REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1913 *June* 7.

GREENWICH OBSERVATIONS, 1912.

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The Report here presented refers to the year from 1912 May 11 to 1913 May 10, and exhibits the state of the Observatory on the last-named day.

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

A number of repairs rendered necessary by the discovery of decayed beams on the west side of the transit circle room, and in the floor and on the roof of the octagon room, have been executed during the year by the Works Department.

Some alterations have been made in the small rooms in the old Altazimuth building, one being converted into a developing room for use with the photo-heliograph, and the other into a spare room for clocks.

The computers' cloak room has been enlarged by the removal of the iron partition.

The arrangements for drainage of the front court were reconstructed in December.

A new iron cupboard was fixed in the lower Record room to house the Parliamentary Copies of the Imperial Standards of Weight and Measure. Additional book-racks have also been fixed in that room.

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The internal painting of the Altazimuth and the Store-room was carried out in September. The internal painting of the Old Observatory is in progress.

The Observatory has ceased to generate its own electric current for lighting and other purposes, and now obtains current from outside. The gas engine and dynamo will shortly be removed, and the battery of accumulators has already been taken away. Alternating instead of direct current is now used, and a small supply of direct current is obtained by means of a rotary converter. The direct current is required for charging small storage batteries (used in lighting the instruments) and for the electro-magnet used in magnetic tests of chronometers and watches.

Eight additional fire-buckets and two stand-pipes with swivel heads have been purchased.

The principal movable instruments are thus distributed:—

At Greenwich—

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

Altazimuths D and E.

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

Photoheliographs:

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

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

No. 3. Complete.

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

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

Two Hilger Chronographs (the one lent to Prof. Turner having been returned in August).

A single prism Spectroscope.

On loan—

Transit A, at the Cape Observatory.

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

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

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

Photoheliographs:

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

No. 4. Complete at Kodaikanal Observatory.

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

Clocks.—Dent No. 1916 and Dent No. 2013, at the Cape Observatory; Dent No. 2011, at the Kew Observatory; Arnold 2, at the University Observatory, Oxford. (Dent No. 2010 has been transferred to Devonport on permanent charge.)

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

On loan to the Royal Observatory—

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

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

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

A Quartz spectroscope from Prof. H. F. Newall, Cambridge, for the eclipse.

The Parliamentary Copy No. 5 of the Imperial Standard Yard and the Parliamentary Copy No. 3 of the Standard Pound, removed on September 21

by Officers of the Standards Department of the Board of Trade for decennial reverification were returned 1912 September 27 and placed in a wrought-iron cupboard specially made to receive them.

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

A valuable collection of magnetic charts from Halley's time to the present has been presented to the Observatory by Captain Creak, R.N.

II.—Astronomical Observations :—

Transit Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. In spite of cloudy weather, good progress has been made with the observation (begun in 1906) of the stars between the limits of + 24° and + 32° of North declination.

The number of observations with the Transit Circle from 1912 May 11 to 1913 May 10 is as follows :—

Transits - - - - - - - - -	12,239
Determinations of Collimation and Level error - -	299, 550
Circle observations - - - - - -	12,069
Determinations of nadir point and reflexion observations of stars (included in the number of circle observations) -	517, 307

The transits and circle observations are completely reduced (so as to exhibit Mean R.A. and N.P.D. 1910·0) to 1913 April 30, and Apparent R.A. and N.P.D. is formed to May 4.

The Ecliptic and Colatitude investigations are awaiting the receipt from Prof. Albrecht of the corrections for variation of latitude for 1912.

The value of the colatitude determined from observations in 1911 and using Pulkowa refractions is 38° 31′ 21″·88. The correction to the tabular value of the obliquity of the ecliptic obtained from the observations of the Sun is + 0″·02. The mean of the observed distances from the pole to the ecliptic is too small by + 0″·15. The apparent correction to the right ascensions of the clock stars, for which Newcomb's Equinox is adopted, is − ^{s}·037.

For the year 1912, the discordance between the zenith point determined by nadir observations and by reflexion observations of stars is $-0''\cdot12$. The values from 1892 to 1910 range from $-0''\cdot16$ to $-0''\cdot42$.

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

	Diurnal Changes of Level.				Diurnal Changes of Nadir.			
	Noon.	6 p.m.	Midnight.	6 a.m.	Noon.	6 p.m.	Midnight.	6 a.m.
1912	$+0''\cdot27$	$0''\cdot00$	$+0''\cdot25$	...	$+0''\cdot08$	$0''\cdot00$	$+0''\cdot08$	...
1897–1905	$+0\cdot25$	$0\cdot00$	$+0\cdot21$	$+0\cdot37$	$+0\cdot14$	$0\cdot00$	$+0\cdot12$	$+0\cdot11$

The correction for R – D discordance from the observations in 1912 is $+0''\cdot033 + 0''\cdot479$ *sin* Z.D., agreeing well with the results of recent years.

