

17
THE KEW OBSERVATORY,

RICHMOND, SURREY.

1887-

REPORT

OF THE

KEW COMMITTEE

FOR THE

Year ending October 31, 1887.

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

[*From the PROCEEDINGS OF THE ROYAL SOCIETY, 1887.*]

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1887.

Report of the Kew Committee for the Year ending October 31, 1887.

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

The Committee regret to announce the death, in July last, of their late member, Lieut.-General W. J. Smythe, R.A. He had held a seat upon the Committee since 1871, but for some years past, owing to his residence in Ireland, he had not been able to take part in their meetings.

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.

Throughout the past year the magnetographs have worked in a satisfactory manner, and the usual determinations of the scale values of all the instruments were made in January last.

Owing to the gradual secular change of Declination the distance between the dots of light upon the cylinder of the magnetometer had become too small for satisfactory registration, and in consequence it

was found necessary to re-adjust the instrument by altering slightly the inclination of the mirror attached to the magnet.

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

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

Bifilar, January 10, 1887, for 1 inch $\delta H = 0 \cdot 0255$ foot grain unit.

„ 1 cm. „ = $0 \cdot 00046$ C.G.S. unit.

Balance, January 11, 1887 „ 1 inch $\delta V = 0 \cdot 0281$ foot grain unit.

„ 1 cm. „ = $0 \cdot 00051$ C.G.S. unit.

In the case of the bifilar magnetometer it was also found necessary to re-adjust the instrument, at the same time its sensibility was slightly altered, after which the scale value was again determined with the following result:—

Bifilar, January 18, 1887, for 1 inch $\delta H = 0 \cdot 0280$ foot grain unit.

„ 1 cm. „ = $0 \cdot 00051$ C.G.S. unit.

With regard to magnetic disturbances, no very exceptional movements have been registered during the year.

The principal oscillations, however, were recorded on the following dates: November 2 to 6, 1886; February 13 and 14, April 5 to 7, August 2, and September 26 and 27, 1887. Much interest was evinced in the curve for February 23, which registered the occurrence of an earthquake.

In February last new adjusting screws were fitted to one of the microscopes attached to the Kew dip circle No. 33.

Information on matters relating to terrestrial magnetism and various data have been supplied to Professor Mascart, Professor Adams, Dr. Atkinson, Professor Schering, Dr. Rijckevorsel, and Messrs. Archbutt and Stanley.

Professors Rücker and Thorpe visited the Observatory in January last, and made a series of base observations, prior to their departure for Ireland to finish their magnetic survey of the British Isles, which was commenced in 1883. On returning to England a further series of observations were made at Kew in October in order to complete the survey.

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	28
„	Inclination	110
„	Absolute Declination	40

Several additional sets of observations of Absolute Declination have been made with the view of investigating certain changes in the values of the torsional effect of the suspending thread upon the determination of the true position of the magnet employed.

The magnetograph curves made use of in the preparation of the tables of diurnal range of Declination (see Appendix, Table III) have been drawn from the original photographs by means of an eidograph kindly lent by Captain W. J. L. Wharton, F.R.S., the Hydrographer.

Magnetic Reductions.—At the request of Professor Balfour Stewart, F.R.S., copies of the Kew declination disturbances for the years 1858–1865, together with the daily wind values for the years 1858 to 1869, have been made and forwarded to him; the Rev. S. J. Perry has also received copies of the records of certain selected days of magnetic disturbance for 1886.

Krakatoa Eruption.—In May last, at the request of the Krakatoa Committee of the Royal Society, a memorandum was prepared for that body on the magnetic effects recorded at the various observatories over the globe which occurred at the time of the great explosion of August 27, 1883, in the Straits of Sunda.

Magnetic Stations.—A list of all known magnetic stations has been prepared jointly by General Sir J. H. Lefroy and the Superintendent for publication by the Committee of the British Association on magnetic reductions, and will be published in the Annual Report for the current year.

It contains references to all localities on the surface of the globe where continuous observations of terrestrial magnetism have been made for periods of at least one month in duration, and gives, together with the geographical position of the stations, references to the publications where the results of such observations are to be found, as well as the names of the authorities, whenever these could be ascertained.

Falmouth Magnetographs.—At the request of the Secretary of the Royal Cornwall Polytechnic Society, the specifications for the magnetographs supplied to the Falmouth Observatory last year, which were drawn up by Mr. Whipple, have been revised and printed with illustrations in the Annual Report of that Society for 1886.

Sectional Lines.—In addition to the sectional lines obtained for the purpose of plotting down magnetic observations on the international scale, as suggested by General Sir J. H. Lefroy, and as mentioned in last report, the Committee have had a number of copies struck off from the stone on tracing paper for the use of observers who may desire to make tracings of existing curves on the same scale.

