REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1906 *May* 30.

GREENWICH OBSERVATIONS, 1905.

THE BOARD OF VISITORS.

The President of the Royal Society - -	Lord Rayleigh.
The President of the Royal Astronomical Society.	Mr. W. H. Maw.
Nominated as Fellows of the Royal Society -	Prof. W. G. Adams. Prof. J. Larmor. Prof. Sir J. Norman Lockyer. Lord Rayleigh. Earl of Rosse. Principal Sir A. W. Rücker.
Nominated as Fellows of the Royal Astronomical Society.	Capt. Sir W. de W. Abney. Prof. Sir R. S. Ball. Prof. R. B. Clifton. Dr. J. W. L. Glaisher. Sir W. Huggins. Mr. E. B. Knobel.
Savilian Professor of Astronomy at Oxford -	Prof. H. H. Turner.
Plumian Professor of Astronomy at Cambridge -	Prof. Sir G. H. Darwin.
Hydrographer of the Navy - - -	Captain A. Mostyn Field, R.N.
Secretary - - - - - - - - -	Mr. W. D. Barber.

REPORT OF THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1906 *May* 30.

The Report here presented refers to the year from 1905 May 11 to 1906 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 had fallen much into arrear owing to insufficient provision of funds in recent years, has now been taken up energetically, and is progressing well.

A defective drain from the Old Observatory building has been reconstructed, and other sanitary improvements have been made.

In preparation for the Eclipse Expedition last August, four new portable canvas-covered huts were made and two others were reconstructed. These were all brought back after the eclipse, and are stored for future occasional use.

A permanent storehouse for portable instruments, huts, chronometer baskets, and general stores, is much needed to take the place of the existing wooden sheds, which have various disadvantages, the most serious being the risk of fire. A

E (3)43540. 50 & 950.—5/06. Wt. 31207. E. & S.

suitable site for this could be found on the south-west side of the New Observatory, where the slope of the ground gives facilities for the erection, at comparatively small cost, of a partly sunk basement, which would not interfere in any way with the New Observatory building.

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).

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; 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.

One Hilger Chronograph lent to Prof. Karl Pearson at University College, London.

Lent to Mr. John Evershed for observation of Solar Eclipse:—

The 9-inch Thompson Objective Prism.
This has been returned to the Royal Observatory.

Lent to the Royal Observatory for observation of Solar Eclipse:—

Coelostat, with 16-inch Mirror by the Government Grant Committee.
4-inch Rapid Rectilinear Lens by Royal Astronomical Society.
(This Lens has been returned since the date of this Report.)
Double Spectroscope, Quartz and Flint, by Major E. H. Hills, R.E.
Heliostat with 12-inch Mirror, by Major E. H. Hills, R.E.

Another Coelostat, with 16-inch mirror, which was lent by the Royal Astronomical Society for the Solar Eclipse, was returned last December.

In the Libraries, special attention has been given to making up arrears of binding, particularly in the East (Magnetic and Meteorological) Library. Some hundreds of volumes of publications have been bound during the year, and a number of old and valuable books which were in a bad state have been carefully repaired and restored, the old binding being retained as far as possible.

A complete card shelf catalogue of the Magnetic and Meteorological Library has now been made, and an author's catalogue is in progress.

The charts, maps, prints, and photographs in the Chart Room have been re-arranged and catalogued.

The annual examination of the Library has been made, the books on the shelves being compared with the catalogue. Of the twelve books missing last year three have since been found, and of 12 books missing this year nine were reported as missing in last year's examination.

II.—Astronomical Observations:—

Transit Circle.—The object glass was removed for repolishing on January 9, and was returned on February 9 with the tarnished surfaces repolished, but in the

process the figure had been affected, difficulty having arisen through the thinness of the lenses, and Mr. Simms did not succeed in correcting this before he had to leave for the Cape. To remedy the aberration near the edge, the aperture was reduced to 6 inches for all observations until April 2, when, on Mr. Simms's return, the object glass was again removed, and finally remounted on April 26, after re-figuring. Since then its performance has been quite satisfactory.

The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. The number of observations from 1905 May 11 to 1906 May 10 is as follows :—

Transits	6,335
Determinations of collimation error	240
Determinations of level error	442
Circle observations	5,531
Determinations of nadir point (included in the number of circle observations)	439
Reflexion observations of stars (similarly included)	257

The notable diminution in the number of observations as compared with previous years is due, as regards 1905, to the fact that the observations required for the Nine-year Catalogue were all but complete at the date of the last report, and, as regards 1906, to the removal of the object glass for repolishing, which interrupted observations for two months.

The transits are completely reduced (so as to exhibit mean R.A. 1905·0) to 1905 December 31, and Apparent R.A. is formed to 1906 May 6.

The circle observations are completely reduced to 1905 December 31, and as far as apparent N.P.D., to 1906 May 6.

As regards the delay in the application of star corrections, it may be remarked that at the time of transition from one catalogue to another, it becomes necessary to form a new working catalogue, and in preparation for future observations the calculation of star constants for star corrections has also been undertaken. This work is now on the point of completion, and the calculation of the star corrections since the beginning of the year, which is a comparatively light piece of work under the circumstances, will be taken in hand without delay.

