29·693	40·2	35·5	65	29·691	39·0	34·7	68		0·4	0·1	— — 8, 8
20	33·3	10·0	29·668	35·0	33·5	87	29·607	35·6	33·6	83		0·3	0·1	— — 6, 6
21	35·4	....	....	......	......	......	....	......	......	......		1·3	3·0	— — — —
22	31·7	8·6	29·130	33·8	32·7	91	29·135	32·2	32·3	100		7·2	3·0	4, 6, 3, 6
23	31·3	9·3	29·120	33·2	31·2	84	29·121	33·6	33·3	98	·100	4·8	0·7	2, 4, 3, —
24	32·5	8·6	29·171	36·2	32·6	71	29·169	39·2	33·7	58		0·2	0·0	— — — —
26	37·0	5·4	29·418	41·3	37·6	72	29·436	41·8	38·9	79		0·1	0·0	— 24, — —
27	34·9	7·2	29·645	37·0	31·9	62	29·732	38·7	33·5	60		1·9	0·6	2, 4, 0, 2
28	35·5	7·1	30·011	37·2	37·1	99	30·117	39·2	36·3	77		1·0	0·2	4, 0, 2, 6
29	34·6	7·5	30·306	37·0	34·7	81	30·290	43·4	37·7	60		0·2	0·0	— — — —
30	37·2	10·0	30·306	40·0	37·9	84	30·252	43·0	39·6	75		0·0	0·0	— — — —
31	37·5	0·6	30·268	40·3	37·7	80	30·232	43·6	37·9	60		0·2	0·1	— — 9, 14
April 2	35·6	4·4	29·884	39·3	35·3	68	29·748	45·6	38·7	55		0·3	0·1	— — 16, 18
3	36·4	10·0	29·602	40·8	35·6	62	29·542	40·8	35·8	63		0·2	0·1	— 12, 14, 15
4	35·4	0·8	29·589	40·6	36·7	71	29·700	40·2	39·3	93		0·2	0·0	— 20, — —
5	39·0	9·1	29·724	48·6	46·9	88	29·741	54·9	48·9	66		0·6	0·2	20, 20, 20, 24
6	50·3	9·2	29·732	54·6	51·7	83	29·668	56·1	52·1	77	·062	2·6	0·4	— 20, 18, 22
7	43·4	4·2	29·884	48·0	41·3	57	29·758	47·0	40·7	59		2·6	0·5	— 26, 24, 23
											·020			
9	......	....	....	......	......	......	....	......	......	......		12·0	......	— — — —
10	......	....	....	......	......	......	....	......	......	......	·030	13·5	......	— — — —
11	......	....	....	......	......	......	....	......	......	......		5·0	......	— — — —
12	......	....	....	......	......	......	....	......	......	......	·068	13·6	......	— — — —
13	......	....	....	......	......	......	....	......	......	......		0·5	......	— — — —
14	......	....	....	......	......	......	....	......	......	......	·550	4·6	......	— — — —
16	......	....	....	......	......	......	....	......	......	......	·050	4·7	......	— — — —
17	......	....	....	......	......	......	....	......	......	......		0·5	......	— — — —
18	......	....	....	......	......	......	....	......	......	......		1·3	......	— — — —
19	49·3	1·4	29·802	55·7	49·7	66	29·801	53·0	44·5	51		1·7	0·6	20, 20, 20, 21
20	43·2	3·4	30·015	47·0	40·7	58	30·108	45·6	39·5	59		1·8	0·5	25, 28, 31, 0
21	40·6	0·2	30·399	42·3	38·6	72	30·344	50·6	43·3	56		1·1	0·2	— 7, 0, 0
23	49·7	0·3	30·319	54·5	44·7	45	30·248	64·1	49·3	32		0·1	0·0	— — — —
24	51·2	3·9	30·136	57·9	45·9	38	30·090	53·6	45·9	56		0·6	0·2	— 28, 30, 0
25	43·3	8·9	30·106	44·0	42·9	92	30·065	46·8	43·8	80		2·2	0·4	2, 4, 4, 3
26	39·8	....	....	......	......	......	....	......	......	......		0·0	......	— — — —
27	48·2	4·9	29·949	53·0	48·3	72	29·900	53·0	48·9	75		0·2	0·1	— — 4, 3
28	43·4	9·1	30·008	45·6	43·3	84	30·119	49·0	43·9	68	·015	0·3	0·1	4, 4, 4, 6
30	44·9	2·7	30·139	53·0	47·1	65	30·124	48·6	43·6	69		0·8	0·1	— — 4, 6

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10^h 10^m A.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.	5 P.M., Göttingen = 4^h 10^m P.M., Makerstoun Mean Time. Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. =100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20^h, 23^h, 2^h, 5^h.