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

Readings of standard barometer	2540
„ dry and wet thermometers	3465
„ maximum and minimum thermometers	730
„ radiation thermometers	880
„ rain gauges	730
Cloud and weather observations	1877
Measurements of barograph curves	8740
„ dry bulb thermograph curves..	9395
„ wet bulb thermograph curves..	8665
„ wind (direction and velocity)..	17242
„ rainfall curves	680
„ sunshine traces	2182

In compliance with a request made by the Meteorological Council to the Committee, Mr. Whipple visited and inspected during his vacation the Observatories at Falmouth and Valencia, and the Anemograph at Mountjoy Barracks, Dublin.

Mr. Baker also visited the Aberdeen and Stonyhurst 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, Captain Abney, Messrs. Gwilliam, Rowland, and others. The cost of these abstracts is borne by the recipients.

The standard barometer (Adie 657) was fixed in the magnetograph room adjacent to the barograph, and read five times daily at observation hours, in order to compare its indications with those of the standard barometer in another part of the building.

Readings were continuously made from January 1 to July last, and are now under discussion.

Turf has been laid down under the screen of the thermograph with a view to avoiding effects of radiation as much as possible.

The use of meteorological self-recording instruments having been partially discontinued at Armagh, Mr. Whipple dismounted and packed the barograph and thermograph, and they have been returned for storage to the Observatory.

Electrograph.—The 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, gave great satisfaction during the year, and was found to be a marked improvement upon the older form of the instrument.

On September 2, during a high wind, a part of the instrument was accidentally set on fire by the gas-burner, and the apparatus narrowly escaped destruction.

Before re-starting the instrument it is proposed to make some minor alterations, suggested by experience, in the recording apparatus, &c.

The portable Thomson electrometer (White No. 53), having been put in thorough order, has been lent, in accordance with instructions received from the Meteorological Council, to the Hon. Ralph Abercromby for the purpose of making observations on the Peak of Teneriffe.

Mr. Abercromby visited the Observatory for the purpose of familiarising himself with the use of the instrument, the scale value having previously been redetermined, by the kindness of the Chairman, at his laboratory in Portland Place.

III. SOLAR OBSERVATIONS.

The sketches of Sun-spots, as seen projected on the photoheliograph screen, have been made on 180 days, in order to continue Schwabe's enumeration, the results being given in Appendix II, Table IV.

Transit Observations.—347 observations of solar and 80 of sidereal transits have been taken, for the purpose of keeping correct local time at the Observatory, and the clocks and chronometers have been compared daily.

The following clocks, French, Shelton K. O., Shelton 35, and the chronometers, Molyneux No. 2125, Breguet No. 3140, and Arnold 86, are kept carefully rated as time-keepers at the Observatory.

The mean-time clock, Dent 2011, was bolted to the wall of the chronometer-room for use in daily comparisons with the chronometers on trial.

Old Solar Observations.—The library of the Observatory has received a present from Wm. J. Davies, Esq., of a MS. volume of sun-spot observations made at Edmonton, Middlesex, from August, 1819, to March, 1823. It is intended to enumerate the spots after the Schwabe method, so as to carry the Observatory catalogue of the new groups of sun-spots back to 1819.

Kew Solar Photographs.—At the request of the Chairman, the MSS. sun-spot measurements and reductions from February, 1862, to December, 1863, together with the tables for computing the spotted positions, as well as the Kew working catalogues from 1864 to 1872, have been forwarded to Mr. A. L. Soper for the purpose of further discussion.

IV. EXPERIMENTAL WORK.

Photo-nephograph.—The cameras used in cloud photography having been put in order, and had new adjustable rapid shutters fitted, were again brought into use, and by request of the Meteorological Council 24 sets of photographs comprising 90 negatives were taken on 14 days, chief attention was directed to the photographing of high cirrus clouds.

Prints of all the pictures have been made on cyanotype paper, which together with the observational data have been transferred to the Meteorological Office for the reduction and computation of cloud heights and velocities, Professor Stokes's cloud projection apparatus having also been transferred there for the purpose.

Solar Radiation.—The observations of the black bulb thermometers in vacuo made during 1886 were reduced and discussed, and the results found to be no more satisfactory than those obtained in previous years, the vacua in all of the instruments having deteriorated, and their readings having become lowered during the time they were under observation, whilst the readings differed considerably amongst themselves.

The Chairman having undertaken to submit the tubes to a lengthy exhaustion, three instruments were fitted with new jackets and sealed on to the air-pump in his laboratory.

They were there exhausted almost daily, the atmospheric pressure being reduced to and maintained at about 0.06 M from April to the end of September. On October 1st they were removed from the laboratory and replaced on the stand at the Observatory, having been read daily ever since.

Large differences are still found to exist in the readings of the similar and similarly placed instruments.

Pendulum Experiments.—The Indian Pendulum Apparatus, returned from the United States by Professor Peirce, was put up in the pendulum room specially erected for its accommodation in the South Hall

of the Observatory, and certain preliminary swings made in the presence of both General Walker and Colonel Heaviside, R.E., which sufficed to show that the apparatus had not undergone any material changes since it left Kew in 1881.

