REPORT

OF THE

ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH.

Read at the Annual Visitation of the Royal Observatory, 1914 *June* 6.

GREENWICH OBSERVATIONS, 1913.

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The Report here presented refers to the year from 1913 May 11 to 1914 May 10, and exhibits the state of the Observatory on the last-named day.

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

A new building has been erected in the Magnetic Enclosure in the Park for the purpose of housing a set of modern instruments for recording the variations of the magnetic elements. The building was constructed by the Works Department of the Admiralty, and consists of a thickly-walled outer room containing an inner room, well insulated by a considerable air-space. To maintain the constancy of the temperature, electric heaters, controlled by a thermostat, are being installed. The building was completed in March, the cable to carry the current was laid in April, and the arrangements for heating are nearing completion.

The minor works necessary for the repairs and maintenance of the buildings carried out during the year by the Works Department include the reconstruction of the drainage of the Magnet House, Central Store, and East Wing of the New Observatory, and the re-pointing of a considerable amount of the brickwork of the Old and New Observatory. The external painting of the Observatory was commenced in April and is now well advanced. The internal painting of the Old Observatory was completed on July 30.

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Fire hydrants, with the necessary hose pipes and nozzles have been fixed in the Central Store and in the basement of the Magnet House.

A motor generator has been installed to obtain continuous current from the town supply, for the purpose of small storage batteries used for lighting the instruments and for other purposes. The gas-engine, dynamo, and accessories formerly used for lighting have been removed to the Royal Marine Infirmary at Deal. Two small motors have been supplied to rotate the dome of the Thompson Equatorial and to wind the clock-weight.

The principal movable instruments are thus distributed:—

At Greenwich—

Transits B, C, D, and E.

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.

A single prism Spectroscope.

On loan—

Transit A, at the Cape Observatory.

Transit, with axis view, at the Science Museum, South Kensington.

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.

Two Heliotropes at the Science Museum, South Kensington.

Object glass of the Sheepshanks Equatorial, and object glass (4-inch) of Portable Telescope, R.O., No. 1, both on loan to the Joint Permanent Eclipse Committee for the observation of the Solar Eclipse of 1914 August.

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.

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, 1914 August.

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

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. Two of the books reported missing last year have been returned.

A silver-gilt Inkstand, presented to Sir G. B. Airy in 1852 by the River Dee Company, has been presented to the Royal Observatory by his son, Mr. Osmund Airy. The Observatory is also indebted to Lady Huggins for a portrait of Sir William Huggins, and to Sir William Christie for a portrait of himself.

II.—Astronomical Observations :—

Transit Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. An exceptionally large number of observations have been made of the stars between 24° and 32° of North declination, with a view of completing the observations for the catalogue of these stars this year. Of the 12,000 stars all but 600 have been observed four or five times. The stars which are insufficiently observed are mostly between 5^h and 7^h of right ascension, partly owing to the instrument being out of use in the early months of 1906.

The number of observations with the Transit Circle from 1913 May 11 to 1914 May 10 is as follows :—

Transits - - - - - - - - -	16,423
Determinations of collimation and level error - - -	311 and 632
Circle observations - - - - - - -	16,455
Determinations of nadir point and reflection observations of stars (included in the number of circle observations) -	607 and 417

The condensing lenses used for illuminating the circle have been removed, as the direct light of the electric lamp is found to be sufficient.

It is intended to replace the present eye-end of the instrument by one with a travelling-wire micrometer, which is being constructed by Messrs. Troughton and Simms.

The transits and circle observations are completely reduced (so as to exhibit Mean R.A. and N.P.D. 1910·0) to 1914 April 8, and Apparent R.A. and N.P.D. is formed to May 10.

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

For the year ended 1912 December 31 the value of the colatitude, using Pulkowa refractions is 38° 31′ 21″·80. The correction to the tabular value of the obliquity of the ecliptic obtained from the observations of the Sun is + 0″·04.

The mean of the observed distances from the pole to the ecliptic is too large by 0″·05. The apparent correction to the right ascensions of the clock stars, for which Newcomb's Equinox is adopted, is − 0ˢ·052.

For the year 1913, the discordance between the zenith point determined by nadir observations and by reflection observations of stars is − 0″·14. The values from 1892 to 1910 range from − 0″·16 to − 0″·42.

