REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1896 *June* 6.

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The Report here presented refers to the year from 1895 May 11 to 1896 May 10, and exhibits the state of the Observatory on the last-named day.

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

The building of the North wing and Central Dome of the Physical Observatory has been delayed by failures in the supply of terra cotta and by labour disputes, and is still unfinished as regards plastering and carpenters' work. The Lassell dome, which was erected in the South Ground in 1884, was taken down in August and has been re-erected on the new building. The completion of the Physical Observatory by the building of the East and West wings has been sanctioned, and provision has been made in the Navy Estimates for commencing the work during the present year.

The new Altazimuth Pavilion and Dome were completed early in January, with the exception of the observing floors and moveable roofs over the collimators, which are now being made.

The building of the Magnetic Pavilion in Greenwich Park has been delayed, as the exact site has not yet been definitely settled in concert with H.M. Office of Works. In view of the great mass of iron in the new Physical Observatory it is important to select a site as near the magnetic East and West line as circumstances will admit, so that there may be no sensible deflection of the declination magnet. It is also very desirable that the enclosure should be of sufficient size to allow of the Standard Thermometers (dry and wet bulb and solar and terrestial radiation) being transferred there in order to secure a free circulation of air, which cannot be obtained in their present position owing to the interference of the new buildings.

Provision has been made for the supplementary chronometer oven referred to in the last Report, and it is now being made.

The proposed water tank on the flat of the lobby of the 36-foot dome for the supply of water to the driving-clock of the Great Equatorial is also being made.

The construction of the proposed balcony to give an all-round view of the sky, from the building in which the 28-inch telescope is mounted, has not yet been sanctioned.

It is proposed to extend the electric light installation to the new Altazimuth and to the Thompson photo-equatorial in the new Physical Observatory, and provision has been made for this in the Navy Estimates.

Two gas stoves have been fitted up in the transit-circle room for occasional use to assist in drying the room and instrument in damp weather, especially when a thaw sets in after a long frost.

The principal moveable instruments are thus distributed :—

At Greenwich—

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

Altazimuth D.

Equatorials (6-inch).—Cooke No. 2; Simms No. 1; Hodgson; and Corbett.

Photoheliographs.—No. 3, complete, mounted on the terrace roof of South wing of Physical Observatory for daily photography; the tube of No. 2, and the driving clock (in use for the Personal Equation Machine).

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

A Hilger Chronograph.

On loan—

Transits.—A, at the Cape Observatory; C, at Montreal.

Altazimuths.—A, at the Science Schools, South Kensington; B, at the Cape Observatory; E, at the Royal Naval College, Greenwich.

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

Photoheliographs.—No. 1, complete, at the Cape Observatory; No. 5, complete, and the mounting of No. 2 (without driving clock), lent to the Science and Art Department; the object-glass of No. 2 lent to Professor Turner for observation of the Solar Eclipse 1896 August 9; No. 4, complete, at the Madras Observatory.

Detached Telescope.—Simms No. 2 (4-inch) lent to Mr. Maunder for the Solar Eclipse.

A single prism Spectroscope, lent to Mr. Maunder for the Solar Eclipse 1896.

A Hilger Chronograph lent to the Oxford University Observatory.

Clocks.—Dent No. 1916, and Dent No. 2013, at the Cape Observatory; Dent No. 2011, at the Kew Observatory; Dent No. 2010, at Devonport; and Arnold 2, at the University Observatory, Oxford.

Anemometer.—Whewell's Anemometer, formerly (1843–1862) mounted above the roof of the Octagon Room of the Royal Observatory, lent for exhibition at South Kensington Museum.

The annual comparison of books in the Libraries with the catalogue has been made, and 4 books are reported missing.

II.—Astronomical Observations :—

Transit-Circle.—The Sun, Moon, planets, and fundamental stars have been regularly observed on the meridian. The number of observations made from 1895 May 11 to 1896 May 10, is as follows :—

Transits, the separate limbs being counted as one observation	11,792
Determinations of collimation error	306
Determinations of level error	684
Circle observations	11,463
Determinations of nadir point (included in the number of circle observations)	636
Reflexion observations of stars (similarly included) . .	570

The annual catalogue of stars observed in 1895 contains 2653 stars.

The wires of the transit-circle were found broken on April 2, and new ones were inserted by Messrs. Troughton and Simms on April 9.

As regards the computations :—

The transits are completely reduced (so as to exhibit Mean R.A. 1896·0) to April 18, the observed R.A. after application of instrumental and clocks errors being formed to May 1. The copy for press is completed to April 9. The whole of the copy for press of the transits for 1895 is in the printer's hands.

The investigation of personal equations is completed for 1895. During the year 29 sets of observations have been made with the personal equation machine for determination of personality in observations of limbs of the Sun or Moon, but they are not fully reduced.

The circle observations are completely reduced to April 18. The copy for press is completed to February 24. The whole of the copy for press of this section for 1895 is in the printer's hands.