The new working catalogue of stars of magnitude 9·0 and brighter, between the limits +24° to +32° of N. declination, forming reference stars for the Oxford astrographic zone, has been completed, and includes more than 12,000 stars. The star places have all been brought up accurately to 1910 from the *Astronomische Gesellschaft Catalogues*, so as to form a basis for a comparison of catalogues when the observations here are completed. The star constants are nearly complete. Star corrections will be applied so as to reduce the apparent places to 1910·0 instead of to the beginning of the year of observation.

The circle observations will be reduced with Pulkowa refractions, colatitude 38° 31′ 21″·80, and a constant flexure term of +0″·60 *sin* Z.D., based on a long series of determinations of R–D.

A new determination of the errors of the pivots was made last November, from which it appears that the errors in the form of the pivots are insensible.

The investigation of personal equations is complete for 1905.

The correction for R–D discordance and the position of the ecliptic have been investigated for 1905.

The corrections for variation of latitude (kindly communicated in advance by Prof. Albrecht) have been applied to the planetary observations for 1905, and are being applied to the observations of stars in the ledgers. The colatitude determination for 1905 is not yet completed, as the application of these corrections has necessarily involved delay. The value found in 1904 with Bessel's refractions is 38° 31′ 21″·74.

The apparent correction for discordance between the nadir observation and stars observed by reflexion in 1905 is −0″·22. The values found since 1892 range from −0″·20 to −0″·41, and since 1897 January 1 a correction of −0″·25 has been applied to observations of the nadir in forming the zenith point on days when no reflexion observations of stars were obtained.

Observations of level and nadir have been made when practicable, three or more times on the same day. The following are the mean values of the diurnal

changes of level and nadir for 1905, 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.
1905	+0″·13	0″·00	+0″·21	+0″·37	+0″·13	0″·00	+0″·04	+0″·03
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 1905 is $+0''\cdot055$ $+0''\cdot310$ *sin* Z.D., a value agreeing well with the results of recent years since 1897, though differing considerably from the mean value for the variable term resulting from years preceding 1897.

The correction to the tabular obliquity of the ecliptic from solar observations in 1905 is $+0''\cdot21$. The discordances between the results of summer and winter solstices is $-0''\cdot28$, indicating that the mean of the observed distances from the Pole to the ecliptic is apparently too great by $0''\cdot14$. The apparent correction from observations of the Sun to right ascensions of clock stars is $+0^s\cdot038$. In determining these quantities the correction for latitude variation has been applied.

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) is $-0^s\cdot337$ in R.A. and $-0''\cdot45$ in N.P.D., deduced from 105 observations. These are equivalent to a mean error of $-5''\cdot29$ in longitude and $-0''\cdot17$ in E.N.P.D.

The Second Nine-Year Catalogue, Epoch 1900, which was terminated at the end of last year, will be divided into two sections, Part I., Fundamental and Zodiacal Stars; Part II., Astrographic Reference Stars. For the latter section the places of the stars for 1900 within 10° of the Pole have already been determined and are available for the computation of plate constants.

New places for the clock and polar stars have been determined and have been used as the basis for the clock star list for the current year.

The mean apparent correction for equinox to the present system of clock stars indicated by the observations of the Sun, 1897–1905, is $-0^s\cdot017$, the values for separate years ranging from $-0^s\cdot046$ to $+0^s\cdot038$.

As regards the N.P.D.'s it has been decided as the result of a discussion of the observations of circumpolar stars and the Sun and of a comparison with the Ten-Year Catalogue, 1890, to adopt the Pulkowa refractions with the value 38° 31′ 21″·80 for colatitude and the value $+0''\cdot60$ *sin* Z.D. for the flexure term in the R–D correction, being sensibly the same as the mean values used in both the 1880 and 1890 Ten-Year Catalogues, though the mean value resulting from the reflection observations for the nine years 1897–1905 is $+0''\cdot26$ *sin* Z.D. It is to be noted that the comparison of N.P.D.'s with those of the 1890 Catalogue shows that no change in the flexure term such as is indicated by the reflection observations from the year 1897 affected the direct observations, and, further, with the unchanged value of the flexure term the observations of the Sun are in perfect agreement with those of circumpolar stars when both are reduced with the Pulkowa refractions, the values for colatitude being 21″·81 and 21″·80 from the Sun and stars respectively.

The discussion of the Greenwich meridian observations of the Moon from 1750 to the present time has been completed by Mr. Cowell. The comparison between the tabular places and the recorded phenomena has been extended to several ancient eclipses, both of the Sun and the Moon, and Mr. Cowell concludes that a small secular change in the length of the mean interval between successive returns of the Sun to the Moon's node, too small to be tested by modern observations, is indicated by the records.

Altazimuth.—As there was suspicion that the mounting of the object glass in its cell was not altogether satisfactory, it was decided last July to discard the existing cell with four compensating arms (two having spring bearings) and to substitute a new cell with three bearings, two being on compensating arms (aluminium and bronze), each inclined 60° to the horizon, and the third a spring acting horizontally. This, and a necessary repolishing of the flint lens, occupied from July 12 to August 30, during which time the instrument was out of use.

