

REPORT
OF
THE ASTRONOMER ROYAL
TO THE
BOARD OF VISITORS,

Read at the Annual Visitation of the Royal Observatory, Greenwich, 1855, June 2.

REPORT OF THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS,

Read at the Annual Visitation of the Royal Observatory, Greenwich, 1855, June 2.

THE Twentieth of the Reports which I have had the honour to present to the Board of Visitors will, I trust, be received with indulgence, less on account of the importance of the history which it is to convey, as applying to a year in which no changes of great consequence have been made, than for the numerical place which it occupies in the series of Annual Documents. The date to which the statements of the Report apply is 1855, May 15, and the interval embraced in its historical portion is that between 1854, May 26, and 1855, May 15.

I. Grounds and Buildings.—The Fire-proof Room, to which I alluded in my last Report, has been completed in all essential parts, and in conformity with the plan which I then explained, except that I have not thought it necessary to remove the central stack of chimneys, but to accommodate new partitions to it, leaving it undisturbed. Two sets of slate shelves are erected. The ironwork, however, of the window shutters is not completed, and, in consequence, we have not yet been able to make full use of the room. These, I expect, will be finished very soon.

The new building for the Reflex Zenith Tube has not yet been erected; but the necessary funds are provided, and I hope in the course of the summer to complete it.

In order to avoid the annoyance which we have several times experienced by being compelled to open the ground for laying down or taking up galvanic wires, I have had several channels constructed of masonry, in the places where wires will usually be required.

These are all the occurrences relating to our buildings and grounds which appear to require mention. But, perhaps, it may be proper in this place to allude to another matter in which the Visitors cannot but feel interest. The Tablet upon Halley's Tomb,

in Lee Churchyard, had apparently received no repair since it was first erected. It had sustained injury, probably from the sinking of the ground, and the unequal dropping of the sides of the tomb; probably also from the strains to which it was exposed when it was taken down for the interment of my predecessor, Mr. Pond, in the same grave. On the last occasion of clearing off the moss from the inscription, I found the stone so much injured, that mere repair appeared hopeless. On my representing this circumstance to the Board of Admiralty, and representing also the public character of the tomb (the inscription is in Latin, and is such as belongs properly to a national monument), their Lordships immediately supplied the necessary funds for its restoration. In order to effect this, I commenced by taking a "rubbing" of the inscription, as a guide to be strictly followed by the masons in cutting the new stone; and the new engraving, in regard both to the excellencies of the inscription applying to Dr. Halley himself, and the faults of those applying to his descendants, is a rigorous copy of the old one.

II. Moveable Property.—I have nothing to mention requiring the notice of the Visitors. Very little alteration has been made to the chattels of the Observatory in any way.

III. Manuscripts.—The arrangement and binding of our manuscripts, especially of those which belonged to the Board of Longitude, will, I trust, be brought into better order when we are able to use our new Record Rooms. Up to the present time, however, nothing has been done.

The binding of the papers constantly accumulating is maintained in good order. A great many volumes have been bound in the present spring.

IV. Library.—No special addition has been made in the past year. The current Observations and other works of technical Astronomy are regularly added.

V. Astronomical Instruments.—On the Transit-Circle, I have only to remark that it is in perfect order, and continues to give the greatest satisfaction to all the observers.

At the instance of the Board of Trade, acting on this occasion through a Committee of the Royal Society, a model of this instrument (with the improvement of perforated cube, &c., introduced in the Cape Transit-Circle,) has been prepared for the Great

(5)

Exhibition at Paris. On collecting the sentiments of the Members of the Committee as regarded the dimensions of the model, and considering also the special points of construction which it was intended to explain, I concluded that on the one hand it was necessary to exhibit a full-sized model, in order to present to the eye the general magnitude and importance of the instrument ; but that on the other hand it was equally necessary to prepare sectional and working models on a smaller scale, in order to show its internal peculiarities. The apparatus, therefore, sent to Paris, consists of one large and four smaller models ; and the assemblage of the whole forms, as I conceive, an instructive series.

The Transit-Circle at the Observatory of the Cape of Good Hope (constructed generally on the pattern of that at Greenwich, with some improvements,) is mounted, and is, I believe, in full work. It seems to be quite satisfactory to Mr. Maclear.

The Reflex Zenith Tube is in general good order.

No alteration has been made in the Altazimuth.

The Barrel-Apparatus, for the register of transits by punctures produced by galvanic communication, has been in constant use without suffering injury except in the parts exposed to continual friction, which require occasional attention. The method of giving the time-second-signals from the Transit-Clock, which I described in my last Report, is found to be perfectly successful. The insulation of the touch-apparatus has sometimes failed in very damp weather ; but, when the sky has cleared, the moistened gutta percha has become dry and the insulation perfect, so speedily that very few transits have been lost.

