

REPORT
OF
THE ASTRONOMER ROYAL
TO THE
BOARD OF VISITORS
OF THE
ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1884 June 7.

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The present Report refers to the period of twelve months from 1883 May 21 to 1884 May 20, and exhibits the state of the Observatory on the last-named day.

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

The new dome for the Lassell telescope was completed by Messrs. T. Cooke and Sons at the end of last March, and is in every respect satisfactory. It is 30 feet in diameter, covered with papier mâché on an iron framework, and turns with great ease. The shutter-opening extends from beyond the zenith to the horizon, and is closed by a single curved shutter (3 ft. 6 in. wide at the zenith and 6 feet wide at the horizon), which turns about a point in the dome-curb opposite to the shutter-opening, and runs on guiding rails at the horizon and near the zenith, the curved shutter being continued by an open framework to complete the semi-circle. This arrangement appears to leave nothing to be desired as regards ease of manipulation. After the completion of the dome, the carpenters' work on the flooring, &c. of the building and the attachment of the observing stage (which is fixed to the dome) have necessarily occupied much time, and the building is hardly yet complete in all details.

Under the supervision of the Director of Works of the Admiralty, extensive improvements have been made in the arrangements for the drainage of the Observatory, and preparations have been made for connecting it with the Main Drainage System. Several rooms in the Observatory Buildings have been painted during the past year.

The only addition to the moveable property, which calls for notice, is the new photograph-micrometer mentioned in Section III. The instruments lent to the Transit of Venus Committee have all been returned, with the exception of a clock

(Dent 1915) which has been sold to the Natal Observatory, and of the instruments lost in the wreck of the "City of Brussels." A 6-inch equatoreal by T. Cooke and Sons has been transferred to the Observatory by the Transit of Venus Committee, with the sanction of the Treasury, to replace the Naylor equatoreal. Of the instruments purchased for the Transit of Venus 1874, there are now at the Observatory two transits, two altazimuths, five 6-inch equatoreals, and two photoheliographs, one of which is mounted for daily use. Three transits, an altazimuth, and a photoheliograph are at the Cape; one photoheliograph and the mounting of another are at South Kensington, and a photoheliograph tube is in India. An altazimuth has been lent to the Observatory of the Royal Naval College, and the 6-inch object-glass of the Hodgson equatoreal has been temporarily lent to the Experimental Light Committee of the Trinity House. The two 4-inch telescopes lent to Captain Wharton, R.N., have been returned.

The annual comparison of the books and manuscripts in the Library with the catalogue is now being made.

II. Astronomical Observations :—

Transit-Circle.—There is no change of importance to notice in this instrument, which has been kept in good working order. A reversion-prism for use with the collimators as well as with the transit-circle is being made by Messrs. Troughton and Simms. The Sun, Moon, planets, and fundamental stars have been regularly observed throughout the year, together with other stars from a working catalogue of 2,600 stars, comprising all stars down to the sixth magnitude inclusive which have not been observed since 1860. Considerable progress has been made in obtaining the requisite three observations of each star, and there is a good prospect that by the end of next year, when it is proposed to form a new Nine-Year Catalogue, the whole of the stars will be cleared off. The annual catalogue of stars observed in 1883 contains about 1,550 stars.

The following statement shows the number of observations with the Transit-Circle made in the year ending 1884 May 20 :—

Transits, the separate limbs being counted as separate observations	5213
Determinations of collimation error	303
Determinations of level error	360
Circle observations	5049
Determinations of nadir point (included in the number of circle-observations)	353
Reflexion-observations of stars (similarly included)	548

As regards the computations,—

Clock times of transit over the true meridian, corrected for collimation, level and azimuth errors, are prepared to .	1884 May 18
Clock errors and rates are determined to	May 11
Mean R.A.'s for 1884 January 1 are prepared to	May 11

The investigation of personal equations has been completed for the year 1883.

The circle observations are completely reduced to 1884 May 11 so as to form mean N.P.D. for 1884 January 1.

