REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1873, *June* 7.

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THE interruption of the use of the Altazimuth for a time has made it less cogent than on other occasions to define the period, to which my Report to the Board of Visitors applies, by New Moon and Full Moon. But, as the termination of the period which is the subject of Report in 1873 becomes the beginning of that which in ordinary course would be included in the Report of 1874, there is still a prospective advantage in retaining the usual principle of limitation; and the Report which I now offer will therefore apply to the interval between New Moon of 1872, May 7, and Full Moon of 1873, May 11.

I. Buildings and Grounds:—

In the buildings which surround the Front Court, the only changes are the insignificant ones, of alteration of the height of the quadrantal steps rising to the Original Entrance, and of erection of small glass roofs outside of the two doors which open into the Observatory Buildings.

The roof-shutter of the South Dome (covering the Altazimuth), of which the iron-work had decayed, was blown off in a heavy gale; but was soon replaced.

The west palings have been extensively repaired. The roof of the carpenters' shed has been raised, to give better fall to the rain-water.

Extensive repairs have been made to our telegraph-wires carried on the poles of the South-Eastern Railway, and new wires have been carried under Deptford Creek. The insulation of the wires appears to be very perfect.

Observations have been made by Mr. Hilgard, principal officer of the American Coast Survey, for determination of a fundamental longitude (as will be further mentioned); and Mr. Hilgard's transit-instrument was planted, for this purpose, in the Magnetic Court. It has been my custom, in similar instances, to fix a stone in the ground, with a short inscription, giving the name of the observer and the instrument which he has used on that spot; and I have followed this custom in the instance of Mr. Hilgard.

The proposed platform above the Magnetic Observatory, to which allusion was made in the last Report, was completed in time for observation of the August shower of meteors in 1872.

In preparation for the proposed photoheliographic observations, a small building with rotatory dome has been erected on the brow of the slope from the Magnetic Ground which overlooks the South Ground, communicating with the Magnetic Office, No. 3; and the office No. 2 is receiving some small alterations to prepare it as Chemical Room.

Provision is made for general external painting of the Observatory Buildings.

The preparations for the Transit of Venus in 1874 still occupy the South Ground. The number of the erections became so considerable, far greater than could with safety or convenience be retained in the South Ground, that I was induced to solicit permission of the First Commissioner of Her Majesty's Works and Parks, for placing many of the buildings, when finished, in the Reserve Ground of Greenwich Park. The First Commissioner's consent was immediately granted, and eight of the buildings have accordingly been transferred to the Park Reserve.

The question of Railway through Greenwich is not yet practically settled. Of the sanctioned line, the eastern portion, from Maze Hill to Charlton, is completed and is opened for daily service. Application has been made to Parliament, and (as I am informed) has been favorably received by the House of Commons, for lengthening the time for completion of the works through Greenwich Town. I could much wish to see the railway actually made.

No further proposal has been made for connexion of this line with the lines of the London, Chatham, and Dover Railway.

II. Moveable Property:—

Omitting for the present the mention of Manuscripts, Books, and Instruments in ordinary use, I have to report that the whole of our Property is at home, except only the following. It was known to the scientific world that several of the original thermometers, constructed by Mr. Sheepshanks (in the course of his preparation of the National Standard of Length), by independent calibration of the bores and independent determination of the freezing and boiling points on arbitrary graduations, were still preserved at the Royal Observatory. It was lately stated to me by M. Tresca, the principal officer of the International Metrical Commission, that, in the late unhappy war in Paris, the French original thermometers were destroyed; and M. Tresca requested that, if possible, some of the original thermometers made by Mr. Sheepshanks might be appropriated to the use of the International Commission. I have therefore transferred to M. Tresca the three thermometers A 6, S 1, S 2, with the documentary information relating to them, which was found in Mr. Sheepshanks' papers; retaining six thermometers of the same class in the Royal Observatory. I am confident that this step will receive the approval of the Board of Visitors.

No addition worthy of mention has been made to our furniture, &c.

I propose that, in the observations for the Transit of Venus, our Portable Altazimuth shall be employed at the New Zealand Station.

III. Manuscripts:—

The same care has been given to the preservation of our manuscripts, and the same system has been adopted for their arrangement, as heretofore. But, since losing the aid of my Assistant, Mr. James Carpenter, to whom this department had been almost entirely intrusted, it has been necessary for me personally to direct, with very close superintendence, the arrangement of a large mass of papers. Advantage has been gained to several parts of the work, by this direction, for a time, of my own vigorous attention. In the mean time, other assistants have been trained to the work, and it is ceasing to be very engrossing to myself.

The manuscripts which admit of being bound in simple masses are bound under the superintendence of H. M. Stationery Office. Those which require notched or index papers are bound, under arrangement of the Controller of the Stationery Office, by a local binder.

The manuscripts have lately been examined and found to correspond with the Catalogue.

There is no difficulty in providing the additional shelves which will shortly be required.

