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THE KEW OBSERVATORY,  
RICHMOND, SURREY.

1885.

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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, 1885,*

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

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[*From the* PROCEEDINGS OF THE ROYAL SOCIETY, 1885.]

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LONDON:  
HARRISON AND SONS, ST. MARTIN'S LANE,  
Printers in Ordinary to Her Majesty.

1885.



*Report of the Kew Committee for the Year ending  
October 31, 1885.*

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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. Warren de la Rue, *Chairman.*

Captain W. de W. Abney,  
R.E.

Prof. W. G. Adams.

Capt. Sir F. Evans, K.C.B.

Prof. G. C. Foster.

Mr. F. Galton.

Vice-Adm. Sir G. H. Richards,  
C.B.

The Earl of Rosse.

Mr. R. H. Scott.

Lieut.-General W. J. Smythe.

Lieut.-Gen. R. Strachey, C.S.I.

Mr. E. Walker.

The work at the Observatory may be considered under the following 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. Rating of Watches.

7th. Miscellaneous.

#### I. MAGNETIC OBSERVATIONS.

The Magnetographs have been in constant operation during the year, and in accordance with the usual practice, determinations of the scale values of all the instruments were made early in January.

As regards magnetic disturbances, no very exceptional variations have been registered. The principal perturbations occurred on the following dates:—November 2-3, 1884; March 15-16, May 13 and 27, and June 25-26, 1885.

In February the Kew 9-inch Unifilar Magnetometer by Jones was

sent to Messrs. Elliott Brothers, London, for the purpose of having Mr. Whipple's arrangement for steadying the Collimator Magnet fitted, and at the same time a rack and pinion adjustment was attached to the small telescope employed in viewing the collimator scale, in order to bring the scale more readily into focus.

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 cm. =  $0^{\circ} 8' \cdot 7$ .

Bifilar, January 13, 1885, for 1 inch  $\delta H = 0 \cdot 0268$  foot grain unit.

„ 1 cm. „ =  $0 \cdot 0005$  C.G.S. unit.

Balance, January 14, 1885 „ 1 inch  $\delta V = 0 \cdot 0280$  foot grain unit.

„ 1 cm. „ =  $0 \cdot 0005$  C.G.S. unit.

Information on matters relating to terrestrial magnetism and various data have been supplied to Dr. Wild, Professor Mascart, Dr. Van der Stok, Mr. R. H. Scott, Professor W. G. Adams, Dr. Rijckevorsel, Professor Rücker, and Dr. Atkinson.

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 . . . . .	34
„ Inclinatio . . . . .	127
„ Absolute Declination . . . . .	53

*International Polar Commission.*—The magnetic observations made during the year September, 1882, to August, 1883, at Fort Rae, North America, by the expedition under Captain Dawson, R.A., have been fully reduced and prepared for publication, on the plan adopted by the International Polar Commission at their Meeting at Vienna in 1884, by the Observatory staff during extra office hours, and the work is at present passing through the press. The readings of the Kew Magnetographs have also been reduced on the same plan at the cost of the Polar Committee of the Royal Society, and copies forwarded to Dr. H. Wild, President of the Commission. Special scales were constructed for the tabulation of the Kew curves on the C.G.S. system by Mr. Baker, the magnetic observer.

*Krakatoa Eruption.*—The Krakatoa Committee of the Royal Society having entrusted to the Kew Committee the data which they have collected relating to electrical and magnetical phenomena which occurred about August 27, 1883, the date of the eruption of Krakatoa, the curves of the magnetographs of the Observatories at

Batavia, Colaba, Lisbon, Mauritius, Melbourne, Paris, Stonyhurst, and Zi-ka-wei have been carefully compared with each other, and a report thereon will shortly be submitted to the Committee.

II. METEOROLOGICAL OBSERVATIONS.

The several self-recording instruments for the continuous registration respectively of atmospheric pressure, temperature, and humidity, wind (direction and velocity), bright sunshine, and rain, have been maintained in regular operation throughout the year.

In February the barometer tube was removed for a short time from the barograph, and a carefully divided glass scale substituted in its place, which was then photographed with the view of re-determining the scale value of the instrument, and also of measuring the amount of distortion the curve undergoes by shrinkage of the gelatinized paper during the photographic operations, to which it is subjected, subsequent to its reception of the luminous image.

In September the action of the barograph was observed to be somewhat sluggish, and an examination of the instrument showed an obstruction of the air-vent in the cistern due to an accumulation of dust. This was removed, and there has since been no want of sensitiveness on the part of the barometer.

The standard eye observations for the control of the automatic records have been duly registered during the year, together with the daily observations in connexion with the U.S. Signal Service synchronous system. A summary of these observations is given in Appendix II.

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 as usual to the Meteorological Office.

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

Readings of standard barometer .....	1750
„ dry and wet thermometers .....	3460
„ maximum and minimum thermometers .....	730
„ radiation thermometers .....	2825
„ rain gauges .....	730
Cloud and weather observations .....	1825
Measurements of barograph curves .....	8760
„ dry bulb thermograph curves..	9490
„ wet bulb thermograph curves..	8760
„ wind (direction and velocity)..	17520
„ rainfall curves .....	680
„ sunshine traces .....	2079

In compliance with a request made by the Meteorological Council to the Committee, Mr. Whipple visited Falmouth in May in order to superintend the removal of the meteorological instruments from the old Observatory to the new building recently erected near that town by the Royal Cornwall Polytechnic Society; he has since inspected the instruments at the Aberdeen, Stonyhurst, and Glasgow Observatories, and the Anemographs at Yarmouth and Sandwick.