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's empirical corrections) derived from observations of the limbs and of Mösting A with the transit-circle and altazimuth is for 1911 $-0^s\cdot568$ in R.A. and $+0''\cdot17$ in declination. The corresponding mean errors in longitude and latitude are $-8''\cdot34$ and $-0''\cdot13$.

The mean error of the Moon's tabular right ascension for 1912 derived from 95 observations with the transit-circle is $-0^s\cdot673$.

Precessions and Secular Variations have been computed during the year for about half the stars of the next Greenwich catalogue, epoch 1910·0.

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

The following observations have been made during the year:—

Meridian transits - - - - -	1,754
Meridian zenith distances - - - -	1,525

Extra-meridian observations - - -	117
Determinations of Collimation and level error -	201 and 390
Determinations of Nadir point - - -	343
Reflexion observations of stars - - -	49

The altazimuth observations are completely reduced to 1913 April 29.

The observations in the four positions of the instrument have been compared with Newcomb's Fundamental Catalogue. Reflexion observations have been suspended from August 1912 to the present date.

It was mentioned in the last report that a new eye-end of the instrument was being made by Messrs. Troughton and Simms. This has just been completed. It includes a travelling-wire micrometer for the right ascensions, in order to eliminate magnitude equation, and a printing micrometer for the zenith distances. Lines ruled on thin glass plates have been substituted for spiders' webs.

The mean error in right ascension of the Moon's tabular place for 1912 is $-0^s\cdot67$ from meridian observations and $-0^s\cdot75$ from extra-meridian observations of the limb and $-0^s\cdot63$ from meridian observations of Mösting A.

The following table shows the number of days on which observations of the Moon were obtained with the transit-circle and altazimuth, respectively, during the year 1912:—

Time of Moon's Meridian Passage.	Transit Circle.		Altazimuth.		
			Meridian.		Extra Meridian.
	Limb.	Mösting A.	Limb.	Mösting A.	Limb.
h. h. 0–3 G.M.T. - - - -	1		1		5
3–6 „ - - - -	6		1		8
6–9 „ - - - -	20	16	16	11	2
9–12 „ - - - -	19	12	20	11	0
12–15 „ - - - -	22	13	23	8	0
15–18 „ - - - -	15	8	13	6	0
18–21 „ - - - -	12	1	4	2	7
21–23 „ - - - -	0		0		2

The total number of observations of the Moon is 95 with the transit-circle and 102 with the altazimuth, viz.:—78 in the meridian and 24 extra-meridian. Taking both instruments, observations of the Moon have been obtained on 115 days during the year.

The printing of the Ten-Year Catalogue of stars observed with the altazimuth in the meridian in the years 1899 to 1908 is completed.

Reflex Zenith Tube.—The observations with this instrument were discontinued on August 24, 1911. All the observations have been reduced and printed. A discussion of the observations from 1906–09 was given in the *Monthly Notices* of the Royal Astronomical Society for May, 1911. This has now been continued to the conclusion of the observations. A summary of the whole series will be given in the volume for 1912.

Cookson Floating Zenith-Telescope.—During the year 134 photographs have been taken, 131 for latitude groups and 3 for scale determination. From the commencement of the observations, 1911 September 7, 210 latitude plates (excluding rejected plates) have been obtained, of which 151 have been measured in the direct, and 178 in the reversed, position. In addition, 10 scale plates have been taken, of which 7 have been measured.

The plates are measured in direct and reversed positions by different measurers. The mean difference between the two measurers for the latitude determined by a single pair of stars varies between $\pm 0''\cdot10$ and $\pm 0''\cdot17$, the larger values occurring in cases where there is a systematic personality due to the difference of magnitude of the two stars. This effect will be eliminated in the mean of the two measures. A preliminary discussion of the results has been made, but a second year's observations will greatly strengthen the connection between successive groups of stars. The results from 143 plates have been compared with the provisional results of the International Latitude Service communicated by Professor Albrecht. If the latter is taken as correct, it appears that the probable error of the latitude determined from a single plate (containing 3, 4, or 5 star-pairs) is $\pm 0''\cdot073$.

Equatorial Observations.—During the year ended 1913 May 10, 6 disappearances and one reappearance of stars occulted by the Moon have been observed by one or more observers.

