REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1912 *June* 1.

GREENWICH OBSERVATIONS, 1911.

THE BOARD OF VISITORS.

The President of the Royal Society	Sir A. Geikie.
Nominated as Fellows of the Royal Society	Prof. W. G. Adams. Prof. Sir J. Larmor. Prof. Sir J. Norman Lockyer. Lord Rayleigh. Sir A. W. Rücker. Prof. A. Schuster.
Nominated as Fellows of the Royal Astronomical Society.	Capt. Sir W. de W. Abney. Prof. Sir R. S. Ball. Prof. R. B. Clifton. Dr. J. W. L. Glaisher. Mr. E. B. Knobel. Sir David Gill.
Savilian Professor of Astronomy at Oxford	Prof. H. H. Turner.
Plumian Professor of Astronomy at Cambridge	Prof. Sir G. H. Darwin.
Hydrographer of the Navy	Rear-Admiral H. E. P. Cust.
Secretary	Mr. W. D. Barber.

REPORT OF THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1912 *June* 1.

The Report here presented refers to the year from 1911 May 11 to 1912 May 10, and exhibits the state of the Observatory on the last-named day.

I.—Buildings and Grounds, Movable Property, and Library:—

The alterations in the Astronomer Royal's official residence were completed in September. They include the provision of three new rooms under the rooms already existing on the West front, the installation of a heating apparatus, the extension of the electric light and a number of minor alterations.

The same system of heating was applied to the Octagon room. Electric light was substituted for gas, and the room was repainted. The Octagon room is now used as a reading room in which the current Astronomical literature may be referred to.

The strong room to the west of the Lower Computing Room was altered between July and November to make it serve as a clock room. A second wall was built separated from the outside walls to the West and South by an air space, and double doors were provided. The necessary extensions and alterations of the electric cables were carried out by the Engineering Department of the General Post Office during the latter part of October and early part of November.

As the heating arrangements of the chronometer rooms under the Great Equatorial by a stove and of the record room by a hot-air supply were unsatisfactory and had become obsolete, a system of hot-water pipes and radiators was installed.

E (12)13110 Wt 38062 1000 5/12 E & S

At the same time the spiral staircase in the record room was removed, and the upper room divided from the lower, a new entrance being made from one of the rooms of the old library. These alterations, which make a substantial addition to the room available for shelves, were completed in March.

The observing hut of the Zenith Telescope of the late Mr. Bryan Cookson, kindly presented by the Cambridge Observatory, was brought from Cambridge and erected in the front Court by the side of the Longitude Pavilion in the first week in August.

The internal painting of the new Observatory was commenced in November and is completed with the exception of the dome.

Four boxes in the Observatory grounds and four in the grounds of the Magnetic Pavilion were fixed near the hydrants during April, to hold the fire hose.

The principal movable instruments are thus distributed:—

At Greenwich—

Transits B, C, D, E, and the transit with axis view.

Altazimuths D and E.

Equatorials (6-inch).—Cooke No. 2, Simms No. 1, Hodgson, and Corbett. (The telescopes of the two last-named are mounted respectively on the Thompson and 28-inch Equatorials.)

Photoheliographs:

No. 1. Equatorial section of mounting and driving clock only.

No. 2. Complete—mounted in dome of Old Altazimuth.

No. 3. Complete.

No. 5. Complete except the object glass. (There is no camera for an 8-inch image of the Sun.)

Detached Telescopes (on tripod stands).—One 4-inch (Simms No. 1), two 4-inch (R.O. Nos. 1, mounted as finder on Thompson Equatorial, and 2), one 3½-inch (R.O. No. 3).

One Hilger Chronograph.

A single prism Spectroscope.

On loan—

Transit A, at the Cape Observatory.

Altazimuths.—A, at the Imperial College of Science and Technology, South Kensington; B, at the Cape Observatory.

Equatorials.—Lee (6-inch), at the Hong Kong Observatory; Simms No. 2 (6-inch), at the Imperial College of Science and Technology.

Detached Telescope, 4-inch, Simms No. 2, lent to Australasian Antarctic Expedition, 1911.

Photoheliographs:

No. 1. At the Cape Observatory with the exception of the parts mentioned above.

No. 4. Complete at Kodaikanal Observatory.

No. 5. Object glass on loan to Professor Newall, Cambridge.

One Hilger Chronograph on loan to Professor Turner, Oxford Observatory.

Clocks.—Dent No. 1916 and Dent No. 2013, at the Cape Observatory; Dent No. 2011, at the Kew Observatory; Dent No. 2010, at Devonport; Arnold 2, at the University Observatory, Oxford.

Anemometer.—Whewell's Anemometer, formerly mounted above the roof of the Octagon Room of the Royal Observatory, lent for exhibition at the Victoria and Albert Museum, South Kensington.

On loan to the Royal Observatory—

The Cookson Floating Zenith Telescope from the Cambridge Observatory for a period of seven years from July 1911.

A 6-inch photographic lens of 27 inches focus from Mr. Franklin Adams; and also

A machine used in the enumeration of the stars in the survey of the sky made with Mr. Franklin-Adams' 12-inch lens.

A 16-inch and a 12-inch cœlostat from the Royal Astronomical Society for use at the forthcoming total Eclipse of the Sun on October 10, 1912.

A 6-inch speculum mirror from the Stonyhurst College Observatory for use at the same eclipse.

The Parliamentary Copy No. 5 of the Imperial Standard Yard and the Parliamentary Copy No. 3 of the Standard Pound were removed on September 21 by Officers of the Standards Department of the Board of Trade for decennial reverification, and are at the Standards Department at the date of this report. The Public Standards of Length fixed to the outside wall of the Observatory, repaired and adjusted last year by that Department, are reported to have no sensible error at the normal temperature of 62° Fahrenheit.