Mr. Baker visited the Valencia and Falmouth Observatories for the purpose of inspection during his vacation.

With the sanction of the Meteorological Council, weekly abstracts of the meteorological results have been regularly forwarded to, and published by "The Times" and "The Torquay Directory." Data have also 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. Gwilliam, Rowland, and others. The cost of these abstracts is borne by the recipients.

*Electrograph.*—The difficulty of maintaining the potential of the charge of this instrument constant, mentioned in last year's Report, having greatly increased, in spite of all measures of precaution which were taken, the Meteorological Council were in July informed of its unsatisfactory condition. They accordingly gave instructions to discontinue its working, and it is intended to draw up a report on the results which may be obtained from the eleven years' curves of variations of atmospheric electricity now available for discussion.

### III. SOLAR OBSERVATIONS.

The sketches of Sun-spots, as seen projected on the photoheliograph screen, have been made on 170 days, in order to continue Schwabe's enumeration, the results being given in Appendix II, Table IV.

*Transit Observations.*—320 observations of solar and 102 of sidereal transits have been taken, for the purpose of keeping correct local time at the Observatory, and the clocks and chronometers have also been compared daily. The Observatory Chronometer, Breguet 3140, has been cleaned and readjusted.

The following clocks, French, Shelton K. O., and Dent 2011, and the chronometers, Molyneux No. 2125, and Breguet No. 3140, are kept carefully rated as time-keepers at the Observatory.

### IV. EXPERIMENTAL WORK.

*Photo-nephograph.*—The experiments with the photo-nephographs having proved satisfactory, and a report to that effect having been presented to the Meteorological Council, it was decided in June to

take frequent pictures for the purpose of determining the rate of motion of clouds. Accordingly the telegraph cable uniting the two stations was buried in the ground (permission having previously been granted by the lessee of the Old Deer Park), and the stands and electrical fittings were made fixtures.

A quantity of photographic plates, prepared in accordance with Captain Abney's formula, were also obtained from a manufacturer, and certain arrangements made in the photographic laboratory of the Observatory for their convenient manipulation. Blank forms for the computation of the cloud positions and motions were also drawn up and printed.

Between July 6th, when the installation of the apparatus was completed, and the date, when the experiments were brought to a close, in accordance with the instructions of the Meteorological Council, 168 cloud negatives were obtained on 23 days, from these 62 approximate determinations of the rate and direction of motion of clouds at heights varying from 3,000 feet to 50,000 feet have been secured.

A detailed report of the work is being drawn up for presentation to the Meteorological Council.

*Solar Radiation Thermometers.*—The Committee have made a great number of experiments on the construction and exhaustion of the solar radiation thermometers, and the Superintendent is engaged on a report to be communicated to the Royal Society. The general result would indicate that solar radiation as measured by the black bulb thermometer in vacuo has hitherto been considerably underrated.

*Baily's Wind Integrator.*—This instrument, after working successfully with electrical counters for some time, was simplified by the inventor by the substitution of mechanical counters. These being found to work satisfactorily, Mr. Baily removed the instrument in May for the purpose of exhibiting it at the International Inventions Exhibition.

The spare Beckley Anemograph to which it was attached has been dismantled, and together with the de la Rue recorder (see report for 1879) has, by direction of the Meteorological Council, been forwarded to Mr. Munro to be reconstructed as a Beckley recorder of the original type.

*Electrical Anemograph.*—The Meteorological Council having granted a sum of money for experiment, and placed at the disposal of Mr. W. Preece, F.R.S., Superintendent of Telegraphs, an old Beckley Anemograph of the 1858 model, that gentleman had it fitted up by Mr. Kempe, of the Chief Engineer's Department, G.P.O., so as to record electrically, and it was erected on the Experimental House of the Observatory. The velocity attachment has worked most satisfactorily for the past six months, neither batteries

nor connexions having needed the slightest attention. The direction gear has, however, occasionally required readjustment of its orientation after strong winds have blown, and is now undergoing alteration.

*Hand Anemometers.*—A number of these instruments, intended to show the velocity of the wind during a brief period of observation, have had their scale values determined by direct comparison with the Standard Anemograph of the Observatory.

*Range-finders.*—Facilities have been afforded to Dr. Ristori, F.R.A.S., by the employment of the Cooke apparatus, for the purpose of graduating some new range-finders invented by Mr. Nordenfeldt, and constructed by Mr. Casella, the cost of the experiments being defrayed by the inventor.

#### V. VERIFICATION OF INSTRUMENTS.

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

- 2 Unifilar Magnetometers and an Inclinator for Elliott Brothers, London.
- 1 Unifilar Magnetometer with two Collimating Magnets, and an Inclinator for the Admiralty, London.
- 1 small-pattern Fox Circle for the Bureau of Navigation, United States Government, and an ordinary Inclinator for Dover, Charlton.

3 pairs of Inclinator Needles have been purchased on commission and verified for Dr. Wild and the Mauritius Observatory.

One Unifilar and an Inclinator are at present undergoing examination for the Falmouth Observatory.

