REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1885 *June* 6.

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THE Report here presented refers to the period of twelve months from 1884 May 21 to 1885 May 20, and exhibits the state of the Observatory on the last-named day.

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

The new building and dome for the Lassell telescope were completed in all details during the past year. A stove has been fixed in it to dry the interior in wet weather, as it was found that the mirror and ironwork of the instrument were exposed to injury from damp.

The work of connecting the drainage of the Observatory with the Main Drainage System has now been completed by the Director of Works' Department. It is intended to lay a drain to carry away the waste water from the sink in the Magnet basement, and I propose to take advantage of the opening of the ground to lay a line of pipes underground for the ventilation of the basement by air which has acquired the temperature of the soil at a depth of several feet below the surface. It is hoped that by this means greater uniformity of temperature may be maintained in the Magnet basement.

A shed for the new photographic thermometers has been erected in the south ground.

The Observatory fences have been thoroughly repaired, and are now in good order.

As regards moveable property, three transits, an altazimuth, and a photoheliograph are at the Cape Observatory; a photoheliograph and the mounting of another are at South Kensington, the photoheliograph tube being in India; a transit, an

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altazimuth, and the Simms 6-inch equatoreal No. 2 have been lent for exhibition at Bethnal Green Museum; an altazimuth and the Lee 6-inch equatoreal have been transferred to the Royal Naval College and to the Hong Kong Observatory respectively; the Hodgson 6-inch object-glass is in the hands of the Elder Brethren of the Trinity House for photometric experiments; a photoheliograph mounting has been lent to the Mountain Observatory Committee of the Royal Society; and a clock (Dent 2011) is at present at Kew Observatory.

The temporary observing hut in the Magnet ground is being used by Major Strahan, R.E., for trial observations of a transit instrument, belonging to the Indian Trigonometrical Survey, which has been recently repaired in England. Piers for the transit and collimators have been built under Major Strahan's instructions.

The annual comparison of the books and manuscripts in the Library with the catalogue has been made, and all have been found on the shelves.

II. Astronomical Observations :—

Transit-Circle.—The apparatus for illuminating the wires has been cleaned and put in good order, the reflecting prisms having become very dirty in course of years. A reversion-prism made by Messrs. Troughton and Simms has been used since last June in observations with the collimators as well as with the transit-circle to reverse the apparent direction of measurement or of motion, a movement towards the left (as in transits of south stars) being converted into a movement towards the right, or upwards, or downwards, according to the position of the plane of reflection of the reversion-prism. The collimation-observations show no sensible personality depending on the apparent direction of measurement; it has, however, been considered well, in order to eliminate any possible effect of the kind, to take half the measures in each determination of collimation with the direction of movement of the wire reversed as regards right and left. In the transits the practice is to observe on each day two clock-stars and also circumpolar stars with the direction of motion reversed. A comparison of the results from the reversed and ordinary observations of clock-stars shows sensible differences in the case of some observers, who, however, have probably not yet settled down into a definite habit of observing stars which appear to move in the reverse direction.

In order to determine absolute personal equations in the observation of slow-moving as well as of quick-moving stars of various magnitudes (whether the motion be from right to left or the reverse) and of limbs of the Sun, Moon, or planets, I have arranged, in concert with Mr. Simms, a Personal Equation Instrument to be

used with the Transit-Circle. In this instrument, which is on the point of completion, a vertical plate with a circular aperture, 6 inches in diameter, to represent the Sun or Moon, and several small pinholes, to represent stars of different magnitudes, is placed in the focus of an object-glass of about 7 inches aperture and of about 50 feet focal length (which is attached to the dew-cap of the transit-circle, when horizontal and pointing north), and is carried smoothly by clockwork from east to west or west to east at a rate which may be varied at will from that of a very close circumpolar star to three or four times that of an equatoreal star by an ingenious but simple mechanical contrivance devised by Mr. Simms. The apertures in the vertical plate are illuminated by direct sun-light or moon-light reflected by a plane mirror towards the object-glass, and the times of transit of the artificial Sun, Moon, or stars, which are to be observed over the wires of the transit-circle, are also registered automatically on the chronograph by means of insulated platinum studs, corresponding to the artificial objects, which make contact with other studs, corresponding to the wires in the field of view of the transit-circle.

