

R E P O R T
OF THE
ASTRONOMER ROYAL
TO THE
BOARD OF VISITORS
OF THE
ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1907 June 8.

GREENWICH OBSERVATIONS, 1906.

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Read at the Annual Visitation of the Royal Observatory, 1907 June 8.

The Report here presented refers to the year from 1906 May 11 to 1907 May 10, and exhibits the state of the Observatory on the last-named day.

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

The painting (external and internal) of the Observatory buildings, which was in progress at the date of the last Report, was practically completed last November.

A new porch and covered glass passage have been erected in front of the Astronomer Royal's official residence in substitution for the old porch and passage, which required renewal, and a new and wider pathway has been laid in granolithic cement in front, leading from the Old Observatory building to the Chronograph room.

The cross-trees of the Time Ball mast have been renewed.

The lightning conductors from the Octagon room roof and from the Magnetic Pavilion have been connected to distant water mains, so that there would in the former case be no risk of interference with the earth connections of the time-signal and other telegraph circuits of the Observatory.

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Provision has been made in the Navy Estimates for the permanent storehouse for portable instruments, huts, chronometer baskets, &c., referred to in the last Report, and plans for the building have been prepared.

The principal movable instruments are thus distributed:—

At Greenwich—

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

Altazimuth 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.—Nos. 2, 3, and 5. (The object glass of No. 5 has been lent to Professor Turner since the Eclipse Expedition of 1898.)

Detached Telescopes (on tripod stands).—Two 4-inch (Simms Nos. 1 and 2), two 4-inch (R.O. Nos. 1 and 2), one $3\frac{1}{2}$ -inch (R.O. No. 3).

Two Hilger Chronographs.

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; D, to the Colonial Office for use of Major Watherston for Longitude Observations on the Gold Coast.

Equatorials.—Lee (6-inch), at the Hong Kong Observatory; Simms No. 2 (6-inch), lent to the Science and Art Department.

Photoheliographs.—No. 1, complete, at the Cape Observatory; No. 4, complete, at the Kodaikanal 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; and 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 South Kensington Museum.

Lent to the Royal Observatory for observation of Solar Eclipse—

Coelostat, with 16-inch Mirror by the Government Grant Committee.

Double Spectroscope, Quartz and Flint, by Major E. H. Hills, R.E.

Heliostat with 12-inch Mirror, by Major E. H. Hills, R.E.

The annual examination of the Library has been made as usual, the book on the shelves being compared with the catalogue. Of the 12 books missing last year two have since been returned, and of 15 books missing this year, 10 were reported as missing last year. As regards the Magnetic and Meteorological Library, no books are missing. Good progress has been made with the Author's Catalogue for this Library, which is completed for 25 bays of the 38 in this Library.

II.—Astronomical Observations :—

Transit Circle.—At the end of May 1906 the friction wheels, on which the axis of the instrument rests, were found to have worn, and were re-turned. At the beginning of July a new Z.D. micrometer screw was applied.

The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. The other stars observed are taken from a new working catalogue of stars of 9.0 magnitude and brighter between the limits $+24^{\circ}$ to $+32^{\circ}$ of N. declination, serving as reference stars for the Oxford Astrographic Zones.

The number of observations from 1906 May 11 to 1907 May 10 is as follows :—

Transits	-	-	-	-	-	-	-	-	7,704
Determinations of Collimation error				-	-	-	-	-	265
Determinations of Level error				-	-	-	-	-	539
Circle observations	-	-	-	-	-	-	-	-	7,311
Determinations of nadir point (included in the number of circle observations)				-	-	-	-	-	509
Reflexion observations of stars (similarly included)							-	-	291

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The transits are completely reduced (so as to exhibit mean R.A. 1910.0) to 1907 April 27 and Apparent R.A. is formed to May 3.

The circle observations are completely reduced to 1907 April 22.

The investigation of personal equations is complete for 1906.

The R-D discordance has been investigated for 1906.

The corrections for variation of latitude to be applied to the observations for 1906 have not yet been received from Professor Albrecht.

The apparent correction for discordance between the nadir observations and stars observed by reflexion in 1906 is $-0''.38$. The values found since 1892 range from $-0''.20$ to $-0''.41$. Four-fifths of this quantity is applicable to observations of the nadir in forming the zenith point on days when no reflexion observations of stars are obtained, and since 1897 January 1 the value $-0''.25$ 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 1906, 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.
1906	$+0''.34$	$0''.00$	$+0''.23$	...	$+0''.19$	$0''.00$	$-0''.01$	...
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 1906 is $+0''.089 + 0''.472 \sin Z.D.$; the co-efficient of $\sin Z.D.$ agreeing better with the adopted value ($0''.600$) than the results of recent years have done.

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) is $-0^{\circ}.412$ in R.A. deduced from 94 observations.

Some observations with the reversion prism, designed to ascertain whether the direction of motion had a systematic effect, revealed the fact that the adopted wire-intervals were sensibly in error. It had been assumed that when one or two wires were renewed the intervals of the remainder were unaffected, but it now appears probable that the process of inserting new wires is liable to displace the existing wires. Correct wire-intervals were determined and all the reductions of transits and determinations of azimuth error affected by the erroneous wire-intervals were corrected. A redetermination of the intervals of the wires for the periods covered by the forthcoming Second Nine Year Catalogue, 1897--1905, was undertaken, 1,200 transits being worked up in each year. The result of this extensive discussion disclosed sensible errors in the adopted wire-intervals, but as these were of the nature of accidental errors as affecting the transits no corrections have been applied, the systematic effect on the catalogue places being presumably negligible.