The instrument has been used as a reversible transit-circle in the meridian in four positions during the year, the positions being changed regularly each 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 will 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	271, 409, and 137 respectively.
Nadir: Reflexion observations of stars	395 and 141 „
Flexure	16
R.A. and N.P.D. of Sun, planets, and stars (in meridian)	1,294 and 1,156 „
R.A. and N.P.D. of Moon (in meridian)	71 and 52 „
R.A. and N.P.D. of Mösting A	48 and 50 „
Azimuth and Zenith distance of stars (extra meridian)	155
Azimuth and Zenith distance of Sun and planets (extra meridian)	19
Azimuth and Zenith distance of Moon (extra meridian)	33

The altazimuth observations are reduced to the end of 1905, but the corrections for latitude variation lately received have not yet been applied. Of the observations for 1906, the meridian zenith distances are reduced to April 2, and the transits to March 5. The extra-meridian observations are completely reduced to 1905 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 $0''\cdot31$ 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.

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 1906 May 10 :—

Time of Moon's Meridian Passage.	Transit Circle.		Altazimuth.		
			Meridian.		Extra Meridian.
	Limb.	Mösting A.	Limb.	Mösting A.	Limb.
h. h. 1–2 G.M.T.	0		0		2
2–3	0		0		4
3–4	3		0		3
4–5	4		0		5
5–6	6		2		3
6–9	20	8	18	12	1
9–12	21	12	19	13	0
12–15	13	4	14	9	0
15–18	18	5	17	14	0
18–19	4		1	0	4
19–20	5		0		7
20–21	1		0		1
21–22	0		0		3
22–23	0		0		0

The total number of observations is 95 with the transit-circle and 104 with the altazimuth, viz.:—71 in the meridian and 33 out of the meridian.

Taking both instruments, observations of the Moon have been obtained on 136 days during the year.

Reflex Zenith Tube.—During the year, 823 double observations and 24 single observations have been obtained, the number of different stars observed being 62. The brighter stars have been observed for as long periods of the year as possible. Thus 67 observations of γ Draconis, 43 of β Draconis, and 37 of ι^2 Cygni, distributed throughout the year, have been obtained; 31 observations of 30 Draconis extend from May 11 (in continuation of last year's series) to September 13 and from March 9 to May 10; while the group of five stars, 27 Lyncis, f Ursæ Majoris, Bradley 1306, Groombridge 1542, and θ Ursæ Majoris, was observed continuously from the middle of November to the middle of April, and the two stars β and 9 Lacertae from September 7 to March 31. The reduction of the observations is completed to March 31.

Clocks and Chronographs.—As the altazimuth chronograph was not going satisfactorily, being liable to large changes of rate, the springs which controlled the friction governor were removed so as to make its action depend on gravity alone. After this change its going was found to be much more uniform. There still remains an inequality with a period of 16 minutes (the same as that of the driving barrel), but this is of no practical importance.

Equatorials.—During the year ending 1906 May 10, 26 disappearances and 6 reappearances of stars occulted by the Moon have been observed by one or more observers. Nine of the stars of which the disappearance was observed were below the limit of magnitude ($6^m \cdot 5$) hitherto adopted in the Nautical Almanac, and the occultation was not notified there. It is satisfactory to note that from 1907 the Nautical Almanac will include such stars in its occultation list.

The 28-inch Refractor.—This instrument has been in use throughout the year for micrometric measurement of double stars, diameters of Jupiter, and of Jupiter's satellites. The weather has been unfavourable for observation of difficult double stars, but fortunately the time could be utilised in completing the measures of such stars in Struve's Mensuræ Micrometricæ, as had not been observed for many years. The total number of double stars measured during the year is 606; of these, 158 have their components separated by less than $1'' \cdot 0$, and 70 by less than $0'' \cdot 5$. On the average these stars have been observed each on two nights.

Series of measures have been obtained of κ Pegasi (10 nights), δ Equulei (15 nights), and 70 Ophiuchi (12 nights). The measures of δ Equulei leave little room for doubting that its period is only 5·7 years.

Equatorial and polar diameters of Jupiter were measured first with the filar micrometer and then with the double-image micrometer on the same night. 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 for diagonal view with the plane mirror. The measures are intended to supplement similar measures made during the opposition of 1895 and 1896. During the past year measures were made on 17 nights. The diameters of the satellites were measured on two nights with the filar micrometer. It is hoped that further measures may be secured in the autumn.

Thompson Equatorial.—The 30-inch mirror was re-silvered in August and again in November.

With the 26-inch Refractor, 72 photographs of Neptune and its satellite have been taken on 28 nights. The occulting shutter has been used as in previous oppositions. These photographs are now being measured.