The total number of other instruments tested in the past year was as follows :—

Barometers, Standard.....	54
„ Marine and Station .....	98
Aneroids .....	104
Total.....	256
Thermometers, ordinary Meteorological .....	1825
„ Standard .....	143
„ Mountain .....	13
„ Clinical .....	8238
„ Solar radiation .....	49
Total.....	10268



Hydrometers.....	461
Anemometers.....	14
Rain Gauges.....	20
Sextants.....	130
Index and Horizon Glasses, unmounted.....	74
Dark Glasses, unmounted.....	235

Besides these, 38 Deep-sea Thermometers have been tested, 32 of which were subjected, in the hydraulic press, without injury, to pressures exceeding two tons on the square inch. 55 Thermometers have been compared at the freezing-point of mercury, making a total of 10,361 for the year.

Duplicate copies of corrections have been supplied in 43 cases.

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

Thermometers, clinical.....	52
„    ordinary meteorological.....	4
Various.....	97

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

1 Evaporation Gauge, 4 Thermograph Thermometers, 1 Sunshine Recorder, 2 Gauge Barometers for comparing Aneroids, 1 Electrical Anemometer, and 1 Richard Thermograph were also tested.

There are at present in the Observatory undergoing verification, 2 Barometers, 222 Thermometers, 100 Hydrometers, 24 Sextants, and 1 self-recording Aneroid.

*Sextant Testing Apparatus.*—In consequence of the increasing number of sextants sent to the Observatory for examination it was found desirable to provide a special accommodation in the building for the work. As the room known as the Pendulum room was unoccupied, and the masonry pier fitted up in it as a support for pendulum apparatus was no longer required, it was resolved to convert the apartment into a sextant room, and accordingly the pier was removed, and the Cooke testing apparatus dismantled from the South Hall and re-erected on its site. Four careful redeterminations were then made of the angles between the collimators, and they were found to have been unaffected by the transfer of the apparatus to the new position.

## VI. RATING OF WATCHES.

The arrangements for rating watches mentioned in previous Reports have been continued during the year with great success, and

up to the present 367 watches have been tried, of which 39 were submitted by the owners, and 328 by the manufacturers or dealers.

The 392 watches received during the year were entered for testing in the following classes:—

For class A, 254; class B, 38; and class C, 10. Of these 72 failed to gain any certificate; 6 passed in C, 60 in B, 110 in A, and 6 others obtained the highest possible form of certificate, the class A especially good.

Owing to numerous requests from manufacturers and others, a system of awarding marks to class A watches, indicating the degree of relative efficiency exhibited during trial, was adopted, being based upon plans already in use in the Geneva and Yale Observatories. In it the number of marks awarded to a watch that only just succeeds in obtaining an A certificate is 0, but to an absolutely perfect watch would be 100, made up as follows:—40 for a complete absence of variation of daily rate, 40 for absolute freedom from change of rate with change of position, and 20 for perfect compensation for effects of alteration of temperature.

As, however, the trials already in use do not comprise a test for the going of travellers' or explorers' watches, experiments are in progress with a view of constructing apparatus to test the behaviour of watches when kept in motion, as in the case of daily wear and travelling, in order to make a special examination on this point for watches submitted for trial by the Royal Geographical Society.

A series of tests for pocket chronographs has also been introduced by special request of the Cyclists' Union.

In Appendix III will be found a table giving the results of trial of the watches which have gained the highest certificates in each class.

The following table will indicate the nature of the trials to which ordinary certificates refer:—

Position of watch during test.	For certificate of Class		
	A.	B.	C.
Vertical, with pendant up .....	10 days	14 days	8 days
"    "    "    right .....	5 "	—	—
"    "    "    left .....	5 "	—	—
Horizontal, with dial up .....	5 "	14 days	8 days
"    "    "    down .....	5 "	—	—
"    at temp. 85° F. ....	5 "	1 day	—
"    "    "    35° F. ....	5 "	1 "	—
Not rated .....	5 "	1 "	—
Total duration of test .....	45 days	31 days	16 days

## VII. MISCELLANEOUS.

*Photographic Paper, &c.*—This has been supplied to the Observatories at Alipore, Colàba, Falmouth, Glasgow, Mauritius, Stonyhurst, St. Petersburg, and Toronto, and to the Meteorological Office.

*History of the Observatory.\**—A paper giving a history of the Kew Observatory from its earliest foundation down to the present date has been compiled by Mr. R. H. Scott, a member of the Committee, and printed in the "Proc. Roy. Soc.," vol. xxxix, p. 37.

*Dowson Gift.*—The Committee are indebted to Mr. E. T. Dowson, F.R. Met. Soc., for the presentation of a large collection of weights and measures formed by the late Mr. James Yates, F.R.S., member of the Metric Committee of the British Association, with books and pamphlets bearing on the Metric System. At the request of Mr. H. J. Chaney, Warden of the Standards, a number of these works, copies of which were not to be found in the Library of the Standards Office, were handed over by the Committee to that Department.

The Observatory has also been presented by the Rev. John Rigaud, B.D., Fellow of Magdalen College, Oxford, with a framed sketch portrait of his father, Stephen Peter Rigaud, Esq., M.A., F.R.S., Savilian Professor of Astronomy and Radcliffe Observer, who, in the early part of the present century, during the Oxford vacations, was in the habit of relieving his uncle, the Rev. S. Demainbray, of his charge as "The King's Observer at Kew."

*Exhibition.*—A number of instruments of interest were exhibited at the Sixth Annual Exhibition of the Royal Meteorological Society, which was devoted to sunshine recorders and actinometry, and held in the rooms of the Institution of Civil Engineers in March last.

*International Inventions Exhibition.*—The Committee have exhibited in Groups 27 and 29 at this Exhibition articles of which the following is the description as given in the Official Catalogue:—

"Forms and papers illustrating the methods employed at the Kew Observatory, Richmond, in examining, rating, and certifying as to the performance of watches, pocket chronometers and chronographs for the manufacturers and general public."