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

The measures made during the year consist of—

106	pairs	under	0″·5 separation.
123	„	between 0″·5 and	1″·0 separation.
132	„	„ 1″·0 „	2″·0 „
139	„	over	2″·0 separation.

κ Pegasi was observed on 5 nights, δ Equulei on 3 nights, 70 Ophiuchi on 13 nights, and ε Hydræ on 1 night.

Thompson Equatorial.—The 26-inch refractor, the 30-inch reflector, and the 6-inch Cooke triplet have been in constant use during the year. The new cell for the crown lens was received and mounted in July. The adjustment of the crown and flint lenses for tilt and eccentricity relative to one another was made in August.

During the year 164 plates were taken for determination of stellar parallax, 124 of these being new plates and 40 being re-exposures of plates taken six months previously. The programme for each star consists of six photographs. Three photographs taken in the evenings are re-exposed in the mornings about six months later, and are then developed. Three plates are exposed in the mornings, and, after re-exposure six months later, are also developed. For several stars the cycle has been completed and the plates have been measured for three stars. The results obtained are $+ ''\cdot 082 \pm ''\cdot 017$, $+ ''\cdot 043 \pm ''\cdot 009$, and $- ''\cdot 014 \pm ''\cdot 012$. The star which gave a negative parallax is one with a small proper motion. It is considered that these probable errors are too large, and that one of $\pm ''\cdot 005$ should be attainable. The increased constancy in the adjustment of the object glass secured by the new cell, and the use of the rotating sector by which the star observed is reduced to the magnitude $10^{m}\cdot 5$ to $11^{m}\cdot 0$ of the comparison stars are expected to make a considerable improvement.

The 6-inch Cooke triplet which belonged to the late Mr. Franklin Adams, and which has been on loan to the Observatory since 1909 December, has been purchased. It has been employed in the determination of the photographic

magnitudes of the stars brighter than $9^m \cdot 0$ in the Greenwich Astrographic Zone. During the year 53 photographs of fields compared with the standard polar area have been taken. Fifty-six plates have been measured, completing the 88 necessary for the whole zone. The catalogue of the resulting magnitudes is nearly completed, and will contain 8,000 stars.

Fifty-nine photographs of Neptune and Satellite, taken in 1909–10, have been measured, and the results published.

In view of the morning parallax observations, when it is difficult to arrange for any assistance for the observer, arrangements are being made for the installation of small electric motors to turn the dome and to wind the clock weight of the equatorial.

Franklin-Adams Photographs.—At the date of the last report, 152 out of the 206 plates had been counted in the manner then explained. During the year, 50 of the remaining plates have been dealt with. The four plates still uncounted have not yet been received from Johannesburg.

The requisite photometric data for the reduction of these counts to statistics based on actual photographic magnitudes are now being obtained at a steady rate. The plan of taking long exposures on a field and a standard polar area has been abandoned, because of the rarity of nights on which the sky is uniform and constant for more than one hour. Instead of this, exposures of 5^m duration are being taken on the central fields of the Franklin-Adams plates and on the standard polar area. The actual procedure consists in giving an exposure of 5^m on a field taken at the same altitude as the pole, two exposures on the pole, and then a second exposure on the field. These will serve to determine standard magnitudes down to the 13^{th} or 14^{th} magnitude on the Harvard Photographic Scale. With these short exposures it will be possible to make several determinations for each field required. For the fainter stars photographs will be taken with a wide grating and the magnitudes derived by comparison with the diffracted images of the brighter stars. These determinations have the advantage of being independent of the changing transparency of the sky.

The star-images are compared with a scale formed by taking a number of different exposures on the same plate—the scale being calibrated by the Harvard Standards.

The following table shows the progress of this work :—

	Number of Plates taken.	Passed as Good.	Measured.
Long exposure (with grating) -	14	11	2
Comparisons with polar standards -	23	15	6
Kapteyn areas and polar standards -	16	10	8

This programme of photometry is being carried out with the 26-inch refractor. Although longer exposures are required than would be necessary with the reflector, this disadvantage is more than counterbalanced by the much larger field and the constancy of the focus.

The plates which have already been taken with the reflector have been partly measured and will be utilized. They include 24 long exposures on fields and standard polar areas, and 27 single exposures taken with the grating. Nine photographs have been received from the Helwan Observatory, in addition to the six taken there last year.

Arrangements have been made with the Royal Astronomical Society for the issue of a limited number of photographic copies of the Franklin-Adams Chart. The reproduction will be carried out at the Observatory under the superintendence of Mr. Melotte.