The discordance between the nadir observation and the mean of the results from reflexion observations of stars north and south of the zenith, which has gradually increased since the year 1879, still continues and has not yet been traced to its source. The mean correction to the nadir observation indicated by the observations of 1883 was $-0''.45$, with considerable fluctuations in the course of the year, the mean discordance for the months of June and July being insensible. The correction deduced from the first four months of the present year is $-0''.34$.

Determinations of flexure by means of the collimators have been made on 1883 October 31, November 2, and November 8, the resulting values (found by three different observers) being $-0''.39$, $-0''.75$, and $-0''.20$. The mean of five determinations made in 1883 is $-0''.49$, whilst the mean of nine accordant determinations in the period from 1879 to 1882 is $+0''.13$. The value of the flexure found in 1883 has the same sign as in the period from 1867 to 1877.

The correction for R—D, the error of assumed colatitude, and the position of the ecliptic have been investigated for 1883. The deduction of geocentric and heliocentric errors for the planetary results is complete for 1883.

The correction for discordance between reflexion and direct observations of stars, deduced from observations in 1883 which extend from Z.D. 72° north to Z.D. $71\frac{1}{2}^\circ$ south is $-0''.02 + 0''.69 \sin Z.D.$ The assumed formula $a + b \sin z$ represents the observations of 1883 fairly well throughout the whole range of zenith distance.

The value found for the colatitude from the observations of 1883 is $38^\circ.31'.21''.86$, very slightly smaller than the assumed value; the correction to the tabular obliquity of the ecliptic is $+0''.15$; and the discordance between the results from the summer and winter solstices is $-0''.32$.

The mean error of the Moon's tabular place is only $+0''.03$ in R.A. and $+0''.42$ in longitude as deduced from the meridian observations of 1883. In this year Prof. Newcomb's corrections to Hansen's tables have been applied in the Nautical Almanac, so that the comparison has reference to Hansen's theory without his empirical term of long period (intended to represent the direct action of Venus) and with an empirical alteration in the epoch of the inequality resulting from the indirect action of Venus. The mean error of Hansen's tables uncorrected was $+0''.82$ in R.A. for the year 1882.

Altazimuth.—The observations with this instrument have been restricted to the period from last quarter to first quarter in each lunation, the total number of observations of various kinds made in the 12 months ending 1884 May 20 being as follows:—

Azimuths of the Moon and stars	.	.	.	.	295
Azimuths of the azimuth-mark	.	.	.	.	174
Azimuths of the collimating-mark	.	.	.	.	194
Zenith-distances of the Moon	.	.	.	.	149
Zenith-distances of the collimating-mark	.	.	.	.	190

The altazimuth observations are completely reduced to April 21, so as to exhibit errors of Moon's tabular R.A., N.P.D., longitude, and ecliptic N.P.D.

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.
0 ^h to 1 ^h mean solar time	.	.	.	.	0	0
1 ^h to 2 ^h	„	.	.	.	0	1
2 ^h to 3 ^h	„	.	.	.	0	5
3 ^h to 4 ^h	„	.	.	.	1	8
4 ^h to 5 ^h	„	.	.	.	5	11
5 ^h to 6 ^h	„	.	.	.	5	8
6 ^h to 9 ^h	„	.	.	.	24	7
9 ^h to 12 ^h	„	.	.	.	22	—
12 ^h to 15 ^h	„	.	.	.	30	—
15 ^h to 18 ^h	„	.	.	.	13	4
18 ^h to 19 ^h	„	.	.	.	5	9
19 ^h to 20 ^h	„	.	.	.	4	7
20 ^h to 21 ^h	„	.	.	.	0	6
21 ^h to 22 ^h	„	.	.	.	0	10
22 ^h to 23 ^h	„	.	.	.	0	3
23 ^h to 24 ^h	„	.	.	.	0	0

The whole number of places of the Moon observed with the transit-circle is 109, or 8·6 per lunation.

The Moon's diameter has been measured with the transit-circle once in R.A. and 15 times in N.P.D., and with the altazimuth twice in Z.D.

