REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1911 *June* 2.

GREENWICH OBSERVATIONS, 1910.

THE BOARD OF VISITORS.

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Read at the Annual Visitation of the Royal Observatory, 1911 *June* 2.

The Report here presented refers to the year from 1910 May 11 to 1911 May 10, and exhibits the state of the Observatory on the last-named day.

Sir W. H. M. Christie resigned his office on 1910 October 1, and a portion of the observations here referred to were made under his superintendence. There seems to be no occasion to separate these from the remainder, as the course of observation has been continued without essential alteration.

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

The painting of the domes and external parts of the buildings referred to in the last report was completed on June 13.

The dome of the old Altazimuth was altered in January and February so as to make it suitable to hold the Dallmeyer Photoheliograph.

During February brick piers were built and rails laid on them to carry a new mercury trough for the New Altazimuth.

In response to the Astronomer Royal's request for additional bedroom accommodation, alterations in the official residence were begun on March 1 and are now in progress. The new rooms are being made under those on the west side

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of the house, and H.M. Office of Works have kindly allowed the path in the park to be moved 8 feet away and an iron fence to be erected. The extension was made in this way in preference to building above the rooms on the south side, because two of the windows of the Octagon Room would have been partially obstructed if the latter plan had been adopted.

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).—Two 4-inch (Simms Nos. 1 and 2), two 4-inch (R.O. Nos. 1, mounted as finder on Thompson Equatorial, and 2), one $3\frac{1}{2}$-inch (R.O. No. 3).

One Hilger Chronograph.

A single prism Spectroscope.

On loan—

Transit A, at the Cape Observatory.

Altazimuths.—A, at the Science Schools, South Kensington; B, at the Cape Observatory.

Equatorials.—Lee (6-inch), at the Hong Kong Observatory; Simms No. 2 (6-inch), lent to the Board of Education.

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 Turner, Oxford Observatory.

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.

A 6-inch photographic lens of 27 inches focus has been kindly lent to the Royal Observatory by Mr. Franklin Adams for use in the observations of Halley's Comet.

The object glass and tube of Photoheliograph No. 3, lent to the Government Astronomer, Melbourne, for the Solar Eclipse of 1910, were returned on September 1.

Altazimuth D, lent to the Colonial Office for the use of Major Watherston for longitude observations on the Gold Coast, was returned on 1911, March 27, after repair by Troughton and Simms.

The Public Standards of Length affixed to the outside wall of the Observatory were sent to the Standards Department on December 16 for repair and adjustment. They were returned and remounted on February 9.

The annual examination of the Library has been made as usual, the books on the shelves being compared with the catalogue. Two books are missing from the shelves and cannot be accounted for at present.

II.—Astronomical Observations :—

Transit Circle.—Two slight changes are being made with the transit circle. Parallel wires instead of cross-wires are being substituted in the reading microscopes.

An alteration in the mounting of the object glasses of the microscopes has been made to make the operation of focussing simpler. Each object glass moves in a slide and is secured by a pair of lock rings with milled edges.

The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years.

The other stars observed are the stars of $9^m \cdot 0$ and brighter, over 12,000 in number, (with about 110 fainter stars in parts of the sky where bright stars are not sufficiently numerous) between the limits of $+24°$ and $+32°$ of North declination. This programme was begun in 1906 with the intention of obtaining 5 observations of each star. Between 1906 January 1 and 1911 May 10 about 48 per cent. of the necessary observations have been obtained. Thus, good progress has been made, especially when it is remembered that the transit circle was out of use for a part of 1906. To facilitate comparison of the catalogue with the fundamental system of the *Comité International Permanent* six stars from Newcomb's Fundamental Catalogue between the limits of 24° and 32° North declination have been observed each night, when possible, since 1910 January 1.

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

Transits - - - - - - - -	9,453
Determinations of Collimation and Level error - -	296 and 469
Circle observations - - - - - -	9,643
Determinations of nadir point and reflexion observations of stars (included in the number of circle observations) -	466 and 255

The transits are completely reduced (so as to exhibit Mean R.A. $1910 \cdot 0$) to 1911 April 15, and Apparent R.A. is formed to April 30. The circle observations are completely reduced to 1911 April 15.

The corrections for variation of latitude for 1910 have been received from Professor Albrecht, and the Ecliptic and Colatitude investigations are in progress.

The apparent correction for discordance between the nadir observations and stars observed by reflexion in 1910 is $-0'' \cdot 20$. The values from 1892 to 1909

range from $-0''\cdot16$ to $-0''\cdot41$. Four-fifths of this quantity is applicable to observations of the nadir in forming the zenith points on days when no reflexion observations of stars are obtained, and since 1897 January 1 the value $-0''\cdot25$ has been adopted for this correction.

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 for 1910, and for the nine years 1897 to 1905, 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.
1910	$+0''\cdot15$	$0''\cdot00$	$+0''\cdot16$	...	$+0''\cdot19$	$0''\cdot00$	$+0''\cdot01$	...
1897–1905	+0·25	0·00	+0·21	+0·37	+0·14	0·00	+0·12	+0·11

The correction for R−D discordance found for 1910 is $+0''\cdot033 + 0''\cdot523$ *sin* Z.D.