The rest of the Galvanic Apparatus is, in most respects, in the same state as at the last meeting of the visitors. In the Galvanic Magnet for dropping the Time Signal Ball, it has been found desirable to guard against the risk of permanent magnetism, by causing the apparatus itself to reverse the poles of the battery at every drop of the ball. When arrangements were originally made for exhibiting the London currents upon the Transit-Clock needle, and for sending currents to and through London by the touch-apparatus of the Transit-Circle ; in order to avoid disturbing the ground, I so connected the wires by turn-plates that one of the wires of the barrel-apparatus was used for these purposes ; but with the increased facilities which I now possess for laying wires, I intend to make the barrel-apparatus-wires entirely independent of the others, preserving, however, the power of connecting the touch-apparatus with the London and foreign wires.

The North Equatoreal has remained deprived of the microscopes of its hour-circle since the last meeting of the Visitors. The reason is, that the divisions of the hour-circle have become nearly invisible, and the connexion of the hour-circle with the rest of the instrument is so intimate, that it appears difficult to remove it for regraduation; and I have been in some indecision as to the course which it will be best to follow.

The intention of attaching photographic apparatus to the East Equatoreal is for the present abandoned.

The old instruments remain as they were last year.

VI. Astronomical Observations.—The well-understood system of meridional observations of stars remains unaltered, each of the stars in the extended standard list being observed, if possible, twenty times in three years. The Moon is observed on the meridian at every opportunity, without exception. In the observation of planets, a slight relaxation has been made, which the increased number of those bodies rendered necessary. The small planets are not observed at all in the morning watch (from 3^h A.M. to daylight), and the large planets are not observed then except in company with the Moon. With this qualification, the Sun and Planets are observed on the meridian at every opportunity, except on Sundays.

The whole number of meridional observations from 1854, May 26 to 1855, May 15, is nearly as follows (an observation of two limbs, or a duplicate transit by eye and ear, and by touch-apparatus, being reckoned as two):—In the Transit Department; Transits, 4680; Observations of Collimators by means of the Transit-telescope, 302; Observations of Transit-wires by Reflexion, 302; Observations of one Collimator by the other, 52: In the Meridian-Circle Department; Observations of all kinds, 4565.

The intervals of Transit-wires have been determined by Collimator-observations (the wire-frame being turned in its cell 90°, so that the graduations of the circle could be made available) on 1854, June 27.

The errors of graduation of the circle have not been investigated afresh since the first examination after the mounting of the instrument. I am not perfectly satisfied with the values in use, and I propose to repeat the examination as soon as leisure can be found.

In the ordinary routine of Adjustment-observations (weekly comparisons of Transit-Collimators, daily observations of Collimators and of Transit-wires by Reflexion,

(7)

observations of Circumpolar Stars, weekly observations of Circle-Micrometers, daily observations of the horizontal Wire by Reflexion, observations of Stars by Reflexion) no change has been made.

The number of days on which γ Draconis has been observed with the Reflex Zenith Tube is 51.

With the Altazimuth, the number of days of complete observations of the Moon during 12 lunations is 178, or 14.8 per lunation, while with the Transit-Circle the number has been 97, or 8.1 per lunation. The sky has evidently been less favourable than usual; the failing has taken place principally in the Spring of the present year. Of the Altazimuth observations, 0 are on days when the Moon passed the meridian between 0^h and 1^h solar time, 2 between 1^h and 2^h, 4 between 2^h and 3^h, 3 between 21^h and 22^h, 2 between 22^h and 23^h, 2 between 23^h and 24^h. There are no observations on the meridian corresponding to these. The whole number of separate observations of the Moon and Stars with the Altazimuth is 878, and the whole number of observations of its Collimator is 604. The observations have been conducted exactly as in the last years.

No observations worth preservation have been made with the Equatoreals, and none with the Double-image-Micrometer.

VII. Reduction of Astronomical Observations.—I shall explain shortly how it has happened that a part of our most efficient force has been withdrawn for a time from Observatory computations; and when due allowance is made for this, it will, perhaps, appear that the position of our reductions is very satisfactory.

For Transits, the Clock Times of True Transits are formed to April 28; the Apparent Right Ascensions from Observation, to March 16; the Star-Corrections in Right Ascension are computed to the present time, but are not yet applied for 1855. For Circle Observations, the Concluded Circle Readings are formed to May 5, the Apparent Zenith Distances to April 14; the North Polar Distances to March 7, to which date the Star-Corrections are computed and applied.

The observations with the Reflex Zenith Tube are reduced, in respect of formation of equivalents, to the present time: the Zero Points for 1854 and 1855 are in course of computation.

With the Altazimuth, the Zenith Distances are completely reduced to March 8, and the Azimuths to January 13: the Tabular Computations of Zenith Distance and

Azimuth are complete to February 10; and the Conversion of Errors of Zenith Distance and Azimuth into Errors of R.A. and N.P.D., to January 13.

