

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

Read at the Annual Visitation of the Royal Observatory, 1869, June 5.

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THE Report on the Royal Observatory (the thirty-fourth in numerical order), which I have the honor now to submit to the Board of Visitors, is intended to give an account of the state of the Observatory on 1869, May 10, and of the general history of the Observatory from 1868, May 6, to 1869, May 10.

I. Buildings and Grounds:—

The roof of one of the newest rooms of the dwelling-house, adjoining the original building of Flamsteed, has been raised, as was anticipated in the last Report, and the room is greatly improved.

The small Safe Room of the Observatory (a portion of the original Quadrant Room) had, from various changes, become very inconvenient for Observatory use. I have now removed the manuscripts which it contained into the Record Room, and have appropriated it to the preservation of Books and Papers, partly my own, partly related to local institutions. By the existing arrangement of doors, &c., the room has in fact been always more closely connected with the dwelling-house than with the Observatory.

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The Chronometers were removed from the room above the Principal Computing Room to the middle story of the South-East Dome, at the end of July 1868 ; and the room was fitted with desks, &c., and is now used as Second Computing Room for the Supernumerary Computers.

It has been found desirable to keep in readiness for use when required a framed stage, which can be planted upon the staircase-roof of the South-East Dome, and which then gives access to every part of the exterior of the revolving drum-dome. For convenient preservation of the parts of this stage, a small shed has been fixed on the leads of the Library.

The air-holes for admitting air to the stove by which the Record Room is warmed were open to the north. In consequence of this position, it was almost impossible to obtain a proper in-draft of air, when the damp S.S.W. wind was blowing, and when drying heat was most wanted. I have lately pierced the south wall, in order to give air-entrance on that side.

The additional sets of slate-shelves have been fixed in the Lower Record Room. And I hope that, before the presentation of this Report, the stores of printed books which now incumber that room will have been transferred to the new depôt on the newly-added ground.

The channels for conveyance of the galvanic wires across the Front Court (connecting the Computing Room, the Altazimuth, the Transit-Circle, the Transit-Clock, the new Chronometer-Room, the S.E. Equatoreal, and its Chronometer, with the Chronograph, the Normal Mean Solar Clock, the Time-Signal-Ball, External Clocks, and External Time-Signals) have been considerably enlarged.

The Middle Room of the South-East Dome is now completely fitted up as Chronometer-Room, with ample accommodation of Tables for Chronometers, with large Chronometer-Oven, and with exposed railed outhouse for chronometers to be placed in the open air. The scale of all these permits us to place the chronometer-boxes, if we think fit, with their lids open, and with the box-fronts towards the observer. The adjustment of the heat of the oven is easy and accurate.

There is nothing to remark on the Observing Room of S.E. Equatoreal, except that we were annoyed for a time with friction of the upper shutter, which however was soon remedied.

On the Magnetic Ground, a shed which has been used as temporary observatory is at present planted as a shelter for detached telescopes and telescope-stands. I intend, as soon as the Great Shed shall be removed (to which I shall soon allude) to erect a shed in its place, for more convenient protection of these telescopes and stands.

No alteration has been made in the Magnetic Observatory. The cautions which we have learned to take, and which are made effective by the incessant attention of Mr. Glaisher, have enabled us to control the temperature generally without actual change of the walls of the building. Still we find that the effect of the sun's radiation in the south-west re-entering angle will sometimes make itself sensible; and at the present time a large wooden screen is mounted there to ward off the heat.

At the last Visitation, I had the great advantage of pointing out, on the spot, to the Hydrographer and the Director of Works of the Admiralty, the too close proximity of the various buildings on the Magnetic Ground, and the increasing necessity for an extension of the domain of the Observatory. Fortified by the concurrence of their opinions, I brought the subject before the Board of Admiralty and the Commissioners of Her Majesty's Works and Parks, &c., suggesting that the eastern boundary of the grounds should be extended 100 feet, that the southern boundary should there be set off at right angles, and that the western boundary should be continued to meet it. My representations were most favourably received by both offices; and, with no greater delay than the nature of the business and the season of the year necessarily produced, the Warrant for the annexation of this space to the Observatory grounds received Her Majesty's Royal Signature on 1868, December 8. The new depôt for the Printed Productions of the Observatory, to the proposed plan of which I alluded in my last Report, was in progress of construction; but, in anticipation of the extension of territory, I had so arranged its frame that it could be transported to a new position with little trouble. The new ground was extremely uneven, but, by a considerable amount of earth-work, and by erection of substantial retaining walls in some parts, I have been able to arrange it in two horizontal planes at different elevations. The depôt is transferred to its position in the new ground, and its internal fittings are advancing. The foundations and underpinning for the Great Shed are completed, and as early as possible, but probably not before the assembly of the Visitors, it will be shifted from its present place on the Magnetic Ground to that new site. The positions selected for both these buildings are close to the new southern boundary. Great advantage will be gained to the Magnetic Ground, and great freedom for many purposes, by this extension of our inclosure.

No important interruption has taken place in our external galvanic communications.