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) derived from the mean of the observations of the limb and the crater Mösting A made with the transit-circle and altazimuth for 1909 is $-0^s\cdot423$ in R.A. and $-0''\cdot53$ in N.P.D. The corresponding mean errors in longitude and Ecliptic N.P.D. from these observations are $-6''\cdot41$ and $+0''\cdot30$.

The mean error of the Moon's tabular R.A. for 1910 derived from 98 observations with the transit-circle is $-0^s\cdot543$.

Altazimuth.—A new mercury trough running on rails has been supplied by Messrs. Troughton and Simms. The rails rest on brick piers and are isolated from the floor. The central lengths of the rails are removable when the instrument is used out of the meridian. The steadiness of the star images as seen in the mercury has been greatly improved.

The instrument has been used as a reversible transit-circle during the second and third quarters of each lunation. Observations of the Sun, Moon, planets, and fundamental stars have been made throughout the year. Observations have also been made of reference stars for a series of photographs of Mars taken with the Thompson Equatorial between 1909 July 23 and 1910 May 14.

Extra-meridian observations of the Moon have been made regularly during the first and last quarters of the lunation. Since 1911 April, observations have been limited to cases in which the Moon's altitude over one of the standard azimuths is not less than 15°, with the Sun below the horizon.

The observations of the crater Mösting A both in Right Ascension and declination have been made whenever the object was observable. The nearly simultaneous observations made at Greenwich and the Cape between 1905 January and 1910 December have been discussed with a view of determining the Moon's parallax. The results were communicated to the Royal Astronomical Society by the Astronomer Royal and His Majesty's Astronomer at the Cape. The probable error of the result, excepting so far as it depends on the assumed value of the Earth's ellipticity, is $\pm 0''.06$. The following table gives the correction to Hansen's value of the Moon's parallax corresponding to various values of the ellipticity, compared with the value determined gravitationally:—

$\frac{1}{e}$	Corrections to Hansen's Value of the Moon's Parallax.	
	Trigonometrical Determination.	Gravitational Determination.
293	+ 0".53	+ 0".46
294	.47	.45
295	.41	.43
296	.35	.42
297	.30	.40
298	.24	.39
299	.18	.37
300	.12	.36

A combination of these determinations gives + 0″44 as the correction to Hansen's parallax, and 294·5 as the value of $\frac{1}{e}$.

The following observations have been made with the altazimuth during the year :—

	No. of Observations.
Collimation, Level, and Azimuth - -	214, 361, and 122 respectively.
Nadir : Reflexion observations of stars -	342 and 154 ,,
R.A. and N.P.D. of Sun, planets, and stars (in meridian) - - - - - - -	1,386 and 1,467 ,,
R.A. and N.P.D. of Moon (in meridian) -	69 and 59 ,,
R.A. and N.P.D. of Mösting A - - -	36 and 36 ,,
Azimuth and Zenith distance of stars (extra meridian) - - - - - - - - -	124
Azimuth and Zenith distance of Jupiter (extra meridian) - - - - - -	1
Azimuth and Zenith distance of Moon (extra meridian) - - - - - - - -	27
Azimuth and Zenith distance of Halley's Comet (extra meridian) - - - -	5

The altazimuth observations are reduced to the end of 1910. Of the observations of 1911, the transits and meridian zenith distances are reduced to 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 have also been compared in reversed positions of the instrument with the positions given in Newcomb's Fundamental Catalogue. The comparison has

revealed a large and nearly constant discordance whose mean for the year is $1''\cdot14$ and which changes sign with the reversal of the instrument. In December the object glass was removed, readjusted in its cell, and the spring which holds it was strengthened, but no appreciable alteration was made in the discordance. The cause was thought to lie in the compensating arms and spring which hold the glass. The object glass and its cell were accordingly turned through a right angle, but the discordance appears to be of the same amount. As the fault may possibly be at the eye end of the instrument, the slides have been removed and thoroughly cleaned. It is not known whether this has had any effect, as no observations have been made since the cleaning of the slides.

The mean error in right ascension of the Moon's tabular place for 1910 is $-0^s\cdot59$ from meridian observations of the limb and $-0^s\cdot55$ from those of Mösting A. The extra meridian observations are not yet completely reduced.

The following table shows the number of days on which observations of the Moon were obtained with the transit-circle and altazimuth, respectively, in the year ending 1911 May 10;—

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		1
3–6 „	7		5		10
6–9 „	18	10	17	14	3
9–12 „	20	18	18	12	0
12–15 „	25	11	18	4	0
15–18 „	17	12	11	6	1
18–21 „	11	1	0		8
21–23 „	0		0		4

The total number of observations of the Moon is 98 with the transit-circle and 96 with the altazimuth, viz.:—69 in the meridian and 27 extra-meridian.