The few copy-manuscripts which were lent out have not been returned; apparently from want of opportunity.

IV. Library:—

Since the departure of Mr. Carpenter, the Library has been placed under the charge of Mr. Dunkin. It is generally in very good order; the binding is slightly in arrear, but will soon be completed, by the binding agents of H. M. Stationery Office.

The Catalogue is properly kept up, and the books are annually compared with it. At the late comparison, every book was producible.

So many additions are made by presents in those classes of which the Library principally consists (astronomy, chronology, geography, magnetism, meteorology, optics, and academical transactions), that few purchases are necessary. These are made principally, when required, through the Stationery Office.

The extension of shelving now required can be made, partly by a new closet (now in preparation) close to the door of Library 2, and partly by the "Upper Depôt," formerly occupied by Greenwich Publications.

The Library is accessible, under simple regulations, to the Assistants of the Observatory.

V. Astronomical Instruments:—

The Transit-Circle is in its usual good state. The lenses of the object-glass have lately been separated and cleaned.

It will be remembered that, for observation of one of the Reversed Telescopes or Collimators by the other (an observation which is of fundamental importance for

determining the Error of Collimation of the Transit-Circle), two methods are applicable; one method by raising the instrument so that there is a perfectly free view of one Reversed Telescope by the other; the other method by view through the pierced cube of the instrument, which is somewhat incumbered by the internal braces. Observations give a trifling difference (a fraction of a second of arc) between the results of these two methods; the cause is not clearly ascertained.

Rough graduations have been painted upon the large iron arcs of the reflexion-apparatus, for the more convenient placing of the quicksilver-trough in the position required in each reflexion-observation.

The film of oil upon the quicksilver has sometimes been used with advantage in windy weather.

The use of a separate quicksilver-trough for observation of the wires by reflexion has been abandoned.

No new determination of the coefficient of flexure of the telescope has been made.

The system of observing the zenith-distances of objects at the passage over several wires in the field of view has been maintained. A method of mechanical registration adapted to this system has been arranged by Mr. Christie, which I propose to introduce as soon as I can command the services of proper workmen.

The Sidereal Standard Clock continues to give great satisfaction. I am considering (with the aid of Mr. Buckney, of the firm of E. Dent & Co.,) an arrangement for barometric correction, founded on the principle of action on the pendulum by means of a magnet which can be raised or lowered by the agency of a large barometer.

In the galvanic relay, by which the time of the Sidereal Standard is communicated to dependent clocks or chronograph, Mr. Ellis has lately introduced large wire, with the view of avoiding the injury to the contact-springs of the clock which is usually produced by the spark when a relay of fine wire is employed.

The Clock Arnold 1 in the North Dome has been much improved by a thorough restoration of its wheel-train. It may be well now to change its gridiron pendulum for a mercurial pendulum.

The steel work of the Chronograph appears to be maintained in a bright state by the use of glycerine instead of pure water. The instrument is in good order.

The Altazimuth has received some important alterations. An examination of the results of observations had made me dissatisfied with the bearings of the horizontal pivots in their Y's. Mr. Simms, at my request, changed the bearing in Y's for bearing

in segments of circles (a construction which has worked admirably well in the pivots of the Transit-Circle); mounting the bearing-pieces so as to render the access to them (for removal when necessary) easier than before, and adopting the principle of contact of different metals, making the gun-metal pivots to rotate in iron segments. The pivots, which were in a bad state, were re-turned. It was necessary, for these operations, to separate all the principal parts of the instrument's frame. The pivots are now provided with oil-lubricators. Other changes are the following:—The upper vertical pivot has been perforated for admission of a gas-pipe, and the instrument can be turned in azimuth without limit; (with the former arrangement of jointed pipes, now removed, the instrument could be turned only about 380°, after which it was necessary to turn it back through a circumference). A new lifting-apparatus has been made. A frame formerly attached to one of the principal vertical cheeks, for facilitating the setting the instrument in azimuth, has been removed; the observers preferring to use a table of calculated azimuths. A spring clutch is applied, to hold the zenith-circle-pinion out of gear when not in use. All the levels are now divided on the glass; and all, except the two lowest parallel to the horizontal axis, are read by means of fixed reflectors; the reading is now much easier than before. By the kindness of the South-Eastern Railway Company (at the instance of C. V. Walker, Esq.,) we have been furnished with hand-lamps for reading the levels, &c., much better suited to our wants than any that we could procure in commerce. The object-glasses of the microscopes have been limited in aperture, for precision of definition. Dust-covers have been applied to the eyeholes of the azimuth-microscopes. The central points (by which the form of the pivots is to be examined) are not yet made on the ends of the horizontal pivots. The object-glass has been cleaned; and new wires have been inserted in the eyepiece.

It was soon discovered in our observations that the inclination of the horizontal axis was inconveniently great; it is not yet sufficiently corrected.

