

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

Read at the Annual Visitation of the Royal Observatory, 1874, June 6.

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THE Report, which I have the honour of laying before the Board of Visitors, refers to the period of twelve and a half lunations included between Full Moon of 1873, May 11, and New Moon of 1874, May 15, and presents the general history of the Royal Observatory during that interval, together with a statement of its condition on the last-mentioned day.

I. Buildings and Grounds :—

The only alteration of any importance in the buildings surrounding the Front Court is the inclosure of the Mean Solar Standard Clock in the Ball Lobby within double sashes, with a view to reducing the alternations of temperature to which this clock is exposed.

A first-floor-room under the Altazimuth Dome, fitted with shelves, formerly called the Upper Dépôt, has been taken for extension of the Library, and is called Library 4.

The whole of the exterior of the Observatory Buildings has been painted, under the superintendence of H. M. Office of Works. New gates for the Front Court have been prepared and hung.

A considerable portion of the East Boundary fence has been repaired, and a tool-house has been built in the South Ground.

The platform above the Magnetic Observatory, for observation of meteors, has been used during the past year as a stage for the telescopes employed in the practice with the Transit of Venus Model, which has been erected on the roof of the Octagon Room. It has been found necessary to strengthen the platform with struts, in order to diminish the tremor experienced in windy weather.

The number of buildings erected in the South Ground, in preparation for the Transit of Venus, has been reduced within reasonable limits by transferring a part of them to a plot of ground belonging to the Admiralty and adjoining the Vicarage, at the north boundary of Greenwich Park. This arrangement has proved more convenient for many of the observers, and has at the same time greatly diminished the risk of fire in the Observatory inclosure. All the huts, except those intended for Egypt, are now taken down and packed for shipment.

A fire-proof chemical room, constructed of zinc, has been erected close to the Photoheliograph, and fitted with a gas-stove for keeping the photographic chemicals at a suitable temperature throughout the winter.

No progress has yet been made in the construction of the Railway through Greenwich; but it is understood that the South-Eastern Railway Company have purchased some property along the line of route sanctioned by Parliament, and which passes on the north side of London Street, at a considerable distance from the Observatory.

II. Moveable Property :—

Leaving out of consideration in this Section the Manuscripts, Books, and Instruments, which form the subjects of separate Reports, all our moveable property is in a satisfactory condition; the only article of importance not in our possession being the Portable Altazimuth, which has been allotted to the New Zealand party of the Transit of Venus Expedition.

A balance of peculiar construction has been made by Mr. Oertling, from my instructions, and fixed near the public barometer at the Entrance Gate. This instru-

ment enables the public to test any ordinary pound weight, showing on a scale the number of grains by which it is too heavy or too light. As a safeguard against injury, it is only open during the office hours of the Observatory.

III. Manuscripts :—

The gradual increase in the number of the valuable manuscript records of observations and calculations, and in general scientific correspondence, has necessitated a corresponding increase in the shelving of the Record Room, and 140 feet of new slate shelves have been erected; and all the manuscript shelves have been classed and numbered.

The general binding of manuscripts continues under the superintendence of H. M. Stationery Office, on the system explained in the last Report.

The usual annual examination of manuscripts has been made, and all were found on the shelves, with the exception of a transcript of Bradley's manuscript observations lent to Dr. Auwers, and not yet returned.

IV. Library :—

The charge of the Library has been transferred from Mr. Dunkin, who undertook the management of it on Mr. Carpenter's resignation, to Mr. Criswick. This arrangement is more convenient, as Mr. Dunkin's regular work of superintending the supernumerary computers was somewhat interrupted by his having the care of the Library.

The books on the shelves have been carefully compared with the Catalogue as usual, and are in good order; some few are missing, which we believe to be merely misplaced. A new set of regulations for the use of the Library has been drawn up, with a view to ensure the due entry in the lending book of every work taken from the shelves, and its return to its proper place on being brought back. Some books have been transferred to the new closet, now called Library 3, close to the door of

Library 2, and some have been placed in the Upper Depôt, now Library 4. The books in Libraries 1 and 2 have also been re-arranged on the shelves, so as to use the space more economically.

An unusual quantity of binding, under the superintendence of H. M. Stationery Office, has been done in the present year. The collection of pamphlets had become very large.

