

*Report of the Kew Committee for the Year ending
October 31, 1886.*

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.	The Earl of Rosse.
Prof. W. G. Adams.	Mr. R. H. Scott.
Prof. G. C. Foster.	Lieut.-General W. J. Smythe.
Mr. F. Galton.	Lieut.-Gen. R. Strachey, C.S.I.
Admiral Sir G. H. Richards, K.C.B.	Lieut.-General J. T. Walker, C.B.

The Committee regret to announce the death, in December last, of one of their members, Captain Sir F. Evans, K.C.B., formerly Hydrographer. He had held a seat upon the Committee since 1874, and was a frequent attendant at their meetings, rendering most valuable assistance in all questions relating to terrestrial magnetism or navigation brought forward for consideration.

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 and Marine Chronometers.
- 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.

The Vertical Force Balance Magnet was found to have a scale value of for 1 inch $\delta V = 0.0296$, and therefore appeared wanting in sensitiveness, it was accordingly re-adjusted and brought up to the proper pitch of delicacy.

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

Declination : 1 inch $= 0^\circ 22' 04$. 1 cm. $= 0^\circ 8' 7$.

Bifilar, January 11, 1886, for 1 inch $\delta H = 0.0268$ foot grain unit.

„ 1 cm. „ $= 0.0005$ C.G.S. unit.

Balance, January 19, 1886 „ 1 inch $\delta V = 0.0274$ foot grain unit.

„ 1 cm. „ $= 0.0005$ C.G.S. unit.

The chief days on which notable magnetic disturbance was recorded were as follows :—January 9, March 30, July 27, and October 7–11.

The magnetic instruments have been studied, and a knowledge of their manipulation obtained by Professor L. M. Russell, Mr. E. Kitto, and Mr. C. Chambers, jun.

Professors Rücker and Thorpe visited the Observatory in April, and made several sets of observations with the instruments which they have employed in their magnetic survey of the British Isles, prior to their commencing operations on the southern section, which have occupied them during the past summer.

At the request of the Royal Cornwall Polytechnic Society, a set of magnetographs on an improved model has been constructed for the Committee by Mr. Munro, which, after a lengthened trial in the Verification House, were forwarded to Falmouth, and erected at the New Observatory, under the supervision of Mr. T. W. Baker. The cost has been defrayed by a grant from the Royal Society's Government Fund.

At the suggestion of General Sir J. H. Lefroy, the Committee have caused a plate to be engraved on which sectional lines are laid down on the scale adopted by the International Polar Conference, for plotting all magnetic curves on a uniform system. Impressions from this plate will be kept at the Observatory, and supplied at cost price to persons desirous of making use of such forms.

Information on matters relating to terrestrial magnetism and various data, have been supplied to Professor W. G. Adams, Dr. Atkinson, General Sir J. H. Lefroy, Professor B. Stewart, M. Moureau, Captain Schück, and others.

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	30
„ Inclination	155
„ Absolute Declination	36

The diurnal range of the Declination having become a somewhat interesting feature in magnetic reductions, an additional table, giving the values for the summer and winter seasons and for the whole year, as determined from selected curves by the graphic method,* has been inserted in the Appendix.

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.

The only alterations made in the above instruments have been the following: a screen of blue glass has been interposed in the barograph between the barometer tube and the light, with the result of improving the definition of the photographic curve, and a Stonyhurst lifter has been fitted to the Beckley rain-gauge, causing the pencil to return to its original position after depression more rapidly than it did previously.

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 to the Meteorological Office.

The terrestrial radiation thermometer (grass minimum) was found broken on July 11, and replaced by a new instrument on July 21.

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

Readings of standard barometer	1725
„ dry and wet thermometers	3450
„ maximum and minimum thermometers	730
„ radiation thermometers	1480
„ rain gauges	730
Cloud and weather observations	1877
Measurements of barograph curves	8751

* See paper by Mr. Whipple in the 'Quart. Jour. Roy. Met. Soc.,' vol. 9, p. 45.

Measurements of dry bulb thermograph curves..	9473
„ wet bulb thermograph curves..	8681
„ wind (direction and velocity)..	17515
„ rainfall curves	740
„ sunshine traces	2113

In compliance with the usual request made by the Meteorological Council to the Committee, Mr. Whipple visited the Observatories at Aberdeen, Glasgow, and Stonyhurst, and the anemograph at Swaubister. He also superintended the erection of new instruments at North Shields and Fleetwood.

Mr. Baker has visited the Valencia and Falmouth Observatories for the purpose of inspection.

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. B. Latham, Gwilliam, Rowland, and others. The cost of these abstracts is borne by the recipients.

Electrograph.—Acting upon the recommendation of the Kew Committee the Meteorological Council have purchased a new quadrant electrometer, constructed on Mr. de la Rue's principle, with Professor Clifton's improvements, together with a chloride of silver battery of 60 cells, for the purpose of maintaining the potential of the quadrants at a certain point.

By the kindness of the Chairman of the Committee, experiments were made at his laboratory in Portland Place by means of which the scale value of the instrument was determined before it was conveyed to the Observatory, and erected in the place of the Thomson instrument formerly employed.

No change has been made in the recording apparatus attached to it. The instrument has been working for the past month in a satisfactory manner.