For 1854, the Ledgers of Star-Places in R.A. and N.P.D. are finished, but the Catalogue is not commenced. The Observed Places of the Sun, Moon, and Planets are compared with the Tabular Places in R.A. and N.P.D., but no further deductions are founded on the comparisons.

The Star Places in the separate Catalogues, for the years from 1848 to 1853, are collected in proper sheets, and operations are now going on for incorporating them in a new grand catalogue, of which the epoch will be 1850.

The following remarks on the result of the reductions may not be without interest.

During the whole time of which I have spoken, the galvanic-contact method has been employed for transits, with the exception of a few days, when the galvanic apparatus was out of order. From the clock-errors, I have deduced the personal equations of the observers in our usual way; not by making special experiments, in which I have very little confidence, but by taking the transits as we find them, and discussing them on the supposition that the clock-rate has been very steady; a supposition in the adoption of which we are amply justified by the comparison of the clock-errors. The result is, that the magnitude of the personal equations in the galvanic-touch-method is not above half of that in the eye-and-ear method.

In former communications to the Visitors, I have alluded to the constancy of relation between the azimuths of the Transit-Circle and of the Collimators, while all seem to change with respect to the heavens. Other instances of the same thing have occurred from time to time, and have left upon the minds of the computers the impression that there is a real change in the position of the ground. I need not remark that such a conclusion can be received as valid only after very careful and complete discussion.

The fluctuations in the Azimuthal Zero of the Altazimuth are still larger than I could wish; while, at the same time, the readings for the Collimator are very consistent. Whether this arises from any shift of the ground, or whether it is produced by an injurious effect of the friction-wheels, (which would be more likely to produce an effect on the azimuths of a celestial body than on those of a Collimator, because in the observation of a celestial body the telescope must be kept in vertical movement, which may induce horizontal strains on the friction-wheels,) I cannot at present pronounce.

VIII. Printing of Astronomical Observations.—The activity of printing, to which I alluded in my last Report, was kept up sufficiently long to bring the volumes in press to their usual state, and the work now goes on nearly with its normal speed. Since the last meeting, the volumes for 1852 and 1853 have been completed and circulated. For 1854 the Transits are printed to June 29, the Circle Observations to April 18, the Altazimuth Azimuths to November 9, and the Altazimuth Zenith Distances to September 9. Several additional sheets have been read but not revised.

The manuscript of other parts of the volume is either in the printer's hands or in preparation.

IX. Magnetical and Meteorological Instruments.—No alteration has been made in these, and no addition, except that a number of thick glass plates have been procured for pressing the photographic sheets upon the photographic paper which is to receive a negative copy.

X. Magnetical and Meteorological Observations.—The system continues unaltered. For the three magnetic elements, and for the barometer and the dry and wet thermometers, eye-observations are made three or four times a day, and these serve as zeros both in time and in measure for the curves formed by continuous self-registration on the photographic sheets. The magnetic dip, and the vibrations and deflexions for absolute magnetic force, are observed by the eye. Thermometers suspended in the water of the Thames are read by Captain Sanders, R.N. Whewell's and Osler's anemometers register the wind and the rain.

XI. Reduction of Magnetical and Meteorological Observations.—In regard to the eye-observations; the equivalents for declination-observations in subdivisions of degrees, and those for horizontal-force-observations in parts of the whole horizontal force, are completed to the present time; the former are reduced to Western Declination to the end of 1854. The equivalents for vertical-force-observations are complete to the end of 1854. The Dips and Deflexions are not completed beyond the end of 1853. The daily meteorological observations are completed to the present time.

The Photographic Sheets for the Declination, Horizontal Force, and Vertical Force, are completely reduced, furnished with time-scales and measure-scales, &c., to the end of 1854. The Barometer base-line, however, is completed only to 1854, April 30.

I have not yet felt sufficiently satisfied with any proposed method of discussing the magnetic results to devote any time to their further treatment.

c

XII. Printing of Magnetical and Meteorological Observations.—No part of the Observations of 1854 is printed. The manuscript of the Declination and Horizontal Force, as read from the photographic sheets, is very nearly ready : that for Vertical Force is not commenced, and till this is ready the other parts cannot be placed in the printer's hands. The Meteorological manuscript is ready for press.

In the process of photographic multiplication of copies of the photographic sheets, the following steps have been made. As regards the sheets of Declination and Horizontal Force, the primaries are waxed from the beginning of 1854 to 1854, July ; two copies of negative and inverted secondaries, for every sheet, are formed to May 31 ; and positive and erect tertiaries are formed to the number of about 250 for the months of January and February 1854. As regards the sheets of Vertical Force and Barometer, the primaries are waxed to the end of February, and duplicate secondaries are formed to the end of January, but no tertiaries. The sheets required much revision.

