

# KEW OBSERVATORY,

1882.

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## REPORT

OF THE

## KEW COMMITTEE

FOR THE

*Year ending October 31, 1882,*

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

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[*From the PROCEEDINGS OF THE ROYAL SOCIETY, 1882.*]

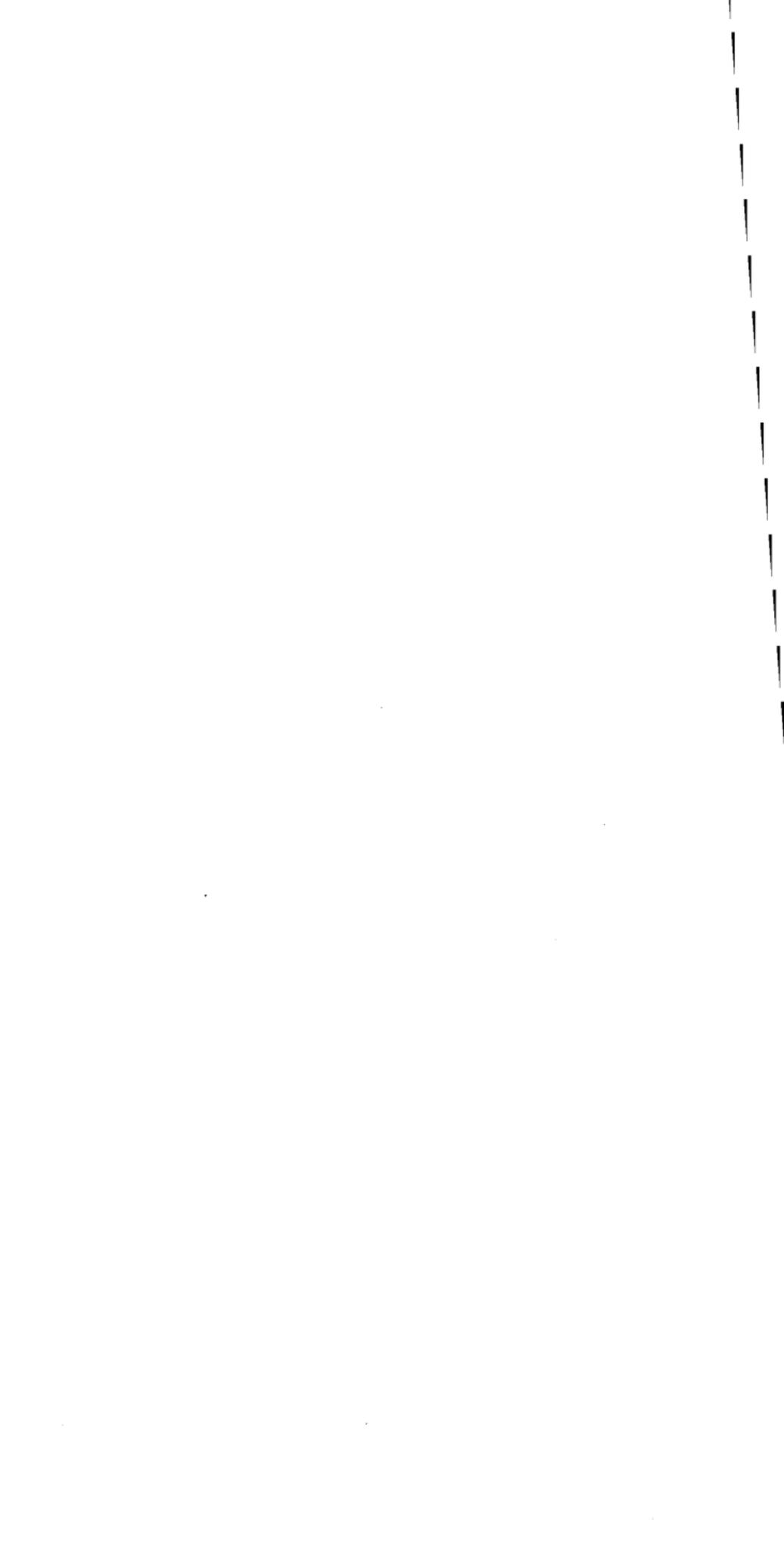
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1882.



*Report of the Kew Committee for the Year ending  
October 31, 1882.*

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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 :

General Sir E. Sabine, K.C.B., *Chairman.*

Mr. De La Rue, *Vice-Chairman.*

Capt. 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 seven 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. Aid to other Observatories.

7th. Miscellaneous and financial.

#### I. MAGNETIC OBSERVATIONS.

The Magnetographs have been in constant operation throughout the year.

In March a new suspension pulley was fitted to the Bifilar magnet in order to reduce the distance between the suspension wires from 6·8 millims. to 5·5 millims., and thus to increase the sensibility of the instrument. This change was recommended by Professor W. G. Adams, in order to make the scale-value about '0005 millim. mgrm. for 1 millim., as suggested in his Report to the British Association last year. Dr. Wild, of St. Petersburg, also recommends that all observatories should adopt as far as possible the same uniform scale

for their instruments, and suggests that the scale-values should be as follows:—

For the Declination	1 mm.	$\delta D = 1'$	
„ Bifilar	1 mm.	$\delta H = 0.0005$ mm. mgr. units.	
„ Balance	1 mm.	$\delta V = 0.0005$	„ „

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The following are the values of the ordinates of the various photographic curves as determined at the various dates stated:—

Declination		1 inch = $0^\circ 22' 04.$	1 mm. = $0^\circ 0' 87.$
Bifilar	Jan. 3, 1882,	for 1 inch	$\delta H = 0.0450$ foot grain units.
	„	1 mm.	„ = $0.0008$ mm. mgr. units.
„	Mar. 27, „	1 inch	„ = $0.0222$ foot grain units.
	„	1 mm.	„ = $0.0004$ mm. mgr. units.
Balance	Jan. 6, „	1 inch	$\delta V = 0.0341$ foot grain units.
	„	1 mm.	„ = $0.0006$ mm. mgr. units.

