

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

Read at the Annual Visitation of the Royal Observatory, 1871, June 3.

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THE Report, now presented to the Board of Visitors, refers to the state of the Royal Observatory on 1871, May 4; giving an account of its general transactions during the interval of twelve and a half lunations, included between 1870, April 30, the date of the last Report, and 1871, May 4. It is divided into the same general heads as in previous years.

I. Buildings and Grounds:—

The changes since the date of the last Report are of no great importance.

In the Astronomical portion of the Observatory some trifling alterations have been made in the roof-shutters of the Transit-Circle-Room.

During the past summer the interior of the Dwelling House has been painted and renovated, many years having elapsed since the execution of any similar works.

The iron door for the Equatoreal Room of the South East Dome, similar to that fitted up for the Chronometer Room, and mentioned in the last Report as in course of preparation, is now mounted in its place, and gives great security against fire in that portion of the buildings.

I have made some preparations for placing sliding doors in front of the Telescope-Shed.

In the Magnetic Observatory, the inclosure of the staircase which leads down into the Basement, by pannelled sides and a door in the lower story, has contributed materially in the last year to confine the changes of temperature in the Magnetic Basement within very small limits, by cutting off all currents of air from the external regions.

In May 1870 the Earth-Current self-registering apparatus was removed to the eastern arm of the Basement, where it is nearly in contact with the south wall, being thus more accessible for general purposes; while the removal of the lights to the eastern arm has assisted in correcting the small excess of temperature in the west end of the Basement. At the same time this change has allowed of a convenient arrangement for the automatic impression of hour-lines on the registering barrels.

In the last Report mention was made of the erection of the Occasional Observatory in the South Ground, in preparation for the reception of the Water Telescope. That instrument having been completed, gas-pipes have been laid on, and other arrangements made, to adapt the building to the purpose for which it is now employed.

The paths to and about the Magnetic Ground have been hardened by a covering of tar-paving.

The four earth-current galvanic wires, which were formerly suspended in the open air from a chimney of the Dwelling House to the Electrometer-Mast, are now led (with other wires) in pipes underground from the Battery Basement to the Magnetic Basement.

A Bill has been introduced into Parliament in the present session, in reference to the proposed line of railway through the town of Greenwich. As far as I can gather, the Bill does not propose any change in the line, but merely asks for an extension of time. I imagine, therefore, that it does not affect the interests of the Royal Observatory. In the meantime, workmen are busily employed about a mile east of the town, in completing a line from Charlton Station towards Greenwich, apparently as far as the point at which the sanctioned line through the town and the projected line through the Park separate.

The line, promoted some years since by the London, Chatham, and Dover Railway Company, was suddenly stopped (in consequence of the financial difficulties of the Company) in an incomplete state, just before reaching the sub-crossing of Blackheath Hill. Workmen are now employed in completing the earthworks and preparing the bridge. The powers of that Company extend to the western wall of Greenwich Park; but it

would appear probable that they may endeavour to make a junction (as they originally proposed) with the South-eastern Line.

Experiments made by Mr. Stone, since the last meeting of the Visitors, show clearly that a local elevation, like that of the Royal Observatory on the hill of Greenwich Park, has no tendency to diminish the effect of railway-tremors.

II. Moveable Property :—

All the moveable articles, not included under the heads of Manuscripts, Library and Instruments, are in good order, and are properly marked; requiring no special mention.

The only valuable article not in our custody is the Portable Transit, still in the hands of Colonel Sir Henry James.

III. Manuscripts :—

The detached papers which arise in the daily operations of the Observatory are carefully collected and arranged in books, on the long-established system, which gives extraordinary facilities of reference, and preserves the papers in remarkable safety. The pencil memorandum-books are preserved, for each year, in proper boxes; and the large Chronograph Sheets are kept in wooden portfolios. The cloth-bound books of calculations are repaired when necessary. These matters are under the charge of Mr. Carpenter.

The bound books, including all from the time of Flamsteed, have, since the beginning of the year, been compared with the Catalogue of Manuscripts; none are missing.

A few papers of Mr. Baily's, relating to the distribution of copies of the "Life of Flamsteed," have been sent to the Observatory by the representatives of the late Professor De Morgan.

The copies of manuscripts by Bradley and Bliss, lent to Dr. Auwers and Mr. O. Struve, are still in their hands.

IV. Library:—

By presents and small purchases, our Library is kept in a good state, in reference to the subjects of optics, astronomy, magnetism, and meteorology ; with a less perfect collection relating to other subjects.

The books are in the general charge of Mr. Carpenter, as librarian. They are accessible to all the assistants and computers.

The annual comparison with the Catalogue was made lately; every book was found.

