

3
THE KEW OBSERVATORY,

RICHMOND, SURREY.

1883.

R E P O R T

OF THE

K E W C O M M I T T E E

FOR THE

Year ending October 31, 1883,

WITH APPENDICES CONTAINING RESULTS OF MAGNETICAL,
METEOROLOGICAL, AND SOLAR OBSERVATIONS MADE
AT THE OBSERVATORY.

[*From the* PROCEEDINGS OF THE ROYAL SOCIETY, 1883.]

LONDON :

HARRISON AND SONS, ST. MARTIN'S LANE,

Printers in Ordinary to Her Majesty.

1883.

*Report of the Kew Committee for the Year ending
October 31, 1883.*

The operations of the Kew Observatory, in the Old Deer Park, Richmond, Surrey, are controlled by the Kew Committee, which is constituted as follows :

Mr. De La Rue, *Chairman.*

Captain W. de W. Abney, R.E.	Vice-Adm. Sir G. H. Richards, C.B.
Prof. W. G. Adams.	The Earl of Rosse.
Capt. Sir F. Evans, K.C.B.	Mr. R. H. Scott.
Prof. G. C. Foster.	Lieut.-General W. J. Smythe.
Mr. F. Galton.	Lieut.-Gen. R. Strachey, C.S.I.

Mr. E. Walker.

The Committee regret to announce the decease of their venerable Chairman, the late Sir E. Sabine, K.C.B., who died on the 26th of June at the very advanced age of ninety-four years and eight months. Sir Edward was one of the chief promoters of the Observatory, and took a leading part in its direction from first its establishment as a Physical Observatory in 1841. Up to within a few weeks of his death he was constant in his inquiries after its condition, although for the last eight years he had been prevented by infirmity from taking an active part in the meetings of its Committee.

The instruments employed for the absolute observations of terrestrial magnetism, as well as several less important pieces of apparatus used in the regular work of the Observatory, were originally provided by Sir E. Sabine.

To speak of that branch of their late Chairman's scientific work, with which the Kew Committee has been more particularly concerned, they may say that, in their opinion, the science of terrestrial magnetism owes more to Sir Edward Sabine than to any man who ever studied it, Gauss alone perhaps excepted.

The work at the Observatory may be considered under six heads:—

1st. Magnetic observations.

2nd. Meteorological observations.

3rd. Solar observations.

4th. Experimental, in connexion with any of the above departments.

5th. Verification of instruments.

6th. Miscellaneous.

I. MAGNETIC OBSERVATIONS.

The Magnetographs have been in constant operation throughout the year.

The values of the ordinates of the different photographic curves determined in January were as follows:—

Declination: 1 inch = $0^{\circ} 22' \cdot 04$. 1 mm. = $0^{\circ} 0' \cdot 87$.

Bifilar, January 9, 1883, for 1 inch $\delta H = 0 \cdot 0221$ foot grain units.

„ 1 mm. „ = $0 \cdot 0004$ mm. mgr. units.

Balance, January 12, 1883 „ 1 inch $\delta V = 0 \cdot 0376$ foot grain units.

„ 1 mm. „ = $0 \cdot 0007$ mm. mgr. units.

It having been decided to attempt to re-adjust the Bifilar and Vertical Force instruments so as to bring their scales more closely in accordance with the generally adopted values, the necessary alterations were made in the adjustments, and on redetermining the scale values on January 17th the following results were obtained:—

Bifilar for 1 inch $\delta H = 0 \cdot 0277$ foot grain units.

„ 1 mm. „ = $0 \cdot 0005$ mm. mgr. units.

Balance „ 1 inch $\delta V = 0 \cdot 0261$ foot grain units.

„ 1 mm. „ = $0 \cdot 0005$ mm. mgr. units.

The tabulation of the traces of the three elements was temporarily suspended at the conclusion of the year for which the observations were promised to the International Polar Commission. Attention is now being devoted to the revision and reduction of the results.

A common gas-jet has been substituted in the Vertical Force instrument with advantage for that formerly employed, but on trial the results obtained by a similar substitution in the case of the other instruments were not satisfactory, and the old burners with chimneys are retained for the present.

Gelatino-bromide paper has been used for all three instruments with great success and economy of time throughout the whole year, and an examination of the curves shows that not a single hour's trace has been lost since its adoption, from purely photographic causes, rapid and minute movements of the needles being recorded.

Several magnetic storms have been observed, the principal being that of November 17th and 18th, 1882, which, together with its accompanying aurora and meteor, excited considerable attention.

Owing to long usage the points of the Dip-needles Nos. 1 and 2 of Circle No. 33, used for monthly observations, were very blunt; they were accordingly re-ground by Mr. Dover in August, and the axles at the same time repolished.

The Committee have to acknowledge with thanks the receipt of photographic copies of magnetic curves from the Observatory at Batavia.

The magnetic instruments have been studied, and a knowledge of their manipulation obtained by—

Dr. Doberck.

Lieutenant A. P. Pinheiro.

Dr. O'Reilly.

Information on matters relating to terrestrial magnetism, and various data, have been supplied to Dr. Buys Ballot, Padre Denza, the Rev. F. Howlett, M. l'Abbé Philippe, and others.

The Unifilar Magnetometer returned by Rev. S. J. Perry, F.R.S., on his arrival in this country from Madagascar was lent to Professor W. G. Adams, F.R.S., for use in the Wheatstone Laboratory, King's College, London. Another Unifilar and Dip-circle have been lent to Professor O. Lodge, for use in the University College, Liverpool.

A Dip-circle with bar-magnets has been lent to Dr. E. van Rijkvorsel for use in an expedition to Central America.

The monthly observations with the absolute instruments have been made as usual, and the results are given in the tables forming Appendix I of this Report.

The following is a summary of the number of magnetic observations made during the year:—

Determinations of Horizontal Intensity	35
„ Dip	123
„ Absolute Declination	29

At the request of the Rev. S. P. Ferrari, of the private astronomical observatory on the Janiculum Hill, Rome, the superintendent designed a set of Magnetometers, for eye observations, on a new pattern, much less costly than the Kew magnetographs.

They were erected in the Verification House, and after a satisfactory trial, were dismantled and forwarded to M. l'Abbé Philippe for the Observatory at Lyons.

A set of Magnetographs has been ordered on behalf of the American Government, and is now in process of construction.