The Committee having been asked by the Secretaries of the International Polar Commission to furnish that body with copies of their hourly determinations of the magnetic elements, recommenced the tabulation of the curves which had been suspended in 1879. (See Report for 1880, p. 4.)

With a view, however, of reducing the labour of tabulation, it was decided that a sufficient degree of accuracy and greater rapidity would be obtained by reading the curves by the unassisted eye, without the aid of the tabulating frame and vernier hitherto employed. Scales graduated on glass plates have therefore been prepared, and the curves tabulated from August 1st up to the present date by this means; the declination being recorded to a tenth of a minute of arc, and the force-traces to the tenth of a millimetre.

In order to obtain a record of the more rapid changes which take place during magnetic storms, a trial has been in progress since July 4 of the highly sensitive argentic gelatino-bromide photographic paper prepared by Messrs. Morgan and Kidd.

The results of the experiment show that the paper indicates clearly small movements of the magnet which the waxed paper is unable to register, and also that less gas-light is needed for the purpose of illumination.

Three magnetic storms, or periods of considerable disturbance of the needles, have been registered during the year; viz., on April 17th and 20th and on October 2nd. All were accompanied by auroral displays, but these were only observed in this country on the latter date.

The Committee have to acknowledge with thanks the receipt of photographic copies of traces during those magnetic disturbances from the Observatories at the Mauritius, Melbourne, Toronto, and Batavia.

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

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

M. Puiseux.

Captain Dawson, R.A., and 3 of his assistants.

Dr. Ristori.

Mr. Dallas.

Information on matters relating to terrestrial magnetism and various data have been supplied to Professor W. G. Adams, J. E. H. Gordon, Dr. Stewart, Messrs. Tate, Zambra, Professor McLeod, The Hydrographic Department of the Admiralty, the Director-General of the Chart Dépôt of the French Marine, Lieutenant Chadwick, the Naval Attaché from the United States, and others.

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

Determinations of Horizontal Intensity . . . . .	33
„ Dip . . . . .	138
„ Absolute Declination . . . . .	28

At the request of the Polar Committee of the Royal Society a number of old magnetic instruments were removed out of store, and after repair, packed and delivered to Captain Dawson, R.A., who has been intrusted by the Government with the charge of a temporary observatory established in connexion with the International system at Fort Rae, Great Slave Lake, N.W. America.

Other instruments were lent to the Rev. S. J. Perry, F.R.S., for use during their residence in Madagascar for the observation of the transit of Venus by a party under his direction ; and a third set were prepared for Dr. Ristori, who projected an expedition to Iceland, but has not yet started for that country. (See Appendix III.)

A Dip-circle was also lent to the Austrian expedition to Jan Mayen, to replace one mislaid at the time of sailing of the vessels ; this, however, having been recovered by the expedition, the Kew circle has been returned.

## II. METEOROLOGICAL OBSERVATIONS.

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

The tube of the wet bulb thermograph was accidentally broken on June 30 by a workman engaged in painting the exterior of the building. A spare tube was substituted for it, and only a few hours'

trace lost. The scale value of the curves has been altered, and new tabulating scales are accordingly being constructed at the Meteorological Office.

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

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

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

Readings of standard barometer .....	1929
„ dry and wet thermometers .....	4358
„ maximum and minimum thermometers .....	930
„ radiation thermometers .....	706
„ rain gauges .....	730
Cloud and weather observations .....	1929
Measurements of barograph curves .....	9125
„ dry bulb thermograph curves..	9125
„ wet bulb thermograph curves..	6850
„ wind (direction and velocity)..	17480
„ rainfall curves .....	809
„ sunshine traces .....	2262

In compliance with a request made by the Meteorological Council to the Kew Committee, the Observatories at Aberdeen, Armagh, Falmouth, Glasgow, Oxford (Radclyffe), Stonyhurst, and Valencia, have been visited as on former occasions, and their instruments inspected by Mr. Whipple during his vacation.

With the concurrence of the Meteorological Council, weekly abstracts of the meteorological results have been regularly forwarded to, and published by “The Times,” “The Illustrated London News,” “The Torquay Directory,” and “The Torquay Standard,” and data have been supplied to the editor of “Symons’s Monthly Meteorological Magazine,” the Secretary of the Institute of Mining Engineers, Messrs. Gee, Greaves, Gwilliam, Mawley, Rowland, and others.

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

In August it was dismantled, and a fresh supply of acid placed in the jar, the charge-keeping properties of which had become slightly deteriorated.

With a view of investigating the effect of locality upon the indications of the electrograph, a portable Thomson's electrometer has been employed, with a burning-match collector to make occasional observations around the exterior of the building. These observations are at present suspended, on account of an accidental derangement of the instrument which has necessitated its return for a time to the hands of the maker.

The curves have been tabulated up to the end of 1881, and a report on the working of the instrument has been submitted to the Meteorological Council.

Mr. W. L. Dallas of the Meteorological Office, having recently been appointed Scientific Assistant to the Meteorological Reporter of India, received instructions in the use of meteorological instruments prior to his departure to that country.

### III. SOLAR OBSERVATIONS.

The only solar work done at Kew during the past year has been the regular maintenance of the eye observations of the sun, after the method of Hofrath Schwabe, as described in the Report for 1872, in order to preserve the continuity of the Kew records of sun-spots. These have been made on 197 days. The sun's surface was found to be free from spots on three of those days.

A small portable 2 $\frac{3}{4}$  inch refracting telescope, with a magnifying power of 42 diameters, was used by the observer till July 3rd, since that date the observations have been made by means of the Photoheliograph, which was removed from the Loan Collection at South Kensington for that purpose, and reinstated on the pedestal in the Dome, a position which it occupied prior to its being sent to the Royal Observatory, Greenwich, in 1873.

The spots are now drawn by the Observer, as they appear projected upon the focussing screen.

