

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

Read at the Annual Visitation of the Royal Observatory, 1915 June 5.

GREENWICH OBSERVATIONS, 1914.

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REPORT OF THE ASTRONOMER ROYAL
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Read at the Annual Visitation of the Royal Observatory, 1915 June 5.

The Report here presented refers to the year from 1914 May 11 to 1915 May 10, and exhibits the state of the Observatory on the last-named day.

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

The electric heaters, controlled by a thermostat, for maintaining a constant temperature, have been installed in the new magnet house, and are working very satisfactorily. Some minor works, including the fixing of lightning conductors, were finished in July.

For the better protection of the Observatory from fire two new hydrants have been fixed by the Metropolitan Water Board in the 12-inch main which runs across the foot of the hill North-West of the Observatory.

The lamp lobby and a small room adjoining it, previously used as a store room, have been converted into a room for the transit-circle chronograph which has been transferred from a room on the North side of the court-yard. The external painting of the domes was carried out during February and March.

In view of the success which has attended the underground meridian marks at the Cape Observatory, borings were made just outside the S. collimator of the transit circle, and at the end of the Astronomer Royal's garden. The first of

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these was stopped at a depth of 37 feet after passing through 29 feet of very hard compact ballast. Throughout the last 24 feet it was necessary to use chisels almost continuously before the core could be removed with an augur. It was considered that this formation was very suitable for the construction of a collimator pit of relatively shallow depth. The boring in the garden, which is about 40 feet below the level of the ground near the transit circle, indicated an entirely different formation. The bore was sunk to a depth of 58 feet in 8 days, the last 42 feet being in very fine dry sand. In consultation with the Civil Engineer the conclusion was reached that it was useless to proceed further, as absolute stability of a mark could not be anticipated, especially as a well shaft would form a channel by which surface water could reach and probably disturb the sand.

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, Lee, Hodgson, and Corbett. (The telescopes of the two last-named are mounted respectively on the Thompson and 28-inch Equatorials.)

Photoheliographs Nos. 2 and 3 complete and the mechanical parts of Nos. 1 and 5.

Detached Telescopes (on tripod stands).—Two 4-inch (Simms Nos. 1 and 2), two 4-inch (R.O. Nos. 1, mounted as finder on Thompson Equatorial, and 2), one 3½-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.—Simms No. 2 (6-inch), at the Imperial College of Science and Technology.

Two Heliotropes at the Science Museum, South Kensington.

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 cœlostet from the Royal Astronomical Society for use at the total eclipse of the Sun, 1914 August. (At present in Russia, at Poulkova Observatory.)

A Quartz spectroscope from Prof. H. F. Newall, Cambridge, for the same eclipse. (At present in Russia, at Poulkova Observatory.)

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

II.—Astronomical Observations :—

Transit Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian as in previous years. The observations for the catalogue of stars down to 9^m.0 on the B.D. scale between the limits 24° and 32° of North declination was completed on January 5.

Between 1914 May 11 and 1915 January 5 the number of observations with the Transit Circle is:—

Transits -	-	-	-	-	-	-	-	9,052
Collimation and level	-	-	-	-	-	-	-	195 and 434
Circle readings -	-	-	-	-	-	-	-	8,865
Nadir point	-	-	-	-	-	-	-	425
Reflection observations	-	-	-	-	-	-	-	302

The catalogue will contain 12,400 stars. Every star has been observed at least four times and all but 385 at least five times. The probable error of a single observation, calculated by taking the first star in each 10 minutes of right ascension, is $\pm 0^s.040$ in R.A. and $\pm 0''.43$ in declination. The observations are completely reduced to the Epoch 1910.0. Those for the years 1910–13 are entered on catalogue sheets. Precessions and Secular Variations are computed. Comparisons are in progress with Lalande's and Bessel's observations and with the catalogues of the Astronomische Gesellschaft for the determination of proper motions.

The results of the observations of clock stars for the nine years 1906–1914, based on twelve-hour groups, have been incorporated in the Clock Star List for 1915.

The instrument was out of use for some weeks after January 5, while a new travelling wire micrometer, made by Messrs. Troughton and Simms, was being fitted to the telescope. This micrometer, owing to the shortness of the contacts, necessitated some alterations in the chronograph, which were carried out at the Observatory. The opportunity was taken to remove the chronograph to a more convenient room adjacent to the transit circle.