II. METEOROLOGICAL OBSERVATIONS.

The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature, and humidity,

wind (direction and velocity), sunshine, and rain, have been maintained in regular operation throughout the year. A summary of these observations is given in Appendix II.

Owing to the necessity of delaying the construction of the new tabulating scales for the wet bulb thermograph until a somewhat lengthened series of observations had been obtained, the work of tabulation became some months in arrear. These, however, have now been worked up, and the tabulations are up to date.

The standard eye observations for the control of the automatic records have been duly registered during the year, together with the daily observations at 0 h. 8 m. P.M. in connexion with the Washington synchronous system.

Owing to the high quality of the photographic records, the Committee considered that the maintenance of the noon eye observation in addition to that at 0 h. 8 m. was superfluous, and accordingly it was discontinued on July 1st.

The tabulation of the meteorological traces has been regularly carried on, and copies of these, as well as of the eye observations, with notes of weather, cloud, and sunshine have been transmitted weekly to the Meteorological Office.

The following is a summary of the number of meteorological observations made during the past year:—

Readings of standard barometer	1825
,, dry and wet thermometers	3650
,, maximum and minimum thermo- meters	730
,, radiation thermometers	3599
,, rain gauges	730
Cloud and weather observations	2176
Measurements of barograph curves	9046
,, dry bulb thermograph curves..	9786
,, wet bulb thermograph curves..	11180
,, wind (direction and velocity)..	17410
,, rainfall curves	864
,, sunshine traces	2252

In compliance with a request made by the Meteorological Council to the Kew Committee, the Observatories at Aberdeen, Stonyhurst, and Valencia, have been visited and their instruments inspected by Mr. Baker during his vacation.

With the concurrence of the Meteorological Council, weekly abstracts of the meteorological results have been regularly forwarded to, and published by "The Times," "The Illustrated London News," "The Torquay Directory," and "The Torquay Standard," and data have been supplied to the Council of the Royal Meteorological Society, the

editor of "Symons's Monthly Meteorological Magazine," the Secretary of the Institute of Mining Engineers, Messrs. Banner and Co., the late Mr. Greaves, and Messrs. Gwilliam, Mawley, Rowland, Dr. Radcliffe, and others. The cost of these abstracts is borne by recipients.

Tracings of rain-gauge curves have been supplied to Mr. Symons for the months of October, November, and December, 1882.

Electrograph.—This instrument has been in continuous action through the year.

In May it was dismantled from the 16th to the 20th, to allow of structural alterations in connexion with the new stairs.

The tabulation of the curves is at present in arrear, not having been completed beyond February 28, 1882.

The portable Thomson Electrometer has not been employed in systematic observations during the year, but has had its scale value experimentally determined, at Mr. De La Rue's laboratory, for tensions ranging from -1240 to $+1030$ volts.

Information as to the working of Atmospheric Electrometers has been given to Professor Atwater, of Middleton, U.S.A., Dr. H. B. Baker, Lansing, U.S.A., and M. Leon Descroix, of Paris.

III. SOLAR OBSERVATIONS.

The sketches of Sun-spots as seen projected on the photoheliograph screen, have been made on 214 days, in order to continue Schwabe's enumeration, the results being given in Appendix No. II. The sun's surface was found to be free from spots on seven of those days.

Solar Negatives.—The correction to the area-measurements for foreshortening, which, at the date of the last report, had not been applied to the reductions of sun-spot observations for the last two years of the series, has since been made under Mr. De La Rue's direction.

The whole series is at the Royal Society, and is now being revised and arranged for reference by Mr. Marth, on behalf of the Council of the Royal Society, who made a grant of money for that purpose.

With the view of utilising the instrument in the transit of Venus of December 5, 1882, the Committee obtained the services of Mr. Reynolds, so long associated with Astronomical Photography, who made every preparation for taking a series of pictures of the transit. The adverse atmospheric conditions which prevailed at the time of the phenomenon, however, prevented any results being obtained.

Dr. Terby, of Louvain, requested a number of photographs, which were selected from the Kew series and sent him on loan. He has since returned them to the Observatory, having embodied the results

of his investigations in a work entitled "Sur l'Existence et sur la Cause d'une Périodicité mensuelle des Aurores Boréales."

Three typical negatives have also been selected, in reply to Professor Pickering's request, and forwarded to the Harvard College Observatory, to be deposited in the collection of astronomical photographs being formed there by the Director.

At the request of Professor Balfour Stewart, some measurements were made by Mr. Whipple and Mr. McLaughlin, in the Library of the Royal Astronomical Society, Burlington House, of Carrington's original sun-spot drawings, with a view of checking the accuracy of the values of solar-spotted areas determined at the Observatory in 1866, and published by Messrs. De La Rue, Stewart, and Loewy in their "Researches on Solar Physics," second series. The work has not yet been completed.

Transit Observations.—One hundred and fourteen observations have been made of sun-transits, for the purpose of obtaining correct local time at the Observatory; 224 clock and chronometer comparisons have also been made.

Shelton's clock, K.O., has been used as the standard timepiece of the Observatory.

IV. EXPERIMENTAL WORK.

Actinometry.—Observations have been made on favourable occasions with the Stewart actinometer on the Observatory lawn, and the results communicated to the Meteorological Council, who defray the cost they entail. Owing to the rarity at Kew of the occurrence of periods of perfectly clear sky sufficient in duration for a satisfactory experiment with Stewart's apparatus, the Superintendent has instituted inquiries with a view to obtaining one of Professor Langley's bolometers for comparison with it.

Solar Radiation Thermometers.—With a view of investigating the causes of the differences in the readings of black bulb thermometers *in vacuo*, the Superintendent obtained on loan from Messrs. Negretti and Zambra six of these instruments constructed according to his suggestions. They were after verification arranged on a stand on the Observatory lawn beside the Observatory standard of reference, and read daily during the summer months. The observations have been discussed, and the results indicate that the discrepancies observed in the readings of this class of instrument are in part to be attributed to want of uniformity in the sizes of the thermometer bulbs, and also in the amount of lampblack with which they are covered.

Photo-Nephograph.—At the request of the Meteorological Council, a series of experiments have been commenced with Captain Abney's Photo-Nephograph, described in the Report of the Council for 1881.