It was, however, found that the vacuum chamber had received such structural damage in transit as to render it incapable of exhaustion to a sufficiently high degree to make the observations comparable with those previously made by Captains Basevi and Heaviside. It was accordingly returned to the maker, Mr. Adie, of London, for thorough repair, and has recently been again erected in its place, and found in a very satisfactory condition, so that the required preliminary observations may now be re-commenced.

By the kindness of Mr. W. H. Preece, F.R.S., the Committee were favoured with the loan of a recording chronograph for use in registering the coincidences. Experience proved that it was unnecessary, and the apparatus has since been returned to the General Post Office.

At the suggestion of Colonel Heaviside, photographs of the invariable pendulums were obtained on their removal from their cases after travelling, in order that a memorandum might be preserved of their figure and shape on their return to the Kew Observatory.

V. VERIFICATION OF INSTRUMENTS.

The following magnetic instruments have been purchased on commission and their constants determined :—

An Inclinator for the Tokio University, Japan.

An Inclinator for the Mauritius Observatory.

1 Collimating Magnet for Professor F. Brioschi, Rome.

2 Collimating Magnets and an Inclinator for Professor Naccori, Turin University, Italy.

1 Magnet for declination and a pair of Inclinator needles for Lisbon Observatory.

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

Air-meters	5
Anemometers	3
Aneroids	83
Artificial Horizons.....	2
Barometers, Marine.....	89
" Standard.....	41
" Station.....	26
Compasses.....	2

Carried forward 251

Brought forward	251
Hydrometers.....	274
Inclinometers	3
Magnets	6
Rain Gauges	7
Range Finders.....	17
Sextants.....	145
„ Shades	52
Sunshine Recorders.....	2
Theodolites	11
Thermometers, Arctic.....	98
„ Avitreous.....	2641
„ Chemical	95
„ Clinical	8668
„ Deep sea.....	35
„ Meteorological	1370
„ Mountain	30
„ Solar radiation	9
„ Standards	43
Unifilars	4
Total.....	<u>13,761</u>

Duplicate copies of corrections have been supplied in 75 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	64
„ ordinary meteorological.....	50
Various	232

5 Standard Thermometers have also been calibrated, and supplied to 4 societies and individuals during the year.

There are at present in the Observatory undergoing verification, 21 Barometers, 462 Thermometers, 2 Hydrometers, and 10 Sextants.

The Committee, after considering the question of certifying the various and numerous classes of instruments on the hydrometer principle, have authorised the Superintendent of the Observatory to refuse to verify any instruments except such as either indicate specific gravities directly or whose indications bear a known and well-defined relation to specific gravities.

Several patterns of range-finders, for use both at sea and on shore, have also been tested; two additional movable adjustable collimators with scales having been fitted to the sextant testing apparatus, to enable it to be used for this purpose.

Aneroid Altitude Scales.—The Committee have also had their attention called to the fact that several scales are in use for graduating the scales of heights upon the dials of aneroids. Upon consideration the Committee recommend as desirable the employment of Sir G. B. Airy's scale, published in 1867, and the equivalent metric scale, in all cases where possible.

Two highly sensitive aneroids with Bourdon tubes substituted for the ordinary corrugated vacuum boxes, constructed by MM. Richard, Frères, of Paris, have been examined for constancy at the request of the Meteorological Council. It was found, however, that the metal of the tubes underwent changes similar to those experienced by the usual aneroid boxes, and the instruments were therefore liable to the same errors as the common aneroid.

A *Beckley Rain Gauge* was obtained, fitted with a Stonyhurst discharger, and, after due trial, sent to the Mauritius Observatory, where an opportunity will be afforded of noting the behaviour of the improved instrument during tropical rains.

Hygrometers.—Dr. Doberck, the Director of the Hong Kong Observatory, having obtained a Royal Society grant for the purpose of re-calculating Hygrometric tables, Mr. Whipple procured and forwarded to him examples of Alluard's, Crova's, and Dines' instruments, after making preliminary observations at Kew.

Hot Springs.—Mr. G. J. Symons, F.R.S., having received a grant from the Government Grant Fund of the Royal Society, for the purpose of investigating the temperatures of certain hot springs in the South of France and the Pyrenees, had a number of specially prepared thermometers carefully verified at the Observatory, both before and after he had made use of them abroad.

Anemometer Constants.—At the request of Colonel Knight, F.R. Met. Soc., a number of comparisons with the standard Anemometer were made of a small Robinson's Anemometer he had constructed, having cups fitted to arms of variable length, and the moving parts provided with friction rollers.

Anemographs.—Mr. Whipple has, at the request of the Imperial Chinese Customs, superintended the construction of a new Beckley Anemograph for use at Formosa, as well as a similar instrument for Dr. A. S. Viegas, of the Coimbra Observatory, and two smaller instruments for the Meteorological Council.