Clocks and Chronograph.—The mean solar clock, made many years ago by Shepherd and Son, has on several occasions in the past year stopped through failure in the electric contact made by the pendulum. Mr. Shepherd has proposed an improved

form of electric escapement, which he has fitted to a pendulum to be placed here for experiment within the next week. Meanwhile, in order to avoid the inconvenience caused by the stopping of the mean solar clock, which sends out the hourly time-signals to the Post Office for general distribution, one of the Transit of Venus clocks (Dent 2012) has been fitted by Messrs. E. Dent and Co., with the requisite contact springs, so that it can be used at any time in place of the electric mean solar clock, and a relay adapted for driving the sympathetic clocks by means of the clock Dent 2012 is being made.

Reflex Zenith Tube.—About 50 transits of γ Draconis over the 30 wires have been taken in order to determine the scale-value corresponding to different temperatures and different readings of the focal length. It is proposed to continue these observations during the present year, with special attention to the focal adjustment.

Equatoreals.—The Lassell equatoreal has required a number of small repairs and general cleaning, some parts of the mounting having been probably strained in process of removal, and the bearings in particular having suffered from wear and subsequent disuse, so that it has been necessary to raise the instrument and re-grind these in several instances. The mirror has been cleaned, and appears to be in very good condition as regards polish. The definition on stars seems to be very good as far as it has been practicable to test it before the mounting of the telescope has been put into proper order. The delay in the completion of the dome has necessarily delayed the work on the instrument, which is now rapidly advancing to completion.

The South-east and Sheepshanks equatoreals are in good order, as also is the Simms' 6-inch equatoreal mounted in the South ground.

With one or more of these equatoreals, or with the altazimuth, 8 occultations of stars by the Moon (6 disappearances and 2 reappearances), the occultation disappearance of Venus on February 29, and 56 phenomena of Jupiter's satellites have been observed in the twelve months ending 1884 May 20 and the observations have all been completely reduced to 1884 March 6. Comet *b* 1883 (Pons-Brooks) was observed on 9 nights, and a few micrometer observations of two of Saturn's satellites (Rhea and Titan) have been made. A number of observations of double stars were made on 25 nights with the Airy double-image micrometer.

III. Spectroscopic and Photographic Observations:—

The solar prominences have been observed with the half-prism spectroscope on 21 days, and four sun-spots have been examined on 5 days with reference to the broadening of lines in their spectra. Displacements of the hydrogen lines in the

spectra of the prominences and chromosphere, and reversals of the metallic lines have been noticed much more frequently than in preceding years.

For the determination of motions of stars in the line of sight, 412 measures have been made of the displacement of the F line in the spectra of 48 stars, 91 measures of the *b* lines in 19 stars, and 2 measures of the D lines in one star, besides measures of the displacements of the *b* and F lines in the spectra of the east and west limbs of Jupiter, and in the spectra of Venus and Mars, and comparisons with lines in the Moon or sky spectrum made in the course of every night's observations of star-motions, or on the following morning, as a check on the adjustment of the spectroscope. Some preliminary measures have also been made of the F line in the spectrum of the Orion-nebula. The progressive change in the motion of Sirius, from recession to approach, alluded to in the last two reports, is fully confirmed by numerous observations since last autumn, and a change of the same character is indicated in the case of Procyon. A discussion of the measures of all the stars observed here, on which I am now engaged, shows that the results of the four periods—1875 June to 1877 May, 1877 June to 1880 December, 1881 January to 1882 March 10, 1882 March 11 to 1884 March 31, in each of which the instrumental conditions were different—accord generally within the limits of the probable errors, and that there is no systematic change from recession to approach, so that the presumption against error arising from defective instrumental adjustment appears to be strong.

The spectrum of Comet *b* 1883 (Pons-Brooks) was examined on two nights, and at the request of Dr. Konkoly a search was made on five nights for bright lines in the spectrum of γ Ceti, but their supposed existence was not confirmed.

The spectroscopic observations of all kinds are completely reduced to 1884 May 20.

In the twelve months ending 1884 May 20 photographs of the Sun have been taken on 219 days, and of these 507 have been selected for preservation. There were 4 days on which the Sun's disk was observed to be free from spots.

The mean spotted area of the Sun was slightly greater in 1883 than during the preceding year, although the faculæ have shown a small falling off. For the year 1883 Greenwich photographs are available on 215 days, and Indian photographs filling up the gaps in the series on 125 days, making a total of 340 days out of 365 on which photographs have been measured. In 1882 the total number of days was 343, viz., Greenwich series 201 days, supplemented by Indian photographs on 142 days.