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

86	photographs	of	Jupiter and Satellite	VI	on 36 nights.
19	„		„ „	VII	„ 15 „
45	„	23 minor planets.			
2	„	Comet	*a* 1905	on	2 nights.
6	„	„	*b* 1905	„	6 „
14	„	„	*c* 1905	„	10 „
18	„	„	*a* 1906	„	13 „
20	„	„	*b* 1906	„	15 „
9	„	Nova Aquilæ		„	8 „

and of the following nebulæ :—

H. 37 - -	4 photographs.	Ring Nebula in Lyra - -	2 photographs.
N.G.C. 281 -	1 „	H.v. 14 Cygni - -	1 „
M. 31 (Andromeda)	2 „	N.G.C. 6853 (Dumb-bell Nebula)	1 „
N.G.C. 2499 -	1 „		

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, 86 and 19 photographs respectively.

Comet *d* 1902	- - - -	36 photographs.
„ *a* 1903	- - - -	23 „
„ *c* 1903	- - - -	26 „
„ *a* 1904	- - - -	85 „
„ *b* 1904	- - - -	1 „
„ *e* 1904	- - - -	7 „
„ *b* 1905	- - - -	6 „

The following have been measured and partly reduced:—

Comet *a* 1905 - - 9 photographs.

53 minor planets - - 172 „ taken in 1903, 1904, and 1905.

The reduction of the measures of the photographs of Eros is complete, and is now in the press. The results have been communicated to M. Lœwy and are printed in the Eros Circular No. 12.

Spectroscope.—In October and November a number of experimental photographs of the spectra of sun-spots were taken with the 3rd order spectrum of the diffraction grating in conjunction with a direct-vision half-prism, to give an extended scale for measurement of the widening of Fraunhofer lines. Arrangements have now been made to take further photographs under improved conditions.

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

Altogether 164 photographs have been taken on 60 nights. Of these 26 have been rejected; 13 with exposure unfinished, owing to cloud, or as not reaching the standard in showing faint stars; 13 owing to errors in setting or for faults in the plate.

The remaining 138 plates are made up as follows:—

Chart plates (exposure 40^m) - - - -	83
Catalogue plates (exposure 6^m, 3^m, and 20^s) - -	3
Plates for Adjustment - - - - -	15
Jupiter and fields surrounding - - -	35
Comet *c* 1905: Mars - - - - -	2

The measurement of the Catalogue Plates for the Greenwich Section was completed at the date of last year's report Since that time re-measures have been made of discordant observations in the zones 80° to the Pole, and measures of the reference stars outside the limits common to the overlapping plates, but within the réseau lines, for the zones 77° to 80°. For the plates zone 81° to the Pole these additional reference stars were measured in the ordinary course of measurement.

Copy for press has been prepared during the year for the seven zones 80° to 86°.

The measures of the eight zones 77° to 84° have been printed during the year. These zones contain 46,329 separate stars, covering an area of 450 square degrees of the sky, and complete the first 880 pages of Vol. II. of the Greenwich Astrographic Catalogue. The remaining 78·5 square degrees between Dec. 85° and the Pole will contain about 6,000 separate stars.

Provisional constants for the plates of the eight zones whose centres are on the parallels of declination 65° to 72° N., computed with the places of the reference stars given in the *Astronomische Gesellschaft Catalogues*, were given in the Introduction to Vol. I. of the Astrographic Catalogue. For the Plates of the zones from 73° to the Pole it was decided to defer the computation of plate constants till the final values could be obtained from the star-places in the Greenwich Second Nine-Year Catalogue for 1900. These are now available for the zones from the Pole to declination 80°, and the computation of the constants for the plates from the Pole to declination 86° is now in hand.

The following table gives the total number of separate stars which have been measured, and will be contained in the Greenwich section of the Astrographic Catalogue, compared with the corresponding numbers in the *Bonn Durchmusterung* and the *Astronomische Gesellschaft Catalogues*:—

Limits of Declination.	Number of Stars measured.	Number in B.D.	Number in A.G.C.	A.G.C.
64°–65°	8,954	1,932	1,200	Helsingfors.
65°–70°	49,016	8,159	3,700	Christiania.
70°–75°	49,849	5,872	—	Dorpat.
75°–80°	42,354	4,451	3,777	Kazan.
80°–85°	22,206	3,610	—	—
85°–90°	about 6,000	1,160	—	—

As regards the Chart plates, the stars in zones 74° to 80°, both inclusive, and zone 81° as far as R.A. 6h 0m have been counted during the year. The following table of the total number of stars shown with exposures 20s, 3m, 6m, 40m, 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 :—

Zone.	No. of Square Degrees.	Number in B.D.		Numbers shown on Photographs.							
		9m·0 and brighter.	Total Number.	Exposure 20s		Exposure 3m		Exposure 6m		Exposure 40m	
74°	96·2	374	1,040	1,085	1,763	5,303	8,543	6,936	8,744	23,960	25,986
75°	90·1	351	933	1,051	1,833	5,346	9,149	7,122	9,379	19,756	20,897
76°	84·0	340	945	1,076	1,829	5,202	8,647	6,877	8,852	20,177	21,307
77°	77·9	320	946	1,097	1,772	4,939	8,324	6,607	8,532	21,691	23,046
78°	71·8	266	847	1,010	1,720	4,736	7,933	6,225	8,123	22,730	24,669
79°	65·6	297	801	1,001	1,598	4,623	7,236	6,101	7,468	23,277	25,095
80°	59·4	255	810	829	1,243	3,787	5,827	4,971	5,984	20,925	22,979
81° (0h to 6h).	13·3	56	220	186	261	852	1,262	1,128	1,311	5,791	6,201
Totals	558·3	2,259	6,542	7,335	12,019	34,788	56,921	45,967	58,393	158,307	170,180
Number per square degree		4·05	11·7	13·1	21·5	62·3	101·9	82·3	104·6	283·6	304·8
Ratios - -		1	2·9	3·2	5·3	15·4	25·2	20·3	25·8	70·0	75·3