The measurements and reductions of sun-spot positions, as determined by means of the Kew photoheliograph, from 1864 to 1872, having been completed for Mr. De La Rue, he has deposited the manuscript with the Council of the Royal Society. The correction of area measurements, for foreshortening, still remains to be applied to the reductions for the last two years, but this work is now being rapidly pushed forward.

*Transit Observations.*—One hundred and twelve observations have been made of sun-transits, for the purpose of obtaining correct local time at the Observatory; 168 clock and chronometer comparisons have also been made.

Shelton's Clock, K.O., has been fitted up in the pendulum room, in a convenient position for observing, and a hearing tube led to the side the transit instrument, so that its errors may be determined

without the intervention of a chronometer. It has accordingly been made the standard timepiece of the Observatory, instead of Shelton R.S. No. 35 fixed in the computing room, which has hitherto been so employed.

A redetermination has been made of the value of the scale divisions of the level of the transit instrument.

The De La Rue Micrometer has been recently employed by Dr. Schuster in the measurement of his photographs of the comet observed during the eclipse of last May.

#### IV. EXPERIMENTAL WORK.

*Exposure of Thermometers.*—The observations, made on the lawn of the Observatory, with the view of determining the relative merits of different patterns of thermometer screens were discontinued in November, 1881, the Wild's screen and the De La Rue portable screen being dismantled and returned to the Meteorological Office. The Stevenson's screen was, however, purchased by the Committee, and remains standing *in situ* for the purpose of exhibition to visitors, and also in order that occasional thermometric experiments may be conducted in it.

An exhaustive discussion of the twenty-eight months' observations has been made by the Superintendent, and submitted to the Meteorological Council, at their request.

It may, however, be stated here, that the results show that the observations of air temperature in the thermograph screen, attached to the Observatory building, only differ in the daily mean from those in a freely exposed Stevenson screen 4 feet above the ground by  $0^{\circ}\cdot4$ , and from a similarly placed Wild's screen, 10 feet above the surface, by  $0^{\circ}\cdot1$ . The extreme variations observed have, however, occasionally reached several degrees.

*Glycerine Barometer.*—This instrument, although still standing in the Library, has not been read since December last. No results having as yet been published of the comparisons made for Mr. Jordan, the inventor, the Committee are unable to form any opinion of the scientific value of the instrument.

*Pendulum Experiments.*—The pendulum operations in progress at the date of the last Report were terminated in November, 1881, by Major Herschel, R.E., and the instruments he employed (see Appendix III, p. 24) were conveyed by him, first to the Royal Observatory, Greenwich, and subsequently to a house near Portland Place, London. Series of observations were made in both those places, and it is hoped that by this means data will have been obtained, which will serve to reduce to a common standard the determinations of gravity made by Kater, Airy, Sabine, and others.

On the conclusion of these experiments, Major Herschel conveyed the pendulums, clock, &c., to America, where, after making a series of observations at Washington, he handed them over to the officers of the United States' Coast Survey Department, in whose charge they now remain.

*Actinometry.*—At the request of the Meteorological Council, the actinometer devised by Professor Balfour Stewart, and described in the Report of the Committee on Solar Physics, 1880, Appendix H, has been obtained on loan from South Kensington, and erected on a suitable stand on the Observatory Lawn. Numerous observations of solar radiation have been made by it during the past summer, and also several comparative observations have been made with the Hodgkinson's Actinometers belonging to the Royal Society and to the India Office.

At the request and cost of the Indian Government, Sergeant Rowland, R.E., who has since proceeded to India with a view of observing, by means of Stewart's instrument, the solar intensity at Leh, for a period of three years, has received special instruction in the use of these actinometers.

The Committee have had under consideration the desirability of continuing the observations on the actinic power of daylight, which ceased in November, 1875, on account of the unsatisfactory performance of the first photometer constructed. The instrument being now made in the improved form suggested by Captain Abney, R.E., is not liable to the derangements experienced by that formerly employed.

*Rating of Chronometers and Watches.*—The Superintendent having, from time to time, been requested to certify as to the going of chronometers, has been in communication with the Directors of the Observatories at Bidston, Geneva, Neuchâtel, and Yale, where arrangements exist for the testing and rating of chronometers and superior watches.

The Committee, after receiving his reports upon the subject and also a favourable expression of opinion from the British Horological Institute, considered, however, that the funds at their disposal were insufficient for the present to allow them to extend their operations in this direction.

*Water-surface Temperature.*—At the request of Mr. C. Greaves, C.E., several series of observations were taken at frequent intervals during last summer of the temperature of the surface of the pond, a quarter of a mile distant from the Observatory. More recently a float has been moored in the centre carrying maximum and minimum thermometers immersed just below the water-line. This is hauled to the shore every morning at 9 A.M., and the temperatures recorded. The cost of the experiment is defrayed by Mr. Greaves.

*Nocturnal Radiation.*—Professor Tyndall having suggested the desirability of making a series of experiments on the fall of temperature near the surface of the ground at the time of sunset, a scheme was organised and apparatus devised by Mr. F. Galton, by means of which thermometers suspended at heights of 2 feet, 4 feet, and 20 feet could be rapidly read and their indications compared with those of a thermometer placed on swans' down on the surface of the ground.

The apparatus employed is conveyed into the open park to some distance from any building or trees, and the thermometers read at five-minute intervals from about half-an-hour before sunset until one or two hours after.

The cost of these experiments will be defrayed by a grant from the Meteorological Council.

#### V. VERIFICATION OF INSTRUMENTS.

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

- 1 Unifilar Magnetometer for Negretti and Zambra.
- 2 Unifilar Magnetometers for Elliott Brothers.
- 2 Dip Circles for Elliott Brothers.
- 1 Dip Circle for Casella.