The courses of our wires adapted to the registration of spontaneous terrestrial galvanic currents have been entirely changed. The lines to Croydon and Deptford are abandoned; and for these are substituted, a line from Angerstein Wharf to Lady Well Station, and a line from North Kent Junction to Morden College Tunnel. At each of these points the communication with earth is made by a copper plate 2 feet

square. The straight line connecting the extreme points of the first station intersects that connecting the two points of the second station, nearly at right angles, and at little distance from the Observatory ; but great length is added to the wires (apparently with no inconvenience) by the necessity of following the railways to their junction in order to lead the wires through the registering apparatus in the Observatory. The arrangement of wires could not have been effected, but from the circumstance that we had two wires disposable which I hope at some time to use for signals on the Start Point, and also two spare wires. A map of the courses of these wires will be exhibited to the Visitors.

I continue to maintain in good order the inclosing fence of the Obelisk on Chingford Hill. As a meridian-mark for the transit-instrument, this pillar is now useless ; but I attach importance to the preservation of the object which, taken in conjunction with the central opening of Bradley's Transit-Room (now the Astronomer Royal's Official Room), defined the first meridian of the Trigonometrical Survey of Britain. It is now backed by trees of Epping Forest, and, when it is to be used, it will be necessary to attach to it a lofty pole.

The question of railway through Greenwich is still unsettled. After abundant consideration of this question, remarking that there is no necessity for carrying London-Woolwich passengers through Greenwich, that the construction of the Great Sewer will render a thorough railway far more annoying to the Town of Greenwich than it might have been formerly, and that every facility for easterly communication may be given to Greenwich and to Deptford at very small expense, I am satisfied that, independently of any consideration of the Royal Observatory, it would be most advantageous to all parties (including the South-Eastern Railway Company) to lay aside all thoughts of a line through Greenwich.

II. Moveable Property :—

Our moveable property, not included in the classes of Manuscripts, Library Books, and Instruments, is generally in good order. The "Parliamentary Copies" of the National Standards of the Yard and the Pound Weight, placed in the Record Room, are safely preserved.

The Portable Transit is still in the hands of Sir Henry James, and the small spectroscope is in the care of Lieut. Col. Smyth. The telescope, which was supplied

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to Major Tennant for observation in India of the Total Solar Eclipse, has been returned.

III. Manuscripts :—

Under a system which I explained in detail in my last Report to the Visitors, our papers of every kind are very carefully preserved. The actual working of the plan is intrusted to Mr. Carpenter, by whom its principles are carried out with great care and accuracy. The course which I adopt collects in chronological order all the papers relating to each subject, so that its history can be perfectly traced.

The bound volumes, both of my predecessors' and of my own correspondence, observations, and calculations, have lately been compared with the catalogue and found correct.

The pencil memorandum-books of observations are collected at the end of every year, and a box is then prepared for the books of the year, in each of the departments of Meridian Observations, Altazimuth and Extrameridional Observations, and Magnetic and Meteorological Observations; and reference to every original observation is very easy. The Chronograph Sheets are preserved in large wooden portfolios.

Various manuscript copies of original observations and calculations are still in the hands of foreign astronomers; namely, Bradley's and Bliss's Meridional Observations, 1750 to 1762, lent to Dr. Auwers; and Bradley's Zenith-Sector Observations, and Bradley's loose papers, lent to Mr. O. Struve.

IV. Library :—

Our Library is very valuable, and is indeed almost a standard library, for physical subjects generally, but more particularly for astronomy, magnetism, meteorology, and optics. Assisted as we are by numerous presents from observatories, academies, philosophical societies, and private men of science, it is not necessary to incur great expense in purchases.

The binding, the cataloguing, and the periodical comparison with catalogue, of such a library, require a distinct systematic arrangement. This is the duty of Mr. Carpenter. The last comparison was made about three months past, when all was found perfect.

I attach much importance to the Library, as a part of the Observatory on which the intellectual character of the whole must greatly depend. That it has contributed materially to raise the tone of the Observatory, I am very confident.

V. Astronomical Instruments :—

The Transit-Circle is in perfect order. I adverted in the last Report to small iron chips in the telescope-tube which gave us some trouble ; at the first opportunity, these were extracted by the insertion of magnets, and we have had no further annoyance.

The screw-movements for focal adjustments, and the jointed sliding caps for the perforations in the central cube, have been found very convenient.

The Reversed Telescopes, for reciprocal observation through the perforated cube, and for carrying the wires which are observed as meridian-marks by the Transit-Circle, when proper care is taken for focal adjustment, give no trouble in the nature of systematic discordance, and are in all respects perfectly efficient.

The suspicion of telescope-flexure produced by the weight of the sunshade, and not properly exhibited in the circle-readings, has led us to examine thoroughly the effects, not only of the weight of the sunshade generally, but also of that weight under different applications of the clamps ; and the result is, that there is no certain effect whatever.

The mean of our two series of determinations of graduation-errors has been used, as was mentioned last year.

The conical milled head which I proposed for the telescope-micrometer was mounted last year.

The four supplementary microscopes have been removed. I shall speak hereafter of the results obtained by their use.

The proposed high-class interior thermometer has been mounted in a position in which it may be expected to indicate fairly the temperature of the air near the object-glass. Several foreign astronomers have considered this important, as they think that the computation of atmospheric refraction is more consistently accurate if it is referred to the interior thermometer than if it is made to rely on the exterior thermometer.

The clocks generally are in good order.