In accordance with a request made by the Meteorological Council, and at their expense, the electrograms for the two years 1882 and 1883 have been tabulated in absolute values.

III. SOLAR OBSERVATIONS.

The sketches of Sun-spots, as seen projected on the photoheliograph screen, have been made on 169 days, in order to continue Schwabe's enumeration, the results being given in Appendix II, Table IV.

Transit Observations.—301 observations of solar and 76 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 Chronometers Arnold 86 and Parkinson and Frodsham 2408, have been cleaned and re-adjusted, and the mean-time clocks, Shelton K. O., and Shelton 35, examined and re-adjusted by Dent.

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

The mean-time clock, Shelton 35, after cleaning, &c., was bolted to the wall of the chronometer-room for use in daily comparisons with the chronometers on trial.

In order to facilitate the inter-comparison of the clocks, the chronometer "Parkinson" has been specially fitted up as a "hack" instrument.

At the request of the Council of the Royal Meteorological Society, certain experiments were made with the view of investigating Professor W. K. Zenger's solar phenomena and an examination was also made of the Kew solar photographs. The results obtained were however of a negative character only. A note of them has been published in the 'Quarterly Journal Roy. Met. Soc.,' vol. 12, p. 215.

A comparative trial extending over five months was made of Professor McLeod's sunshine recorder (see 'Phys. Soc. Proc.,' vol. 6, p. 216), and the Stokes' instrument, which proved the results given by the two instruments to be practically identical.

IV. EXPERIMENTAL WORK.

Photo-nephograph.—The report on last year's work in cloud photography was duly submitted to the Meteorological Council, and placed by them in the hands of Professor Stokes for consideration.

Professor Stokes having investigated the methods employed at the Observatory, devised a new graphic process for determining the cloud heights and motions in a much simpler manner than by the use of mathematical formulæ only. He invented a special apparatus called a projector, which has been constructed by C. Baker, and is now being utilized in the reduction of the pictures taken during the past season. These have amounted to 112 cloud negatives, and were obtained in 15 days.

For convenience of dealing with the cloud pictures in the projection apparatus with greater facility, the negatives have all been printed off on paper prepared by the cyanotype process.

Certain minor additions were made to the cameras, and accessory apparatus, which have tended to facilitate their working, and their action has been fairly satisfactory ever since. There is, however, still an occasional failure due to uncertainty of the duration of the

time of exposure of the twin cameras, although this is apparently instantaneous.

Solar Radiation Thermometers.—The experiments with these thermometers have been continued during the past summer months, and at times as many as 8 instruments have been under observation.

It having appeared that during the winter the *vacua* in certain of the instruments had deteriorated either by leakage or evolution of gas from the lamp-black coating of the bulbs, experiments were made in the Chairman's laboratory which proved that such was the case. New thermometers were made and enclosed in jackets not provided with platinum electrodes; the bulbs were also made of black glass, having the stems covered with black enamel. These, after careful exhaustion, were placed under observation, but did not register temperatures higher than had been previously observed.

Advantage was taken of an offer kindly made by Professor Thorpe to make solar radiation observations on his recent Eclipse Expedition to Grenada, and two of the instruments were lent to him. He has now returned them to the Observatory, together with copies of the readings he was able to procure on the occasion.

Electrical Anemograph.—This instrument, after a lengthened trial in the Experimental House and the execution of certain minor alterations by Mr. Kempe, has been dismantled and forwarded to the Valencia Observatory by instructions of the Meteorological Council. The external parts were previously put into thorough repair by Mr. Munro, in order to fit the anemograph for the rough weather to which it will be exposed when erected on a hill almost overlooking the Atlantic.

Dines' Anemometer.—Trials have been made of two anemometers constructed on a new principle by Mr. W. H. Dines, B.A. Owing, however, to structural defects, both instruments broke down before any final results were obtained, and were returned to the maker for repair.

Glycerine Barometer.—This instrument, having very considerably deteriorated by age, was dismantled by Mr. Jordan in June, and after thorough cleaning and repair by Mr. J. Steward, was again erected and refilled with new fluid.

Pendulum Experiments.—At the request of General Walker, certain experiments were made with the view of ascertaining the stability of the Experimental House as a site for pendulum operations. These having proved that building unsuitable, a wooden erection 13 ft. \times 9 ft. \times 8 ft. has been constructed, at the desire of the Pendulum Committee of the Royal Society, in the lower South Hall of the Observatory, on the spot occupied in 1873 by Captain Heaviside, when experimenting with the Russian pendulum. (See Report for 1873.)

In this room it is the intention to erect the Indian Pendulum Appa-

ratus recently returned by Professor Peirce from the United States, and swing the pendulums so as to obtain a differential connexion with recent swings in New York. Subsequently, it is intended to convey the whole to the Royal Observatory at Greenwich, where other series of observations and experiments will be conducted with a view to connecting Greenwich with Kew.

At the request of the Meteorological Council, various experiments were tried with the view of selecting a suitable paper for use with the Beckley anemographs, and also of remedying certain defects found attendant on the employment of gelatinised photographic curves in processes of mechanical reduction in the Meteorological Office.