The apparent correction for discordance between the nadir observations and stars observed by reflexion for 1895 is $-0''\cdot31$. This has been systematically negative since 1892, as will be seen from the following table :—

1888	− 0″·12	1892	− 0″·25
1889	+ 0·07	1893	− 0·34
1890	+ 0·08	1894	− 0·27
1891	+ 0·07	1895	− 0·31

The correction for R—D, the error of the assumed colatitude, and the position of the ecliptic have been investigated for 1895 ; and the whole of the planetary reductions are complete.

The correction for R—D, $+0''\cdot065 + 0''\cdot414$ sin Z.D., is decidedly smaller than the results of recent years. The observations of Zenith Distance of pairs of stars directly and by reflexion, alternately on alternate nights, referred to in the last report, have been continued, 151 pairs having been observed in the year ending 1896 May 10. The following table gives a comparison of the R—D discordance for different Zenith Distances obtained in 1895.

Z.D.	R. observations taken immediately before D.	R. and D. observations on different nights.	No. of pairs of observations on different nights.
°	″	″	
− 57	− ·43	− ·26	22
− 51	− ·39	− ·40	23
− 29	+ ·19	+ ·10	21
+ 21	+ ·38	+ ·24	15
+ 37	+ ·53	+ ·41	28
+ 49	+ ·64	+ ·34	32
+ 59	+ ·71	+ 1·09	19

The colatitude of the transit-circle as found from the observations of 1895 is 38° 31′ 21″·98, differing by $+0''\cdot08$ from the adopted value.

The correction to the tabular obliquity of the ecliptic from solar observations in 1895 is $+0''\cdot05$. The discordance between the results from the summer and winter solstices is $+0''\cdot28$, indicating that the mean of the observed distances from the pole to the ecliptic is too small by $0''\cdot14$. The apparent correction from the observations of the Sun to the right ascensions of the clock stars is $+0^s\cdot027$. As in past years the readings of the Standard Meteorological Thermometer have been used for reducing observations of the Sun. The mean monthly excess of the adopted readings over

those of the ordinary exterior thermometer (corrected for index error) was least in December (+0°·5) and greatest in September (+4°·1), May (+3°·0), and June (+3°·1).

The mean error of the Moon's tabular place (computed from Hansen's lunar tables with Newcomb's corrections) is $-0^{s}\cdot066$ in R.A. and $-0''\cdot20$ in N.P.D. deduced from 130 observations. These are equivalent to an error of $-0''\cdot77$ in longitude and $-0''\cdot27$ in ecliptic north polar distance.

The preparation of the New Ten Year Catalogue of Stars 1887–1896 has been commenced in view of the conclusion of the observations at the end of this year.

Altazimuth.—The total number of observations made in the year ending 1896 May 10 is as follows :—

Azimuths of the Moon and Stars	257
Azimuths of Mark I.	119
Azimuths of Mark II.	108
Zenith distances of the Moon	120
Zenith distances of Mark I.	102
Zenith distances of Mark II.	100

The observations have been completely reduced as far as 1896 March 21.

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

Moon's Time of Meridian Passage.	Transit-circle.	Altazimuth.
12^{h} to 13^{h} civil time	0	0
13^{h} to 14^{h} ,,	0	3
14^{h} to 15^{h} ,,	0	5
15^{h} to 16^{h} ,,	3	9
16^{h} to 17^{h} ,,	7	7
17^{h} to 18^{h} ,,	4	9
18^{h} to 21^{h} ,,	28	2
21^{h} to 0^{h} ,,	30	—
0^{h} to 3^{h} ,,	29	—
3^{h} to 6^{h} ,,	19	3
6^{h} to 7^{h} ,,	7	5
7^{h} to 8^{h} ,,	4	7
8^{h} to 9^{h} ,,	1	5
9^{h} to 10^{h} ,,	0	4
10^{h} to 11^{h} ,,	0	4
11^{h} to 12^{h} ,,	0	1

The total number of places of the Moon observed with the transit-circle is 132 or 10·1 per lunation, and with the altazimuth 64 or 5·0 per lunation.

The Moon's diameter has been measured with the transit-circle twice in R.A. and 25 times in N.P.D.

The erection and completion of the new Altazimuth have taken a longer time than was anticipated, but it is hoped that the instrument will be ready for use very shortly. The instrument which has been constructed by Messrs. Troughton and Simms is virtually a reversible transit-circle of improved form which may be placed in the meridian or in any azimuth, though it is only proposed to use it in certain definite azimuths, for which auxiliary reduction tables are calculated, so as to make the computations comparatively light. Two zenith distance circles are provided, one of which can be turned on the axis and, by means of a clamp and slow motion, fixed in any position, so that it may be made available for the determination of division errors by comparison of corresponding angular intervals on the two circles. The system of wires has been carefully arranged to secure complete observations of stars in both elements in the different azimuths. The collimators which are in the meridian are each mounted on two pairs of arms (counterpoised) turning about centres below, so that they can be brought up into the position for observation, or lowered to be clear of the telescope and dome, when they are housed under hinged flaps.