The annual examination of the Library has been made as usual, the books on the shelves being compared with the catalogue. Three books are missing from the shelves and cannot be accounted for at present. The two books reported missing last year have since been found.

The Observatory is indebted to Mrs. Story-Maskelyne for a present of a number of Manuscripts by Nevile Maskelyne, as well as of 79 books and pamphlets, dating from 1735 to 1811, which were formerly in his possession.

A new Inventory of the Instruments and Scientific apparatus belonging to the Observatory has been completed during the year.

II.—Astronomical Observations :—

Transit Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. Good progress has been made with the observation (begun in 1906) of the stars between the limits of + 24° and + 32° of North declination. An unusually large number of observations were made during the year, thanks to the fine summer. In consequence, the part of the catalogue which depends on observations made in the summer is very well forward, but the part from 2^h to 6^h of right ascension is somewhat under-observed.

The number of observations with the Transit Circle from 1910 May 11 to 1911 May 10 is as follows:—

Transits	13,721
Determinations of Collimation and Level error	293 and 626
Circle observations	13,664
Determinations of nadir point and reflexion observations of stars (included in the number of circle observations)	596 and 333

The transits are completely reduced (so as to exhibit Mean R.A. 1910·0) to 1912 April 13, and Apparent R.A. is formed to April 28. The circle observations are completely reduced to 1912 April 13.

The corrections for variation of latitude for 1911 have been received from Professor Albrecht, and the Ecliptic and Colatitude investigations are in progress.

The value of the colatitude determined from observations in 1910 and using Pulkowa refractions is 38° 31′ 21″·83. The correction to the tabular value of the obliquity of the ecliptic obtained from the observations of the Sun is + 0″·07. The mean of the observed distances from the pole to the ecliptic is too small by + 0″·16. The apparent correction to the right ascensions of the clock stars, for which Newcomb's Equinox is adopted, is − ˢ·037.

For the year 1911, the discordance between the zenith point determined by nadir observations and by reflexion observations of stars is − 0″·22. The values from 1892 to 1910 range from − 0″·16 to − 0″·42.

Observations of level and nadir have been made when practicable three or more times a day. The following are the mean values of the diurnal changes of level and nadir during the year, observations within three hours of noon, 6 p.m., midnight, and 6 a.m., respectively, being grouped together:—

	Diurnal Changes of Level.				Diurnal Changes of Nadir.			
	Noon.	6 p.m.	Midnight.	6 a.m.	Noon.	6 p.m.	Midnight.	6 a.m.
1911	+ 0″·29	0″·00	+ 0″·25	″...	+ 0″·17	0″·00	+ 0″·05	″...
1897–1905	+ 0·25	0·00	+ 0·21	+ 0·37	+ 0·14	0·00	+ 0·12	+ 0·11

The correction for R – D discordance from the observations in 1911 is $+ 0''\cdot052 + 0''\cdot496$ *sin* Z.D, agreeing well with the results of recent years.

An investigation by Mr. Thackeray, published in the *Monthly Notices of the Royal Astronomical Society*, Vol. LXXII., p. 178, shows that different observers obtain different values for the R – D discordance, and that the changes from year to year are not wholly due to changes in the instrument, but arise partly from changes in the observing staff.

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's empirical corrections) derived from observations of the limbs and of Mösting A with the transit-circle and altazimuth is for 1910 $- 0^s\cdot537$ in R.A. and $+ 0''\cdot32$ in declination. The corresponding mean errors in longitude and latitude are $- 7''\cdot85$ and $- 0''\cdot05$.

The mean error of the Moon's right ascension for 1911 derived from 124 observations with the transit-circle is $- 0^s\cdot603$.

Altazimuth.—This instrument has been used as a reversible transit-circle during the second and third quarters of each lunation for observations of the Sun, Moon, planets, and fundamental stars. In the first and last quarters of each lunation extra-meridian observations of the Moon are made whenever they can be obtained with the Moon at an altitude of not less than 15° and the Sun below the horizon.

The following observations have been made during the year :—

Meridian transits	1,955
Meridian zenith distances	2,164
Extra-meridian observations	145
Determinations of Collimation and level error	195 and 431
Determinations of Nadir point	418
Reflexion observations of stars	257

The altazimuth observations are completely reduced to the end of 1911. The meridian transits and zenith distances are reduced to 1912 March 31.

The R – D discordance has been investigated separately for each two months of the year, reversal of the instrument taking place at that interval. The direct observations in the four positions of the instrument have also been compared with Newcomb's Fundamental Catalogue.

As mentioned in the last report there is a large discordance between the North Polar distances given in reversed positions of the instrument. This

discordance was not found to be altered to any great extent when the object glass and its cell were turned through 90°, as would have been expected if the fault had been in the compensating arms and the spring which holds the glass. Attention was next directed to the eye end. This was removed and all springs and slides thoroughly cleaned on May 14. The discordance changed sign and the slides were again removed on June 21. It was then found that some of the screws had been placed in different holes. These were placed in their former positions and the discordance returned.

It seems that part of the discordance at any rate is to be attributed to faults in the eye end of the instrument. A new one is being made by Messrs. Troughton and Simms in which the micrometer-screws will be in the same plane as the wires. At the same time a travelling-wire micrometer will be introduced for the observation of right ascensions, and a printing micrometer for the zenith distances.

The mean error in right ascension of the Moon's tabular place for 1911 is $-0^s\cdot61$ from meridian observations and $-0^s\cdot49$ from extra-meridian observations of the limb and $-0^s\cdot60$ from meridian observations of Mösting A.