V. VERIFICATION OF INSTRUMENTS.

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

1 Unifilar Magnetometer and an Inclinator for the Falmouth Observatory.

Two Inclinatorometers have been purchased on commission for the Bureau of Navigation, Washington, 1 each also for the Ekaterinburg Observatory and the Lighthouse Board, Helsingfors. 2 Dip Needles have been procured and tested for the Mauritius Observatory; also 1 pair for the Lisbon Observatory; 7 Thomson's patent compasses with 7 vertical force instruments have also been examined for the Imperial Japanese Navy.

1 Unifilar, 2 Compasses, and 2 Inclinatorometers have been tested for opticians, and 2 Unifilars are at present undergoing verification.

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

Barometers, Standard.....	31
„ Marine and Station.....	92
Aneroids.....	124
Total.....	<u>247</u>

Thermometers, ordinary Meteorological	1320
„ Standard and Chemical.....	210
„ Mountain	45
„ Clinical	9054
„ Avitreous	816
„ Solar radiation.....	45
Total.....	<u>11490</u>

Hydrometers.....	512
Anemometers.....	15
Rain Gauges.....	6
Sextants.....	139
Index and Horizon Glasses, unmounted.....	170
Dark Glasses, unmounted.....	597
Theodolites.....	9

Besides these, 32 Deep-sea Thermometers have been tested, 16 of which were subjected, in the hydraulic press, without injury, to pressures exceeding two tons on the square inch. 27 Thermometers have been compared at the freezing-point of mercury, making a total of 11549 for the year.

Duplicate copies of corrections have been supplied in 84 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.....	67
„ ordinary meteorological.....	49
Various.....	112

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

1 Redier Barograph, 1 Richard Hygrometer, 1 Air Meter, 2 Telescopes, &c., were also examined.

There are at present in the Observatory undergoing verification, 43 Barometers, 904 Thermometers, 2 Hydrometers, and 27 Sextants.

A question having arisen as to the true interpretation of the tables of Specific Gravity used in connexion with the verification of instruments of the hydrometer class, a Sub-Committee has been appointed to consider the matter and authorize the adoption by the Observatory of certain definite rules.

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 834 watches have been examined, of which 16 were submitted by the owners, and 818 by the manufacturers or dealers.

490 watches were received as contrasted with 302 received during the corresponding period of last year. They were entered for testing in the following classes:—

For class A, 436; class B, 36; and class C, 18. Of these 148 failed to gain any certificate; 16 passed in C, 102 in B, 224 in A, and 8 obtained the highest possible form of certificate, the class A *especially good*.

All the watches which obtained Class A certificates had marks assigned to them, indicating the degree of relative efficiency they exhibited during their trial, according to the following scale:—

The number of marks awarded to a watch that only just succeeds in obtaining an A certificate is 0, while that awarded 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 temperature.

In Appendix III will be found a statement giving the results of trial of the 20 watches which obtained the highest numbers of marks during the year, the first position being again attained—with 86·7 marks—by the maker who occupied it—with 86·1 marks—last year.

The number of watches obtaining a high figure in the marks list has, however, much increased.

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. 40° F.	5 "	1 day	—
" " 85° F.	5 "	1 "	—
Not rated	5 "	1 "	—
Total duration of test	45 days	31 days	16 days

Owing to the inconvenience and delay attendant on the employment of one safe for both hot and cold tests, a second was procured, and has been fitted up as a refrigerator, thereby enabling two sets of watch trials to proceed simultaneously, and more constant temperatures in both heat and cold to be sustained for the necessary periods.

Special attention has been given to the examination of *pocket chronographs*, in accordance with the request of the Cyclists' Union.

Manufacturers have also been advised of certain mechanical defects in the action of the chronograph work, and latterly an improvement has taken place in respect of this.

Early in the year a communication was received from the President

of the Section d'Horlogerie de la Société des Arts à Genève, asking for full particulars of the system of rating at this Observatory. These were forwarded to him, and in acknowledging receipt of the same he expressed the gratification of his Council at the degree of accuracy obtained in the Kew trials during the year.

Rating of Chronometers.—Application having been made to the Committee to extend their system of watch rating to marine chronometers, arrangements were carried out for effecting this. A chronometer oven formerly constructed for the Testing Office of the Board of Trade, being unemployed, was obtained on loan from the Meteorological Council, in whose possession it was, and erected with the necessary gas-fittings in the Thermograph-room of the Observatory.

A scheme for rating and certifying was drawn up, of which the following is a brief abstract.

The trial occupies 35 days, divided into 5 periods of 6 days each, and 5 intermediate days, namely, 1 day at the commencement of each period of test :—

1st period.	Chronometer at temperature of 55° F. or 13° C.			
2nd	„	„	70°	„ 21° „
3rd	„	„	85°	„ 29° „
4th	„	„	70°	„ 21° „
5th	„	„	55°	„ 13° „

Certificates are granted to chronometers which have undergone 35 days' test as specified above, and whose performance is such that :—

1. The mean of the differences in each stage of the examination, between (a) the average daily rate during that period, and (b) the several daily rates, does not exceed one second in any one of the stages.

2. The mean daily rate has not been affected by change of temperature more than one-sixth of a second per 1° F., which is about a quarter of a second per 1° C.