Two of the cameras, with their tripod stands, have been received at the Observatory, a base line of 180 yards has been marked off on the level path leading across the park from the Observatory, and a carriage for conveying the battery and reels of wire constructed.

A code of signals has been arranged to enable the observers at the cameras to work in accordance with each other, and several successful pairs of cloud negatives have been obtained, both on the plates prepared by Captain Abney and also on gelatino-bromide paper.

No steps have yet been taken towards the permanent installation of the apparatus at the Observatory.

Water Surface Temperature.—The observations of the maximum and minimum temperature of the surface water of the pond which were taken for the late Mr. Greaves, C.E., daily at 9 A.M., were discontinued at his request on May 1, and the results forwarded to him.

Mr. Greaves applied to the Committee for permission to excavate a tank in the ground attached to the Observatory, in order that continuous registration of water surface temperature might proceed in the immediate neighbourhood of the thermograph. The Committee, however, were unable to afford him the facilities he desired, the time of the Observatory staff being fully occupied with their existing duties.

Nocturnal Radiation.—The experiments on the fall of temperature of the lower layers of the atmosphere at sunset, instituted at the suggestion of Professor Tyndall, were terminated on February 16, on the resignation of the assistant by whom the readings of the thermometers were made, the grant devoted by the Meteorological Council to the purpose being almost expended.

Graphic Reductions.—The Superintendent, having made some experiments on the deduction of mean values, &c., from curves by a graphic method, based on Mr. Galton's composite portraiture, has communicated a paper on the subject to the Royal Meteorological Society, which has been published in the "Quarterly Journal," vol. ix.

Artificial Horizon.—Some experiments have been made with a view of testing an attachment to sextants answering the purpose of an artificial horizon, which has been invented by Mr. T. Tennent, of San Francisco, and constructed by Messrs. Elliott Brothers. The results appear to indicate that the invention will prove a useful addition to a sextant under certain conditions.

Watch-rating.—The Committee, having decided to make a trial of a system of watch-rating for the public, have granted £100 for the preliminary expenses. In accordance with a scheme prepared by the Superintendent, they have fitted up at the Observatory a first-class burglar- and fire-proof safe for the safe custody of the watches, and with a view to the obtaining of star-transits, have permitted Mr. Whipple to fit up a temporary transit-house at his residence in the

neighbouring town of Richmond, where he has erected a Sheepshanks 30-inch transit (No. 27) lent by the Royal Astronomical Society. The apparatus used for determining the temperature correction of aneroids is being fitted up to receive the watches for rating them at extreme temperatures, and arrangements are in progress for their reception and delivery at the Meteorological Office by Mr. Strachan, and at the Horological Institute, Northampton Square, by Mr. Britten, the Secretary.

A circular has been drafted, which will be issued to watchmakers on the completion of these arrangements, and it is hoped that operations will be commenced early in the new year.

Pendulum Experiments.—Professor C. S. Peirce, of the United States Coast Survey, who made a series of pendulum observations at Kew and elsewhere in 1876, visited the Observatory in July last, and made a subsidiary series of experiments with a view of determining the flexure of his stand when on the Kew piers, using for the purpose an instrument termed a “noddy.”

Major J. E. Herschel, R.E., F.R.S., and Mr. Chaney, of the Standards Department, visited the Observatory and witnessed some of his experiments.

V. VERIFICATION OF INSTRUMENTS.

The following magnetic instruments have been verified, and their constants have been determined:—

- 6 Unifilar Magnetometers for Elliott Brothers, London.
- 2 Dip Circles for Casella, London.
- 1 Dip Circle for Dover, Charlton.

There have also been purchased on commission and verified:—

- A Unifilar Magnetometer for Professor Brioschi, Naples.
- A Unifilar Magnetometer for Professor Ferrari, Rome.
- A Dip Circle for Professor Thalén, Upsala.
- A Dip Circle for Professor Ferrari, Rome.
- A complete set of Magnetometers for the Lyons Observatory France.

Two Dip Circles are at present undergoing examination:—

The number of meteorological instruments verified continues still to increase, having been in the past year as follows:—

Barometers, Standard	45
,, Marine and Station	114
Aneroids.....	52
Total.....	<u>211</u>

Thermometers, ordinary Meteorological	1165
„ Standard	116
„ Mountain	39
„ Clinical	7255
„ Solar radiation	35
	<hr/>
Total	8610
	<hr/>

Besides these, 51 Deep-sea Thermometers have been tested, 2 of which were subjected in the hydraulic press, without injury, to pressures exceeding three and a half tons on the square inch, and 78 Thermometers have been compared at the freezing-point of mercury, making a total of 8739 for the year.

Duplicate copies of corrections have been supplied in 17 cases.

The number of instruments which were rejected on account of excessive error, or which from other causes did not record with sufficient accuracy, was as follows:—

Thermometers, clinical	19
„ ordinary meteorological	4
Barometers	31

Seven Standard Thermometers have also been calibrated and divided, and supplied to societies and individuals during the year.

A Barograph and Thermograph have been examined, and had their scale values determined for the Hong Kong Observatory, also a Barograph for the Japanese Hydrographic Department, and a large Anemograph for the Zi-Ka-Wei Observatory.

The following miscellaneous instruments have also been verified:—

Hydrometers	59
Anemometers	12
Rain Gauges	9
Theodolite	1
Sextants	55
Index and Horizon Glasses, unmounted	111
Dark Glasses, unmounted	277
Prismatic Compasses	2
Marine Telescopes	3

There are at present in the Observatory undergoing verification, 27 Barometers, 932 Thermometers, 1 Anemometer and 4 Sextants, and a self-registering Aneroid for the Meteorological Council.

The Committee have recently revised the regulations for the verification of graduated instruments, fixing a linear value equal to 0.01 inch or 0.25 millim. as the limit to which corrections are to be assigned to scales intended to be read by the unassisted eye.

With a view of facilitating the examination of the dark glasses and mirrors of sextants, of which a large number are now tested and marked for makers before mounting in frames, the Superintendent has devised a special apparatus for the purpose, an illustrated description of which appeared in the "Proceedings of the Royal Society" (vol. 35, p. 42).

Redeterminations have been made of the angles between the collimators of the Cooke sextant apparatus, which show that they retain their positions with a satisfactory degree of constancy.