It is intended to rely as much as possible on star-observations for all constants of azimuthal errors, but to determine the zenith-points solely by use of the Reversed Telescope.

The Sheepshanks Equatoreal and the Shuckburgh Equatoreal are in their usual state; the former being quite efficient and frequently used. In the South-East Equatoreal, the mode of attaching the bridle-rods has been altered; iron rods have been substituted for brass, in the manipulators of the N. P. D. clamp and slow motion (a change which we shall probably introduce also in the hour-angle-movements); and a rope has been fixed for easier movement of the telescope through large arcs of N. P. D., and especially for bringing the object-glass downwards: the instrument is in perfectly good condition. A bar eyepiece is made, and a spectroscope is in hand.

The Reflex Zenith Tube is in good order.

The Water-Telescope is kept in order, only for the intended final set of transits, for verifying its micrometer-scale.

The Ancient Instruments are in their usual condition.

With the consent of the Royal Society and of the Kew Committee, the Kew Heliograph has been planted in the new dome looking over the South Ground. It is not yet finally adjusted.

VI. Astronomical Observations:—

The regular subjects of observation on the meridian have been, as for many years past, the Moon, Sun, and large Planets, with Stars for the determination of Clock error and of Azimuth error; the small Planets have been observed as usual only during the first half of each lunation. A great portion of the time of the different observers has been given to the observation of Circumpolar stars, on those nights when a good determination of azimuth error could be obtained; on other occasions the stars from the Zenith-point-list, to the number of 850, referred to in the last Report, have been observed with a view to securing 5 determinations both of R. A. and N. P. D. of each star. The stars in Dr. Auwers' list, of Bradley's stars hitherto omitted, have been partially observed; and also some other stars of which observations were required for some special purpose, notably those used by Prof. Hilgard in his recent longitude operations. The system of repeated observations of zenith-distance during the passage through the field of view (to which allusion has been made) is to be extended.

The observations with the Altazimuth were interrupted, by the dismounting of the instrument, from 1872, September 19, to 1873, January 5; with the exception of this interval, the Moon has been observed at every available opportunity. The practice of observing a Low Star instead of the Collimator has been continued with satisfactory results.

The concluding set of observations with the Water-Telescope was obtained last Autumn, and no further use will be made of the instrument except for verification of the adopted value of its micrometer scale. For the rest of the year, γ Draconis has been observed with the Reflex-Zenith-Tube as usual.

The statement of the number of observations made between 1872, May 7, and 1873, May 11, is as follows:—

With the Transit-Circle:

Transits, the separate limbs being counted as separate observations	4,123
Pairs of observations of the nearly vertical wires of the Reversed Telescopes	287
Reciprocal observations of the nearly vertical wires of the Reversed Telescopes	322
Reflexion-observations of the central wire	430
Circle-observations, each requiring a separate reading of the six microscope-micrometers	4,223
Reflexion-observations of zenith-distance wire (included in the circle-observations)	407
Reflexion-observations of stars (similarly included)	429

With the Reflex-Zenith-Tube:

Pairs of observations of γ Draconis, the instrument being reversed between the observations	8
Single observations	6

With the Water-Telescope:

Pairs of observations of γ Draconis, the instrument being reversed between the observations	8
Single observations	7

With the Altazimuth:

Azimuths of the Moon and Stars	631
Azimuths of the Collimating-mark	60
Zenith distances of the Moon	256
Zenith distances of the Collimating-mark	170

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	1
,, ,, between 22^h and 23^h	2
,, ,, between 23^h and 24^h	0
,, ,, between 0^h and 1^h	0
,, ,, between 1^h and 2^h	0
,, ,, between 2^h and 3^h	5

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

With the Transit-Circle, 102, or 8·2 per lunation.

With the Altazimuth, in 17 semi-lunations, 129, or 14·5 per lunation.

Observations of 13 disappearances and 4 reappearances of stars occulted by the Moon, and of 29 phenomena of Jupiter's satellites, have been made, usually with the Great Equatoreal. The observations generally have suffered from the exceptionally cloudy weather of last Winter; and much difficulty has been experienced in securing observations of Circumpolar Stars corresponding to those made in the Summer.

Several drawings of Venus and Jupiter have been made with the Great Equatoreal. No certain marks could be detected on either Venus or Uranus; though the former was examined on every favourable opportunity during the approach to and passage through inferior conjunction.

VII. Reduction of Astronomical Observations:—

The following table shows the state of the various stages of the reductions on 1873, May 11:—

For Meridional Transit Observations:

The observed transits are cleared of instrumental errors, and clock-times of transit over the true meridian are exhibited, to .	1873, May 4.
Apparent right-ascensions from observation are formed by application of clock-errors and rates, to	May 4.
Stars' corrections are computed, to	May 11.
Mean right ascensions of Stars from observation, reduced to 1873, January 1, are formed by combination of the two last-mentioned elements, to	May 4.
Mean solar times of observation of Sun, Moon, and Planets are prepared, to	May 4.
Corrections for deficient illumination of Moon's and Planets' limbs are applied, to	May 4.