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

	Diurnal Changes of Level.				Diurnal Changes of Nadir.			
	Noon.	6 p.m.	Midnight.	6 a.m.	Noon.	6 p.m.	Midnight.	6 a.m.
1913	+ 0″·14	0″·00	+ 0″·21	...	+ 0″·19	0″·00	+ 0″·09	...
1897-1905	+ 0·25	0·00	+ 0·21	+ 0·37	+ 0·14	0·00	+ 0·12	+ 0·11

The correction for R − D discordance from the observations in 1913 is + 0″·035 + 0″·426 *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 1912 − 0ˢ·662 in R.A. and + 0″·84 in declination. The corresponding mean errors in longitude and latitude are − 9″·79 and + 0″·23.

The mean error of the Moon's tabular right ascension for 1913 derived from 98 observations with the transit-circle is − 0ˢ·832.

The formation of the next Greenwich catalogue, epoch 1910, is in hand. The computation of precessions and secular variations is completed.

Altazimuth.—This instrument has been used as a reversible transit-circle during the second and third quarters of each lunation for observations of the 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 - - - - -	1,862
Meridian zenith distances - - - -	1,031
Extra-meridian observations - - -	72
Determinations of collimation and level error -	252 and 184
Determinations of nadir point - - -	152

The altazimuth observations are completely reduced to 1914 April 25.

The travelling-wire micrometer, which was completed at the time of the last report, has been used throughout the year for the determination of right-ascensions. The following table gives a comparison of the clock-error found by different observers in the four positions of the instrument with that obtained by the transit-circle and reduced to the standard observer :—

Clock Slow (T.C.) — Clock Slow (Altaz.).

Position of Instrument.	Observer.				
	A. C.	H. F.	A. S.	E. C.	G. B.
180° *d*	$+0^{s}\cdot18_{2}$	$+0^{s}\cdot24_{3}$	$+0^{s}\cdot31_{1}$	—	—
180° *r*	$+0\cdot23_{1}$	$+0\cdot15_{4}$	$+0\cdot22_{2}$	$+0\cdot17_{3}$	—
0° *r*	$+0\cdot26_{6}$	$+0\cdot23_{7}$	$+0\cdot37_{3}$	$+0\cdot26_{3}$	—
0° *d*	$+0\cdot26_{7}$	$+0\cdot23_{2}$	—	$+0\cdot07_{1}$	$+0\cdot23_{4}$
	$+0\cdot25_{16}$	$+0\cdot22_{16}$	$+0\cdot31_{6}$	$+0\cdot19_{7}$	$+0\cdot23_{4}$

The four positions of the instrument agree, and the personal equations of the different observers are very small. The mean value $+0^{s}\cdot24$ has been considered as the absolute personal equation of the transit-circle standard observer, and, since January 20, the Greenwich Time has been adopted on this basis.

It will be observed that the number of observations of right ascension is considerably in excess of the observations of north polar distance. This is due to the inclusion in the working list of a number of faint and bright stars for comparison with the transit-circle and the determination of the magnitude equations of the observers with the latter instrument.

The north polar distances have been observed with the new printing micrometer. Comparison with Newcomb's catalogue for different periods gives the following results:—

Date.	(Newcomb-Altaz.)	Position of Instrument.
1913 May, June - - -	$+0''\cdot25 + 0''\cdot27 \sin Z$	180° *d.*
„ July, August - -	$+0''\cdot13 + 0''\cdot00 \sin Z$	180° *r.*
„ September, October -	$+0''\cdot03 - 0''\cdot17 \sin Z$	0° *r.*
„ November, December -	$-0''\cdot06 - 0''\cdot59 \sin Z$	0° *d.*
1914 January, February -	$-0''\cdot11 - 0''\cdot58 \sin Z$	180° *r.*

The term depending on Z (the zenith distance) is practically unchanged as compared with the results of recent years. The constant term which for several years has been $1''\cdot1$, changing sign with the position of the instrument, has been removed by the introduction of the new eye-end of the telescope.

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 1913:—

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. - - - -	0	0	0	0	2
3–6 „ - - - -	9	0	4	0	6
6–9 „ - - - -	19	12	14	9	0
9–12 „ - - - -	21	16	17	4	0
12–15 „ - - - -	23	15	16	9	0
15–18 „ - - - -	16	10	13	8	0
18–21 „ - - - -	9	0	1	0	2
21–23 „ - - - -	0	0	0	0	2

The total number of observations of the Moon is 97 with the transit-circle and 79 with the altazimuth, viz.:—67 in the meridian and 12 extra-meridian. Taking both instruments, observations of the Moon have been obtained on 109 days during the year.