Astrographic Equatorial.—With this instrument 176 photographs have been taken on 59 nights, the weather conditions having been specially unfavourable. Of these, 154 were for the determination of the photographic magnitudes of the stars in the Greenwich section of the Astrographic Catalogue by the method described in last year's Report, and 107 of them were considered satisfactory for the purpose. There are now 29 plates on the working list to be taken to complete the series.

The work of the department during the year has consisted of the preparation and printing of the catalogue of right ascensions and declinations of all the stars in the Greenwich Astrographic Catalogue which are found in existing meridian

catalogues. The computation of precessions, the writing of the copy for press, and comparison with the Astronomische Gesellschaft Catalogues have been completed. The determination of photographic magnitudes on the Harvard scale has been effected for the stars from the Pole to Zone 77° inclusive. The printing is proceeding contemporaneously with the determination of magnitudes, and the Catalogue is in type to Zone 77° R.A. 14 hours, comprising 6,160 stars out of the whole number of 16,500.

The stars in the Catalogue within 10° of the pole have been carried down to the B.D. limit of magnitude so as to include all the stars in Carrington's Catalogue, but those in the remaining zones will be limited to the stars of the Gesellschaft Catalogues. Out of 4,770 stars in the Bonn Durchmusterung within 10° of the pole, 4,450 are given in this Catalogue. The numbers within given limits of photographic magnitude are shown in the following table :—

Limits of Magnitude.	Number.	Limits of Magnitude.	Number.
Brighter than $6^{m}\cdot0$	17	$9^{m}\cdot5$ —$9^{m}\cdot9$	662
$6^{m}\cdot0$—6·9	55	10·0—10·4	1,037
7·0—7·4	59	10·5—10·9	939
7·5—7·9	91	11·0—11·4	456
8·0—8·4	163	11·5—11·9	123
8·5—8·9	309	12·0—12·6	16
9·0—9·4	523		

As the B.D. limit of magnitude is a visual one, the stars photographically fainter than $11^{m}\cdot0$ in this Catalogue are presumably of types K or later.

During the course of the work differences of the right ascensions of this Astrographic Catalogue and those of the stars of the Greenwich Second Nine-year Catalogue which were used as the reference stars have been tabulated and discussed to show the magnitude equation of the Meridian Catalogue at different declinations. The magnitude equation for different distances from the pole appears

to be constant when measured in time. The amount of the equation is shown in the following table :—

Limits of Magnitude.	Magnitude Equation.	Number of Stars,
Brighter than $6^{m}\cdot0$	$+^{s}\cdot040$	211
$6^{m}\cdot1$—7·2	+·033	684
7·3—7·7	+·035	658
7·8—8·2	+·026	1,502
8·3—8·5	+·015	1,580
8·6—8·8	—·008	1,724
8·9—9·1	—·026	2,739
9·2—9·4	—·066	721
9·5	—·085	168

The zero in this determination is the mean magnitude of all the stars. To reduce to the Clock stars as origin $-^{s}\cdot040$ must be applied to these figures.

III.—Heliographic Observations :—

In the year ended 1912 May 10, photographs were obtained on 252 days, as against 256 in the previous year.

The Photoheliographic Results for the year 1911 have been printed; and the copy for press for 1912 of the daily results is ready for the printer.

Of the photographs taken in the year ended 1913 May 10, 498 have been selected for preservation, including 19 with double images of the Sun for the determination of zero of position-angles. The photographs from the Royal Observatory, Cape of Good Hope, have been received up to 1913 March 31; and supplementary photographs have been received, through the Solar Physics Committee, from Dehra Dûn, India, up to 1912 December 8.

The series of photographs for the year 1912, as made up from the four contributing observatories, is complete, except for one day, 1912 July 20, for which no photograph is at present available.

The record for 1912 is made up from the different sources as under:—

Greenwich	235 days.
Cape	102 „
Dehra Dûn	24 „
Kodaikánal	4 „
Unrepresented as yet	1 day.
Total	366 days.

The measurement of the photographs for 1912 is complete, and for those taken at Greenwich up to 1913 April 30, and at the Cape up to 1913 January 30.

There has been very little change in the general condition of the Sun's surface since the date of the last report, and the mean daily spotted area in 1912 was even smaller than in 1911; the figures being 36 millionths of the Sun's visible hemisphere in 1912 as against 64 in 1911. The Sun has continued to be exceedingly quiet in the opening months of the present year, but since 1912 December 18, when a group of spots was observed in a high northern latitude, most of the few spots that have appeared have been in high latitudes, north or south; so that though no increase has yet been seen in numbers or areas, the latitudes observed indicate that the new cycle of solar activity has definitely commenced.