Taking both instruments, observations of the Moon have been obtained on 114 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 in progress. All the observations for the ten years have been entered up and the reduction to the equinox 1900·0 has been completed.

Reflex Zenith Tube.—During the year, 1,023 double observations and 21 single observations have been obtained. The observations are completely reduced to 1910 December 31, and, as far as Apparent Zenith Distance, to 1911 April 30. Since work with this instrument was recommenced in 1902, the number of observations obtained in the complete years are as follows:—

1903	781	1907	1,638
1904	817	1908	1,107
1905	799	1909	1,302
1906	1,170	1910	1,362

The observations from 1906–1909 have been discussed by Mr. Eddington, and the results communicated to the Royal Astronomical Society in May 1911. On the whole a fair agreement is shown with the results of the International Latitude determinations published by Professor Albrecht. The most serious difficulty is caused by the changes of the scale value. A good deal of attention has been given to the instrument in recent years, and the results are probably as good as the instrument and conditions of observation admit of.

The following table shows the resulting values of the Latitude Variation compared with Professor Albrecht's results. The results are the means of groups of equal weight:—

Date.	Correction for Latitude Variation.			Date.	Correction for Latitude Variation.		
	R.Z.T.	Albrecht.	Diff.		R.Z.T.	Albrecht.	Diff.
1906.				1908.			
Jan. 25 -	−″·26	−″·06	−″·20	Jan. 15 -	+″·09	+″·04	+″·05
March 20 -	−·18	+·10	−·28	Feb. 15 -	+·04	−·05	+·09
June 1 -	−·11	+·18	−·29	April 10 -	−·05	−·17	+·12
July 10 -	+·11	+·15	−·04	June 5 -	−·17	−·20	+·03
Aug. 20 -	−·17	+·08	−·25	July 20 -	−·16	−·13	−·03
Sept. 5 -	+·04	+·05	−·01	Aug. 20 -	−·15	−·04	−·11
Oct. 1 -	+·06	+·01	+·05	Sept. 5 -	−·04	·00	−·04
Nov. 10 -	−·07	−·04	−·03	Oct. 5 -	+·03	+·08	−·05
Dec. 15 -	−·08	−·07	−·01	Nov. 20 -	+·21	+·18	+·03
1907.							
Jan. 30 -	+·06	−·05	+·11	1909.			
March 1 -	+·09	−·03	+·12	Jan. 30 -	+·57	+·20	+·37
March 25 -	+·13	−·02	+·15	April 10 -	+·09	+·02	+·07
May 1 -	−·15	+·01	−·16	May 10 -	−·16	−·10	−·06
June 25 -	+·03	+·04	−·01	June 10 -	−·11	−·19	+·08
July 25 -	+·07	+·06	+·01	July 20 -	−·21	−·29	+·08
Aug. 25 -	+·07	+·07	·00	Aug. 10 -	−·38	−·32	−·06
Sept. 10 -	+·24	+·09	+·15	Sept. 1 -	−·36	−·32	−·04
Sept. 20 -	+·14	+·09	+·05	Sept. 20 -	−·11	−·28	+·17
Oct. 1 -	+·13	+·10	+·03	Oct. 15 -	−·23	−·20	−·03
Oct. 20 -	+·05	+·11	−·06	Nov. 20 -	+·15	−·02	+·17
Dec. 1 -	+·24	+·10	+·14				

Clocks and Chronographs.—The clock Mudge and Dutton has been repaired during the year, and the clocks Molyneux and Dent 2017 are now in the hands of Messrs. E. Dent & Co. for repair.

Equatorial Observations.—On the night of the total eclipse of 1910 November 16, 10 disappearances and 9 reappearances of stars at the eclipsed limb of the Moon were observed, as well as 2 disappearances at the bright limb. Excluding this night, 23 disappearances at the Moon's dark limb and 1 at its bright limb were observed in the year.

The 28-inch Refractor.—A troublesome irregularity in the driving of the instrument was traced to the fact that the worm on the top of the driving shaft was very much worn. A new worm was therefore obtained from Messrs. Troughton and Simms in November.

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—

110	pairs	under	0″·5	separation.	
153	„	between	0″·5	and	1″·0 separation.
156	„	„	1″·0	„	2″·0 „
280	„	over	2″·0	separation.	

κ Pegasi was observed on 5 nights, δ Equulei on 5 nights, 70 Ophiuchi on 9 nights, and ε Hydræ on 2 nights.

Measures of the diameters of the planet Saturn and of the ring-system were made on 8 nights with the bi-filar micrometer.

Thompson Equatorial.—The 30-inch mirror has not been re-silvered since 1910 February 22. Its condition is still good owing to the cover having been made airtight by means of a band of pure rubber.

A new plate holder for the 26-inch Refractor has been made in the workshop.