V. Astronomical Instruments:—

The Transit-Circle is in perfect working order. The object-glass was cleaned in January by Mr. Simms.

Some difficulty having been experienced in the use of the finder, owing to want of illumination of the field, a reflector has been added, which, by giving a distinct view of the wires, has proved of great use in cases where the circle had to be read off before the time of transit.

The correction for level-error in this instrument having become inconveniently large, owing apparently to a gradual subsidence of the eastern support since the erection of the instrument, about a ton weight of stone was placed on the western pier in August last. Not the slightest change, however, could be traced as due to this; the level-error maintaining its usual value. This plan having failed, the stones were removed on November 19, and a sheet of very thin paper, $\frac{1}{270}$ inch in thickness, was placed under the eastern Y, which was raised from its bed for the purpose. The Collimators having been observed just before this operation, no difficulty was experienced in adjusting the instrument so as to have very nearly the same error of Azimuth as before. The mean annual value of the level-error appears to be now sensibly zero.

Two of the vertical wires having been found broken, Mr. W. Simms replaced them on January 18, and at the same time inserted a new horizontal wire, so as to reduce the inclination, which for the old wire was rather large.

A re-determination of the Astronomical Flexure of the Telescope-tube in the early part of this year, from two sets of measures made at widely different temperatures, leads to a result differing by $0''.25$ from that previously found. The individual results are so accordant that I have thought myself justified in adopting this value for use in the present year. In April an examination of the form of the pivots was made, which seems to show that there is no sensible deviation from circularity.

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When the old Collimators were replaced by those of much larger aperture now used, no provision was made for raising the Transit-Circle any higher than had previously been sufficient to allow of a clear view of one Collimator by the other; and in consequence a portion of the object-glasses of the new Collimators was interrupted. This has now been remedied by shortening the chains of the large counterpoises; and a great improvement of the image is the result. Some improvements have been made in the brass shutters closing the apertures in the central cube, which now work with perfect smoothness, and are not likely again to get out of order.

The method used in the adoption of Zenith-Point, mentioned in the last Report, has been somewhat modified, in consequence of a discordance (which now amounts to 1'') between the results from the Nadir observation and from stars. From the commencement of the present year, those Zenith-Points only have, in general, been used for which observations of stars by reflection, as well as of the wire, were made. The Zenith-Point Correction, used for the reduction of each night's observations, has been taken from the determination of that night alone, except in cases where there has been no appreciable instrumental change for several days. For days on which no reliable determination has been obtained, the mean of preceding and succeeding values has been adopted.

The Transit-Clock has lately been going very well. The remarkably severe weather of the past winter caused some sudden variations of rate, necessitating in one or two instances the separation, into two groups, of the morning and evening observations of the same day.

One pair of contact-springs has been withdrawn, the other by a re-arrangement of the batteries and wires being made to work both the Chronograph Pricker and the Sidereal clocks. This arrangement has been in action from March 10.

The clocks Graham 1 and 2, placed in the South Dome and Occasional Observatory respectively, were cleaned in August 1870, and some small repairs have at times been made to the galvanic clocks. The new clock by Messrs. E. Dent and Co. has not yet been received.

The Chronograph is in excellent condition.

The Altazimuth is in good order. On 1871, Jan. 20, the insulation of all the galvanic parts was renewed by Mr. Simms, using ebonite instead of gutta percha; the registering apparatus is now in better order than ever before. At the same time a new system of wires was inserted in the field of view of the telescope, having the middle interval larger than the others for convenience of identification on the Chronograph Sheet. The object-glass was taken out and cleaned on May 3. No alteration has been made in the levels; the artist apparently having been unable to perfect the

construction to which I alluded in the last Report. Gas burners are fixed for illumination of the microscopes of the Horizontal Circle.

The Sheepshanks Equatoreal has been taken to pieces and thoroughly cleaned this spring, and is now in excellent condition. No change has been made in the Shuckburgh Equatoreal. The South East Equatoreal is in perfect order. Previously to the eclipse of the Sun, the reading-microscopes of the Declination Circle were cleaned and adjusted, and at the same time the oil which had hardened in the pivot bearings was cleaned out, after which all stiffness in the motions of the instrument was found to have disappeared.

No change is to be remarked in the Reflex-Zenith-Tube.

The new Water-Telescope has been got into working order, and performs most satisfactorily.

No special remark on the Ancient Instruments is called for; they are in their usual condition.

VI. Astronomical Observations :—

The usual course of observations carried out for so many years has been adhered to. The list of fundamental stars used for determination of clock-error has been increased to 210. Besides these, Nautical Almanac, circumpolar, and Moon-culminating stars have been observed; also refraction-stars, stars with large proper-motion, and stars which are required for any special investigation. A few of Bradley's stars which had been inadvertently omitted have been observed in the past year. The Sun, Moon, and large planets have been observed as usual. As the siege and war operations in Paris seriously interfered with the observations of small planets made at the Paris Observatory, observations of them were continued at Greenwich throughout each entire lunation during the investment of the city.