It is proposed during the next five years to observe the stars in the list prepared by Dr. Backlund and Mr. Hough. This list consists of fundamental stars equally spaced over the celestial sphere. A working catalogue has been prepared containing all the stars in the list which transit at altitudes greater than 10° —the number of entries, including sub-polar stars, being approximately 3,000. To May 10, 1915, the number of observations made is as follows:—

Transits -	-	-	-	-	-	-	-	1,119
Collimation	-	-	-	-	-	-	-	46
Level -	-	-	-	-	-	-	-	110
Circle observations	-	-	-	-	-	-	-	1,079
Nadir point	-	-	-	-	-	-	-	105
Reflection observations	-	-	-	-	-	-	-	44

For the year ended 1913 December 31, the value of the colatitude, using Pulkova refractions is $38^{\circ} 31' 21''.78$. The correction to the tabular value of the obliquity of the Ecliptic from observations of the Sun is $-0''.01$. The mean of the observed distances from the pole to the Ecliptic is too small by $0''.17$. The apparent correction to the right ascensions of the clock stars, for which Newcomb's Equinox is adopted is $-0^s.055$.

For the year 1914 the discordance between the zenith point determined by nadir observations and by reflection observations of stars is $-0''.28$. The values from 1892 to 1914 range from $-0''.12$ 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.
1914	$+0''.17$	$0''.00$	$+0''.24$	...	$+0''.13$	$0''.00$	$+0''.03$	...
1897-1905	$+0.25$	0.00	$+0.21$	$+0.37$	$+0.14$	0.00	$+0.12$	$+0.11$

The correction for R-D discordance from the observations in 1914 is $+0''.058 + 0''.366 \sin Z.D.$

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 1913 $-0^s.803$ in R.A. and $-0''.53$ in declination. The corresponding mean errors in longitude and latitude are $-11''.93$ and $-0''.28$.

The mean error of the Moon's tabular right ascension for 1914 derived from 107 observations with the transit-circle is $-0^s.899$.

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 and zenith distances	-	-	-	2,660 and 1,704
Extra-meridian observations	-	-	-	165
Determinations of collimation, level, and nadir point	-	-	-	251,223 and 200.

The observations, with the exception of star-corrections, are completely reduced to 1915 April 15.

The travelling-wire micrometer has been used throughout the year for the determination of right-ascensions. The clock-errors obtained in the four different positions of the instrument are accordant in showing a difference of $0^s.30$ from the clock-errors determined from the transit-circle reduced to the standard observer with that instrument. With the installation of the travelling-micrometer on the transit-circle this difference has disappeared. It is interesting to note that the standard observer made the meridian passage earlier than the travelling wire micrometer.

The number of observations of right ascension exceeds the number of observations in declination, because of the inclusion in the working list of a number of bright and faint stars selected from Küstner's Bonn Catalogue for comparison with the transit-circle observations and the determination of the magnitude equation of the observers with that instrument. This series of observations was brought to a close in 1914. At the beginning of 1915 observations were commenced of the list of *Etoiles intermédiaires* drawn up by the Astrographic Conference of 1907, which lie between declinations 0° and $+24^\circ$. They are 2,225 in number, and it is expected that their observation will occupy five years.

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 1914:—

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Time of Moon's Meridian Passage	Transit Circle.		Altazimuth.		
	Limb.	Mösting A.	Meridian.		Extra Meridian.
			Limb.	Mösting A.	Limb.
h. h. 0-3 G.M.T. - - - -	0	0	0	0	5
3-6 " - - - -	12	0	2	0	12
6-9 " - - - -	25	18	19	14	5
9-12 " - - - -	19	16	14	9	0
12-15 " - - - -	22	15	14	7	0
15-18 " - - - -	17	9	8	4	3
18-21 " - - - -	12	0	5	0	7
21-23 " - - - -	0	0	0	0	2

The total number of observations of the Moon is 107 with the transit-circle and 98 with the altazimuth, viz.:—64 in the meridian and 34 extra-meridian. Taking both instruments, observations of the Moon have been obtained on 127 days during the year.