The Committee have been offered the loan of the apparatus employed by Mr. J. M. Crafts, of Paris, for the comparison of mercurial thermometers at high temperatures, but have not yet been able to avail themselves of his offer.

Standard Barometers.—From time to time comparisons have been made between the two Welsh Standard Barometers and Newman No. 34, the working Standard of the Observatory, and their relative values have been found to remain unchanged.

Mr. F. Waldo, of the United States Signal Department, being instructed by Major-General W. B. Hazen, Chief Signal Officer, United States of America, to compare the Standard Barometers of their Department with the European Standards, visited the Observatory in July, and made a lengthened comparison of two Standards by Fuess, which he brought with him, with the Observatory Working Standard, Newman No. 34. The results of his comparison have not yet been communicated to the Committee, but Dr. Chistoni, of the Italian Meteorological Service, having published in the "Annale della Meteorologia" an account of the results of his comparisons of Kew and other Standard Barometers, the Committee desire to publish an abstract of that part of his paper which more especially refers to the Observatory Standard.

Taking the absolute standard barometer of St. Petersburg as the basis for his comparisons, Dr. Chistoni finds that the corrections of the Continental standards, referred to this instrument, are as follows:—

Barometer.	Millim.	In.
Hamburg, Fuess, No. 9	−0·35	−0·014
" " No. 5	−0·14	−0·006
" " No. 10	−0·22	−0·009
Berlin, Old Standard, by Greiner	−1·16	−0·046
Copenhagen, Jünger	−0·11	−0·004
Rome, Deleuil, No. 6	−0·22	−0·009
Stockholm, Pistor and Martins, No. 579	0·00	0·000
Vienna, Pistor	−0·17	−0·007

His first comparison with the Kew Standard was an indirect one,

made by means of a Negretti and Zambra's Standard, No. 1042, which he found at Pesaro, and which had been compared at Kew in 1877. By means of an indirect comparison of this instrument with the Standard, Deleuil No. 6, at Rome, he found the correction of the latter, so referred to the Kew Standards, to be $-0\cdot23$ millim. ($-0\cdot009$ inch). Subsequently, Professor Tacchini conveyed another barometer directly to Kew, and this when compared with the Roman Standard, indicated the difference between the two instruments to be $-0\cdot19$ millim. ($-0\cdot008$ inch). From these two comparisons he assumes the true correction of Deleuil No. 6 to be $-0\cdot21$ millim. ($-0\cdot008$ inch). Having already determined the correction of that instrument referred to the St. Petersburg Standard to be $-0\cdot22$ millim. ($-0\cdot009$ inch), he concludes that the two absolute Standard Barometers of Kew and St. Petersburg perfectly agree, and taking into account the possible error of reading the instrument at Rome, "they cannot differ between themselves more than half the tenth of a millim. ($0\cdot002$ inch)." With the absolute Standard of the Collège de France he found the correction of Deleuil, No. 6 to be $-0\cdot18$ millim. ($-0\cdot007$ inch). Hence he also concludes that the absolute Standard Barometer of the Collège de France perfectly agrees with the absolute standards of Kew and St. Petersburg within the limits of the half-tenth of a millim. ($0\cdot002$ inch).

VI. MISCELLANEOUS.

Waxed Papers, &c., supplied.—Waxed paper has been supplied to the following Observatories:—

Colaba, Toronto, Mauritius, and the Meteorological Office.

Anemograph Sheets have been sent to Mr. Pogson, Madras Observatory.

Blank Magnetic Observation Forms have been supplied to Professor Brioschi, Naples.

Two glass tabulating scales for measuring magnetograph curves were constructed for the Toronto Observatory, and five various glass scales for the Hong Kong Observatory.

Two Additional Divided Plates for the Sun Picture Micrometer have been supplied to the Mauritius Observatory.

A Thomson Quadrant Electrometer was procured from the maker, and after examination, forwarded to Senhor Capello, of Lisbon. A portable Thomson Electrometer has also been purchased, and had its scale value determined for M. le Directeur de l'Institut Technique et Nautique de Bari, Italy.

Magnetic Survey of Great Britain and Ireland.—The attention of the Committee having been called to the fact that twenty-four years have elapsed since the surveys of Sabine and Welsh were completed, and

that a new survey is now desirable, they have requested the Hydrographer (Sir F. Evans), Professors W. G. Adams and G. Carey Foster to act as a sub-committee with a view of recommending the course to be adopted for the carrying out of the survey.

A number of instruments of interest were exhibited at the Fourth Annual Exhibition of the Royal Meteorological Society, which was devoted to meteorological instruments used by explorers and travellers, held in the rooms of the Institution of Civil Engineers in March last.

Library.—During the year the Library has received, as presents, the publications of—

27 English Scientific Societies and Institutions, and

88 Foreign and Colonial Scientific Societies and Institutions.

153 Volumes of duplicates of works on Astronomy, Terrestrial Magnetism, and Meteorology, have been presented to the Library of the newly established Observatory at Hong Kong.

Observatory and Grounds.—The buildings and grounds have been kept in order throughout the year. A new staircase leading from the ground to the first floor has been constructed; a new chimney fitted to the barometer-room stove, and the exterior of the building maintained in repair by Her Majesty's Commissioners of Works, &c.

A temporary vestibule has been put up in the Entrance Hall.

Owing to the giving way of a gas-pipe support attached to the Electrograph, the building narrowly escaped being set on fire on the night of March 9th; the housekeeper fortunately being near at the time, the fire was extinguished without damage being done. Steps have been taken to prevent a recurrence of the accident.

PERSONAL ESTABLISHMENT.

The staff employed is as follows:—

G. M. Whipple, B.Sc., Superintendent.

T. W. Baker, Chief Assistant and Magnetic Observer.

J. Foster, Verification Department.

H. McLaughlin, Librarian and Accountant.

E. G. Constable, Solar Observations and Tabulation of Meteorological Curves.

T. Gunter, Verification Department.

W. Boxall, Photography.

E. Dagwell, Office duties.

E. Coates } Verification Department.
C. Henley }

M. Baker, Messenger and Care-taker.

During the Spring, Mr. Whipple met with an accident which

entailed his absence from the Observatory for three months on a medical certificate, during the interval Mr. R. H. Scott undertook the general supervision of its affairs, Mr. T. W. Baker, as chief assistant, conducting the work at the Observatory.