With the Altazimuth, the Moon, and stars for determination of instrumental errors, have been observed on every night when it was practicable. Observations of γ Draconis have been made with the Reflex-Zenith-Tube at all times when the time of transit was not very inconvenient; and with the Water-Telescope when the star passed between 20^h and 17^h, with some observations for adjustment at a still more advanced time.

The numbers of observations made between 1870, May 1, and 1871, May 4, are as follows :—

With the Transit-Circle :

Transits, the separate limbs being counted as separate observations	3,623
Pairs of observations of the nearly vertical wires of the reversed telescopes	299
Reciprocal observations of the nearly vertical wires of the reversed telescopes	341
Reflexion-observations of the central wire	296
Circle-observations, each requiring a separate reading of the six micrometer-microscopes	3,252
Reflexion-observations of zenith-distance wire (included in the circle-observations)	294
Reflexion-observations of stars (similarly included)	378

With the Reflex-Zenith-Tube :

Pairs of observations of γ Draconis, the instrument being reversed between the observations	67
Single observations	1

With the Water-Telescope :

Pairs of observations of γ Draconis, the instrument being reversed between the observations	11
Single observations	2

With the Altazimuth :

Azimuths of the Moon and stars	788
Azimuths of collimating-mark	338
Zenith distances of the Moon	414
Zenith distances of collimating-mark	338

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	1
”	”	between 23 ^h and 24 ^h	0
”	”	between 0 ^h and 1 ^h	0
”	”	between 1 ^h and 2 ^h	5
”	”	between 2 ^h and 3 ^h	12

Besides which, 18 observations of Azimuth and 6 of Zenith Distance were made during the eclipse of the Sun, 1870, December 21–22.

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

With the Transit-Circle, 107, or 8·6 per lunation.

With the Altazimuth, 205, or 16·4 per lunation.

In the lunation commencing on 1871, March 22, complete determinations of the Moon's place were obtained with the Altazimuth on nine different days before one could be obtained with the Transit-Circle.

Observations of seven disappearances and three re-appearances of stars occulted by the Moon, and of twenty-three phenomena of Jupiter's satellites, have been registered. Besides these, the disappearance of Saturn, in the occultation of 1870, Sept. 30, was observed.

The South-East Equatoreal was employed in a series of 108 observations of the Sun and Moon during the eclipse of the Sun, 1870, Dec. 21–22. The position of the Moon deduced, by a laborious computation, from these measures, supports the accuracy of that obtained with the Altazimuth; the Equatoreal operation, however, gives the corrections of all the four elements affecting the eclipse.

Mr. Carpenter has used this instrument in making a drawing of Mars near its opposition. Venus, also, has been examined, with the view of recording any markings on her disc; but none have been seen.

VII. Reduction of Astronomical Observations :—

The following table, drawn up in the form which has been used for many years, exhibits the state of the reductions on 1871, May 4 :—

For Meridional Transit Observations :

The observed transits are cleared of instrumental errors, and	
clock-times of transit over the true meridian are exhibited, to . 1871, April 30	
Apparent right-ascensions from observation are formed by	
application of clock-errors and rates, to	April 29
Stars' corrections are computed, to	May 3
Mean right-ascensions of Stars from observation, reduced to	
1871, January 1, are formed by combination of the two last-	
mentioned elements, to	April 29
Mean solar times of observation of Sun, Moon, and Planets are	
prepared, to	April 29
Corrections for deficient illumination of Moon's and Planets'	
limbs are applied, to	April 29

In consequence of the change of office of Mr. Dunkin, and his withdrawal from regular observations, the personal equations are now referred to Mr. Criswick as Standard Observer. Making due allowance for this change, the results for personal equation in 1870 agree very closely with those for the preceding year.

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-distance, to	1871, April 22
Refraction, parallax, and colatitude are applied to form true geocentric north polar distances, to	April 22
Stars' corrections are applied, forming mean north polar distances on 1871, January 1, to	April 22
Corrections for deficient illumination of Moon's and Planets' limbs are applied, to	April 22

In the reductions of the Circle-Observations, the diminished Mean Refractions (Bessel's $\times 0.99797$) are used.

Since the last Report the corrections for R—D and for error of assumed latitude have been computed both for 1869 and 1870, but the position of ecliptic and the geocentric and heliocentric errors of planetary tables for the former year only.