The Second Nine-Year Catalogue, Epoch 1900, which was terminated at the end of 1905, will be divided into two sections—Part I., Fundamental and Zodiacal Stars; Part II., Astrographic Reference Stars. For both sections the places of the stars for 1900 have been determined, and it is hoped to have the catalogue ready for press before the end of the year. Some 1,200 of these stars, which are common to the Carrington Catalogue for 1855, have been compared with it, and from the comparison, after corrections for systematic discordances have been applied, proper motions have been determined. These proper motions and those derived from the new reduction of Groombridge's Catalogue, have been used by Mr. Eddington as the data for a paper on the "Systematic Motions of the Stars," in which Kapteyn's hypothesis of two star-drifts has been examined and independently confirmed (*Monthly Notices R.A.S.*, Vol. lxvii., p. 34).

The manuscript computations of Mr. Cowell's discussion of the Greenwich meridian observations of the Moon, 1750 to 1901, have been bound in 28 volumes. Three type-written copies of the deduced errors of the Moon's tabular longitude and latitude for each day of the whole period have been made, so that they may be available for any future discussion of lunar theory.

Altazimuth.—A new system of webs was inserted in the instrument in 1906 October. In connection with the determination of their intervals, the errors of

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the three micrometer screws (viz., azimuth, zenith-distance, and position micrometers) were re-investigated; the wear was found to be small but sensible. In 1907 March, the object glass was taken off and the lenses separated in order to remove some moisture that had penetrated between them. The lenses were replaced without causing any sensible alteration of focus or line of collimation.

An improved method of illumination of the field, which has been found to be successful with one of the portable transit instruments, is being applied to the altazimuth. The existing arrangement with a small reflecting prism cemented on the object glass has the disadvantage of reproducing in the illuminated field any optical defects of the combination in a highly magnified form, and to obviate this scattered light from finely ground opal glass is substituted for reflected light from the prism, so as to give uniformly diffused illumination of the field, which is a matter of importance as affecting observations over the wires as seen on the illuminated background.

The instrument has been used as a reversible transit-circle in the meridian in four positions during the year, the positions being changed regularly every two months. Observations of the Sun, Moon, planets, and the fundamental stars contained in the National Ephemerides and in Newcomb's Fundamental Catalogue, have been made throughout the year.

The instrument has been used regularly for extra-meridian observations of the Moon during the first and last quarters of the lunation.

The observations of the crater Mösting A, started in 1905, are being continued, whenever it is observable. The observations of transits serve to connect the observations of the first and second limbs made before and after full moon respectively; and the observations of zenith distances will, in combination with similar observations now being made at the Cape Observatory, serve to determine the parallax of the Moon.

Mösting A has also been observed with the transit-circle when practicable.

The following observations have been made during the year:—

	No. of Observations.
Collimation, Level, and Azimuth - -	275, 363, and 115 respectively.
Nadir: Reflexion observations of stars - -	345 and 108 „
Flexure - - - - -	11
R.A. and N.P.D. of Sun, planets, and stars (in meridian) - - - - -	1,265 and 1,205 „
R.A. and N.P.D. of Moon (in meridian) -	70 and 69 „
R.A. and N.P.D. of Mösting A - -	41 and 41 „
Azimuth and Zenith distance of stars (extra meridian) - - - - -	156
Azimuth and Zenith distance of Sun and planets (extra meridian) - - - - -	3
Azimuth and Zenith distance of Moon (extra meridian) - - - - -	36

The altazimuth observations are reduced to the end of 1906, but the corrections to be applied for latitude variation have not yet been received. Of the observations for 1907, the transits are reduced to March 11 and the meridian zenith distances to January 30. The extra-meridian observations are completely reduced to 1906 December 31.

The R-D discordance has been investigated separately for each two months of the year during which the instrument remained in one position. The direct observations have also been compared in reversed positions of the instrument with the positions given in Newcomb's Fundamental Catalogue. In this way a correction of $0''.47$ has been derived, agreeing with the constant part of the R-D correction, which, applied with one sign to two positions of the instrument and the opposite sign to the other two, reduces the observations to the mean which would have been obtained had the stars been equally observed in all positions of the instrument.

The observations of the Moon both in and out of the meridian seem very satisfactory, as shown by the agreement between the two instruments—transit-circle and altazimuth.

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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 1907 May 10:—

Time of Moon's Meridian Passage. h. h. 1-2 G.M.T.	Transit Circle.		Altazimuth.		
	Limb.	Mösting A.	Meridian.		Extra Meridian.
			Limb.	Mösting A.	Limb.
1-2	0		0		1
2-3	0		0		2
3-4	3		0		5
4-5	4		0		7
5-6	7		2		3
6 9	28	16	19	10	5
9-12	27	19	18	12	0
12-15	21	17	18	12	0
15-18	16	8	12	7	0
18-19	2		0	0	3
19 20	3		1		3
20-21	3		0		5
21-22	0		0		2
22-23	0		0		0

The total number of observations of the Moon is 114 with the transit-circle and 106 with the altazimuth, viz.:—70 in the meridian and 36 extra-meridian.