Two ounces of quicksilver were added to the bulb of the Transit-Clock-pendulum, and it does not appear to require more. Lime is used, as I mentioned in the last Report, to keep the air in the head of the clock dry ; it is changed once each month.

The East Dome Clock (Earnshaw) has been cleaned, and an alteration has been made in its spring-suspension, to remedy a wobbling motion of the pendulum.

The Ball Clock (Graham 3) has been cleaned.

A new clock by Messrs. Dent is in progress. It is to be constructed with an escapement analogous to the chronometer-escapement, which produces [maintaining power with a smaller amount of friction than any other. I have arranged a method of altering the rate without stopping or touching the pendulum, by a sliding weight upon the crutch-rod. I am endeavouring also to prepare a construction for altering the thermal compensation through a small extent, without touching the pendulum. I have not succeeded to my satisfaction in planning a barometrical compensation. I propose to place the clock in the Magnetic Basement, where the temperature is more uniform than in any other of our rooms, and to lead galvanic wires from it to the Transit-Clock and other clocks.

The Motor Clock (Shepherd's) for Mean Solar Time, by which time-signals are given and received, and sympathetic clocks are maintained in action, is in good order. The sympathetic clock used for chronometer-rating has been transferred to the new chronometer-room; and two new sympathetic dials have been mounted there, showing seconds only. A clock by Dent, used for chronometer-comparisons only when the galvanic process fails, has also been removed to the new chronometer-room.

The Chronograph Barrel-Clock and the Chronograph generally are in good order.

The Reflex-Zenith-Tube and the Altazimuth are in their usual efficient state, and require no special notice. They have received no alteration in the past year.

The Shuckburgh Equatoreal and the Sheepshanks Equatoreal are both in serviceable state. The latter has aperture approaching to 7 inches, and is furnished with clock-work, which, though not of a high order of excellence, is good enough to increase greatly the utility of the instrument.

The South-East Equatoreal is in excellent condition. Very lately, the revolving arms of the reaction-machine of its clock-work burst (the internal pressure of the water amounts sometimes to 50 lbs. per square inch), and during the absence of these arms, which describe a circle of about 15 inches diameter, for repair, we have substituted the arms originally constructed by Messrs. Ransomes, which describe a circle of 20 inches diameter; and we think that, with full pressure of water, the motion is now free from some very minute inequalities which could be discovered with the smaller arms. The motion of this clock, in the combination of definiteness and smoothness, is probably the most perfect in existence.

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A complete set of plans of the South-East Equatoreal has been prepared, under my instruction and under the more immediate superintendence of Mr. Carpenter, by an accomplished draftsman. But I have not had leisure for drawing up the letter-press explanation.

The Barometers and Thermometers, and all the minor instruments ancillary to the principal instruments, are in efficient condition.

In our portable Altazimuth it was found that the principal zenith-distance-level was too much concealed by the frame of the stand. I have had its position altered, so as to bring it fully into view.

The ancient instruments appear to be in their usual state. It will perhaps be desirable soon to clean and varnish the graduated limbs of Bradley's quadrants.

The question of dependence of the measureable amount of sidereal aberration upon the thickness of glass or other transparent material in the telescope (a question which involves, theoretically, one of the most delicate points in the Undulatory Theory of Light) has lately been agitated on the Continent with much earnestness. I have calculated the curvatures of the lenses of crown and flint glass (the flint being exterior) for correcting spherical and chromatic aberration in a telescope whose tube is filled with water, and have instructed Mr. Simms to proceed with the preparation of an instrument carrying such a telescope. I have not finally decided whether to rely on zenith-distances of γ Draconis or on right-ascensions of Polaris. In any form the experiment will probably be troublesome.

VI. Astronomical Observations :—

I can scarcely better describe the fixity of our plan of routine-observations, and the steadiness with which we adhere to it, than by saying that the sentences used for many years past in describing our subjects of observation may be used, nearly without altering a word, for the year now under review. The stars observed on the meridian are 188 clock-error stars; all Nautical Almanac stars; circumpolar stars; occultation stars; stars near the Moon; stars for completing our own catalogues; stars for geodetic surveys; refraction-stars; Argelander's stars; proper-motion stars; variable stars. To these should be added γ Draconis with the Reflex-Zenith Tube. The

planets observed on the meridian are, on every practicable day, the Moon; and, with the omission of Sundays, the Sun; the large planets when they transit before 15^h, or when they are near the Moon, and the small planets when they transit before 13^h during the Moon's two first quarters (M. Le Verrier having accepted as an engagement of the Imperial Observatory of Paris the observation of small planets during the Moon's third and fourth quarters). The only regular extra-meridional observations are those of the Moon and zero-stars, and of a collimating-mark, with the Altazimuth, on every night when she can be seen in any part of the sky.

The regularity in the routine of consecutive years to which I have alluded has arisen, in great measure, from adherence to the rule which I first laid down to myself in the Observatory of Cambridge, and which I introduced and have maintained in the Royal Observatory, namely, to form the plan of observations for each year in the greatest practicable detail before the close of the preceding year. Not only the scientific but also the administrative duties of the Observatory are thus arranged; and the general business of the Observatory during the year then flows on with great smoothness.