A working catalogue, giving the sidereal time and zenith distance at which fundamental stars cross the azimuths in which it is proposed to use the instrument, has been completed.

Clocks and Chronographs.—The Standard Sidereal clock, which was repaired in 1895 March, has gone very well throughout the year. As illustrating the performance of the clock its error is given below for the beginning and middle of each month from October 1 to May 1 :—

1895.			1896.		
October	1	4ˢ·50 slow.	January	1	5ˢ·60 slow.
,,	16	4·72 ,,	,,	16	5·40 ,,
November	1	4·81 ,,	February	1	5·42 ,,
,,	15	5·54 ,,	,,	14	5·10 ,,
December	1	6·22 ,,	March	1	5·05 ,,
,,	16	6·15 ,,	,,	16	4·51 ,,
			April	1	4·65 ,,
			,,	15	4·99 ,,
			May	1	4·60 ,,

The Clock Hardy (in the Transit-circle room) was repaired in March, and the Clock Earnshaw (in the Sheepshanks dome) in April.

The mean solar clock Dent 2012 has been in use for driving the sympathetic dials in the observatory through a relay, and for sending the hourly time-signals to the

General Post Office, except during the months of October and November, when the clock Shepherd was used.

Reflex Zenith Tube.—Since the date of the last Report, 46 double observations of γ Draconis have been made.

Equatorials.—The new equatorial with photographic telescope of 26 inches, presented by Sir Henry Thompson, is now nearly finished and ready for inspection at Sir Howard Grubb's works. Sir Henry Thompson has completed his valuable gift by the addition of a Cassegrain reflecting telescope of 30 inches aperture, to be carried in place of the counterpoise at the other end of the declination axis. Dr. Common has kindly undertaken to figure the mirrors and to supervise the construction of this telescope. The new equatorial is to be mounted in the Physical Observatory under the Lassell Dome.

The photographic spectroscope mentioned in the last Report, which will be available for use with the Thompson Equatorial, is now nearly completed.

The 28-inch refractor has been in constant use for micrometric observations during the year, and for spectroscopic observations till 1895 November, when Mr. Maunder was relieved from observing duty, to enable him to devote his whole time to the heliographic reductions, which have been very heavy owing to the large number of spots on the Sun. Several slight improvements have been made in the accessories of the instrument, the most important being the substitution of new taps (Lord Kelvin's patent) in the water clock; an arrangement for obtaining fields of different colours; blue glass shades which can be placed over the eye-pieces, and more delicate wires in the micrometer (about $0''{\cdot}07$ thick). Micrometer measures have been made of 172 double stars, each star being measured on the average on two nights: in 88 of these the distance of the components was under $1''{\cdot}0$, and in 45 under $0''{\cdot}5$. Amongst these are κ Pegasi, distance $0''{\cdot}10$, and γ^2 Andromedæ, distance $0''{\cdot}2$.

The measures of the dimensions of Saturn and his rings, begun last year, were continued on 9 nights, and the results communicated to the Royal Astronomical Society in November. The diameters of Jupiter were measured on 19 nights with the filar micrometer and, for comparison, with the double-image micrometer; the results were communicated to the Royal Astronomical Society in May. The weather during the opposition of Jupiter and Neptune made it impossible for any systematic search to be made for Jupiter's fifth satellite, and the position of Neptune's satellite was only observed on one night.

Since the date of the last Report, 14 disappearances and 14 reappearances of stars occulted by the Moon have been observed, and 41 phenomena of Jupiter's satellites.

Comet *d* 1895 has been observed with the Sheepshanks Equatorial on one night, Comet *a* 1896 on 10 nights, and Comet *b* 1896 on 13 nights. Comet *c* 1895 was observed on two nights with the Altazimuth.

With the Astrographic Equatorial 502 plates, with a total of 1224 exposures, have been taken on 123 nights in the year ending 1895 May 10. Of these, 135 have been rejected, viz. :—13 partially fogged plates ; 27 because the reticules were not clearly printed ; 35 because the images were too faint to show 9th magnitude stars with a 20^s exposure ; 14 for faults in development ; 15 for mistakes in setting ; 14 because the exposure was interferred with by clouds ; and 17 for miscellaneous defects.

The following statement shows the progress made with the photographic mapping of the heavens between 1895 May 11 and 1896 May 10 :—

	For the Chart (Exposure 40^m).	For the Catalogue (Exposures 6^m, 3^m and 20^s).
Number of Photographs taken	118	353
„ successful plates	89	247
„ fields photographed successfully .	79	223
Total number of fields photographed successfully since the commencement of the work . .	490	732

It has been a practice to take a trail each night on a catalogue plate as a check on the orientation, and during the year 97 plates with trails have been obtained.