There have also been purchased on commission and verified :—

- A Unifilar Magnetometer for the Toronto Observatory.
- A Unifilar Magnetometer for the Zi Ka Wei Observatory, China.
- 2 Dip Circles, with tripod stands, for Dr. Neumayer, Hamburg.
- 1 Dip Circle, with tripod stand, for Professor Brioschi, Naples.
- 1 „ „ for M. Snellen, Utrecht.
- 1 „ „ for Dr. Hann, Vienna.
- 1 „ „ for Dr. Wild, St. Petersburg.
- 1 „ „ for Professor Nordenskiold, Helsingfors.
- A Vertical Force Needle for Dr. Viegas, Coimbra.
- A Deflection Bar and Pair of Magnetizing Bars for Dr. Rijkvorsel, Rotterdam.
- A Pair of Dip-circle Agates for Senhor Capello, Lisbon.

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

Barometers, Standard .....	48
„ Marine and Station .....	105
Aneroids .....	30
	<hr/>
Total .....	183
	<hr/>

Thermometers, ordinary Meteorological .....	1518
,, Standard .....	166
,, Mountain .....	69
,, Clinical .....	5365
,, Solar radiation .....	143
Total.....	<u>7261</u>

Besides these, 27 Deep-sea Thermometers have been tested, 2 of which were subjected in the hydraulic press, without injury, to pressures exceeding three and a half tons on the square inch, and 73 Thermometers have been compared at the freezing-point of mercury making a total of 7361 for the year.

Duplicate copies of corrections have been supplied in 145 cases.

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

The following miscellaneous instruments have also been verified :—

Hydrometers .....	195
Anemometers .....	12
Rain Gauges .....	4
Theodolites .....	4
Sextants .....	36
Index Glasses for ditto, unmounted.....	2
Horizon   ,,       ,,       ,, .....	2
Prismatic Compasses .....	4

There are at present in the Observatory undergoing verification, 7 Barometers, 160 Thermometers, 10 Anemometers and 7 Sextants.

A Barograph and Thermograph have been examined, and had their scale values determined for the Government Astronomer, Adelaide, South Australia; and a Standard Barometer has also been compared for Professor Tacchini, of the Italian Meteorological Service.

A Redier Barograph, purchased by Mr. Dowson at the suggestion of the Superintendent, was put up at the Observatory, and its performance tested for a fortnight before being forwarded to him.

Dr. Siemens having placed one of his Electrical Thermometers at the disposal of the Meteorological Society for their observations of the temperature at the summit of Boston Church Tower, 270 feet high, this instrument was tested for a few days at the Observatory and found to work satisfactorily.

*Sextant-testing.*—A report upon the errors of Sextants, based upon the comparisons made at the Observatory since the introduction of the present system in 1865, has been submitted to Mr. Galton, at his request.

With a view of checking the values given by means of the Cooke Collimators, a series of angles subtended by various distant well-defined objects at a point at the Observatory, have been carefully determined.

The number of surveying instruments tested has satisfactorily increased during the past year.

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

*Standard Thermometers.*—Dr. Waldo, Director of the Thermometric Bureau of the Winchester Observatory, United States of America, has visited the Observatory, and selected several standard thermometers for use in that establishment in the verification of American thermometers, and for comparison with other instruments purchased of Continental makers.

Experiments have been made, but hitherto without complete success, for the direct comparison of chemical thermometers at high temperatures, an operation for which a demand has recently arisen amongst those who supply these instruments in commerce.

## VI. AID TO OBSERVATORIES.

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

Coimbra, Vienna, Valencia, Colaba, Batavia, and to the Meteorological Office.

Photographic Material, &c., has been also procured for, and transmitted to, the Coimbra Observatory.

*Anemograph Sheets* have been sent to the Coimbra Observatory, and *Blank Magnetic Observation Forms* have been supplied to

Mr. W. N. Shaw, Cavendish Laboratory ;  
 Professor Mohn, Christiania ;  
 Dr. Lodge, Liverpool Science College ;  
 Captain Dawson, R.A., Circumpolar Expedition ;  
 The Toronto Observatory ;

and to Messrs. Casella, Elliott Brothers, and Negretti and Zambra.

At the request of the Crown Agents for the Colonies, a copy of the apparatus used at Kew for measuring the areas of sun-spots has been procured for the Mauritius Observatory.

A Standard Barometer has also been obtained for the same Observatory.

A request has been received from the Director of the Lisbon Observatory for an Electrograph similar to that employed in the Observatory. The instrument is now in course of construction.

In accordance with instructions received from the Council of the Royal Society, ten volumes of miscellaneous registers, principally of magnetic observations made at Toronto during the years 1840-49, which were deposited in the Magnetic Office of General Sir E. Sabine, in the Observatory, have been returned to Canada, in order that they may be utilised by Mr. Carpmael, the Director of the Toronto Observatory.

Particulars as to the method employed for testing sextants at Kew have been forwarded at his request to Dr. G. Neumayer, Director of the Deutsche Seewarte, Hamburg.

#### VII. MISCELLANEOUS AND FINANCIAL.

*Tenure of the Observatory.*—In January last an inquiry was instituted by Her Majesty's Commissioners of Works and Public Buildings as to the conditions under which the President and Council of the Royal Society occupied the Observatory building, and it was discovered that through inadvertence no intimation had been made, in 1872, to their office of the transfer of the building from the British Association to the Royal Society.

Steps were immediately taken to rectify the omission, and in May Mr. Mitford, Secretary to the Office, informed the Secretary of the Royal Society that Her Majesty's sanction had been obtained for the continuance of the occupation of the Royal Observatory at Kew by the Royal Society upon the following conditions:—

1st. The occupation shall be only during the pleasure of Her Majesty and of the Department.

2nd. The internal repairs, painting, papering, and whitewashing shall be done by the tenants once at least in every seven years, the external works being executed by the Department.

3rd. No structural alteration shall be effected without the consent of the Board.

The above conditions were submitted by the President and Council to the Kew Committee, who have agreed to the terms laid down.

The Secretary of State for the Colonies having consulted the Committee as to the equipment of the new Observatory at Hong Kong, has been advised by them as to the instruments they would recommend as desirable for use at that Institution.

The Committee have also recommended the establishment at the Royal Observatory at the Cape of Good Hope of a set of self-recording magnetographs.