The general subjects of ordinary observations being thus described, I present the following as the number of observations made between 1868, May 6, and 1869, May 10.

With the Transit-Circle :

Transits, the separate limbs being counted as separate observations	4,900
Pairs of observations of the nearly vertical wires of the reversed telescopes	308
Reciprocal observations of the nearly vertical wires of the reversed telescopes	340
Reflexion observations of the central transit-wire	292
Circle observations, each requiring a separate reading of the six microscope-micrometers	3894
Reflexion observations of zenith-distance wire (included in the circle observations)	290
Reflexion observations of stars (similarly included)	227

With the Reflex-Zenith-Tube,

Pairs of observations of γ Draconis, the instrument being reversed between the observations	69
Single observations	5

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With the Altazimuth :

Azimuths of the Moon and stars	823
Azimuths of collimating-mark	406
Zenith distances of the Moon	442
Zenith distances of collimating-mark	406

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

On days when the Moon transited between 21^h and 22^h Mean Solar

Time	5
„ „ 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 . . .	4

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

With the Transit-Circle, 115, or 9·3 per lunation.

With the Altazimuth, 221, or 17·7 per lunation.

It may be interesting to place on record that, on 1868, Nov. 20, 89 Herculis, a star of the 6th magnitude, N.P.D. 64°, was observed with the Transit-Circle when passing 1^h. 50^m. after the Sun; and, it would appear from the Assistant's report, was observed without difficulty.

The number of observed occultations of stars by the Moon is four; all disappearances. The number of phenomena of Jupiter's satellites is 29.

The transit of Mercury on 1868, November 4, was observed by six observers; Mr. Stone using the S.E. Equatoreal. The atmospheric circumstances were favourable; and the singular appearances usually presented in a planetary transit were well seen. These appearances had been observed at the Royal Observatory in a preceding transit of Mercury (1848, Nov. 8), but they had escaped from memory; and we must regard it as a fortunate circumstance that, when preparations for observing the transits of Venus in 1874 and 1882 are in agitation, we have had an opportunity of seeing, though on a somewhat different scale, the characteristic difficulties of the observation.

Mr. Stone has attached to the South-East Equatoreal a thermo-multiplier, with the view of examining whether heat radiating from the principal stars can be made sensible in our instruments. The results hitherto obtained are encouraging, but they show

clearly that it is vain to attempt this inquiry except in the most superb weather; and there has not been a night deserving that epithet for some months past.

Mr. Carpenter has made, with the South-East Equatoreal, three drawings of the lunar spot Linnæus, three drawings of Jupiter, and two of Winnecke's Comet.

VII. Reduction of Astronomical Observations :—

I may with advantage, on this as on former occasions, present my brief Report to the Visitors in the same form in which, in the ordinary conduct of the Observatory, a more detailed Report is from time to time made to myself; namely, by statement of the dates up to which the critical points of reduction are completed. The following is the list of dates which exhibits the state of reduction on May 10 :—

For Meridional Transit Observations :

Corrections for instrumental errors are applied to the observed transits, and clock-times of transit over the true meridian are formed, to	1869, May 1
Clock-errors and clock-rates are computed, and apparent right ascensions are formed by their application to clock-time of transit, to	April 24
Stars' corrections are computed, with trifling exceptions, to	May 8
Stars' corrections are applied to apparent right ascensions, and mean right ascensions for the first day of the year from observation are formed, to	1868, Dec. 31
Mean Solar Times of observation of Sun, Moon, and Planets are computed, to	Dec. 31
Corrections for deficient illumination of limbs of Moon and Planets are computed and applied, to	Dec. 31

For Meridional Circle Observations :

Corrections for errors of graduation, flexure of telescope, inclination of the wire used for zenith-distance observations, and zenith points, are computed and applied to the corrected mean of microscopes, to	1869 April 30
True geocentric zenith distances given by observation are formed, by application of refraction and parallax, to	Jan. 23
Stars' corrections are applied, to	1868, Dec. 31
Corrections for deficient illumination of Moon and Planets are applied, to	Dec. 31

The mean refractions are computed by diminishing those of Bessel's *Fundamenta* in the proportion 1 : 0.99797. This is nearly the same as the effect of altering the temperature at observation by 1° Fahrenheit.

The collection of mean results of each star observed, for every day's observation through the year 1868, is completed, but the means are not taken; and the inferences for the value of $R-D$, for the correction to assumed latitude, and for the position of the ecliptic, as well as the final results of planetary observations, are therefore not yet made. The investigation of personal equations in transits is finished: the results are almost an exact reproduction of those for 1866, and do not differ from those for 1867 by more than 0^s.02. As compared with past years, these deductions from meridional observations are somewhat in arrear. Sufficient explanation of this will be found when I speak of the new 7-year Catalogue of Stars.

The observations of γ Draconis made with the Reflex-Zenith-Tube are reduced, to 1868, December 31.