A number of miscellaneous photographs (included in the total number of 502 given above) have also been taken :—

	No. of Plates.
For Zero of Scales	6
North Pole (for adjustments of Equatorial) . .	1
Typical Areas (Chart plates)	12
Typical Areas (Catalogue plates)	12

Each plate has undergone a preliminary examination to see whether it is generally satisfactory, and whether the adopted limits of magnitude were approximately reached, as inferred from the 20^s exposure, which should give 9th magnitude stars of Argelander's scale.

The *réseau* supplied by M. Gautier coated with collodion, at present in use, shows several pinholes and scratches which have been stopped out as far as practicable with black varnish. It was mounted in the dark slide on 1895 June 8, and will be available for some time yet.

In the period 1895 May 11–1896 May 10, the co-ordinates of the 6^m and 3^m images have been measured on 820 quarter plates, the duplex micrometer described in the last Report being used for this purpose. The number of separate stars measured during the 12 months is approximately 21,000, of which about 16,000 are measured on each of two plates, the number of pairs of images of stars measured being the sum of these two numbers, or about 37,000 stars.

The following statement shows the progress made with the measurement of the plates :—

Zone.	Limiting R.A.	—
64	0^h–2^h 42^m and 18^h 36^m–20^h 6^m	Measured on one plate only
65	0^h–24^h	„ „ two plates
66	0^h–24^h	„ „ „
67	0^h–6^h 10^m, 6^h 30^m–7^h 20^m, and 11^h 40^m–24^h	„ „ „
68	18^h 50^m–20^h	„ „ „

During the year plate constants have been determined for 107 plates from a comparison of the measured co-ordinates with " standard co-ordinates " deduced from the Right Ascensions and Declinations of such stars as are contained in the catalogues of the Astronomische Gesellschaft. In this manner corrections are obtained for the errors of setting and orientation of the plates, and corrections, in the form of residuals, are found for the stars of the Astronomische Gesellschaft Catalogues.

In connection with this work the Right Ascensions and Declinations of the Astronomische Gesellschaft Catalogues (Helsingfors and Christiania), between Dec. + 64° and Dec. + 70°, have been brought up from 1875·0 to 1900·0.

An explanation of the method adopted, and a discussion of the results, is given in the Monthly Notices R.A.S. for 1896 January.

The following statement shows the progress made in the determination of plate constants :—

Centres of Plates.					Number of Plates.
Dec. + 65°	From R.A.	11^h 33^m	to R.A.	21^h 9^m	33
+ 66°	„	11^h 42^m	„	20^h 24^m	30
and	„	0^h 0^m	„	5^h 42^m	20
+ 67°	„	11^h 50^m	„	20^h 23^m	27
and	„	0^h 10^m	„	2^h 10^m	7
69°	„	19^h 30^m	„	19^h 50^m	2

Some experiments have been made in the reproduction of the chart plates so as to form a map of the portion of the sky from R.A. $19^h\ 0^m$ to $20^h\ 50^m$ and Dec. 64° to 70°. Positives on glass of the 57 negatives covering this region have been taken, and from these, platinotype, gelatino-chloride and bromide card prints have been made for comparison. From a preliminary examination of these it seems that the bromide cards are the most suitable, and that, on these very few, if any, stars are lost, which is far from being the case with the platinotype prints. The bromide cards have the advantage of not needing to be mounted and rolled, and are very convenient for use. Positives on glass of 107 other chart plates have also been taken.

III.—Spectroscopic and Heliographic Observations :—

Since the date of the last Report, 189 measures have been made of the displacement of the F line in the spectra of 17 stars, as well as 33 measures of the F line in the spectrum of the Moon for comparison. Some experiments have also been made in photographing stellar spectra, to give data as to the work to be done with the new photographic spectroscope.

In the year ending 1896 May 10, photographs of the Sun have been taken with the Dallmeyer photoheliograph, mounted on the terrace roof of the South wing of the Physical Observatory, on 229 days, and of these 459 have been selected for preservation, besides 14 photographs with double images of the Sun for determination of zero of position-angle.

For the year 1895 Greenwich photographs have been selected for measurement on 249 days, and photographs from India and Mauritius (filling up the gaps in the series) on 113 days, making a total of 362 days out of 365 on which photographs are available.

The spot activity of the Sun has steadily declined from the date of the last Report, and on five occasions in the months of 1896 April and May the Sun has been entirely free from spots ; a condition which had not previously been observed on any day since 1891 March 28.

The mean daily spotted area of the Sun was decidedly smaller in 1895 than in 1894, but the work of measurement and reduction has not been lightened in proportion, owing to the greater number of small spots observed. Nearly 29 volumes of the chief form used in the reductions were filled in 1895 as against 31 in 1894, and 27 in 1893, the year of maximum spot-area.

The measures are in a forward state, the Greenwich photographs having been measured up to April 7, and the Indian and Mauritius photographs as far as they have been received. The conversion of the measures into heliographic longitude and latitude is well advanced, having been carried forward for the Greenwich photographs as far as 1896 March 30, and for the Indian and Mauritius photographs as far as 1896 February 9, the date of the last negative received. The copy for press of the Daily Results has been prepared as far as 1895 December 13.