The mean error in right ascension of the Moon's tabular place for 1913 is $-0^s\cdot81$ from meridian observations and $-0^s\cdot87$ from extra-meridian observations of the Moon's limb, and $-0^s\cdot81$ from meridian observations of the crater Mösting A. The transit circle gives $-0^s\cdot832$. Attention may be drawn to the great increase in recent years of the mean tabular error of the Moon's longitude. From 1883, when Newcomb's Empirical Correction was introduced into the Nautical Almanac, the values (all reduced to the same equinox) are—

1883	-	$-0''\cdot03$	1891	-	$+0''\cdot72$	1899	-	$-2''\cdot18$	1907	-	$-5''\cdot96$
84	-	$-0\cdot16$	92	-	$+0\cdot79$	1900	-	$-2\cdot69$	8	-	$-5\cdot97$
85	-	$-0\cdot09$	93	-	$-0\cdot06$	1	-	$-2\cdot77$	9	-	$-6\cdot41$
86	-	$-0\cdot11$	94	-	$-1\cdot20$	2	-	$-3\cdot15$	10	-	$-7\cdot85$
87	-	$+0\cdot21$	95	-	$-1\cdot47$	3	-	$-3\cdot08$	11	-	$-8\cdot34$
88	-	$+0\cdot76$	96	-	$-1\cdot68$	4	-	$-3\cdot16$	12	-	$-9\cdot79$
89	-	$-0\cdot38$	97	-	$-2\cdot77$	5	-	$-5\cdot29$	13	-	$-11\cdot8$
90	-	$-0\cdot27$	98	-	$-3\cdot03$	6	-	$-5\cdot91$			

Cookson Floating Zenith-Telescope.—During the year 182 photographs have been taken, 174 for latitude groups and 8 for scale determination. From the commencement of the observations, 1911 September 7, 387 latitude plates (excluding rejected plates) have been obtained, of which 229 have been measured in the direct, and 257 in the reversed position. In addition, 18 scale plates have been taken, of which 7 have been measured. A discussion of the results up to date will be made at the end of 1914.

Equatorial Observations.—During the year ended 1914 May 10, 18 disappearances of stars occulted by the Moon have been observed by one or more observers. They completely confirm the results of the meridian instruments as to the large change in the Moon's mean longitude.

The 28-inch Refractor.—Observations of double stars have been made from a working catalogue containing all known double stars showing appreciable

relative motion, which are within the range of declination of the instrument. A number of other stars are included for various reasons, particularly some of those discovered by Hussey and Aitken under 2″ separation.

The measures made during the year consist of—

105	pairs	with	separation	less than 0″·5.
110	„	„	„	between 0″·5 and 1″·0.
123	„	„	„	„ 1″·0 „ 2″·0.
125	„	„	„	greater than 2″·0.

κ Pegasi was observed on 8 nights, δ Equulei on 5 nights, 70 Ophiuchi on 12 nights, and ϵ Hydræ on 3 nights, β Delphini on 7 nights, and Procyon on 1 night.

As early publication of the results of the double star measures is provided for by communicating the mean results each year to the Royal Astronomical Society, the annual publication of the results in the Greenwich volume has been discontinued, and the measures from 1893 to 1915 will be formed into one catalogue, each separate observation being given. This will contain 3,000 double stars, and will contain, besides the measures, notes on the more interesting stars.

All the measures to the end of 1912 have been collected and entered on catalogue forms, and examined for the first 18 hours of R.A. to the end of 1903. The limiting date of the catalogue is extended till the end of 1915, to give an opportunity of observing the stars which have not been sufficiently observed.

Thompson Equatorial.—The work with this instrument has been concentrated on parallax and photometric determinations. No observations have been made with the 30-inch reflector or the 6-inch triple objective, all the photographs taken during the year having been made with the 26-inch refractor.

Parallax.—The method adopted for the parallax observations consists in an exposure of the same plate at two different epochs, approximately six months apart, on the star whose parallax is required and the surrounding field. During the year the first exposure has been given to 292 plates, and a second exposure to 219 plates. Measures have been made of 82 plates and 53 of these have been measured

in duplicate. The work of measurement is proceeding continuously, and it is expected that the measurement of the plates will be able to keep pace with the photography. The parallaxes of the seven stars in the following list have already been determined, and the results are given as showing the high level of this work.