The duplicate copies of works in the Library, which have hitherto been kept in the East Dome, have been removed to the Record Room, and thoroughly overhauled. All those that appeared worth preserving have been set aside, and I am now considering where they can most conveniently be placed. Many of these books are valuable as works of reference, and it is important to have them readily accessible. Some old copies of De Morgan's Five-figure logarithms, a work which has long been out of print, were found in the course of this examination, and secured for the Transit of Venus Expedition.

V. Astronomical Instruments :—

The Transit-Circle is in good working order; it has not been found necessary to clean the object-glass since the practice was introduced of turning that end of the telescope downwards after observing.

The lenses of the object-glass of the North Collimator have been separated and cleaned.

Allusion was made in the last Report to a discordance between the results obtained for coincidence of the two Collimators in the two cases; first, when the instrument was raised so as to admit of a perfectly free view of one Collimator by the other; and, secondly, when a partial view was obtained through the pierced cube of the Transit-Circle. Since 1874, January 1, the Collimation Errors deduced from readings taken through the cube have been corrected by the quantity $+0^{\text{r}}.019$ or $+0^{\text{r}}.28$; the effect of this correction on the resulting R. A.'s of stars is entirely differential, and therefore very slight.

A new determination of the coefficient of flexure was made on 1873, May 30, agreeing well with the adopted value.

The recording-micrometer, referred to in the last Report, has been in regular use since 1873, June 20; some mistakes in reading off have been corrected by its means. By the help of this arrangement, the system of making several bisections of an object in its passage through the field of view has been more fully carried out.

The arrangement for correction of the barometric inequality, to which I alluded last year, has been applied to the Sidereal Standard Clock with satisfactory results. The inequality is now considerably reduced; but a further adjustment of the magnets is required for its complete correction, and this is necessarily a slow process, as a long series of observations is required to determine the effect of the barometer. A uniform acceleration of rate has been shown since the clock was brought into use again (after adaptation of the apparatus) on 1874, January 24, and this has somewhat masked the barometric inequality.

The clock Hardy, which was in a bad state, has been thoroughly renovated by Messrs. E. Dent & Co., the principal alterations being the substitution of new contact-apparatus and of a new escape-pinion for the old parts. While these repairs were being executed, the clock Arnold 1 was placed in the Transit-Circle-pit for use in observations of Circumpolar Stars, &c. The rate of this clock would probably be improved by the substitution of a zinc and steel pendulum (which has been found to answer so well in the Sidereal Standard and Transit of Venus clocks) for its old grid-iron pendulum. This clock has now been fixed in the East Dome, where it takes the place of the clock Earnshaw, which has been lent to the Transit of Venus Expedition.

The Chronograph has worked satisfactorily throughout the past year, but will probably require cleaning before long. A pair of wires in connexion with the Chronograph is now carried to the Sheepshanks Equatoreal, and an additional pair to the Great Equatoreal.

The Altazimuth is in a very satisfactory state. The form of its pivots was ascertained by observation in 1873, May, when the apparent deviations from circularity were found to be well within the probable error of observation, so that no correction is required on this account. The instrument has been raised regularly each lunation about the time of New Moon, and the pivots cleaned and oiled. The new lifting-apparatus, which is provided with screw-jacks, is used for this purpose.

The Sheepshanks and Shuckburgh Equatorials are in an efficient state for observation of occultations and other phenomena.

The Great Equatoreal is in excellent condition. Some trouble has been caused by the deposition of moisture between the lenses of its object-glass, which has been cleaned

twice during the last winter. The quantity of water was too great to be expelled by a gentle heat, and it was eventually found necessary to separate the lenses on each occasion. Mr. Simms is engaged in making a light bridle-rod for more convenient setting in N. P. D. Fresh counterpoises have been attached to the instrument to balance the additional weight of the new Spectroscope, which was finally received from Mr. Browning's hands on May 2 of the present year.

The Spectroscope is specially adapted to sweeping round the Sun's limb, with a view to mapping out the prominences, and is also available for work on Stars and Nebulæ, the dispersive power being very readily varied. An induction-coil, capable of giving a six-inch spark, has been made for this instrument by Mr. Browning; and various subsidiary apparatus has been procured.