"(1.) Photo-nephograph or Cloud-height Measuring Apparatus. (2.) Apparatus employed in the examination and testing of sextants, quadrants, theodolites, &c. (3.) Specimens of certificates awarded to instruments, and general information relating thereto."

The Jury Commission has awarded to the Committee a Diploma of Honour for their exhibits.

The Superintendent, with the consent of the Committee, read the

\* This paper was based upon a short note on the History of the Observatory, submitted by Mr. McLaughlin one of the staff, to a local Society in Richmond.

following papers before the Aberdeen Meeting of the British Association:—

“On the Errors of first class Sextants, as determined from the Records of the Verification Department at the Kew Observatory;” and “On the Behaviour of first class Watches whilst undergoing Tests in the Rating Department of the Kew Observatory.”

At the request of the Royal Cornwall Polytechnic Society the Kew Committee have undertaken the purchase and trial of a set of Magnetographs now in course of construction for the Falmouth Observatory, on a new plan, the designs and specification for which have been prepared by Mr. Whipple, as the Royal Society grant was inadequate to provide for instruments of the ordinary Kew pattern.

By the kindness of Captain Rung, of the Meteorological Institute, Copenhagen, the Superintendent has been able to procure two specimens of his apparatus for whirling thermometers. These, with the necessary thermometers, have been forwarded to Dr. Doberck, the Government Astronomer at Hong Kong.

*Magnetic Disturbances.*—By permission of the Committee, Mr. W. Lant Carpenter has visited the Observatory for the purpose of extracting certain magnetic information from the tabulations in order to assist Professor Balfour Stewart in his investigations on Terrestrial Magnetism.

*Workshop.*—The machine tools procured by grants from the Government Grant Fund or the Donation Fund for the use of the Kew Observatory have been kept in thorough order. In consequence of the increased number of clinical thermometers submitted for verification, a new specially constructed Galton testing apparatus has been purchased at a cost of 38*l.*, as well as a duplicate Hall-marking apparatus. Accommodation has been found in the workshop for the assistants engaged in the new department specially devoted to the examination of this class of instruments.

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

- 26 Scientific Societies and Institutions of Great Britain, and
- 78 Foreign and Colonial Scientific Societies and Institutions.

*House, Grounds, and Footpath.*—These have all been kept in order during the year. A step ladder has been set up to give more convenient access to the roof of the Sun-room for the purpose of testing Anemometers. The dome has also been lifted and its fittings readjusted. The necessary external repairs to the building, as well as an examination and cleaning of the drains, have been effected by Her Majesty's Commissioners of Works.

The Committee has addressed a memorial to Her Majesty's Commissioners of Woods and Forests, through the President and Council of the Royal Society, with the object of securing free passage to the

Observatory at all hours through the yard tenanted by the lessee of the park at the entrance gates, and negotiations are in progress on the subject.

The Committee has effected an insurance of the contents of the Observatory and outbuildings against loss by fire in the Liverpool, London, and Globe Fire Insurance Company.

PERSONAL ESTABLISHMENT.

The staff employed is as follows :—

- G. M. Whipple, B.Sc., Superintendent.
- T. W. Baker, Chief Assistant and Magnetic Observer.
- H. McLaughlin, Librarian and Accountant.
- E. G. Constable, Solar Observations and Watch Rating.
- W. Hugo, }  
J. Foster, } Verification Department.  
T. Gunter, }  
W. Boxall, }
- E. Dagwell.
- H. A. Widdowson.
- F. Oliver.
- W. C. Gough.
- E. Redding.
- M. Baker, Messenger and Care-taker.

The following resignations have taken place during the year :—  
H. Barton, C. Henley, and A. Nish.

*Abstract. The Kew Observatory Receipts and Payments Account from November 1, 1884, to November 7, 1885.*

Dr.	£ s. d.	PAYMENTS.	Cr.
			£ s. d.
To Balance from 1883-84 .....	482 7 0	By Salaries .....	£1199 4 8
Royal Society (Gassiot Trust) .....	491 8 10	Extra Payments .....	23 11 0
Meteorological Office .....	400 0 0	Fuel and Gas .....	53 11 6
Meteorological Office, for Postages, &c. ....	12 1 10	Furniture and Fittings .....	10 17 0
Instruments on Commission .....	242 7 2	Chandlery, &c. ....	7 15 8
Experimental Work for Meteorological Office.....	36 6 3	Painting and Repairs.....	48 12 9
" " Sanitary Institute .....	6 9 11	Rent and Maintenance of Enclosure and Road  .....	22 5 2
Sale of Standard Thermometers.....	5 9 6	Printing, Stationery, and Wood-engraving.....	143 2 1
"Times" Diagrams and Copying Registers, &c. ....	62 2 0	Postages, &c. ....	36 15 11
Verification Fees, Meteorological Office .....	90 15 0	Library .....	12 2 10
" " Observatories and Institutions .....	29 6 8	Messenger and Housekeeper .....	14 10 5
" " Instrument Makers and others .....	607 2 11	Porterage, Insurance, &c. ....	58 6 0
Watch Rating Fees, &c. ....	727 4 7	Chemicals and Photographic Paper .....	19 19 0
	185 8 6	Clinical Thermometer Tester .....	141 14 2
		Anemograph Sheets .....	28 6 4
		Repairs and Purchase of Instruments .....	37 8 9
		Carpenter's Work and Sundries .....	2 4 7
		Postages, Portrages, &c., for Meteorological Office .....	24 15 9
		Instruments and Paper purchased on Commission .....	22 19 4
		International Circumpolar Committee .....	115 14 9
		Experimental Account—The Observatory .....	14 9 3
		" " Meteorological Office .....	203 8 4
		" " W. Bally, Esq. ....	19 8 10
		" " Sanitary Institute .....	8 2 8
		"Times" Diagrams, Copying, &c. ....	81 17 2
		Exhibitions (Models, Mounts, Portrage, &c.) .....	3 18 10
		Verifications. Extra Payments .....	4 4 0
		" " Ice, Carbonic-Acid Gas and Tubes .....	98 2 8
		" " Postages and Portrages .....	30 16 6
		" " Printing and Stationery .....	25 12 8
		" " Pantagraph, Packing Cases, &c. ....	7 0 2
			141 19 11