Star's Name.	Magnitude.		Centennial Proper Motion.	Parallax.	Number of Plates
	Visual.	Phot.			
	m	m	″	″	
B.D. 68°, 278 - - -	9·0	10·0	35·3	+ ·070 ± ·013	4
Lal. F. 635 - - - -	8·5	9·1	25·8	+ ·014 ± ·008	5
Gr. 986 - - - -	7·3	7·7	25·3	+ ·025 ± ·007	4
Car. 824 - - - -	8·8	9·5	35·3	− ·008 ± ·007	4
O.A.N. 13407 - - -	8·5	9·4	74·7	+ ·006 ± ·009	4
O.A.N. 16017 - - -	9·0	9·6	28·0	+ ·011 ± ·008	5
Lal. 32407 - - - -	6·3	6·8	54·8	+ ·070 ± ·008	5

Photographic Magnitudes with 6-inch Astrographic Triplet.—Resulting from the comparisons of fields with the area surrounding the north pole, a catalogue has been published during the year giving the photographic magnitudes of 2,329 stars between the pole and + 75° dec., and believed to be complete down to magnitude $9^m \cdot 0$. This catalogue is being continued to + 65° dec., and at the date of the last report all the plates had been measured within a radius of about $3\frac{1}{2}°$. In order to duplicate results from the overlap of the plates it was necessary to extend the measurement to a distance of 5°. This has been accomplished by extending the field of polar reference stars. The work is nearly finished and copy for press is being proceeded with.

In addition, it was considered that it would be more economical to utilize these plates for some of the fainter stars required in the Astrographic Catalogue, rather than take special plates for this purpose with the Astrographic Equatorial; but, as the images of these stars are not black and, therefore, unsuitable for measurement of diameters, being of varying shades of grey, their magnitudes have been determined by a comparator method.

Photographic Magnitudes with 26-inch Refractor.—During the year 157 plates of the Kapteyn areas and of the central regions of the Franklin-Adams Charts have been taken. The progress of this work during the year is shown by the following table :—

	Exposure.	Number of Plates.		
		Taken.	Good.	Measured.
Franklin-Adams Fields :				
Long exposure (with grating) - - -	60^m	35	23	11
Comparison with Standard Area - - -	6^m, 6^m, 6^m, 6^m	63	40	17
Kapteyn Areas :				
Comparison with Standard Area - - -	6^m, 6^m, 6^m, 6^m	59	50	45

Twenty-three plates have been taken with the diffraction gratings for the purpose of comparing different parts of the scale of the Harvard Sequence of Polar Standards.

Thirteen plates have been received from the director of the Helwan Observatory. This completes the series of comparisons of fields in Zones $-15°$ and $-30°$ dec. with fields in Zone $+15°$ dec., which have been directly compared with the pole at Greenwich. The measurement of these plates has been commenced.

In the course of this work on stellar magnitudes, a catalogue has been formed giving the magnitudes of 262 stars within 35′ of the pole, which is probably complete to the 15th magnitude and includes many fainter stars. These were determined from short exposure plates by direct comparison with the Harvard Standards.

The photometry plates taken in 1912 and 1913 have been utilized to standardize the magnitudes of 30 of the Franklin-Adams plates on which the numbers of the stars have been counted. From these and other *data* a discussion has been made by Dr. Chapman and Mr. Melotte of the number of stars of different magnitudes in different galactic latitudes. The results, which reach down to stars of magnitude

17·0, are published in the *Memoirs of the Royal Astronomical Society*, Vol. LXX., Part 4.

Franklin-Adams Chart.—In accordance with an arrangement with the Royal Astronomical Society, photographic copies of the Franklin-Adams Chart have been made during the year. Of the total of 206 plates, 30 copies of each of 163 have been made. A series of ten plates, being a selection of the most interesting regions of the Milky Way, have been reproduced in the *Memoirs of the Royal Astronomical Society*, Vol. LXX., Part 3.

Astrographic Equatorial.—With this instrument 192 photographs have been taken on 72 nights. Of these 121 were for the determination of photographic magnitudes of stars in the Greenwich Section of the Astrographic Catalogue by comparison with the standard magnitudes of the stars round the North Pole. Of the 121 photographs, 85 were satisfactory. This work is now completed.