Taking both instruments, observations of the Moon have been obtained on 146 days during the year.

Reflex Zenith Tube.—The scheme of observation with this instrument has been hitherto much hampered by unforeseen vacancies which have occurred in the staff of established computers during the last three or four years, the number of regular observers with the transit-circle and reflex zenith tube being consequently reduced from four to three, as vacancies occurred too rapidly to allow of their

being filled up. It was not till last October that the staff of regular observers was completed and it became practicable to carry out fully the original scheme of observation, which comprised two principal groups of stars with a supplementary group to strengthen the overlap of the two groups at the critical time in the spring, when one group runs into daylight in the evening, while the other, with the exception of β and γ Draconis and ι^2 Cygni, is not yet observable in the morning. To strengthen the connection of the two principal groups in the late autumn another supplementary group has been added, and arrangements have been made for the regular transit-circle observer to take part in the zenith-tube observations as far as circumstances allow. This enlarged scheme of observations has been in operation since last November.

During the year, 901 double observations and 34 single observations have been obtained, the number of different stars observed being 85. 74 observations of γ Draconis, 54 of β Draconis, and 46 of ι^2 Cygni, distributed throughout the year, have been obtained; 38 observations of 30 Draconis extend from May 11 (in continuation of last year's series) to September 10 and from March 18 to May 10; the group of stars from 27 Lyncis to θ Ursæ Majoris was observed continuously from the middle of November to the middle of April, the supplementary group which includes 5 Canum Venaticum to θ Boötis from the end of January onwards, and the two stars β and 9 Lacertæ from August 21 to January 4. The reduction of the observations is completed to December 31.

Clocks and Chronographs.—The clock Dent 2, fitted with a mercurial pendulum, has been thoroughly overhauled, the contact springs improved, and a new contact spring for a minute signal added. The clock is intended to be used when the Sidereal Standard is under repair. Dent 2009, in the S.E. Dome, has been cleaned, and Graham 1, in the Altazimuth Dome, is now being cleaned by E. Dent & Co.

Equatorials.—During the year ending 1907 May 10, 24 disappearances and 3 reappearances of stars occulted by the Moon have been observed by one or more observers. 14 of the stars of which the disappearance was observed were below the limit of magnitude adopted by the Nautical Almanac, viz., 6.5 for 1906 and 7.0 from the beginning of 1907, and these occultations were not notified there.

The 28-inch Refractor.—The wheelwork at the top of the dome, used for the purpose of opening the shutters, became defective, and it was found necessary to have certain portions renewed. These repairs occupied the whole of July, the

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instrument being out of use from June 27 to July 31. This, in addition to the long spells of bad observational weather, reduced the number of nights on which measures were made to 86, as compared with 105 in the previous year. The new working catalogue of double stars contains primarily the pairs discovered by Hough, and is completed by selected pairs from the various catalogues of Struve, Otto Struve, Burnham, Hussey, and Aitken. The measures made consist of—

—	Hough.	Miscellaneous.
Double stars under $0''.5$ separation - - -	13	45
„ „ between $0''.5$ and $1''.0$ separation - -	20	42
„ „ between $1''.0$ „ $2''.0$ „ - -	26	36
„ „ over $2''.0$ separation - - -	135	83

Measures were made of κ Pegasi on 14 nights, of δ Equulei on 10 nights, and of 70 Ophiuchi on 11 nights. The period of κ Pegasi is 11.4 years, so that last autumn one revolution was completed since observations of this star with the 28-inch were commenced. During this time measures have been made on 129 nights, distributed all round the orbit, the separation never exceeding $0''.3$. Similarly, δ Equulei has been measured on 88 nights during its revolution of 5.7 years.

Equatorial and polar diameters of Jupiter have been measured first with the filar micrometer, and then with the double-image micrometer on the same nights. The 28-inch is well adapted for this, as the breech end is arranged for either direct or diagonal view by means of a plane mirror which can be readily inserted or withdrawn. The bi-filar was mounted for direct view, and the double-image micrometer for diagonal view with the plane mirror. Complete sets of measures were made on 13 nights; they are in continuation of those mentioned in the last Report, the series being intended to supplement similar measures made during the opposition of 1895–1896. The diameters of the satellites were measured on two nights with the filar micrometer.

Thompson Equatorial.—The 30-inch mirror was re-silvered in November. Before remounting the mirror an attempt was made to hold it more rigidly in its cell without pinching it by means of 12 wedges of *lignum vitæ* placed symmetrically around the mirror and driven between the cell and the steel supporting band. This has proved fairly satisfactory.

With the 26-inch *Refractor*, 37 photographs of Neptune and its satellite have been taken on 18 nights. The occulting shutter has been used as in previous oppositions.

In connection with the observations of Jupiter's Sixth and Seventh satellites with the 30-inch Reflector, 10 photographs of Jupiter have been taken on seven nights with the 26-inch Refractor, for determination of its position with reference to the stars used in the reductions of the observations of the satellites.

With the 30-inch *Refractor*, the following photographs have been taken:—

55 photographs of Jupiter and Satellite VI on 29 nights.

11 „ „ „ VII „ 7 „

135 „ 54 minor planets.

22 „ Comet *d* 1906 on 18 nights.