IV.—Magnetic Observations :—

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

The magnetic reductions for 1895 are completed to the following stages :—

The eye observations of the upper declination magnet, and of the horizontal and vertical force magnets, are completely reduced. The time-scales for the magnetic registers are complete; the base line values, deduced from eye observations, are entered on the sheets, and the hourly ordinates of the photographic curves are read out and reduced. 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 time-scales for earth currents are laid down. The dip and deflexion observations are completely reduced.

The principal results for the magnetic elements for 1895 are as follows :—

Mean declination . . .	16° 57′·4 West.
Mean horizontal force . .	3·9739 (in British units). 1·8323 (in Metric units).
Mean dip (3 months, January to March) . . .	67° 15′·3 (by 9-inch needles). 67° 14′·8 (by 6-inch needles). 67° 16′·6 (by 3-inch needles).
Mean dip (4 months, September to December) . . .	67° 10′·7 (by 9-inch needles). 67° 11′·8 (by 6-inch needles). 67° 12′·4 (by 3-inch needles).

Uncertainty attaches to the results for mean horizontal force owing to the permanent effect of the iron in the new Altazimuth Pavilion, and an independent determination at a distance from this building is required.

From 1895 April to August, during the progress of the building work on the new Altazimuth, the observations of magnetic dip were subject to great uncertainty on account of the masses of iron for the building being stored near the north end of the New Library in immediate proximity to the dip instrument. And after the completion of the building, that is to say, since 1895 September, the results of magnetic dip are affected to the extent of about 3′ or 4′ by the permanent iron in the building and instrument. An independent determination at a place sufficiently removed from the Altazimuth building is urgently required. The question, however, has necessarily been deferred, pending the settlement of the site for the new Magnetic Pavilion.

The mean determination of horizontal magnetic force with the Elliott instrument for 1895 in metrical units is 1·8387. This is greater than the value given by the Gibson instrument by 0·0064. The difference is larger than in preceding years, viz. :— 0·0030, the increase of the difference being no doubt due to the permanent effect of the iron in the Altazimuth building.

The magnetic disturbances during the year 1895 have been comparatively trifling. There were no days of great magnetic disturbance and 16 days of lesser disturbance, Tracings of the photographic curves for these days, selected in concert with M. Mascart, will be published in the annual volume as usual. The calculation of diurnal inequalities from 5 typical quiet days in each month has been continued.

Information and results of observations have been supplied in reply to inquiries on various occasions during the year.

V.—Meteorological Observations :—

The meteorological instruments are all in good order. The registration of atmospheric pressure, temperature of the air and of evaporation, pressure and velocity of the wind, rainfall, sunshine, and atmospheric electricity has been continuously maintained.

The meteorological work has been carried out under difficult conditions throughout the year on account of the space at disposal for the meteorological instruments (at all times somewhat limited) being still further curtailed by the masses of terra cotta and other materials heaped upon it, and care has been necessary to prevent interference by workmen. It is hoped that in the future there may be space, at the North end of the enclosure for the Magnetic Pavilion, available for an independent meteorological station, where much better conditions of exposure for the standard thermometers could be secured.

On account of the extension of the buildings in the South ground, it was found necessary to remove the sunshine recorder from the roof of the Magnetic Observatory to a commanding position on the stage carrying the Robinson anemometer, on the roof of the Octagon Room, about 50 feet above the ground. This was done on 1896 February 6. A clear view of the Sun is obtained in this new position from sunrise to sunset, but some inconvenience is caused by the smoke from neighbouring chimneys, and it is proposed to mount this instrument eventually on the flat roof of the Physical Observatory.

It should have been mentioned in the last Report that the standard thermometer stand and the Stevenson screen were shifted on 1894 November 5 to positions further removed from the new building and nearer the Magnetic Observatory.

On 1895 December 30 one of the springs of Osler's pressure apparatus was found broken. It was renewed by Mr. Simms on 1896 January 15, and the pressure scale was afterwards re-determined.

The meteorological reductions are in the following state:—The observations of barometers, thermometers, anemometers, rain-gauges, and sunshine recorder (corrected, where necessary, for instrumental error) are reduced up to the present time. On the photographic sheets all the time-scales are laid down, and the hourly ordinates are read out and completely reduced for the dry and wet bulb thermometers and the electrometer to the end of the year 1895. The table of principal changes in the direction of the wind for 1895 is complete.

The mean temperature of the year 1895 was 49°·3, being 0°·1 below the average for the 50 years 1841–1890.

During the twelve months ending 1896 April 30, the highest daily temperature recorded was 87°·3 on September 24. On May 30 a temperature of 86°·2 was recorded. The temperature rose above 80° on 26 days in 1895 as compared with seven days in the preceding year. The monthly mean temperatures were all in excess of the average values with the exception of the month of October, which was in defect. The mean for September was in excess to the amount of 4°·7; that for November in excess by 4°·2, and that for 1896 March by 4°. The mean temperature for the twelve months 1895 May to 1896 April was 51°·1, being 1°·7 above the 50 years' average.