The mean error in right ascension of the Moon's tabular place for 1914 is — $0^{\circ}876$ from meridian observations and — $0^{\circ}933$ from extra-meridian observations of the Moon's limb, and — $0^{\circ}915$ from meridian observations of the crater Mösting A. The transit circle gives — $0^{\circ}899$. 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 - - - $0^{\circ}03$	1891 - - + $0^{\circ}72$	1899 - - - $2^{\circ}18$	1907 - - - $5^{\circ}96$
84 - - - $0^{\circ}16$	92 - - + $0^{\circ}79$	1900 - - - $2^{\circ}69$	8 - - - $5^{\circ}97$
85 - - - $0^{\circ}09$	93 - - - $0^{\circ}06$	1 - - - $2^{\circ}77$	9 - - - $6^{\circ}41$
86 - - - $0^{\circ}11$	94 - - - $1^{\circ}20$	2 - - - $3^{\circ}15$	10 - - - $7^{\circ}85$
87 - - + $0^{\circ}21$	95 - - - $1^{\circ}47$	3 - - - $3^{\circ}08$	11 - - - $8^{\circ}34$
88 - - + $0^{\circ}76$	96 - - - $1^{\circ}68$	4 - - - $3^{\circ}16$	12 - - - $9^{\circ}79$
89 - - - $0^{\circ}38$	97 - - - $2^{\circ}77$	5 - - - $5^{\circ}29$	13 - - - $11^{\circ}93$
90 - - - $0^{\circ}27$	98 - - - $3^{\circ}03$	6 - - - $5^{\circ}91$	14 - - - $13^{\circ}0$
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Cookson Floating Zenith-Telescope.—During the year 238 photographs have been taken, 231 for latitude groups and 7 for scale determination. From the commencement of the observations, 1911 September 7, 609 latitude plates (excluding rejected plates) have been obtained, of which 553 have been measured in the direct, and 549 in the reversed position. In addition, 24 plates taken for scale have been measured and one plate rejected.

The results obtained since the commencement of the seven years series of observations until the end of 1914 have been discussed, and the results communicated to the Royal Astronomical Society. The value of the aberration constant obtained is $20''.467 \pm 0''.006$. The observations also furnish a determination of the latitude variation, although not designed primarily for this purpose. The latitude variation derived in this way shows a satisfactory agreement with the results of the International Latitude Service, and it is hoped that a comparison of the two series of results when the Cookson results have been brought to a conclusion will throw some light upon the origin of the z term in the latitude variation.

Equatorial Observations.—During the year ended 1915 May 10, 17 disappearances and 5 reappearances of stars occulted by the Moon have been observed by one or more observers. The reappearances and 11 of the disappearances were observed on December 1 when the Pleiades were occulted. They completely confirm the large errors in the tabular place of the Moon's mean longitude shown by the transit circle and altazimuth.

Both phases of the partial Solar Eclipse were observed on August 21. The transit of Mercury was well observed on November 7 both at ingress and egress.

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. Since October 16 M. Jonckheere, the Director of the Lille Observatory, has also had the use of the instrument in connection with the catalogue he is preparing of double stars of less than $5''$ separation discovered since 1905, the date of Burnham's General Catalogue, and has carried out many remeasures and verification of positions.

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There have been made during the year—

280	measures	of	118	pairs	with	separation	less	than	$0''.5$.
289	"	"	130	"	"	"	between	$0''.5$	and $1''.0$.
330	"	"	210	"	"	"	"	$1''.0$	" $2''.0$.
465	"	"	330	"	"	"	greater	than	$2''.0$.

Among the stars of special interest, κ Pegasi was measured on 6 nights, δ Equulei on 4 nights, 70 Ophiuchi on 10 nights, ϵ Hydræ on 5 nights, β Delphini on 8 nights, and Sirius on 10 nights. M. Jonckheere has also found 60 new pairs. Numerous observations of the diameter of Mercury were made during the transit on November 7.

Thompson Equatorial.—The work with this instrument has been concentrated on stellar parallax and photographic photometry. The photographs have all been taken with the 26-inch refractor.