May 1	39·7	9·7	30·048	39·3	38·9	96	30·128	42·0	40·3	87	·160	3·7	1·5	4, 4, 4, 6
2	48·0	7·0	29·962	51·6	45·3	62	29·730	58·2	47·7	45		1·7	0·1	18, 20, 24, 24
3	35·1	7·5	29·656	39·3	36·3	77	29·642	38·0	32·3	56	·025	3·3	0·8	1, 2, 0, 31
4	35·1	5·2	29·709	37·8	32·6	59	29·709	40·3	35·5	65		2·6	0·3	0, 0, 0, 4
5	42·2	9·2	29·609	45·0	40·9	72	29·444	45·8	43·6	85		7·0	1·3	18, 21, 20, 18
7	40·2	10·0	29·472	41·8	41·1	95	29·119	48·0	46·6	91	·160	1·7	0·5	18, 4, 4, 21
8	39·7	6·7	29·492	44·0	37·9	58	29·616	46·8	38·9	50	·468	3·2	1·4	24, 29, 30, 28
9	41·3	5·1	29·590	48·6	42·6	62	29·592	38·0	34·3	71		1·8	0·5	20, 22, —, 6
10	39·9	....	....	......	......	......	....	......	......	......	·230	......	......	—, —, —, —
11	38·3	9·5	29·292	41·0	41·0	100	29·432	41·6	39·6	85	·302	1·3	0·6	4, 2, 4, 4
12	41·0	10·0	29·644	44·0	41·6	83	29·630	45·2	42·5	81		2·0	0·4	4, 4, 4, 5
14	41·2	9·4	29·584	41·6	41·3	98	29·536	46·0	41·5	70	·020	0·7	0·2	4, 4, 4, 5
15	40·7	10·0	29·481	44·4	42·1	84	29·514	42·0	41·9	99		0·8	0·2	1, 2, 4, 2
16	45·0	8·5	29·547	47·8	43·1	70	29·526	50·0	45·3	71	·030	0·1	0·0	30, —, —, —
17	46·7	10·0	29·645	47·7	44·6	79	29·649	52·2	46·3	65		0·6	0·1	—, —, —, 22
18	49·2	4·6	29·798	52·0	47·1	70	29·779	56·4	49·9	64		1·3	0·1	—, —, 20, 20
19	56·5	9·4	29·691	61·8	56·4	73	29·657	60·4	55·3	73		1·4	0·2	15, 22, 18, 15
21	45·5	10·0	29·753	50·8	47·4	79	29·728	46·0	42·6	76		2·8	0·7	31, 2, 1, 2
22	45·7	10·0	29·609	47·0	44·6	84	....	......	......	......		1·4	0·1	31, —, —, —
23	49·6	6·2	29·494	52·2	46·9	69	29·447	58·3	50·9	61		0·3	0·1	—, 24, —, 20
24	56·0	8·7	29·457	58·7	53·6	73	29·488	60·0	55·2	75		1·8	0·4	14, 14, 14, 13
25	60·6	8·0	29·637	66·9	59·6	66	29·643	62·2	57·8	77		2·4	0·6	10, 12, 14, 14
26	57·1	4·1	29·792	61·8	57·9	80	29·684	65·8	59·4	69		1·8	0·8	4, 4, 2, 4
28	44·8	5·6	29·803	48·3	43·3	68	29·813	48·4	42·9	65		2·7	1·3	4, 4, 3, 2
29	41·8	7·4	29·785	45·3	43·1	85	29·931	41·6	39·8	87		12·8	3·2	0, 2, 4, 2
30	42·6	6·4	29·980	46·0	40·3	61	29·952	47·3	41·3	61		3·0	1·3	31, 2, 2, 2
31	41·7	10·0	29·908	44·8	41·7	78	29·869	44·6	40·9	74	·180	3·1	1·6	4, 2, 4, 3
June 1	40·6	10·0	29·684	42·0	41·9	99	29·655	43·3	43·1	99	·226	3·1	0·4	4, 3, 4, 2
2	46·9	10·0	29·684	53·0	50·3	84	29·671	51·6	48·3	80	·058	0·2	0·0	—, —, 20, 18