The photography of Chart plates for the zone + 25° to + 31° has been resumed. Some experiments were made with a grating (giving a difference of three magnitudes between the central and first diffracted images) so that there should be on each plate a definite scale, derived from the bright stars, to determine the magnitudes of the fainter stars when those of the brighter ones are known. There is, however, a considerable advantage in having two exposures on each plate, especially if the photographs are reproduced on paper on the same scale, in the ready distinction of stars from photographic faults. For this reason two exposures of half an hour, without the grating, with a separation of about 10″ between the images, has been preferred to a single exposure of one hour with the grating.

Fifty-one of these plates have been taken, but only twenty-five have been successful. The number of failures is partly due to the fact that the telescope has been used for a long time on the Northern part of the sky. When used on a Southern zone, various slight adjustments were required, particularly a wind-screen to protect the telescope from being shaken by the S.W. winds. Other failures are due to clouds arising before the exposures were completed and a few to defective plates.

The printing of the catalogue of right ascensions and declinations of the stars of the Greenwich Astrographic zone found in existing meridian catalogues has been

carried on from Zone 77° to Zone 64° and is almost completed. This catalogue will contain the positions for 1900.0 of 16,765 stars as well as their photographic magnitudes. The latter are to a large extent determined from the special comparison plates with the polar sequence taken with the Astrographic telescope and, for the brighter stars, with the 6-inch triple-objective. The diameters measured on Astrographic plates themselves have also been used, when the plates have been standardised by the additional photographs.

III.—Heliographic Observations :—

In the year ended 1914 May 10, photographs of the Sun were obtained on 258 days. Of these photographs 515 have been selected for preservation, including 29 with double images of the Sun for the determination of zero of position-angle. Photographs have been received from the Royal Observatory, Cape of Good Hope, to 1914 March 1; and supplementary photographs have been received, through the Solar Physics Committee, from Dehra Dûn, India, to 1913 December 7, and from the Director of the Kodaikanal Observatory, to 1913 December 13.

The series of photographs for the year 1913 is made up completely from the four contributing observatories.

The measurement of the photographs for 1913 is completed. For 1914 the Greenwich photographs are measured to May 8 and the Cape photographs to February 28.

The mean daily spotted area of the Sun has been 8 millionths of the Sun's visible hemisphere during 1913, as against 37 in 1912 and 64 in 1911. The appearance of a moderately large spot in March points to the end of this very low minimum of Solar activity.

Solar Eclipse.—An expedition will be sent to Minsk, in Russia, to observe the total solar eclipse of August 20–21. The programme which it is hoped to carry through will be similar to that attempted in Brazil in 1912. The instrumental equipment will consist of the Thompson 9-inch coronagraph giving the corona on a scale of 4 inches to the Sun's diameter; the Hills quartz spectroscope (kindly lent by Professor Newall) for the spectrum in the ultra-violet of the chromosphere and corona; and two 6-inch telescopes for photographing the corona in the light of the green coronal line (λ 5303) by the aid of a green colour filter near the focus and a prism of small dispersion in front of the lens.

IV.—Magnetic Observations :—

The variations of magnetic declination, horizontal force and vertical force have been registered photographically. Observations of absolute declination and horizontal force have been made with the declinometer and the Gibson deflection instrument. Observations of dip have been made with the Airy dip circle and with the dip-inductor lately obtained from the Cambridge Scientific Instrument Company. The dip-inductor has been in regular use since 1914, January 1, and gives very satisfactory results. Observations with the dip-needles are being continued for a time for purposes of comparison. The declination and deflection instruments have been improved by the substitution of tungsten wire for silk suspensions.

The magnetic reductions are completed to the following stages :—

The hourly ordinates of the photographic registers of the declination and horizontal and vertical force magnets for the year 1913 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 absolute observations of declination, dip, and deflection, are completely reduced.

The mean values of the magnetic elements for 1913 and three previous years from observations in the Magnetic Pavilion are as follows :—

Year.	Declination W.	Horizontal Force in C.G.S. Units.	Dip (3-inch Needles).
1910 - - - -	15 41·2	0·18532	66° 52′ 37″
1911 - - - -	15 33·0	0·18529	66 52 6
1912 - - - -	15 24·3	0·18528	66 51 46
1913 - - - -	15 15·2	0·18514	66 50 27

In 1913 there were no days of great magnetic disturbance; one day was classified as of lesser disturbance. Traces of the photographic curves for this day will be published in the annual volume.