The values of R—D found in 1869 and in 1870 agree closely. The colatitude found from the observations of 1869 is $38^{\circ}. 31'. 21''.61$, and that from the observations of 1870 is $38^{\circ}. 31'. 21''.57$; confirming the result obtained in 1868. The elements for the position of the ecliptic in 1869 agree generally with those of preceding years.

The planetary ledgers for the minor planets are waiting for the Paris observations made in 1870; the last results received from M. Delaunay bear date at the end of April 1870.

The observations of γ Draconis made with the Reflex-Zenith-Tube in 1870 are completely reduced.

The observations of γ Draconis with the Water-Telescope, made in the spring of the present year, are completely reduced, with the exception of a small correction for the positions of the micrometer-wires, to be determined shortly. As the astronomical latitude of the place of observation is not known, the bearing of these observations on the question of aberration cannot be certainly pronounced until the autumn observations shall have been made; but, supposing the geodetic latitude to be accordant

with the astronomical latitude, the result for aberration appears to be sensibly the same as with ordinary telescopes.

The Altazimuth reductions are in the following state :—

In Azimuth, Means of Micrometer-Microscopes are formed, and corrections for level-readings, instrumental errors, and Azimuthal Zero applied, so as to exhibit True Azimuths, to	1870, Mar. 14
In Zenith Distance, True Greenwich Zenith Distances are formed, by similar combinations, to	April 12
The corresponding Tabular Azimuths and Zenith Distances are computed, to	April 12
The apparent Tabular Errors of Moon's place in R.A. and N.P.D. are computed, to	Mar. 14
The apparent Tabular Errors of Moon's place in Longitude and E.N.P.D. are computed, to	Mar. 14

The Occultations of Stars by the Moon are reduced to the present time.

VIII. Printing and Distribution of Astronomical Observations :—

The New Seven-Year Catalogue has been printed and distributed with the Volume for 1868.

The whole of the volume for 1869 is printed, and will be distributed as soon as it is received from the binder.

The number of copies printed is 350.

The general arrangement is the same as that of preceding volumes for many years past. The combination of the individual results for Mean R.A. and Mean N.P.D. of each star in one ledger, first introduced in the volume for 1868, is continued in the volume for 1869, and is found very convenient.

As regards the observations made in 1870, all the manuscripts of the principal sections have been sent to the printer, and several sheets are printed off.

IX. Magnetical and Meteorological Instruments :—

The same attention has been given in the last year as in that preceding, to the maintenance of uniform temperature in the Magnetic Basement, and perhaps with

slightly improved results. Referring to the thermometers outside the magnetic boxes (whose changes of temperature are undoubtedly greater than those of the magnets themselves):—the daily changes rarely exceed 1° Fahrenheit, though in very few instances they amount to 3° . During the cooler half of the year the temperature is maintained between 60° and 62° ; in the warmer half it sometimes rises higher, on very rare occasions to 70° .

The Upper Declination-Magnet, with reversed telescope and theodolite, for determination of absolute declination, and the photographic magnets with their telescopes for occasional eye-observation, are in perfect order. We once had reason to suspect that the wooden plugs by which the telescopes are attached to the brick piers had become loose in their holes; but liquid plaster of Paris was poured in (by a method known to practical men), and they have since that time been indisputably firm.

With the care and long experience of Mr. Glaisher, we have no difficulty, at the end of each year, in thoroughly examining the Declination and Horizontal Force instruments; but we are glad to avail ourselves of the assistance of Mr. Simms for the Vertical Force Magnetometer. All were found, in December 1870, in the best possible order. There have been no dislocations of photographic curve since we have carefully abstained from bringing a magnetic body near to the instruments.

The apparatus registering earth-currents is in perfect order. We have, from time to time, indirect evidence of the correctness of identification of the four earth-current wires; an early opportunity will, however, be taken for repeating the direct and absolute verification.

A plan was arranged last year for photographic impression of hour-lines upon the photographic sheets carrying the records of the three Magnetometers and of the Earth-Current Galvanometers. The beam of light, constantly directed through a cylindrical lens to fall upon the sheet, emanates from one of the existing lamps, or (in one instrument) from a flame specially mounted for it; it is, however, obstructed by a shade till $2\frac{1}{2}$ minutes before each hour, and acts till $2\frac{1}{2}$ minutes after each hour. I had so arranged the connexions of the shades that all could be opened and closed by a single wire. With the assistance of Mr. Buckney, of the firm of Messrs. E. Dent and Co., a plan was arranged for a clock to act upon that wire; it has been in action with general success from 1870, September. It will readily be seen that much manual spacing and ruling of lines is avoided by this arrangement.

Every part of the dip-instrument has been revised, and the deflexion-apparatus has been examined; both are in excellent order.