Navy Telescopes.—By the kindness of the Astronomer Royal the Kew Observatory has been favoured with descriptions of the tests applied to Navy telescopes supplied by contractors to H.M. Service, and also with descriptions of the apparatus employed at the Royal Observatory, Greenwich, for applying the tests.

A standard Admiralty telescope has been purchased, and the necessary appliances are now being constructed, with the view of enabling

the Committee to apply similar tests to telescopes submitted to them for verification by opticians and others.

VI. RATING OF WATCHES.

The arrangements for rating watches mentioned in previous Reports have been carried on during the year with continued success, and up to the present 1344 watches have been examined and reported upon.

510 entries of watches were made as contrasted with 490 during the corresponding period of last year. They were sent for testing in the following classes:—

For class A, 463; class B, 25; and class C, 22.

Of these 174 failed to gain any certificate; 19 passed in C, 21 in B, 296 in A, and 13 of the latter obtained the highest possible form of certificate, the class A *especially good*.

In Appendix III will be found statements giving the results of trial of the 26 watches which obtained the highest numbers of marks during the year, the premier position being attained—with 88·1 marks—by a keyless, double-roller, going-barrel watch, submitted by Jos. White, Earlsdon, Coventry.

This total exceeds that of last year, and it is also extremely satisfactory to note that a very marked increase has taken place in the number of watches which have gained more than 80 marks.

As some inconvenience was caused by the employment of temporary expedients to maintain the large watch-safe at an average of 65° F. for the "middle-temperature" test, a burner was procured and fitted up with a shield, and the safe can now be kept at the desired point, whilst at the same time no deleterious fumes of coal-gas can penetrate into the interior chamber.

The three rating safes are therefore now maintained by means of gas and ice at practically the three constant temperatures of 40°, 65°, and 90° F. respectively, all the year round.

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

Rating of Chronometers.—Since the institution of chronometer trials, as mentioned in last year's Report, 27 movements have been examined, and certificates issued giving the mean daily rate and variation of rate at each change of temperature.

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 ten seconds in any stage of the test.

A Kullberg's temperature regulator has been fitted by the maker to the chronometer oven, and a Richard thermograph is also arranged to work in the case with the chronometers, affording 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 serious objections have yet been received from makers or others to the adoption of the above range.

VI. MISCELLANEOUS.

Photographic Paper, &c.—This has been supplied to the Observatories at Coimbra, Colàba, Falmouth, Lisbon, Mauritius, Stonyhurst, and Toronto. It has also been supplied to the Meteorological Office, the U.S. Navy Department, and others.

Anemograph sheets have, in addition, been forwarded to Madras, and blank forms for the entry of observations to several persons.

Extension of Building.—The Committee having decided on building an additional floor on the east wing of the Observatory, for the purpose of providing increased space for carrying on the Observatory work, now very much cramped, have obtained from the Council the promise of a loan of £200 if needed.

Application has therefore been made to the Chief Commissioner of Works and Public Buildings for permission to proceed with the work, but the reply granting leave has not yet been received.

Mr. Whipple has recently designed two new simple forms of maximum pressure anemometers, which he exhibited before the Royal Meteorological Society, and described in a paper read on April 20th.* They were also shown at the Falmouth Exhibition of the Royal Cornwall Polytechnic Society in September.

Stevenson's Screen.—The Stevenson's screen fixed on the lawn was blown over during the gale of September 2nd last, but fortunately the injury done by the accident was very trivial, as the screen was not in use at the time.

Exhibitions.—Photographic curves and pictures have been by request shown at the Exhibition at Newcastle-upon-Tyne and the Royal Jubilee Exhibition, Manchester.

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

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

98 Foreign and Colonial Scientific Establishments, as well as numerous private individuals;

the special thanks of the Committee being due to Dr. Neumayer, the Director of the Deutsche Seewarte, Hamburg, for a complete set of the publications of that establishment since 1876.

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.

PERSONAL ESTABLISHMENT.

The staff employed is as follows:—

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

T. W. Baker, Chief Assistant.

H. McLaughlin, Librarian.

E. G. Constable, Observations and Rating.

W. Hugo, Verification Department.

M. Baker, Messenger and Care-taker, and nine other Assistants.

(Signed)

WARREN DE LA RUE, *Chairman.*

November 25th, 1887.

* See 'Quart. Jour. Roy. Met. Soc.,' vol. xiii, p. 224.

The Kew Observatory. Account of Receipts and Payments for the year ending October 31st, 1887.

RECEIPTS.

Dr.	£	s.	d.
To Balance from 1885-86	£576	14	6
Royal Society (Gasiot Trust)	490	8	7
" (Pendulum)	150	0	0
Meteorological Office (Allowance)	400	0	0
Experimental Work	61	19	3
Magnetic Work	28	1	4
Miscellaneous	88	3	6
Verifications	824	3	0
Rating of Watches and Chronometers.....	405	5	4
	3024	15	6
Meteorological Office for Postages and Portrages	26	2	5
Commissions executed for Colonial and Foreign Institutions, &c.	570	18	0
	£3621	15	11

November 10, 1887.