The new Magnetograph House, standing in the Magnetic Pavilion Enclosure, is now complete, and will shortly be ready to receive the instruments. It consists

of a small room inside a larger one. The inner chamber in which the instruments are to be placed is 15 by 12 by 8 feet high, and is provided with a system of low temperature electrical resistance heaters and regulators, for the maintenance of a temperature constant throughout the year within a fraction of a degree. The instruments and recording drums are to rest on concrete piers isolated from the floor of the chamber, the recording drums being placed close to the walls so that the daily renewal of the photographic sheets can be effected through shutters in the walls. The instrument room will therefore be entered only when it is necessary to calibrate or adjust the instruments. The walls of this room are composed of fibrous plaster 4 inches thick, the floor and ceiling consisting of two layers of wood enclosing a layer of slag wool. This inner chamber is surrounded on all sides, and above and below, by an air space of from two to three feet in breadth. The outer enclosing chamber rests on a thick concrete foundation with sheet-lead dampcourse, and its walls are 2 feet thick, consisting of an outer layer of concrete blocks, an air space, another layer of concrete blocks, a layer of slag wool, and a layer of fibrous plaster. The ceiling is also well protected with layers of wood and slag wool. The whole building is above ground; at the entrance is a developing room, opening off a small entrance passage, from which the outer chamber is entered through two self-closing doors. A line of cable has been laid to the enclosure for the supply of alternating current to the radiators.

Two of the instruments for installation in the Magnetograph House have already been obtained, and the recording apparatus for these is nearing completion. These two instruments, registering the variations of the horizontal component of the force, are intended to measure the changes of declination and North force, instead of declination and horizontal force (as in the present Magnet Basement) or North and West force (as in many other modern observatories). The declination instrument is retained because of its extreme convenience and accuracy, its scale value being determined by purely geometrical means. The North force instrument is simpler than the horizontal force instrument in that the suspended magnet and the deflecting magnets for determining the scale value occupy constant positions.

The instruments and recording apparatus are of the Cambridge Scientific Instrument Company's construction; the declination instrument is of their usual pattern, with the addition of an enclosing cylinder to protect the instrument and maintain its temperature constant throughout. The horizontal force instrument

has a similar casing, and also two arms, on a ring concentric with the base, for the support of the deflecting magnets by which the scale value of the instrumental record is to be determined.

The two instruments will record on the same drum, worked by a pendulum clock with two-speed gear. The light will be supplied from a straight metal-filament electric lamp (obviating the use of a slit), in three separate beams to each instrument, by means of six reflecting prisms placed in pairs at a distance from one another nearly equal to the width of the drum. By this means, when the normal (middle) trace runs off the sheet during a magnetic disturbance, one of the two outer beams of light will continue the register at the opposite end of the drum. Hourly time marks right across the drum will be made by a special lamp turned on through a relay actuated by hourly time signals from the Observatory.

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 1914, except for the electrometer registers, which are completely reduced to the end of 1912. The table of principal changes of the wind for 1913 is not yet completed.

The mean temperature for the year 1913 was 50°·5, or 1°·0 above the average of the 70 years 1841–1910. For the 12 months ended 1914 April 30 the mean temperature was 50°·8. During the 12 months ended 1914 April 30 the highest temperature in the shade (recorded on the open stand in the enclosure of the Magnetic Pavilion) was 87°·1 on June 17. On 8 days the highest temperature in the shade equalled or exceeded 80°, but 5 of these days occurred in May and none in July. The lowest temperature of the air recorded during the same period was 19°·9 on January 24. There were 28 days during the winter on which the temperature fell as low as 32°·0.

The mean daily horizontal movement of the air in the year ended 1914 April 30 was 288 miles, which is 4 miles above the average of the previous 46 years. The greatest recorded daily movement was 759 miles on April 6, and the least 79 miles on October 24. The greatest recorded pressure to the square foot was 26·0 lbs. on December 26, and the greatest velocity in an hour 44 miles on March 16 and April 6. During the year 1913, Osler's anemometer showed an excess of 18 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 1914 April 30, by the Campbell-Stokes instrument, was 1,446 out of a possible 4,457 hours, giving a mean proportion of 0·325, constant sunshine being represented by 1. This is not far below the average amount, a very fine April nearly counterbalancing an exceedingly dull July.