The following table shows the number of days on which observations of the Moon were obtained with the transit-circle and altazimuth, respectively, during the year 1911:—

Time of Moon's Meridian Passage.	Transit Circle.		Altazimuth.		
			Meridian.		Extra Meridian.
	Limb.	Mösting A.	Limb.	Mösting A.	Limb.
h. h.					
1–3 G.M.T. - - - -	0		0		3
3–6 „ - - - -	15		6		9
6–9 „ - - - -	27	18	21	15	6
9–12 „ - - - -	29	27	25	21	0
12–15 „ - - - -	29	22	26	17	0
15–18 „ - - - -	16	13	10	8	2
18–21 „ - - - -	8	0	1		9
21–23 „ - - - -	0		0		2

The total number of observations of the Moon is 124 with the transit-circle and 120 with the altazimuth, viz.:—89 in the meridian and 31 extra-meridian. Taking both instruments, observations of the Moon have been obtained on the unusually large number of 141 days during the year.

The work on the Ten-Year Catalogue of stars observed with the altazimuth in the meridian in the years 1899 to 1908 is completed, and will be sent to the printers as soon as some discussions, which will appear in the Introduction, are completed.

Reflex Zenith Tube.—Between 1911 May 11 and August 24, 641 double observations and 5 single observations were obtained. From August 24 the Reflex Zenith Tube was superseded.

From the discussion of the observations 1906–1909 referred to in the last report, it appeared that the present instrument could not give the accuracy that is now demanded in latitude-work, and that the time had come when a new instrument was required. There were two alternatives open, either the construction of a much larger Reflex Zenith tube with some modifications in the design, or the use of a different pattern of Zenith-Telescope. Circumstances rendered the latter alternative advisable; for at this time the late Mr. Cookson's Floating Zenith-Telescope was not in use, and the Cambridge Observatory Syndicate kindly consented to lend it. It was felt that this unique instrument, designed and constructed with much ingenuity, deserved a very thorough trial, and the loan was gladly accepted.

Cookson Floating Zenith-Telescope.—This instrument, which was designed by the late Mr. Bryan Cookson, was presented by Mrs. Cookson to the Cambridge Observatory, and has now been lent to the Royal Observatory for a period of seven years. In principle it is similar to an ordinary Zenith-Telescope, the distinctive feature being that the rotation about a truly vertical axis is secured by carrying the Y's of the telescope on an iron annulus, which floats in an annular trough of mercury. The object glass has an aperture of $6\frac{1}{2}$ inches and a focal length of 65·4 inches. Observations are made photographically.

Mr. Cookson had made trial of the instrument in a research on the aberration-constant and variation of latitude, extending over two years. During this time

it was used for observing stars transiting near the zenith, a reversal of the instrument being made on each star; but the telescope was designed for observing Talcott pairs of stars as an alternative method, and this has been adopted in the programme of work now being undertaken. The advantages of the Talcott method are: (1) The star-trails, whose distance apart is to be measured, are much closer together (generally within 10′ of one another); it is thus possible to dispense with a réseau, measuring the distance by direct comparison with a scale. (2) The trails are registered during the meridian transit, and are all near the centre of the field; accordingly the effect of any uncertainty in the collimation, level, azimuth or tilt of the plate is a minimum. (3) The trails are all parallel. This permits the use of a pair of close parallel lines on the microscope-diaphragm for setting on definite lengths of the trail, an arrangement which considerably improves the accuracy of measurement. The disadvantage of the Talcott method is that the observations are obtained less rapidly.

The Cookson Telescope and its hut were brought here and erected in the courtyard, by the side of the Longitude Pavilion, in August; and the necessary adjustments having been completed, regular observations were begun on September 7. The working programme consists of sixteen groups of stars, each group extending over about an hour and containing 4 or 5 Talcott star-pairs. Two consecutive groups are observed at each watch, and morning and evening watches are taken alternately in order to provide a good determination of the aberration-constant. Occasional long spells of cloudy weather during the winter have rendered the linking up of the groups rather weak in some cases; but as Küstner's method of determining the aberration does not require that each year should be treated independently it may be hoped that the strength and weakness will become evenly distributed in the average of a number of years. Up to May 10, 82 plates, each containing a group, have been obtained. In addition, plates were taken for adjustments and determination of the scale value of the telescope; the total number of plates exposed is 106.

For the measurement of the plates one of the micrometers used in the Astrographic Department has been reconstructed with new microscopes. The arrangement consists of two microscopes, connected by a bar whose length can be adjusted, moving longitudinally in a slide. The photographic plate is under one microscope and a glass millimetre-scale under the other; the distance between two star-trails can thus be projected and read off on the scale. Both microscopes

are provided with micrometer-screws; but the one which views the star-trails is used only for a few hundredths of a revolution as its "runs" are not so easily determined. 49 latitude-plates and 7 scale-plates have been measured in one position and reduced. Until the observations have been continued for a longer time, it is not possible to say whether the difficulties which appeared in Mr. Cookson's pioneer investigation have been surmounted; but the results obtained so far show a satisfactory accordance among themselves.

Clocks and Chronographs.—The Sidereal Standard Clock was dismounted from the Magnet House Basement on 1911 September 8, and taken away by Messrs. E. Dent & Co. for complete overhauling, preparatory to its erection in the New Clock Room. It was returned on October 20, and was brought into use again as the Standard Clock on December 4. During the period September 8—December 4 the clock Dent 2 was used as Standard.

The Mean Solar Clock, Dent 2012, was dismounted from the Ball Lobby on November 13, and cleaned by E. Dent & Co. at the Royal Observatory. It was re-erected in the New Clock Room and brought into use again on November 14.

Equatorial Observations.—During the year ended 1912 May 10, 15 disappearances of stars occulted by the Moon have been observed by one or more observers. Both contacts were observed during the Partial Solar Eclipse of 1912 April 17.

The 28-inch Refractor.—Observations of double stars have been made from a working catalogue containing all known double stars showing appreciable relative motion, and a number of pairs from the catalogues of Hussey and Aitken under 2″ separation.

The measures made during the year consist of—

129	pairs	under	0″·5	separation.		
154	„	between	0″·5	and	1″·0	separation.
172	„	„	1″·0	„	2″·0	„
258	„	over	2″·0	separation.		