The Reflex-Zenith-Tube is in an efficient state.

The Water-Telescope was dismantled in August last, the observations with it having been brought to a satisfactory termination.

The Ancient Instruments are in the same state as in former years.

The Kew Photoheliograph has been adjusted to focus, and brought into good working order. It has been used regularly since 1874, April, on every day on which the Sun could be seen; before that date the photographs for the regular series were taken with one of the photoheliographs constructed by Mr. Dallmeyer, under Mr. De La Rue's superintendence, for the Transit of Venus Expeditions. These instruments are an improved form of the Kew Heliograph, and were used by preference, until it became necessary to dismount and pack them for shipment.

VI. Astronomical Observations:—

The Moon on all days, and the Sun and large Planets on week-days, have been observed on the meridian whenever practicable; and great attention has been given as usual to the determination of all the instrumental errors. The observations of small Planets have been confined to the first half of each lunation, as in former years.

Some progress has been made with the observations of wide Circumpolar Stars; but, in view of the large number of stars included in our Working Catalogue, I have thought it desirable to limit the number of observations of each object to three

measures of R. A. and N. P. D. above the Pole and three below. By this arrangement, it is hoped that the list will be cleared off in a few years; whilst accuracy will be attained sufficient for the object I had in view when this class of observations was introduced.

A few other stars have been observed, at the request of foreign astronomers; and, at the suggestion of Mr. Birmingham, the places of some of the stars of Schjellerup's list of Red stars were determined, and estimates of magnitude made. Though the determinations of brightness were necessarily somewhat rough, interesting changes in the light of one of these stars were fully established, thus confirming Mr. Birmingham's suspicions.

With the Altazimuth, the Moon and two stars for instrumental errors have been observed at every available opportunity; whenever haze or cloud prevented the observation of a Low Star, the Collimator was used.

The following is a statement of the number of observations made from 1873, May 11, to 1874, May 15:—

With the Transit-Circle :

Transits, the separate limbs being counted as separate observations	4,268
Pairs of observations of the nearly vertical wires of the Reversed Telescopes	296
Reciprocal observations of the nearly vertical wires of the Reversed Telescopes	331
Reflexion-observations of the central wire	446
Circle-observations, each requiring a separate reading of the six microscope-micrometers	4,031
Reflexion-observations of the zenith-distance wire (included in the circle-observations)	436
Reflexion-observations of stars (similarly included)	459

With the Reflex-Zenith-Tube :

Pairs of observations of γ Draconis, the instrument being reversed between the observations	43
Single observations	4

With the Altazimuth :

Azimuths of the Moon and Stars	913
Azimuths of the Collimating-mark	114
Zenith-distances of the Moon	389
Zenith-distances of the Collimating-mark	228
Zenith-distances of 8 stars were also observed for clock-error.	

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The number of complete observations of the Moon near to her conjunction with the Sun is:—

On days when the Moon passed between 21 ^h and 22 ^h Mean Solar			
Time	.	.	4
”	”	between 22 ^h and 23 ^h	3
”	”	between 23 ^h and 24 ^h	0
”	”	between 0 ^h and 1 ^h	1
”	”	between 1 ^h and 2 ^h	2
”	”	between 2 ^h and 3 ^h	4

The following comparison shows the number of places of the Moon observed with the Transit-Circle and Altazimuth respectively:—

With the Transit-Circle, 112, or 9.0 per lunation.

With the Altazimuth, 194, or 15.5 per lunation.

Observations of 10 disappearances and 3 re-appearances of stars occulted by the Moon, and of 27 phenomena of Jupiter's satellites, have been registered either with the Sheepshanks or with the Great Equatoreal; and differential measures of Tempel's Comet of short period were made with the latter instrument in 1873, May.

Since the Spectroscope was received from Mr. Browning, the glimpses of the Sun which have been obtained have been too transient to admit of any systematic work on the solar prominences; but some progress has been made in determining the adjustments of the instrument.

A large number of photographs of the Sun have been taken since 1873, June 1, either with the Kew Photoheliograph or with one of the other instruments, and of these 266 have been selected for preservation, two photographs being usually reserved on every day of observation. Some of the negatives, for which the exposure has been but slight, exhibit the delicate mottlings on the Sun's surface in a remarkable manner; and it is proposed in future to take such photographs whenever practicable, besides those with a full exposure, which are more suitable for showing the details of spots. On two occasions a spot was photographed on the actual limb of the Sun, presenting the appearance of a notch partially filled up with less luminous matter.