Watch Rating—Extra Payments .....	43 16 0
Advertisements, Ice, Tools, &c. ....	17 3 1
Postages and Forgeries .....	6 16 1
Printing and Stationery .....	3 9 7
Carpenter's Work, &c. ....	5 17 3
	<u>77 2 0</u>
Balance—Bank of England .....	331 8 3
London and County Bank .....	66 0 5
Cash in hand .....	19 10 1
	<u>416 18 9</u>
	<u>£2651 5 7</u>

Examined and compared with the Vouchers, and found correct.

(Signed) ROBERT H SCOTT, Auditor.

November 19, 1885.

ASSETS.

	£	s.	d.
By Balance as per Statement .....	416	18	9
Meteorological Office, Allowances, Experimental, and Sundries .....	105	17	3
Verification Fees due, &c. ....	84	11	11
Watch Rating Fee due .....	2	19	6
Photographic Paper .....	13	0	0
Commissions, &c. ....	20	9	10
Blank Forms .....	7	2	9
Standard Thermometers .....	99	12	0
	<u>£750 12 0</u>		

November 19, 1885.

LIABILITIES.

	£	s.	d.
To Gas, Fuel, and House Account .....	8	19	8
Apparatus, Chemicals, &c. ....	4	6	9
Commissions, &c. ....	3	2	0
Verification Account .....	3	15	4
Watch Rating Account .....	1	2	6
Balance .....	729	5	9
	<u>£750 12 0</u>		

(Signed) G. M. WHIPPLE,  
Superintendent.

## APPENDIX I.

*Magnetic Observations made at the Kew Observatory, Lat. 51° 28' 6" N.  
Long. 0<sup>h</sup> 1<sup>m</sup> 15<sup>s</sup>.1 W., for the year October 1884 to September 1885.*

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 101 B 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  $3\frac{1}{2}$  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  $\log \pi^3 K$  employed in the reduction is 1.64365 at temperature 60° F.

The induction-coefficient  $\mu$  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  $\frac{m}{X} = \frac{m'}{X'} \left(1 - \frac{P}{r_0^2}\right)$ , is -0.00129.

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 Mr. T. W. Baker.



Vibration Observations for Absolute Measure of Horizontal Force.

Table I.

Month.	G. M. T.	Temperature. Fahr.	Time of one Vibration.*	Log $mX$ . Mean.	Value of $m$ .†
1884.	d. h. m.	°	secs.		
October.....	29 11 25 A.M.	48·1	4·6517	0·30820	0·51988
	30 12 29 P.M.	56·3	4·6542		
	2 17 P.M.	57·9	4·6530	0·30841	0·51976
November.....	27 11 44 A.M.	46·7	4·6472		
	3 51 P.M.	49·3	4·6473	0·30906	0·51979
December.....	29 11 57 A.M.	39·1	4·6493		
	2 55 P.M.	40·3	4·6458	0·30850	0·51948
1885.					
January.....	29 1 50 P.M.	55·0	4·6509	0·30880	0·51978
	30 12 19 P.M.	51·6	4·6543	0·30798	0·51937
February.....	26 11 52 A.M.	51·4	4·6503		
	3 6 P.M.	54·0	4·6482	0·30898	0·51970
March.....	23 12 10 P.M.	47·0	4·6494		
	2 10 P.M.	48·0	4·6477	0·30876	0·51965
	24 12 21 P.M.	49·1	4·6496		
	2 3 P.M.	51·6	4·6498	0·30870	0·51970
April.....	27 11 38 A.M.	64·7	4·6555		
	2 55 P.M.	71·8	4·6552	0·30875	0·51971
	28 2 19 P.M.	74·2	4·6590	0·30846	0·51976
May....	28 11 12 A.M.	68·8	4·6608		
	2 55 P.M.	75·0	4·6583	0·30822	0·51983
	29 2 9 P.M.	67·5	4·6566	0·30850	0·51926
June.....	29 11 23 A.M.	63·1	4·6538		
	2 57 P.M.	72·5	4·6523	0·30915	0·51971
July.....	29 11 28 A.M.	66·0	4·6572		
	2 56 P.M.	71·8	4·6540	0·30872	0·51965
August.....	28 11 20 A.M.	63·7	4·6541		
	2 48 P.M.	66·8	4·6563	0·30859	0·51955
September.....	28 11 38 A.M.	55·0	4·6542		
	3 17 P.M.	61·7	4·6522	0·30857	0·51922

\* 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.

## Observations of Deflection for Absolute Measure of Horizontal Force.

Table II.