κ Pegasi was observed on 5 nights, δ Equulei on 5 nights, 70 Ophiuchi on 13 nights, and ϵ Hydræ on 4 nights.

Measures of the diameters of the planet Saturn and of the ring-system were made on 11 nights, the diameter of Mars on 15 nights, and the diameter of Venus on 8 days, with the bi-filar micrometer.

Thompson Equatorial.—The 26-inch refractor, the 30-inch reflector, and the 6-inch Franklin-Adams lens, all of which are carried on this equatorial, have been in constant use during the year. The 26-inch refractor has been employed chiefly in obtaining photographs for the determination of the parallaxes of stars in the Greenwich Astrographic Zone, exposures being made on the same plate at intervals of approximately six months. Photographs have been taken of 48 stars of large proper motion; exposures have been made on 148 plates, and on 73 of these second exposures have been made after the stars had completed half their parallactic cycles. A large number of photographs with exposures of 20 minutes have also been taken on the Kapteyn Areas, especially of the pole, for the determination of parallax. In addition, 3 photographs of Comet *g* 1911 (Beljawsky) and 8 of Jupiter have been taken for place.

In connection with the photographs for parallax, the attempt was made to adjust the crown and flint lenses for their tilt and eccentricity relatively to one another with greater accuracy. It was found necessary to have a new cell for the crown lens, with special provision for these adjustments being made with all possible accuracy. This is now being constructed by Sir Howard Grubb. The crown lens was dismounted on May 3 in order that the cell might be used as a guide in making the new one.

For refinement in parallax observations an apparatus has been made by which one of a series of rotating sectors driven by clockwork can be placed immediately in front of the plate to intercept part of the light of the star whose parallax is sought. The magnitude of the photographic image is thus reduced to that of the fainter comparison stars surrounding it. The 10 different sectors allow of reduction by intervals of half a magnitude to the extent of 5 magnitudes.

The 30-inch reflector has been chiefly used to obtain photographic standards for the determination of the magnitudes of the stars counted on the Franklin-Adams plates. The progress has been somewhat slow as the number of nights on which the transparency of the sky is the same at the pole and at an equal altitude in the south is very limited. Further, an exposure of half an hour on the field and half an hour on the pole is not possible when there is any considerable amount of moonlight. Difficulties have also been experienced with a change of focus of the mirror

when it is turned from one part of the sky to another. As a check on the focus a small convex mirror has been mounted on an arm fixed on the back of the exposing shutter, which brings it to a definite distance in front of the focal plane and enables the focus to be examined visually by means of a small telescope fixed to the cell of the large mirror. Although a large number of plates have been taken, only 21 have been successful. It is hoped that the new apparatus will diminish the number of failures in future. In addition, 17 photographs of the Comets *b*, *c*, *f*, *g*, of 1911 have been taken for position; two of the tail of Comet *b* with long exposures, and 23 of the tail of Comet *c*. Five photographs were taken in the attempt to obtain Planet M.T. discovered by Palisa, and from its direct motion inferred to be very near to the Earth. These were examined at the time and thought to be unsuccessful. A later examination made after the receipt of Lick Observatory Bulletin, No. 210, containing an Ephemeris made at Berkeley, has led to the discovery of an object on three plates taken on October 11th, which is believed to be the planet.

The Franklin-Adams 6-inch lens has been mainly used for determining the photographic magnitudes of the bright stars in the Greenwich Astrographic Zone. It is necessary to supplement the photographs taken with the Astrographic telescope in this manner, because there are no stars brighter than $8^{m}\cdot 8$ sufficiently near the pole to serve as standards of comparison. This lens having a field which is sufficiently uniform over 3° radius, enables the whole zone to be completely observed by dividing it into 84 fields. Each of these fields is photographed when its centre is at the same altitude as the pole, and the polar area containing Pickering's standards is photographed on the same plate with an equal exposure.

The distribution of the 84 fields and the progress of the work is shown in the following table :—

Declination.	Number of Fields.	Number of Plates taken.	Number of Plates measured.
87°	4	4	4
84	10	10	10
78	16	16	14
72	24	10	9
66	30	15	4

With the exception of three fields in Zone 78°, the photographic magnitudes of the stars from the pole to declination 75° have been collected in ledger form.

With this lens 10 photographs have been taken of the tails of Comets *b* and *c*, 1911, and five in the search for Planet M.T. on October 25 and 26.

With a 30° prism placed in front of the lens, 17 photographs of the spectrum of Nova Geminorum (2) were obtained. A drawing made from the spectra on March 19 and April 3 is reproduced in the Monthly Notices of the Royal Astronomical Society for April, 1912.

During the year a series of seven photographs of Saturn's Ninth Satellite (Phœbe), taken in 1910, have been measured and reduced. By arrangement with the Superintendent of the Helwân Observatory, the measurement and reduction of a valuable series of 17 photographs of Jupiter's Eighth Satellite taken at Helwân has also been carried out during the year.

Astrographic Equatorial.—With this instrument 475 photographs have been taken on 142 nights. Of these, 360 were for the determination of the photographic magnitudes of the stars in the Greenwich section of the Astrographic Catalogue. Professor Pickering's polar sequence is taken as a standard with which various fields are compared by photographing on the same plate—(1) the pole, (2) any given field when at the same altitude as the pole, and (3) the pole a second time. Of the 360 photographs taken, 91 have been rejected because of differences in the two exposures on the pole. In all it is proposed to photograph 420 regions in this way, of which 346 are already taken. During the year 206 of these plates have been measured, which, with the 65 reported last year, completes nearly two-thirds of this portion of the work. With the aid of the magnitudes of the stars determined in this manner, magnitude constants for all the photographs in the Greenwich Section of the Astrographic Catalogue are being determined, and of these 233 are completed.