The meteorological instruments, namely:—barometers, dry and wet thermometers (all adapted both to eye-observation and to photographic self-registration):—anemo-

meters for pressure and speed, and pluviometers, (all for mechanical self-registration):—other pluviometers at different heights, and thermometers in the ground and in the Thames:—are all in good order. Only one change has been made. The thermometers formerly attached to the 'Dreadnought' Hospital Ship were removed on 1870, April 13; since 1871, Jan. 11, they have been attached to the 'Scorpion,' Thames Police ship, moored off Blackwall; and the observations have been regularly made by the Resident Inspector of Police on board that ship, by permission of Colonel Henderson, R.E., C.B., Commissioner of Metropolitan Police.

We are still without self-registering electrical apparatus; but the old apparatus has been brought into a more satisfactory state, and is used for eye-observations.

Several years since, I prepared a barometer, by which the barometric fluctuations are enlarged, for the information of the public; its indications are exhibited on the wall, near to the entrance-gate of the Observatory. A card is now also exhibited, in a glass case near the public barometer, giving the highest and lowest readings of the thermometer in the preceding twenty-four hours.

X. Magnetical and Meteorological Observations:—

The self-registering instruments are considered as the truly important instruments for their respective purposes; and they have all been maintained in constant action, with no intentional and very few accidental interruptions. Of the instruments for eye-observations, which give zeros for the self-registering instruments, the theodolite and telescopes of the Magnetometers, and the thermometers, have been used about four times every day; circumpolar stars having been observed with the theodolite about twice in a month, and a fixed mark more frequently.

Instruments for maximum and minimum are read, and diurnal accumulations of rain, &c. are measured, every day.

Deflexions for measure of Horizontal Magnetic Force are observed one or twice in a month; dips two or three times in a month. Occasionally, observations of dip have been made at different hours of the day, with the view of ascertaining diurnal change; but it is unsafe to venture on this in damp weather.

Arrangements were made for observations of meteors on all the nights specially mentioned by the Meteor-Committee of the British Association; and particularly on the nights of expected meteor-showers in August, November, and April last. That of August was well observed; that of November only on November 14 and 15; the other nights were cloudy.

XI. Reduction of Magnetical and Meteorological Observations :—

The astronomical observations made with the theodolite of the Declination-Magnet are computed to 1871, January 26. The theodolite-readings of the Declination-Magnet, and the eye-observations of the Horizontal Force Magnet, are reduced to the present time; those of the Vertical Force Magnet to the end of 1870. These observations, uncorrected for temperature, give the zeros for the ordinate-measures of the photographic curves.

Time-scales and secondary base-lines are drawn on the photographic sheets of the three Magnetometers, and ordinates are measured, to the end of 1870.

The number of disturbed days in the year 1869, on the same scale of disturbance as that which I have used in the Philosophical Transactions, is only 5. But, to meet the expressed wishes of some members of the Board of Visitors, I have added 22 days on which the disturbance was somewhat smaller; and for these 27 days measures have been taken, on the sheets, of the ordinates of the photographic curve. In this state they are left for use, no further reduction being made at present. In 1870 the number of disturbed days is 16; and this list has not been extended. For the remaining days of 1869 and 1870, mean pencil-curves have been drawn by hand through the inequalities of the photographic curves, and the ordinates of the pencil-curves have been measured at every hour. From these measures, diurnal and other inequalities are obtained on the mean of each month, and mean diurnal curves are drawn for each month. No progress has been made in further treatment of the observations on days of magnetic storms since 1857.

The absolute measures of terrestrial horizontal force at Greenwich are computed to the end of 1870; the dips to the present time.

The following numerical results for 1870 may be interesting :—

Mean westerly declination		19°. 54' nearly.
Mean horizontal force		{ 3.865 (in English units). 1.782 (in Metrical units).
Mean dip		{ [°] 67. 51. 9 (by 9-inch needles). ['] 67. 52. 25 (by 6-inch needles). ["] 67. 53. 41 (by 3-inch needles).

The observations of dip at different hours appear to show a diminution from 9^h A.M. to 3^h P.M., but the number of observations is at present too small to enable me to state the quantity as a result of observations with the dip-instrument; (it can, of course, be computed from the reduced hourly registers of the horizontal and vertical forces on their photographic sheets). The dips of which I have given the result were usually taken at about 2^h P.M.; sometimes earlier, sometimes later.

The ordinates of the photographic curves given by the earth-currents have not been measured since the position of the wires was changed.

For the meteorological observations :—remarking that, in virtue of the constructions of the instruments, the anemometers and the photographic registers of the thermometers require no new ordinate-scales,—it is sufficient to state that all eye-observations are cleared of known errors, and that dew-point and degree of moisture are computed, to the present time; and that time-scales and new base-lines are drawn upon the photographic sheets to the end of 1870.