3. The mean daily rate has not exceeded five seconds in any stage of the test.

The trials were commenced in August, and up to present date seventeen ordinary marine and one sidereal chronometer have been rated.

The Astronomer Royal having on enquiry certified as to the excellent working of Kullberg's temperature regulator in the chronometer oven at the Royal Observatory, Greenwich, the inventor has been instructed to fit a similar one to the Kew testing case.

A Richard Thermograph has also been procured, and is arranged to work in the case with the chronometers, so as to afford a continuous

record of the temperatures which they have experienced during the whole of their trial.

The range of temperature from 55° to 85° F., to which the marine chronometers are submitted, has been decided upon after careful consideration, as being amply sufficient for determining the behaviour of chronometers under conditions to which they are usually exposed at sea, and no objections have yet been received from makers or others to the adoption of the above range.

VII. MISCELLANEOUS.

Photographic Paper, &c.—This has been supplied to the Observatories at Batavia, Coimbra, Falmouth, Glasgow, Lisbon, Mauritius, Oxford, Stonyhurst, St. Petersburg, and Toronto, and to the Meteorological Office. Blank forms have also been supplied to various Observatories and individuals.

At the request of Senhor Capello, of the Lisbon Observatory, an astronomical clock was procured and shipped to the Loanda Observatory, for use during the recent solar eclipse.

Two barograph tabulators, photographic appliances, and various other instruments have been procured, verified, and forwarded to the Observatories at Hong Kong and Mauritius.

The Observatory has been presented by the Rev. John Rigaud, B.D., Fellow of Magdalen College, Oxford, with a bust of his father, Stephen Peter Rigaud, Esq., M.A., F.R.S., Savilian Professor of Astronomy and Radcliffe Observer, who formerly assisted his uncle, the Rev. S. Demainbray, in carrying on the Observatory.

Exhibitions, &c.—At the request of the Council of the Royal Meteorological Society a number of old instruments were exhibited at the Exhibition held by the Society in the rooms of the Institution of Civil Engineers in March, and devoted this year to barometers.

Four sets of photographs illustrative of the various processes in use at different periods at the Observatory have been contributed to the Photographic Exhibition, held in the Corporation Galleries of Art at Glasgow.

Library.—In July the Superintendent received a letter from the Secretary of the Royal Society offering a number of duplicate volumes about to be removed from the Library at Burlington House, and forwarding a catalogue.

A selection was made of those suitable for the Observatory Library, and sixteen volumes were accordingly sent down to Kew.

Presents of publications were received during the year from—

34 Scientific Societies and Institutions of Great Britain and Ireland, and

92 Foreign and Colonial Scientific Establishments, as well as numerous private individuals.

Magnetic Reductions.—At the request of Professor Balfour Stewart, the Superintendent prepared and submitted to the Committee of the British Association on the Reduction of Magnetic Observations, a report on the comparison between Wild's, Sabine's, and the Greenwich methods of determining the solar diurnal range of the declination.

Workshop.—The machine tools procured for the use of the Kew Observatory by grants from the Government Grant Fund or the Donation Fund have been kept in thorough order.

House, Grounds, and Footpath.—These have all been kept in order during the year.

Her Majesty's Commissioners of Woods and Forests have kindly complied with the request of the President and Council of the Royal Society that the Observatory Staff should have a free passage at all hours through the yard tenanted by the lessee of the Old Deer Park, and accordingly an iron turnstile has been erected at the expense of the Committee at the entrance gate to the Park.

The necessary external repairs and painting of the building have been carried out by Her Majesty's Commissioners of Works as usual.

Owing to the increase of work now undertaken by the Observatory Staff it has become necessary to consider means of increasing the available accommodation, and of providing more space by addition either to the Observatory building itself or to one of the out-buildings.

Plans for both schemes have been submitted to the Committee, together with estimates of the approximate cost.

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 Rating.	
W. Hugo,	} Verification Department.
J. Foster,	
T. Gunter,	
W. Boxall,	
E. Dagwell.	
H. A. Widdowson.	
F. Oliver.	
W. C. Gough.	
E. Redding.	
M. Baker, Messenger and Care-taker.	

Abstract. The Kew Observatory. Account of Receipts and Payments for the year ending October 31st, 1886.