Examined and compared with the Vouchers, and found correct.

(Signed) GEO. HENRY RICHARDS, Auditor.

PAYMENTS.

Cr.	£	s.	d.
Salaries and Extra.....	£1397	2	3
Gas, Fuel, Rent, Insurance, &c.	188	3	4
Stationery, Postages, Carstaker, &c.	131	15	3
Instruments, Apparatus, &c.	44	4	10
Experimental work	34	1	2
Miscellaneous	50	7	7
Exhibition	2	1	9
Verifications	109	14	1
Rating of Watches and Chronometers	114	16	7
Pendulum	98	0	9
	2170	7	7
Postages and Portrages, &c., for Meteorological Office	30	0	3
Commissions executed for Colonial and Foreign Institutions, &c.	645	16	5
Balance—Bank of England.....	681	11	2
London and County Bank	87	14	10
Cash in hand	6	5	8
	775	11	8
	£3621	15	11

ASSETS.

	£	s.	d.
By Balance as per Statement	775	11	8
Meteorological Office, Allowances, Experimental, and Sundries.....	100	17	3
Verification Fees due, &c.....	88	9	4
Rating of Watches, &c.....	59	7	11
Photographic Paper	7	4	2
Commissions, &c.	21	7	1
Blank Forms	25	19	3
Standard Thermometers in Stock	89	4	0
	£1168	0	8

November 11, 1887.

(Signed) G. M. WHIPPLE, Superintendent.

LIABILITIES.

	£	s.	d.
To Gas, Fuel, and House Account	6	17	6
Balance, Pendulum Account.....	40	10	1
Chemicals, &c.	4	15	11
Purchases on Commission.....	3	0	0
Balance	1112	17	2
	£1168	0	8

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 1886 to September 1887.

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 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 $\log \pi^2 K$ 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

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

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 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

$$\frac{m}{X} = \frac{m'}{X'} \left(1 - \frac{P}{r_0^2} \right), \text{ is } -0.00186.$$

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, has been carefully determined.

The observations have been made and reduced by Mr. T. W. Baker.

Table I.
Observations of Dip or Inclination.

Month.	Mean Inclination.	Month.	Mean Inclination.
1886.		1887.	
November 2.....	67 37'5	April 25.....	67 37'9
3.....	67 39'0	27.....	67 35'4
Mean.....	67 38'3	28.....	67 35'5
November 25.....	67 37'2	Mean.....	67 36'3
26.....	67 37'7	May 24.....	67 36'8
Mean.....	67 37'5	26.....	67 37'5
December 28.....	67 40'5	Mean.....	67 37'2
29.....	67 39'4	June 24.....	67 35'9
30.....	67 38'0	25.....	67 35'7
Mean.....	67 39'3	Mean.....	67 35'8
1887.		July 26.....	67 35'6
January 26.....	67 38'0	28.....	67 35'0
28.....	67 36'6	Mean.....	67 35'3
Mean.....	67 37'3	August 26.....	67 35'6
February 21.....	67 39'0	29.....	67 36'2
22.....	67 37'1	Mean.....	67 35'9
23.....	67 38'4	September 22.....	67 35'7
Mean.....	67 38'2	24.....	67 37'5
March 22.....	67 37'8	Mean.....	67 36'6
23.....	67 37'1		
Mean.....	67 37'5		

Table II.

Observations for the Absolute Measurement of Horizontal Force.

Month.	Log $\frac{m}{X}$ mean.	Log mX mean.	Value of m^* .
1886.			
November 4th	9·12210	0·30690	0·51820
" 29th	9·12069	0·30786	0·51794
December 31st.....	9·12105	0·30767	0·51804
1887.			
January 27th.....	9·12141	0·30785	0·51836
February 24th.....	9·12077	0·30799	0·51806
March 28th	9·12078	0·30799	0·51806
April 25th	9·12060	0·30816	0·51806
May 31st	9·12063	0·30835	0·51819
June 29th and 30th.....	9·12080	0·30824	0·51823
July 29th	9·12061	0·30815	0·51806
August 30th and 31st....	9·12052	0·30766	0·51771
September 23rd	9·12003	0·30803	0·51764

Table III.—Solar Diurnal Range of the Kew Declination as derived graphically from selected quiescent days.