The number of rotations of the vane of Osler's Anemometer in 1870 was about —9.

Circumstances prevent me from making in the present year any great progress in the systematic reduction of photographic meteorological records from 1848 to 1868. The ordinates of the dry and wet thermometers for every hour, as well as the corresponding eye-observations, had been entered (at the last Report) into the proper printed forms; the portions relating to waves of high and low temperature and to waves of high and low atmospheric pressure have been marked off through the whole period; and the means have been taken for the temperature-waves, as well as for each month, through about 10 years.

XII.—Printing of Magnetical and Meteorological Observations :—

The magnetic work of 1869 is entirely printed. It contains the simple records of magnetometer-indications on twenty-seven disturbed days, as measured from the photographic sheets, without further treatment; the Diurnal Inequalities in Monthly Groups, of the three elements, obtained by a process described in the last section; the observations for absolute measure of horizontal force, with their reductions; and the results of individual observations of dip.

The daily meteorological observations are printed, as has been done for many years past, in a monthly division, giving results rather of civil than of scientific utility; still, however, embodying several scientific results, which could be established without requiring great labour and great space. The observations of meteors of the April, August, and November periods, as well as of meteors generally, are given in sufficient detail. The highest and lowest barometric readings, the depth of rain registered at different heights above the ground, and the daily readings of the thermometers at different depths of the earth, are printed.

The Introduction, besides its usual details, contains the information to which I alluded in the last Report, on the determination of thermal correction for the magnetometers; leading to the conclusion that, for the Vertical Force Magnetometer, no method can be trusted except that of observing the instrument as mounted.

A small Appendix is attached, which I trust will be interesting to the Visitors. Those who have given attention to the history of Terrestrial Magnetism are aware that Halley's Magnetic Chart is very frequently cited; but I could not learn that any person, at least in modern times, had ever seen it. I made inquiries of nearly all the principal scientific bodies in Europe, and in several of the best continental libraries, and could not find it. At last, by the kind assistance of J. Winter Jones, Esq., Principal Librarian of the British Museum, I discovered a copy in the library of the Museum. With the liberal assistance of that officer, I have been allowed to take copies by photolithography in two forms. The chart being very large I have had only a limited number of copies taken of its full size, but I have had 600 copies taken in a reduced size, for insertion, as an Appendix, in the Magnetical and Meteorological Volume for 1869.

The number of printed copies of Magnetical and Meteorological Observations is 600; 350 of these are bound with the Astronomical Observations, and 250 are retained for separate distribution.

Some simple meteorological observations, made at a definite hour every morning, were sent every day to M. De Launay, for publication in his daily Bulletin, by the gratuitous assistance of the telegraph companies, until 1870, December 17. In the transfer of telegraphic operations to the Post Office, it appears doubtful whether this can be continued. A small table of meteorological results is communicated every week to the Registrar General of Births, Deaths, and Marriages, and is printed in his Weekly Reports.

In preparation for the volume for 1870, nearly the whole of the magnetic results and of the meteorological abstracts are ready for press.

XIII.—Chronometers, Communications of Time, &c. :—

There are at the present time 202 chronometers in our chronometer-room, of which 123 box-chronometers, 21 pocket-chronometers, and 13 deck-watches, are the property

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of the Government ; one, belonging to an officer of the Navy, is on trial for purchase ; and 44 are placed here by chronometer-makers to take part in the annual trial. The chronometers are compared with a Mean Solar Clock, some every day, some every week, sometimes in high temperatures, and sometimes in different magnetic positions, as usual.

Though the average of the trial numbers for the first six chronometers in the last competition shows a slight falling off in their merits, as compared with the previous year, one of the number was of unusual excellence.

The performance of chronometers, as depending on their mechanical construction, is very admirable ; I have remarked but one point on which I could desire change, namely, that the balance should be struck more lightly, at a greater distance from its axis ; the late Mr. Charles Frodsham, at my suggestion, had made some experiments on this point, which promised to be successful. The principal errors of even moderately good chronometers are, however, produced by defective compensation, which the most skilful makers cannot perfectly manage. I have long been of opinion that the final adjustment for compensation ought to be made by some more delicate operation than that which suffices for approximate compensation ; but the able chronometer-makers whom I have consulted have not yet devised a satisfactory plan. Allusion was made in the last Report to a plan for securing the balance of a chronometer from injury in its transit by rail or otherwise. Nothing quite satisfactory has yet been proposed by any of the chronometer-makers who have turned their attention to the subject.

Chronometers have been selected, as usual, for purchase by the Admiralty, and occasionally for foreign men of science.

On eight days the Observatory Time-Ball was not raised on account of high wind ; and once the drop failed from the piston not being properly discharged. On all other occasions everything has worked with the greatest regularity.