Complete specimen sets of curves from the various photographic and autographic instruments in use at the Observatory have been prepared and forwarded to the exhibitions of the Society of Arts, London, and the Royal Cornwall Polytechnic Society, Falmouth.

A number of anemometers and other instruments of interest were

also exhibited at the Anemometrical Exhibition of the Meteorological Society, held in the rooms of the Institution of Civil Engineers in March.

By the consent of the Committee the Superintendent, in conjunction with Mr. Baker, submitted the following paper to the Meteorological Society, which has been published in the Quarterly Journal (Vol. VIII, p. 198):—

Barometric gradients in connexion with wind velocity and direction at the Kew Observatory.

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

26 English Scientific Societies and Institutions, and

91 Foreign and Colonial Scientific Societies and Institutions.

*Observatory and Grounds.*—The buildings and grounds have been kept in order throughout the year, and portions of the exterior as well as the interior have been painted by Her Majesty's Commissioners of Works, &c. They have also fitted stoves in the Superintendent's room and Library, and re-covered with sheet zinc the roof of the sun-room.

The footpath and entrance to the Old Deer Park still remain in an unsatisfactory condition, no action having been taken by Her Majesty's Commissioners of Woods and Forests in the matter.

#### PERSONAL ESTABLISHMENT.

No changes having taken place during the year,

The staff employed now is as follows:—

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

T. W. Baker, First Assistant.

J. Foster, Verification Department.

H. McLaughlin, Librarian and Accountant.

F. G. Figg, Magnetic Observer.

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

T. Gunter } Verification Department.

C. Taylor }

W. Boxall, Photography.

E. Dagwell, Office duties.

J. Dawson, Messenger and Care-taker.

With the view of exhibiting the financial position of the Observatory during the first decade of its operations under the present Committee, a summarised statement is appended of the receipts and disbursements during the ten years 1871-1881. (Appendix IV.)

An appendix is also given showing what instruments belonging to the Observatory are out of the custody of the Superintendent on loan, at the present time.

Abstract. Kew Observatory Receipts and Payments Account from November 2, 1881, to November 4, 1882.

Dr. RECEIPTS.

To Balance from 1880-81 .....	£	s. d.
Royal Society (Gassiot Trust) .....	414	1 8
Meteorological Office .....	486	14 6
Meteorological Office, for Researches, Postages, &c. ....	400	0 0
Verification Fees, Meteorological Office .....	35	11 7
" " Observatories and Institutions .....	£97	8 0
" " Instrument Makers and others .....	53	2 0
Payment for Instruments on Commission .....	471	7 0
Sale of Waxed Paper .....	621	17 0
" Photographic Residues .....	516	10 11
" Standard Thermometers .....	34	5 0
" Forms, &c. ....	4	7 11
Payments for Copying Registers .....	26	15 0
Mr. Jordan, for Glycerine Barometer Experiments .....	24	7 3
Mr. Greaves, for Water Surface Temperature Observations..	65	2 1
	116	4 4
	1	9 0
	7	17 10
	9	6 10

PAYMENTS.

By Salaries .....	£	s. d.
Extra Payments .....	£1034	10 10
Fuel and Gas .....	156	7 4
Furniture and Fittings .....	1190	18 2
Chandlery, &c. ....	77	10 4
Painting and Repairs .....	16	15 3
Rent and Maintenance of Enclosure and Path .....	10	6 9
Printing and Stationery (General) .....	26	4 11
" (Verification Department) .....	25	14 1
Postages .....	30	15 6
Library .....	24	12 6
Messenger and Housekeeper .....	16	3 1
Advertisements .....	19	0 7
Portage and Contingencies .....	62	8 0
Purchase of Chemicals and Materials .....	3	5 4
" Tubes for Standard Thermometers .....	19	13 10
" Anemograph Sheets .....	17	8 0
Verification Department Expenses (Ice, Carbonic-Acid Gas, &c.) ..	1	0 10
Repair of Instruments, and Purchase of New .....	1	8 4
Carpenter's Work and Sundries .....	15	1 3
Postages and Payments on behalf of Meteorological Office .....	31	15 8
Instruments purchased on Commission .....	5	15 7
Purchase of Waxed Paper, Packing ditto, &c. ....	72	9 8
Payments on behalf of Experimental Work .....	33	4 0
Balance—Bank of England .....	449	5 7
London and County Bank .....	46	11 4
Cash in hand .....	19	5 10
	415	11 9
	70	0 0
	19	3 3
	504	15 0
	£2648	19 9

November 15, 1882. Examined and compared with the Vouchers, and found correct.

(Signed) GEO. HENRY RICHARDS, Auditor.

ASSETS.

By Balance as per Statement .....	£	s. d.
Meteorological Office, Allowances and Sundries .....	504	15 0
Commissions .....	38	6 4
Waxed Paper .....	35	0 0
Blank Forms .....	43	0 0
Verification Fees due .....	7	17 10
Standard Thermometers .....	45	10 5
Experimental and Miscellaneous .....	83	6 6
	20	10 0
	£178	6 1

LIABILITIES.

To Gas, Fuel, and House Account .....	£	s. d.
Apparatus, Chemicals, &c. ....	11	12 3
Commissions .....	6	3 9
Balance .....	34	15 0
	725	15 1

November 17, 1882.

(Signed) G. M. WHIPPLE.

£778 6 1

## APPENDIX I.

*Magnetic Observations made at the Kew Observatory, Lat. 51° 28' 6" N. Long. 0<sup>b</sup> 1<sup>m</sup> 15<sup>s</sup>.1 W., for the year October 1881 to September 1882.*

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

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

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

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

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

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

The value of  $\log \pi^2 K$  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 -0.00109.

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

The observations have all been made and reduced by Mr. F. G. Figg.

Observations of Deflection for Absolute Measure of Horizontal Force.