7 „ „ *e* 1906 „ 7 „

6 „ „ *g* 1906 „ 6 „

and of the following nebulae:—

M. 31 (Andromeda) - 1 photograph. Ring Nebula in Lyra - 6 photographs.

M. 51 Can. Ven. - 4 photographs. Pleiades - - 1 photograph.

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

Jupiter, Satellites VI and VII, 55 and 11 photographs respectively.

Comet *c* 1905 - - - 9 photographs.

„ *a* 1906 - - - 19 „

„ *b* 1906 - - - 20 „

Neptune and Satellite - - - 62 „

Minor Planets 1903 - - - 55 „

„ „ 1904 - - - 146 „

„ „ 1905 - - - 59 „

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The following have been measured and partly reduced :—

Comet <i>d</i> 1906	-	-	22	photographs.
„ <i>e</i> 1906	-	-	7	„
„ <i>g</i> 1906	-	-	6	„
30 minor planets	-	-	75	„ taken in 1906.
9 „ „	-	-	25	„ „ 1907.

The discussion of the photographs of Eros 1900–1901 has been completed, and the value of the solar parallax deduced from them. In connection with this, an extensive series of measures of errors of the lines of the silver réseau and of its images as photographed on the plates, with special reference to the central lines near which Eros is usually placed, has been made to supplement the preliminary determinations made in 1903. An account of this investigation and a discussion of the resulting value of the solar parallax have been published in the *Monthly Notices R.A.S.* for January and April of this year.

Astrographic Equatorial.—Work with this instrument is still confined in the main to replacing Chart plates which, though satisfactory in other respects, are, owing to slight photographic defects, unsuitable for reproduction of enlarged prints.

Altogether 188 photographs have been taken on 91 nights. Of these 55 have been rejected : 17 because the exposure was unfinished owing to cloud, or because they did not reach the standard in showing faint stars ; 20 owing to faults in the plates, as received from the makers ; and 18 for miscellaneous causes, 14 of these being that the réseau was printed askew on the plate, the result of an accident to the réseau printing frame.

The remaining 133 plates are made up as follows :—

Chart plates (exposure 40 ^m)	-	-	-	-	102
Catalogue plates (exposure 6 ^m , 3 ^m , and 20 ^s)	-	-	-	-	4
Plates for adjustment	-	-	-	-	24
Pleiades	-	-	-	-	3

Positives have been made and passed for the 62 plates, which complete the zones 71°–74°. The remaining 461 Chart plates covering the zones 75° to the Pole have been examined, and it appears that of these 75 have slight defects which

render them unsuitable for reproduction. It is proposed to photograph these fields again in the course of the next year.

During the year copy for press was prepared of the measures of the stars on the upper halves of the plates whose centres are at declination $+87^\circ$, of all the stars on the plates of declination 88° and 89° , and on five plates whose centres are at the Pole, but whose central réseau lines have orientation differing by multiples of 90° . For these plates the method of measurement in the duplex micrometer adopted for the lower zones was so far modified that each plate was measured by itself, and all the star images up to the extreme lines of the réseau were included. In the copy for press the stars on each plate were numbered separately, and the plates were afterwards compared with those adjacent, and to every star reference numbers are assigned showing all the plates (of which there may be as many as seven) on which the star appears.

The measures of the Zones 85° , 86° , and of the plates above described have been printed during the year. These zones contain 6,223 separate stars covering 79 square degrees of the sky, and fill 116 pages of the printed catalogue. Volume II. of the Greenwich Astrographic Catalogue is now complete, except for the preparation and printing of the Introduction, which will contain the constants of the plates.

As mentioned in last year's Report, the computation of the plate constants for Volume II. was deferred until the final values of the star places could be obtained from the Greenwich Second Nine-year Catalogue for 1900. These being now available, Standard Co-ordinates (8,798 in all) have been computed for the reference stars on the 444 plates of Zones 72° to 80° inclusive, and the constants, excluding the constants of the centre, have been computed for these plates, excepting 22 in Zone 72° and also for those of Zones 86° to the Pole inclusive. The whole number of plates for which constants have been computed during the year is 479.

As regards the Chart plates, the stars in Zone 81° from 6^h to 24^h , and in Zones 82° to the Pole, have been counted during the year. The following table of the total number of stars shown with exposures 20^s , 3^m , 6^m , 40^m , as well as the number shown in duplicate, is in continuation of the table given last year. The first column for each exposure gives the number of stars shown in duplicate, *i.e.*, on both of the overlapping plates.

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Zone.	No. of Square Degrees.	Number in B.D.		Numbers shown on Photographs.							
		9 ^m .0 and brighter.	Total Number.	Exposure 20 ^m		Exposure 3 ^m		Exposure 6 ^m		Exposure 40 ^m	
81°	53.4	205	850	680	1,042	3,101	4,743	4,048	4,862	17,386	18,675
82°	46.6	181	740	531	894	2,716	4,341	3,598	4,456	14,142	15,090
83°	41.0	176	686	485	764	2,332	3,651	3,020	3,712	11,731	12,770
84°	34.7	146	548	441	665	2,035	3,117	2,620	3,191	9,607	10,351
85°	28.1	117	409	316	501	1,643	2,409	2,094	2,493	6,724	7,392
86°	22.3	90	361	246	392	1,042	1,680	1,393	1,723	4,933	5,559
87°	15.6	53	203	142	215	664	938	755	1,092	2,871	3,166
88°	9.7	45	153	79	135	321	529	417	678	1,751	2,075
89°	3.3	8	40	12	32	132	187	161	237	554	605
Totals	254.7	1,021	3,990	2,932	4,640	13,986	21,595	18,106	22,444	69,699	75,683
Number per square degree }		4.01	15.7	11.5	18.2	54.9	84.8	71.1	88.1	273.7	297.2
Ratios - -		1	3.9	2.9	4.5	13.7	21.1	17.7	22.0	68.3	74.1