The 26-inch Refractor has been employed chiefly in obtaining photographs for determining the parallaxes of stars in the Greenwich Astrographic Zone. The method employed is that suggested by Prof. Kapteyn, exposures being made on the same plate at intervals of 6 months, as nearly as may be. Up to the

present 27 photographs of Kapteyn areas with one exposure of 20 minutes on each have been obtained (24 of these are of the Polar area). Besides these, 21 plates, each with two exposures of 4 minutes, have been exposed on 13 stars having large proper motion, and two on the planetary nebula N.G.C. 6543. In addition, two photographs of Saturn with the occulting shutter were taken for determining its position with reference to the stars used in the reduction of the photographs of the Ninth satellite. A number of plates have also been exposed for experimental purposes and for the adjustments of the instrument.

With the 30-inch Reflector—

7	photographs of	Saturn and Satellite IX.	were taken on	4	nights.
10	„	Comet *c* 1909 (Halley)	„ „	4	„
12	„	„ *b* 1910	were taken on	7	nights.
4	„	„ *e* „	„ „	3	„

and 14 photographs with an exposure of 90 minutes on each were taken for identifying and determining the positions of some of Herschel's nebulæ.

Some experimental plates have also been taken with the reflector in connection with the photographic magnitudes of the Franklin-Adams plates.

During the year the following photographs have been measured and the results published in the *Monthly Notices R.A.S.*:—

Jupiter, Satellite VIII. 1910	9	photographs.
Comet *c* 1909 (Halley)	52	„
„ *e* „ (Daniel)	26	„
„ *a* 1910	2	„
„ *b* „ (Metcalf)	9	„
„ *e* „ (Faye)	4	„
24 minor planets, 1909	70	„
and positions of 40 nebulæ measured on	10	„

The measurement of the photographs of Comet Morehouse for the determination of the motions of the matter forming its tail is complete, but the discussion is not yet concluded.

Jupiter is too far south of the Equator for observations of J. VIII. to be made here, but the Director of Helwan Observatory has undertaken to continue its observation. The photographs are to be sent to Greenwich for measurement, and 8 successful photographs on 8 nights have already been received. Mr. Hough has kindly co-operated in having the region covering the path of Jupiter during the opposition photographed with the Astrographic telescope at the Cape of Good Hope so that the method of referring the satellite to faint stars as in previous years may be continued. Approximate measures of the first two photographs of the satellite show that the ephemeris computed by Mr. Crommelin from the elements determined by Mr. Cowell is only 20″ in error.

Astrographic Equatorial.—The photography of the fields of the Oxford Astrographic Zone + 25° to + 31° declination was continued till November. Since that date the instrument has been fully occupied in taking photographs to determine the magnitudes of the stars whose co-ordinates and measured diameters are given in the two volumes of the Greenwich section of the Astrographic Catalogue which have been already published. Professor Pickering has lately given the photographic magnitudes of a number of stars near the North Pole. These are very suitable standards, and a comparison with them has been obtained by photographing on the same plate fields of stars when at the same altitude as the Pole and the polar region itself. As a check on possible changes in the atmospheric conditions the plates are exposed first on the Pole, then on the area required, and a second time on the Pole, each exposure being of 10^m duration. In this way the magnitudes of a sufficient number of stars are determined to serve as reference stars for the determination of the magnitudes of the stars from the measured diameters already published. Commencing at the Pole, photographs of the Astrographic fields whose centres are at the even degrees of declination are being taken. It will probably be desirable to compare every alternate field in the even zones with the polar region.

Photographs have also been taken with this instrument of fields of reference stars for the determination of positions of the faint satellites of Jupiter and Saturn on photographs taken with the 30-inch Reflector. Also of Halley's Comet, of Nova Lacertae with stars for comparison, and of the field of stars surrounding the Moon on the occasion of the eclipse of November 16.

Altogether, with the 13-inch Astrographic Telescope, 376 photographs have been taken on 110 nights. Seventy-five of these have been rejected; 29 because

the exposure was unfinished owing to cloud or because the plate did not come up to the standard in showing faint stars, 44 for faults of setting or guiding.

The remaining 301 plates are made up as follows:—

Chart Plates (exposure 40^m) Dec. + 25° to + 31°	83
Catalogue (exposures 6^m, 3^m, 20^s)	90
Plates for Photographic Magnitudes Dec. 78° to Pole	78
Halley's Comet	11
Nova Lacertae	19
Reference fields for satellites of planets	15
Lunar Eclipse	2
Plates for adjustment of instrument	3
	301

Five photographs of Halley's Comet were also taken with the Ross 4-inch lens mentioned in last year's Report.

In continuation of the work referred to in last year's Report, the right ascensions and declinations of 7,200 stars have been determined from the rectangular co-ordinates given in the two published volumes. This completes the computation of the right ascensions and declinations of all the stars which it is proposed to publish in this form. This catalogue will contain all stars in the Greenwich section of the Astrographic Catalogue which are found in existing meridian catalogues. The results have been collected and the work examined from the Pole to declination 72°. Comparisons have been made with the Greenwich Second Nine-Year Catalogue for 1900, and the Kasan and Dorpat Zones of the *Astronomische Gesellschaft* Catalogue. It is proposed to convert the coordinates of all the stars between declination 87° and the Pole given in Volume II. of the Astrographic Catalogue into rectangular coordinates on a plane tangent at the Pole. This work is in progress.