Some experiments in the determination of absolute photographic magnitudes have been made by means of coarse gratings placed in front of the object glass of the telescope. One of these, made of strips of zinc, 7·5 mm. wide, separated by intervals of the same width, gives a series of diffracted images on each side of the central image, differing from it by $0^m \cdot 98$, $3^m \cdot 36$, $4^m \cdot 48$. The first two of these are not sensibly elongated, and are in all respects similar in appearance to ordinary stellar images.

A second grating made of drawn steel wire of 1·65 mm. diameter with an interval of 5 mm. from centre to centre gives first diffraction images sensibly round, differing nearly two magnitudes from the principal image, and well separated from it when suitable exposures are given.

These gratings were applied to determine the changes of magnitude of Nova Geminorum (2) by comparison with a neighbouring star. In all 47 photographs on 29 nights were taken of the Nova, and its changes of magnitude were followed from March 15 to April 30.

The preparation of a catalogue giving the right ascensions and declinations of all the stars in the Greenwich Astrographic Catalogue which are found in existing meridian catalogues has been continued during the year. Copy for press of the zones 64° to 67° North declination has been written and comparison made with the Greenwich Nine-Year Catalogue for 1900 and the *Astronomische Gesellschaft* Catalogues (Christiania and Helsingfors) for 1875. It is hoped to commence the printing very shortly.

A catalogue of 2,212 stars within 3° of the North Pole has been formed from the measures of the rectangular co-ordinates, and diameters of star images on 41 plates given on pp. 929–996 of Volume II. of the Astrographic Catalogue. Some copies of this will be distributed next month.

Franklin-Adams Photographs.—The determination of the number of stars of different photographic magnitudes on Mr. Franklin-Adams' series of photographs of the whole sky has been continued during the year. The salaries of the computers employed in the actual enumeration have been defrayed partly by Mr. Franklin-Adams and partly by a grant from the Royal Society. The total number of plates counted during the year is 157. Thirty of these had been counted before (1911 March–May), but the experience gradually acquired by the enumerators was such that these early counts were not comparable with the later ones, so that it seemed desirable to repeat this part of the work. The total number of plates completed is 152, and there are 54 still to be counted.

The charts of the Southern hemisphere (and a few other plates in zones Declination + 15° and + 30°) are being retaken at the Johannesburg Observatory, by arrangement between the Director and Mr. Franklin-Adams, to replace the original series. Already 72 repeat plates have been received and counted. A further box of 28 plates is expected to arrive shortly, and others are ready for

despatch from Johannesburg. A small number of plates remain to be taken. All the plates received have been counted.

On each plate the stars in 25 uniformly distributed regions are counted, the centres of the regions being the intersections of réseau lines 3° apart. The stars are tabulated according to magnitude by comparison with a scale in the eye-piece. Auxiliary photometry plates for the calibration of the scale are taken with the 30-inch reflector for the central region counted on each plate. Twenty-six such plates have been reduced, while 14 others have been provisionally passed as good and await examination. Six photographs for the comparison of Southern fields with Northern ones in Dec. + 15°, and through them with the polar area, have been received from the Helwân Observatory. The co-operation kindly accorded by this Observatory will make it possible to standardise the Franklin-Adams plates as far as those whose centres are in Dec. − 15°.

III.—Heliographic Observations:—

In the year ended 1912 May 10, photographs were obtained on 256 days, as against 182 in the previous year. The increase is partly due to the unusual amount of bright sunshine experienced during last summer, but chiefly to the arrangement that the observing duty with the photoheliograph should commence at 8 a.m. during the months of April and September, and at 7 a.m. during the four intermediate months.

The Photoheliographic Results for the year 1910 have been printed; and the copy for press for 1911 of the daily results, and of the ledger of spot-groups is ready for the printer, with the exception of one day, 1911 December 27, for which a photograph is expected from the Kodaikánal Observatory.

Of the photographs taken in the year ending 1912 May 10, 546 have been selected for preservation, including 28 with double images of the Sun for the determination of zero of position-angles. The photographs from the Royal Observatory, Cape of Good Hope, have been received up to 1912 February 29; and supplementary photographs have been received, through the Solar Physics Committee, from Dehra Dûn, India, up to 1912 February 22.

The series of photographs for the year 1911, as made up from the four contributing observatories, is complete, except for two days. Of these, a photograph is expected from the Kodaikánal Observatory for one day; for the other day, 1911 January 1, no photograph is at present available.

The record for 1911 is made up from the different sources as under:—

Greenwich	225	days.
Cape	116	„
Dehra Dûn	18	„
Kodaikánal	4	„
Unrepresented as yet	2	„
Total	365	„

The measurement of the photographs for 1911 is complete, and for those taken at Greenwich up to 1912 April 6.

Besides the photographs enumerated above, a set of 15 was obtained during the partial eclipse of 1912 April 17, together with two photographs having double images of the Sun, for the determination of zero of position-angles. The measurement of these 17 plates for the determination of the Moon's place is in progress.

The solar activity has continued to decline since the date of the last report, the mean daily spotted area for 1911 being less than one-fourth of that for 1910. The present year opened with a period of complete quiescence, no spots being observed during January and February, though two or three interesting groups have been seen since. It is clear that the general period of minimum activity has set in, and there are, as yet, no signs of an early revival.

Advantage has been taken of this lull in the solar activity to discuss the 38 years' observations, now available, for a determination of the position of the Sun's axis; and a preliminary paper, showing that Carrington's position requires only a very small correction, was communicated to the Royal Astronomical Society on 1912 May 10.

As the Thompson photoheliograph will be required for use in the observation of the total solar eclipse of October 10 next, it was felt desirable that the performance of the Dallmeyer photoheliograph, which will have to be used for the ordinary photographic record while the Thompson instrument is away, should be made as satisfactory as possible. Sir Howard Grubb was, therefore, asked to supply a new object-glass for it. This has proved satisfactory, and its focal length being 2 inches greater than that of the Dallmeyer lens, it has been possible to have the camera shortened, which is an advantage. A telescope of 4-inches aperture, fitted with a solar diagonal eye-piece, has also been mounted in place

of the counterpoise, at the other end of the declination axis, so that the Sun can be viewed directly at the time when the photograph is being taken, and the moment of best definition selected for the exposure.