In comparing the number of stars counted and measured on the Chart and Catalogue plates respectively in Zones 73° to 79°, with those in the zones of less declination which had been previously counted, it appeared that the number of faint stars counted was relatively less in the higher zones. An examination of this point showed that this was due to a personality of the counters. The Zones 64° to 72° had been counted by practically the same persons. Owing to changes in the staff, Zones 70°, 71°, and 72° were counted by two of these and four new computers. Zones 73° to 79° were counted by these four last-mentioned alone, and an investigation has been made to find how their habit of counting compares with that of the original counters. As the result of this, it has been found that the numbers given in previous Reports, which indicate the stars shown in duplicate on plates of 40 minutes' exposure in Zones 73° to 79°, should be increased in the ratio 1.26 to 1, and that the total number of stars in the same zones (given in the last column of the table) should be increased in the ratio 1.35 to 1.

The reproduction of enlarged prints of the Chart plates has been carried on throughout the year. The reproductions of the three Zones 68° , 69° , and 70° have been completed, and in Zones 71° , 72° , 73° , and 74° the reproductions have been made of the plates from 12^h to 24^h and from 0^h to 6^h . The total number of photographic prints made during the year is about 13,000, reproducing on double scale 225 plates. Altogether reproductions have been made of 626 plates since the work was begun in 1904, being more than half of the total of 1,149 plates which make up the Greenwich Section.

In view of the approaching return of Halley's comet, which may be observable at the end of this year, though its perihelion passage does not occur till 1910, Mr. Cowell and Mr. Crommelin have undertaken a re-computation of the perturbations, which has been completed as far as the action of Jupiter and Neptune is concerned, and is far advanced for Saturn. A preliminary investigation of the action of the Earth and Venus has also been made. An important result of the discussion is the correction of an error in the eccentricity given by Pontécoulant, which will make a difference of about 2° in the geocentric position of the comet next November. Papers on the subject have been published in the *Monthly Notices R.A.S.* for December, January, and April last.

A fine drawing showing a great amount of detail in the inner corona has been made by Mr. Wesley from the photographs of the Total Solar Eclipse of 1905, August 30, taken at Sfax with the Thompson coronagraph, and another drawing to show the coronal streamers is now being made by him from the photographs with the Astrographic 13-inch refractor. These drawings complete the series of drawings made by Mr. Wesley for the Eclipses of 1898, 1900, 1901, and 1905 photographed by parties from the Royal Observatory, which will be available for publication by photo-lithography.

III.—Heliographic Observations:—

In the year ending 1907 May 10, photographs of the Sun were taken in all upon 210 days, the Thompson photo-heliograph being in regular use for this work throughout the year, except for a few days in 1906 November, when it was not available, as the 30-inch mirror, carried by the same equatorial mounting, was being re-silvered. During this interval the Dallmeyer photo-heliograph, which has throughout remained on its own mounting on the South Terrace of the New Building, was used; and occasionally a supplemental photograph has been taken

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with the Dallmeyer on days when the Thompson has also been used. In all, the Thompson photo-heliograph was used alone on 190 days, the Dallmeyer alone on 7 days, and both instruments were used on 13 days.

Of the photographs taken, 464 have been selected for preservation, besides 14 with double images of the Sun for the determination of zero of position angles. Supplementary photographs have been received from Kodaikānal Observatory, India, up to 1907 February 9; from Dehra Dûn, India, through the Solar Physics Committee, up to 1907 March 25; and from Mauritius up to 1906 March 26.

The arrangement, mentioned in last year's Report as having been made in concert with Dr. Walker and Mr. Michie Smith, has worked well. The Greenwich series of photographs, supplemented by the photographs from the two Indian observatories, was complete for 360 days in the year 1906, and 4 of the 5 missing days were supplied from Mauritius, leaving only one day—1906 December 28—unrepresented. The record for 1907 is complete up to February 9, the date of the last photograph received from Kodaikānal, which came to hand on April 25.

The photographs selected for measurement for the year 1906 are from the following sources :—

Greenwich	-	-	-	-	-	184 days.
Dehra Dûn	-	-	-	-	-	155 „
Kodaikānal	-	-	-	-	-	21 „
Mauritius	-	-	-	-	-	4 „
Total						364 „

The measurement and reduction of these photographs are complete to the middle of 1906 September.

In order to meet the wishes of several Directors of Solar Physical Observatories, the experiment has been undertaken during the past year of making a preliminary examination of the solar photographs as soon as possible after those from the two Indian observatories, required to complete the Greenwich series, have come to hand, and of numbering and describing the spot-groups shown upon them. This work of numbering and describing the spot-groups has formerly constituted the last stage in the preparation of the copy for press. These numbers and

descriptions of the spot-groups, together with rough estimations of their areas and mean heliographic longitudes and latitudes, have been published in *The Observatory* month by month, the first list appearing in the issue of that periodical for 1906 August, when the groups of 1906 January to March were numbered and described; whilst the most recent list was that of the groups of 1907 January published in the issue for 1907 May. The work of preparing these lists has proved heavier than was at first anticipated and has tended somewhat to retard the complete measures and reductions, but it is expected that a considerable saving of work, partly compensating for this, will result in the preparation of the final copy for press.