The public clock near the entrance gate of the Observatory has been cleaned and put in thorough order. All the wires concerned in driving the system of sympathetic clocks have been renewed.

Some repairs have lately been made in the mast of the Time-Ball at Deal. An improvement is to be remarked in the regularity of our communication with that Ball. On 89·4 per cent. of days in the past year the ball was dropped freely ; on 4·9 per cent., principally in damp weather, the current was too weak to release the trigger without assistance from the attendant ; on 1·9 per cent. the wind was too high to permit the raising of the ball ; on 3·2 per cent. communication was interrupted ; on a single day the ball was falsely dropped by telegraph currents ; while on another

occasion a defect in the trigger (which has since been remedied) prevented the dropping of the ball.

A proposal has been made to have a ball dropped on the same plan at Queenstown, which can be done without any difficulty.

The report of the Westminster Clock shows that 55 per cent. of its errors are under 1^s, and 94 per cent. under 3^s.

The charge of the Lombard Street Post-Office Clocks has been transferred to the Telegraph Department of the Post-Office, time being communicated by the Observatory, and return signals being received here, as before.

In December two attempts were made to determine the longitude of Gibraltar, at the request of Professor Newcomb, but without success, the cable connecting Falmouth and Gibraltar being out of order. Every facility for these operations was given by Mr. Culley, Principal Engineer of the Post Office Telegraphs, and by Sir James Anderson, Managing Director of the Falmouth, Gibraltar, and Malta Telegraph Company.

XIV.—Personal Establishment :—

The Astronomer Royal is responsible to the Government and the public for all transactions within the Observatory; the repairs and extension of buildings, the care of the property of the Observatory, the daily discipline, the planning of instruments, observations, calculations, and publications, are under his superintendence. The office of Chief Assistant was held by Mr. Stone till the summer of 1870, when he was appointed to the charge of the Cape Observatory; he was succeeded in this Observatory in the autumn by Mr. William Henry Mahony Christie, Fellow of Trinity College, Cambridge. Mr. Glaisher superintends the Magnetical and Meteorological Department; Mr. Dunkin now controls the staff of supernumerary computers in the Astronomical Department, and, as senior assistant, is relieved as much as possible from severe observations; Mr. Ellis takes charge of the Time Department (chronometers and galvanic communications); Mr. Criswick of the Circle Reductions; Mr. Lynn of the Altazimuth; Mr. Carpenter of the Equatoreals, the arrangement and safety of the library and manuscripts, and the distribution of printed works; Mr. Nash, under the direction of Mr. Glaisher, is engaged with work incidental to the Magnetical and Meteorological Department. These gentlemen are considered as permanent assistants, borne by name on the books of the Admiralty. From a sum of money placed at my

disposal by the Admiralty, stipends are provided for six supernumerary computers in the Astronomical Department (increased to seven during the absence of Mr. Carpenter at Oran, for observation of the Total Eclipse of 1870, December 22), and for three in the Magnetical and Meteorological Department; and by these (who for the most part are very young men) a large proportion of the daily work of calculation is performed.

I cannot speak too highly of the zealous and orderly conduct of the assistants generally.

A labourer, a gate porter, and a watchman for the night are indispensable servants of an institution of this character; and if, from family absence or other cause, there is no gentleman or man servant of my own family in residence, I always appoint another person to attend at the gate between the hours of the porter and the watchman.

The principal carpenter is considered as *de facto* a permanent officer, and this arrangement is approved by practical men who are acquainted with the circumstances of the Observatory. There are usually other workmen in employ.

XV.—Extraneous Work :—

The trials and certificates of hand-telescopes for the use of the Royal Navy have lately been so frequent that they almost become a regular part of the work of the Observatory. The labour and occupation of time upon them, when due respect is paid to the convenience of the Observatory, are not great; but without proper care, an intrusive task of this kind might be very injurious to the interests of the Observatory (as chronometers were, many years ago). I may state here that by availing myself of a theory of eyepieces which I published long since in the Cambridge Transactions, I have been able to effect a considerable improvement in the telescopes furnished to the Admiralty.

The occurrence of the Total Eclipse of the Sun in December last has brought much labour upon the Observatory. As regards myself, the antecedent work in reference to general observers, the preparation for the Greenwich Observations, and the undertaking (which I found it difficult to avoid) of some degree of superintendence of General Report, have greatly occupied my time. As regards the assistants and computers, the actual observation on a complicated plan with the Great Equatoreal (a plan for which few Equatoreals are sufficiently steady, but which when properly carried out gives a most complete solution of the geometrical problem) has required, in observation and in computation, a large expenditure of time. At the request of Mr. Huggins, and with the sanction of the Admiralty, Mr. Carpenter was detached, to assist in observations at Oran; a valuable assistant was thus withdrawn from the routine work of the Observatory.