Month.	G. M. T.	Distances of Centres of Magnets.	Tempe- rature. Fahr.	Observed Deflection.	Log $\frac{m}{X}$ . Mean.
1884.	d. h. m.	foot.			
October . . . . .	29 12 15 P.M.	1.0	51.4	15 21 56	9.12360
		1.3	....	6 55 41	
	30 11 45 A.M.	1.0	50.7	15 21 28	9.12319
		1.3	....	6 55 48	
	3 0 P.M.	1.0	57.9	15 18 58	9.12259
		1.3	....	6 54 45	
November . . . . .	27 12 15 P.M.	1.0	47.7	15 19 54	9.12259
		1.3	....	6 55 6	
	2 15 "	1.0	49.4	15 19 53	9.12264
		1.3	....	6 54 56	
December . . . . .	29 12 36 P.M.	1.0	40.1	15 21 30	9.12264
		1.3	....	6 55 53	
	2 13 "	1.0	40.0	15 20 44	9.12283
		1.3	....	6 55 25	
1885.					
January . . . . .	29 2 47 P.M.	1.0	56.0	15 19 13	9.12283
		1.3	....	6 54 48	
	30 11 27 A.M.	1.0	49.6	15 20 48	9.12298
		1.3	....	6 55 13	
February . . . . .	26 12 28 P.M.	1.0	53.0	15 19 22	9.12251
		1.3	....	6 54 44	
	2 23 "	1.0	54.2	15 18 34	9.12279
		1.3	....	6 54 34	
March . . . . .	23 11 33 A.M.	1.0	45.0	15 21 3	9.12266
		1.3	....	6 55 9	
	2 49 P.M.	1.0	47.3	15 20 37	9.12277
		1.3	....	6 54 55	
	24 11 40 A.M.	1.0	45.7	15 20 58	9.12279
		1.3	....	6 55 15	
	2 44 P.M.	1.0	52.5	15 20 2	9.12277
		1.3	....	6 54 50	
April . . . . .	27 12 20 P.M.	1.0	65.6	15 18 34	9.12277
		1.3	....	6 54 14	
	2 12 "	1.0	69.8	15 16 45	9.12313
		1.3	....	6 53 25	
	28 2 58 "	1.0	72.2	15 17 13	9.12226
		1.3	....	6 54 5	
May . . . . .	28 12 4 P.M.	1.0	71.2	15 19 14	9.12350
		1.3	....	6 54 26	
	2 12 "	1.0	74.0	15 17 16	9.12226
		1.3	....	6 54 10	
	29 3 22 "	1.0	70.5	15 16 10	9.12236
		1.3	....	6 53 7	
June . . . . .	29 12 9 P.M.	1.0	64.8	15 17 33	9.12236
		1.3	....	6 53 48	
	2 17 "	1.0	72.5	15 15 21	9.12236
		1.3	....	6 53 4	

Table II—continued.

Month.	G. M. T.	Distances of Centres of Magnets.	Tempe- rature. Fahr.	Observed Deflection.	Log <sup>m</sup> $\bar{X}$ . Mean.
1885.	d. h. m.	foot.			
July .....	29 12 17 P.M.	1·0	67·6	15 17 42	9·12270
		1·3	....	6 54 7	
	2 14 „	1·0	71·4	15 16 6	
		1·3	....	6 53 25	
August .....	28 12 5 P.M.	1·0	64·4	15 17 4	9·12267
		1·3	....	6 54 19	
	2 9 „	1·0	65·9	15 17 12	
		1·3	....	6 54 7	
September.....	28 12 37 P.M.	1·0	57·0	15 18 22	9·12213
		1·3	....	6 54 27	
	2 32 „	1·0	60·8	15 16 12	
		1·3	....	6 53 26	

Inclination Observations.—Table III.

Month.	G. M. T.	Needle.	Inclination.	Month.	G. M. T.	Needle.	Inclination.
			North.				North.
1884.	d. h. m.	No.		1885.	d. h. m.	No.	
Oct.	6 2 58 P.M.	1	67° 39' 31	April	20 2 45 P.M.	1	67° 38' 44
	3 0 "	2	38 43		2 51 "	2	38 25
	23 2 33 "	1	38 59		21 2 47 "	1	37 06
	2 33 "	2	39 90		2 47 "	2	37 22
	24 2 30 "	1	39 25		24 3 2 "	1	36 41
	2 29 "	2	39 66		3 3 "	2	37 13
	Mean..	....	67 39 19		Mean..	....	67 37 42
Nov.	25 2 46 P.M.	1	67 40 47	May	26 3 8 P.M.	1	67 40 69
	2 47 "	2	40 31		3 9 "	2	38 10
	26 2 30 "	1	38 63		27 2 34 "	1	40 25
	2 29 "	2	38 90		2 33 "	2	40 03
	Mean..	....	67 39 58		30 2 43 "	1	39 00
					2 42 "	2	39 06
					Mean..	....	67 39 52
Dec.	30 2 20 P.M.	1	67 39 03	June	23 2 40 P.M.	1	67 38 18
	2 18 "	2	39 40		2 42 "	2	38 28
	31 2 33 "	1	38 25		25 2 52 "	1	37 26
	2 33 "	2	39 44		2 47 "	2	37 53
	Mean..	....	67 39 03		Mean..	....	67 37 81
1885.	26 2 48 P.M.	1	67 38 46	July	27 3 24 P.M.	1	67 37 97
Jan.	2 46 "	2	39 22		3 24 "	2	37 22
	28 2 37 "	1	39 50		28 3 4 "	1	37 03
	2 36 "	2	39 56		3 4 "	2	37 06
	Mean..	....	67 39 18		Mean..	....	67 37 32
Feb.	23 2 45 P.M.	1	67 37 53	Aug.	25 2 48 P.M.	1	67 37 62
	2 43 "	2	38 87		2 45 "	2	36 59
	24 2 35 "	1	38 68		27 3 52 "	1	36 09
	2 35 "	2	37 68		3 52 "	2	37 62
	25 2 49 "	1	36 88		28 3 51 "	1	38 25
	2 49 "	2	37 40		3 52 "	2	37 34
	Mean..	...	67 37 84		Mean..	....	67 37 25
Mar.	25 2 48 P.M.	1	67 36 96	Sept.	21 3 40 P.M.	1	67 36 09
	2 45 "	2	37 53		3 40 "	2	37 34
	26 2 46 "	1	38 06		22 2 44 "	1	38 18
	2 44 "	2	38 85		2 44 "	2	36 40
	Mean..	....	67 37 85		25 3 18 "	1	39 31
					3 16 "	2	39 90
					Mean..	....	67 37 87