The programme of stars whose parallaxes are being determined contains all those between declination $+64^\circ$ and the North pole which are known to have a proper motion of more than $20''$ a century. Each star is photographed at times of opposite parallactic displacement in right ascension on the same plate. It is found that six such plates give a good determination. For three of the plates the first exposure is given when the star transits soon after Sunset and the second exposure when it transits a little before Sunrise, and for the other three the morning exposures are made first. Generally, the series of exposures will be extended over two or possibly three years, so as to avoid anything systematic in observational or instrumental conditions.

During the year ended 1915 May 10, a first exposure has been given to 238 plates and a re-exposure to 294. In the same period 234 plates have been measured and 39 in duplicate. Experience seems to show that duplicate measurement is unnecessary, it being understood that each plate contains six images of each star, three at each epoch, and that in the first measurement the plates are reversed and every image measured twice. The parallaxes of 40 stars have been determined, with an average probable error of $\pm .''009$, and the results will be communicated to the Royal Astronomical Society. It appears that an average of from 30 to 40 stars a year can be maintained with this probable error, except for stars around 18^h of R.A. where the short nights make it impossible to obtain a

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large parallax factor. The output is limited entirely by weather conditions, and there seems no reason to anticipate any difficulty in coping with the measurement and reductions.

The determinations of photographic magnitudes with the 26-inch refractor have been made by comparing certain fields with the polar Standards determined by Professor Pickering. Generally, exposures of 6 minutes have been made on Ilford "Monarch" plates, and the limiting magnitude reached is about $14^m.0$ on the Harvard scale. During the year 88 photographs of this kind have been taken of the "Selected areas" of Professor Kapteyn. Of these, 63 are satisfactory, the rejections being mainly due to want of uniformity of the sky during the times of exposure. In addition, 11 plates of similar character, of which 8 were satisfactory, have been taken for standardisation of the Franklin-Adams plates. A few photographs with long exposure have been taken with a wire grating in front of the object glass. During the year, 44 plates of Kapteyn's "Selected areas" have been measured and reduced, and also 20 of the short exposure plates and 11 of the grating plates for standardisation of the Franklin-Adams Charts. Provisional magnitudes of the stars in 36 of the "Selected areas" have been forwarded to Professor Kapteyn.

Six inch Astrographic Triplet.—The catalogue of photographic magnitude of stars down to the 9th Magnitude between Dec. $+75^\circ$ and $+65^\circ$ has been completed and published. It contains 5,514 stars whose magnitudes are determined with an average probable error of $\pm 0^m.06$. The large field of this lens makes it very suitable for the determination of the photographic magnitudes of the brighter stars, and it is hoped to carry on this work in other declinations as opportunity offers.

Franklin-Adams Chart.—The limited edition of copies which was made at the Royal Observatory in accordance with an arrangement with the Royal Astronomical Society was completed and published last summer.

The original photographs have been examined and a catalogue made of the star clusters shown on them. This has been published in the *Memoirs of the Royal Astronomical Society*, Vol. LX., Part 5.

Astrographic Equatorial.—The observing has consisted mainly of Chart Plates for the Oxford Zone Dec. $+ 25^{\circ}$ to $+ 31^{\circ}$. Two exposures of 30 minutes each are given to each field, Wellington "Xtreme" plates being used on account of their speed. 209 plates have been taken, but of these 38 had to be rejected on account of atmospheric conditions and 20 owing to imperfect guiding or wrong setting. In addition 22 plates have been taken for adjustment of the instrument, verification of proper motions or for photographic magnitudes.

The printing of Vol. III. of the *Astrographic Catalogue* was finished in August. This volume contains the right ascensions and declinations, as well as the photographic magnitudes, of 16,780 stars from declination $+ 64^{\circ}$ to the North Pole deduced from the measurements of the *Astrographic plates*. These stars consist of the reference stars which were used in the reductions (approximately 10,000) of the *Greenwich Second Nine-Year Catalogue* for 1900, and such other stars as are to be found in other Meridian catalogues. Comparisons are given with the *Greenwich Catalogue* for 1900, *Carrington's Catalogue* for 1855, and the *Catalogues of the Astronomische Gesellschaft*. Photographic magnitudes are also given.