The Personal Equations of the observers who have taken transits in the year 1872 have been investigated in the usual way, and agree closely with those found in the preceding year.

In the last Report, I called attention to the proposed plan of observing the transits of circumpolar stars below the pole as well as above. This has now been done to an extent which enables me to give a general idea of its result. On comparing the mean

right ascensions of the stars observed, as inferred from reductions of the transits above the pole and from those below the pole, it appears certain, in the first place, that there is no systematic discordance which supports the idea of any prevalent error of collimation; but in the next place it appears almost equally certain that the fundamental Clock Stars in the neighbourhood of 0^h Right Ascension give results for dependent R. A. which are too great, and therefore that the assumed R. A. of those Clock Stars are too great. The amount, however, is small, perhaps $0^s \cdot 05$; and the conclusion cannot at present be received as indisputable.

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 . . . . . 1873, April 8.

Refraction, parallax, and colatitude are applied to form true geocentric north polar distances, to . . . . . March 21.

Stars' corrections are applied, forming mean north polar distances on 1872, January 1, to . . . . . 1872, Dec. 31.

Corrections for deficient illumination of Moon's and Planets' limbs are applied, to . . . . . 1873, March 14.

The refractions used are the same as those employed since the beginning of 1868, namely, those of Bessel's Tabulæ Regiomontanæ $\times$ 0·99469, or of Bessel's Fundamenta $\times$ 0·99797.

The corrections for R—D and for error of assumed latitude, and the position of the Ecliptic, have been computed for 1872; and the calculations of the geocentric and heliocentric errors of planetary tables are in hand.

The variable term of the R—D correction is rather less in 1872 than in the preceding year, whilst the constant part remains very small. The discordance between the Nadir observation and the mean of the results from North and South stars for 1872 is $0''\cdot76$, almost identical with the value obtained in 1871; every observation of the Wire has been corrected by this quantity, and the adopted Zenith-points are thus made to depend essentially on observations of stars alone. The result for co-latitude obtained from an unusually large number of observations is $38°.\ 31'.\ 21''\cdot43$, the smallest ever found; there appears to be no sensible discordance depending on the N. P. D. of the star.

No observations of small planets have been received from the Paris Observatory since 1872, June; the planet ledgers, and the results based upon them, are thus unavoidably delayed.

The observations of γ Draconis with the Reflex-Zenith-Tube are completely reduced up to 1872, October 7, the date of the last observation.

All the observations with the Water-Telescope are reduced; and the results for the latitude of the instrument, deduced from the apparent places of γ Draconis which are computed in the Nautical Almanac with the received value of the aberration, are as follows:—

	Spring.	Autumn.
	° ′ ″	° ′ ″
1871 . . .	51. 28. 34·4	51. 28. 33·6
1872 . . .	51. 28. 33·6	51. 28. 33·8
Means . .	51. 28. 34·0	51. 28. 33·7

The value of the level-divisions, on which the result for the Autumn of 1871 depends sensibly, has been verified by comparison with the portable level mentioned in the last Report, with the following results:—

$$1 \text{ div. of level } (a\ b) = 1''\cdot027$$
$$1 \text{ div. of level } (c\ d) = 1\cdot066$$

agreeing sensibly with the adopted value 1″·00.

The Altazimuth reductions are advanced to the following stages:—

In azimuth, the means of microscopes are corrected for level, collimation, and azimuthal zero (forming true azimuths,) to 1873, March 21.

In zenith distance, true Greenwich zenith distances are formed, to . . . . . April 19.

Corresponding tabular azimuths and zenith distances are computed, to . . . . . April 19.

Apparent tabular errors of Moon's R.A. and N.P.D. are computed, to . . . . . March 21.

Apparent tabular errors of Moon's Longitude and E.N.P.D. are computed to . . . . . March 21.

The Occultations of Stars by the Moon are completely reduced.

VIII. Printing and Distribution of Astronomical Observations:—

The volume for 1871 is printed, with the exception of the section "Zenith-points of the Transit Circle," which has been accidentally delayed in transmission to the printer. The number of copies printed is 350, with 150 separate copies of the Results.

At the end of the Introduction is an Appendix containing a History and Description of the Water-Telescope, with plans. Of this, 250 separate copies are printed.

All the manuscripts of the principal sections for 1872 have been in the printer's hands some time, but no sheets are yet printed off. The extension of the system of repeated observation of zenith-distance while the object passes the field of view, compels me to make a small alteration in the form of printing.