The solar activity as shown in the numbers and areas of sun-spots has shown some remarkable fluctuations during the past year. A great revival began soon after the date of the last Report, culminating in the months of 1906 July and August. A decline followed, and October was a very quiet month. A steady recovery set in with November, which continued until March in the present year, and some of the largest spot-groups of the present sun-spot maximum were observed during December, January, and February. During the year ending 1906 December 31 fifteen separate groups were recorded as having been seen by the naked eye, and fourteen such groups during the present year up to 1907 May 10. On 1907 February 10 and 11 four such groups were seen upon the Sun at one and the same time.

During the past year a number of photographs of portions of the Sun's surface have been taken with the 26-inch photographic refractor, which has been fitted with a negative enlarger so as to give an image on a scale of about 30 inches to the solar diameter, and with a rapid exposing shutter of the same model as that in use on the Thompson photo-heliograph. Of these photographs, 23, taken upon 12 days, have been selected for preservation.

The supplementary reductions necessary to render the heliographic results for the twelve years 1874 to 1885 uniform with those for 1886 and the succeeding years are all but completed. The sun-spot ledgers for the whole 12 years have been printed and the proofs passed for press. The total projected areas of sun-spots and faculae for each day have likewise been completed and passed for press. The mean daily areas, and mean latitudes of sun-spots for each rotation of the Sun, and for each year, have also been computed for the first eight years concerned, and require only to be computed for the last four years in order to complete the work.

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IV.—Magnetic Observations :—

The variations of magnetic declination, horizontal force and vertical force, and of earth currents, and accompanying eye observations of absolute declination, horizontal force and dip, have been made as in former years.

The regular determinations of magnetic declination, horizontal force and dip, have been made with the new declinometer, the Gibson deflexion instrument, and the Airy dip circle mounted in the Magnetic Pavilion.

The magnetic reductions for 1906 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 declination, dip, and deflexion observations made in the Magnetic Pavilion are completely reduced.

The principal results for the magnetic elements for 1906 are as follows :—

Mean declination	-	-	-	16° 3'·6 West.
Mean horizontal force	-	-	-	{ 4·0174 (in British units).
				{ 1·8524 (in metric units).
Mean dip (with 3-inch needles)	-			66° 55' 17".

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

In 1906 there were no days of great magnetic disturbance, and 8 of lesser disturbance. Traces of the photographic curves for these days will be published in the annual volume. The calculation of diurnal inequalities from five typical quiet days in each month, selected in concert with M. Moureaux and Dr. Chree, has been continued.

The list of "quiet" or "normal" days is also communicated to M. Snellen for publication by the International Committee on Terrestrial Magnetism in their "quiet day" circular.

V.—Meteorological Observations :—

The meteorological instruments are all in good order. 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.

Examination of the pressure-scale of the Osler anemometer has shown that the springs are in need of renewal, and advantage has been taken of the opportunity to modify the scale with a view to simplifying the determination of mean pressure.

During 1906 all the old 8-inch rain gauges in use in the Observatory grounds were replaced by new ones similar to the standard rain-gauge in the Magnetic Pavilion enclosure. One of these was placed in the South Ground on 1906 March 1, and the others brought into use on the roofs of the Octagon Room, the Magnet House, and the Thermograph respectively on 1906 November 1.

The meteorological reductions are in the following state :—The observations of barometer, thermometers, anemometers, rain-gauges, and sunshine recorder (corrected, where necessary, for instrumental error) 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 1906 for the wet bulb thermometer, and to the end of 1907 April for the dry bulb thermometer and the barometer. The table of principal changes of the wind is complete for 1906.

The mean temperature for the year 1906 was $50^{\circ}\cdot5$, or $0^{\circ}\cdot9$ above the average for the 65 years 1841–1905.

During the twelve months ending 1907 April 30 the highest temperature in the shade (recorded on the open stand in the Magnetic Pavilion enclosure) was $94^{\circ}\cdot3$, on August 31. On the same day the highest temperature in the Stevenson screen in the Magnetic Pavilion enclosure was $92^{\circ}\cdot4$, and in the Observatory Grounds $92^{\circ}\cdot8$.

The lowest temperature of the air recorded in the year was $19^{\circ}\cdot8$ on December 30. During the winter there were 58 days on which the temperature fell below $32^{\circ}\cdot0$, being two more than the average number. The temperature also fell below $32^{\circ}\cdot0$ on 1906 May 18.

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The mean daily horizontal movement of the air in the year ending 1907 April 30 was 280 miles, which is 2 miles above the average of the preceding 39 years. The greatest recorded daily movement was 936 miles, on February 20, and the least 54 miles, on November 13. The greatest recorded pressure of the wind was 23.0 lbs. on the square foot, on March 19, and the greatest hourly velocity 50 miles, on February 20.

During the year 1906 Osler's anemometer showed an excess of 16 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 1907 April 30, by the Campbell-Stokes instrument, was 1,687 out of 4,457 hours during which the Sun was above the horizon, so that the mean proportion of sunshine for the year was 0.379, constant sunshine being represented by 1.