Since last October transits of the close circumpolar stars have been taken at the middle wire set to successive revolutions of the R.A. micrometer, thus virtually introducing a system of very close equidistant wires for the slow-moving stars. It is thus found that a larger number of separate observations can be obtained in a moderate time, a point of special importance in changeable weather. The equality of successive intervals of the R.A. micrometer-screw was tested last January for each revolution through a range of twelve revolutions, and also for every tenth of the three middle revolutions, and the errors of the screw appear not to exceed the errors of observation. The determination was made by means of the South Collimator, the eye-piece of the Transit-Circle having been turned through 90°. The observations of close circumpolar stars have also been discussed with a view of testing the equality of successive revolutions of the R.A. micrometer-screw, the results being very satisfactory. The screws of the microscope-micrometers also were examined by means of the South Collimator on March 27 and following days, successive intervals being measured for each revolution and third of a revolution from -1^r to 6^r. Though there is evidence of considerable wear in the individual screws, which have been in constant use since 1875, the method of using them (the action of the spring being in opposite directions for the micrometers of each pair) entirely eliminates this effect from the mean, and the resulting errors (which are probably casual errors of observations) do not exceed $0''{\cdot}05$ at any part of the screws.

The subjects of meridian observations in the past year have been as usual the Sun, Moon, planets, and fundamental stars, with other stars from a working catalogue, which now contains about 2,750 stars. About 380 stars have been lately added to the list from the "Harvard Photometry," with a view of making the forthcoming

Greenwich Catalogue of Stars down to the sixth magnitude as complete as possible. It is hoped that all of these stars will have been sufficiently observed by the end of 1886, when it is proposed to form a Ten-Year Catalogue, epoch 1882·0. The annual catalogue of stars observed in 1884 contains about 1,370 stars.

The following statement shows the number of observations with the Transit-Circle made in the twelve months ending 1885 May 20 :—

Transits, the separate limbs being counted as separate observations	5523
Determinations of collimation error	299
Determinations of level error	376
Circle observations	5321
Determinations of nadir point (included in the number of circle-observations)	294
Reflexion-observations of stars (similarly included)	619

As regards the computations,—

The transits are completely reduced (so as to exhibit mean R.A. on 1885 Jan. 1) as far as May 8, the means of wires being taken and collimation and level-errors being applied as far as May 19.

The investigation of personal equations has been completed for the year 1884. A large number of eye-and-ear transits having been made last spring, whilst the chronograph was under repair, a determination of personal equations in eye-and-ear transits has been made. With a view to keeping up the practice of observers in this mode of observation, it has been arranged that two clock-stars are to be observed by the eye-and-ear method on each night of observation with the Transit-Circle.

The circle observations are completely reduced (so as to exhibit mean N.P.D. on 1885 Jan. 1) as far as April 25, apparent N.P.D., corrected for refraction and parallax, being formed to May 9.

The discordance between the nadir observation and the mean of the results from reflexion observations of stars north and south of the zenith has recently become very small, the correction deduced for the first four months of the present year being only $-0''{\cdot}07$. The mean correction indicated by the observations of 1884 was $-0''{\cdot}36$, whilst those of 1883 gave the value $-0''{\cdot}45$. The steady increase of this discordance from 1878 to 1883 and its subsequent decrease remain unexplained, no change having been introduced into the method of observation of the nadir point or of stars by reflection during the last two years.