The impression of the "Greenwich Observations" was originally limited to 250 copies. About the year 1840, in consequence of a representation made (I believe) by the Royal Society to the Board of Visitors, the number of copies was increased to 350. Circumstances connected with the change of apartments of the Royal Society and of the R. Astronomical Society lately brought it to my knowledge that great numbers of the Observations remained in store in their possession. This arose partly from the disinclination of many persons to encumber themselves with the large volumes, but more particularly from the dissemination of separate copies of the Results. The copies not required were collected at the Observatory; and I published a notice that persons desirous of possessing some of these volumes might be furnished with them on application. To my great surprise, the applications were so numerous, especially for Results, Appendixes, Star Catalogues, &c., that more than one thousand volumes have been thus distributed. Laying down as a rule that forty copies of the "Observations," and one hundred copies of Results, &c. &c., and one hundred copies of Hansen's Tables, Maclear's Arc, &c., shall be left in our Depôt, there still remains a very large mass of books, which, with the approval of the Admiralty, are to be sent to the Stationery Office as waste stores. And, beginning with the year 1872, I propose to reduce the impression of the "Observations" to 300 copies, with the same number of separate copies of Results, &c. &c., as before. I calculate that the stores in the Depôt will thus be kept up in future to the numbers mentioned above.

IX. Magnetical and Meteorological Instruments:—

The temperature of the Magnetic Basement is still maintained, as during several past years, in almost perfect uniformity.

In the Upper Declination-Magnet a change has been made in the method of connecting the damper (which is in water) with the magnet; facility is thereby given for removing the magnet and substituting the brass bar, and for other adjustments: the instrument is in perfect order.

The Lower Declination-Magnet is in perfect order.

The suspension-skein of the Horizontal-Force-Magnet is a little frayed, and will soon require change.

The Vertical-Force-Magnet has been carefully examined, and found to be in an excellent state.

The action of the apparatus for forming photographic hour lines is perfect.

The Earth-current wires were identified on 1873, April 17. Their insulation was found to be very perfect. Some parts were renewed last Autumn under the superintendence of C. V. Walker, Esq.

The Dip-instrument was examined by Mr. Simms in January 1873, and was found to be in an excellent state; the axis of one of the needles was accidentally broken on 1873, January 11, and repaired shortly after.

No change is to be noticed in the meteorological instruments, which are all in perfect order.

The question may perhaps be considered whether chronographic registration should be introduced for sudden meteorological phenomena, such as shooting stars, auroral beams, &c. A small portable chronograph adapted to mechanical registration, which the Observatory possesses, appears likely to be suitable for these observations.

The public barometer, near the front gate, continues to perform satisfactorily.

X. Magnetical and Meteorological Observations :—

The usual observations consist of continuous photographic records with all the self-registering instruments, and occasional eye-observations to determine their zeros, great attention being given to the maintenance of uninterrupted continuity in the former class. The readings of each of the magnetometers have been taken four times a day; a circumpolar star has been observed with the theodolite once or twice a month, and the absolute measure of Horizontal Magnetic Force at similar intervals; the dip is usually taken two or three times a week. Besides these instruments, various thermometers, pluviometers, and the standard barometer, are read at certain hours of the day, for determination of the zeros of the photographic curves.

Some magnetic observations in the Britannia and the Conway tubular bridges were made last Autumn. For this purpose I detached an Assistant (Mr. Carpenter), who was aided by Capt. Tupman, R.M.A.; in other respects the enterprise was private and at private expense.

Dense clouds prevented any observations of the remarkable meteor-shower which appears to be connected with Biela's comet; though sufficient preparations had been already made, in anticipation of the recurrence of the second ordinary shower of November, which is usually seen about the same time.

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 Declination Magnet, and the telescope-observations of the Horizontal Force Magnet, to the present time; those of the Vertical Force Magnet, to the end of 1872. These determinations give the zeros for the measures of ordinates of the photographic curves.

The time-scales and new base-lines for the Horizontal Force are laid down on the photographic sheets to the end of 1872; the base-lines for the Declination and Vertical Force are not yet done for 1872; the ordinates of the curves are measured for part of 1872.

The number of days selected in the year 1872, as presenting the same general amount of disturbance as that which I have used in Memoirs in the "Philosophical Transactions" for 'disturbed' days, is 15. For these days, the ordinates are to be measured for all the salient points of the curves; no further reduction of those 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 1871.

The absolute measures of horizontal magnetic force are prepared to the end of 1872; the dips, as usual, are reduced to the last observation.

The following are the principal results for 1872:—

Mean westerly declination	19°. 37′ nearly.
Mean horizontal force	3·876 (in English units). 1·787 (in Metric units).
Mean dip	° ′ ″ 67. 46. 15 (by 9-inch needles). 67. 47. 44 (by 6-inch needles). 67. 49. 35 (by 3-inch needles).

A suggestion was made last year by Mr. Chambers of Bombay that the disturbances of the magnetic forces should be given in terms of Gauss' unit, expressed in British

elements. It appears to me, however, that a measure of this kind, whose value depends entirely on the facility of general comparison, ought to be expressed by the elements which are most likely to be adopted by all nations for philosophical purposes; and these are undoubtedly the Metrical elements. But as the present system is convenient for many purposes, the Magnetic Indications for 1872 and following years will be prepared in their old form, and additional columns will be given exhibiting the changes from an arbitrary zero in terms of the Metric unit of Absolute Magnetic Force.