Of the plates taken for photographic magnitudes, 65 have been measured. From these measures magnitude constants have been determined for plates in the zones of even degrees, and those for plates in the odd zones are being deduced by comparison of stars in overlapping portions.

Franklin-Adams Photographs.—The determination of the number of stars of different magnitudes on the series of photographs of the whole sky taken by

Mr. Franklin-Adams is being carried out at the Observatory, the cost of the computers employed in the enumerating being borne by Mr. Franklin-Adams. The actual counting of the plates was begun on 1911 March 14, after some time spent in preparatory work. On each plate the stars in 25 uniformly distributed regions are counted. Each region is a square of 20′ side, the centres of the regions being the intersections of réseau lines 3° apart. The stars are tabulated according to their photographic magnitudes by comparison with a scale in the eye-piece. The calibration of the scale for each plate will be obtained by a comparison of regions on the plates with the Pole, in a manner similar to that employed for the Astrographic plates. Twenty-six plates have been dealt with, covering the part of the sky from the North Pole to dec. + 53°. The number of stars enumerated to 1911 May 10 is 42,284. The greatest number counted on any one plate (in twenty-five 20′ squares) is 5,138, and the least 301. The plates whose centres are at 45° N. declination are now being counted.

III.—Heliographic Observations:—

The Dallmeyer photoheliograph No. 2 has been removed from the roof of the South wing of the New Building and mounted in the dome of the Old Altazimuth. The dome has been altered to make it more suitable for observation of the Sun in accordance with a suggestion made by Mr. Jacob, the Civil Engineer. One quarter of the original dome has been cut out, and a corresponding quadrant has been fixed permanently in the North, so that the dome is closed by bringing the opening under this fixed covering. The wider opening given by this arrangement is necessary in order to secure good definition in the photographs of the Sun.

In the year ending 1911 May 10, photographs of the Sun were taken on 182 days, on 179 of which the Thompson photoheliograph was used, and the Dallmeyer on the remaining three days.

From the beginning of May the photoheliograph duty has commenced at 7 a.m., instead of 9 a.m., with the result that photographs of the Sun have been obtained on some days when they would otherwise have been lost. It is proposed to continue this arrangement to the end of August, and in the months of September and April to commence the duty at 8 a.m.

The Photoheliographic Results for the years 1907, 1908, and 1909 have been printed; and the copy for press of the daily results for the entire year, 1910, has gone to the printer.

With the end of the year 1909 the Royal Alfred Observatory, Mauritius, ceased to be a source from which the Greenwich series of solar photographs could be supplemented. On 1910 March 1 the daily photographic record of the Sun's surface was commenced at the Royal Observatory, Cape of Good Hope, under the direction of Mr. S. S. Hough, H.M. Astronomer, and from 1910 June 1 the photographs taken at the Cape have been regularly used to supplement those taken at Greenwich. The combined Cape and Greenwich series represents for the 10 months ending 1911 March 30, 280 days out of the 303, leaving only 23 days to be supplied from India.

The numeration of the spot-groups from a preliminary examination of the solar photographs, and the publication, month by month, in *The Observatory* of the lists of the spot-groups thus numbered, with their descriptions and rough estimations of their areas and mean heliographic longitudes and latitudes, have been continued during the year, the last list published being that of the groups of 1911 January, appearing in *The Observatory* for 1911 May. This numeration of the spot-groups has been officially communicated, month by month, to the Director of the Kodaikánal Observatory.

Of the photographs taken, 393 have been selected for preservation, including 21 with double images of the Sun for the determination of zero of position angles. Supplementary photographs have been received from Dehra Dûn, India, through the Solar Physics Committee, up to 1911 January 27; and from the Royal Observatory, Cape of Good Hope, up to 1911 March 30.

The Greenwich series of photographs, supplemented by the photographs from the Cape, and the observatories of Kodaikánal and Dehra Dûn, is complete for each day of the year 1910, the record being made up from the following sources:—

Greenwich	171	days.
Cape	104	„
Dehra Dûn	89	„
Kodaikánal	1	„
Total	365	„

The measurement of these photographs is complete to the end of 1910, and for those taken at Greenwich to 1911 March 10, whilst those taken at the Cape have been measured up to 1911 March 6.

The solar activity in 1910, as evidenced by the numbers and areas of spots and faculæ showed a great falling off from 1909; the mean daily spotted area for the year just passed being considerably less than half that in the preceding year. There were two short-lived revivals of activity in 1910; the one in February, when two important disturbances were observed during the latter half of the month; the other consisting of two great groups seen at the end of September, and during October. Since the last of these disappeared the solar surface has been very quiet; the groups of spots have been few and small, and the Sun's disc has been free from spots on about 67 days in the five months ending with March 31. The Sun appears to be rapidly approaching the minimum phase of spot activity.