The rainfall for the year ending 1907 April 30 was 23.86 inches, being 0.26 inches less than the average of the 65 years 1841-1905. The number of rainy days was 148.

The progress made during the year with the summaries and abstracts referred to in the last Report is as follows:—

- (1) The Greenwich Temperature Reductions, 1841-1890, have been extended to 1905, and the additional tables to complete the 65 years' record printed and published forming Part IV of Greenwich Meteorological Reductions.
- (2) The extension of Glaisher's tables of diurnal inequalities of air pressure and temperature, evaporation and dew point, using 50 years' observations (1854-1903) instead of 20 years, has been completed, and was brought into use from 1907 January 1 in the preparation of the Registrar-General's Report.
- (3) The 40 years' record of the Robinson anemometer was completed at the end of 1906, and the form and scope of the summary and tables practically decided upon. A considerable amount of the work has also been entered in forms ready for press.
- (4) The investigation of daily rainfall has been postponed, no decision having yet been made as to the method to be adopted in dealing with discontinuities in the record caused by alterations of the gauge, or its position, or the time of measurement.

From 1907 January 1, fresh averages have been used for the Registrar-General's Report and other purposes, 65 years for air temperature and for rainfall (1841-1905) instead of 50 years (1841-1890); 40 years for daily movement of the air (1867-1906) instead of 16 years, obtained from two different instruments; and for sunshine 10 years (1897-1906), during which the identity and position of the instrument have been unaltered.

VI.—Printing and Distribution of Greenwich Publications :—

The copies of the volume of Greenwich Observations for 1904 were distributed in December 1906, together with the Meridian Zenith Distances of γ Draconis with the Reflex Zenith Tube, 1886-1899, and the Meteorological Reductions, Part IV., Temperature, 1891-1905.

The printing of the volume of Greenwich Observations for 1905 is just completed, and the copies are being bound.

The printing of the volume for 1906 has been commenced with the Transit-Circle Transits. The Rates of Chronometers and Watches for 1906-7 have been printed and distributed.

The second volume of the Astrographic Catalogue is completed with the exception of the Introduction, the preparation of which is in hand.

Other special publications now in the press are—

Heliographic Results, 1874 to 1885, nearly complete.

Measures of Photographs of Eros for Determination of the Solar Parallax, completed with the exception of the Introduction.

VII.—Chronometers, Time Signals, and Miscellaneous :—

The number of Government marine chronometers and watches now at the Observatory is 510, viz., 347 box chronometers, 20 pocket chronometers, 76 chronometer watches, and 67 hack watches. In addition to these there are, at the Observatory, 18 hack watches and 10 chronometer watches on trial for purchase, and 5 box chronometers belonging to the Indian Government.

In the year ending 1907 May 10, the average daily number of chronometers and watches being rated was 656, the total number received was 1,351, the total number issued was 1,420, and the number sent for repair 548. These include

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27 box chronometers, 1 pocket chronometer, and 3 deck-watches for the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 42° to 106° , 46 chronometers were sent in. During the trial 21 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 25 chronometers, 6 were purchased for the Navy and 7 for the Indian Government. The performance of the chronometers generally is hardly up to the high average of recent years, but a good proportion fully come up to the standard for the Royal Navy.

A competitive trial of pocket chronometers took place concurrently with the trial of box chronometers, and under the same conditions as regards length of trial and temperature—trials in position as for chronometer watches being included. None of the 14 pocket chronometers sent in came up to the standard for purchase.

For the annual trial of chronometer watches, lasting 16 weeks and including trials in the oven and in positions, 179 watches were entered, of which 102 were classified, and of these 16 were purchased for the Navy. Among the watches classified were 27 with centre seconds dials, of which 6 were purchased. There were 61 "Karrusel" or "Tourbillon" watches classified, of which 8 were purchased. The performance of the watches is not quite so good as for the last two years, but there are a good number which may be fairly classed as chronometer watches.

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

The Greenwich time-ball was not raised on one day, owing to the violence of the wind. On November 14 the clips failed to hold the ball, which fell about two minutes early. It was raised again and dropped correctly.

On February 8 the Greenwich clock (Dent 2012) closed the circuit 2^{s} late, and on March 12 the clock was 1^{s} fast. On these days the signals were wrong, and the ball also was not dropped correctly at 13^{h} . It was raised again and dropped correctly at 14^{h} .

The automatic drop of the Deal time-ball failed on 7 days owing to interruptions of the telegraphic communications; but on 3 of these occasions the attendant, being warned, dropped the ball correctly by hand. On 3 days the ball was not raised owing to the violence of the wind. On October 16 the current was too weak to drop the ball.

The return signal from Devonport failed on 40 days (of which 9 were Sundays), and could not be observed on 6 days 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 $0^s.2$ on 89 per cent. of the 318 days of observation, and did not exceed $0^s.5$ on 97 per cent. On 10 occasions it exceeded $0^s.5$, but never exceeded $1^s.0$. The average error for the year was $\pm 0^s.12$.

The return signal from Portsmouth failed on 40 days (of which 26 were Sundays), and could not be observed on 6 days owing to interruption by telegraph signals. The apparent error of the clock (corrected in the same manner as the Devonport clock) did not exceed $0^s.2$ on 80 per cent. of the 319 days of observation, did not exceed $0^s.5$ on 98 per cent., and exceeded $1^s.0$ on one day. The average error for the year was $\pm 0^s.18$.