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; and time-scales and new base-lines are laid down where required, to the end of 1872.

The vane of Osler's Anemometer made, in the year 1872, 3·0 complete rotations in the positive direction N, E, S, W.

Considerable progress has been made in the reductions of the photographic records of thermometers from 1848 to 1868. The diurnal changes of the dry-bulb thermometer, as depending on the month, on the temperature waves, and on the barometric waves, have been computed and examined for the whole period; and a considerable portion of the exhibition of results is ready for press. The similar reductions for the wet-bulb thermometer are far advanced.

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

The subjects included under this heading, observations and calculations to their usual extent, are entirely printed for 1871. The number of copies printed is 600. In future I propose to print 550, of which 300 will be bound in the general volume of Greenwich Observations, leaving 250 (as before) for separate distribution.

Detailed measures of ordinates of the curves traced by the three photographic magnetometers, without further computation, are printed for fourteen days of unusual disturbance. For the less disturbed days, the mean diurnal inequalities for each month only are printed. There are also the observations for absolute measure of horizontal force in Gauss's method, and their reductions; and the results of all dip-observations.

Tracings of the photographic curves on 1872, February 4, a day of very great magnetic disturbance, and remarkable for a magnificent display of aurora, were sent to Mr. G. H. Preece, at his request, and are published in the Journal of the Society of Telegraph Engineers; they will also appear in the volume of Greenwich Observations for 1872.

The principal part of the meteorological observations are divided into monthly groups, containing daily observations or daily results for barometer, thermometers (dry and wet), temperature of the Thames, winds, clouds, rain, electricity, and deep-sunk thermometers. Various monthly means, barometric waves, and entire changes of wind-direction through months and the year, are subjoined.

A short meteorological report is sent daily by telegraph to the Paris Observatory, for insertion in the Bulletin. A morning report is also sent by post to the Paris Observatory, to the British Meteorological Office, to some post offices, and some newspapers; and a report of the weather to 3^h p.m. of each day is sent to three newspapers. The extremes of temperature during the 24 hours preceding 9^h A.M., deduced from observations with the ordinary instruments, are exhibited to the public on a card, which is placed every morning below the public barometer.

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

The operations which are recorded in this Section of my Report relate almost entirely to Mean Solar Time. A sympathetic action by galvanic wires causes the indications of a small chronometer in the Computing Room to correspond exactly to those of the Sidereal Standard, and another such connexion causes the indications of another chronometer to correspond exactly to those of the Mean Solar Standard; and the Assistant in charge of time-adjustments, on whose desk these two chronometers are placed, can therefore compare, by coincidence of beats, the Sidereal Standard and the Mean Solar Standard without quitting his seat. Correcting the indication of the Sidereal Standard by means of star-transits, so as to obtain true Sidereal Time, and converting this by calculation into true Mean Solar Time, he has a comparison of true Mean Solar Time with the indication of the Mean Solar Standard, and thus he obtains the error of the Mean Solar Standard. To correct this mechanically, he puts in action (by the ordinary speaking-instrument) a galvanic current which animates a galvanic magnet in the clock-case, fixed there below a steel magnet which is carried by the pendulum of the Mean Solar Standard. With one position of the speaking-handle he introduces an attractive force which slightly accelerates the pendulum-vibrations; with the other position he produces a force which slightly retards them. The amount of acceleration

or retardation for each second being known, he possesses the power, by regulating the kind and duration of connexion of the speaking-instrument, of correcting the Mean Solar Standard, even to one-hundredth part of a second of time. It is unnecessary to describe the constructions by which this Mean Solar Standard maintains the rigorous correctness of sympathetic clocks, with which chronometers are compared, or by which time-signals are disseminated or time-balls dropped, &c.

We have now in the chronometer-room 169 chronometers, whose errors and rates are ascertained by comparison with one of these sympathetic clocks. Of these, 100 box-chronometers, 15 pocket-chronometers, and 13 deck-watches, are the property of Government; 41 are the property of chronometer-makers, and are placed here on competitive trial, with the prospect of purchase to a limited extent. The Government chronometers are compared every day or every week, as appears necessary; the competitive chronometers are compared every day; and are also rated, at some time, in different positions with respect to the magnetic meridian. All chronometers are at some time rated in a temperature approaching to 100° Fahrenheit.

Among the various issues of chronometers made in the last year, by authority of the Admiralty, are 18 to the Foreign Office for use of the North American Boundary Commission, and 17 to the Challenger.

The average merit of the six first chronometers whose trial closed in 1872, August, was slightly superior to that of any preceding year. That of 1869 approached very near to it.