<i>Dr.</i>		<i>Cr.</i>	
RECEIPTS.		PAYMENTS.	
£ s. d.		£ s. d.	
To Balance from 1884-85		Salaries and Extra	
..... £416 13 9		..... £1328 6 0	
Royal Society (Gassior Trust)		Gas, Fuel, Rent, Insurance, &c.	
..... 489 17 7		..... 169 13 0	
Meteorological Office (Allowance)		Stationery, Postages, Caretaker, &c.	
..... 400 0 0		..... 141 3 11	
Experimental Work		Instruments, Apparatus, &c.	
..... 96 9 9		..... 61 16 3	
Magnetic Work		Experimental work	
..... 6 10 8		..... 56 17 1	
Miscellaneous		International Circumpolar Committee ..	
..... 81 18 1		..... 2 6 0	
Verifications		Pendulum	
..... 729 5 5		..... 11 9 2	
Rating of Watches and Chronometers.....		Magnetic	
..... 343 2 3		..... 24 7 7	
..... 2564 2 6		Miscellaneous	
..... 7 17 0		..... 43 5 3	
Meteorological Office for Postages and Portages		Exhibition	
..... 525 4 6		..... 7 11 6	
Commissions executed for Colonial and Foreign Institutions, &c.		Verifications	
..... 525 4 6		..... 131 9 5	
..... 2119 19 2		Rating of Watches and Chronometers	
..... 25 6 11		..... 141 14 0	
Commissions executed for Colonial and Foreign Institutions, &c.		Postages and Portages, &c., for Meteorological Office	
..... 375 3 5		..... 493 8 11	
Balance—Bank of England		Commissions executed for Colonial and Foreign Institutions, &c.	
..... 69 0 0		..... 493 8 11	
London and County Bank		Balance—Bank of England	
..... 14 5 7		..... 69 0 0	
Cash in hand		London and County Bank	
..... 576 14 6		..... 14 5 7	
£3097 4 0		Cash in hand	
..... £3097 4 0		..... 576 14 6	
Examined and compared with the Vouchers, and found correct.		(Signed) J. T. WALKER, Auditor.	
November 19, 1886.		(Signed) J. T. WALKER, Auditor.	
ASSETS.		LIABILITIES.	
£ s. d.		£ s. d.	
By Balance as per Statement		To Gas, Fuel, and House Account	
..... 576 14 6		..... 9 8 5	
Meteorological Office, Allowances, Experimental, and Sundries.....		Stationery, &c.	
..... 95 6 4		..... 3 16 5	
Verification Fees due, &c.		Rating	
..... 18 1 6		..... 13 16 3	
Rating of Watches, &c., due		Instruments, Chemicals, &c.	
..... 20 0 0		..... 3 10 7	
Photographic Paper		Commissions, including Grant on account for the Hong Kong Observatory	
..... 89 3 6		..... 165 13 0	
Commissions, &c.		Balance.....	
..... 7 0 9		..... 805 13 0	
Blank Forms .....		..... £1001 17 8	
Standard Thermometers .....		..... £1001 17 8	
..... 91 18 0		..... £1001 17 8	
Magnetic Pendulum, &c. ....		..... £1001 17 8	
..... 38 5 11		..... £1001 17 8	
..... £1001 17 8		..... £1001 17 8	
Examined and compared with the Vouchers, and found correct.		(Signed) G. M. WHIPPLE, Superintendent.	
November 19, 1886.		(Signed) G. M. WHIPPLE, Superintendent.	
Francis Galton, for Chairman.		(Signed) G. M. WHIPPLE, Superintendent.	

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 1885 to September 1886.*

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 $\log \pi^2 K$ 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

$$0\cdot0001194(t_0 - 35) + 0\cdot000,000,213(t_0 - 35)^2.$$

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

$$\frac{m}{X} = \frac{m'}{X'} \left(1 - \frac{P}{r_0^2} \right), \text{ is } -0\cdot00148.$$

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.

Table I.
Observations of Inclination.

Month,	Mean inclination.	Month.	Mean inclination.
1885.		1886.	
October 26.....	67 37'·8	April 27.....	67 36'·8
27.....	67 37'·8	29.....	67 37'·2
Mean.....	67 37'·8	Mean.....	67 37'·0
November 23.....	67 37'·1	May 25.....	67 38'·0
24.....	67 37'·3	26.....	67 35'·7
28.....	67 37'·5	Mean.....	67 36'·8
Mean.....	67 37'·3	June 24.....	67 36'·2
December 22.....	67 37'·6	26.....	67 36'·1
23.....	67 38'·2	Mean.....	67 36'·2
24.....	67 37'·7	July 21.....	67 37'·7
Mean.....	67 37'·8	22.....	67 37'·2
1886.		Mean.....	67 37'·5
January 26.....	67 37'·8	August 23.....	67 35'·7
27.....	67 37'·0	24.....	67 37'·5
Mean.....	67 37'·4	Mean.....	67 36'·6
February 22.....	67 36'·4	September 23.....	67 36'·3
23.....	67 37'·3	29.....	67 36'·2
26.....	67 36'·4	Mean.....	67 36'·3
Mean.....	67 36'·7		
March 22.....	67 38'·7		
27.....	67 37'·0		
29.....	67 37'·0		
Mean.....	67 37'·6		

Table II.

Observations for the Absolute Measure of Horizontal Force.

Month.	Log $\frac{m}{X}$ mean.	Log mX mean.	Value of m^* .
1885.			
October 29th and 30th ..	9·12250	0·30825	0·51925
November 26th	9·12195	0·30872	0·51919
December 29th.....	9·12187	0·30874	0·51916
1886.			
January 28th.....	9·12154	0·30902	0·51913
February 24th	9·12184	0·30923	0·51943
March 25th	9·12221	0·30860	0·51928
April 1st and 2nd	9·12230	0·30865	0·51937
„ 28th	9·12086	0·30800	0·51812
May 27th	9·12103	0·30932	0·51901
June 28th	9·12095	0·30836	0·51838
July 23rd	9·12171	0·30807	0·51867
August 26th	9·12193	0·30775	0·51861
September 27th	9·12122	0·30823	0·51847

Table III.—Solar Diurnal Range of the Declination.