By the application of a new secondary magnifier and longer camera, the Dallmeyer photoheliograph has been adapted (since April 4) to take eight-inch photographs

of the Sun instead of four-inch. A new and improved micrometer adapted to the measurement of photographs of the Sun up to 12 inches in diameter has been made by Messrs. Troughton and Simms, and is now used exclusively in the measurement of the solar photographs.

As regards the reduction of the Greenwich photographs :

The photographs have been measured in duplicate, and the measures entered, to	1884 April 2
Radii of the Sun, Corrections for zero of position-circle, and Heliographic elements, have been computed to . . .	April 2
Distances from the Sun's centre and Position-angles of spots and faculæ, corrected for distortion and refraction, have been formed to	March 17
Heliographic longitudes and latitudes of spots have been computed to	Jan. 11
The areas of spots and faculæ have been completely reduced, so as to exhibit areas in millionths of the Sun's visible surface, to	Jan. 11

The Indian photographs received from the Solar Physics Committee have been measured to the end of 1883, and the measures have all been completely reduced so as to exhibit heliographic latitudes and longitudes of spots and areas of spots and faculæ.

IV. Magnetical Observations :—

The continuous record by photography of changes in the magnetic declination, horizontal force, and vertical force, and of earth-currents has been maintained with perfect regularity, whilst absolute values of the magnetic elements are determined periodically by eye-observation.

The time of vertical vibration of the vertical magnet has been adjusted (relatively to the time of horizontal vibration) so that the same length of ordinate on the photographic sheets represents very nearly the same absolute amount of disturbance for vertical force as for horizontal force and declination. The movements recorded in the three elements are thus immediately comparable.

The identity and insulation of the earth-current wires have been recently tested and found satisfactory, except that the insulation of the " Blackheath " line seemed a little defective.

The new position of the Dip and Deflexion instruments in the new Library appears to be generally satisfactory.

The ironwork of the Lassell dome did not affect the magnetic registers in the slightest degree when it was brought into the South ground on 1883 December 31. Although there is a large mass of iron in the Lassell equatoreal and dome, it is at such a distance from the magnets, and so nearly in the magnetic meridian passing through the declination magnet, that no appreciable effect was to be anticipated.

As regards the magnetic reductions, the eye-observations of the upper declination magnet and of the horizontal and vertical force magnets are completely reduced to the end of 1883. The time-scales for declination and horizontal and vertical force are complete to the end of 1883, and the base line values, deduced from the eye-observations, are entered on the photographic sheets.

The hourly ordinates of the photographic curves are read out to the end of 1883 for declination and horizontal force. The daily and hourly means are taken for declination to the end of 1883, and for horizontal force to last June. The time-scales for the earth-currents are laid down to the end of August 1883. The observations of dip are completely reduced to the present time, and those for absolute horizontal force to the end of 1883.

The following are the principal results for magnetic elements for 1883 :—

Approximate mean westerly declination	. . .	18°. 15'.
Mean horizontal force		{ 3.926 (in English units). 1.810 (in Metric units).
Mean dip		{ 67. 31. 10 ^o (by 9-inch needles). 67. 31. 36 (by 6-inch needles). 67. 31. 59 (by 3-inch needles).

In the year 1883 there were only five days of great magnetic disturbance, as against 15 in 1882, but there were also about 30 days of lesser disturbance for which it appears desirable to publish tracings of the photographic curves.

As proposed in the last Report, tracings of the photographic curves of magnetic movements and earth-currents, reproduced by photo-lithography on a reduced scale, have been given in the volume of "Greenwich Observations," 1882, for 34 days of greater or less disturbance, in substitution for the tables of ordinates measured from the photographic trace. Besides these, a brief description of all magnetic movements (superposed on the ordinary diurnal inequality) has been given for other days

with a view of affording facilities for comparing them with solar phenomena. In the preparation of these particulars as well as of the plates Mr. Ellis has rendered very valuable assistance.