The rainfall for the year ended 1914 April 30 was 22·30 inches, being 1·82 inches less than the average for the period 1841–1905. The number of rainy days (0·005 inch or over) was 164. January with 0·50 inch was the driest month and March with 3·93 inches the wettest.

VI.—Printing and Distribution of Greenwich Publications:—

The Greenwich Observations for 1911, including a Catalogue of Stars observed with the Altazimuth for epoch 1900 were distributed in July 1913.

The following publications were distributed in May 1914:—

(1) The Greenwich Observations for 1912.

(2) Position of the Sun's Axis, determined from measures of solar photographs, 1874–1912.

(3) Photographic magnitude of stars brighter than $9^{m}\cdot0$, between Dec. $+75^{\circ}$ and the pole.

The third volume of the Astrographic Catalogue is near completion, and will probably be issued in the early autumn.

The printing of the 1913 observations has been commenced. This volume will include a small Catalogue of Stars observed with the Altazimuth, epoch 1910.

VII.—Chronometers :—

The number of Government marine chronometers and watches now at the Observatory is 479, viz., 216 box chronometers, 16 pocket chronometers, 185 chronometer watches, and 62 hack watches. These include 6 non-magnetic chronometer watches and 3 non-magnetic hack watches.

In addition to these there are at the Observatory 3 box chronometers and 2 watches, being tested after repair, for the Indian Government.

There are at present 47 hack watches and 5 non-magnetic watches on trial for purchase by the Admiralty.

In the year ended 1914 May 10, the average daily number of chronometers and watches being rated was 712, the total number received was 2,094, the total number issued was 2,110, and the number sent for repair 934. This last number includes 41 box chronometers, and 7 watches belonging to the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 50° to 105°, 53 chronometers were sent in. During the trial 30 were rejected because the difference between one week's rate and the next exceeded 12 seconds. Of the remaining 23 chronometers, 18 were purchased for the Navy. The performance of these chronometers was satisfactory.

For the annual trial of chronometer watches, lasting 16 weeks and including trials in the oven and in positions, 170 watches were entered, of which 63 were classified, and of these 59 were purchased for the Navy, and 2 for the Indian Government. Among the watches classified were 17 with centre-seconds' dials; all of which were purchased. There were 12 "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 regards duration of trial, temperatures, and positions. Three pocket chronometers were sent in, but none purchased.

The trials of hack watches and non-magnetic watches have been continued throughout the year, 213 of the former and 30 of the latter having been tested. Of these, 97 hack watches and 10 non-magnetic watches have been purchased.

The next trial of box chronometers will commence on June 20, and of pocket chronometers and chronometer watches on August 1.

VIII.—Clocks and Time Service :—

The Clock room near the base of the pier of the Astrographic telescope has proved very satisfactory. It is in a sheltered part of the Observatory, and is insulated by double walls, so that there is little variation of temperature beyond a steady annual change from about 50° to 60° Fahrenheit. The Sidereal Standard and Mean Time Clocks have performed very satisfactorily since their removal to this room, owing to freedom from damp and the stability of the suspension of the pendulums. The Mean Solar Clocks, Shepherd and Graham, have been recently removed to this room.

The renewal of the Time-Ball and the general overhaul and reconstruction of its mechanism has been sanctioned. A new teak mast is being constructed for the Observatory by the Works Department of the Admiralty. Messrs. E. Dent & Co. are supplying a new aluminium ball, and a new winch for winding, and are repairing and adapting parts of the existing machinery. The winch will be removed from its present position near the Octagon Room to the Ball Lobby. [It may be noted that the Time Ball was first erected in 1833. An electric current from the clock was first used to drop it at 1 o'clock in 1852. In 1855 the Ball was blown down into the courtyard. Some repairs were made in 1895 when the chain broke during winding, and again, in August 1913, some temporary repairs were made to the ball.]

The signals from the Eiffel tower and Norddeich have been regularly received and compared with the Greenwich Time. The results to 1914 May 10, using the impersonal micrometer of the altazimuth as the standard for the personal equations of the Greenwich Observers, are as follows :—

Observer.	Eiffel Tower.				Norddeich.			
	No. of Obs.	Signal late on G.M.T.	Personal Equation.	Mean Discordance.	No. of Obs.	Signal late on G.M.T.	Personal Equation.	Mean Discordance.
		s	s	s		s	s	s
L (Morn.)	412	0·002	—	±·110	336	·016	—	±·225
W B (Morn.)	539	·044	—	±·114	526	·060	—	±·209
L—W B	375	—	—·057	±·060	300	—	—·051	±·075
Rhythmic signals	175	·041	—	±·065	—	—	—	—
W B (Night)	256	·050	—	±·122	242	·062	—	±·214

A "field set" of Mr. S. G. Brown's relays and syphon recorder were obtained in March, and very satisfactory records have been obtained on 25 occasions.