The rates of those chronometers are published, in a form which appears most likely to lead to examination of the causes that influence their merits or demerits. This report is extensively distributed to British and foreign horologists and instrument-makers. All these artists appear to entertain the conviction that the careful comparisons made at this Observatory, and the orderly form of their publication, have contributed powerfully to the improvement of chronometers.

On 10 days the Greenwich Time-Signal-Ball has not been raised, on account of the violence of the wind; and on one day the ball hung in its clips.

The clock at the London Bridge Station which changes the connexions of wires was cleaned and partially renovated by the S. E. Railway Company in 1872, October.

The Deal Time-Ball was not raised on 8 days, and was not dropped on 15 days, principally by the fault of a clerk. On 345 days it was dropped correctly; on 10 of these days the action of the galvanic current was assisted by a touch of the finger.

No action or correspondence has taken place with regard to the establishment of hourly time-signals on the Start Point.

Very lately, application has been made to me, through the Board of Trade, for plans and other information regarding time-signal-balls, to assist in guiding the autho-

rities of the German Empire in the establishment of time-signals at various ports of that State. In other foreign countries (see Professor Langley in Silliman's Journal, 1872, November,) the system is extending, and is referred to Greenwich as its origin.

In Britain the demand for these signals has increased so much that a tariff of annual charges for time-signals, originating from this Observatory and circulated by the Post Office Telegraphs, is published in the 'British Postal Guide,' and exhibited at some post-offices.

It seems proper now that the Observatory should be relieved from the expense attending these issues.

In the important post-office of Lombard Street, the action of a galvanic current sent from Greenwich mechanically corrects the clock. At the Westminster Palace a signal is sent from Greenwich for the guidance of the attendant. Each of these clocks automatically sends us signals to acquaint us with its state. The errors of the Westminster clock were below 1^s on 67 per cent. of days, below 2^s on 96 per cent., and below 3^s on 99·6 per cent.

The longitude of Teheran has been determined by signals from the General Post Office. This circumstance induces me to give additional attention to the accuracy of the Mean Solar Standard Clock.

Chronographic registration having been established at the Paris Observatory, Mr. Hilgard, principal officer of the American Coast Survey, has made use of it for determining the longitude of Harvard from Greenwich, through Paris, Brest, and St. Pierre. I understand that the result does not sensibly differ from that obtained by Mr. Gould, through Valentia and Newfoundland.

XIV. Personal Establishment:—

Till the end of September 1872, the establishment and division of employments of the Assistants were the same which they have been for several years past. At that time, Mr. Carpenter (at his own desire) resigned his office; and on 1873, January 17, Mr. A. M. W. Downing, appointed as Junior Assistant by the Commissioners of Civil Services, entered upon his duties at the Royal Observatory. The employments of the several Assistants may now be nearly described 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; especially charged with the reduction of Meridional Transits; and intrusted with the care of the Library and Manuscripts.

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

Mr. Criswick, Superintendent of Reductions of Meridional Circle Observations; charged also 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 Observations with the Altazimuth, and their reduction.

Mr. Nash, General Assistant (in subordination to Mr. Glaisher) in the Department of Magnetics and Meteorology.

Mr. Downing, chiefly employed hitherto, under the immediate superintendence of Mr. Criswick, in examining the reduction of Circle Observations.

Astronomical observations are made by all these gentlemen except Mr. Glaisher, Mr. Nash, and (in great measure) Mr. Dunkin.

The sanction of the Government has been given to the appointment of another Assistant, to be charged mainly with photoheliographic and physical observations; but I have not yet applied for the authority to act under that sanction.

Funds are placed at my disposal, sufficient to provide six supernumerary computers for the Astronomical and three for the Magnetical and Meteorological Department. Occasional assistance in observations is given by these computers.

A labourer, a gate-porter, a watchman, and a clerk of works, complete the establishment of the Observatory. From these, or from my own family, it is always arranged that there be one man within the inclosure.

To the Government, and to the public, the Astronomer Royal is responsible for all that passes in the Observatory. The corresponding supervision is effected by arrangements (which have been prepared with much care) for precise apportionment of labours of all kinds, and by exact and regular reports of various kinds and periods, which bring all the work of the Observatory to his knowledge.

Some years ago there was drawn up, and printed as an Appendix to the Greenwich Observations, an account of "Regulations of the Royal Observatory," applying in great measure to the personal relations of the Officers of the Observatory. The impression is nearly exhausted, and some changes have been made in the Observatory since that time. I contemplate, therefore, the preparation of a new edition of the "Regulations."

XV. Extraneous Work:—

The impression of a Catalogue of southern stars, observed at the Royal Observatory of the Cape of Good Hope to 1857, and reduced by Mr. Stone, was received by me

some time since. In the incessant pressure of our work, I have been compelled to defer the distribution for a time; but I intend very shortly to send them out with the impression of the Greenwich Observations for 1871.