The apparent flexure of the transit-circle, as found by means of the collimators, has again changed sign. From six determinations made on 1884 June 3, Sept. 9, Sept. 29, Oct. 5, Oct. 20, and May 20 (the reversion-prism being used on each occasion except the first) the resulting values (found by four different observers) are $-0''\cdot47$, $+1''\cdot00$, $+0''\cdot33$, $-0''\cdot03$, $+0''\cdot10$, and $+0''\cdot08$, the mean of which is $+0''\cdot17$, agreeing closely with the value $+0''\cdot13$ found by nine accordant determinations in the period 1879 to 1882, whilst the mean of five determinations by three different observers in 1883 gave the value $-0''\cdot49$. No correction for flexure (as distinct from the R—D correction) has been applied to the observations since 1879.

The correction for R—D, the error of assumed colatitude, and the position of the ecliptic, have been investigated for 1884. The computation of the geocentric and heliocentric errors for the planetary results is not yet complete.

The correction for discordance between reflection and direct observations of stars, deduced from observations in 1884 which extend from Z.D. 69° north to Z.D. 70° south is $-0''\cdot02 + 0''\cdot66 \sin$ Z.D. The assumed formula $a + b \sin z$ represents the observations of 1884 satisfactorily throughout the whole range of zenith distance.

The value found for the colatitude from the observations of 1884 is $38°.31'.21''\cdot91$, differing only by $0''\cdot01$ from the assumed value; the correction to the tabular obliquity of the ecliptic is $+0''\cdot57$; and the discordance between the results from the summer and winter solstices is $-0''\cdot99$.

The mean error of the Moon's tabular place (computed from Hansen's Lunar Tables with Prof. Newcomb's corrections) is $+0^s\cdot02$ in R.A. and $+0''\cdot29$ in longitude as deduced from 104 meridian observations in 1884.

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 1885 May 20 being as follows:—

Azimuths of the Moon and stars	321
Azimuths of the azimuth-mark	181
Azimuths of the collimating-mark	192
Zenith-distances of the Moon	178
Zenith-distances of the collimating-mark . . .	196

Since last December a "reversion prism" has been used to reverse the apparent direction of motion in the observation with lamp right and in that with lamp left on alternate nights.

The altazimuth observations are completely reduced to March 11, 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.
1^h to 2^h mean solar time . . .	0	2
2^h to 3^h „ . . .	0	11
3^h to 4^h „ . . .	3	11
4^h to 5^h „ . . .	5	11
5^h to 6^h „ . . .	7	11
6^h to 9^h „ . . .	22	5
9^h to 12^h „ . . .	22	—
12^h to 15^h „ . . .	20	—
15^h to 18^h „ . . .	17	2
18^h to 19^h „ . . .	8	8
19^h to 20^h „ . . .	4	8
20^h to 21^h „ . . .	0	8
21^h to 22^h „ . . .	0	3
22^h to 23^h „ . . .	0	1

The whole number of places of the Moon observed with the transit-circle is 108, or 8·8 per lunation.

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

Clocks and Chronograph.—The Sidereal standard clock was cleaned at the beginning of April. The Chronograph has required extensive repair, the train of wheels having become much worn in course of years. Various improvements suggested by experience have been carried out by Messrs. E. Dent and Co., and the instrument appears now to be in very good order. The chronograph was out of use for two and a half months, during which time the transits were observed by eye-and-ear.

On Jan. 1 the public clock at the Observatory entrance and the other mean solar clocks were put forward 12 hours so as to show Greenwich civil time, starting at midnight and reckoning from 0^h to 24^h, which would correspond with the Universal time recommended by the Washington Conference. The change from astronomical to civil reckoning has also been made in all the internal work of the Observatory, and has been carried out without any difficulty. Greenwich civil time is found to be more convenient on the whole for the purposes of this Observatory, but its introduction into the printed astronomical observations has been deferred to allow

time for a general agreement amongst astronomers to be arrived at. It is proposed, however, to adopt the civil day without further delay in the printed magnetical results, thus reverting to the practice previous to 1848, and making the time-reckoning harmonize with that used in the meteorological results, the reckoning from 0^h to 24^h being for the future adopted in both cases.