During the minimum the opportunity will be taken to use the 37 years' observations, now available, for a determination of the direction of the Sun's axis. A preliminary discussion has been made of the years 1907–9 with a view of seeing how to utilise all the available material to the best advantage.

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 as in former years with the declinometer, the Gibson deflexion instrument, and the Airy dip circle mounted in the Magnetic Pavilion.

The correction required for the scale of the horizontal force magnetograms for 1910 January (mentioned in last year's Report), gave rise to a discussion of the method employed in the annual scale determination, and some modifications were made by Mr. Chapman both in the observations and in the method of deduction of the scale value.

The magnetic reductions for 1910 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 principal results for the magnetic elements for 1910 are as follows:—

Mean declination - - -	15° 41′·2 West.
Mean horizontal force - - -	0·18532 (in C.G.S. units).
Mean dip (with 3-inch needles) -	66° 52′ 37″.

These results depend on observations in the Magnetic Pavilion, and are free from any disturbing effect of iron in the Observatory buildings.

In 1910 there were no days of great and six of lesser magnetic disturbance. Traces of the photographic curves for these days, 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, selected till the end of 1910 in concert with Dr. Chree, has been continued. From 1911 it is proposed to use the days adopted by the International Committee on Terrestrial Magnetism, to which quarterly reports are sent classifying the days in three divisions according to their magnetic character.

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. Cloud observations in connection with the international balloon ascents have been made with a Fineman nephoscope.

From 1911 March 1 regular observations of the thermometers on the roof of the Magnet House were discontinued, and from the same date the daily observations of the earth thermometers were replaced by weekly ones, except in the case of that at 3 ft. 2 in. depth.

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 read out and completely reduced to the end of 1911 April, except for the electrometer, which is complete to the end of 1910. The table of principal changes of the wind for 1910 is not yet completed.

The mean temperature for the year 1910 was 49°·7, or 0°·1 above the average for the 65 years 1841–1905.

During the 12 months ending 1911 April 30 the highest temperature in the shade (recorded on the open stand in the Magnetic Pavilion enclosure) was 82°·2 on June 20. On the same day the highest temperature in the Stevenson screen in the Magnetic Pavilion enclosure was 79°·9, in that in the Observatory Grounds 81°·2, and in the new screen in the Magnetic Pavilion enclosure, 80°·7.

The lowest temperature of the air recorded during the same period was 21°·6 on February 1. During the winter there were 43 days on which the temperature fell to or below 32°·0, being 13 less than the average number.

The mean daily horizontal movement of the air in the year ending 1911 April 30 was 313 miles, which is 30 miles above the average of the preceding 43 years. The greatest recorded daily movement was 820 miles on December 16, and the least 78 miles on January 20. The greatest recorded pressure of the wind was 30·5 lbs. on the square foot on December 16, and the greatest velocity in an hour 52 miles on the same day.

During the year 1910, Osler's anemometer showed an excess of 12 revolutions of the vane in the positive direction N., E., S., W., N., excluding the turnings which are evidently accidental.

The number of hours of bright sunshine recorded during the 12 months ending 1911 April 30, by the Campbell-Stokes instrument, was 1,300 out of 4,458 hours during which the Sun was above the horizon, so that the mean proportion of sunshine for the year was 0·292, constant sunshine being represented by 1. Most of the months showed a deficiency in the duration recorded, especially July, which, like June in the previous year, provided only about half the average amount. The only month showing substantially more than the average was May.

The rainfall for the year ending 1911 April 30 was 25·93 inches, being 1·81 inches greater than the average of the 65 years, 1841–1905. The number of rainy days (0·005 inch or over) was 175. The greatest daily amount was on April 2, when the total reached 0·790 inches. On ten other days more than half an inch of rain fell. The wettest months were July, November, and December, in each of which the total just exceeded $3\frac{1}{2}$ inches.

The hourly velocities from the early records of the Robinson anemometer (mentioned last year) have been read in and tabulated; and the 40 years' summary is to be printed by the end of the year.

VI.—Printing and Distribution of Greenwich Publications:—

The copies of the volume of Greenwich Observations for 1908, including the Photoheliographic Results for 1907, were distributed in January 1911.

The printing of the Greenwich Observations for 1909 is finished and the volumes will be distributed shortly.

The Photoheliographic Observations for 1910 are in the press, the Rates of Chronometers and Watches for 1910 are printed and are being distributed.

The printing of the new investigation of the motion of Halley's Comet from 1759 to 1910 by Messrs. Cowell and Crommelin, alluded to in last year's Report, has now been completed, and it will appear as an Appendix to the Greenwich Observations for 1909. The result of the revision was to change the predicted time of perihelion in 1910 from April 16·61 G.M.T. to April 17·01, still leaving a discordance of 2·68 days between prediction and observation.

VII.—Chronometers, Time Signals, and Longitude Operations:—

The number of Government marine chronometers and watches now at the Observatory is 405, viz., 174 box chronometers, 25 pocket chronometers, 111 chronometer watches, and 95 hack watches.