As stated in the last report advantage has been taken of the present sun-spot minimum to discuss the determinations of the heliographic co-ordinates of the spot-groups which have now been accumulated since 1874 in order to ascertain whether any correction is required to the assumed position of the Sun's Axis, which has been used in the reduction of the measures of the solar photographs. This position was that assigned by Carrington, viz.:—

Inclination of the Sun's equator to the ecliptic = 7° 15′.

Longitude of its ascending node on the ecliptic = 73° 40′ for 1850·0.

The object has been to use the material available as completely as possible. This, since the longitudes of the spots are hardly affected by small errors in the position of the Axis, is practically confined to the observed latitudes. The latitude of each group that has been observed for 8 or more consecutive days has been compared, when first seen, with that given when it was last seen, and this has

yielded an equation of condition for the determination of the errors in the two co-ordinates. These equations, 2,211 in number, have been supplemented by 738 others, derived from spot-groups that have returned a second time to the visible hemisphere; their latitudes as observed near the West Limb before disappearance being compared with those observed near the East Limb after reappearance. In the case of groups observed for 11 or more consecutive days, *i.e.*, practically from East Limb to West Limb across the visible hemisphere, the mean latitude as derived from observations made near the two limbs has been compared with the latitude observed near the Central Meridian; and this third method has yielded 1,304 equations, in which the co-efficients are considerably smaller than in the first two methods, but which are free from the effects of errors of orientation of the photographs, and from the proper motions of spots so far as these are linear in character. The weighted combination of the three methods gives a correction of $-4'\cdot5$ to Carrington's value for the inclination, and of $+6'\cdot8$ to the longitude of the ascending node; or $I = 7°\ 10'\cdot5$ and $N = 73°\ 46'\cdot8$ for 1850·0. The details of the discussion will form a small separate publication of the Observatory, and is now passing through the press.

Solar Eclipse.—An expedition was sent to Brazil to observe the total solar eclipse of 1912 October 10. The instrumental equipment consisted of the Thompson 9-inch coronagraph, the Hills quartz spectroscope kindly lent by Professor Newall, and two telescopes for photographing the corona through a green colour filter. The party, consisting of Mr. Eddington and Mr. Davidson accompanied by Mr. J. J. Atkinson, proceeded to a site at Passa Quatro in the State of Minas Geraes. Unfortunately, heavy rain fell throughout the day of the eclipse, and no results could be obtained.

The observers were greatly indebted to the Brazilian Government for valuable help and facilities, and for the hospitality extended to them.

IV.—Magnetic Observations :—

The variations of magnetic declination, horizontal force and vertical force have been registered photographically, and accompanying eye observations of absolute declination, horizontal force and dip, have been made with the declinometer, the Gibson deflexion instrument, and the Airy dip circle mounted in the Magnetic Pavilion. Observations of absolute horizontal force have been made weekly and determinations of the moment of the deflecting magnet monthly. Since 1913

January experiments have been made with a view to adopting a satisfactory substitute for the silk suspension of the declinometer on account of the uncertainty of the changes of torsion of the silk, but these experiments have not yet been completed.

The dip-inductor mentioned in last year's report has been received from the Cambridge Scientific Instrument Company and set up in the Magnetic Pavilion. A number of trial observations have been made with it.

The magnetic reductions are completed to the following stages:—

The eye observations of the declination and horizontal and vertical force magnets for the year 1912 are completely reduced, and the hourly ordinates of the photographic registers are read off and tabulated. The temperature of the magnet basement at every hour has been read from the Richard thermograph sheets, and the daily and hourly means have been taken. The eye observations of declination, dip, deflexion and magnetic moment are completely reduced.

The magnetic elements for 1912 determined from observations in the Magnetic Pavilion are as follows:—

Mean declination - - -	15° 24′·3 West.
Mean horizontal force - -	0·18528 (in C.G.S. units).
Mean dip (with 3-inch needles) -	66° 51′ 46″.

In 1912 there were no days of great magnetic disturbance; five days were classified as 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 has been made, the days being selected, as also were the five days of disturbance, by the International Committee on Terrestrial Magnetism from the reports sent in from a number of Observatories.

In connection with the work transferred from the Compass Branch of the Hydrographic Department, the declination charts for 1912 have been received

from the Admiralty and used for checking the computations forwarded from the Hydrographic Department in connection with the smaller Pilot and Anchorage Charts. A systematic card catalogue is being made of all data previously collected in the Library, and all results received from time to time from any source are included in it as time permits, with a view to the preparation of the next set of complete declination charts.

Some progress has been made with a determination of the surface potential of the magnetic diurnal variations using data from a number of observatories in both hemispheres. Two years are being dealt with, one of few and the other of many sun-spots.