Reflex Zenith Tube.—The observations of γ Draconis for determination of the temperature correction have been continued, and about 45 transits over the 30 wires have been observed at temperatures ranging from 46° to 72°. Seven transits of 9 Aurigæ were also observed last February at low temperatures ranging from 42° to 56°.

Equatoreals.—The work on the Lassell equatoreal has occupied a great deal of attention during the past year, a number of repairs and alterations having been required in order to get the instrument into proper working order. The driving clock, which was found to drive the instrument at only three-fifths of the proper speed, has been altered, a slow motion in R.A. (to be worked from the observing stage) has been contrived, a new slide of improved construction has been made for gearing the driving-screw into the hour-circle, the teeth of the hour-circle have been re-cut, a firm declination clamp has been applied, an improved edge suspension for the large mirror (consisting of a steel band which encircles the mirror and is supported by brackets at six equidistant points of the circumference) has been contrived, a new and firmer mounting of the small mirror has been made, and the eye-piece has been mounted firmly on a plate which allows it to be tilted in any direction, for optical adjustment. The framed iron base which supports the instrument has been bricked up and filled with concrete, and this with the other alterations has greatly increased the stability of the telescope, which is now quite satisfactory. Difficulty is, however, still experienced from want of stability of the optical axis of the large mirror, which requires to be readjusted continually, as the telescope is moved. When the mirrors have been properly adjusted the definition appears to be very good, the companion to Vega being shown with remarkable distinctness without any trace of scattered light from the large star.

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, 30 occultations of stars by the Moon (19 disappearances and 11 reappearances, including 7 disappearances and 9 reappearances during the lunar eclipse of Oct. 4), and 57 phenomena of Jupiter's satellites, have been observed in the 12 months ending 1885 May 20, and the observations have all been completely reduced to the end of 1884. Comet (*c*) 1884 has been observed on 4 nights, the Lassell reflector or one of the other equatoreals

being employed, and some measures of distances and position-angle of double stars, as well as a large number of observations for determining the value of $1^{rev.}$ of the screw in different parts of the field of view have been made with the Airy double-image micrometer mounted on the Sheepshanks' or Simms' equatoreal.

Micrometer measures of some of the satellites of Saturn (including Enceladus) were made on 7 nights with the Lassell equatoreal.

III. Spectroscopic and Photographic Observations:—

The solar prominences have been observed with the half-prism spectroscope on only 2 days, the photographic reductions having pressed very severely on the Spectroscopic Assistant during the long continued maximum of sun-spots.

For the determination of motions of stars in the line of sight, 569 measures have been made of the displacement of the F line in the spectra of 47 stars, and 72 measures of the *b* lines in 14 stars, besides measures of the displacements of the *b* and F lines in the spectra of the east and west limbs of Jupiter, and of the east and west ansæ of the rings of Saturn, and comparisons with lines in the spectrum of the Moon, or of the sky, made in the course of each night's observations of star-motions, or on the following morning, as a check on the general accuracy of the results for star-motions. The observations of the last twelve months confirm the change in the motion of Sirius, which now appears to be approaching the Sun at the rate of about 20 miles a second. As there is great difficulty in the use of a pointer or cross-wires for measuring both the broad dark line in the star's spectrum and the narrow bright comparison line, Mr. Maunder has suggested the use of a Reversion Spectroscope (on the double-image principle) for these observations, and Professor Pritchard has kindly lent the reversion spectroscope of the Oxford University Observatory, in order that the suitability of that form of instrument may be tested. The spectroscopic observations of all kinds are completely reduced to the present time.

In the twelve months ending 1885 May 20 photographs of the Sun have been taken on 173 days, and of these 431 have been selected for preservation, the record being not so complete as usual, owing partly to the loss of several days during the adjustment of the instrument after the adaptation of the secondary magnifier, and partly to a failure of the supply of dry plates in July last during the absence of Mr. Maunder. There were only 2 days on which the Sun's disk was observed to be free from spots.