The following are the stages of Altazimuth reductions:—

In Azimuth, True Azimuths are formed by applying the effects of instrumental errors and the Azimuthal Zero to the means of circle-microscopes and the effects of level-readings, to	. . . 1869, April 4
In Zenith Distance, True Zenith Distances are formed, to	. . . May 1
The Tabular Azimuths and Zenith Distances corresponding to these are computed, to	. . . April 24
The apparent Tabular Errors of Moon's R.A. and N.P.D. are exhibited, to	. . . April 4
The apparent Tabular Errors of Moon's Longitude and E.N.P.D., to	. . . April 4

The fluctuations of Azimuth-errors of the Transit-Circle and the Altazimuth have nearly the same character as in preceding years. The two instruments give very nearly the same amount (small, but sensible) for the errors of the lunar tables.

The computations of the 7-year Catalogue, including the results of all the star-observations made in the years 1861 to 1867, are now completed and examined in every part, and preparations are begun for sending it to press. I propose to publish it in the same general form as the last 7-year Catalogue. The amount of labour in preparing this catalogue has been considerable; and, in spite of our having taken a little unusual assistance of supernumerary computers, has pressed heavily upon our establish-

ment, and has caused a little retardation of other computations. The number of stars is 2,761; they include the hitherto unobserved stars of Bradley's Catalogue.

Among other results from the Greenwich Reduced Observations, I may mention the following :—

From the discordances among the separate results for N.P.D. of each star (without reference to any N.P.D. assumed as true), Mr. Stone has inferred the probable error of a single result for N.P.D. In the zenith, it appears to be $0''.47$; at zenith distances 40° , 50° , 60° , 70° , 80° , it appears to be $0''.55$, $0''.65$, $0''.85$, $1''.20$. After this it increases with great rapidity, rising at 87° to $3''.30$. The comparison by Mr. Stone of observations made by the four supplementary microscopes with observations made by the usual six microscopes leads to the result, that the uncertainty in a star's polar distance, depending on uncorrected error of graduation, amounts to $0''.20$ or $0''.25$.

At different times Mr. Dunkin has made investigations of personal errors of various kinds, founded on the Reduced Greenwich Observations; which are published in the Monthly Notices of the Royal Astronomical Society. The last of these is one on the results of transit-observations of the Moon. They lead to the conclusion (to me totally unexpected) that in general there is greater consistency among different observers in the transits of the Moon's second limb with the Altazimuth than in the transits of the first limb.

Mr. Stone has given, in the Monthly Notices, the result of an elaborate investigation of the co-efficient of Lunar Nutation from the Right Ascensions of Polaris observed with the Transit Circle from 1851 to 1867. The resulting value is $9''.115$. When this is combined with the values obtained from N.P.D. of Polaris, δ U. Minoris, and 51 Cephei, the mean found is $9''.134$, subject to a change for corrections of proper motion, which are probably insensible.

VIII. Printing and Distribution of Astronomical Observations :—

The principal part of the impression for 1866 was distributed, in the last summer, to the usual list.

The whole of the astronomical part, including the Introduction and the Index, of the annual volume for 1867, is printed. Nothing remains to be set up but the Errata, which are in the printer's hands.

To this volume will be attached, as Appendixes, the reprints of the Description of the Transit-Circle and the Altazimuth. The text of the original descriptions is preserved, but new sentences are inserted where necessary, explanatory of the changes which have been made in the instruments.

In accordance with the decision of the Visitors, the number of copies struck off is the same as in former years, namely, 350 copies of the volume, including everything; 150 separate copies of Astronomical Results; also 100 separate copies of each of the Appendixes; and 250 separate copies of Magnetical and Meteorological Results.

A portion of the manuscript of Transit Observations for 1868, the whole of the Circle Observations, and the whole of the Altazimuth Observations, &c., have been sent to the printer, but no proofs are yet received.

Observations are very frequently communicated to applicants in manuscript before printing, especially observations of lunar transits or statements of errors of the lunar tables, which are in great request for the determination of geographical longitudes all over the world.

IX. Magnetical and Meteorological Instruments :—

Continued attention has been given by Mr. Glaisher to the equalization of the temperature of the Magnetic Basement, and with general good success. From October to May there is no difficulty in keeping the temperature between 59° and 62° . From June to September the difficulty is much greater; on a solitary occasion the temperature rose to 72° . The daily change is kept down to 3° , and in the great majority of days it does not exceed 1° . With our system of inclosing the magnets in double boxes, every box-side being gilt within and without, the corresponding changes of temperature about the magnets are very small. This system of inclosure deserves special notice; it appears absolutely to suppress all currents of air about the magnets, and almost all causes of accidental vibration; and the magnets, under the ordinary terrestrial disturbances, seem to take up their positions without any further fluctuation.

The Upper Declination Magnet; the theodolite by which the collimator of the Upper Declination Magnet is viewed, and which is also used to observe circumpolar stars; and the Lower Declination Magnet, which carries the concave mirror by which a photographic trace is made on the revolving photographic barrel; are all in good order, requiring no special remark. The Horizontal-Force-Magnet and its apparatus are perfectly efficient. The Vertical-Force-Magnet is in an excellent state; its knife-edge was revised in the winter by Mr. Simms; it has exhibited no dislocations of photographic curve in the records of last year.

The great magnetic storm of April 15 was admirably recorded on all the instruments, but on none was it registered in greater beauty than on the Vertical Force.

The disturbance in that element was, I believe, the greatest that we have ever registered.*

I am contemplating, as possible, a self-acting tracing of hour-lines in the photographic sheets, but have not yet arranged the plan.