During the past two years plans have been in preparation for a new building to house a set of modern instruments for recording the variations of the magnetic elements. The erection of the building has been sanctioned and will be proceeded with during the coming summer. It will be situated in the Enclosure at a little distance from the Magnetic Pavilion where the absolute observations are made. The building will be above ground and the inner chamber containing the instruments will be thoroughly well insulated. The temperature will be maintained by electric heating; a supply of alternating current will be installed for this purpose and for lighting.

A new declination variometer has already been obtained, and the details of the other instruments are under consideration.

The variometers in use at present will be continued till a sufficient comparison is obtained with the new instruments.

V.—Meteorological Observations:—

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

The meteorological reductions are in the following state:—The observations of barometer, thermometers, anemometers, rain-gauges, and sunshine recorder

are reduced up to the present time. On the photographic sheets all time-scales are laid down, and the hourly ordinates are entered and completely reduced to the end of April 1913, except for the electrometer registers, which are completely reduced to the end of 1911. The table of principal changes of the wind for 1912 is not yet completed.

The mean temperature for the year 1912 was 50°·2, or 0°·7 above the average of the 70 years 1841–1910. The mean monthly temperatures have been computed from the thermograph registers, standardised by a revised method which takes account of the discordance of the night minimum as well as of the routine observations during the day. For the purpose of comparison the monthly means have been corrected as far back as appeared to be necessary having regard to the changes of the position and surroundings of the thermograph and the standard thermometers; this period corresponds with that of the installation of the present thermograph in 1887. It is found that the effect of the modification is to diminish the values of the monthly means as a rule, especially at certain seasons of the year, but the mean value for the year from the 70 years observations is the same as that from the 50 years 1841–1890 which have been practically unaltered. For the 12 months ended 1913 April 30 the mean temperature was 49°·8.

During the 12 months ended 1913 April 30 the highest temperature in the shade (recorded on the open stand in the enclosure of the Magnetic Pavilion) was 90°·0 on July 12. On the same day the highest temperature in the Stevenson screen in the Magnetic Pavilion enclosure was 87°·9, in that in the Observatory Grounds 88°·6, and in the new screen in the Magnetic Pavilion enclosure 88°·7. On 12 days the highest temperature in the shade equalled or exceeded 80°, but none of these days occurred after July, maximum readings of 70° and upwards occurring only seven times in August and not at all later.

The lowest temperature of the air recorded during the same period was 24°·2 on February 23. There were 27 days during the winter on which the temperature fell as low as 32°·0, or less than half the average. This is the more remarkable as it follows the exceptionally mild winter referred to in last year's report, when the corresponding number of days was 22.

The mean daily horizontal movement of the air in the year ended 1913 April 30 was 310 miles, which is 26 miles above the average of the previous 45 years. The greatest recorded daily movement was 845 miles on March 19, and the least 56 miles on October 11. The greatest recorded pressure to the square foot was 25·3 lbs. on March 16, and the greatest velocity in an hour 51 miles on March 19.

During the year 1912, Osler's anemometer showed an excess of 14 revolutions of the vane in the positive direction N., E., S., W., excluding the turnings which are evidently accidental.

The number of hours of bright sunshine recorded during the 12 months ended 1913 April 30, by the Campbell-Stokes instrument, was 1,313 out of a possible 4,457 hours, giving a mean proportion of 0·295, constant sunshine being represented by 1. As compared with the previous twelvemonth, the deficiency of more than 500 hours is fully accounted for by the fact that in July, August, September, and April the duration of sunshine was only about half what it was in the corresponding months.

The rainfall for the year ended 1913 April 30 was 25·61 inches, being 1·49 inches greater than the average for the period 1841–1905. The number of rainy days (0·005 inch or over) was 188. February with 0·81 inch was the only month with less than an inch, and August, with 4·14 inch the only month with more than 3 inches.

VI.—Printing and Distribution of Greenwich Publications :—

The Greenwich Observations for 1910 were distributed in July 1912.

The Greenwich Observations for 1911, including a Catalogue of Stars for the epoch 1900 from observations with the altazimuth between 1899 and 1908, are printed and will be distributed shortly. The Rates of Chronometers and Watches for 1912 are in the press.

A publication on the Position of the Sun's Axis as determined from Photographs 1874–1912 is being printed.

The Astrographic Catalogue, Vol. III., is being printed. At the date of this Report the Catalogue of Right Ascensions and Declinations is complete from the Pole to declination 77°.