VII. Reduction of Astronomical Observations:—

The following table exhibits the various stages of the reductions on 1874, May 15:—

For Meridional Transit Observations :

The observed transits are cleared of instrumental errors, and clock-times of transit over the true meridian are exhibited, to .	1874, May 9.
Apparent right-ascensions from observation are formed by application of clock-errors and rates, to	May 8.
Stars' corrections are computed, to	May 15.
Mean right-ascensions of Stars from observation, reduced to 1874, January 1, are formed by combination of the two last-mentioned elements, to	May 8.
Mean solar times of observation of Sun, Moon, and Planets are prepared, to	May 8.
Corrections for defective illumination of Moon's and Planets' limbs are applied, to	May 8.

The Personal Equations of the observers who have taken transits in the year 1873 have been investigated in the usual way, and show no noteworthy change in the method of observing of the principal observers.

For Meridional Circle Observations :

Means of microscope-micrometers are taken, and corrected for telescope-micrometer, errors of graduation, flexure, inclination of wire, and zenith-point, exhibiting apparent zenith-distances, to	1874, May 3.
Refraction, parallax, and colatitude are applied to form true geocentric north polar distances, to	May 3.
Stars' corrections are applied, forming mean north polar distances on 1874, January 1, to	April 20.
Corrections for defective illumination of Moon's and Planets' limbs are applied, to	May 3.

The refractions used are the same as those employed since the beginning of 1868.

The corrections for R—D and for error of assumed latitude, and the position of the Ecliptic, have been computed for 1873; and the computations of the geocentric and heliocentric errors of the planetary tables are commenced.

The variable term of the R—D correction is slightly larger than in 1872, and the constant part has changed sign. This latter circumstance may be partly accounted for by the fact that a smaller correction has been applied to the Nadir-observation ($0''\cdot76$, deduced from observations in 1872,) than that resulting from the observations of the year 1873 itself, $0''\cdot87$, which is only available for correction of the Wire-observations in 1874.

The result for co-latitude, $38^{\circ}.21'.21''\cdot41$, supports that obtained last year, and is unprecedentedly small.

The planetary ledgers, and the sections which depend on them, were unavoidably delayed until the receipt of the observations of the minor planets for 1873 from the Paris Observatory, which have only lately arrived.

The observations of γ Draconis with the Reflex-Zenith-Tube are completely reduced to the end of 1873.

The Altazimuth observations are reduced to the following stages:—

In azimuth, the means of microscopes are corrected for level, collimation, and zero of azimuth (forming true azimuths), to 1874,	March 12.
In zenith distance, true Greenwich zenith distances are formed,	
to	May 11.
Corresponding tabular azimuths and zenith distances are computed, to	March 12.
Apparent tabular errors of Moon's R.A. and N.P.D. are computed, to	March 12.
Apparent tabular errors of Moon's Longitude and E.N.P.D. are computed to	March 12.

The Occultations of Stars by the Moon are completely reduced.

The register of photographs of the Sun is complete to the present time, and all the negatives are properly labelled.

VIII. Printing and Distribution of Astronomical Observations:—

The printing of the volume for 1872 is in rather a backward state, the section "Star Ledgers" and the Introduction not being yet printed off. The impression will, as stated in the last Report, be limited to 300 for the volume, 150 separate copies of the Results being printed as in former years.

The manuscripts of the principal sections for 1873 have been in the printer's hands some time, but no proofs have yet been received.

The observatories, institutions, and individuals, who formerly received copies of the "Greenwich Observations" from the Royal Society, are now supplied directly from the Royal Observatory; this has very much increased the work of our distribution of the volume for 1871, but the confusion arising from the existence of two separate distribution lists is now removed.

IX. Magnetical and Meteorological Instruments:—

On a few very hot days during the past summer it was found impracticable to keep the temperature of the Magnetic Basement down to the usual level; but during the rest of the year it was maintained sensibly constant.

The Upper Declination-Magnet is in perfect order; no change has been made in any part of the instrument.