The characteristics of the fine and hot month of September require to be examined in detail. It has been mentioned that the highest temperature of the year (87°·3) occurred on September 24, a temperature greatly exceeding all temperatures previously recorded at this advanced period of the year during the 54 years 1841–1894.

Only two instances of higher temperature, both in the earlier part of the month, have been experienced in September, viz., 92°·1 on 1868 September 7, and 87°·7 on 1886 September 1. The number of hours of bright sunshine amounted to 194·8, giving a percentage of 52 on the possible amount. The month was the least cloudy on record, the mean amount of cloud amounting to 2·6 only as compared with an average for September of 6·2. The next lowest amounts in any month in previous years were :—3·0 in 1848 May, 3·1 in 1893 April, and 3·2 in 1865 September. The rainfall for the month amounted to $0^{in.}\cdot93$, of which $0^{in.}\cdot80$ fell during the thunderstorm on September 7. The fall was deficient as compared with the 50 years' average (1841–1890) to the amount of $1^{in.}\cdot32$. Smaller rainfalls have been experienced in September on seven occasions, notably in 1865, when the rainfall amounted to $0^{in.}\cdot16$, in 1843 when it was $0^{in.}\cdot46$, and in 1851 when it was $0^{in.}\cdot50$.

The winter of 1895–96 was very mild and there were only 19 days on which the temperature of the air fell to or below the freezing-point. As contrasted with past seasons we find that in the mild winters of 1883–84 and 1845–46 there were 25 and 29 frosty days respectively, these being the smallest numbers previously recorded ; whilst in the severe winters of 1887–88, 1854–55, 1846–47 and 1894–95 there were 90, 86, 83 and 62 frosty days respectively. The lowest winter temperature was 24°·3 on 1896 February 25.

The mean daily horizontal movement of the air in the twelve months ending 1896 April 30 was 275 miles, which is 6 miles below the average for the preceding 28 years. The greatest recorded movement was 1002 miles on December 5, and the least 70 miles on October 20. The greatest recorded pressure of the wind was 27·5 lbs. on the square foot on March 16, with an extreme hourly velocity of 49 miles.

During the year 1895 Osler's anemometer showed an excess of 23 revolutions of the vane in the positive direction N., E., S., W., N., excluding the turnings, which are evidently accidental.

The number of hours of bright sunshine recorded during the twelve months ending 1896 April 30 by the Campbell-Stokes instrument was 1176 out of the 4465 hours during which the Sun was above the horizon, so that the mean proportion of sunshine for the year was 0·263, constant sunshine being represented by 1. In the corresponding period for 1894–95 the number of hours of sunshine was 928, and the mean proportion 0·208.

The rainfall for the year ending 1896 April 30 was 19·76 inches, being 4·78 below the 50 years' average. This is the smallest rainfall since the year 1884–85,

when the fall was 19·61 inches. In 1864–65 the rainfall was 17·71 inches, and in 1858–59 it was 17·38 inches. The number of rainy days in the twelve months was 151.

VI.—Printing and Distribution of Greenwich Publications :—

The printing is still far from satisfactory, though it is two months' further in advance than last year.

The copies of the Greenwich Observations for 1892 were distributed in July.

Some of the copies of the volume for 1893 have been received, and will be distributed shortly.

As regards the volume for 1894, Transits and Meridian Zenith Distances are printed to November 10, and the Heliographic Results to July 18. The Altazimuth Section and the Magnetic and Meteorological Results are completely printed with the exception of the Introduction.

For the volume for 1895, the manuscript of the Transits, Meridian Zenith Distances, and Altazimuth Results, as well as the Chronometer and Deck Watch Rates 1895–96, have been sent to the printers.

The printing of the 50 years' Meteorological Reductions 1841–1890 (Part III.) was completed last December, and the copies were received in February and have been distributed.

VII.—Chronometers, Time Signals, and Longitude Operations :—

The number of Government marine chronometers and deck-watches now being tested at the Observatory is 215 (127 box chronometers, 31 pocket chronometers, and 57 deck-watches). In addition to these, there are on trial for the Indian Government, 18 box chronometers and 1 pocket chronometer. In the year ending 1896 May 10, the average daily number of chronometers and deck-watches being rated was 395 ; the total number received was 958, the total number issued 1,002, and the number sent for repair 477. These include 22 box chronometers, and 4 pocket chronometers, for the Indian Government, and 5 deck-watches for the Crown agents for the Colonies.

For the annual trial of chronometers, which lasted for 29 weeks, with a range of temperature from 42° to 105°, 83 chronometers were sent in, and of these, 55 have been purchased for the Navy. The performance of the chronometers generally is remarkably good and sustains the improvement shown last year. The relaxation in 1892 of the rule limiting the entry for each maker to two chronometers seems to have worked well in securing a large supply of good chronometers.