The mean spotted area of the Sun was slightly less in 1884 than in 1883 and slightly greater than in 1882, whilst the faculæ in 1884 showed a slight increase as compared with 1883, and a slight falling off as compared with 1882. It would seem that the maximum both of sun-spots and faculæ occurred about the end of 1883 or beginning of 1884.

For the year 1884 Greenwich photographs are available for measurement on 152 days, and Indian photographs filling up the gaps in the series on 159 days, making a total of 311 days out of 366 on which photographs have been measured. In 1883 the total number of days was 340, viz., Greenwich series 215 days, supplemented by Indian photographs on 125 days.

As regards the reduction of the Greenwich photographs:

The photographs have been measured in duplicate, and the measures entered, to	1885 April 21
Radii of the Sun, Corrections for zero of position-circle, and Heliographic elements, have been computed to . .	April 21
Distances from the Sun's centre and Position-angles of spots and faculæ, corrected for distortion and refraction, have been formed to	April 21
Heliographic longitudes and latitudes of spots have been computed to	April 17
The areas of spots and faculæ have been reduced, so as to exhibit areas in millionths of the Sun's visible surface, to	April 17

The Indian photographs received from the Solar Physics Committee have been measured to 1885 February 27, and the measures have been completely reduced so as to exhibit heliographic latitudes and longitudes of spots and areas of spots and faculæ to February 8.

IV. Magnetical Observations:—

There is no important change to notice in the magnetic instruments. Mention has already been made of the proposal to ventilate the Magnet basement with air of sensibly constant temperature coming through underground pipes.

The changes in the magnetic declination, horizontal force, and vertical force are continuously registered by photography with the three magnetometers, absolute values of the magnetic declination, horizontal force, and dip being determined by eye-observation. Earth-currents, in two directions on the earth's surface nearly at right angles to each other are also continuously recorded. The identity and insulation of the earth-current wires have been recently tested, and found satisfactory, except that the "Blackheath" line shows a little defect of insulation.

The iron gutter of the Lassell dome (in 16 pieces weighing together 2 tons 6 cwt.) did not affect the magnetic registers in the slightest degree when it was brought into the South ground on 1884 June 26. In order to determine the effect of a mass of iron on the magnets, experiments were made on July 2 with 4, 8, 12, and 16

pieces of the gutter respectively, placed at a distance of 25 feet from the declination magnet in a direction south-east (magnetic) from it, so that the maximum effect would be produced. It was found that the effect of every 4 pieces (weighing together about 12 cwt.) was to increase the apparent declination by 1′ exactly, the whole 16 pieces causing a deflection of 4′. As the effect of a mass of iron on a magnet varies as the sine of twice its magnetic azimuth divided by the cube of its distance from the magnet, these experiments show that the deflection caused by the whole of the iron in the Lassell instrument and dome (which is at a distance of 100 feet and very nearly in the magnetic meridian of the declination magnet) would be quite insensible.

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 1884. The time-scales for declination, horizontal force, and vertical force are complete to the end of 1884, 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 1884 for declination and horizontal force, and the daily and hourly means are taken. The time-scales for the earth-currents are laid down to the end of 1884. The observations of dip are completely reduced to the present time, and those for absolute horizontal force to the end of 1884.

Experiments for determination of the temperature corrections of the horizontal and vertical force magnets have been recently made by warming and cooling the magnet basement on successive days, but the results have not yet been finally deduced.

The following are the principal results for magnetic elements for 1884 :—

Approximate mean westerly declination . .	18°. 8′.
Mean horizontal force	3·931 (in English units). 1·812 (in Metric units).
Mean dip	67. 29. 8 (by 9-inch needles). 67. 29. 32 (by 6-inch needles). 67. 30. 9 (by 3-inch needles).