A thorough examination of these stars for the determination of proper motion is being carried out, and in addition to the catalogues mentioned comparisons are being made with the observations of Lalande, Argelander and others. Proper motions have been determined for the Stars of *Carrington's Catalogue* (Dec. 81° to the pole), of the *Kasan Catalogue* (Dec. 75° to 80°), and of the *Dorpat Catalogue* (Dec. 70° to 75°) as far as 18^h . In a number of cases large proper motions have been verified by comparison of plates taken at an interval of from 15 to 20 years. The largest proper motion found by this examination is $1''.0$ annually belonging to B. D. 77° , 361 a star of $9^{m.2}$ visual and $10^{m.9}$ photographic magnitude.

An investigation of the photographic magnitudes of the fainter stars of Vols. I. and II. of the *Astrographic Catalogue* has made some progress, but has had to be discontinued for the present.

III.—Heliographic Observations:—

In the year ended 1915 May 10, photographs of the Sun were obtained on 239 days. Of these photographs 503 have been selected for preservation, including 55 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 1915 January 31; and supplementary photographs have been received, through

the Solar Physics Committee, from Dehra Dûn, India, to 1914 May 30, and from the Director of the Kodaikanal Observatory, to 1914 August 7.

The series of photographs for the year 1914 will be made up completely from the four contributing observatories.

The measurement of the photographs for 1914 is nearly completed. For 1915 the Greenwich photographs are measured to May 3.

The mean daily spotted area of the Sun was 140 millionths of the Sun's visible hemisphere during 1914, as against 8 in 1913, 37 in 1912, and 64 in 1911, thus showing the usual rapid rise from minimum.

Solar Eclipse.—An expedition was sent to Russia to observe the total solar eclipse of August 20–21. The programme was similar to that attempted in Brazil in 1912. The instrumental equipment consisted of the Thompson 9-inch coronagraph; the Hills quartz spectrograph (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 ($\lambda 5303$) by the aid of a green colour filter near the focus and a prism of small dispersion in front of the object glass. The party, consisting of Mr. Jones and Mr. Davidson, accompanied by Mr. P. H. Hepburn, proceeded to a station near Minsk, situated almost on the central line. The eclipse was observed in a clear patch of sky containing much cloud, under good atmospheric conditions. Seven photographs of the corona with exposures of various lengths up to 25 seconds were obtained with the coronagraph. The flash spectrum contains about 140 lines of a shorter wave-length than have previously been accurately measured. The photographs taken with the colour screens indicated a complete absence of the usually strong green ray, a result which has been confirmed by other expeditions. Owing to the outbreak of war, it was impossible for the observers to bring back the instruments with them, and these were therefore left at the Poulkova Observatory in charge of Dr. Backlund.

The observers were greatly indebted to the Russian Government for granting customs and railway facilities, and to Dr. Backlund, Director of the Poulkova Observatory, for help in many ways and for taking charge of the instruments pending the termination of the war.

IV.—Magnetic Observations :—

The variations of magnetic declination, horizontal force and vertical force have been registered photographically. Absolute observations of declination are made five or six times a week, of horizontal force with the Gibson deflection instrument twice a week, and of dip with the dip-inductor three times a week. The inductor has been in regular use since the beginning of 1914, and gives very satisfactory results. Observations with the dip-needles were discontinued at the end of 1914.

The magnetic reductions are completed to the following stages :—

The hourly ordinates of the declination and horizontal force registers are read off and tabulated for 1914, and those of the vertical force register for the first three months of the year. 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 are all reduced. The mean values of the magnetic elements for 1914 and three previous years are as follows :—

Year.	Declination W.	Horizontal Force in C.G.S. Units.	Dip.
1911 - - - -	15° 33' 0	0.18549*	66° 52' 6" (3-inch needles)
1912 - - - -	15 24.3	0.18548*	66 51 46 " "
1913 - - - -	15 15.2	0.18534*	66 50 27 " "
1914 - - - -	15 6.3	0.18518	{ 66 49 27 66 51 13 (dip inductor)

* The values given in last year's report have been increased by 20γ, arising from a redetermination of the moment of inertia of the deflecting magnet.

There were no days of great magnetic disturbance in 1914, but four were classified as of lesser disturbance. Traces of the photographic curves for these days will be published in the annual volume.

The new Magnetograph House appears to be perfectly satisfactory. The arrangements for maintaining constancy of temperature have so far worked well, the indication of a set of maximum and minimum thermometers showing differences

of only a small fraction of a degree Fahrenheit during periods of several weeks between successive visits of the observer to the chamber for the purpose of making scale determinations.