The deck-watches in the annual trial were separated into two classes, A and B, 92 being entered (by their makers) as A, and 37 as B, the trial in positions for the latter being limited to "dial up" and "pendant up." Of these, 51 have been purchased for the Navy, 42 being classed as A and 9 as B. The performance of the watches was fully up to the standard of previous years. Four of the watches entered in class B are non-magnetic, and one of these was purchased. The next competitive trial of chronometers commences on July 4, and the trial of deck-watches, class A, on October 24. It has been decided to discontinue the trial and purchase of class B deck-watches.

As mentioned in the last Report, the Greenwich time-ball required extensive repairs, which were carried out in May and June, and the ball was not raised between the dates May 10–May 28 and June 6–June 25. On five days it was not raised on account of the violence of the wind. It failed to drop on January 2 and February 2, when the failure was traced to wear in the trigger levers, which were taken off and repaired. On January 12 (Sunday) the ball was not dropped through inadvertence in making the connections.

There were two failures in the Greenwich time signal at 13 on 1895 May 14 and 1896 January 12, respectively, owing to a break in the electric connections.

The automatic drop of the Deal time-ball failed on six days owing to interruptions of the telegraph connections and once through inadvertence in setting the trigger. On ten days the ball was not raised owing to high wind.

The return-signal from the Devonport clock failed on 27 days. The apparent error of the clock signal (after daily correction of the clock by aid of a time-signal from Greenwich) was under $0^s{\cdot}2$ on 65 per cent. of the 337 days of observation, under $0^s{\cdot}5$ on 97 per cent., and never exceeded $1^s{\cdot}0$.

The return-signal from the Portsmouth clock (similarly corrected by the help of a daily signal from Greenwich) failed on 50 days. The apparent error of the clock-signal was under $0^s{\cdot}2$ on 34 per cent. of the 316 days of observation, under $0^s{\cdot}5$ on 95 per cent., under $1^s{\cdot}0$ on 99 per cent., and exceeded $1^s{\cdot}0$ on three occasions.

The automatic signals from the Westminster clock have been received regularly throughout the year ending 1896 May 10, except on 46 days when the signal failed. The apparent error of the clock was under $0^s{\cdot}5$ on 37 per cent. of the days of observation, under $1^s{\cdot}0$ on 56 per cent., under $2^s{\cdot}0$ on 90 per cent., under $3^s{\cdot}0$ on 93 per cent., under $4^s{\cdot}0$ on 98 per cent., and exceeded $4^s{\cdot}0$ on three days.

Longitude Operations.—The Indian Government having decided to make a re-determination of the longitude of Madras *viâ* Potsdam and Teheran, Capt. Burrard, R.E., and Capt. Lenox Conyngham, R.E., made the requisite observations for the

section Greenwich–Potsdam in June and July last, their transit instrument being mounted in the Transit Pavilion in the Front Court.

VIII.—Personal Establishment :—

The scheme for re-organisation of the Staff referred to in the last two Reports has now been sanctioned. With a view to strengthening the supervising power and increasing the permanent subordinate Staff, an additional Chief Assistant is appointed, and the five Second class Assistants of the old Staff are to be replaced by eight Established Computers, two of these to be of a higher grade, the number of temporary Computers being correspondingly reduced.

The future Staff will be thus constituted :—

Upper Staff	- -	2 Chief Assistants. 5 Assistants.
Lower Staff	- -	2 Higher Grade Established Computers. 6 Established Computers.
Temporary Staff	-	Non-Established Computers.

Mr. P. H. Cowell, M.A., Fellow of Trinity College, Cambridge, was appointed the additional Chief Assistant on April 20, and it is hoped that the appointments of the Established Computers will very shortly be made.

On January 31, Mr. Criswick retired on pension after a useful and honourable service of forty-one years at the Observatory, and Mr. Hollis was promoted to fill the vacancy thus occasioned in the Staff of First Class Assistants.

The Staff at the present time is thus constituted, the names in each class being arranged in alphabetical order :—

Chief Assistants—Mr. Cowell, Mr. Dyson.

Assistants—Mr. Hollis, Mr. Lewis, Mr. Maunder, Mr. Nash, Mr. Thackeray.

Second Class Assistants—Mr. Bryant, Mr. Crommelin.

Clerk—Mr. Outhwaite.

Established Computers—Six vacancies.

The two Second Class Assistants will be replaced by Higher Grade Established Computers as vacancies occur.

Mr. Dyson and Mr. Cowell have the general superintendence of all the work of the Observatory, Mr. Cowell's appointment being too recent to make a precise apportionment of the respective duties of the two Chief Assistants advisable at the present time. Mr. Maunder is charged with the heliographic photography and reductions. Mr. Lewis has the charge of time-signals and chronometers, and of the 28-inch equatorial. Mr. Thackeray superintends the miscellaneous astronomical computations and meridian zenith-distance reductions. Mr. Hollis has charge of the photographic mapping of the heavens, the measurement of the plates, and the computations for the astrographic catalogue. Mr. Crommelin undertakes the altazimuth and Sheepshanks equatorial reductions, and Mr. Bryant the transit-reductions and time-determinations. In the magnetic and meteorological branch, Mr. Nash has the charge of the whole of the work. Mr. Outhwaite acts as responsible accountant officer, has charge of the library, records, manuscripts, and stores, and conducts the official correspondence.