Hour.	Summer mean.	Winter mean.	Annual mean.
1887.			
Midnight	-0·9	-1·6	-1·3
1	-1·0	-1·3	-1·2
2	-1·4	-1·3	-1·4
3	-1·8	-1·4	-1·6
4	-2·2	-1·3	-1·8
5	-3·0	-1·2	-2·1
6	-4·2	-1·4	-2·8
7	-4·8	-2·0	-3·4
8	-4·4	-2·3	-3·4
9	-3·3	-2·3	-2·8
10	-0·4	-0·9	-0·7
11	+3·7	+1·4	+2·6
Noon	+6·3	+3·4	+4·9
13	+6·4	+3·9	+5·1
14	+5·8	+3·3	+4·6
15	+4·1	+2·1	+3·1
16	+2·2	+1·1	+1·6
17	+1·0	+0·4	+0·7
18	+0·2	+0·3	+0·3
19	0·0	+0·1	0·0
20	-0·2	-0·3	-0·3
21	-0·3	-0·8	-0·6
22	-0·5	-1·4	-1·0
23	-0·8	-1·5	-1·2

* m = magnetic moment of vibrating magnet.

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

Months.	Thermometer.						Barometer.*						Mean vapour-tension.	
	Mean.	Means of—			Absolute Extremes.			Mean.	Absolute Extremes.			Date.		
		Max.	Min.	Max. and Min.	Max.	Date.	Min.		Date.	Max.	Date.			
		d.	h.	d.	h.	d.	h.		ins.	d.	h.			ins.	d.	h.
1886.	53.1	47.5	53.3	76.7	4 2 P.M.	37.3	22 8 A.M.	29.799	30.432	29 10 P.M.	28.643	16 9 A.M.	in. .336	
Oct.	43.7	38.2	43.3	58.6	1 3 P.M.	27.6	24 8 "	29.926	30.739	24 9 A.M.	28.964	6 10 "	.251	
Nov. ...	36.5	31.4	36.6	53.3	6 1 P.M.	17.7	20 8 "	29.711	30.599	31 10 "	28.312	9 5 "	.184	
Dec. ...	35.7	31.3	35.6	51.4	19 2 "	14.9	2 7 "	30.019	30.695	21 11 "	28.838	5 9 "	.189	
1887.	38.9	33.3	39.1	53.8	5 2 "	20.7	17 8 "	30.337	30.759	7 Noon.	29.753	2 7 P.M.	.193	
Jan.	38.1	32.8	38.6	55.7	27 3 "	23.8	19 7 "	30.083	30.662	2 9 A.M.	28.991	23 8 A.M.	.181	
Feb. ...	43.8	36.4	44.4	64.5	19 4 "	27.4	17 6 "	30.010	30.737	17 7 "	29.310	24 9 "	.204	
March..	50.0	43.3	50.2	67.6	8 4 "	34.8	1 5 "	30.019	30.429	8 10 "	29.269	20 6 "	.271	
April. ...	60.2	50.8	60.4	81.0	15 6 "	44.1	27 4 "	30.197	30.493	10 11 P.M.	29.556	3 1 & 2 A.M.	.360	
May ...	65.2	54.9	65.3	85.3	3 4 "	45.3	18 4 & 5 A.M.	30.050	30.393	1 1 A.M.	29.578	27 4 A.M.	.403	
June ...	61.5	52.1	61.9	84.5	6 4 "	41.5	15 5 "	29.988	30.389	3 8 "	29.461	31 6 "	.358	
July ...	54.0	47.3	54.0	67.8	5 2 & 4 P.M.	32.9	29 7 "	29.944	30.493	19 9 "	29.266	2 7 "	.320	
Aug.	48.4	41.6	48.6	..	....	..	....	30.007	..	....	..	....	.271
Sept.	Means..													

The above Table is extracted from the "Hourly Readings," vols. 1886-87, of the Meteorological Office, by permission of the Meteorological Council. * Reduced to 32° at M.S.L.

Meteorological Observations.—Table II.

Kew Observatory.

Months.	Mean amount of cloud (0=clear, 10=over-cast).		Rainfall*.		Weather. Number of days on which were registered								Wind †. Number of days on which it was								Variable.	
	Total.	Maxi-mum.	Date.	in.	Rain.	Snow.	Hail.	Thun-der-storms.	Clear sky.	Over-cast sky.	Calms.	Calms.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.		
1886.																						
October ..	2.310	0.385	12	in.	23	..	..	..	3	16	1	8	2	4	5	2	4	6	5	1	1	2
November	2.845	0.570	10		17	..	..	..	3	14	..	6	..	5	3	..	5	7	3	2	2	3
December	3.465	1.270	26		20	3	1	..	9	8	2	7	..	2	..	..	2	10	5	4	4	5
1887.																						
January..	1.465	0.545	3		17	7	..	..	4	19	..	11	1	3	1	2	10	6	3	2	2	3
February.	0.570	0.190	17		6	..	..	..	9	11	1	6	2	2	7	2	1	8	1	1	1	1
March...	1.705	0.405	15		12	3	..	..	4	9	1	7	1	3	4	1	1	2	3	3	2	5
April....	1.310	0.315	23		12	..	1	..	5	9	2	2	..	9	1	..	4	6	1	4	2	1
May.....	1.680	0.300	3		20	..	1	1	1	17	..	..	..	11	4	..	1	3	4	4	1	3
June.....	1.130	0.570	2		4	..	..	..	11	7	..	3	..	7	5	..	1	6	3	3	1	2
July.....	0.820	0.295	24		10	..	..	2	7	2	..	5	2	2	2	1	5	12	1	2	2	3
August..	2.680	1.135	17		10	..	..	2	8	7	..	8	..	4	5	..	6	6	3	3	3	2
September	2.165	0.425	16		13	..	..	1	3	15	1	5	..	7	1	..	1	12	4	2	2	1
Totals..	22.145				164	13	3	6	67	134	8	68	8	57	45	33	41	84	36	30	30	31