The reproduction of enlarged prints of the Chart plates has been carried on as far as circumstances would allow throughout the year. The reproductions of the three zones 65°, 66°, 67° have been completed, and of zones 68°, 69°, and 70°, the reproductions have been made of the plates from 12h to 24h and from 0h to 7h. The total number of photographic prints made during the year is 12,000, reproducing on double scale 191 plates. Altogether reproductions have been made of 401 plates since the work was begun, being rather more than a third of the total of 1,149 plates which make up the Greenwich section. The work of reproduction has been twice interrupted seriously during the past year, viz., from September 21 to October 16

for the development and copying of the Eclipse photographs, and from December 15 to January 13 for the repair and alteration of the concrete flooring of the dark rooms.

III.—Heliographic Observations :—

In the year ending 1906 May 10 photographs of the Sun were taken in all upon 210 days; the Thompson photoheliograph being employed on 159 days and the Dallmeyer on 51 days. The Thompson photoheliograph was in regular use up to 1905 July 21, when it was dismounted in order that it might be employed in the observations of the Total Solar Eclipse of 1905 August 30. It was mounted again on 1905 October 1 on its return from the Eclipse Expedition. The Dallmeyer photoheliograph was mounted in the place of the Thompson instrument upon the 26-inch equatorial on 1905 July 22, but was transferred temporarily to its own mounting on the West Terrace of the New Building on 1905 July 31. It was replaced on the 26-inch equatorial on 1905 August 10, and remained there until 1905 September 30, when it was again dismounted in order to allow the Thompson photoheliograph to be replaced in its usual position.

Of the photographs taken, 480 have been selected for preservation, besides 26 with double images of the Sun for the determination of zero of position angles. Supplementary photographs have been received from Kodaikánal Observatory, India, up to 1906 February 18, from Dehra Dûn, India, through the Solar Physics Committee, up to 1906 March 11, and from Mauritius up to 1905 June 30.

The photographic record of the Sun's surface is complete for the year ending 1905 December 31, with the exception of one day—1905 January 1. The photographs selected for measurement are from the following sources :—

Greenwich	179 days.
Dehra Dûn	165 ,,
Kodaikánal	16 ,,
Mauritius	4 ,,
Total	364 ,,

The measurement and reduction of these photographs are complete for the year 1905, and the copy for press of the "Daily Results" is ready for the printer up to the end of August.

The solar activity as shown in the numbers and areas of sun-spots was very pronounced throughout the whole of 1905, the record for that year being about double that for 1904. In particular a great number of large groups, visible to the naked eye, were observed. During the present year there has, so far, been a considerable falling off in this activity—no groups really of the first magnitude having been observed since 1906 January 1.

The measures of areas and positions of sun-spots on photographs lent from the Harvard College Observatory, Cambridge, U.S.A., and the Melbourne Observatory some years ago, in order to fill so far as possible the gaps in the Greenwich series of solar photographs for the years 1874–1877 have been printed. Photographs taken in Mauritius on 23 days in the years 1878 and 1879 have also been received from the Solar Physics Committee, and have been measured and reduced, and the results collated with the results already published for those years. The sun-spot ledgers for the years 1874 to 1885 have been completed and are now in the hands of the printer, proofs of the ledgers from 1874 to 1881 having already been received. From 1886 onwards the spot-ledgers have been given annually in the Photo-heliographic Results.

A rapid shutter of the same model as that in use on the Thompson photo-heliograph has been made for use with the 26-inch photographic refractor, which instrument has also been fitted with a roller blind before the object-glass, it being proposed to take photographs of spots of special interest on a scale of about 30 inches to the solar diameter.

An arrangement has been made in concert with Dr. Walker and Mr. Michie Smith, by which it is hoped that the solar photographs needed to supplement those taken at Greenwich may be received without any avoidable delay. The list of the days for which negatives are required to complete the Greenwich series will be sent at the beginning of each month, both to the Secretary of the Solar Physics Committee and to the Director of the Observatory, at Kodaikánal, India. The officer in charge of the Dehra Dûn Observatory will likewise report to the Director of the Kodaikánal Observatory, at the beginning of each month, as to the days for which the Dehra Dûn series is defective, and the latter has arranged to send direct to Greenwich at once photographs for the days represented neither at Greenwich nor at Dehra Dûn. The Dehra Dûn negatives will be sent at short intervals to the Solar Physics Committee, according to the present practice. It is expected that in this way the photographs required for any month will all be

to hand within five or six weeks of the end of that month. In the comparatively rare case of a day not being represented at any one of the three observatories, application would be made at once to the Director of the Royal Alfred Observatory, Mauritius, to send from his series a photograph for the day required, by mail direct to Greenwich.