Hour.	Summer mean.	Winter mean.	Annual mean.
0	+5·6	+2·9	+4·3
1	+6·8	+4·8	+5·8
2	+6·0	+4·4	+5·2
3	+5·0	+3·5	+4·3
4	+2·8	+1·5	+2·2
5	+1·8	+0·6	+1·2
6	+0·7	−0·5	+0·1
7	−0·2	−0·4	−0·3
8	−0·3	−1·0	−0·7
9	−0·3	−0·9	−0·6
10	−0·9	−1·3	−1·1
11	−0·7	−1·3	−1·0
12	−1·0	−1·3	−1·2
13	−1·2	−1·1	−1·2
14	−2·0	−0·8	−1·4
15	−2·2	−0·4	−1·3
16	−2·5	−0·8	−1·7
17	−3·0	−0·7	−1·9
18	−3·8	−0·9	−2·4
19	−4·0	−1·3	−2·7
20	−4·2	−1·5	−2·9
21	−3·5	−2·1	−2·8
22	−1·5	−1·7	−1·6
23	+1·8	+0·8	+1·3

* m = moment of vibrating magnet.

Table IV.

Month.	Declination.	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.				
1885.	West.													
October	18 23 34	3·9163	9·5161	10·2903	1·8058	4·3877	4·7447	0·1806	0·4388	0·4745				
November	18 20 1	3·9209	9·5227	10·2984	1·8078	4·3908	4·7484	0·1808	0·4391	0·4748				
December	18 18 1	3·9213	9·5282	10·3036	1·8080	4·3933	4·7508	0·1808	0·4393	0·4751				
1886.														
January	18 20 19	3·9241	9·5315	10·3077	1·8093	4·3948	4·7527	0·1809	0·4395	0·4753				
February.....	18 17 45	3·9237	9·5251	10·3017	1·8092	4·3919	4·7500	0·1809	0·4392	0·4750				
March.....	18 20 36	3·9192	9·5212	10·2963	1·8071	4·3901	4·7474	0·1807	0·4390	0·4747				
April	18 19 9	3·9208	9·5201	10·2960	1·8078	4·3896	4·7473	0·1808	0·4390	0·4747				
May.....	18 19 51	3·9277	9·5361	10·3134	1·8110	4·3969	4·7553	0·1811	0·4397	0·4755				
June	18 17 47	3·9237	9·5209	10·2977	1·8092	4·3900	4·7481	0·1809	0·4390	0·4748				
July.....	18 17 59	3·9190	9·5198	10·2949	1·8070	4·3894	4·7468	0·1807	0·4389	0·4747				
August	18 15 23	3·9163	9·5071	10·2823	1·8059	4·3836	4·7410	0·1806	0·4384	0·4741				
September	18 16 11	3·9219	9·5172	10·2937	1·8083	4·3882	4·7462	0·1808	0·4388	0·4746				

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

Months.	Thermometer.*					Barometer.†					Mean vapour-tension.		
	Means of—			Absolute Extremes.			Absolute Extremes.						
	Mean.	Max.	Min.	Max. and Min.	Date.	Min.	Date.	Mean.	Max.	Date.		Min.	Date.
1885.													
Oct.	46.5	51.7	40.9	46.3	d. h.	32.8	d. h.	ins.	ins.	d. h.	ins.	d. h.	
Nov.	43.9	48.1	39.0	43.6	2 2 P.M.	31.1	30 7 A.M.	29.718	30.206	17 9 A.M.	29.955	10 7 A.M.	
Dec.	38.7	42.7	34.1	38.4	30 11 A.M.	31.1	16 3 "	29.912	30.415	16 9 P.M.	29.250	26 Midt.	
1886.					3 8 P.M.	23.2	11 7 "	30.223	30.600	23 {10 & 11 A.M.	29.263	6 1 A.M.	
Jan.	36.3	40.5	31.3	35.9	2 3 "	15.8	7 11 P.M.	29.675	30.166	12 10 "	29.007	18 4 "	
Feb. ...	33.9	37.5	30.5	34.0	13 3 "	22.3	10 {7 & 9 A.M.	30.139	30.759	8 10 P.M.	29.246	1 7 "	
March..	39.9	46.1	34.6	40.4	24 3 "	22.2	17 6 "	29.982	30.426	9 8 A.M.	23.257	2 {8 P.M. & Midt.	
April. .	46.3	53.7	40.0	46.9	24 2 "	33.8	11 3 "	29.923	30.340	11 1 "	29.209	8 3 P.M.	
May ...	52.5	60.8	44.4	52.6	{7 3 " 8 2 " }	30.9	1 4 "	29.942	30.501	5 8 A.M.	29.101	13 9 A.M.	
June ...	57.0	65.6	49.0	57.3	29 4 "	40.3	5 4 "	29.992	30.305	30 Midt.	29.710	12 2 P.M.	
July ...	62.2	70.8	53.5	62.2	29 4 "	45.6	28 5 "	29.929	30.326	3 7 A.M.	29.366	26 2 A.M.	
Aug.	61.8†	70.9	53.9	62.4	{30 2 " 31 p }	44.1	3 5 "	29.999	30.299	20 7 "	29.514	13 3 P.M.	
Sept.	58.4‡	65.3	50.6	58.5	1 ?	41.2	18 6 "	30.040	30.491	15 Midt.	29.616	21 {1 & 3 P.M.	
Means..	48.1	54.6	41.8	48.2	....	..	....	29.357	..	....	..	....
					</								

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.