In the year 1884 there were only five days of great magnetic disturbance, but there were also about 20 days of lesser disturbance for which it appears desirable to publish tracings of the photographic curves. It may be interesting to add the tracings for a few quiet and nearly quiet days in order to exhibit the characteristics of the ordinary diurnal movement.

In the Magnetical Results for 1883 the values for horizontal and vertical force have been given corrected for temperature so as to make them immediately available for use, the uncorrected values being also printed in order that any person may readily be able to revise the correction for temperature should this appear at any time to be necessary. Space has been gained for the exhibition of both sets of values by the omission of unnecessary figures which are constant in each series.

Commencing with 1883 the magnetic diurnal inequalities of declination, horizontal force, and vertical force have been discussed by the method of harmonic analysis, the harmonic expressions for these inequalities being obtained for each month and for the year with arguments expressed in apparent solar time as well as in mean solar time.

In the carrying out of the changes above-mentioned I have received much valuable assistance from Mr. Ellis.

V. Meteorological Observations:—

The meteorological instruments and the Thomson electrometer are all in good order. The thermometers in ordinary use for eye-observation (excepting the four earth thermometers) are compared yearly with the standard.

The new photographic thermometer apparatus was completed (with the exception of the cover) after many delays at the beginning of this year, but pressure of work has somewhat retarded the trials which were necessary before bringing the new instrument into use. Arrangements have now been made for provisionally mounting the new thermometer apparatus under a suitable shed in the South ground, in order that a series of daily records may be obtained for comparison with the existing apparatus before the latter is finally removed.

A new copper rain-gauge was substituted at the beginning of this year for the old standard gauge of generally similar construction. In the new gauge the water is collected at once in the measuring vessel, which is made conical in order that small amounts may be measured with accuracy.

The observations of the temperature of the Thames made at the Deptford Cattle Market are regularly communicated to the Royal Observatory for publication in the Registrar-General's Weekly Reports. Owing to accidental breakage of the thermometers, the observations were interrupted for six months, from July to December last year.

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 1884. The hourly ordinates are read out for the dry-bulb thermometer to 1884 April, for the wet-bulb to 1884 March, and for the electrometer to 1884 April. The table of principal changes of direction of the wind has been re-cast and much extended in the volume for 1883, so as to exhibit all changes of direction amounting to or exceeding two points of the compass ($22\frac{1}{2}^\circ$).

The mean temperature of the year 1884 was 50°·7, being 1°·4 higher than the average of the last 43 years. The highest air temperature (in the shade) was 94°·1 on Aug. 11, and the lowest 24°·5 on Nov. 25. The mean monthly temperature was above the average excepting in the months of April, June, Oct. and Nov.

The mean daily motion of the air in 1884 was 286 miles, being 3 miles greater than the average of the last 17 years. The greatest daily motion was 891 miles on Jan. 23, and the least 78 miles on Feb. 8. The only recorded pressure exceeding 20 lbs. on the square foot in 1884 was 22·7 lbs. on Jan. 23, after which the connecting chain of the pressure plate broke, as mentioned in the last Report. It is probable that greater pressures occurred afterwards on the same day, and also in the gale of Jan. 26, at which date the chain had not been renewed.

During the year 1884 Osler's anemometer showed an excess of about 25 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 by Campbell's sunshine instrument during 1884 was 1115, which is about 100 hours less than the average of the seven preceding years. The aggregate number of hours during which the Sun was above the horizon was 4465, so that the mean proportion of sunshine for the year was 0·250, constant sunshine being represented by 1. We have quite recently received from Mr. Jordan one of his sunshine recorders of improved form, but no observations have yet been made with this instrument.

The rainfall in 1884 was 18·0 inches, being about 7 inches below the average of the last 40 years.

Reports of meteorological observations are sent daily to the Meteorological Office, London, and to the Bureau Météorologique, Paris, weekly to the Registrar-General, and twice a month to the Chief Signal Officer, U.S.A.