											·020			
4	53·8	7·1	29·493	56·3	52·3	77	29·432	61·1	53·7	62		0·8	0·2	20, 22, 20, 18
5	55·3	5·5	29·452	58·0	54·9	83	29·483	64·0	55·6	60	·062	1·9	0·2	—, 18, 18, 18
6	57·3	7·4	29·589	59·3	56·3	84	29·572	61·8	59·7	89		0·7	0·1	18, 18, 18, —
7	55·1	9·7	29·593	57·8	54·1	80	29·600	61·8	55·9	70	·560	0·3	0·1	—, 26, 18, 20
8	55·5	7·7	29·671	61·4	54·7	66	29·654	57·5	54·3	82		0·3	0·1	—, 8, 8, 8
9	53·4	9·8	29·637	55·9	51·3	74	29·648	57·9	54·7	82	·148	0·5	0·1	—, 16, 18, 18
											·060			
11	56·9	....	....	......	......	......	....	......	......	......		0·3	......	—, —, —, —
12	58·5	4·8	29·878	62·1	54·3	61	29·764	64·4	56·8	63		0·4	0·1	15, 16, 18, 18
13	59·9	6·4	29·520	65·2	56·8	60	29·379	63·8	56·8	66		0·2	0·0	—, —, 16, —
14	50·1	10·0	29·183	53·0	50·9	87	29·130	57·5	54·4	83	·298	0·2	0·0	4, —, —, 20
15	50·4	10·0	28·814	54·0	52·3	90	28·904	56·1	53·3	84	·072	0·3	0·1	—, —, 5, 7
16	44·6	10·0	29·161	47·6	45·3	85	29·259	46·2	45·9	98	·162	8·6	2·2	0, 30, 0, 2
											·050			
18	45·8	10·0	....	......	......	......	29·693	49·6	45·7	76	·030	0·2	0·1	—, —, 20, 4
19	46·0	10·0	29·936	49·6	46·3	79	....	......	......	......		0·0	0·0	—, —, —, —
20	55·7	4·0	30·193	57·9	54·1	79	30·166	63·8	56·2	63		0·2	0·0	9, —, —, —
21	64·9	6·0	30·164	67·5	62·1	74	30·127	71·0	62·1	61		0·1	0·0	—, —, —, 4
22	63·1	9·0	30·057	64·8	61·5	83	29·984	72·0	63·3	62		0·2	0·0	—, —, —, —
23	53·1	8·2	30·042	56·1	54·3	89	29·989	63·2	54·9	59		0·2	0·1	—, 6, 6, 30
25	56·3	10·0	29·640	58·9	56·2	85	29·604	61·4	58·4	84	·080	2·7	0·9	20, 20, 20, 20
26	59·7	8·6	29·869	63·0	60·1	85	29·934	64·8	58·8	70	·035	1·9	0·3	28, 20, 20, 20
27	62·0	6·7	30·093	65·8	58·5	65	30·094	69·1	60·4	61		1·2	0·2	20, 20, 22, 24
28	65·6	2·6	30·029	68·5	62·3	71	29·962	77·3	66·8	58		0·2	0·0	—, —, 20, 20
29	68·0	5·0	29·885	68·9	61·6	66	....	......	......	......		0·4	0·1	—, 15, 15, —
30	59·4	10·0	29·685	64·8	62·7	89	29·685	59·9	58·2	91		0·4	0·0	2, —, —, 20

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.*		11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time.				5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time.				Rain in Inches.	Force of Wind.		Direction of Wind at the following Hours, Göttingen Mean Time.