‡ Reduced to 32° at M.S.L.

§ Means for three days are approximate.

Meteorological Observations.—Table II.

Kew Observatory.

Months.	Rainfall *.		Weather. Number of days on which were registered						Wind †. Number of days on which it was														
	Mean amount of cloud (0=clear, 10=over- cast).	Total.		Maxi- mum.	Date.	Rain.	Snow.	Hail.	Thun- der- storms.	Clear sky.	Over- cast sky.	Gale.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.	Variable.	Calm.	
1885.		in.	in.																				
October ..	7.1	3.865	0.905	23	20	..	..	..	3	18	..	..	5	2	2	2	1	7	6	4	2	2	4
November ..	7.5	2.970	0.555	24	16	..	..	..	3	17	1	..	2	7	7	2	2	6	1	1	3	3	4
December ..	6.6	1.165	0.350	5	14	1	..	..	7	17	1	..	5	3	2	1	3	10	3	2	2	8	8
1886.																							
January ..	6.5	3.510	0.685	5	24	11	1	..	3	13	..	..	3	1	1	2	3	7	4	5	5	3	3
February ..	7.7	0.670	0.270	2	8	3	..	..	5	17	..	..	6	8	1	2	2	2	2	2	3	9	9
March	6.9	1.350	0.280	20	12	3	..	..	5	14	3	..	2	5	6	1	3	9	2	1	2	2	2
April	6.3	1.495	0.310	28	12	3	1	..	5	12	..	..	3	9	3	..	2	7	5	1	2	2	2
May	6.8	4.100	1.200	12	19	..	..	2	5	13	1	..	1	4	4	1	4	9	5	1	6	4	7
June	6.3	0.845	0.440	10	10	..	..	1	5	10	..	..	6	4	4	..	1	4	1	3	4	3	3
July	5.9	2.380	0.510	25	15	..	..	1	7	11	..	..	2	2	2	1	5	8	3	3	5	3	4
August	5.7	0.675	0.150	1	10	..	..	..	4	7	..	..	3	..	2	1	1	8	1	3	4	7	4
September ..	5.8	1.790	0.385	10	11	..	..	..	6	9	..	..	5	5	3	1	4	7	4	1	3	4	4
Totals..		24.815			171	21	2	6	58	158	6		43	50	36	14	33	84	87	27	41		54

* 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.	deg.	Mean.	Highest.	Date.	deg.	Mean.	Lowest.	Date.
1885.	h. m.		h. m.		deg.		deg.		deg.			
October	93 12	29	9 36	7	93		113	1	36		deg.	30
November	39 6	14	7 6	1	66		95	2	35		deg.	16
December	48 36	20	5 54	10	58		79	1	29		deg.	11
1886.												
January	47 0	18	6 18	16	64		89	28	27		deg.	8
February	38 12	14	6 48	1	59		86	26	26		deg.	9
March	72 48	20	9 12	9	86		114	31	30		deg.	16
April	151 0	36	11 6	23	106		121	6	36		deg.	10
May	169 0	35	12 54	4	114		137	8	40		deg.	1
June	222 30	45	13 54	4	124		138	27	45		deg.	17
July	211 0	42	14 54	5	129		142	7	49†		deg.	11
August	189 12	42	11 54	3	125		138	3	50		deg.	3
September	134 18	35	11 12	7	114		130	1	47		deg.	17

* As indicated by a Robinson's anemograph, 70 feet above the general surface of the ground. † Approximate mean for 21 days only.

Table IV.

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

Months.	Days of observation.	Number of new groups enumerated.	Days without spots.
1885.			
October	15	6	2
November	7	4	0
December	13	5	1
1886.			
January	13	3	3
February	8	4	0
March	15	9	0
April	17	9	0
May	12	3	2
June	18	9	1
July	17	9	1
August	17	6	3
September	17	6	2
Totals	169	73	15

APPENDIX III.

Results of Watch Trials. Performance of 20 Watches which obtained the highest number of marks during the year.