VI. Printing and Distribution of the Greenwich publications :—

The volume of Greenwich Observations 1882 was distributed last July, as well as the separate copies of Results, and the volume for 1883 has been passed for press, with the exception of the Magnetic and Meteorological Introduction, of which the proof sheets have been received.

As regards the volume for 1884, the whole of the altazimuth section is printed to the end of the year. The MSS. of the Transits, Meridian Zenith Distances, and Spectroscopic observations are in the printers' hands.

VII. Chronometers and Time Signals :—

The number of chronometers now being tested at the Observatory is 151, and of these 103 (79 box-chronometers, 13 pocket-chronometers, and 11 deck-watches) belong to the Navy, 40 are placed here for the annual competitive trial, and 8 are on trial for purchase by the Austrian Government.

The first six chronometers in the competitive trial of 1884 were rather above the average of the last ten years as inferred from the trial numbers. As much difficulty is experienced in maintaining the chronometer oven at a nearly constant temperature, an apparatus has been procured from Mr. Kullberg which is designed to effect this automatically, by the action of a compensation-bar, which, as the temperature rises, gradually closes a small hole through which the supply of gas to the gas burners passes. The apparatus has not yet been brought into use, as the chronometer oven has been constantly required for testing chronometers since it has been received.

The automatic drop of the Greenwich time-ball failed on 6 days through the clock-train stopping. The ball was not raised on 3 days on account of the violence of the wind.

As regards the Deal time-ball, which is now dropped by current passing through the chronopher of the Post Office telegraphs, there have been 14 cases of failure owing to interruption of the telegraphic connections, and on one day the current was too weak to release the trigger without the assistance of the attendant.

In connection with the establishment of hourly time-signals at the Start or Lizard, which was long advocated by Sir G. B. Airy, I have received from the Committee of Lloyds', in answer to my inquiry, an assurance that that corporation would be willing to undertake the maintenance of hourly time-signals at any of their signal stations, provided the Government would supply the necessary apparatus. After consultation with Capt. Wharton, it has been thought better that, before taking further steps, some preliminary trials should be made of a collapsible cone as an hourly time-signal, facilities for doing which exist at Devonport. As regards ball-drop or other time-signal, I would propose that it should be made automatically by a local clock, to be corrected daily by the help of a time-signal from Greenwich at 10 a.m., which should automatically start an auxiliary seconds' pendulum, suspended freely just behind the clock pendulum. The attendant would then accelerate or

retard his clock pendulum (by electro-magnetic action as in the Greenwich mean solar clock) so as to make it pass through the middle of its vibration at the same time and in the same direction as the auxiliary pendulum, and thus to indicate accurately Greenwich mean time. A return signal to Greenwich sent by the local clock at the next hour (11 a.m.) would show that this clock had been properly corrected, and would be a guarantee for the general accuracy of the time-signals. Preliminary trials have shown that the observation of coincidence of vibration of two pendulums can be made with great certainty, and Messrs. E. Dent and Co. are now arranging for the mounting of an auxiliary pendulum on one of the Transit of Venus clocks, and for adapting it to give hourly time-signals.

The errors of the Westminster Clock have been under 1^s on 50 per cent. of the days of observation, between 1^s and 2^s on 29 per cent., between 2^s and 3^s on 10 per cent., between 3^s and 4^s on 7 per cent., and over 4^s on 4 per cent.

VIII. Personal Establishment :—

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

Mr. Turner, Chief Assistant ;

Mr. Criswick, Mr. Downing, Mr. Ellis, and Mr. Maunder, First-class Assistants ;

Mr. Hollis, Mr. Lewis, Mr. Nash, and Mr. Thackeray, Second-class Assistants.

During the past year the Observatory has lost the valuable services of Mr. Dunkin, who retired on August 25, after an honourable service of forty-six years, which has been throughout characterized by remarkable zeal and ability, and has contributed largely to maintain the credit of the Observatory. Mr. Dunkin has been succeeded in the post of Chief Assistant by Mr. H. H. Turner, B.A., of Trinity College, Cambridge.