Records with the new declination magnetograph have been obtained since January 1, and with the new instrument for the North force since March 1. The registers appear to be very satisfactory. A new vertical force instrument cannot be obtained at present. An instrument has been kindly lent by Professor Watson, and another of different type promised by Dr. Shaw, which it is hoped to instal experimentally during the summer.

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. Routine observations of rain-gauges other than the two standard ones in the Magnetic Pavilion Enclosure, were discontinued from 1915 March 8.

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 1915, except for the electrometer registers, which are completely reduced to the end of 1913.

The mean temperature for the year 1914 was $50^{\circ}\cdot8$, or $1^{\circ}\cdot3$ above the average of the 70 years 1841–1910. For the 12 months ended 1915 April 30 the mean temperature was $50^{\circ}\cdot2$. During the 12 months ended 1915 April 30 the highest temperature in the shade (recorded on the open stand in the enclosure of the Magnetic Pavilion) was $92^{\circ}\cdot1$ on July 1. On 21 days the highest temperature in the shade equalled or exceeded 80° . The lowest temperature of the air recorded during the same period was $22^{\circ}\cdot3$ on January 23. There were 36 days during the winter on which the temperature fell as low as $32^{\circ}\cdot0$.

The mean daily horizontal movement of the air in the year ended 1915 April 30 was 288 miles, which is 4 miles above the average of the previous 47 years. The greatest recorded daily movement was 791 miles on December 4, and the least 75 miles on April 11. The greatest recorded pressure to the

square foot was 26·3 lbs. on December 28, and the greatest velocity in an hour 55 miles on the same day. During the year 1914, Osler's anemometer showed an excess of 11 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 1915 April 30, by the Campbell-Stokes instrument, was 1,573 out of a possible 4,457 hours, giving a mean proportion of 0·353, constant sunshine being represented by 1. This is above the average amount, principally on account of a fine June and a fine September.

The rainfall for the year ended 1915 April 30 was 24·73 inches, being 0·61 inch greater than the average for the period 1841–1905. The number of rainy days (0·005 inch or over) was 171. September with 0·73 inch was the driest month and December with 6·02 inches the wettest; it was, in fact, the wettest December in the Greenwich series, and the three winter months, with 12·86 inches, the wettest winter in 100 years.

VI.—Printing and Distribution of Greenwich Publications:—

The third volume of the Astrographic Catalogue was distributed, as far as practicable, in January; that is, in the British Isles, the Colonies, and the United States. Distribution of publications on the continent of Europe is postponed for the present, owing to the war.

The printing of the 1913 observations has been completed, and the copies are now being bound. They will be distributed as soon as received, together with another publication—The Photographic Magnitudes of Stars, brighter than the 9th Magnitude, between Declination + 65° and Declination + 75°.

The printing of the 1914 observations has been commenced.

VII.—Chronometers:—

The number of Government marine chronometers and watches now at the Observatory is 325, viz., 125 box chronometers, 19 pocket chronometers, 80 chronometer watches, and 101 hack watches. These include 3 non-magnetic chronometer watches and 1 non-magnetic hack watch.

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In addition to these there is at the Observatory 1 box chronometer, being tested after repair, for the Indian Government.

There are at present 107 hack watches and 157 chronometer watches on trial for purchase by the Admiralty.

In the year ended 1915 May 10, the average daily number of chronometers and watches being rated was 657, the total number received was 3,273, the total number issued was 3,207, and the number sent for repair 1,007. This last number includes 8 box chronometers, and 2 watches belonging to the Indian Government.

For the annual trial of chronometers, which lasted 29 weeks with a range of temperature from 49° to 105° , 42 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 24 chronometers, 12 were purchased for the Navy, and 3 for the Indian Government. 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, 228 watches were entered, of which 81 were classified, and 81 were purchased for the Navy. Among the watches classified were 30 with centre-seconds' dials.

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. Six pocket chronometers were sent in, and three were purchased.

The trials of ordinary hack watches have been continued, but those for non-magnetic watches were discontinued at the end of 1914. Of 562 hack watches sent in for trial 278 have been purchased, and of 31 non-magnetic watches submitted 28 were purchased.

Three 8-day chronometers were tested for the Indian Government.