	Tem. of Air.	Sky clouded.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.	Barom. at 32°.	Tem. of Air.	Tem. of Evap.	Rel. Hum. Satur. = 100.		Max.	Mean.*	20h, 23h, 2h, 5h.
	°			°	°			°	°		·150			
July 2	59·1	8·3	29·904	66·7	61·1	73	29·879	63·6	53·0	50		0·4	0·0	— 17, — 24
3	58·3	9·4	29·911	61·6	56·2	72	29·873	62·4	59·5	85		0·4	0·2	18, 18, 17, 18
4	56·9	6·3	29·966	60·2	56·2	78	29·943	63·1	57·2	70	·030	0·7	0·1	— 4, 7, 7
5	51·8	10·0	29·938	53·8	51·3	85	29·892	55·9	53·9	88		0·3	0·1	— 4, 8, 8
6	58·1	3·7	29·887	58·4	55·2	82	29·860	67·9	61·3	69		0·3	0·0	— — 8, —
7	63·1	1·2	29·888	65·8	61·1	77	29·847	69·8	63·5	72		0·4	0·2	8, 6, 4, 6
9	61·2	0·7	29·649	68·1	60·7	66	....	......	......	......		0·3	0·0	— 4, — —
10	52·4	10·0	29·506	56·4	55·8	97	29·491	55·1	55·2	100		0·2	0·1	4, 4, 4, 4
11	58·8	10·0	29·503	64·4	61·4	85	29·526	64·8	61·4	83	·112	0·2	0·0	— — 6, —
12	64·9	7·0	29·644	66·1	62·4	82	29·636	74·0	65·1	63		0·3	0·1	— — 6, —
13	68·3	8·6	29·691	72·8	65·8	70	29·676	79·7	71·6	68		0·1	0·0	— — — —
14	60·4	8·7	29·581	61·4	......	......	29·516	71·0	64·4	71	·618	0·3	0·0	— — — 20
											·068			
16	55·7	10·0	29·323	58·7	57·4	93	29·244	59·4	57·2	88	·352	0·0	0·0	— — — —
17	56·7	10·0	....	......	......	......	29·372	59·9	56·6	82	·800	0·4	0·2	31, — 0, 31
18	59·7	6·6	29·424	63·4	59·2	79	29·411	66·1	57·7	61		0·4	0·2	20, 22, 20, 18
19	56·6	9·9	29·393	61·8	57·8	80	....	......	......	......	·030	0·4	0·1	20, 20, — —
20	58·2	7·9	29·518	61·8	57·8	79	29·621	63·8	57·8	70	·400	0·3	0·1	27, 28, 28, 0
21	61·8	6·9	29·813	64·6	58·2	69	29·838	66·1	60·5	73		0·7	0·1	— 0, 0, 19
23	66·3	7·3	29·779	72·8	67·5	76	29·639	67·1	65·9	94		0·0	0·0	— — — —
24	58·0	10·0	29·406	63·8	63·1	96	29·386	60·4	60·1	98	·150	0·2	0·0	— — 2, 2
25	......	....	....	......	......	......	....	......	......	......	·406	0·2	......	1, — — —
26	......	....	....	......	......	......	....	......	......	......	·100	0·3	......	— — — —
27	......	....	....	......	......	......	....	......	......	......	·025	0·1	......	— — — —
28	......	....	....	......	......	......	....	......	......	......		0·1	......	— — — —
											·270			
30	......	....	....	......	......	......	....	......	......	......	·503	0·1	......	— — — —
31	......	....	....	......	......	......	....	......	......	......	·330	0·1	......	— — — —
Sep.† 1	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
3	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
4	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
5	......	....	....	......	......	......	....	......	......	......	·010	......	......	— — — —
6	......	....	....	......	......	......	....	......	......	......	·012	......	......	— — — —
7	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
8	......	....	....	......	......	......	....	......	......	......	·048	......	......	— — — —
10	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
11	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