VII.—Chronometers :—

The number of Government marine chronometers and watches now at the Observatory is 512, viz., 194 box chronometers, 22 pocket chronometers, 122 chronometer watches, and 174 hack watches.

In addition to these there are at the Observatory 4 box chronometers and 3 watches being tested after purchase or repair, and 4 stop-watches on trial for purchase for the Indian Government.

There are also 2 box chronometers on trial for purchase for Hong Kong Observatory.

There are at present 25 hack watches and 3 non-magnetic watches on trial for purchase by the Admiralty.

In the year ended 1913 May 10, the average daily number of chronometers and watches being rated was 553, the total number received was 1,930, the total number issued was 1,802, and the number sent for repair 861. This last number includes 31 box chronometers, 1 pocket chronometer, and 5 watches belonging to the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 49° to 102°, 53 chronometers were sent in. During the trial 18 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 35 chronometers, 22 were purchased for the Navy, and 2 for the Indian Government.

The performance of these chronometers was very satisfactory.

For the annual trial of chronometer watches, lasting 16 weeks and including trials in the oven and in positions, 171 watches were entered, of which 57 were classified, and of these 53 were purchased for the Navy, and 3 for the Indian Government. Among the watches classified were 29 with centre-seconds' dials; of these, 23 were purchased. There were 11 "Karrusel" or "Tourbillon" watches classified, all of which were purchased. The performance of the watches was good.

A trial of pocket chronometers took place concurrently with the trial of chronometer watches, and under the same conditions as regard duration of trial, temperatures, and positions. Of the 7 pocket chronometers sent in, 1 was purchased for the Navy.

The trials of hack watches and non-magnetic watches have been continued throughout the year, 76 of the former and 28 of the latter having been tested. Of these, 24 hack watches and 2 non-magnetic watches have been purchased.

The next trial of box chronometers will commence on June 21, and of pocket chronometers and chronometer watches on August 2.

Provision is now made to receive and test two classes of non-magnetic watches at the Royal Observatory, (*a*) those comparable with chronometer watches and (*b*) watches less highly adjusted. These may be brought in for trial at any time.

A box chronometer Dent 54835 in a specially made metal box is now being tested in a magnetic field.

VIII.—Time Signals:—

An apparatus was set up on July 5 for the reception of the wireless time-signals from the Eiffel Tower and Norddeich. The signals have been constantly observed by Mr. Lewis and Mr. Bowyer since this date, the morning signals being observed each day (except Sundays). The night signals from the Eiffel Tower have been observed on 128 and the rhythmic signals on 82 occasions. The night signals from Norddeich have been observed on 124 occasions. The morning signals from the Eiffel Tower were observed by both Mr. Lewis and Mr. Bowyer on 167 days: there is a mean difference L − WB = $-^{s}\cdot066$ in their times of observation with an accidental discordance of $\pm^{s}\cdot06$ between the observers.

Similarly in the receipt of the Norddeich Signals the two observers showed a mean personal difference L − WB = $-^{s}\cdot043$ and a similar accidental discordance. Thus the ordinary signals are observed by either observer with a mean error of less than $\pm^{s}\cdot05$. The rhythmic signals are apparently received with an error of less than $\pm^{s}\cdot01$, and the mean discordances between these and the ordinary signals are less than $\pm^{s}\cdot05$.

As regards the actual difference between the time sent out by the Eiffel Tower and that of the Greenwich 10^{h} and 1^{h} signals, from 184 observations Mr. Lewis makes the Eiffel Tower Signal $0^{s}\cdot256$ late on Greenwich, and Mr. Bowyer from 234 observations makes it $0^{s}\cdot313$ late. It is supposed that the difference is mainly due to the difference of personal errors of the Standard Observers at Paris and Greenwich. The mean discordance after allowing for this constant difference is $\pm^{s}\cdot11$.

The following table shows the actual differences found during May, the mean of the two observers being taken after allowance for their constant difference :—

May 1	$+0^{s}\cdot35$	May 9	$+0^{s}\cdot46$	May 17	$+0^{s}\cdot20$	May 25	—
2	·42	10	·39	18	·28	26	$+0^{s}\cdot31$
3	·35	11	—	19	·26	27	·33
4	—	12	—	20	·28	28	·32
5	·46	13	·35	21	·28	29	·21
6	·43	14	·32	22	·29	30	·37
7	·30	15	·18	23	·28	31	·40
8	·34	16	·13	24	·29		

The Norddeich Signals are according to 160 observations of Mr. Lewis $0^{s}\cdot297$ late on the Greenwich Time Signals, and $0^{s}\cdot340$ late according to 229 observations of Mr. Bowyer. Allowing for this there is an accidental discordance of $\pm0^{s}\cdot23$.