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 1905 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 1905 are as follows :—

Mean declination - - -	16° 9′·9 West.
Mean horizontal force - - -	4·0173 (in British units). 1·8523 (in metric units).
Mean dip (with 3-inch needles) -	66° 55′ 55″.

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

In 1905 there were no days of great magnetic disturbance, and 12 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.

Arrangements have also been made in accordance with a resolution passed at the Innsbruck conference on Terrestrial Magnetism to forward to the Committee, once a quarter, daily reports of the state of the Earth's magnetism as shown by the photographic curves, each day being assigned a number 0, 1, or 2 (indicating quiescence, slight disturbance, or great disturbance). The number 2 at Greenwich is assigned to days the diagrams for which are suitable for reproduction in the annual volume, and 1 to those days for which the traces show disturbance sufficiently marked to be described in the volume.

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.

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 1905 for the dry and wet bulb thermometers and the barometer. The table of principal changes of the wind is complete for 1905.

The mean temperature for the year 1905 was 49°·7, or 0°·2 above the average for the 50 years 1841–90.

During the twelve months ending 1906 April 30 the highest temperature in the shade (recorded on the open stand in the Magnetic Pavilion enclosure) was 87°·2, on July 26. On the same day the highest temperature in the Stevenson screen in the Magnetic Pavilion enclosure was 83°·6, and in the Observatory Grounds 85°·0.

The lowest temperature of the air recorded in the year was 23°·1 on November 22. During the winter there were 59 days on which the temperature fell below 32°·0, being three more than the average number.

The mean daily horizontal movement of the air in the year ending 1906 April 30, was 300 miles, which is 18 miles above the average of the preceding 38 years. The greatest recorded daily movement was 767 miles, on January 6, and the least 69 miles, on December 11. The greatest recorded pressure of the wind was 19·4 lbs. on the square foot, on January 18, and the greatest hourly velocity 50 miles, on January 6.

During the year 1905 Osler's anemometer showed an excess of 21 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 1906 April 30, by the Campbell-Stokes instrument, was 1,523 out of 4,457 hours during which the Sun was above the horizon, so that the mean proportion of sunshine for the year was 0·342, constant sunshine being represented by 1.

The rainfall for the year ending 1906 April 30 was 23·33 inches, being 1·21 inches less than the average of the 50 years 1841–90. The number of rainy days was 164. No rain fell for a period of 18 consecutive days, from March 27 to April 13 inclusive.

Time has been found during the year to undertake several discussions of the nature of summaries or abstracts of the steadily accumulating series of homogeneous meteorological observations and registers:—

(1) The Greenwich Temperature Reductions, 1841–90, have been extended to 1905, furnishing data from sixty-five years' records of temperature. The manuscript has been prepared and sent to the printers, and the greater portion has been printed.

(2) An extension of Glaisher's tables of diurnal inequalities of air pressure and temperature, evaporation, dew point, and humidity, using 50 years' observations (1854–1903) instead of 20 years, is in hand.

(3) An investigation into the relative frequency of winds of different velocities has been begun: it is intended to make use of 40 years' records with the same instrument, 1867–1906, which will be completed at the close of the current year.

(4) An investigation of daily rainfall is in contemplation, on lines similar to those followed in the Temperature Reductions.

VI.—Printing and Distribution of Greenwich Publications :—

The copies of the volume for 1903 were distributed in April 1906, together with the new reduction of Groombridge's Catalogue of Circumpolar Stars and the Determinations of Longitude, 1888–1902.

The determination of the longitude of Killorglin has been printed during the year, thus completing the volume containing the Determinations of Longitude, 1888–1902.

The printing of the volume for 1904 is complete, with the exception of a few miscellaneous observations, and the Astronomical Introduction.

The printing of the volume for 1905 has been commenced with the Altazimuth Meridian Transits and Zenith Distances. The Rates of Chronometers and Watches for 1905–6 have been printed and distributed.

The second volume of the Astrographic Catalogue is printed to the end of Zone +84°, and will be completed shortly.

Other special publications now in the press are—

Heliographic Results, 1874 to 1885.
Meridian Zenith Distances of γ Draconis with the Reflex Zenith Tube, 1886–1899.
Temperature Reductions, 1891–1905.
Measures of Photographs of Eros for Determination of the Solar Parallax.

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

The number of Government marine chronometers and watches now at the Observatory is 584, viz., 393 box chronometers, 48 pocket chronometers, and 90 chronometer watches, and 53 hack watches. In addition to these there are at the Observatory, 21 hack watches on trial for purchase and 10 box chronometers belonging to the Indian Government.