The suspension-thread of the Lower Declination-Magnet gave way on 1874, January 2; a new skein was mounted on January 14. The instrument is in good condition.

The same favourable remark applies to the Vertical-Force-Magnet and to the Dip-instrument, which, as well as the other magnetic instruments, have been carefully examined.

The Earth-current wires were identified on 1874, April 15, and their insulation was then found to be very good.

All the meteorological instruments (including the public barometer, near the front gate,) are in good order.

X. Magnetical and Meteorological Observations:—

Great care has been taken to maintain the self-registering instruments in constant action; and to obtain an uninterrupted record of the magnetic elements, of earth-currents, and of atmospheric changes.

The zeros of the photographic curves have been determined by readings of the magnetometers taken four times a day; a circumpolar star has been observed with the theodolite for Zero of Azimuth once or twice a month, and a meridian mark more frequently; the dip has usually been taken two or three times a week; and deflexions for absolute measure of Horizontal Magnetic Force once or twice a month.

The meteorological instruments are read at certain hours of the day, for comparison with the photographic curves.

XI. Reduction of Magnetical and Meteorological Observations:—

The theodolite-observations of stars, giving astronomical zeros for the Declination Magnet, are reduced to the last observation. The theodolite-readings of the Declina-

tion Magnet, and the telescope-observations of the Horizontal Force Magnet, to the present time; those of the Vertical Force Magnet to the end of last year. These determinations give the zeros for the ordinates of the photographic curves.

The whole of the time-scales are complete for the Horizontal Force, Declination, and Vertical Force for 1873; the new base-lines for the Horizontal Force are laid down on the photographic sheets to the end of July 1873; those for the Vertical Force to the end of December 1873; and those for the Declination to the end of January 1873. The ordinates of the curves are measured for the Horizontal Force to the end of May 1873, and for the Vertical Force to the end of the year 1873; no measures of the Declination curves have as yet been made for 1873.

Adopting the scale of disturbance which I have used in the Philosophical Transactions, the number of disturbed days in 1873 is only 3. For these days the ordinates are to be measured for all the salient points of the curves; no further reduction of these numbers has been made since 1857. For the other days, pencil curves are being drawn, smoothing down the principal inequalities, and their ordinates are being measured for every hour; these measures will be used to form tables of diurnal and other inequalities to the end of 1873.

The absolute measures of horizontal magnetic force are prepared to the end of 1873; the dips, as usual, are reduced to the last observation.

The following are the principal results for 1873:—

Mean westerly declination	19°. 30' nearly.
Mean horizontal force	{ 3.883 (in English units). 1.791 (in Metric units).
Mean dip	{ 67. 43. 52 (by 9-inch needles). 67. 45. 46 (by 6-inch needles). 67. 47. 17 (by 3-inch needles).

The ordinates of the photographic curves given by the earth-current wires in their present position have not been measured.

The meteorological results are in the following state:—The eye-observations are corrected for instrumental errors, and the dew-point and degree of humidity are computed to the present time; time-scales and new base-lines to the Barometer traces are laid down to 1873, April.

The vane of Osler's Anemometer made, in the year 1873, 10 complete revolutions in the positive direction N, E, S, W.

Some new classes of reductions of the meteorological observations from 1848 to 1868 have been undertaken and completed in the past year. The general state of this work is as follows:—The diurnal changes of the dry-bulb thermometer, as depending on the month, on the temperature waves, on the barometric waves, on the overcast and cloudless states of the sky, and on the direction of the wind, have been computed and examined for the whole period; and the exhibition of the results is ready for press. The similar reductions for the wet-bulb thermometer in all these classes are rapidly approaching completion.

XII. Printing and Publication of Magnetical and Meteorological Observations:—

The Magnetical and Meteorological Results for 1872 are entirely printed. The number of copies is 550, 300 of which are bound in the volume of Greenwich Observations, while 250 are reserved for separate distribution.

In the Magnetical section, detailed measures of the ordinates of the photographic curves, expressed in terms of the Metric Absolute unit, as well as on the old system, are given on fourteen days of unusual disturbance. For the rest of the year, the mean diurnal inequalities of the three magnetic elements for each month only are printed. The deflexion-observations and their reductions, and the result of every dip-observation, are also given.