Solar Eclipse of 1912 *October* 10.—Provision has been made in the Navy Estimates to send two observers to Brazil for the observation of the total Solar Eclipse of 1912 October 10. Enquiries have been made as to a suitable site, and it appears that the neighbourhood of Cruzeiro (lat. 22° 39′ S., long. 44° 58′ W.), which is accessible by railway from Rio, offers the greatest advantages. The programme, so far as it has been decided, includes (1) photography of the detail of the corona with the Thompson 9-inch coronagraph, in continuation of the series of photographs obtained at previous eclipses, and (2) photographs with a quartz spectroscope lent by Professor Newall, used in conjunction with a 6-inch speculum-metal concave mirror lent by Father Sidgreaves and a new 9-inch flat speculum-mirror mounted on a coelostat, for the purpose of obtaining the extreme ultra-violet part of the spectrum.

IV.—Magnetic Observations :—

The variations of magnetic declination, horizontal force and vertical force, have been registered photographically, and accompanying eye observations of absolute declination, horizontal force and dip, have been made with the declinometer, the Gibson deflexion instrument, and the Airy dip circle mounted in the Magnetic Pavilion. From 1912 February, observations of absolute horizontal force have been made weekly instead of twice every month, and determinations of the moment of the deflecting magnet have been made monthly.

On account of the uncertainty attending the observations of magnetic dip with a dip circle it has been decided to use a dip-inductor as well, and an instrument is now being constructed by the Cambridge Scientific Instrument Company.

The magnetic reductions are completed to the following stages :—

The eye observations of the declination and horizontal and vertical force magnets are completely reduced, and the hourly ordinates of the photographic registers are read off and tabulated. The temperature of the magnet basement at every hour has been read from the Richard thermograph sheets, and the daily and hourly means have been taken. The eye observations of declination, dip, and deflexion made in the Magnetic Pavilion are completely reduced.

The magnetic elements for 1911 determined from observations in the Magnetic Pavilion are as follows:—

Mean declination - - -	15° 33′·0 West.
Mean horizontal force - - -	0·18529 (in C.G.S. units).
Mean dip (with 3-inch needles) -	66° 52′ 6″.

In 1911 there were no days of great magnetic disturbance; six days were classified as of lesser disturbance. Traces of the photographic curves for these days and some others, selected in concert with M. Angot, will be published in the annual volume. The calculation of diurnal inequalities from five typical quiet days in each month has been made, the days being selected by the International Committee on Terrestrial Magnetism from the reports sent in from a number of Observatories.

Part of the work on terrestrial magnetism has been transferred from the Compass Branch of the Hydrographic Department to the Royal Observatory. The chart of declination for 1912 is being completed by the Compass Branch, but future charts will be prepared at the Royal Observatory. The collection of all available data at land stations will be made at the Observatory, but the Compass Branch will collect and reduce observations made on board ships and communicate the results for incorporation in the charts.

V.—Meteorological Observations:—

The registration of atmospheric pressure, temperature of the air and of evaporation, pressure and velocity of the wind, rainfall, sunshine, and atmospheric electricity has been continuously maintained.

The meteorological reductions are in the following state:—The observations of barometer, thermometers, anemometers, rain-gauges, and sunshine recorder are reduced up to the present time. On the photographic sheets all time-scales are laid down, and the hourly ordinates are entered and completely reduced to the end of April 1912, except for the electrometer registers, which are completely reduced to the end of 1910. The table of principal changes of the wind for 1911 is not yet completed.

The mean temperature for the year 1911 was 51°·5, or 1°·9 above the average of the 65 years 1841–1905. For the 12 months ending 1912 April 30 the mean temperature was 52°·4.

During the 12 months ending 1912 April 30 the highest temperature in the shade (recorded on the open stand in the enclosure of the Magnetic Pavilion) was 100°·0 on August 9. On the same day the highest temperature in the Stevenson screen in the Magnetic Pavilion enclosure was 96°·6, in that in the Observatory Grounds 97°·5, and in the new screen in the Magnetic Pavilion enclosure 98°·1. The temperature of 100°·0 was given by the thermometer on the stand which has been accepted since 1840 as the Greenwich Standard, and the differences from the other thermometers are such as are usually found in hot weather. On seven days the highest temperature in the shade exceeded 90°, and on 45 days equalled or exceeded 80°.

The lowest temperature of the air recorded during the same period was 19°·1 on the two days January 29 and February 3. There were only 22 days during the winter on which the temperature fell as low as 32°·0. This is 34 less than the average, and is the smallest number in any winter of the series commencing in 1840.

The mean daily horizontal movement of the air in the year ended 1912 April 30 was 295 miles, which is 12 miles above the average of the previous 44 years. The greatest recorded daily movement was 817 miles on November 5, and the least 77 miles on October 13. The greatest recorded pressure to the square foot was 17·5 lbs. on December 10, and the greatest velocity in an hour 43 miles on April 8.

During the year 1911, Osler's anemometer showed an excess of 19 revolutions of the vane in the positive direction N., E., S., W., excluding the turnings which are evidently accidental.

The number of hours of bright sunshine recorded during the 12 months ended 1912 April 30, by the Campbell-Stokes instrument, was 1,847 out of a possible 4,472 hours, in striking contrast to 1,300 hours in the previous year, giving a mean proportion of 0·413, constant sunshine being represented by 1. This is the highest proportion of sunshine for a whole year at Greenwich since the record was commenced. July had 334 hours of sunshine, and September with 234 hours was equally remarkable.