APPENDIX II.  
 Meteorological Observations.—Table I.  
 Mean Monthly results.

Months.	Thermometer.*				Barometer.†				Mean vapour-tension. in.	
	Means of—		Absolute Extremes.		Absolute Extremes.		Absolute Extremes.			
	Max.	Min.	Max.	Date.	Min.	Date.	Max.	Date.		
1884.	°	°	°	d. h.	ins.	d. h.	ins.	d. h.	in.	
Oct. ....	48·9	41·4	48·5	16 2 P.M.	33·9	29 6 A.M.	30·086	5 { 8 A.M. } 9 " "	29·367	9 11 P.M. 10 2 A.M.
Nov. ....	42·6	37·2	42·2	2 3 "	25·6	25 4 "	30·172	10 10 "	29·725	28 3 P.M.
Dec. ....	41·6	37·2	41·4	3 Noon	26·9	31 5 "	29·885	31 Midd.	28·848	20 5 A.M.
1885.										
Jan. ....	37·1	40·4	33·5	29 10 A.M.	25·4	22 5 "	29·908	7 10 A.M.	28·909	11 6 "
Feb. ....	43·9	49·0	39·1	12 { 1 P.M. } 2 " "	27·6	21 7 "	29·729	21 11 "	29·076	16 8 P.M.
March..	40·3	47·4	33·6	20 { 3 " } 3 " "	25·0	8 6 "	30·089	14 Noon	29·262	6 7 A.M.
April...	47·2	55·4	39·5	20 4 "	47·5	5 { 3 " } 4 " "	29·798	19 10 A.M.	29·216	6 5 "
May ...	49·2	57·2	42·3	28 2 "	49·8	8 5 "	29·813†	30·240§	29·156	22 10 "
June ...	58·8	67·1	49·9	4 4 "	58·5	11 5 "	30·040	30·405	29·525	20 7 "
July ...	63·0	73·0	53·7	26 4 "	63·4	2 5 "	30·178	30·433	29·852	19 4 "
Aug. ....	57·9	66·6	50·5	17 { 2 " } 3 " "	58·6	14 5 "	29·981	30·349	29·640	10 7 P.M.
Sept....	55·0	62·4	47·7	15 1 "	55·1	27 4 "	29·895	30·359	29·191	11 3 A.M.
Means..	48·8	55·6	42·1	....	48·9	....	29·965	....	..	....

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.

† Mean for one day is approximate.

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

§ Approximate reading.

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.	Variable.	Calm.	
		in.	in.																			
1884.																						
October ..	6.4	1.115	0.590	9	..	1	..	7	13	..	..	4	1	2	1	7	7	4	4	5	6	5
November	7.0	1.770	0.705	5	..	..	..	5	12	..	..	6	1	3	1	3	3	5	5	5	6	6
December	7.8	2.135	0.365	5	..	..	..	1	20	..	..	2	1	1	1	8	8	1	1	3	3	2
1885.																						
January ..	7.9	1.535	0.390	31	1	..	1	3	21	2	2	2	4	4	6	2	4	2	2	4	6	6
February .	7.1	2.860	0.655	16	..	..	..	4	14	3	3	1	7	4	1	3	3	1	1	2	1	1
March ....	6.0	1.475	0.740	21	..	..	..	4	8	..	..	6	4	1	1	2	1	2	2	4	3	4
April ....	5.6	1.780	0.545	15	..	1	..	6	10	..	..	2	2	1	1	3	1	2	2	4	4	7
May .....	6.4	2.895	0.435	4	..	5	2	3	9	..	..	3	1	3	5	9	5	1	1	2	1	1
June .....	5.6	1.835	0.535	8	..	..	..	9	11	..	..	9	1	1	3	6	2	1	1	3	3	3
July .....	4.8	0.475	0.280	11	..	..	1	9	6	..	..	6	..	3	3	9	4	2	2	2	7	9
August ..	6.1	1.085	0.335	26	..	..	3	5	7	..	..	7	..	..	..	6	1	1	1	3	9	9
September.	6.4	4.325	1.370	10	..	..	1	3	9	..	..	9	1	2	..	10	3	4	4	3	4	3
Totals...		23.285			155	6	7	8	140	9	9	53	45	31	14	36	75	42	26	43	51	51