The preparations for publishing the accounts of the Total Solar Eclipses of 1860 and 1870 are not yet perfectly complete; the delay, as I understand from A. C. Ranyard, Esq., being principally caused by the wood-cutters and engravers. But I believe that there remains little to be done.

In describing the preparations for the observation of the Transit of Venus, 1874, it will be advantageous first to mention the stations originally selected by me. They are, Alexandria, Honolulu, Rodriguez, Christchurch in New Zealand, Kerguelen's Land. To these I have been induced to add (by recommendation to the Indian Department) a station in Northern India, principally for photographic records, to be combined with those in Kerguelen's Land. In choosing these localities, I relied on the assistance to be received principally from Russia in Northern Asia and the Chinese coasts. My selection has been generally confirmed by the authorities of other countries, whose stations, except those just mentioned, have been principally in reinforcement of mine. The weak part still is in the Pacific Ocean; and I contemplate the possibility of establishing there some branch-stations dependent on Honolulu.

For all the five stations I have transit-instruments, altazimuths, equatoreals, detached telescopes, and clocks, wanting only petty adjustments; and I have two photoheliographs (three more being expected in the coming summer). Two of the altazimuths are adapted to accurate azimuthal observations (as well as accurate observations of altitude). In preparing the photoheliographs, I propose to make trial of a plan proposed by M. Janssen, for numerous photographs of Venus when very near to the Sun's limb. The portable buildings are finished, except those for the photoheliographs, which are advancing. The skeleton forms for calculations are prepared. I have begun to collect the necessary scientific books which the observers will require in the course of the work.

Some meteorological instruments are necessary for the prosecution of the merely astronomical observations. It might be a question whether magnetical instruments should be carried out, adapted to fairly good but not the most exact determinations; the most expensive of these are dip-instruments.

Mr. Stone has prepared a catalogue of 78 southern circumpolar stars, and at my request Mr. Hind has computed the reduction-numbers for them. With these, and with the general southern catalogues furnished by Mr. Stone and Mr. Ellery, we shall be well prepared on the side of the sidereal observations.

The personal arrangements are not yet complete.

Some of the officers employed with Lieut. Anderson, R.E., on the North American Boundary Commission spent some time here in the practise of astronomical observations.

Mr. Finlay, appointed by the Commissioners of Civil Service to the Office of First Assistant at the Cape Observatory, has been gaining experience in the routine of observations and in the general conduct of an Observatory.

Mr. James Carpenter, as I have mentioned, was detached for a time to make observations on the magnetic state of the tubular iron bridges in North Wales.

XVI. General Remarks :—

Of the subjects which, in my last Report, I indicated as having been brought forward from a preceding notice, only one has been fully urged; namely, the continued prosecution of the Reductions of the Photographic Meteorological Registers from 1848 to 1868. But the Magnetic Reductions are borne in mind; and, having received the approval of the Board, I hope at some future time to carry them on.

On the establishment of photographic and spectroscopic observations, and the appointment of an Assistant expressly to attend to these subjects, I have to report that the sanction of the Government was given in time for insertion of the required sums in the Navy Estimates. But the tardiness of instrumental and other preparations, and our own incessant work, have prevented us from bringing this department into action.

The skeleton annals of the Observatory to which I alluded in 1872 have been carried forward to 1861.

As regards the present conduct and immediate interests of the Observatory, I think that the last year, though one of unusually severe external pressure, has not been unfavourable to the internal efficiency of the institution. I trust that the labours undertaken and carried through will fairly bear comparison with those of any other year.

As regards the future probable history, there is one matter which has gradually been forcing itself on my attention, and which I think may ultimately bring on an extensive change in the personal arrangements of some observatories; namely, the increase of facilities for making observations. This applies principally to magnetical and meteorological observations. The inevitable result of it is, that observations are

produced in numbers so great that complete reduction becomes almost impossible. At the time of making the observations, reduction such as can then be effected is rather annoying; and when the reduction is long deferred, the amount of work to be done is sufficient to dishearten even a resolute computer. In former years I have felt this in some measure in regard to magnetical observations; which, however, I have succeeded in reducing in two long periods of years, and of which the results, as I trust, possess considerable value. In the last few years, I have entered vigorously upon the reduction of 21 years' photographic registers of the thermometers; but the labour has been very great, far greater than, upon a hasty examination, I could have conceived; and some time must yet elapse before the reductions can be carried out to the extent which I contemplated. Yet until this, or at least a large part of it, is done, the rich store of observations is useless.

Of the enormous number of meteorological observations now made at numerous observatories, very few can ever possess the smallest utility.

It may soon be necessary to alter the proportion of the two great sections of an observatory-establishment; perhaps to diminish the observing power, certainly to increase the computing power. It is even conceivable that it may be found political to refer the computations to a national computing establishment. I do not, however, urge these matters as requiring immediate action; I merely desire to record ideas which may possibly have their influence in guiding future arrangements.

G. B. AIRY.

Royal Observatory, Greenwich,
1873, *May* 22.