Mr. F. G. Figg having been appointed first assistant in the Hong Kong Observatory, left at the end of June, and Mr. T. W. Baker undertook the duties of Magnetic Observer, Mr. Foster taking charge of the Meteorological Instruments Verification Department.

Mr. Dawson, messenger and caretaker, resigned in March on account of ill-health. Messrs. C. Taylor and S. Henley have also resigned. H. Clements was temporarily re-engaged in the Verification Department for six weeks.

<i>Dr.</i>	<i>£ s. d.</i>	<i>Cr.</i>	<i>£ s. d.</i>
To Balance from 1881-82	604 15 0		£1035 17 10
Royal Society (Gassiot Trust)	493 11 1		200 11 10
Meteorological Office	400 0 0		1236 9 8
Meteorological Office, for Researches, Postages, &c.	9 5 1		61 6 3
Verification Fees, Meteorological Office	£91 3 0		7 6 5
Observatories and Institutions	23 5 6		7 19 2
" " Instrument Makers and others	501 10 0		21 2 4
Instruments on Commission	615 18 6		21 3 11
Sale of Waxed Paper	360 6 8		118 18 1
Standard Thermometers	68 10 11		26 1 10
" " Forms, &c.	15 17 6		26 4 8
Copying Registers	2 14 5		15 17 8
Mr. De La Rue for Sun Work, &c.	79 13 6		8 4 8
Experimental Work	98 5 5		71 11 0
	15 8 3		20 19 9
	24 4 6		168 19 7
	£2590 5 5		66 4 4
	£2590 5 5		5 10 10
			291 2 10
			50 10 10
			14 8 0
			10 8 8
			80 7 8
			479 16 4
			50 0 0
			17 8 7
			547 4 11
			£2590 5 5

PAYMENTS.

RECEIPTS.

<i>Dr.</i>	<i>£ s. d.</i>	<i>Cr.</i>	<i>£ s. d.</i>
By Salaries	£1035 17 10		1236 9 8
Extra Payments	200 11 10		61 6 3
Fuel and Gas	61 6 3		7 6 5
Furniture and Fittings	7 6 5		7 19 2
Chandlery, &c.	7 19 2		21 2 4
Painting and Repairs	21 2 4		21 3 11
Rent and Incidentals (Enclosure and Path)	21 3 11		118 18 1
Printing and Stationery (General)	118 18 1		26 1 10
" " (Verification Department)	26 1 10		26 4 8
Postages	26 4 8		15 17 8
Library	15 17 8		8 4 8
Messengers and Housekeepers	8 4 8		71 11 0
Portage and Contingencies	71 11 0		20 19 9
Purchase of Chemicals and Materials	20 19 9		168 19 7
" " Tubes for Standard Thermometers	30 14 6		3 15 0
" " Anemograph Sheets	3 15 0		2 1 0
Verification Department Expenses (Ice, Carbonic-Acid Gas, &c.) ..	2 1 0		11 8 2
Repair of Instruments, and Purchase of New	11 8 2		13 14 11
Carpenter's Work and Sundries	13 14 11		4 10 9
Postages and Payments on behalf of Meteorological Office	4 10 9		66 4 4
Instruments purchased on Commission	66 4 4		5 10 10
Purchase of Waxed Paper, Packing ditto, &c.	5 10 10		291 2 10
Payments on behalf of Sun Work	291 2 10		50 10 10
" " Experimental Work	50 10 10		14 8 0
" " Watch Rating	14 8 0		10 8 8
Balance—Bank of England	10 8 8		80 7 8
London and County Bank	80 7 8		479 16 4
Cash in hand	479 16 4		50 0 0
	50 0 0		17 8 7
	547 4 11		£2590 5 5

<i>Dr.</i>	<i>£ s. d.</i>	<i>Cr.</i>	<i>£ s. d.</i>
To Gas, Fuel, and House Account	£12 5 5		12 5 5
Apparatus, Chemicals, &c.	9 6 2		9 6 2
Commissions	134 6 4		134 6 4
Balance	736 3 7		736 3 7
	£892 1 6		£892 1 6

November 24, 1883. Examined and compared with the Vouchers, and found correct.

(Signed) B. STRACHEY, Auditor.

ASSETS.

LIABILITIES.

APPENDIX I.

Magnetic Observations made at the Kew Observatory, Lat. 51° 28' 6" N. Long. 0^h 1^m 15^s.1 W., for the year October 1882 to September 1883.

The observations of Deflection and Vibration given in the annexed Tables were all made with the Collimator Magnet marked K C 1, and the Kew 9-inch Unifilar Magnetometer by Jones.

The Declination observations have also been made with the same Magnetometer, Collimator Magnets N D and N E being employed for the purpose.

The Dip observations were made with Dip-circle Barrow No. 33, the needles 1 and 2 only being used; these are 3½ inches in length.

The results of the observations of Deflection and Vibration give the values of the Horizontal Force, which, being combined with the Dip observations, furnish the Vertical and Total Forces.

These are expressed in both English and metrical scales—the unit in the first being one foot, one second of mean solar time, and one grain; and in the other one millimetre, one second of time, and one milligramme, the factor for reducing the English to metric values being 0.46108.

By request, the corresponding values in C.G.S. measure are also given.

The value of π^2K employed in the reduction is 1.64365 at temperature 60° F.

The induction-coefficient μ is 0.000194.

The correction of the magnetic power for temperature t_0 to an adopted standard temperature of 35° F. is

$$0.0001194(t_0 - 35) + 0.000,000,213(t_0 - 35)^2.$$

The true distances between the centres of the deflecting and deflected magnets, when the former is placed at the divisions of the deflection-bar marked 1.0 foot and 1.3 feet, are 1.000075 feet and 1.300097 feet respectively.

The times of vibration given in the Table are each derived from the mean of 12 or 14 observations of the time occupied by the magnet in making 100 vibrations, corrections being applied for the torsion-force of the suspension-thread subsequently.

No corrections have been made for rate of chronometer or arc of vibration, these being always very small.

The value of the constant P, employed in the formula of reduction

$$\frac{m}{X} = \frac{m'}{X'} \left(1 - \frac{P}{r_0^2} \right), \text{ is } -0.00109.$$

In each observation of absolute Declination the instrumental readings have been referred to marks made upon the stone obelisk erected 1,250 feet north of the Observatory as a meridian mark, the orientation of which, with respect to the Magnetometer, was determined by the late Mr. Welsh, and has since been carefully verified.