Month.	G. M. T.	Distances of Centres of Magnets.	Temperature.	Observed Deflection.	Log $\frac{m}{X}$ Mean.
1881.	d. h. m.	foot.			
October.....	26 12 30 P.M.	1.0	51.5	15 28 52	
		1.3	....	6 58 55	
	2 35 "	1.0	51.7	15 27 12	9.12639
		1.3	....	6 58 3	
November.....	25 12 37 P.M.	1.0	55.6	15 27 0	
		1.3	....	6 58 5	
	2 30 "	1.0	54.7	15 26 46	9.12613
		1.3	....	6 57 58	
December.....	23 12 32 P.M.	1.0	32.1	15 29 59	
		1.3	....	6 59 26	
	2 19 "	1.0	34.9	15 29 15	9.12600
		1.3	....	6 59 14	
1882.					
January.....	26 12 30 P.M.	1.0	35.0	15 29 31	
		1.3	....	6 59 19	
	2 32 "	1.0	35.9	15 28 40	9.12591
		1.3	....	6 58 57	
February.....	28 12 27 P.M.	1.0	49.1	15 26 30	
		1.3	....	6 57 51	
	2 40 "	1.0	51.5	15 25 54	9.12548
		1.3	....	6 57 33	
March.....	24 12 34 P.M.	1.0	57.7	15 27 0	
		1.3	....	6 58 3	
	2 56 "	1.0	58.2	15 25 41	9.12608
		1.3	....	6 57 31	
April.....	25 12 43 P.M.	1.0	57.2	15 27 17	
		1.3	....	6 58 26	
	2 50 "	1.0	54.2	15 26 43	9.12632
		1.3	....	6 58 7	
May.....	26 12 34 P.M.	1.0	68.5	15 23 51	
		1.3	....	6 56 51	
	2 51 "	1.0	66.5	15 23 23	9.12558
		1.3	....	6 56 40	
June.....	27 12 34 P.M.	1.0	71.7	15 25 18	
		1.3	....	6 57 28	
	2 35 "	1.0	73.8	15 23 35	9.12627
		1.3	....	6 56 31	
July.....	26 12 29 P.M.	1.0	67.7	15 24 6	
		1.3	....	6 57 0	
	2 35 "	1.0	69.6	15 22 57	9.12560
		1.3	....	6 56 20	
August.....	30 12 48 P.M.	1.0	66.8	15 23 50	
		1.3	....	6 56 48	
	2 51 "	1.0	68.7	15 22 41	9.12539
		1.3	....	6 56 12	
September.....	27 12 31 P.M.	1.0	59.6	15 25 22	
		1.3	....	6 57 24	
	2 32 "	1.0	57.8	15 24 30	9.12553
		1.3	....	6 57 5	

## Vibration Observations for Absolute Measure of Horizontal Force.

Month.	G. M. T.	Temperature.	Time of one Vibration.*	Log $mX$ . Mean.	Value of $m$ .†
1881.	d. h. m.		secs.		
October.....	26 11 54 A.M.	50·8	4·6483		
	3 13 P.M.	51·9	4·6465	0·30915	0·52212
November.....	25 11 51 A.M.	54·3	4·6510		
	3 4 P.M.	54·1	4·6502	0·30883	0·52177
December.....	23 11 53 A.M.	30·2	4·6438		
	2 50 P.M.	36·4	4·6448	0·30876	0·52165
1882.					
January.....	26 11 50 A.M.	33·1	4·6427		
	3 3 P.M.	36·0	4·6425	0·30918	0·52184
February.....	28 11 50 A.M.	47·9	4·6468		
	3 11 P.M.	51·9	4·6499	0·30903	0·52149
March.....	24 11 55 A.M.	56·3	4·6536		
	3 34 P.M.	56·6	4·6495	0·30880	0·52172
April.....	25 12 4 P.M.	57·6	4·6540		
	3 36 P.M.	52·7	4·6485	0·30877	0·52184
May.....	26 11 59 A.M.	68·2	4·6557		
	3 27 P.M.	68·3	4·6548	0·30885	0·52145
June.....	27 11 48 A.M.	71·5	4·6579		
	3 13 P.M.	74·8	4·6578	0·30866	0·52176
July.....	26 11 54 A.M.	67·4	4·6535		
	3 12 P.M.	70·1	4·6535	0·30918	0·52166
August.....	30 12 14 P.M.	65·5	4·6551		
	3 24 P.M.	69·6	4·6526	0·30904	0·52145
September.....	27 11 49 A.M.	59·7	4·6550		
	3 19 P.M.	60·1	4·6513	0·30870	0·52133

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

†  $m$  = magnetic moment of vibrating magnet.

Dip Observations.

Month.	G. M. T.	Needle.	Dip.	Month.	G. M. T.	Needle.	Dip.
			North.				North.
1881.	d. h. m.	No.		1882.	d. h. m.	No.	
Oct.	28 3 10 P.M.	1	67 41'31	April	26 3 32 P.M.	1	67 40'56
	3 10 "	2	41'31		3 32 "	2	40'40
	31 3 15 "	1	42'43		27 3 43 "	1	40'81
	3 15 "	2	42'62		3 43 "	2	41'50
	Mean..	....	67 41'92		Mean..	....	67 40'82
Nov.	29 3 7 P.M.	1	67 43'12	May	25 3 27 P.M.	1	67 39'43
	3 7 "	2	43'34		3 25 "	2	40'18
	30 2 59 "	1	42'43		30 3 20 "	1	41'31
	2 58 "	2	42'99		3 19 "	2	41'43
	Mean..	....	67 42'97		Mean..	....	67 40'59
Dec.	29 3 6 P.M.	1	67 41'25	June	26 3 13 P.M.	1	67 42'65
	3 6 "	2	41'81		3 14 "	2	42'56
	30 3 11 "	1	41'93		29 3 6 "	1	41'12
	3 13 "	2	41'87		3 3 "	2	40'78
	Mean..	....	67 41'71		Mean..	....	67 41'78
1882.	30 3 4 P.M.	1	67 41'50	July	28 3 3 P.M.	1	67 39'71
Jan.	3 4 "	2	41'37		3 3 "	2	38'31
	31 3 16 "	1	41'62		31 3 5 "	1	39'81
	3 15 "	2	41'25		3 5 "	2	39'56
	Mean..	....	67 41'43		Mean..	....	67 39'35
Feb.	21 3 10 P.M.	1	67 41'25	Aug.	26 3 23 P.M.	1	67 41'34
	3 11 "	2	42'12		3 23 "	2	39'96
	23 3 20 "	1	40'68		28 3 49 "	1	41'37
	3 19 "	2	41'06		3 50 "	2	39'74
	Mean..	...	67 41'28		Mean..	....	67 40'60
Mar.	28 3 11 P.M.	1	67 40'87	Sept.	28 3 13 P.M.	1	67 40'24
	3 10 "	2	41'31		3 14 "	2	39'68
	29 3 14 "	1	41'31		29 3 14 "	1	40'81
	3 15 "	2	40'62		3 13 "	2	40'12
	Mean..	....	67 41'03		Mean..	....	67 40'21