The next trial of box chronometers will commence on June 19. The trial of chronometer watches is now in progress.

VIII.—Clocks and Time Service :—

The Clock Graham 2 has been fitted with an electro-magnetic corrector and contact springs to give a signal every minute. The Mean Solar Clock Shepherd has been dismantled from the Ball Lobby and sent to be overhauled. Dent 2014 and Dent 2017 have been cleaned.

The renewal of the Time-Ball and the general overhaul and reconstruction of its mechanism, which was sanctioned last year, has not yet been completed. The new teak mast has been constructed for the Observatory by the Works Department of the Admiralty. Messrs. E. Dent & Co. have supplied a new aluminium ball, and a new winch for winding, and are adapting parts of the existing machinery.

The daily time signals from the Eiffel tower have been regularly observed by Mr. Lewis and Mr. Bowyer. The mean of the times as observed by Mr. Lewis is $+ 0^s.026$ late on Greenwich Time from 209 observations, and by Mr. Bowyer $+ 0^s.043$ late from 280 observations. The difference of a quarter of a second between the Eiffel Tower signal and the time as determined by the transit circle which existed two years ago appears to have been the personal equation of the Standard Observer as compared with the new impersonal micrometer.

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 December 4 owing to the violence of the wind.

The accuracy of the time-balls at the Admiralty Signal Stations and of the Westminster Clock is 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	0.2	-	-	-	-	-	271	251	293	21
Between	0.2 and 0.5	-	-	-	-	-	13	12	14	28
"	0.5 „ 1.0	-	-	-	-	-	1	0	4	65
Greater than	1.0	-	-	-	-	-	0	0	0	74

The Westminster Clock was on two occasions only found to be more than $3^s.0$ in error. The clock was under repair from March 17 to May 5.

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The clocks at Portsmouth, Portland, and Devonport are corrected daily by means of the Greenwich 10^h signal; the Westminster Clock is not corrected daily.

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.

The Time-Ball at Deal which is released by the 13^h signal from Greenwich failed to drop accurately on four occasions. On three occasions the Ball was not raised. On 39 occasions the return-signal failed to reach Greenwich or was interrupted.

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. Jackson 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. S. Chapman resigned the post of Chief Assistant on October 1, on his appointment as Lecturer at Trinity College, Cambridge. In his short term at Greenwich Mr. Chapman rendered valuable services to the Observatory, especially in connection with the counting of the Franklin-Adams plates, and the new magnetic installation. He was succeeded on October 8 by Mr. J. Jackson, Scholar of Trinity College, Cambridge.

Mr. F. E. Entwistle, one of the Senior Temporary Computers, left on November 30 to take up the position of Second Assistant at the Cambridge University Observatory.

On the outbreak of war, Mr. Burkett was called out with the London Yeomanry. He has since been given a Commission in the same regiment.

At the beginning of August 26 Temporary Computers were employed at the Observatory. The following list contains the names of those who have volunteered for military service and are temporarily absent :—

G. C. Baldwin.	W. A. Lambert.
H. H. J. Barton.	W. G. Percival.
A. W. Berry.	P. Perry.
E. A. Chamberlain.	R. L. Sims.
W. G. Davies.	L. S. Symms.
H. W. Davis.	G. Vaizey.
S. T. Divers.	F. Whitaker.
H. H. M. Kilby.	P. J. White.

At the present time 11 Computers are actually employed at the Observatory.

M. Jonckheere, Director of the Lille Observatory, as stated in the section of the Report dealing with the 28-inch Equatorial, has been working at the Royal Observatory since October 16. Mr. van Dingenen, a Belgian refugee, has been employed in the Magnetic and Meteorological Department since April 1.

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 gate-porter, A. Holbrook, the messenger, D. Weston, and the night watchman, D. R. Weston, are Naval Reservists, and have been called up for service. C. J. Symms has returned to the Observatory temporarily as gate porter, and S. Hancock has been employed as night watchman.

X.—General Remarks :—

All departments of the Observatory have necessarily been affected by the absence of the Senior Computers. It is only due to special efforts by the staff that the work has not been more seriously curtailed. Observations have been somewhat diminished and the reduction and publication of results will suffer some delay.

F. W. DYSON.

Royal Observatory, Greenwich,
1915 May 26.