12	......	....	....	......	......	......	....	......	......	......	·076	......	......	— — — —
13	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
14	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
15	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
											·400			
17	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
18	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
19	......	9·0	29·736	......	......	......	29·695	58·7	56·5	88		0·3	0·1	— 20, — 18
20	58·7	8·7	29·731	62·8	60·1	86	29·797	62·8	60·3	87		1·4	0·4	16, 16, 16, 18
21	58·5	3·6	29·920	61·4	59·3	88	29·962	62·6	59·5	84		2·0	0·5	18, 20, 20, 20
22	62·5	10·0	30·087	66·0	63·4	87	30·074	67·9	64·1	82		0·4	0·0	18, — — —
											·070			
24	48·2	6·9	30·399	51·0	46·6	73	....	......	......	......		0·2	0·1	— 5, 4, —
25	45·2	5·2	30·275	52·0	48·3	77	30·161	55·0	49·9	70		0·2	0·1	20, 20, 18, 20
26	51·7	9·4	29·984	54·6	50·6	76	29·914	56·5	52·3	76		0·3	0·1	— 20, 17, 20
27	50·5	9·5	29·703	55·5	52·5	83	....	......	......	......		0·0	0·0	— — — —
28	54·0	9·3	29·206	57·7	54·1	80	29·121	56·1	55·5	97		0·5	0·2	16, 16, — —
29	51·1	3·5	29·379	53·8	52·3	91	29·445	58·5	55·3	83	·462	0·0	0·0	— — — —
											·020			

* See Introduction for a description of the methods by which these mean have been obtained. † No observations during August.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10ʰ 10ᵐ A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4ʰ 10ᵐ P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20ʰ, 23ʰ, 2ʰ, 5ʰ.
Oct. 1	54·0	8·2	29·313	56·7	55·8	95	29·288	55·0	53·3	90		0·3	0·1	4, 2, 4, —
2	50·7	9·9	29·427	53·8	52·1	90	......	......	......	......		0·1	0·0	— — — —
3	52·6	10·0	29·467	54·0	53·3	96	......	......	......	......		0·2	0·0	— — — —
4	54·6	8·3	29·026	57·5	56·2	93	28·872	56·7	55·5	93	·378	0·2	0·0	10, 15, 15, —
5	50·9	7·5	28·852	55·9	52·6	81	28·925	52·2	47·3	71	·045	2·1	0·7	— 18, 17, 17
6	52·0	5·7	29·021	53·8	50·3	80	28·961	55·5	52·5	83	·025	1·3	0·2	— 15, 14, 14
											·425			
8	46·9	9·2	29·286	46·8	46·1	95	29·266	53·0	50·3	84		0·1	0·0	— — — —
9	48·6	9·9	29·306	53·0	52·3	96	29·346	46·8	43·1	75	·100	0·3	0·2	26, 30, 31, 1
10	......	......	......	......	......	......	......	......	......	......		1·2	......	— — — —
11	48·1	9·7	29·180	51·0	47·9	81	29·093	49·2	47·9	92	·080	0·5	0·0	— 20, — —
12	46·5	8·0	29·209	49·4	46·1	79	29·203	50·8	45·3	67	·100	0·5	0·1	— 20, 22, 20
13	44·5	8·4	29·215	41·6	......	......	29·212	45·8	43·3	83		1·6	0·2	18, 20, 22, 20
											·050			
15	40·0	2·5	29·191	40·2	39·1	92	29·188	47·2	43·1	73		0·0	0·0	— — — —
16	41·4	6·5	29·383	46·0	43·5	83	......	......	......	......		0·0	0·0	— — — —
17	39·0	5·4	29·656	38·5	37·8	95	29·607	45·5	40·9	69		0·3	0·0	— — 20, —
18	48·6	5·6	29·429	53·2	49·3	77	29·519	49·0	46·1	81		2·7	0·4	20, 20, 26, 22
19	49·2	9·4	29·618	51·3	49·3	88	29·629	52·8	50·1	84	·030	1·0	0·3	20, 20, 20, 20
20	53·1	9·7	29·644	53·8	52·5	92	29·594	54·2	......	......	·025	11·0	1·1	16, 19, 18, 18