No further experiments have been made for determining the thermometrical corrections of the Horizontal-Force and Vertical-Force Magnetometers.

It was mentioned, in an early page of this Report, that a complete change has been made in the courses of the wires used for examining the spontaneous galvanic earth-currents. No change, however, has been made in the galvanometers and other parts of the recording apparatus; all these are in excellent condition. The violent currents which accompanied the great magnetic storm to which I have alluded were very well recorded.

The ebonite barrels for magnetic records and earth-current records are now reduced exactly to the same gauge.

The dip-instrument and its needles have been revised by Mr. Simms. The action of this instrument is now so delicate and so certain that I propose to recommence the observations at different hours of the day, which were commenced, but brought to a close, many years ago. The deflexion-instrument is in good order.

It has been my object, in establishing our plant of meteorological instruments, in the first place to introduce photographic self-registration where possible (this applies to barometer and wet and dry-bulb thermometers), secondly to introduce mechanical self-registration (namely, for pressure, direction, and speed of wind, and for rain-fall), thirdly to provide ample means of eye-observation (for barometer, ordinary thermometers, wet and dry; thermometers at different depths in the ground; thermometers in the Thames; and seven pluviometers at different elevations). All are in good order, and have worked well through the year.

I can hear nothing from the artist about the intended electrical apparatus. I understand that it has not anywhere been brought into satisfactory use.

X. Magnetical and Meteorological Observations:—

The Declination Theodolite has been referred to circumpolar stars, for absolute zero, about twice in a month; and to a fixed mark, for steadiness of zero, more frequently.

* While this Report is under preparation, a magnetic storm has occurred, accompanying the Aurora Borealis of May 13, comparable with that of April 15, and equally well recorded.

The photographic magnetometers have worked constantly, without any avoidable interruption. Deflexions have been taken, for absolute measure of horizontal force, once or twice in a month. Dips have been observed oftener than once a week. The photographic registers of spontaneous galvanic earth-currents, exhibited by the new system of wires, commenced effectively on 1868, August 20.

I propose to maintain the register of earth-currents for a limited time only, perhaps two or three years, unless some new points shall present themselves for examination, or unless the establishment of registers of the earth-currents in other observatories shall render our co-operation desirable.

The meteorological instruments have been constantly in employ. The meteor-shower on 1868, Nov. 14, was well observed by eye.

XI.—Reduction of Magnetical and Meteorological Observations :—

The micrometer-readings of the Theodolite-Telescope in observation of the Upper Declination Magnet have been converted into arc and applied to the circle reading, to the present time. The astronomical zero of the Theodolite is computed to 1869, April 27. The equivalents for telescope-observation of the Horizontal-Force Magnet are prepared to the end of 1868, and that for the Vertical-Force Magnet to the end of 1867. No corrections are applied for temperature.

The time-scales are laid down on the magnetic sheets to the end of 1868, and on the earth-current sheets to the end of 1867. The new base-lines are drawn, and the ordinates measured as often as appeared necessary, to the end of 1867.

The absolute measure of horizontal force is computed to the end of 1868. The dips are reduced to the present time.

The mean westerly declination in 1868 was $20^{\circ}.13'$ nearly; the mean value of horizontal force was 3.854 (English units) or 1.777 (French units); and the mean dip about $67^{\circ}.56'.31''$.

It may be interesting to point out how the value obtained for the dip is related to the dimensions of the needle employed.

The mean value obtained in 1868 was, with 9-inch needle	. $67^{\circ}.54'.53''$
6-inch „	. $67^{\circ}.56'.39''$
3-inch „	. $67^{\circ}.58'.0''$
Observations made in 1868, August, gave with 3-inch „	. $67^{\circ}.58'.12''$
with Kew $3\frac{1}{2}$ -inch „	. $67^{\circ}.58'.28''$

I alluded in my last Report to the results, apparently important, obtained from a discussion of the Magnetometer Indications, 1858 to 1863. The principal tabular numbers of these reductions are printed in the Greenwich Observations, 1867; the more critical numbers, and the curves formed from them, are communicated to the Royal Society.

No step has been taken for the reduction of the observations on disturbed days.

It is my intention, commencing with 1868, to reduce the observations on undisturbed days to the stage of exhibition of diurnal inequalities, year by year. I shall allude to this hereafter, in treating of the printing.

In stating, last year, the results obtained from the comparison of the magnetic disturbing forces due to the spontaneous galvanic currents, on 17 selected days in the years 1865, 1866, 1867, with the magnetic disturbances actually observed, I notified my intention of extending the comparison to all the disturbed days occurring during the use of the galvanometer-apparatus in those years, and also of examining the undisturbed days. In carrying out this plan, First, the comparison has been extended to 36 additional disturbed days (making 53 in all), and, for 5 of these, the curves of comparison have been drawn and will be exhibited to the Visitors; the character of the results derived from the comparison is sensibly the same as that obtained from the 17 days. Secondly, the earth-current indications for all the undisturbed days have been reduced, and their results laid down in curves, to be exhibited to the Visitors; their dimensions, when laid down on the same scale which makes galvanic disturbances comparable to magnetic disturbances, are extremely small, and follow a law totally different from that of ordinary diurnal inequalities, having greater resemblance to the curve, or rather line, which would best represent luno-diurnal inequalities. The important negative result is thus obtained, that the ordinary diurnal inequalities cannot be explained by the spontaneous galvanic currents.