In the year ending 1906 May 10, the average daily number of chronometers and watches being rated was 736, the total number received was 1,525, the total number issued was 1,478, and the number sent for repair 658. These include 27 box chronometers, 1 pocket chronometer, and 1 deck-watch for the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks, with a range of temperature from 44° to 104°, 59 chronometers were sent in. During the trial 33 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 26 chronometers, 6 were purchased for the Navy and 6 for the Indian Government. The performance of the chronometers shows a decided falling off as compared with previous years, from 1894 onwards. The number of chronometers rejected in the course of the trial is larger than in any previous year, though the number sent in was smaller than usual, and the number classified as not having exceeded the limit of 12 seconds for b is the smallest in any trial of recent years.

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 positions as for chronometer watches being included. Only 2 of the 14 pocket chronometers sent in came up to the standard for purchase; but these showed a marked improvement on the best in last year's trial.

For the annual trial of chronometer watches, lasting 16 weeks and including trials in the oven and in positions, 221 watches were entered, of which 123 were classified, and of these 30 were purchased for the Navy. Among the watches classified were 44 with centre seconds dials, of which 9 were purchased. There were 77 "Karrusel" or "Tourbillon" watches classified, of which 21 were purchased. The performance of the watches is very satisfactory, and compares well with that of the box chronometers. Taking the trial number $a + 2b$ as a criterion the first 30 watches may be considered as coming up to the standard for a marine chronometer. The trial number $a + 2b$ for the first watch this year, is equal to that for the first watch last year, both being markedly superior to that for the first box chronometer this year.

The next trial of watches will commence on August 4.

The Greenwich time-ball was not raised on one day, owing to the violence of the wind. On December 7 it dropped from the cross correctly, but was jammed by the check rope when about half way down. A new cover to the cylinder to prevent water entering has been so arranged as to guard against such accidents in the future.

The Greenwich time signal at 13^h was $1^s{\cdot}0$ early on one day. On all other days the error of the signal was a small fraction of a second.

The automatic drop of the Deal time-ball failed on 5 days owing to interruptions of the telegraphic communications. There was no day on which the ball was not raised owing to the violence of the wind. On January 9 the ball was dropped $17^s \cdot 0$ early owing to a false signal on the line just before the Greenwich signal. On June 19 the current failed to drop the ball.

The return signal from Devonport failed on 24 days (of which 10 were Sundays), and could not be observed on 12 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 $0^s \cdot 2$ on 92 per cent. of the 326 days of observation, and did not exceed $0^s \cdot 5$ on 97 per cent. On 8 occasions it exceeded $0^s \cdot 5$, and on one exceeded $1^s \cdot 0$. The average error for the year was $\pm 0^s \cdot 08$.

The return signal from Portsmouth failed on 41 days (of which 23 were Sundays), and could not be observed on 10 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 $0^s \cdot 2$ on 74 per cent. of the 311 days of observation, did not exceed $0^s \cdot 5$ on 97 per cent., and never exceeded $1^s \cdot 0$. The average error for the year was $\pm 0^s \cdot 17$.

The automatic signals from the Westminster clock have been received regularly during the year. On 14 days the signal failed, and on 3 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 $0^s \cdot 5$ on 31 per cent. of the days of observation, not greater than $1^s \cdot 0$ on 64 per cent., not greater than $2^s \cdot 0$ on 96 per cent., not greater than $3^s \cdot 0$ on 99 per cent., and exceeded $3^s \cdot 0$ on only two occasions.

Messrs. E. Dent & Co. report that the Westminster clock stopped at $9^h\ 20^m$ p.m. on March 13 owing to a plank having been inadvertently left behind the dial in such a position that it fouled the internal counterpoise of the hand as it travelled round. The clock was started going again a little after 9^h on the following morning.

The insulated wires for the clock and observing circuits leading, in an underground pipe, from the Transit Circle room to the Altazimuth Pavilion and the sidereal standard clock in the Magnet Basement had, for some time past,

given trouble through their defective state, and last August an entirely new set of wires, carried above ground where practicable, was provided by the Post Office authorities. Ample provision has now been made in these circuits to meet all our requirements.

Provision having been made in the Navy Estimates for the observation of the Total Solar Eclipse of 1905 August 30, the Astronomer Royal, with Mr. Dyson and Mr. Davidson, went to Sfax, in Tunisia, taking with them the Thompson 9-inch photographic telescope with 4-inch concave enlarging lens for large-scale photographs of the corona; the 13-inch astrographic refractor for photographing the corona and extension on a smaller scale; a double camera carrying the 4-inch Dallmeyer and $2\frac{1}{2}$-inch Unar lenses for photographing the coronal streamers; and a pair of photographic spectroscopes with quartz and flint prisms, with heliostat lent by Major Hills, R.E., for photographing the spectra of the flash and of the corona. Prof. Sampson, Mr. J. J. Atkinson, and Major Brett, D.S.O., generously volunteered their assistance.

The following results were obtained :—

By the Astronomer Royal with the Thompson coronograph. Scale: Sun's diameter = 4 inches.

No.	Exposure.	Plate.	
	s		
1	5	Fine Grain	12 in. × 10 in.
2	5	Sovereign	12 in. × 10 in.
3	11	Special Rapid	15 in. × 15 in.
4	20	Rocket	15 in. × 15 in.
5	30	Special Rapid	15 in. × 15 in.
6	10	Special Rapid	15 in. by 15 in.
7	7	Sovereign	12 in. × 10 in.