The rainfall for the year ended 1912 April 30 was 25·03 inches, being 0·91 inches greater than the average for the period 1841–1905. The number of rainy days (0·005 inch or over) was 164. The wettest months were from

October to January, each with a rainfall of over 3 inches, while that for December exceeded 4 inches. The driest months were July 1911 with 0·25 inch and April 1912 with 0·07 inch.

VI.—Printing and Distribution of Greenwich Publications :—

The Greenwich Observations for 1909, including as an appendix the "Investigation of the Motion of Halley's Comet, 1759–1910," were distributed in July 1911.

The Greenwich Observations for 1910 are printed and will be distributed shortly. The amount of printing has been diminished in accordance with the proposals of the last Report, and the volume for 1910 is much smaller than recent volumes. The Rates of Chronometers and Watches for 1911 are printed and are being distributed.

The printing of Vol. III. of the Astrographic Catalogue has been commenced with a small section giving a catalogue of the positions and photographic magnitudes of the stars within 3° of the North Pole. It is hoped to commence very shortly the printing of the main part of this volume, a catalogue of the right ascensions and declinations of all stars in this part of the sky which have previously been observed with Meridian instruments.

VII.—Chronometers :—

From the beginning of the year 1912 some changes of procedure came into force with regard to the receipt and issue of chronometers to the Fleet, and the upkeep of the stocks at the Admiralty depôts, the Astronomer Royal being now responsible for the maintenance of the stocks in these establishments. In future all applications for permission to submit chronometers and watches to the annual trials are to be made directly to the Astronomer Royal, to whom also all claims in connection with the purchase and repair of chronometers and watches are to be sent. The Hydrographer is kept informed by periodic reports.

The number of Government marine chronometers and watches now at the Observatory is 396, viz., 141 box chronometers, 22 pocket chronometers, 98 chronometer watches, and 135 hack watches.

In addition to these there are at the Observatory 6 box chronometers being tested after repair, and 2 box chronometers awaiting repair, belonging to the Indian Government.

There are at present 10 hack watches and 13 non-magnetic watches on trial for purchase by the Admiralty.

In the year ended 1912 May 10, the average daily number of chronometers and watches being rated was 573, the total number received was 1,782, the total number issued was 1,793, and the number sent for repair 794. This last number includes 36 box chronometers, 1 pocket chronometer, and 3 watches belonging to the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 49° to 106°, 55 chronometers were sent in. During the trial 16 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 39 chronometers, 20 were purchased for the Navy, 2 for the Indian Government, and 1 for the Commonwealth of Australia.

The performance of these chronometers was very satisfactory.

For the annual trial of chronometer watches, lasting 16 weeks and including trials in the oven and in positions, 195 watches were entered, of which 72 were classified, and of these 60 were purchased for the Navy. Among the watches classified were 29 with centre-seconds' dials; of these, 23 were purchased. There were 15 "Karrusel" or "Tourbillon" watches classified, of which 12 were purchased. The performance of the watches was good.

A trial of pocket chronometers took place concurrently with the trial of chronometer watches, and under the same conditions as regard duration of trial, temperatures, and positions. Of the 11 pocket chronometers sent in, 2 were purchased for the Navy.

The trials of hack watches and non-magnetic watches have been continued throughout the year, 58 of the former and 27 of the latter having been tested. Of these, 19 hack watches and 12 non-magnetic watches have been purchased.

The next trial of box chronometers will commence on June 15, and of pocket chronometers and chronometer watches on August 3.

Provision is now made to receive and test two classes of non-magnetic watches at the Royal Observatory, (*a*) those comparable with chronometer watches and (*b*) watches less highly adjusted.

The experiments mentioned in the Report for 1911, which were undertaken to investigate the effect of magnetic fields on the rates of chronometers and watches (both ordinary and non-magnetic), have been continued throughout the year and brought to a satisfactory conclusion.

It was found that a vertical magnetic field has little or no effect as such—if, however, it is deflected in passing through the chronometer, its horizontal component will affect the rate.

The effect of a horizontal field varies with the direction in which it passes through the chronometer. If the latter is not permanently magnetised, a reversal of the field does not affect the rate; but if the chronometer is turned through 90° in the field, the change of rate will be exactly reversed in sign. There are certain directions in which the rate is entirely unaffected by a magnetic field.

If, however, the chronometer becomes permanently magnetised, the change of rate is reversed in sign by reversing the field. In this case the change of rate is directly proportional to the intensity of the magnetic field, whereas in the case of temporary magnetisation the change of rate is proportional to the square of the intensity of the field.

It was found that a field of intensity one c.g.s. unit is liable to change the rate of an average chronometer by approximately one second per day.

The changes of rate are due to the mechanical couple acting on the magnetised steel in the balance arm and rim when in the magnetic field.

Watches can be shielded from the above effects by being placed in suitable iron boxes.

Tests on non-magnetic watches have shown that slight changes of rate may be produced in very strong magnetic fields, but no permanent change of rate takes place. Changes of rate produced in non-magnetic watches do not follow the same laws as those occurring in ordinary watches or chronometers, and must arise from different causes.

A full account of these experiments is given in a paper by Mr. Chapman and Mr. Lewis, which will be published in the *Monthly Notices of the Royal Astronomical Society*.

VIII.—Time Signals:—

The Greenwich time-ball was not raised on two days (November 5 and December 10) owing to the violence of the wind, and could not be raised on one day (January 18) owing to accumulation of ice on the mast.

On November 13 no signal left the Royal Observatory at 13^h owing to failure in the Mean Solar Clock springs. The Time Ball failed to drop, but was released by a false signal at three and a half minutes after 13^h. It was raised again and dropped correctly by signal at 14^h.

The general performance and accuracy of the drop of the time-ball at the Admiralty Signal Stations, and of the going of the Westminster Clock, is shown by the following table of the signals received at Greenwich:—

It should be borne in mind in comparing these results that the Deal time-ball is dropped directly from Greenwich at 13^h; that the clocks at Portsmouth, Portland, and Devonport are corrected daily by the Greenwich 10^h time-signal; and that the Westminster clock is not corrected daily.