V. Meteorological Observations:—

The meteorological instruments and the Thomson electrometer have been maintained in good order. In the gale of Jan. 23 the short connecting chain attached to the pressure plate of Osler's anemometer gave way, having perished in course of many years' exposure to the weather. After some delay through our having to wait for a quiet day before the pressure plate could be examined, a new chain was substituted on Feb. 26. The flexible brass chain connecting the external chain with the recording pencil continues to give very satisfactory results.

A new photographic thermometer apparatus, in which I have arranged that the dry and wet bulb traces shall fall on the same part of the photographic cylinder as regards time-scale, is being made by Messrs. Negretti and Zambra, and, after many delays, is now nearly finished. By means of a long air bubble in the wet-bulb thermometer, with a column of mercury above, the degrees and decades of degrees are registered for this thermometer just below the trace of the dry-bulb thermometer, and without any interference of the two records. The scale of time for the thermometers will in this arrangement be the same as for all the other registers, both magnetical and meteorological.

A slight shift has been made in the positions of the rain gauges in the Magnetic ground.

The observations of the temperature of the Thames made at the Deptford Cattle Market are regularly communicated to the Royal Observatory, and appear to be quite satisfactory.

The meteorological reductions are in the following state:—The observations of barometer, thermometers, anemometers, rain-gauges, and sunshine instrument (corrected, where necessary, for instrumental error) are reduced up to the present time. On the photographic sheets all the time-scales are laid down to the end of 1883. The hourly ordinates are read out for the barometer to 1883 February, for the dry-bulb thermometer to 1883 July, for the wet-bulb to the end of 1882 only, and for the electrometer to 1883 June. Commencing with the year 1882 the electrometer results have been drawn up so as to exhibit the mean diurnal inequality in each month for rainy days and for non-rainy days, as well as for all days taken together.

The mean temperature of the year 1883 was $49^{\circ}3$, being $0^{\circ}4$ lower than the average. The highest air temperature was $85^{\circ}1$ on August 21, and the lowest $20^{\circ}6$ on March 24. The mean monthly temperature was above the average in January and February, and below in March and July. In the other months it differed little from the average.

The mean daily motion of the air in 1883 was 291 miles, being 12 miles greater than the average. The greatest daily motion was 842 miles on December 12, and the least 62 miles on December 26. The pressures exceeding 20 lbs. in 1883 were 28.0 lbs. on January 27, 28.5 lbs. on February 2, 24.4 lbs. on March 6, 20.5 lbs. on October 17, and 26.5 lbs. on December 12.

During the year 1883 Osler's anemometer showed an excess of 16 revolutions of the vane in the positive direction N, E, S, W, N, if all the turnings are counted; or of 19 revolutions in the positive direction if the turnings which are evidently accidental are excluded.

The number of hours of bright sunshine recorded by Campbell's sunshine instrument during 1883 was 1241, which is about 30 hours above the average of the six preceding years. The aggregate number of hours during which the Sun was above the horizon was 4454, so that the mean proportion of sunshine for the year was 0.280, constant sunshine being represented by 1.

The rainfall in 1883 was 21.9 inches, being about 3 inches below the average.

Tracings of the barometer registers for the days following the Krakatoa eruption have been sent to Mr. R. H. Scott and to M. Paul Schreiber. Two series of atmospheric disturbances recurring at intervals of about 36 hours are recorded from August 27 to September 1.

We remarked no definite connexion between magnetic or electrical disturbances and the phenomena of the remarkable sunsets of the past winter.

VI. Printing and Distribution of the Greenwich publications :—

The volume of Greenwich Observations 1881 was distributed last June and July, as well as the separate copies of Results, and the volume for 1882 was passed for press early in May, the preparation of the plates of magnetic disturbances having somewhat delayed the completion of the printing. The copies are now in the binders' hands. [The copies of the Spectroscopic and Photographic Results 1882 have been received while this Report is passing through the press.]

As regards the volume for 1883, the transits are printed to May 26, the meridian zenith distances to March 27, and the whole of the altazimuth section is printed to

the end of the year. The MS. of the Spectroscopic observations is in the printers' hands.