											·025			
22	49·7	7·6	29·889	52·0	49·3	83	29·788	51·0	47·9	80		3·0	0·1	— 22, 18, 18
23	47·4	8·0	29·342	46·6	44·1	83	29·333	45·2	42·3	80		4·8	1·2	19, 18, 22, 20
24	38·0	3·0	29·379	41·0	38·9	85	29·467	39·6	37·9	87	·372	4·7	0·6	18, 18, 19, 22
25	48·4	10·0	29·204	50·3	47·8	84	28·843	50·6	50·9	100		7·0	2·0	18, 18, 18, 18
26	42·6	5·6	28·553	48·0	45·3	82	28·692	40·6	39·9	95	·292	3·3	0·6	17, 18, 19, 26
27	31·5	5·2	29·233	36·6	34·6	84	......	......	......	......	·032	0·2	0·0	— — — —
29	34·8	8·7	29·403	33·6	33·5	99	29·350	43·0	42·5	96		0·2	0·0	— — 4, 4
30	43·0	10·0	29·432	44·0	42·1	86	29·412	45·0	41·9	78	·529	7·7	1·1	2, 1, 2, 1
31	42·3	9·4	29·529	45·0	40·7	70	29·611	42·0	39·1	79	·020	8·2	2·1	0, 0, 0, 31
Nov. 1	36·7	4·5	29·563	38·5	33·7	63	29·526	38·0	35·3	78		4·2	1·1	26, 28, 28, 28
2	42·1	7·3	29·687	43·8	41·9	86	29·746	44·0	41·3	81	·180	3·0	0·2	31, 31, 31, 0
3	43·8	9·4	29·826	44·8	44·6	99	......	......	......	......	·190	1·0	0·1	— 1, 6, —
5	43·6	10·0	29·790	44·8	44·1	95	29·720	47·8	47·1	95		0·6	0·1	— 17, 18, 16
6	41·9	......	......	......	......	......	......	......	......	......		2·7	......	— — — —
7	42·6	10·0	29·386	40·3	40·3	100	29·148	49·0	48·3	96	·498	1·5	0·4	— 2, — 16
8	40·9	5·6	29·115	44·8	43·1	88	29·110	40·0	38·3	87	·228	3·0	0·1	— 18, 18, —
9	36·6	7·7	29·481	34·2	33·9	97	29·486	42·2	40·9	90	·030	0·0	0·0	— — — —
10	44·0	5·5	29·543	44·9	44·1	94	29·543	46·6	45·1	90		1·6	0·0	— — 15, —
12	49·5	10·0	29·871	51·0	49·3	89	29·871	49·2	47·9	91	·040	1·5	0·2	18, 15, 14, 14
13	44·4	10·0	......	......	......	......	29·848	44·2	43·1	92		0·2	0·0	14, — — —
14	41·7	10·0	29·851	43·0	40·9	84	29·816	42·0	39·8	83		0·2	0·0	— 4, — 2
15	36·9	7·4	......	......	......	......	29·907	37·6	37·5	99		0·9	0·0	— — — —
16	32·4	3·6	30·060	34·6	33·3	88	30·072	35·0	34·6	96		0·0	0·0	— — — —
17	30·7	5·1	30·191	30·3	30·0	97	30·157	35·2	34·7	95		0·0	0·0	— 20, — —
19	41·9	10·0	30·132	43·0	41·5	89	30·083	43·0	40·3	80	·083	0·2	0·1	4, 4, 4, 4
20	41·6	10·0	30·016	42·6	39·3	75	29·963	42·0	39·3	80		0·6	0·2	4, 6, 4, 5
21	41·5	9·9	29·866	42·6	40·1	81	29·832	41·6	39·6	85		0·3	0·1	4, 4, 4, —
22	40·3	9·2	29·770	41·0	37·9	77	29·724	39·8	38·5	90		0·3	0·1	— — 4, 4
23	40·7	10·0	29·669	43·0	42·1	93	......	......	......	......	·030	0·3	0·2	4, 4, 4, —
24	38·6	9·9	29·867	40·3	38·9	89	29·905	39·8	38·9	92	·280	1·5	0·3	4, 4, 28, 30
											·150			
26	......	......	......	......	......	......	......	......	......	......	·100	......	......	— — — —
27	......	......	......	......	......	......	......	......	......	......		......	......	— — — —
28	......	......	......	......	......	......	......	......	......	......	·003	......	......	— — — —
29	......	......	......	......	......	......	......	......	......	......		......	......	— — — —
30	......	......	......	......	......	......	......	......	......	......		......	......	— — — —

* See Introduction for a description of the methods by which these means have been obtained.