* Measured at 10 A.M. daily 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.
1886.												
October	77 42	23	8 30	2	93	122	4	42	29.4	22	10	37
November	45 54	17	6 12	4	72	100	1	33	23.4	19	8	33
December	71 54	29	6 12	25	65	82	8	26	14.5	20	13	42
1887.												
January	36 30	14	6 54	26	58	90	5	27	10.8	2	8	34
February	67 42	24	7 48	26	75	102	25	29	18.3	18	12	36
March	98 6	26	9 36	13	79	109	26	29	17.9	17	10	43
April	170 42	41	12 36	20	103	120	19	31	19.2	18	14	38
May	137 42	29	13 54	15	105	126	9	39	27.3	15	11	33
June	245 12	50	15 48	13	122	137	8	44	32.3	27	9	25
July	280 54	56	14 18	3	132	141	12	46	33.6	19	9	29
August	240 54	53	12 54	9	125	140	7	43	29.2	15	8	27
September	119 6	31	11 18	8	111	123	7	41	26.9	25	10	39

* 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.
1886.			
October.....	14	4	4
November.....	8	2	6
December.....	13	4	5
1887.			
January.....	10	3	3
February.....	12	4	4
March.....	11	4	4
April.....	17	2	7
May.....	16	5	2
June.....	21	5	0
July.....	23	6	5
August.....	20	3	8
September.....	15	2	12
Totals.....	180	44	60

APPENDIX III.—Table I.

RESULTS OF WATCH TRIALS. Performance of 26 Watches which obtained the highest number of marks during the year.