The observations have been made and reduced by Messrs. F. G. Figg and T. W. Baker.

Observations of Deflection for Absolute Measure of Horizontal Force.

Month.	G. M. T.	Distances of Centres of Magnets.	Tempe- rature.	Observed Deflection.	Log $\frac{m}{X}$ Mean.
1882.	d. h. m.	foot.			
October.....	26 12 39 P.M.	1.0	49.8	15 27 30	
		1.3	....	6 58 28	
	2 35 "	1.0	51.7	15 27 12	9.12609
		1.3	....	6 58 10	
November.....	28 12 41 P.M.	1.0	44.9	15 27 43	
		1.3	....	6 58 26	
	2 33 "	1.0	45.4	15 27 30	9.12583
		1.3	....	6 58 24	
December.....	20 12 32 P.M.	1.0	37.9	15 28 1	
		1.3	....	6 58 40	
	2 23 "	1.0	38.8	15 29 46	9.12599
		1.3	....	6 59 22	
1883.					
January.....	26 12 46 P.M.	1.0	45.1	15 27 10	
		1.3	....	6 58 11	
	2 32 "	1.0	46.5	15 27 21	9.12570
		1.3	....	6 58 18	
February.....	27 12 36 P.M.	1.0	46.2	15 26 45	
		1.3	....	6 58 1	
	2 27 "	1.0	49.1	15 25 6	9.12527
		1.3	....	6 57 29	
March.....	29 1 1 P.M.	1.0	53.8	15 25 41	
		1.3	....	6 57 50	
	2 40 "	1.0	55.1	15 24 59	9.12554
		1.3	....	6 57 28	
April.....	25 12 39 P.M.	1.0	58.5	15 26 24	
		1.3	....	6 57 40	
	2 37 "	1.0	60.6	15 23 10	9.12549
		1.3	....	6 56 35	
May.....	24 12 53 P.M.	1.0	77.1	15 20 26	
		1.3	....	6 55 12	
	2 44 "	1.0	80.5	15 19 12	9.12457
		1.3	....	6 54 41	
July.....	12 3 50 P.M.	1.0	67.4	15 19 30	
		1.3	....	6 55 13	
	13 12 2 "	1.0	70.9	15 21 33	9.12423
		1.3	....	6 55 22	
August.....	1 11 46 A.M.	1.0	67.9	15 22 2	
		1.3	....	6 55 51	
	3 32 P.M.	1.0	73.9	15 19 49	9.12459
		1.3	....	6 55 17	
August.....	22 12 31 P.M.	1.0	78.0	15 19 35	
		1.3	....	6 54 55	
	2 23 "	1.0	78.7	15 19 6	9.12431
		1.3	....	6 54 30	
October.....	1 12 42 P.M.	1.0	57.0	15 22 24	
		1.3	....	6 56 13	
	2 18 "	1.0	58.1	15 20 52	9.12414
		1.3	....	6 56 9	

Vibration Observations for Absolute Measure of Horizontal Force.

Month.	G. M. T.	Temperature.	Time of one Vibration.*	Log <i>mX</i> . Mean.	Value of <i>m</i> .†
1882.	d. h. m.		secs.		
October.....	26 12 1 P.M.	46°9	4·6500		
	3 8 P.M.	53·1	4·6525	0·30844	0·52151
November.....	28 12 7 P.M.	43·5	4·6517		
	3 4 P.M.	45·4	4·6498	0·30824	0·52123
December.....	20 11 50 A.M.	35·7	4·6478		
	2 58 P.M.	38·5	4·6505	0·30808	0·52109
1883.					
January.....	26 12 13 P.M.	43·9	4·6485		
	3 6 P.M.	46·8	4·6507	0·30848	0·52130
February.....	27 11 52 A.M.	45·0	4·6483		
	3 37 P.M.	52·0	4·6502	0·30875	0·52121
March.....	29 12 22 P.M.	52·6	4·6523		
	3 15 P.M.	55·0	4·6497	0·30873	0·52135
April.....	25 11 56 A.M.	56·9	4·6566		
	3 15 P.M.	60·1	4·6521	0·30839	0·52112
May.....	24 12 6 P.M.	76·1	4·6534		
	4 6 P.M.	84·0	4·6543	0·30989	0·52147
July.....	12 2 52 P.M.	67·0	4·6518		
	13 12 38 P.M.	72·6	4·6540	0·30939	0·52097
August.....	1 12 26 P.M.	69·1	4·6532		
	2 57 P.M.	73·1	4·6534	0·30935	0·52116
August.....	22 11 51 A.M.	76·9	4·6575		
	3 14 P.M.	78·3	4·6543	0·30930	0·52095
October.....	1 11 51 A.M.	55·9	4·6542		
	3 3 P.M.	57·7	4·6500	0·30870	0·52050

* A vibration is a movement of the magnet from a position of maximum displacement on one side of the meridian to a corresponding position on the other side.

† *m* = magnetic moment of vibrating magnet.

Dip Observations.

Month.	G. M. T.	Needle.	Dip.	Month.	G. M. T.	Needle.	Dip.
			North.				North.
1882.	d. h. m.	No.		1883.	d. h. m.	No.	
Oct.	30 3 12 P.M.	1	67 40'56	April	26 3 15 P.M.	1	67 39'37
	3 12 "	2	41'06		3 20 "	2	39'72
	31 3 12 "	1	40'75		27 3 30 "	1	39'81
	3 12 "	2	41'19		3 30 "	2	38'40
	Mean..	....	67 40'89		Mean..	....	67 39'32
Nov.	29 3 2 P.M.	1	67 41'56	May	29 2 48 P.M.	1	67 41'55
	3 1 "	2	40'56		3 45 "	2	41'49
	30 3 3 "	1	41'06		30 3 10 "	1	42'60
	3 5 "	2	40'56		3 32 "	2	39'74
	Mean..	....	67 40'93		Mean..	....	67 41'34
Dec.	22 2 58 P.M.	1	67 41'28	June	27 2 15 P.M.	1	67 41'62
	2 58 "	2	41'40		2 52 "	2	39'22
	Mean..	....	67 41'34		28 2 49 "	1	40'12
					3 26 "	2	37'91
					Mean..	....	67 39'72
1883.	29 3 44 P.M.	1	67 41'81	July	26 2 15 P.M.	1	67 40'25
Jan.	3 42 "	2	40'25		2 50 "	2	40'18
	30 3 18 "	1	41'50		28 4 40 "	1	38'28
	3 16 "	2	39'47		5 12 "	2	40'90
	Mean..	....	67 40'76		Mean..	....	67 39'90
Feb.	23 4 1 P.M.	1	67 42'50	Aug.	20 3 0 P.M.	1	67 40'46
	4 2 "	2	41'18		3 3 "	2	39'78
	26 3 13 "	1	40'50		21 2 42 "	1	39'19
	3 12 "	2	40'75		2 41 "	2	39'65
	Mean..	...	67 41'23		Mean..	....	67 39'77
Mar.	30 3 40 P.M.	1	67 41'21	Sept.	29 2 56 P.M.	1	67 40'94
	3 40 "	2	40'06		2 56 "	2	42'00
	31 3 0 "	1	40'93	Oct.	2 2 44 "	1	42'62
	3 1 "	2	39'81		2 45 "	2	40'15
	Mean..	....	67 40'50		Mean..	....	67 41'43