In addition to these there are, at the Observatory, 7 box chronometers and 2 watches being tested after repair for the Indian Government.

There are also 19 hack watches and 3 chronometer watches on trial for purchase by the Admiralty.

In the year ending 1911 May 10, the average daily number of chronometers and watches being rated was 550, the total number received was 1,672, the total number issued was 1,732, and the number sent for repair 744. This last number includes 25 box chronometers, 1 pocket chronometer and 4 watches belonging to the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 47° to 107°, 62 chronometers were sent in. During the trial 28 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 34 chronometers, 12 were purchased for the Navy.

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, 208 watches were entered, of which 77 were classified, and of these 60 were purchased for the Navy. Among the watches classified were 30 with centre-seconds' dials; of these 24 were purchased. There were 14 "Karrusel" or "Tourbillon" watches classified, of which 12 were purchased. The performance of the watches was exceptionally good.

A trial of pocket chronometers took place concurrently with the trial of chronometer watches, and under the same conditions as regards duration of trial, temperatures, and positions. Of the 15 pocket chronometers sent in, 3 were purchased for the Navy.

The next trial of box chronometers will commence on June 17, and of pocket chronometers and chronometer watches on July 31.

Since 1905 November, watch makers have been permitted to send hack watches for trial at any time. On receipt at the Royal Observatory they are at once rated under certain conditions, and those coming up to the required standard are purchased for the Admiralty. Altogether 420 such watches have been submitted, and of these 204 have been purchased. There are at present 19 under trial. A trial of

non-magnetic watches took place concurrently with and under the same conditions as the chronometer watches. Eight were sent in for trial and 4 were purchased.

To obtain data as to the relative performance of ordinary and non-magnetic watches in the actual conditions of service a number of watches of both classes were under the Hydrographer's direction specially rated on submarines.

Experiments on the effect of a strong magnetic field on non-magnetic watches have been made and are still in progress at the Royal Observatory.

Provision is now being 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.

(*a*) A trial of non-magnetic chronometer watches will take place under the same conditions as last year, but, in addition, those coming up to the standard for chronometer watches will be further tested in a strong magnetic field.

(*b*) The less highly adjusted non-magnetic watches may be sent to the Royal Observatory at any time by the makers. They will be rated for a period of six weeks, including two weeks in the oven. Those coming up to the necessary standard will then be tested in a strong magnetic field.

Since there has been of recent years a large increase in the number of electric motors and other sources of magnetic disturbance on board the ships of His Majesty's Navy, it has become important to determine the minimum distances from such disturbed regions at which chronometers can safely be placed. At the request of the Hydrographer the determination of the maximum intensity of magnetic fields (horizontal and vertical) in which a chronometer may be placed without the alteration in its rate exceeding certain limits is being investigated. Preliminary experiments have been made during March and April 1911, the apparatus consisting of two horse-shoe magnets excited by current drawn from the lighting circuit of the Observatory, suitable resistances being inserted in the circuit. More exhaustive observations will begin shortly with a much larger magnet, consisting of the pole piece of a disused dynamo.

The Greenwich time-ball was not raised on 3 days (December 16, February 22, and March 26) owing to the violence of the wind.

The automatic drop of the Deal time-ball failed on 11 days owing to interruptions of the telegraphic communications. On December 12, the current was too weak to drop the ball. On 5 days the time-ball could not be raised on account of the violence of the wind. Return signals have been received daily except on 26 days.

The return signal from Devonport failed on 64 days (of which 12 were Sundays), and could not be observed on 21 days (of which 7 were Sundays) owing to interruptions by telegraph signals. The apparent error of the clock signal (after daily correction of the clock by aid of a time signal from Greenwich, on the plan described in the Report for 1885) did not exceed $0^s \cdot 2$ on 88 per cent. of the 279 days of observation, and did not exceed $0^s \cdot 5$ on 97 per cent. On 9 occasions it exceeded $0^s \cdot 5$, but never exceeded $1^s \cdot 0$. The average error for the year was $\pm 0^s \cdot 12$.

The return signal from Portsmouth failed on 61 days (of which 30 were Sundays), and could not be observed on 16 days (of which 7 were Sundays) owing to interruptions by telegraph signals. The apparent error of the clock (corrected in the same manner as the Devonport clock) did not exceed $0^s \cdot 2$ on 79 per cent. of the 288 days of observation, and did not exceed $0^s \cdot 5$ on 98 per cent. On 6 occasions it exceeded $0^s \cdot 5$, but never exceeded $1^s \cdot 0$. The average error for the year was $\pm 0^s \cdot 18$.

The return signal from Portland failed on 96 days (of which 49 were Sundays or Holidays), and could not be observed on 14 days (of which 7 were Sundays), owing to interruptions by telegraph signals. The apparent error of the clock (corrected in the same manner as the Devonport clock) did not exceed $0^s \cdot 2$ on 87 per cent. of the 255 days of observation, did not exceed $0^s \cdot 5$ on 97 per cent., exceeded $0^s \cdot 5$ on 7 occasions, on one of which it was over $1^s \cdot 0$. The average error for the year was $\pm 0^s \cdot 14$.