VII. Chronometers and Time Signals :—

The number of chronometers now being tested at the Observatory is 192, and of these 155 (115 box-chronometers, 17 pocket-chronometers, and 23 deck-watches) belong to the Navy, 33 are placed here for the annual competitive trial, and 4 are on trial for purchase by the Austrian Government.

The first six chronometers in the competitive trial of 1883 were slightly above the average of recent years as inferred from the trial numbers.

No failure in the automatic drop of the Greenwich time-ball has occurred during the year to which this Report refers. The ball was not raised on two days on account of the violence of the wind, and on four other days during the repair of the machinery.

As regards the Deal time-ball, after various delays the arrangement, referred to in the last Report, for sending a current to Deal and receiving a return-signal through the Chronophor of the Post Office telegraphs, was brought into operation on February 29, and has worked well since. The change has necessitated some slight alteration in our arrangements in order that we may be able to receive the Westminster signal through the same wire which is now used for the Deal current and its return signal. There have been 16 cases of failure in the dropping of the Deal time-ball owing to interruption of the telegraphic connexions, 12 under the old system, and 4 since the new arrangement with the Post Office. On 19 days the current was weak and required the assistance of the attendant to release the trigger, and on 9 days the violence of the wind made it imprudent to raise the ball.

The errors of the Westminster Clock have been under 1^s on 53 per cent. of the days of observation, between 1^s and 2^s on 30 per cent., between 2^s and 3^s on 13 per cent., between 3^s and 4^s on 3 per cent., and between 4^s and 5^s on 1 per cent.

VIII. Personal Establishment :—

The staff is thus constituted, the names in each class being arranged in alphabetical order :—

Mr. Dunkin, Chief Assistant ;

Mr. Criswick, Mr. Downing, and Mr. Ellis, First Class Assistants ;

Mr. Hollis, Mr. Lewis, Mr. Maunder, Mr. Nash, and Mr. Thackeray, Second Class Assistants.

The only change to notice is that, with the approval of the Treasury, the Magnetical and Meteorological Assistant now ranks as a Second Class Assistant, an improvement in the position of this Assistant which has removed an anomaly prejudicial to the interests of the Observatory.

As regards the duties of the establishment:—Mr. Dunkin has the general superintendence of all the work of the Observatory. Mr. Criswick takes charge of the transit, equatoreal, and miscellaneous computations, and superintends generally the astronomical computers. Mr. Downing is charged with the circle-reductions. Mr. Thackeray has the care of the library and manuscripts, and of stores and stationery. He also undertakes the work of the chronograph. Mr. Lewis superintends the time department, including chronometers, and prepares the money accounts. In the Spectroscopic and Photographic branch, Mr. Maunder has the general superintendence of the work, Mr. Hollis being specially charged with the measurement and reduction of the Indian photographs. Mr. Hollis is also charged with the altazimuth-reductions. In the Magnetic and Meteorological branch, Mr. Ellis superintends generally, Mr. Nash having the special charge of the instrumental adjustments and of the meteorological reductions.

There are at the present time six computers attached to the Astronomical branch, three to the Spectroscopic and Photographic, and four to the Magnetic and Meteorological.

A gate-porter, watchman, and gardener, and a foreman of works, with two carpenters and a labourer, are also regularly employed as part of the establishment.

IX. General Remarks :—

In the past year the work of the Observatory has gone on steadily on the same lines as in former years, with such small extensions in certain directions as could be made without infringing the long-established principle that all observations are to be reduced and published without delay.

A larger number than usual of meridian observations has been made, whilst the reductions are maintained in a very forward state. In the Spectroscopic and Photographic branch there has been considerable pressure during the long-continued maximum of Sun spots, the work of measuring the photographs having been somewhat further increased by the adoption of large-scale photographs of the Sun.

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The preparation of the particulars of magnetic movements and of the plates for disturbed days has pressed somewhat heavily on the Magnetic and Meteorological department, but I trust that the facilities thus afforded for comparing magnetic and solar phenomena will be appreciated, and in ordinary years the labour involved will be very much less. I regret that this work has compelled me to postpone for a short time, amongst other things, the completion of the Meteorological Reductions to which I referred in the last Report.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1884 *May* 21.