The only other change to notice is that, consequent on a recommendation of the Board of Visitors at their last meeting, the Admiralty have raised the Spectroscopic and Photographic Assistant to the position of a First-class Assistant in recognition of his increased duties and responsibility.

The duties of the establishment are thus distributed, some changes having been made at the beginning of this year :—

Mr. Turner superintends generally all the work of the Observatory.

In the Astronomical branch, Mr. Criswick, assisted by three or four computers, has the charge of the transit reductions and miscellaneous computations, and the care of the Sheepshanks and Simms equatoreals. Mr. Downing with two computers undertakes the altazimuth and equatoreal reductions with the care of the library and MSS.

and of the altazimuth and Lassell equatoreal. Mr. Thackeray, with one computer, is charged with the circle and zenith-tube reductions, the reading out of chronograph transits, and the care of the transit-circle, zenith-tube, and chronograph. Mr. Lewis, with one computer, manages the business relating to chronometers, time-signals, money accounts, and stores, and has the care of clocks, chronometers, and electric communications.

In the Spectroscopic and Photographic branch, Mr. Maunder and Mr. Hollis, assisted by two computers, undertake all the reductions (including those relating to Indian photographs), and the care of the south-east equatoreal, the photoheliograph and spectroscopes.

In the Magnetic and Meteorological branch, Mr. Ellis controls and superintends the whole of the work, Mr. Nash being charged specially with the instrumental adjustments and meteorological reductions. They are assisted by four computers.

The record of work done during the past twelve months is perhaps the best testimony to the zealous spirit with which the Assistants have laboured to sustain the credit of the Observatory.

A gate-porter, watchman, and labourer, and a foreman of works, with two carpenters and a labourer, complete the establishment.

IX. General Remarks:—

During the past year the various classes of work carried on in this Observatory have been somewhat extended. The meridian observations are more numerous than usual, and various subsidiary investigations involving considerable labour have been undertaken with a view to increase their accuracy. A large number of spectroscopic determinations of star-motions have been obtained, and the long continued maximum of sun-spots has made the photographic measurements and computations much heavier than in any previous year. Extensions have also been made in the magnetic and meteorological branch, which appeared very desirable, but which have pressed rather severely on Mr. Ellis and his staff.

Turning to the future, I wish to invite the attention of the Visitors to the circumstance that an increase in our optical means is required to enable us to carry out satisfactorily the determinations of proper motions of stars in the line of sight with the spectroscope, a work which peculiarly belongs to this Observatory, as supplementing the determinations of proper motions from meridian observations.

The aperture of our largest refractor ($12\frac{3}{4}$ inches) is too small to allow of our observing successfully with the spectroscope any but the brightest stars, and though the Lassell reflector is somewhat more powerful, its mounting and clock-work are not

adapted to carry a heavy spectroscope with the necessary steadiness and accuracy of motion. The firmness of the mounting of the South-east equatoreal and the perfection of its clock-work would make it peculiarly suitable for this class of work if it carried a much larger object-glass.

After careful consideration of the conditions I have satisfied myself that an object-glass of 28 inches aperture and of 28 feet focal length could be mounted on the South-east equatoreal, in place of the present object-glass of less than half that aperture; and I have ascertained that Mr. Grubb would be prepared to undertake the construction of such an object-glass with a tube suited to the special requirements of the case, so that the telescope would be equally available for eye-observation or for use with the spectroscope. With Mr. Grubb's assistance, I have prepared a model showing how this may be arranged.

While a large refractor is required specially for spectroscopic observations, it seems desirable also on other grounds that this Observatory should possess an equatoreally mounted telescope comparable with those of other first-class Observatories, so that we may no longer be prevented by deficient optical means from obtaining complete series of observations of comets and faint satellites.

W. H. M. CHRISTIE.

Royal Observatory, Greenwich,
1885 *May* 21.