Civil Day.	Calculated Daily Means.* Tem. of Air.	Calculated Daily Means.* Sky clouded.	11 A.M., Göttingen = 10h 10m A.M., Makerstoun Mean Time. Barom. at 32°.	11 A.M. Tem. of Air.	11 A.M. Tem. of Evap.	11 A.M. Rel. Hum. Satur. = 100.	5 P.M., Göttingen = 4h 10m P.M., Makerstoun Mean Time. Barom. at 32°.	5 P.M. Tem. of Air.	5 P.M. Tem. of Evap.	5 P.M. Rel. Hum. Satur. = 100.	Rain in Inches.	Force of Wind. Max.	Force of Wind. Mean.*	Direction of Wind at the following Hours, Göttingen Mean Time. 20h, 23h, 2h, 5h.
Dec. 1	°	....	....	°	°	......	....	°	°	......		......	......	— — — —
3	......	....	....	......	......	......	....	......	......	......	·028	......	......	— — — —
4	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
5	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
6	......	....	....	......	......	......	....	......	......	......	·080	......	......	— — — —
7	......	....	....	......	......	......	....	......	......	......	·118	......	......	— — — —
8	......	....	....	......	......	......	....	......	......	......		......	......	— — — —
10	24·2	0·3	30·005	36·2	35·9	97	29·954	16·9	17·2	100	·310	0·0	0·0	— — — —
11	26·6	3·1	29·868	27·9	27·0	91	29·674	23·7	23·5	98		0·2	0·0	— — 28, —
12	19·1	3·4	29·541	22·2	22·5	100	29·593	14·3	14·4	100		0·2	0·0	— — — —
13	26·3	7·3	29·886	25·6	25·0	94	29·850	30·7	30·6	99		0·2	0·2	— 30, 26, 28
14	45·2	8·2	29·527	45·6	44·9	95	29·543	48·0	47·3	95		3·0	0·6	24, 22, 20, 21
15	44·2	9·5	29·750	47·0	45·8	91	....	......	......	......		3·2	0·3	20, 19, 19, —
17	31·1	9·5	29·974	29·7	29·6	98	29·944	32·0	32·1	100		0·3	0·0	— — — —
18	35·9	8·7	30·031	38·6	37·3	89	30·077	33·8	32·5	88		3·8	1·0	20, 14, 14, 13
19	28·3	9·1	30·046	28·4	28·0	96	....	......	......	......		6·0	2·1	15, 16, 16, —
20	27·6	5·8	29·824	37·0	37·1	100	29·732	28·1	28·4	100		6·0	1·3	15, 15, 16, 16
21	24·0	....	....	......	......	......	....	......	......	......		†	......	— — — —
22	22·0	....	29·669	24·2	24·5	100	29·611	22·0	21·5	94		......	......	— — — —
24	41·0	9·6	29·004	41·6	40·3	91	29·013	42·5	41·3	91	·076	......	2·6	— — 18, 19
25	40·2	9·6	29·172	41·6	40·9	95	29·150	39·0	39·3	100		4·8	0·9	20, 18, 18, —
26	39·7	9·2	28·822	40·0	39·5	97	28·670	40·3	40·6	100	·026	2·7	0·3	14, 14, 15, 16
27	40·6	7·0	29·097	41·6	40·9	95	29·271	39·0	39·3	100	·020	2·0	0·5	18, 18, 18, 18
28	39·9	10·0	29·263	36·8	36·1	94	29·171	43·6	43·9	100		2·1	0·0	— — — 18
29	44·8	7·9	29·419	44·6	43·9	95	29·356	46·4	45·6	94	·100	2·7	0·9	18, 18, 18, 18
											·003			
31	45·3	2·6	29·756	45·6	45·3	98	....	......	......	......		5·0	0·5	18, 18, 18, —

* See Introduction for a description of the methods by which these means have been obtained. † Anemometer frozen.