Watch deposited by	Number of watch.	Balance spring, &c.	Mean daily rate. — Gain- ing. — Los- ing.	Mean variation of daily rate.	Mean change of rate for 1° R.	Difference between pendant up and dial up.	Difference of mean daily 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.	Temperature compensation.		
E. F. Ashley, Clerkenwell ...	03385	Overcoil, fusee	secs. +0.5	secs. 0.3	secs. 0.01	secs. -0.9	secs. -0.8	secs. +1.9	secs. -3.7	secs. 7.75	secs. 33.3	secs. 34.1	secs. 19.3	86.7	Class A.
Baume & Co., London.....	2163	Overcoil, going barrel	secs. -2.1	secs. 0.5	secs. 0.03	secs. +3.4	secs. -0.4	secs. +0.2	secs. -3.7	secs. 4.75	secs. 30.5	secs. 35.6	secs. 18.0	84.1	"
Parkinson and Frodsham, London	6660	Duo-in-Unio, fusee.....	secs. -0.1	secs. 0.4	secs. 0.07	secs. -1.1	secs. +1.8	secs. -0.4	secs. +1.3	secs. 5.75	secs. 31.2	secs. 37.1	secs. 15.3	83.6	"
Baume & Co., London.....	2160	Overcoil, going barrel	secs. +0.2	secs. 0.4	secs. 0.03	secs. -2.3	secs. -4.7	secs. -0.5	secs. +3.6	secs. 7.75	secs. 32.6	secs. 32.9	secs. 17.7	83.2	"
Staufner & Co., London	114322	Overcoil, going barrel	secs. +2.0	secs. 0.4	secs. 0.05	secs. +1.6	secs. -2.6	secs. +3.2	secs. +1.3	secs. 7.75	secs. 32.2	secs. 32.5	secs. 16.5	81.2	"
Baume & Co., London.....	2272*	Overcoil, going barrel	secs. +3.3	secs. 0.7	secs. 0.01	secs. +2.0	secs. +2.0	secs. -0.5	secs. -0.2	secs. 6.25	secs. 25.9	secs. 35.8	secs. 19.3	81.0	"
Baume & Co., London.....	2161	Overcoil, going barrel	secs. +1.7	secs. 0.3	secs. 0.06	secs. +2.4	secs. -3.0	secs. -4.4	secs. -0.5	secs. 7.25	secs. 34.1	secs. 30.2	secs. 16.3	80.6	"
D. Bucknery, London	12925	Overcoil, going barrel	secs. -1.2	secs. 0.6	secs. 0.08	secs. 0.9	secs. +0.7	secs. +1.5	secs. +0.4	secs. 7.5	secs. 27.5	secs. 38.4	secs. 14.3	80.2	"
D. Keys, London	15317	Overcoil, going barrel	secs. -3.6	secs. 0.6	secs. 0.07	secs. +2.2	secs. -2.2	secs. +0.6	secs. +0.4	secs. 5.25	secs. 28.6	secs. 35.8	secs. 15.6	80.0	"
Baume and Co.	2159	Overcoil, going barrel	secs. -2.7	secs. 0.5	secs. 0.02	secs. +3.7	secs. -2.3	secs. +1.5	secs. +0.4	secs. 8.25	secs. 29.0	secs. 31.8	secs. 18.9	79.7	"
Holland, Rockerry	35.76	Overcoil, fusee	secs. -1.0	secs. 0.5	secs. 0.06	secs. +4.1	secs. +0.8	secs. +4.8	secs. -0.4	secs. 7.5	secs. 30.8	secs. 32.7	secs. 16.0	79.5	"
Staufner & Co.	111115	Overcoil, going barrel	secs. -0.4	secs. 0.5	secs. 0.05	secs. +0.6	secs. -3.8	secs. -3.9	secs. -0.9	secs. 6.75	secs. 30.2	secs. 32.5	secs. 16.8	79.5	"
Margery & Co., London	6001	Overcoil, going barrel	secs. -1.8	secs. 0.6	secs. 0.03	secs. +0.6	secs. -2.0	secs. +2.1	secs. +2.5	secs. 8.25	secs. 27.4	secs. 34.0	secs. 18.0	79.4	"
Carley & Co., London	44568	Overcoil, going barrel	secs. +3.1	secs. 0.6	secs. 0.05	secs. +2.4	secs. +1.4	secs. -2.0	secs. -1.2	secs. 6.5	secs. 27.6	secs. 35.0	secs. 16.7	79.3	"
Staufner & Co.	114318	Overcoil, going barrel	secs. -3.1	secs. 0.5	secs. 0.10	secs. 0.0	secs. -2.4	secs. +1.8	secs. +0.5	secs. 7.75	secs. 29.5	secs. 36.2	secs. 13.4	79.1	"
Player, Coventry	13491	Overcoil, fusee	secs. -2.4	secs. 0.5	secs. 0.10	secs. +1.3	secs. +0.5	secs. -2.9	secs. -0.1	secs. 6.75	secs. 30.4	secs. 35.3	secs. 13.3	79.0	"
Staufner & Co.	24044	Overcoil, going barrel	secs. +1.3	secs. 0.7	secs. 0.04	secs. -1.4	secs. -2.9	secs. -4.1	secs. -2.4	secs. 7.5	secs. 27.0	secs. 34.4	secs. 17.5	78.9	"
Usher & Cole, London.	14693†	Overcoil, going barrel	secs. +0.3	secs. 0.7	secs. 0.09	secs. +1.3	secs. -0.4	secs. +3.7	secs. +1.1	secs. 7.5	secs. 30.0	secs. 34.7	secs. 14.0	78.7	"
H. Gloy, London	12455	Overcoil, going barrel	secs. -0.7	secs. 0.6	secs. 0.08	secs. +3.3	secs. +3.5	secs. -1.3	secs. +2.0	secs. 6.0	secs. 28.4	secs. 35.4	secs. 14.8	78.6	"
D. Bucknery, London	2243	Overcoil, going barrel	secs. -0.5	secs. 0.6	secs. 0.07	secs. -1.5	secs. -2.8	secs. -3.8	secs. +1.3	secs. 6.75	secs. 28.4	secs. 34.6	secs. 15.3	78.5	"

* Fly-back chronograph.

† Minute repeater and clock watch.

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
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
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
Professor Rücker ...	Tripod stand	1886