\* 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.	Date.	Hour.
1884.					deg.	deg.		deg.	deg.		miles.	miles.		
October . . . .	86 30	26	h. m.	13	94	110	3	36	23·9	29	8	32	28	11 A.M.
November . . . .	42 48	16	8 42	3	70	95	5	31	17·2	25	9	35	21	2 P.M.
December . . . .	23 36	10	3 42	19	60	81	5	34	20·4	31	15	37	7	11 P.M.
1885.														
January . . . .	15 36	6	4 12	7	55	75	27	29	17·3	22	13	38	31	11 A.M.
February . . . .	54 12	19	7 42	18	79	98	24	34	17·8	21	13	38	3	11 A.M.
March . . . . .	106 42	29	9 42	24	96	109	20	27	19·0	31	10	28	8	7 P.M.
April . . . . .	161 36	38	13 0	28	103	128	27	32	19·8	5	12	37	25	4 P.M.
May . . . . .	200 0	41	12 0	21	115	132	31	36	25·2	12	10	28	29	3 P.M.
June . . . . .	232 6	47	14 30	4	121	137	24	45	35·1	18	10	29	16	11 A.M.
July . . . . .	243 42	49	14 12	6	126	139	11	47	38·0	9	9	25	19	2 P.M.
August . . . . .	160 0	39	12 36	13	118	135	17	44	32·0	14	10	34	28	11 A.M.
September . .	125 18	33	9 24	15	113	126	3	42	26·8	27	9	28	11	8 A.M.
													12	9 P.M.

\* 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.
1884.			
October .....	14	11	0
November .....	13	10	1
December .....	7	7	0
1885.			
January .....	6	6	0
February.....	16	17	0
March .....	20	7	1
April .....	18	8	0
May.....	17	14	0
June .....	13	8	0
July.....	20	10	0
August .....	15	8	0
September.....	11	6	0
Totals .....	170	112	2

## APPENDIX III.

Results of Watch Trials. Performance of the Watches which stood highest in each class during the year.

Watch deposited by	Number of watch.	Balance spring, &c.	Mean daily rate.	Mean daily variation of rate.	Mean variation for 1° F.	Difference between pendant up and dial up.	Mean difference of rate			Difference between extremes of daily rate.	Marks awarded for			Total Marks. 0-100.	Character of test.
							Between pendant up and pendant right.	Between pendant up and pendant left.	Between dial up and dial down.		Daily variation of rate.	Change of rate with positions.	Temperature compensation.		
E. F. Ashley, Clerkenwell ...	03267	Overcoil, fusee .....	secs. -1.9	secs. $\pm 0.4$	secs. 0.04	secs. -1.2	secs. -0.1	secs. -1.5	secs. +2.0	secs. 4.75	31.8	37.0	17.3	86.1	Class A.
Kullberg, London .....	2901	Overcoil, fusee .....	+0.8	$\pm 0.5$	0.04	-0.7	+0.2	+1.2	-0.9	7.5	30.2	36.9	17.3	84.4	"
Baume & Co., London .....	2262	Overcoil, going barrel .....	+2.2	$\pm 0.4$	0.07	-1.0	-1.5	-1.3	+2.1	8	31.4	36.5	15.3	83.2	"
Baume & Co., London .....	2266	Overcoil, going barrel .....	-2.7	$\pm 0.6$	0.03	-0.7	-1.8	-2.1	+1.5	5	28.0	36.2	18.0	82.2	"
E. F. Ashley, Clerkenwell ...	03033	Overcoil, fusee .....	+0.4	$\pm 0.4$	0.07	-0.8	-2.4	+0.1	-4.1	7	32.2	33.4	15.3	80.9	"
Baume & Co., London .....	2259	Overcoil, going barrel .....	+0.5	$\pm 0.5$	0.06	+1.1	+0.7	-1.8	+2.4	7.5	29.4	34.8	16.0	80.2	"
D. Buckney, Clerkenwell ...	15017	Overcoil, going barrel .....	-0.2	$\pm 0.4$	0.10	+2.0	+4.5	+1.0	-1.5	8	31.4	34.8	13.3	79.5	"
G. Carley & Co., London .....	46937	Cylindrical, fusee .....	+4.0	$\pm 0.4$	0.12	+3.4	+2.0	+3.3	+1.2	7	32.0	35.4	12.0	79.4	"
G. Carley & Co., London .....	46991	Volute, going barrel .....	-5.7	$\pm 0.4$	0.09	+2.5	...	...	...	6.5	...	...	...	...	Class B.
W. Holland, Rockferry .....	3552	Overcoil, going barrel .....	+3.0	$\pm 0.5$	...	-1.0	...	...	...	2.5	...	...	...	...	Class C.
W. Holland, Rockferry .....	3340	Overcoil, fusee .....	-1.5	$\pm 0.7$	...	-1.0	...	...	...	3	...	...	...	...	"

## APPENDIX IV.

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
Lieutenant A. Gordon, R.N.	Unifilar Magnetometer by Jones, No. 102, complete, with three Magnets and Deflection Bar. Dip-Circle, by Barrow, one Pair of Needles, and Magnetizing Bars. One Bifilar Magnetometer. One Declinometer. Two Tripod Stands.	1883
Major-General Sir H. Lefroy, R.A., F.R.S.	Toronto Daily Registers for 1850-3 .....	1885
Professor W. Grylls Adams, F.R.S.	Unifilar Magnetometer, by Jones, No. 101, complete.	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
Mr. W. F. Harrison .	Condensing lens and copper lamp chimney ..	1883
Captain W. de W. Abney, F.R.S.	Mason's Hygrometer, by Jones .....	1885