The adjustment-constants are determined for the meteorological instruments, and are applied to the eye-observations, to the present time; and the thermometer-results are reduced to the stage of exhibiting dew-point and degree of moisture. The record sheets of the two anemometers are perfect in themselves. The photographic sheets of the barometer and dry-and-wet thermometers are furnished with time-scales to the end of 1868; and the new base-line for barometer is prepared to the end of 1867.

The number of rotations of the vane in 1868 is $+20.4$. This record interrupts the law which had appeared to prevail for a long time, and which gave a periodical recurrence of numbers in seven years.

XII.—Printing of Magnetical and Meteorological Observations :—

The indications of magnetometers for 1867, the observations and reductions for absolute measure of magnetic horizontal force for 1867, the dip observations for 1867, the discussion of the magnetic observations on undisturbed days, 1858–1863, the indications of the galvanometers for the seventeen selected days above mentioned, 1865–1867, the meteorological observations for 1867 in their usual monthly arrangement, the November meteors, the great barometric waves, the readings of deep-sunk thermometers, and other meteorological particulars for 1867, are printed. The Introduction and Index are not printed.

The number of copies worked off is 350, to be bound in the general volume of Greenwich Observations, 1867, and 250 for separate distribution.

Meteorological results are communicated by telegraph to M. Le Verrier for his Bulletin, every day ; and a summary is sent to the Registrar-General of Births, Deaths, and Marriages, for insertion in his Weekly Report, every week.

No photographic copies of the photographic sheets have been taken.

The abstracts of dip observations and observations for absolute measure of horizontal force, and the greater part of the meteorological abstracts, for 1868, are ready for press.

In printing the indications of magnetometers for 1868 and following years, it is my intention, if it meet with the approval of the Visitors, to make an important change. As long as I was undecided on the course to be adopted for reduction of the indications, it seemed that the publication of all was necessary. But a course has now been adopted, based on the division of the indications into two classes (disturbed days and undisturbed days), which I have applied to two periods each of several years, and which is satisfactory to me. I propose now to make the division into two classes every year, and at once to proceed with the reduction and exhibition in monthly groups of the results, for the undisturbed days, year by year. When this is done, the presentation of the results of separate ordinate-measures for those days will have very little interest for the public, and I propose to suppress entirely that part of the printing. This will save much labour and expense. For the disturbed days, in which the collation of individual measures at different localities may become important, I propose to print the details as heretofore.

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

The number of chronometers on hand is 188, namely, 111 box chronometers, 23 pocket chronometers, and 8 deck watches, the property of the Admiralty; and 46 chronometers, the property of chronometer makers, on the annual competitive trial.

We have tried and have delivered to the Admiralty a chronometer to be used in trial of the speed of ships, and we have tried and reported on two chronometers intended for use in heaving the log.

All matters of expense on Government chronometers, whether for purchase or for repair, are referred to me in the first instance. The system of valuation and examination is founded upon the practice of rating all the chronometers, the greater part daily and others weekly, both in the open chronometer-room, whose daily range of temperature rarely exceeds 2° , and in the oven, where a temperature not exceeding 90° is steadily maintained.

The issues of chronometers to the Royal Navy are effected, for the most part, by sending them with balances wedged, in hampers under the Observatory seal, by ordinary railway conveyance, to the Admiralty agents at the outports. Scarcely an accident has occurred in this transmission. I am desirous, however, of seeing some apparatus arranged, by which the chronometer balance can be securely grasped, without the necessity for inserting cork wedges.

The experience of the use of bright white steel springs instead of blue springs, as preservative against rust, is favourable, but not decisive.

The error-number for chronometers under trial in the year 1868 is larger by an accidental quantity than that in the last two years; it is much smaller than it was five or six years ago.

The Motor Clock, and the entire system of communication of time from it by galvanic signals almost to the extremities of Britain, are in perfect order. For the difficult communication to the Time Signal Ball at Deal, for which alone I am responsible, the report of success is as follows: on 92·4 per cent. the ball was dropped freely by the galvanic current; on 3·8 per cent., in damp weather, the current required the assistance of the attendant's hand; on 1·4 per cent. the wind was too high to permit the raising of the ball; on 1·6 per cent. the communications were interrupted; and on 0·8 per cent. (3 days) the ball was falsely dropped by telegraph-signals of the railway.

For the Great Clock at Westminster Palace, to which we send signals for the guidance of the attendant, and which reports its own time to us, the report is less favourable than last year; the number of errors under 1^{s} is 56 per cent. of the whole; the number under 3^{s} is 93 per cent. of the whole.

At the Lombard Street Post Office, the clock upon which the others depend, and which has a gaining rate, stops itself at $0^h. 0^m. 0^s$ clock-time a few seconds before Greenwich Noon, and is released by our current at Greenwich Noon.

A clock at the India Store Department is now regulated by a current sent at every second from the Royal Observatory.

There has been no farther correspondence in reference to signals on the Start Point.

No determination of longitude has been made by galvanic signals in the past year.