The automatic signals from the Westminster clock have been received regularly since the last Report. On 14 days the signal failed, and on 9 days it was interrupted by telegraph signals. Its apparent error was not greater than $0^s \cdot 5$ on 46 per cent. of the days of observation, not greater than $1^s \cdot 0$ on 77 per cent., not

greater than $2^s \cdot 0$ on 95 per cent. The error was between 2^s and 3^s on 10 occasions, but never exceeded $3^s \cdot 5$.

It has been found desirable to have a permanent record of the time and duration of time-signals, and a small Krille Chronograph has been brought into use to register the outgoing signal and the returns from Deal, Portsmouth, Portland and Devonport.

Three gentlemen have spent a short time at the Royal Observatory during the year in order to gain knowledge of certain parts of the work. Mr. B. F. Bawtree, Assistant in the Nautical Almanac Office, attended from October 25 to November 8 for the purpose of making himself better acquainted with the manner in which predictions made in the Nautical Almanac are dealt with at the Observatory. Lieutenant A. J. Coleman, R.N., Harbour Master at Singapore, attended from November 15 to January 24 to learn the use of the transit instrument in making time determinations, to enable him to take charge of the time-ball there. Mr. Royds attended from December 5 to December 19, prior to taking up his appointment as Assistant Director at the Kodaikánal Observatory.

VIII.—Personal Establishment:—

Mr. Sydney Chapman was appointed Chief Assistant on December 13 to fill the vacancy caused by the resignation of Mr. Cowell.

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

The names in brackets are those of Computers who have joined since 1911 May 10.
* Qualified as Observers with one or more of the instruments.

Two Computers, Lambert and Entwistle (not included in this Table) are employed temporarily at the expense of Mr. J. Franklin-Adams in connection with counting stars on his 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 whole number of persons regularly employed at the Observatory is 60.

IX.—General Remarks:—

In the present state of Sidereal Astronomy there is no work to which a large refractor can be more profitably put than to the determination of stellar parallax

The determination of the Solar parallax from photographs of Eros has given valuable experience to the Staff of the Observatory in the treatment of stellar photographs where great accuracy is required. It is therefore proposed to undertake measurements of stellar parallax from photographs taken with the 26-inch Refractor, and a commencement of the photography, though not of the measurement, has already been made. The researches will be mainly confined to the part of the sky which fell to the share of Greenwich in the Astrographic Chart, viz., from 64° North Declination to the Pole. The Kapteyn Areas will be studied, and it is also hoped to determine the parallaxes of individual stars in this area with proper motions greater than 20″ a century given in the Introduction to the Greenwich Second Nine Year Catalogue.

As stated in the paragraph of the Report dealing with the Astrographic Equatorial, the work of the Astrographic Chart and Catalogue is near completion as regards the positions of the stars. This work can now be supplemented by a determination of the photographic magnitudes of the stars, which can be more readily undertaken now than would have been possible a few years ago. A convenient standard has been recently published by Prof. Pickering, who has given the photographic magnitudes of a sequence of stars near the North Pole. A comparison of a sufficient number of areas with this standard appears to be the most direct and practicable method of obtaining on a uniform system the photographic magnitudes of the large number of stars of the Astrographic Catalogue. By giving a suitable exposure with the Astrographic Equatorial to any field of stars when at the same altitude as the Pole, and photographing the polar area on the same plate, the magnitudes of all stars in the field fainter than $8^{m}\cdot8$ on Pickering's scale can be determined without any extrapolation. The brighter stars in Pickering's sequence are too far from the Pole to be used as standards in this way, and it is proposed to supplement this work for the stars brighter than $8^{m}\cdot8$ by taking photographs on a similar plan with the Franklin-Adams 6-inch lens, which has a much larger field.

The counting of the stars on the Franklin–Adams plates so as to show the number of stars of different magnitudes over the whole sky presents an attractive and difficult problem which will be approached in the same way, *i.e.*, by comparison, direct or indirect, with the polar standards.

Till the end of 1896 full details of all meridian observations were given in the Greenwich Volume. From 1897 these details were confined to the Sun, Moon,

planets and fundamental stars, and a considerable reduction made in the amount of printing. Owing to the gradual increase of work in various departments, the Volume is still inconveniently large, and the advisability of making further reductions in it has been considered. Experience shows that nothing has been lost so far as security against mistakes and facilities for detection of errors are concerned by the change made in 1897. I think it will be sufficient in future to print particulars of the instrumental and clock errors only and to omit the detailed journal of the meridian transits and zenith distances. No changes are proposed in the printing of the extra-meridian observations of the Altazimuth or the observations made with the Reflex Zenith Tube.

F. W. DYSON.

Royal Observatory, Greenwich,
1911 May 11.