Month.	Declination. Mean of Observations.	Magnetic Intensity.																	
		English Units.			Metric Units.			C. G. S. Measure.											
		X, or Horizontal Force.	Y, or Vertical Force.	Total Force.	X, or Horizontal Force.	Y, or Vertical Force.	Total Force.	X, or Horizontal Force.	Y, or Vertical Force.	Total Force.									
1882.	West.																		
October	18 43 37	3·9009	9·5028	10·2721	1·7987	4·3816	4·7363	0·1799	0·4382	0·4736									
November	18 41 3	3·9012	9·5036	10·2733	1·7988	4·3820	4·7369	0·1799	0·4382	0·4737									
December	18 39 51	3·9025	9·5100	10·2795	1·7994	4·3849	4·7397	0·1799	0·4385	0·4740									
1883.																			
January	18 38 1	3·9029	9·5065	10·2766	1·7996	4·3833	4·7384	0·1800	0·4383	0·4738									
February	18 38 51	3·9061	9·5179	10·2880	1·8010	4·3885	4·7438	0·1801	0·4388	0·4744									
March	18 40 36	3·9047	9·5089	10·2795	1·8004	4·3844	4·7397	0·1800	0·4384	0·4740									
April	18 40 9	3·9035	9·4964	10·2674	1·7998	4·3787	4·7341	0·1800	0·4379	0·4734									
May	18 35 44	3·9144	9·5390	10·3107	1·8048	4·3983	4·7541	0·1805	0·4398	0·4754									
June	18 40 46	3·9136	9·5245	10·2972	1·8045	4·3916	4·7479	0·1804	0·4392	0·4748									
July	18 50 23	3·9118	9·5214	10·2987	1·8037	4·3902	4·7462	0·1804	0·4390	0·4746									
August	18 45 5	3·9128	9·5230	10·2953	1·8041	4·3909	4·7470	0·1804	0·4391	0·4747									
September	18 42 4	3·9109	9·5313	10·3024	1·8033	4·3947	4·7503	0·1803	0·4395	0·4750									

APPENDIX II.

Meteorological Observations.—Table I.

The Kew Observatory, Richmond, Surrey.

Longitude 0^h 1^m 15^s.1 W. Latitude 51° 28' 6" N. Height above sea-level = 34 feet.

Mean Monthly results from the continuous Records for the Twelve Months ending September 30th, 1883.

Months.	Thermometer.*				Barometer.†				Means of vapour-tension.	
	Means of max. temp.	Means of min. temp.	Extreme maximum.		Extreme minimum.		Means.	Date.		Bar.
			Date.	Ther.	Date.	Bar.				
1882.	°	in.	d. h.	°	d. h.	inches.	d. h.	inches.	inch.	
Oct.	50.6	44.4	1 4 P.M.	68.6	26 6 A.M.	29.842	4 10 P.M.	30.525	28.852	
Nov. ...	43.8	38.8	5 { 1 " } 3 " } " } " }	59.8	18 { 4 " } 7 " } " } " }	29.709	28 6 "	30.195 †	29.121	
Dec. ...	40.3	36.0	27 1 "	57.1	11 5 "	29.678 §	20 10 A.M.	30.341	29.057	
1883.										
Jan.	41.8	37.2	1 { 2 " } 6 " }	55.0	31 4 "	29.915	23 9 "	30.670	29.083	
Feb. ...	43.0	37.9	22 4 "	54.9	17 3 "	30.086	23 { 9 " } 10 " } 11 " }	30.860	28.938	
March. .	36.3	30.1	5 3 "	53.7	24 6 "	29.939	3 10 P.M.	30.722	29.221	
April. .	46.7	38.5	5 2 "	64.9	1 6 "	30.015	7 { 8 " } A.M. }	30.673	29.410	
May ...	52.6	44.2	24 4 "	76.0	4 5 "	29.967 §	17 8 "	30.403	29.495	
June ...	58.7	49.6	29 4 "	83.4	1 4 "	29.973	13 9 "	30.408	29.746	
July ...	59.7	52.0	2 3 "	82.3	16 4 "	29.868	16 2 P.M.	30.183	29.475	
Aug. ...	61.7	53.4	21 2 "	79.2	12 4 "	30.022	19 8 A.M.	30.298	29.588	
Sept. ...	56.7	50.2	19 2 "	79.6	9 6 "	29.836	13 9 "	30.276	28.777	
Means..	49.3	42.7	....	..	....	29.904	....	..	..

The above Table is extracted from the Quarterly Weather Report of the Meteorological Office, by permission of the Meteorological Council.

* The thermometers are 10 feet above the ground.

† Approximate reading.

‡ Readings reduced to 32° F. and to sea-level.

§ Mean for one day is approximate.

Meteorological Observations.—Table II.

Kew Observatory.