XIV.—Personal Establishment :—

The establishment consists of the Astronomer Royal, who is responsible externally for everything ; of eight assistants, who are appointed (usually on the recommendation of the Astronomer Royal) by the Board of Admiralty, and whose salaries are fixed in the Navy Estimates ; and of Supernumerary Computers, usually about nine in number, of whom the choice is made and the stipend defined by the Astronomer Royal, a gross sum being annually allotted for that purpose in the Navy Estimates.

Mr. Stone is First or Confidential Assistant, not limited in his employment to any special class ; Mr. Glaisher superintends the Magnetical and Meteorological Department ; Mr. Dunkin manages the Altazimuth generally and the adjustments of the Meridional Instruments ; Mr. Ellis has the sole charge of the Time Department, Chronometers, Time Signals, and (quarterly) of Money Accounts ; Mr. Criswick is responsible for the Reductions of Transit-Circle Observations in Zenith Distance ; Mr. Lynn superintends the mass of reductions effected by the Supernumerary Computers, in which the Transit Reductions are included ; Mr. Carpenter takes the care of the Equatoreals, but is principally occupied with the Library, the Manuscripts, the distribution of our printed Observations, and the general literary administration of the Observatory, which is very heavy ; Mr. Nash assists Mr. Glaisher in the Magnetical and Meteorological Department.

I am confident that the statements which I have made will justify the remark, that all these gentlemen have worked honourably, zealously, and well, in the cause of the Observatory and of the sciences to which it is devoted.

Usually, six supernumerary computers are attached to the Astronomical Department, and three (at the present moment four) to the Magnetical and Meteorological Department.

The remainder of the establishment, for whom annual provision is made, consists of a gate-porter, a night-watchman, and a labourer ; but we are never without workmen,

of the class of carpenters and joiners, and it is found convenient to recognize one of these as leading-man, and to keep him always in employ.

We have had the pleasure of visits, lasting several days, from Dr. Auwers (who was particularly interested in the examination of the Bradley manuscripts, in which, among other things, he discovered some stars which have not been reduced) and from Mr. Wagner (who gave great attention to personal equations and to observation of circumpolar stars). We have also had occasional visits of inspection from several foreign men of science. We had the satisfaction of frequently seeing in the Observatory Lieutenant Ielagin, till the month of September, when he finally quitted England on his return to Russia.

XV.—Extraneous Work :—

The examination of the reductions of Bradley's first series of observations, as far as the reductions had proceeded, has been taken up by Mr. Stone. The decision on further steps is not easy. There is great want of correspondence of observations in the two elements; and of the stars on which we might reckon as additions to the recognized list, a large proportion are observed in only one element, sometimes right ascension, sometimes polar distance. The value of a catalogue of such stars is much diminished by the want of combination of the two elements.

The approach of the Transits of Venus has made it a duty of official astronomers to consider what steps ought to be taken now in preparing for their observation. I have with much care and with the consumption of much time examined into the circumstances of the two transits, and have come to the conclusion, that after every reliance is placed on foreign and colonial observatories, it will be necessary for the British Government to undertake the equipment of five or six temporary stations. It is much to be desired that authority should be promptly given for procuring the instruments which will be required. On those by which local time and longitude will be determined, there is no uncertainty; on the viewing telescopes there may be some question. Still I conceive that it may be assumed as beyond doubt that a 6-inch telescope and a second telescope ought to be provided for every station.

Questions relating to the two East Indian Observatories have sometimes been placed before me by the Government. The clock required for the transmission of galvanic time-signals from the Observatory of Colaba (Bombay) has been sent to India, and clocks for a similar purpose at Madras are in course of construction.

The approval of telescopes purchased for the use of the Navy has in several instances been referred to me.

The Royal Commission on National Standards, of which I have been acting Chairman, has had under its consideration some very important questions, which could not be treated without great labour and anxiety to myself.

I have given a short course of lectures in the University of Cambridge on the subject of Magnetism, with the view of introducing that important physical science into the studies of the University. The want of books available to students, and the novelty of the subject, made the preparation more laborious than the duration of the lectures would seem to imply.

XVI.—General Remarks.

In my last Report to the Visitors, I considered the duties of the Royal Observatory as divisible into four classes: the utilitarian observations, &c., serviceable to astronomy and geography; the unceasing register of natural phenomena; the discussion of those phenomena; and the giving to the State, as far as possible, any assistance of scientific character of which it may stand in need.

The first, second, and fourth of these classes have been steadily kept in view, in the last as in preceding years. The third also has received full attention; as regards astronomy, from my first connexion with the Observatory; and as regards magnetism, from a later year, when, in order to give a proper beginning to the complete reductions, they were made to commence from the first year of the magnetic establishment. But, as regards meteorology, the observations have not been discussed to the extent which their excellence and their possible importance seem to demand.

I now contemplate entering upon a systematic reduction of the meteorological observations during the whole time of their efficient self-registration. And I propose, in the first instance, to endeavour to ascertain the laws of diurnal inequality of atmospheric temperature and evaporation temperature. My idea is, to divide the groups of days in which such reductions must be made, not necessarily according to the divisions of the calendar, but possibly in reference to other ascertained phenomena, as perhaps the direction of the wind. I am very desirous of receiving suggestions on the course to be pursued.

G. B. AIRY.

*Royal Observatory, Greenwich,
1869, May 15.*