There have been no large errors in the time signal sent to the G.P.O. during the year. The Greenwich Time-Ball was not dropped on March 16 and April 6 owing to the violence of the wind. On January 11 and January 31 it was not dropped owing to defects in the mechanism.

The accuracy of the time-balls at the Admiralty Signal Stations and of the Westminster Clock are shown by the following table of the errors of the return-signals received at Greenwich.

Apparent Error of Return Signal.	Portsmouth.	Portland.	Devonport.	Westminster.
Not greater than $0^s \cdot 2$	271	267	286	47
Between $0^s \cdot 2$ and $0^s \cdot 5$	14	9	10	48
„ $0^s \cdot 5$ „ $1^s \cdot 0$	3	1	3	73
Greater than $1^s \cdot 0$	0	1	0	87

The Westminster Clock was only on one occasion found to be more than $3^s \cdot 0$ in error.

The return-signals are seldom received from Portsmouth and Portland on Sundays, and there are in the year a number of days on which some of the return-signals fail or are interrupted by telegraph signals. This year the Devonport clock was under repair during April.

The time-ball at Deal is dropped directly from Greenwich; the clocks at Portsmouth, Portland, and Devonport are corrected daily by the Greenwich 10^h signal; the Westminster Clock is not corrected daily.

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. Jones.

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

Clerical Assistant.—Mr. Outhwaite.

Junior Assistants (Higher Grade).—Mr. Bowyer and Mr. Davidson.

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

Mr. H. S. Jones, Fellow of Jesus College, Cambridge, was appointed Chief Assistant on July 1. The Observatory has lost the valued services of Mr. Maunder, who retired in November after completing 40 years' service. The solar photography has been put in the charge of Mr. Bryant in addition to the Magnetic and Meteorological Work. In this he is assisted by Mr. Edney and by Mr. Newton, who was appointed to the vacancy caused by the promotion of Mr. Bowyer to the Higher Grade of Junior Assistants.

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 (Higher Grade).	*Lambert, Baldwin, Showell, W. F.
Astrographic Equatorial	Hollis	Stevens, Jeffries	*Barton, *Sims.
Thompson Photographic Equatorial.	*nil*	Davidson (Higher Grade).	*Martin, Whitaker, Hills.
		Melotte	*Entwistle, Vaizey, Symms.
Photoheliograph	Bryant	Edney, Newton	*Berry, Smith.
Magnetic and Meteorological	Bryant	Edney, Newton	*Divers, *Showell, H. G., *Mitchell, Walden.
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.

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 excellent spirit which animates both the permanent and temporary staff of the Observatory is shown by the large number of observations and by the extent to which measurements, computations, and other work are kept up to date. Attention may be drawn to the improvement in the altazimuth observations by the introduction of the impersonal micrometer and new eye-end to the instrument, to the success which has so far attended the observations for stellar parallax, and to the changes which are in progress in the magnetic observations.

The aim of the parallax observations is to determine the parallaxes of stars within 25° of the North Pole which may be suspected from the size of their proper motions of being near the Solar system. It is satisfactory to find that a probable error of less than $\pm 0''\cdot01$ can be obtained from a small number of photographs. This is attributable to (1) the method of obtaining two exposures at different epochs on one plate; (2) always working on the meridian; (3) the careful adjustment of the object-glass; (4) the use of the rotating shutter, which makes it possible to equalise the apparent magnitude of the star whose parallax is sought and the comparison stars. At the present rate it appears to be possible to make 30 or 40 complete determinations annually.

It is a pleasure to acknowledge the assistance of the Civil Engineer of the Royal Naval College, Greenwich, and of the Electrical Station Supervisor of the district in the erection of the new house for the Magnetographs. Both the planning and erection of the building owe much to the deep interest which the Civil Engineer has taken in meeting the very special requirements of a magnetic observatory.

F. W. DYSON.

Royal Observatory, Greenwich,
1914, May 23.