The Meteorological portion contains the results of the daily readings of barometer, wet-bulb and dry-bulb thermometers, maximum and minimum thermometers, anemometers, and pluviometers, besides observations of cloud and weather, and records of the temperature of the Thames water and of the soil at various depths.

XIII. Chronometers, Time Signals, Regulation of External Clocks, Operations for Longitude, &c.:—

There are at the present time in the Chronometer Room 194 chronometers, which are regularly rated at least once a week. Of this number, 121 box-chronometers, 14 pocket-chronometers, and 19 deck-watches are the property of the Government, and are being rated after repair by the makers preparatory to their issue to ships of H. M. Navy and 40 belong to chronometer-makers, who have placed them here for the annual competitive trial. These latter are compared every day with the Mean

Solar Standard Clock ; and all the chronometers are, for one or more periods of three weeks each, tried in a temperature of nearly 100° Fahrenheit. Artificial cold has not been used for any chronometer. New chronometers are always tried in different positions with respect to the magnetic meridian.

During the past year three chronometers have been transferred to the War Office, for use in the Gold Coast Expedition, and have been replaced by three others, paid for by the War Office. The number of chronometers required for the Transit of Venus Expeditions is 46 ; and in view of such a large demand on the ordinary stock of Government chronometers, great exertions have been made to get the repairs of chronometers (returned from service) executed by the makers with as little delay as possible.

One chronometer has been transferred to the Eastney Royal Marine Artillery Barracks, and replaced by another purchased at the same price ; three chronometers, intended for the Survey of Canada, have been tried for Mr. L. Russell.

The two chronometers at the head of the competitive list for 1873 had smaller trial numbers (representing the amount of unsteadiness of rate) than any chronometer in any previous year.

With the exception of eight days, on which the violence of the wind prevented the raising of the ball, and of two days on which accidental failures occurred, the Greenwich Time-Ball has been regularly dropped every day through the year to which this Report refers.

The Deal Time-Ball was not raised on five days on account of high wind, and was not dropped on five days owing to interruption in the telegraphic communication. On one day, October 10, it was erroneously discharged four seconds before 1^h by a telegraph-signal ; on 321 days it was dropped correctly by the current ; and on 37 days, principally in rainy weather, the current was too weak to release the trigger without the assistance of the attendant's hand.

A proposal has been made to me to drop a ball at Portsmouth by direct current from the Royal Observatory, but no further action appears to have been taken in the matter by the Admiralty.

Since the removal of the Telegraph Department from Telegraph Street, Lothbury, to the new building facing the General Post Office, a new and more elaborate chronopher has been constructed for the signal at 10^h A.M., in which provision is made for sending signals in sixty different directions, the old chronopher being still in use for the signal at 1^h P.M. Mr. H. Eaton, of the Post Office Telegraphs, has kindly furnished me with the following account of the distribution of signals :—

“ The Greenwich current is received hourly. This hourly current is transmitted to 10 subscribers (mostly chronometer-makers) in London. The method of observing

the current varies, and is fixed by the subscriber. In two cases, time-balls are dropped on the top of the buildings; in some other cases, model time-balls are placed in the windows; and others again use an electric bell; while two or three have a simple galvanometer, and observe from the deflexion of the needle.

“The Westminster clock records its correctness and errors at Greenwich, as does also the clock at the Lombard Street Post Office.

“The 10 a.m. current is most extensively used for the Provinces. It is transmitted automatically to 21 provincial towns in England (where there are subscribers), to Guernsey, Edinburgh, Glasgow, Dublin, and Belfast. In addition to the automatic sender, a sound-signal is established in the Instrument Room here; when heard, a current is sent by the clerks to over 600 offices in direct communication with the Central Telegraph Office, including the principal railway termini. Many of these offices re-distribute the time-signal to the offices radiating from them, so that practically from the 10 a.m. current from Greenwich most of the post-office and railway clocks in the kingdom are regulated.

“The 1 p.m. current is transmitted automatically to nine provincial towns, viz., Newcastle, Sunderland, Middlesboro', Kendal, Hull, Norwich, Stockton, Worcester, and Nottingham. At the first four named, guns are fired; at the others, the current is observed by means of time-balls or galvanometers.