APPENDIX II.  
 Meteorological Observations.—Table I.  
 Kew Observatory.

Longitude 0<sup>h</sup> 1<sup>m</sup> 15<sup>s</sup>.1 W. Latitude 51° 28' 6" N. Height above sea-level = 34 feet.  
 Mean Monthly results from the continuous Records for the Twelve Months ending September 30th, 1882.

Months.	Thermometer.*			Barometer.†				Means of vapour-tension. inch.	
	Extreme maximum.		Extreme minimum.		Extreme maximum.		Extreme minimum.		
	Date.	Ther.	Date.	Ther.	Date.	Bar.	Date.		Bar.
1881. October.....	45.4	61.7	d. h. 17 7 A.M.	25.4	inches. 30.017	d. h. 7 11 A.M.	30.516	inches. 29.079	
November.....	49.0	61.5	5 noon	29.3	29.962	13 10 P.M.	30.449	28.889	
December.....	39.8	53.5	18 5 A.M.	23.7	30.008	27 10 A.M.	30.655	28.802	
1882. January.....	40.6	52.8	6 1 P.M.	23.4	30.371	18 10 "	30.983	29.213	
February.....	42.5	55.1	26 noon	23.2	30.245	20 { 8 " } { 9 " }	30.857	28.924	
March.....	45.9	61.7	18 { 3 P.M. } { 4 " }	30.6	30.021	16 8 "	30.661	28.807	
April.....	48.1	62.7	20 { 3 " } { 21 1 " }	33.6	29.785	8 8 "	30.367	28.996	
May.....	54.3	71.9	22 2 "	36.8	30.055	17 8 "	30.504	29.320	
June.....	56.7	72.2	27 5 "	41.3	29.916	1 1 "	30.351	29.446	
July.....	59.9	75.5	3 4 "	42.8†	29.876	27 7 "	30.484	29.321	
August.....	60.1	79.8	12 2 "	45.0	29.924	4 { 9 " } { 10 "	30.299	29.236	
September.....	54.5	68.0	3 3 "	36.5§	29.868	8 10 "	30.396	29.229	
Means.....	49.7	..	.....	..	30.004	.....	..	..	

The above Table is extracted from the Quarterly Weather Report of the Meteorological Office, by permission of the Meteorological Council, except the temperatures and vapour-tensions for July, August, and September.

\* The thermometers are 10 feet above the ground. † Readings reduced to sea-level.  
 ‡ Corrected reading of minimum thermometer, obtained from weather sheets. § Approximate reading.

## 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 blew							
		Total.	Maxi-mum.	Rain.	Snow.	Hail.	Thun-der-storms.	Clear sky.	Over-cast sky.	N.	N.E.	E.	S.E.	S.	S.W.	W.	N.W.
1881.		in.	in.														
October ..	6·4	2·395	0·900	17	..	1	..	7	13	7	6	7	1	1	4	3	2
November	7·4	2·495	0·455	21	..	..	..	1	15	1	..	4	2	6	17	1	..
December	6·9	2·505	0·640	20	4	..	..	3	17	3	2	..	1	7	12	4	1
1882.																	
January ..	8·1	1·260	0·415	14	..	..	..	1	22	1	1	1	3	6	14	5	1
February .	8·1	1·515	0·385	13	..	..	..	2	19	2	..	6	3	4	5	5	3
March ...	5·8	1·045	0·570	11	3	4	..	7	11	4	..	4	2	..	16	7	2
April ....	6·7	2·620	0·750	18	..	..	..	4	14	3	4	..	2	..	7	3	2
May .....	6·0	1·240	0·340	14	..	..	1	5	10	2	8	4	1	6	7	2	1
June .....	8·0	2·030	0·330	18	..	..	1	..	21	..	2	2	1	4	8	8	5
July .....	7·3	2·205	0·485	20	..	1	1	..	12	..	2	..	2	5	17	1	3
August ..	7·1	1·150	0·305	13	..	..	..	1	14	1	2	3	..	3	8	9	5
September	6·7	2·380	0·810	15	..	..	1	1	9	1	4	4	3	2	5	3	2
Totals..		22·840		194	7	6	4	32	177	31	31	35	21	49	120	51	27

\* Measured daily at 10 A.M. by gauge 1·75 feet above surface of ground. † Derived from observations made at 10 A.M., noon, 2, 4, and 10 P.M.

‡ As registered by the anemograph.

Meteorological Observations.—Table III.

Kew Observatory.