There are at the present time thirteen Computers attached to the astronomical branch, four to the astrographic, four to the heliographic, and five to the magnetic and meteorological.

A gate-porter, a messenger, a watchman, and a gardener; a foreman of works, with two carpenters, and one or two labourers; a skilled mechanic with an assistant; and a charwoman, are also attached to the Observatory.

The whole number of persons regularly employed at the Observatory is 49.

IX.—General Remarks :—

The re-organisation of the Staff of the Observatory which has now been approved, as mentioned in the preceding section, will provide the much needed increase in the permanent staff of trained observers, and in the supervising power by the appointment of an additional Chief Assistant. The benefit of this increase of permanent staff will, it is hoped, be felt in the future, but during the past year the work of the Observatory has had to be carried on by a reduced staff, there being three vacancies in the staff of five Second Class Assistants, which could not be filled up, as, under the scheme now sanctioned, six Established Computers are to be appointed in lieu of three Second Class Assistants. Under these difficult circumstances (aggravated by the inconvenience arising from the building operations in progress) it is highly creditable to the Assistants and Computers that the record of work for the past year compares so well with that of any previous year, and I take this opportunity of acknowledging the zeal and energy with which the whole Staff has worked to maintain the credit of the Observatory.

But, with the diminished staff of Assistants, it has been necessary to suspend the spectroscopic observations, and it has not been found practicable to carry out supplementary investigations such as the proposed determination of the longitude of Killorglin (at the western end of the great European arc of longitude), and the discussion of discordances in the Paris longitude determinations referred to in previous Reports. It is hoped that these may be undertaken next year.

The question of the utilization of the photographs taken for the Astrographic Chart, and the formation of a catalogue of stars down to the eleventh magnitude by means of photography, has occupied much attention during the past year, and a satisfactory working scheme for the measurement of the photographic plates and determination of the positions of the stars on them has been brought into operation. Even under the circumstances of the past year good progress has been made notwithstanding changes in the staff which necessitated provisional arrangements, and it is hoped that next year, under more settled conditions, the work will advance rapidly. It is estimated that if no unforeseen difficulties arise the measures and calculations for the Greenwich Astrographic Catalogue of Stars down to the eleventh magnitude, from Dec. 64° N. to the Pole, will be completed in about seven years, and that the positions of about 120,000 stars will be determined with a degree of accuracy at least twice as great as that of the Astronomische Gesellschaft Catalogues from meridian observations. When it is considered that the Greenwich Astrographic Catalogue will contain about ten times as many stars as the catalogues of the Astronomische Gesellschaft for the corresponding zones, and that the Astrographic Catalogue for the whole heavens will give the positions of from two to three million stars with an accuracy hitherto unattained, and at a relatively small expenditure of labour, the great advantage resulting from the application of photography to the mapping of the heavens will be sufficiently evident.

But the basis of the Astrographic Catalogue must necessarily be a meridian catalogue giving accurate positions of a sufficient number of stars for the determination of the constants for each plate (position of centre, orientation, scale value, &c.), and though the catalogues of the Astronomische Gesellschaft are of great value for this purpose, it is desirable that the stars should be re-observed in order to reduce the uncertainty in their positions resulting from error of observation and unknown proper motion. It is proposed to undertake this work for the Greenwich Zone, from Dec. 64° N. to the Pole, on the conclusion of the observations for the new Greenwich Ten Year Catalogue at the end of this year, and it is hoped that it may be completed in ten years.

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The largely increased number of meridian observations made during the last three years, representing a corresponding increase in the efficiency of the Observatory, which is mainly due to the zeal of the observers, has caused a difficulty in the printing of the annual volume of Greenwich Observations, arising from the great increase in the number of proof sheets to be read and the delay in setting them up, and though this has been to a certain extent overcome in the last year, the question requires careful consideration in view of the large number of observations required for the next Ten Year Catalogue if the stars of the Astronomische Gesellschaft Catalogues from Dec. 64° to the Pole are to be re-observed as proposed. While I am unwilling to give up the principle of publishing all the details of meridian observations, as giving security against mistakes and facilities for detection of errors, I think that a compromise, which would furnish these details for the Sun, Moon, planets and fundamental stars (stars for clock-error, azimuth, zenith point, &c.), but only give results (Mean R.A. and N.P.D. for each observation) for other stars, would satisfy most requirements, while it would effect a great reduction in these heavy sections, which delay the subsequent sections of results dependent on them and thus unduly retard the printing of the annual volume.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich.
1896 May 11.