“With regard to the 10 a.m. current, I should have said that there is no rule as to the method of observing; the subscribers use the form of apparatus most suitable to themselves. At the Telegraph Office the signal is recorded or observed on the telegraph instrument.”

To this account it is proper to add that wire-communication has been made, experimentally, from the chronopher to the Royal Observatory, so that, by two galvanometers, the time of a current leaving Greenwich and the time of its distribution by the chronopher could be immediately compared. No sensible difference could be discovered. It follows that the hourly time-signals, based upon the most accurate determinations of time that the Observatory can furnish, may be used for accurate determinations of longitude.

At the Lombard Street Post Office, the Greenwich current at noon *starts* the clock, which had stopped itself some few seconds previously, or at noon of its own time, the clock having a gaining rate. For the guidance of the attendant who regulates the Westminster clock, a signal is received at the Clock Tower from Greenwich, and a return signal is sent to the Observatory by this clock, as well as by the Lombard Street clock, to give us information as to their errors. The errors of the Westminster clock were below 1^s on 67 per cent. of days, below 2^s on 25 per cent., and below 3^s on 5 per cent.; when the error amounts to 4^s it can be corrected by the attendant, by lifting a pallet.

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The rate of the Mean Solar Standard Clock seems more steady since its inclosure within double sashes.

XIV. Personal Establishment :—

The establishment of Assistants has been increased since the date of the last Report by the appointment of Mr. E. W. Maunder on 1873, November 6, as Photographic and Spectroscopic Assistant; and the division of employments has been slightly changed in the case of some of the other Assistants, so as to apportion their duties in a more convenient manner. The present arrangement is as follows :—

Mr. Christie, Chief Assistant, and confidential representative of the Astronomer Royal.

Mr. Glaisher, Superintendent of the Magnetical and Meteorological Department.

Mr. Dunkin, Superintendent of Supernumerary Astronomical Computers; charged with the reduction of Meridional Transits and of observations generally, and especially with all computations of the more advanced deductions from observation.

Mr. Ellis, Superintendent of Clocks, Chronometers, Galvanic Communications, and Time Signals; also of Stationery Stores, and of the Money Accounts of the Observatory.

Mr. Criswick, charged with the translation of the punctures of the Chronographic Barrel into numbers; and, as Librarian, with the superintendence of the binding of Books and Manuscripts, and with the distribution of the Publications of the Royal Observatory.

Mr. Lynn, Superintendent of Reductions of Altazimuth Observations.

Mr. Nash, General Assistant (in subordination to Mr. Glaisher) in the Magnetical and Meteorological Department.

Mr. Downing, Superintendent of Reductions of Circle Observations.

Mr. Maunder, Assistant for Photographic and Spectroscopic Observations.

Astronomical observations are made by all these gentlemen except Mr. Glaisher, Mr. Dunkin, and Mr. Nash; Mr. Maunder's observations are almost entirely with extra-meridional instruments.

The demands for the Transit of Venus preparations have been so great that it has been found necessary to increase the staff of supernumerary computers to meet this unusual pressure. At present eight computers are employed in the Astronomical Department, two in the Magnetical and Meteorological Department, and four on the Meteorological Reductions, 1848-1868. A reduction in these numbers will be made very shortly.

A labourer, a gate-porter, and a watchman are also attached to the Observatory; and care is taken that there be always at least one man on the premises.

The Astronomer Royal is responsible to the Government for everything that passes in the Observatory. An elaborate system of Reports enables him to exercise a constant supervision over all observations, reductions, employ of workmen, and other transactions of the Observatory.

XV. Extraneous Work :—

The principal matters to be mentioned in this Section are the preparations for the Transit of Venus Expeditions.

Originally five stations were selected and fully equipped with equatorials, transits, altazimuths, photoheliographs, and clocks; but I have since thought it desirable to supplement these by two branch stations in the Sandwich Isles and one in Kerguelen's Island; and the additional instruments thus required have been borrowed from various sources, so that there is now an abundant supply of instrumental means.

Telescopes have been lent by the Royal Astronomical Society, by the Cambridge Observatory Syndicate, and by Capt. Tupman, Mr. Barnacle, and Mr. Burton (observers in the Transit of Venus Expedition), the last-named gentleman taking out with him a 12-inch equatorially-mounted reflector.