Months.	Mean amount of cloud (0=clear, 10=overcast).		Rainfall*.		Weather. Number of days on which were registered						Wind †. Number of days on which it was										
	Total.	Maxi-mum.	Date.		Rain.	Snow.	Hail.	Thun-der-storms.	Clear sky.	Over-cast sky.	Gales.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Calm.	
1882.																					
October ..	7.6	5.770	0.845	15	23	..	1	..	..	16	1	3	5	1	4	4	7	3	4	7	1
November	6.9	2.340	0.375	15	22	..	1	..	..	14	2	3	2	1	..	2	9	8	5	1	5
December	8.4	2.115	0.420	7	19	..	..	..	..	17	..	5	..	1	4	4	8	6	3	5	5
1883.																					
January ..	8.0	2.215	0.535	15	22	..	..	..	..	23	4	1	3	6	3	2	11	4	1	..	3
February ..	7.3	3.415	0.570	10	18	..	..	..	3	16	3	..	..	2	1	6	12	5	2	2	1
March ..	6.1	0.965	0.370	19	6	7	..	..	4	12	4	..	8	2	..	2	2	3	6	1	1
April ..	6.4	1.620	0.525	18	7	1	..	..	3	13	..	..	3	5	2	3	3	5	2	8	8
May ..	6.2	1.830	0.475	11	10	..	..	..	4	11	..	..	7	3	3	10	9	3	3	8	8
June ..	6.4	1.165	0.300	26	13	..	1	2	4	12	..	..	6	2	2	2	12	2	2	4	4
July ..	7.2	2.030	0.540	14	14	..	2	5	..	18	..	..	..	2	2	2	12	7	6	11	11
August ..	6.1	0.930	0.490	31	11	..	..	1	5	11	..	3	..	2	2	1	10	9	4	11	7
September	6.5	3.285	0.775	29	16	..	..	..	1	14	1	4	5	1	1	5	5	8	1	7	7
Totals..		27.680			181	12	5	8	24	177	15	46	35	23	25	35	98	63	40	63	63

* Measured daily at 10 A.M. by gauge 1.75 feet above surface of ground. † As registered by the anemograph.

Meteorological Observations.—Table III.

Kew Observatory.

Months.	Bright Sunshine.			Maximum temperature in sun's rays. (Black bulb <i>in vacuo</i> .)			Minimum temperature on the ground.			Horizontal movement of the Air.*				
	Total number of hours recorded.	Percentage of possible sunshine.	Greatest daily record.	Date.	Mean.	Highest.	Date.	Mean.	Lowest.	Date.	Average hourly Velocity.	Greatest hourly Velocity.	Hour.	Date.
1882.														
October	78.42	24	8 36	2	deg. 93	deg. 118	2	deg. 40.8	deg. 25.9	30	miles. 9	miles. 38	1 P.M.	24
November	75.12	28	6 12	11	80	104	3	34.0	19.0	18	15	39	9 & 10 P.M.	3
December	23.42	10	5 6	4	59	79	4	32.8	18.0	10	10	31	2 A.M.	29
1883.														
January	46.18	18	5 36	26	66	87	28	32.7	20.8	24	13	48	11 A.M.	29
February	71.48	26	8 54	23	83	106	28	32.5	20.9	17	12	38	7 & 8 P.M.	2, 10
March	141.54	39	10 42	25	93	115	31	24.9	11.9	24	14	38	1 & 2 P.M.	6, 22
April	155.36	38	10 48	17	109	128	30	32.1	19.1	9	9	29	9 & 11 A.M.	6, 18
May	205.54	43	14 48	24	118	133	31	38.7	25.2	4	8	30	8 A.M. & 1 P.M.	1, 13
June	186.12	38	14 48	3	125	141	29	44.7	30.6	17	8	27	10 A.M.	3
July	168.12	35	12 36	1	128	137	2	45.3	35.3	16	9	31	1 P.M.	11
August	180.18	40	12 36	10	124	135	21	47.4	36.4	20	8	32	2.3, & 4 P.M.	14
September	129.00	34	9 54	9	112	127	1	45.8	33.3	9	9	34	9 A.M.	2

* As indicated by a Robinson's anemograph, 70 feet above the general surface of the ground.

Table IV.

Summary of Sun-spot Observations made at the Kew Observatory.

Months.	Days of observation.	Number of new groups enumerated.	Days without spots.
1882.			
October.....	15	10	1
November.....	20	20	0
December.....	10	7	0
1883.			
January.....	13	14	0
February.....	14	10	1
March.....	22	13	2
April.....	21	15	0
May.....	23	10	2
June.....	22	12	0
July.....	19	14	0
August.....	16	11	0
September.....	19	13	1
Totals.....	214	149	7

APPENDIX III.

List of Instruments, Apparatus, &c.; the Property of the Kew Committee, at the present date out of the custody of the Superintendent, on Loan.

To whom lent.	Articles.	Date of loan.
G. J. Symons, F.R.S.	Old Kew Thermometer Screen Portable Transit Instrument.....	1868 1869
The Science and Art Department, South Kensington.	The articles specified in the list in the Annual Report for 1876, with the exception of the Photo-Heliograph, Pendulum Apparatus, Dip-Circle, Unifilar, and Hodgkinson's Actinometer.	1876
Dr. T. Thorpe, F.R.S.	Three * Open Scale Standard Thermometers, Nos. 561, 562, and 563. Tripod Stand	1879 1883
Major Herschel, R.E., F.R.S.	Invariable Pendulums, Nos. 1821, 4, and 11, Shelton Clock, R.S. No. 34. Stands, and Accessories.	1881
Mr. R. W. Munro ..	Standard Straight-edge.....	1881
Capt. Dawson, R.A. .	Unifilar Magnetometer by Jones, No. 102, complete, with three Magnets and Deflection Bar. Dip-Circle, by Barrow, one Pair of Needles, and Magnetizing Bars. Two Bifilar Magnetometers. One Balance Magnetometer. Two Declinometers. Two Tripod Stands.	1882
Major-General Sir H. Lefroy, R.A., F.R.S.	Two parcels Magnetical and Meteorological MSS. from the Sabine Magnetic Office.	1882
Dr. E. van Rijckevorsel	Dip-Circle by Barrow, No. 24, complete, with four Needles, and a Pair of Magnetizing Bars.	1883
Professor W. Grylls Adams, F.R.S.	Unifilar Magnetometer, by Jones, No. 101, complete.	1883
Mr. E. Mawley	Small Air Meter, with Robinson's Cups	1883
Professor O. J. Lodge	Unifilar Magnetometer, by Jones, No. 106, complete. Barrow Dip-Circle, No. 23, with two Needles, and Magnetizing Bars. Tripod Stand.	1883