Months.	Bright Sunshine.			Maximum temperature in sun's rays.			Minimum temperature on the ground.			Horizontal movement of the Air.*		
	Total number of hours.	Number of hours Sun was above the horizon.	Percentage of possible sunshine.	Mean.	Highest.	Date.	Mean.	Lowest.	Date.	Average daily Velocity.	Greatest Movement in a day.	Date.
1881.												
October . . . . .	h. m. 110 25	h. m. 328 26	34	deg. 89·7	deg. 109·2	7	deg. 34·1	deg. 19·3	31	miles. 280	miles. 751	14
November . . . . .	62 55	264 8	24	82·1	102·9	19	38·1	25·1	2	321	738	27
December . . . . .	42 40	242 55	17	62·4	83·2	17	29·5	19·5	24	232	600	20
1882.												
January . . . . .	31 35	259 7	12	61·3	84·7	9	31·8	20·4	25	218	559'	2
February . . . . .	43 10	277 46	12	74·7	99·0	12	32·8	17·3	2	233	601	26
March . . . . .	155 20	366 47	42	101·4	120·0	30	33·6	20·7	4	279	594	26
April . . . . .	165 35	414 33	40	110·5	121·8	20	34·9	26·0	11	337	616	29
May . . . . .	258 30	482 4	54	122·2	134·2	29	38·8	27·9	17	260	549	20
June . . . . .	142 0	494 22	29	120·1	133·3	20	44·7	33·7	16	271	543	5
July . . . . .	202 50	497 00	41	127·1	139·0	21	49·2	40·3	1	256	463	7
August . . . . .	147 10	449 31	33	120·4	138·7	2	47·5	37·3	9	221	494	23
September . . . . .	124 35	377 40	33	110·0	126·5	3	40·8	32·5	16	183	568	2

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

## APPENDIX III.

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

To whom lent.	Articles.	When lent.
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, Kew Dip-Circle, Portable Unifilar, and Hodgkinson's Actinometer.	1876
Dr. T. Thorpe, F.R.S.	Three Open Scale Standard Thermometers, Nos. 561, 562, and 563.	1879
Major Herschel, R.E.	Invariable Pendulums, Nos. 1821, 4, and 11, Shelton Clock, R.S. No. 34. Stands, Telescopes, and Accessories.	1881
Mr. R. W. Munro ..	Standard Straight-edge .....	1881
Capt. Dawson, R.A. .	Unifilar Magnetometer by Jones, No. 102, complete, with three Magnets and Deflection Bar. Dip-Circle, by Barrow, one Pair of Needles, and Magnetizing Bars. Two Bifilar Magnetometers. One Balance Magnetometer. Two Declinometers. Two Tripod Stands.	1882
Rev. S. J. Perry, F.R.S.	Unifilar Magnetometer, No. 101, complete . . . Dip-Circle by Barrow, No. 24, complete, with four Needles, and a Pair of Magnetizing Bars.	1882
Mr. Casella.....	Dip-Circle, by Barrow, with two Needles .....	1882
Dr. E. Ristori .....	Small Theodolite, by Robinson, No. C. 41 . . . . Old mahogany Declinometer, with Mirror Magnet, N.L. Tripod Stand.	1882
Major-General Sir H. Lefroy, R.A.	Two parcels Magnetical and Meteorological MSS. from the Sabine Magnetic Office.	1882

APPENDIX IV.

Working Receipts and Expenses of the Kew Observatory for the Ten Years 1872 to 1881 inclusive.

	1872.	1873.	1874.	1875.	1876.	1877.	1878.	1879.	1880.	1881.
<b>RECEIPTS.</b>										
British Association .....	£ 240	£ 608	£ 499	£ 500	£ 499	£ 498	£ 496	£ 496	£ 497	£ 497
Gassiot Trust .....	480	614	650	650	650	650	650	650	650	650
Meteorological Committee.....	104	349	270	456	419	456	585	470	539	596
Verification and other Fees .....	8	2	63	36	15	24	5	15	18	17
Sales, &c. ....	£ 1,446	£ 1,608	£ 1,482	£ 1,642	£ 1,583	£ 1,399	£ 1,486	£ 1,391	£ 1,454	£ 1,510
Totals.....	9	9	11	13	12	11	11	13	13	11
<b>PAYMENTS.</b>										
Salaries and Extra Work .....	£ 985	£ 863	£ 1,006	£ 1,063	£ 1,101	£ 924	£ 959	£ 1,094	£ 1,092	£ 1,071
House .....	182	108	143	162	173	133	140	148	150	151
Printing, Stationery, and Contingencies .....	117	140	129	110	158	134	160	170	159	145
Instruments, Apparatus, &c.....	37	74	168	229	113	168	144	67	94	80
Experimental.....	...	4	60	22	38	15	12	13	95	3
Totals.....	£ 1,241	£ 1,189	£ 1,506	£ 1,586	£ 1,583	£ 1,374	£ 1,415	£ 1,492	£ 1,890	£ 1,450
Cash Balances .....	£ 85	£ 522	£ 549	£ 586	£ 501	£ 501	£ 621	£ 512	£ 376	£ 414
<b>Extraordinary Payments met by Balances of previous Years.</b>										
Salaries—Beekley, Mechanician .....	£ 54	£ 10	£ 10	£ 10	£ 10	£ 10	£ 10	£ 10	£ 10	£ 10
Tuition.....	...	18	31	31	31	31	31	31	31	31
Arrears of Work and Checking .....	...	...	29	...	49	...	...	...	...	...
Honoraria and Gratuities .....	...	...	...	...	100	...	...	70	...	13
House—Furniture.....	...	...	...	28	8	12	...	...	...	10
Illness .....	...	...	...	...	...	...	...	...	...	20
Contingencies—Advertisements.....	...	...	...	...	...	...	...	17	...	5
Instrumental { Magnetographs	...	...	83	64	...	4	...	...	35	...
Repairs, &c. { Ther. Tester (Galton's)	...	...	...	...	...	71	...	...	...	...
Sundries .....	...	...	...	...	...	16	...	...	...	...
Totals .....	£ 54	£ 28	£ 153	£ 133	£ 214	£ 117	£ 45	£ 87	£ 125	£ 61
					Pendulums, Stand. Bar. Hyd. Press.				Sun-spots.	Cloud cam.
					16	14	45	...	90	13

Errata

Table II. p. 22. Rainfall Totals.

January -	For 1.260	read 1.280 in.
March -	" 1.045	" - " 1.035 "
April .	" 2.620	" - " 2.660 "
Total -	" 22.840	" - " 22.890 "