By Mr. Davidson.—With the 13-inch astrographic refractor. Scale: Sun's diameter = $1\frac{1}{4}$ inches.

No.	Exposure.	Plate.
	s	
1	2	Fine grain.
2	5	Fine grain.
3	10	Ordinary.
4	5	Sovereign.
5	20	Sovereign.
6	5	Ordinary.
7	5	Fine grain.
8	2	Fine grain.

By Prof. Sampson.—With the double camera for the coronal streamers.

No.	Exposure.	Plate.
	s	
1	2	Fine grain.
2	5	Fine grain.
3	10	Ordinary.
4	10	Sovereign.
5	20	Sovereign.
6	5	Ordinary.
7	5	Fine grain.

By Mr. Dyson.—With the spectroscopes, extremely interesting spectrographs of the corona and of the large prominence were obtained. The plates used were Barnet orthochromatic in the green and Rocket in the blue and violet.

(Further details are published in the Proceedings of the Royal Society, Vol. 77.)

As mentioned in the last Annual Report, Mr. Maunder, having been invited by the Canadian Government to join the expedition which they were sending out to Labrador, took out there the Dallmeyer 4-inch coronagraph, and a 4-inch rapid rectilinear lens for photographs of the corona, as in Mauritius in 1901. Unfortunately the day of the eclipse was completely cloudy, and no observations could be obtained. No part of the cost of this expedition fell on the Navy Estimates, as Mr. Maunder was the guest of the Canadian Government from the starting of the expedition from Quebec to its return thither again, and the remaining expenses were met by Mr. Maunder himself, aided by a grant of 40*l.* from the Government Grant Committee of the Royal Society.

VIII.—Personal Establishment :—

During the past year the Observatory has lost the valuable services of Mr. Dyson, who has been appointed Astronomer Royal for Scotland and Professor of Astronomy in the University of Edinburgh. Mr. Dyson, who had filled the office of Chief Assistant with conspicuous ability for twelve years, resigned that post on January 13, on taking up his new appointment. Mr. A. S. Eddington, B.A., Scholar of Trinity College, Cambridge, was appointed on February 19 to fill the vacancy.

Mr. E. V. Vagg was appointed on February 21 to fill the vacancy for an Established Computer. To our great regret he died on April 11, after a very short illness, and the vacancy has not yet been filled up.

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.
Clerical Assistant—Mr. Outhwaite.
Established Computer (Higher Grade)—Mr. Davidson.
Established Computers—Mr. Bowyer, Mr. Burkett, Mr. Edney, Mr. Evans, Mr. Furner, Mr. Melotte, Mr. Stevens, Mr. Storey, Mr. Witchell, and one vacancy.

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, and this year has been specially engaged in completing the re-reduction of Groombridge's observations. Mr. Hollis superintends the photographic mapping of the heavens, the measurement of the plates, and the computations for the Astrographic Catalogue. He also has charge of the reductions of the longitude determinations. 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 this year been employed on the discussion of the photographs of Eros taken in the opposition of 1900–1 for the determination of the Solar parallax. Mr. Bowyer, Mr. Edney, and Mr. Furner assist Mr. Lewis, 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 31; of these, 14 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 employed at the Observatory is 65.

I wish to express my thanks to the whole Staff for the zealous spirit in which they have worked.

IX.—General Remarks :—

The continued efficiency of the Observatory is seriously threatened by the schemes for the supply of electric power to the whole of London and surrounding districts from generating stations planted, or to be planted, in the immediate neighbourhood of the Observatory. Amongst these the most serious danger arises from the generating station of the London County Council, which is planted exactly in the Greenwich meridian, in a position where its excessively tall chimneys will, unless their height be materially reduced, interfere with observations of stars near the north horizon (which are essential for latitude and refraction) and will, through the effect of heated air, render the results untrustworthy. A reduction in the height of the chimneys (possibly accompanied by the introduction of forced draught) would provide an obvious remedy for this interference with the Greenwich meridian work.

Further, as this generating station is at a distance of only half a mile from the Observatory, there is grave risk that vibrations from the extremely powerful engines which are being installed there with a view to the supply of electric power wholesale to London, though authorised only for the requirements of the tramways, will seriously affect the value of observations by reflection from a mercury horizon, which are essential for the fundamental work of the Observatory. Tests which have been made show that, even with the small portion of the engineering plant which is now available for work, serious tremors are produced, and though it is hoped that these may be reduced by improved working of the engines, the alternative of providing a remedy for interference in this way with the Greenwich meridian work may have to be faced.

It is to be noted that no such tremors have been detected from a generating station at Deptford on a much more modest scale, which has hitherto sufficed to supply the London Council Tramways with electric power, this station being at a distance of nearly a mile from the Observatory.

The question arises why the immediate neighbourhood of the Observatory should be selected for the planting of generating stations on an unprecedented

scale to supply electric power to distant districts. The very powerful engines required for such a large output are liable to cause vibrations, the extent of which could hardly be anticipated from previous experience of ordinary engineering plant or of railway trains, which have hitherto not affected the work of the Observatory.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1906 May 22.