Watch deposited by	Number of watch.	Balance spring, escapement, &c.	Mean daily rate. — +Gaining.—Losing.	Mean variation of daily rate. †	Mean change of rate for 10 P.	Difference of mean daily rate				Difference between extreme gaining and losing rates.	Marks awarded for			Total Marks. 0—100.	
						Between pendant up and dial up.	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 change of position.	Temperature.		
Jos. White, Coventry	29999	Single overcoil, d.r., g.b.	+0.4	secs.	secs.	secs.	secs.	secs.	secs.	secs.	32.7	37.7	17.7	88.1	
Baume & Co., London	2646†	Single overcoil, d.r., g.b.	+2.4	secs.	0.4	0.03	-0.5	+1.3	+0.6	+0.4	4.5	36.2	18.9	85.1	
W. Holland, Rockferry	3563	Single overcoil, d.r., fusee	+3.3	secs.	0.5	0.02	-1.5	-2.1	-2.6	-1.8	4.25	36.2	19.8	83.1	
Stauff & Co., London	120186	Single overcoil, d.r., g.b., bar-layer	+3.8	secs.	0.6	0.003	-0.2	-1.1	+0.5	+2.8	5.25	27.1	17.2	82.9	
Donne & Son, London	1545	Two-in-One, d.r., resting barrel	+1.1	secs.	0.4	0.04	+0.8	4.5	-1.1	-1.1	6.25	34.3	17.2	82.7	
D. Buckney, London	30191	Single overcoil, d.r., fusee	+0.8	secs.	0.5	0.03	-0.1	+0.6	+2.0	-0.5	5.0	37.0	17.8	82.4	
Baume & Co., London	2528	Single overcoil, d.r., g.b.	+3.4	secs.	0.4	0.10	-1.3	-1.3	+2.7	+3.7	6.75	33.1	18.9	82.4	
Stauff & Co., London	123174	Single overcoil, d.r., g.b., bar-layer	+1.9	secs.	0.7	0.03	-0.1	-1.6	+0.8	-0.8	6.5	37.4	13.2	82.1	
Stauff & Co., London	111353	Single overcoil, d.r., g.b.	+1.5	secs.	0.5	0.03	4.7	-1.3	+0.2	+3.0	8.5	37.2	17.9	81.9	
Stauff & Co., London	122288	Single overcoil, d.r., g.b.	+0.9	secs.	0.6	0.06	+2.3	+2.7	+0.7	-0.8	29.0	34.6	18.0	81.6	
Stauff & Co., London	114351	Single overcoil, d.r., g.b.	+2.4	secs.	0.4	0.05	+2.4	-2.8	+3.9	+0.7	8.25	32.9	31.4	81.3	
Baume & Co., London	2529	Single overcoil, d.r., g.b., bar-layer	+4.3	secs.	0.5	0.06	-0.2	3.5	-1.7	-0.4	6.75	29.8	17.0	81.2	
Jas. White, Coventry	28026	Single overcoil, s.r., g.b.	-0.9	secs.	0.6	0.06	+0.6	-1.3	-2.8	-1.4	6.0	28.6	36.2	16.3	81.1
Jas. White, Coventry	29024	Single overcoil, s.r., g.b.	+0.4	secs.	0.6	0.02	-4.7	-0.4	+4.3	+3.6	8.5	27.5	35.0	18.5	81.0
Stauff & Co., London	123173	Single overcoil, d.r., g.b., bar-layer	+1.9	secs.	0.5	0.04	-1.7	-3.0	-5.3	+1.9	7.5	30.9	33.0	17.1	81.0
Stauff & Co., London	122289	Single overcoil, d.r., g.b.	+3.6	secs.	0.7	0.03	+4.1	+1.5	+2.0	-1.4	7.75	28.8	34.1	18.0	80.9
Usher & Cole, London	25738	Flat spring, s.r., g.b.	+0.5	secs.	0.6	0.03	-1.5	-2.9	-0.8	+1.6	6.75	26.5	36.3	18.0	80.8
R. Crook, London	899	Single overcoil, s.r., g.b.	-2.3	secs.	0.6	0.04	-0.8	+2.3	3.0	+0.1	7.25	28.4	34.8	17.6	80.8
Baume & Co., London	2530	Single overcoil, d.r., g.b., bar-layer	+1.5	secs.	0.4	0.10	+1.4	+1.0	+3.8	-2.5	7.0	31.8	35.4	13.5	80.7
Stauff & Co., London	123158	Single overcoil, d.r., g.b., bar-layer	+4.8	secs.	0.4	0.09	-4.0	+0.4	+3.1	-1.0	8.0	31.2	35.5	14.0	80.7
Stauff & Co., London	120184	Single overcoil, d.r., g.b., bar-layer	-1.0	secs.	0.5	0.05	+0.8	-2.0	-3.7	-1.2	6.0	29.6	34.3	16.7	80.6
A. P. Roger, Guernsey	123172	Single overcoil, d.r., g.b.	-0.5	secs.	0.6	0.01	+1.0	-0.7	-3.4	-4.6	8.0	28.5	33.0	19.1	80.6
J. Player, Coventry	24619	Single overcoil, d.r., g.b.	+5.7	secs.	0.6	0.08	-0.1	-0.7	-0.1	-0.8	5.75	27.0	38.6	14.7	80.4
H. Gelay, London	14776	Double overcoil, d.r., g.b.	+3.0	secs.	0.4	0.05	+0.5	-4.6	+2.2	-2.5	7.5	32.0	31.8	16.5	80.3
A. E. Fridlander, Coventry	52465	Single overcoil, d.r., g.b.	+2.8	secs.	0.4	0.09	+1.2	-2.1	-2.2	-0.2	5.75	31.0	34.5	14.6	80.1
Stauff & Co., London	120842	Single overcoil, d.r., g.b., bar-layer	+1.6	secs.	0.5	0.08	+4.0	+1.3	+1.9	-0.6	6.5	30.8	34.9	14.4	80.1

† Split-seconds chronograph without minute-recorder.

* d.r., double-roller; s.r., single-roller; g.b., going barrel.

Table II.
Highest Records obtained by Complicated Watches during the year.

Description of watch.	Number.	Deposited by	Marks awarded for			Total marks, 0—100.
			Variation.	Position.	Temperature.	
Minute and seconds chronograph and repeater..	14768	H. Gokay, London	32.1	34.2	10.7	77.0
" " " "	14750	H. Gokay, London	27.7	33.3	11.3	72.3
Perpetual calendar and repeater	01922	S. Smith and Son, London	26.1	34.2	16.7	77.0
" " " "	14759	H. Gokay, London	28.3	35.5	10.7	74.5
Split-seconds and minute-recorder chronograph.	9818	E. R. Shipton, London	26.6	34.5	17.6	78.7
" " " "	07369	H. Gokay, London	28.8	30.2	14.7	73.7
Split-seconds chronograph (without minute-dial)	2646	Baume and Co., London	30.0	36.2	18.9	85.1
Ordinary minute and seconds chronograph.....	2427	Baume and Co., London	27.6	35.8	16.4	79.8
" " " "	128820	Staufer and Co., "	27.8	32.4	16.9	77.1
" " " "	2426	Baume and Co., "	28.0	33.2	15.5	76.7
Repeaters	31578	H. Capt, Geneva	30.0	34.3	14.2	78.5
"	14752	H. Gokay, London	26.8	33.9	13.8	74.5

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.	Portable Transit Instrument	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
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
Lord Rayleigh	Standard Barometer (Adie, No. 655)	1885
University of Japan..	Barrow's Inclinator, No. 24.....	1887