The automatic signals from the Westminster clock have been received regularly during the year ending May 10. On 4 days the signal failed, and on 9 other days it was interrupted by telegraph signals. The improvement in the performance of the clock reported last year has been fully maintained. Its apparent error was not greater than $0^s.5$ on 39 per cent. of the days of observation, not greater than $1^s.0$ on 67 per cent., not greater than $2^s.0$ on 93 per cent., not greater than $3^s.0$ on 99 per cent., and exceeded $3^s.0$ on only two occasions.

At the request of the Hydrographer, Lieutenant F. C. Hanning-Lee, R.N., attended the Observatory from October 17 to December 14 for a course of instruction in the use of the portable transit instrument for time determination and in the work of the chronometer branch before taking up his appointment as Superintendent of the chronometer depôt at Malta.

VIII.—Personal Establishment:—

After some delay, Mr. Cullen was appointed on October 11 to fill the vacancy for an Established Computer caused by the death of Mr. Vagg in 1906 April.

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

Chief Assistants—Mr. Cowell, Mr. Eddington.

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

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Clerical Assistant—Mr. Outhwaite.

Established Computer (Higher Grade)—Mr. Davidson.

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

Mr. Cowell and Mr. Eddington have the general superintendence of all the work of the Observatory. Mr. Maunder is charged with the heliographic photography and reductions. Mr. Lewis has charge of the clocks, time signals, and chronometers, and of the 28-inch equatorial. Mr. Thackeray superintends the meridian work and miscellaneous astronomical computations. Mr. Hollis superintends the photographic mapping of the heavens, the measurement of the plates, and the computations for the Astrographic Catalogue. Mr. Crommelin has charge of the altazimuth and of the observations of occultations. Mr. Bryant superintends the magnetic and meteorological observations and reductions. Mr. Outhwaite acts as responsible accountant officer, has charge of the library, manuscripts and stores, and conducts the official and general correspondence. Mr. Davidson has charge of the Thompson equatorial and the measurement of the photographs taken with it. In particular, he has been employed on the discussion of the photographs of Eros taken in the opposition of 1900–1901 for the determination of the Solar parallax. Mr. Bowyer, Mr. Cullen, Mr. Edney, and Mr. Furner assist Mr. Lewis, Mr. Thackeray, Mr. Bryant, and Mr. Crommelin respectively. Mr. Witchell and Mr. Storey, under Mr. Thackeray's direction, undertake respectively the reduction of the meridian zenith distances observed with the transit circle and with the reflex zenith tube, and of the transit observations with the transit circle. Mr. Melotte and Mr. Stevens are engaged alternate weeks, under Mr. Hollis's direction, in the reproduction of the enlarged prints of the astrographic chart. At other times Mr. Melotte assists in the measurement and reduction of the Thompson photographs, and Mr. Stevens in the astrographic work. Mr. Evans also assists Mr. Hollis in the measurement and reduction of the astrographic plates. Mr. Burkett assists Mr. Outhwaite.

The number of Supernumerary Computers at present employed in the Observatory is 26; of these, 9 are attached to the Astronomical Branch, 3 to the Chronometer and Time Signal Branch, 6 to the Astrographic Branch including the Thompson equatorial measures and reductions, 3 to the Heliographic Branch, 4 to the Magnetic and Meteorological Branch, and 1 to the Clerical Branch.

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 62.

I take this opportunity of expressing my thanks to the whole Staff for the zeal with which they have worked during the past year.

IX.—General Remarks :—

In view of the danger threatening the astronomical efficiency of the Observatory from the working of the generating station of the London County Council in the immediate future, to which attention was called in the last Report, a small committee consisting of Lord Rosse, the late Sir Benjamin Baker, and Dr. Ewing representing the Board of Visitors, the London County Council, and the Admiralty respectively, was appointed in July to enquire into the question. In their Report presented to Parliament they make definite recommendations as to the working of the generating station, and if these are all strictly carried out it may be hoped that the work of the Observatory will not be seriously interfered with, though further experience when the generating station is completed and in full work may modify this view. The recommendation of the committee that the question as to the effects of vibration and discharge from chimneys should be further reviewed after, say, two years is of great importance for the protection of the Observatory in the future.

As regards vibration, test experiments made last summer showed that the vibrations from the engines of the completed portion of the generating station can be effectually damped out when the film of mercury in the amalgamated trough is as thin as practicable. This condition of a very thin film had been long previously secured for the Reflex-Zenith tube where the trough is a fixture, but special arrangements for levelling the trough have to be made in the case of an instrument which has to be reversed, and thus practical difficulties in longitude determinations are introduced through the vibrations from the generating station. But though the tremors which are undoubtedly caused by the generating station may be masked by the use of a very thin film of mercury, it is a question whether they do not cause the telescopes to oscillate to such an extent as to interfere with the delicate work of which they are capable, such as the observation of close double stars with the large telescope. Further experience is required to decide this.

The danger to be feared from the chimneys and the heated gases they discharge in the immediate neighbourhood of the Greenwich meridian is more insidious, as

the effect on the accuracy of observations of stars near the north horizon may only become apparent in course of years when it is found that the results are untrustworthy from this cause. The recommendations of the committee in this respect represent the minimum which is absolutely necessary, and a further reduction in the height of the chimneys may be required to safeguard the Greenwich meridian work.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1907 May 31.