Transits have been lent by the Royal Astronomical Society and by Messrs. Barclay, Garnett, Jackson, and Shaw; and an altazimuth by Mr. De La Rue. Other transit-instruments have been lent by the Glasgow Observatory and W. R. Birt, Esq., of which it has not been necessary to avail ourselves.

Of double-image-micrometers, five have been made by Mr. Simms, two have been lent by the Royal Astronomical Society, and one each by Mr. Barclay and Capt. Tupman.

There will thus be available for observation of the Transit of Venus 23 telescopes, nine of which will be provided with double-image-micrometers; and five photoheliographs; and for determination of local time, and latitude and longitude, there will be nine transits and six altazimuths.

A model representing accurately the circumstances of the Transit of Venus has been erected on the roof of the Octagon Room, and has been observed regularly since last October from the stage on the top of the Magnetic House. The personal equations of the various observers have been determined, and the different telescopes

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have been compared, by means of this contrivance. Regular observations of the model have also been made with the double-image-micrometer.

All the observers have undergone a course of training in photography; first, under a professional photographer, Mr. Reynolds, and subsequently under Capt. Abney, R.E., whose new dry-plate process is to be adopted at all the British stations. Capt. Abney has also trained at Chatham 15 non-commissioned officers and privates of the Royal Engineers in all the photographic manipulations required for his process. A Janssen slide, capable of taking 50 photographs of Venus and the neighbouring part of the Sun's limb at intervals of one second, has been made by Mr. Dallmeyer for each of the five photoheliographs.

No magnetical instruments are to be carried out as part of the official enterprize, but some of the observers have furnished themselves with such instruments as their private property.

The active Head of the Expedition is Captain G. L. Tupman, R.M.A. Captain Tupman also, as Local Chief, superintends the stations on the Sandwich Islands. Other Local Chiefs are Rev. S. J. Perry, Major Palmer, R.E., Captain O. Browne, R.A., and Lieut. Neate, R.N. Other observers are Rev. W. Sidgreaves, Professor G. Forbes, Captain Abney, R.E., Lieutenants Coke, R.N., Corbet, R.N., Crawford, R.N., Darwin, R.E., Goodridge, R.N., Hoggan, R.N., Noble, R.M.A., Ramsden, R.N.; Messrs. Barnacle, Burton, Hunter, Johnson, Nichol, Smith. Lieut. Corbet has special charge of the longitudes in the Kerguelen seas.

The printing of Accounts of the Total Solar Eclipse of 1870 is not yet completed.

XVI. General Remarks :—

In former Reports I have indicated to the Visitors some of the considerations which, as I conceive, must guide the conduct of this Observatory. Though the terms of its establishment recognised its scientific character, yet the purpose which led to its foundation was utilitarian; and, happily for its steadiness of action and its fair fame even in a scientific view, this purpose has always been kept in sight. I need not point out more explicitly than is done in the preceding pages that both objects have been assiduously followed in the last year. Indeed, when the wants of the State are frequent and those of the Public incessant, and when a continuous system has been thoroughly fixed as a duty and a routine in the habits of the practical observers, it is not easily disturbed by the intervention of any subject of a partially foreign character.

But those more advanced discussions which require the special attention of the Astronomer Royal and the Chief Assistant are liable to be greatly retarded by the accidental intrusion of new demands on their time. In the present year two such have taken place,—the commencement of systems of heliography and spectroscopy,—and, occupying far more of our time, the preparations for the Transit of Venus. The claims of these for precedence are undoubted; they have, however, interfered with some intended discussions of magnetical results, and the reduction of the 21-years' series of meteorological observations has proceeded rather languidly.

I have not been willing, however, to abandon entirely the prosecution of astronomical investigations of a higher class; and in the past spring I published in the Monthly Notices of the Royal Astronomical Society a statement of the fundamental points in a new treatment of the Lunar Theory, by which, availing myself of all that has been done in the best algebraical investigations of that theory, I trust to be able by numerical operations only to give greater accuracy to final results. Considerable progress has been made in the extensive numerical developments, the work being done, at my private expense, entirely by a junior computer; and I hope, at any rate, to put it in such a state that there will be no liability to its entire loss.

G. B. AIRY.

*Royal Observatory, Greenwich,
1874, May 20.*