My own time has been partly occupied in preparations for the Transit of Venus, 1874. I have taken measures for equipping each of five stations with a Transit, an Altazimuth, and an Equatoreal. Of transits I have five new, all mounted on stone piers. Of clocks to accompany them, I have two from the R. Observatory, three new. Of Altazimuths I have one from the R. Observatory, four new. Of Equatoreals, 6 inches in aperture, and carried by clock-work, I have five, purchased or new. Of clocks of an inferior class, to accompany the two last classes of instruments, I can supply only one, and must procure nine. Fifteen portable observatories must be prepared, of which I shall be able to exhibit specimens to the Visitors. The R. Observatory can supply three 4-inch detached telescopes, and two more will be desirable.

My preparations have respect only to eye-observation of contact of limbs. With all the liabilities and defects to which it is subject, this method possesses the inestimable advantage of placing no reliance on instrumental scales. I hope that the error of observation may not exceed four seconds of time, corresponding to about $0''.13$ of arc. I shall be very glad to see, in a detailed form, a plan for making the proper measures by heliometric or photographic apparatus; and should take great interest in combining these with the eye-observations, if my selected stations can be made available. But my present impression is one of doubt on the certainty of equality of parts in the scale employed. An error depending on this cause could not be diminished by any repetition of observations. As, in the event of any national enterprise being promoted in the direction of photographic record, it is probable that the Astronomer Royal may ministerially take an important part, I venture to submit to the Board of Visitors that suggestions on the value and plan of such observations fall entirely within their competence.

Several gentlemen of the corps of Royal Artillery have expressed their wish to take part in the observations of the Transit of Venus, and I propose to give them opportunities of making the adjustments, &c. of instruments, in the same manner as in the actual observation. I trust that they will be joined by officers of the Royal Navy.

The Catalogue of Stars from Bradley's old observations is drawn out in manuscript, and is in my hands for examination and final decision upon the use to be made of it.

As a part of the general history of the Observatory, though in a sense totally different from that of the preceding paragraphs, it appears proper to state that we have been gratified by visits of all the American observers of the Solar Eclipse, as well as by that of M. Jannsen.

XVI.—General Remarks :—

I adverted in my last Report to the advantage that might be obtained if the attention of the Chief of the Observatory could be in some measure withdrawn from the

routine and manual labour of the office, and could be allowed to expand itself more freely in the direction of physical investigation, and (perhaps) of scientific literature. Although the time is far advanced, I do not abandon all hope of making some progress in these subjects. This will, however, imply the delegation (under instructions) of much work which I have been accustomed to do myself; and that change will be felt in all employments, down to those of the youngest computer.

In the ordinary conduct of an Observatory of this class, as applying both to its scientific observations and to its civil services, there is little difficulty (although much labour) in maintaining general regularity. As illustrating this, I may remark that the current reductions of observations, in spite of formation of seven-year catalogue, solar eclipses, and preparations for Transit of Venus, are in as healthy a state as they have ever been in. And these regular reductions give, in general, great facility for the most advanced inferences; the star-catalogues, and solar, lunar, and planetary errors, lend themselves immediately to investigations of a physical character; the magnetic reductions distinctly, though tacitly, exhibit some of those results (for instance, annual inequalities) which in various observatories have been the subject of special memoirs.

But from time to time it becomes desirable to unite some of those annual or nearly annual results in groups, so as to exhibit the results justly derivable from masses of observations extending over long periods of years. These operations require new organisations; and, what is worse, they require additional grants of money. I have usually refrained from asking for these, without the distinct approval of the Visitors. I would now submit for their judgment the following subjects:—

The vigorous prosecution of the Meteorological Reductions (exhibiting the results deducible from the photographic registers) already begun.

The combination of the results of Magnetic Observations on undisturbed days, from the year 1864.

The discussion of Magnetic Storms, from the year 1858.

Perhaps, also, the discussion of observations in groups depending on Lunar Declination, or other phases.

There is another consideration which very often presents itself to my mind; the waste of labour in the repetition of observations at different observatories. The actual Greenwich system was established when there was little to compete with it. Other observatories have since arisen, equipped with and principally using the same classes of instruments, and devoting themselves in great measure to the same subjects of observation (except the unrelenting pursuit of the Moon, and perhaps the fundamental elements of the ecliptic). Ought this Observatory to retire from the

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competition? I think not; believing that there is greater security here than anywhere else for the unbroken continuity of system which gives the principal value to series of observations. Still, I remark that much labour is wasted, and that, on one side or another, that consideration ought not to be put out of sight in planning the courses of different observatories.

G. B. AIRY.

*Royal Observatory, Greenwich,
1871, May 16.*