On January 19 the Greenwich Time Ball was dropped $7^{s}\cdot7$ early, and the Time Signal was also this amount in error.

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

Apparent Error of Return Signal.	Portsmouth.	Portland.	Devonport.	Deal.	Westminster.
	Days.	Days.	Days.	Days.	Days.
Not greater than 0·2	239	220	261	—	53
Between 0·2 and 0·5	31	10	8	—	48
„ 0·5 „ 1·0	4	1	4	—	83
Greater than 1·0	0	0	1	—	91*
Average error of signal for the year	±·14	±·07	±·07	—	±·88
Failures of return signal on Sunday	43	49	23	17	—
Total failures	76	118	64	64	8
Interruptions by telegraph signals on Sunday	6	7	3	5	—
Total interruptions	14	15	25	11	—

* Exceeded 3·0 on one occasion.

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

In consequence of the fire at the G.P.O. the total failures are in excess of the average. In the case of Deal, the time was supplied direct from the Observatory by Telephone.

A few failures can also be ascribed to change of electrical apparatus in the G.P.O. and at Deal.

The electrical apparatus used for dropping the Time Ball at Deal has been completely overhauled. The wiring has been renewed, the old instruments in use since 1853 replaced, and the arrangements in general brought more into line with modern methods.

The Westminster clock stopped at about $10^h\ 40^m$ a.m. on December 6 and $6^h\ 52^m$ a.m. on December 23. These stoppages were due to temporary adjustment of the clock.

IX.—Personal Establishment:—

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

Chief Assistants—Mr. Chapman and Mr. Eddington.

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

Clerical Assistant—Mr. Outhwaite.

Junior Assistant (Higher Grade)—Mr. Davidson.

Junior Assistants.—Mr. Acton, Mr. Bowyer, Mr. Burkett, Mr. Cullen, Mr. Edney, Mr. Furner, Mr. Jeffries, Mr. Melotte, Mr. Stevens, Mr. Witchell.

Mr. B. D. Evans resigned on May 17, 1912, to take up his appointment as First Assistant at Hong Kong Observatory, and Mr. J. E. Evans resigned on January 3, to go as Second Assistant Astronomer in Ceylon. The vacancies thus occurring were filled by the appointment of Mr. Harold Acton on July 25, and of Mr. Frank Jeffries on January 4.

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

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

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

One Computer, Mr. Perry (not included in this Table), is employed temporarily in connection with the reproduction of the Franklin-Adams chart plates.

Since the date of this Report Mr. Eddington, who has filled the post of Chief Assistant with conspicuous ability since February 1906, has resigned his position, having been appointed Plumian Professor of Astronomy at Cambridge.

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

The total number of persons regularly employed at the Observatory is **61.**

X.—General Remarks:—

The daily comparison of the Eiffel Tower signal affords a useful regular check on the time as determined at Greenwich. At the request of the Director of the Paris Observatory, this comparison has, since the installation of the receiving apparatus, been forwarded daily to him as a check on the rate of the clock at Paris. These comparisons are specially serviceable in cloudy weather. In October the Astronomer Royal attended the "Conference internationale de l'heure" as one of the British delegates, where the further development of the wireless time-service was discussed. The distribution of time in this way is of great value to navigators and is likely to be of importance in the determination of longitude on land.

Attention may be drawn to the determination of the position of the Sun's axis which has been carried out by Mr. Maunder. The attempt has been made to utilize as fully as possible the long series of measures of the positions of Sun spots made at Greenwich. Although Carrington's determination proves to be only a few minutes in error, it is desirable that the position of the Sun's axis should be obtained with all possible precision, and that the limits of accuracy should be known. A redetermination should be made at each Sun-spot cycle.

In the new magnetic observatory, shortly to be erected, provision is made for the continuation of the long series of Greenwich observations of the variations of the magnetic elements. This series is unique as regards the length of time during which observations have been made on the same site. The care which has been taken to guard the observatory from all artificial electro-magnetic disturbances

which could affect the accuracy of the observations has preserved the suitability of the site for such work. The present wooden structure, however, is old, and needs extensive repairs or renewal. The latter course was considered preferable, and designs have been prepared for a new building in the magnetic pavilion enclosure where the absolute observations are made. The main feature of the building is the provision by insulation and heating for the reduction of the daily range of temperature. Also to avoid damp it will be above ground. The building will therefore be adapted to house a set of modern instruments. Although the change of site is small, the new and the old instruments will be run concurrently for a period sufficient to give a good comparison between the two.

F. W. DYSON.

Royal Observatory, Greenwich.
1913, May 30.