Apparent Error of Return Signal.	Portsmouth.	Portland.	Devonport.	Deal.	Westminster.
	Days.	Days.	Days.	Days.	Days.
Not greater than 0·2	230	209	250	—	58
Between 0·2 and 0·5	48	24	25	—	26
„ 0·5 „ 1·0	3	18	9	—	72
Greater than 1·0	1	2	1	—	104*
Average error of signal for the year	±ˢ·15	±ˢ·17	±ˢ·13	—	±ˢ·97
Failures of return signal on Sunday	35	43	25	4	—
Total failures	64	87	66	14	6
Interruptions by telegraph signals on Sunday	6	6	5	3	—
Total interruptions	16	15	15	9	—

* Never exceeded $3^s \cdot 0$.

The above figures do not include the period January 5 to 8 (Portsmouth) and September 17 to 30 (Portland), when owing to special causes large errors occurred. the inclusion of which would give a wrong idea of the general accuracy.

As I was informed by the General Post Office that it would be more convenient for them if the return from Deal was sent at 10 seconds past one o'clock instead of at 5 seconds past, the time of this return signal has been changed. To effect this a wheelwork mechanism was designed which is set in motion by the actual drop of the ball, and which after a fixed interval transmits the signal to Greenwich. It has acted very satisfactorily.

While these alterations were being made it was discovered that certain bearings and pinions of the raising apparatus, which were put up in 1853, showed considerable wear. These have been renewed and the machinery made quite effective by the Works Department.

Lieutenant F. C. Hanning-Lee attended at the Observatory on the 9th, 10th, and 11th of May for a short course of practice with the transit instrument, before proceeding to Malta to take charge of the Chart and Chronometer Depôt there.

IX.—Personal Establishment :—

The permanent staff at the present time is constituted as follows, the names in each class being arranged in alphabetical order :—

Chief Assistants—Mr. Chapman and Mr. Eddington.

Assistants—Mr. Bryant, Mr. Crommelin, Mr. Hollis, Mr. Lewis, Mr. Maunder, Mr. Thackeray.

Clerical Assistant—Mr. Outhwaite.

Established Computer (Higher Grade)—Mr. Davidson.

Established Computers—Mr. Bowyer, Mr. Burkett, Mr. Cullen, Mr. Edney, Mr. B. Evans, Mr. J. Evans, Mr. Furner, Mr. Melotte, Mr. Stevens, Mr. Witchell.

The following table shows the arrangement of the Staff (permanent and temporary) under the general superintendence of the Chief Assistants :—

Branch.	Established Staff.		Temporary Computers.
	Assistants.	Established Computers.	
Transit Circle:—			
1. Meridian Computations	Thackeray	Cullen	Chamberlain, Davis, and a vacancy.
2. Transits		Witchell	Percival, White.
3. Zenith Distances		B. Evans	*Davies, *Bartle.
Altazimuth	Crommelin	Furner	*Jeffries.
Time Signals, Chronometers, and 28-inch Refractor.	Lewis	Bowyer	*Green, *Newton, Maddock.
Astrographic Equatorial	Hollis	Stevens J. Evans	*Passfield, Barton, Sims, and a vacancy.
Thompson Photographic Equatorial.	*nil*	Davidson (Higher Grade). Melotte.	* Lord, Martin.
Photoheliograph	Maunder	*nil*	*Smith, *Berry.
Magnetic and Meteorological	Bryant	Edney	*Timbury, *Divers, *Brown, *Showell.
Clerical	Outhwaite	Burkett	Kilby.

* Qualified as Observers with one or more of the instruments.

Since the date of this Report Mr. B. D. Evans has resigned his position as Established Computer, having been appointed First Assistant at the Hong Kong Observatory. He left on May 16.

Two Computers, Lambert and Entwistle (not included in this Table), are employed temporarily in connection with counting stars on the Franklin-Adams chart plates.

A foreman of works, with 2 carpenters and 2 labourers; a foreman mechanic, with 2 assistants; a gate-porter, 2 messengers, a watchman, a gardener, a labourer, and a charwoman are also attached to the Observatory.

The total number of persons regularly employed at the Observatory is 60.

X.—General Remarks:—

The record of the Observatory for the past year shows that in addition to the routine work several special investigations have been made by different members of the staff. In addition to those which have been already referred to in the course of the report mention may be made of Mr. Eddington's continued studies of stellar movements and distribution.

Special attention may be drawn to the successful conclusion of the long-continued observations on the influence of magnetic fields on chronometers and watches. The Time Department of the Observatory is peculiarly well suited to carry out such a research.

The Cookson Floating Zenith Telescope has been substituted for the Reflex Zenith Tube during the year, and a complete scheme of work arranged. The results which have already been obtained give good reason to hope for valuable determinations of the variation of latitude and of the constant of aberration.

The observations for stellar parallax have been prosecuted with vigour. Two important improvements are being made, firstly, by provision for the more delicate adjustment of the 26-inch object glass, and also by the use of rotating sectors to equalise the magnitudes. With these additions thoroughly satisfactory results may be anticipated.

The question of photographic magnitudes has received a great deal of attention during the year. Three different instruments have taken a share in this work. In the Greenwich Astrographic Zone the magnitudes of the stars brighter than $8^m \cdot 8$ are being rapidly determined with the Franklin-Adams 6-inch lens, and those of the stars from $8^m \cdot 8$ to $12^m \cdot 0$ or $13^m \cdot 0$ with the Astrographic telescope; while with the 30-inch reflector data are being obtained to standardise the magnitudes of the stars counted on the Franklin-Adams chart plates.

F. W. DYSON.

Royal Observatory, Greenwich,
1912 May 11.