XIII. Chronometers, Communication of Time, and Operations for Longitude.—The number of Chronometers now on hand is about sixty : twenty of these being on trial for purchase. They are compared, some every day and some every week, and occasionally in extreme temperatures ; the repairs of those which belong to the Government are managed ; and weekly reports of rates, and monthly reports of repairs, are made to the Admiralty.

The system of Galvanic Normal Clock and Sympathetic Clocks is in the state described in the last year's Report ; with this difference only, that the wires to the clock at the Hospital Schools, instead of being suspended across the Park, are carried underground. The clock at the London Bridge Station is made to distribute the galvanic hourly signals to the Electric Telegraph Company's wires and to the different branches of the South-Eastern Railway wires.

The Time-Signal Ball at Deal was brought into regular use at the beginning of the present year. In a short time, however, its action was interrupted, partly by derangement of the apparatus, and partly by the severity of the weather, which froze the sulphuric acid to the state of jelly. I sent an Assistant and workman to put it in order, and since that time it has generally acted very well. Since March 2 there have been three failures ; one of these arose from the Ball hanging on the clips, which were not properly oiled, and one from the turning off of the current on the Railway line ; the cause of the third has not been traced out with certainty. The success or failure of the drop is known immediately at Greenwich ; as the Deal Ball, at the termination of its fall, so alters the connexions of wires that a signal is sent to the Observatory. A register

is kept in a prescribed form in the Ball-Tower at Deal, and copies of this are sent to the Observatory, leaf by leaf, as soon as they are filled. These cautions I consider to be absolutely necessary for maintaining the regular action of the mechanism under rather difficult circumstances. The whole system is so successful that I have no hesitation in recommending its extension to the Government.

Application has been made to me from one of the important offices of Government, for the galvanic regulation of their clocks. On considering the risks to which various galvanic communications are liable, and the financial necessity for occupying wires as little as possible, I perceived that it was necessary to devise constructions which should satisfy the following conditions. First, that a current sent once a-day should suffice for adjusting the clock, even if it had gone ten or more seconds wrong. Secondly, that an occasional failure of the current should not stop the clock. I have arranged constructions which possess these characters, and the artist (Mr. C. Shepherd) is now engaged in preparing estimates of the expense. I think it likely that this may prove to be the beginning of a very extensive system of clock regulation.

The details of the operation for determining the longitude of Brussels Observatory are published in the Memoirs of the Royal Astronomical Society.

At the last meeting of the Visitors, M. Faye was present at Greenwich, having come as the representative of M. Le Verrier, to conduct the first part of the Transits and Galvanic Signals, by which our difference of longitude with Paris was to be determined. Mr. Dunkin, at the same time, had gone to Paris. After finishing that series of Observations, M. Faye returned to Paris, and Mr. Dunkin to Greenwich, and the second series was completed in a similar manner. The whole number of days of signal-transmission was eighteen, and the whole number of signals transmitted was 2,530. The number of days considered available for longitude, in consequence of Transits of Stars having been observed at both Observatories, was twelve; and the number of Signals was 1,703. Very great care was taken on both sides, for the adjustments of the instruments. The resulting difference of longitude, $9^m. 20^s. 63$, is probably very accurate. It is less by nearly 1^s of time than that determined in 1825 by Rocket-signals, under the superintendence of Sir John Herschel and Colonel Sabine.

The time occupied by the passage of the galvanic current appears to be $\frac{1}{12}$ of a second.

No other operation has been undertaken for determination of longitude.

XIV. Personal Establishment.—The number of Assistants remains unvaried, and only one name has been altered, Mr. Todd having undertaken the charge of the

colonial telegraphic establishment at Adelaide, and being succeeded here by Mr. G. S. Criswick (formerly supernumerary computer in this Observatory, and lately Assistant in the Cambridge Observatory). The actual list is: First Assistant, Rev. R. Main; Astronomical Assistants, Mr. Henry, Mr. Dunkin, Mr. Breen, Mr. Ellis, Mr. Criswick; Magnetical and Meteorological Assistants, Mr. Glaisher, Mr. Downs.

Mr. Henry takes general charge of the Transit-Circle and of Chronometers, Mr. Dunkin of the Altazimuth; Mr. Breen has a general supervision of calculation and printing, and controls the supernumerary computers; Mr. Ellis and Mr. Criswick are charged with all galvanic adjustments, and with attention to the Barrel-Apparatus for register of transits by galvanic touch.

Four supernumeraries are at present employed in the Astronomical Department, and three in the Magnetical and Meteorological Department. In the normal state of the Observatory, neither Mr. Breen nor the supernumerary computers in the Astronomical Department are required to make observations; but in the pressures which have lately fallen upon us, it has been necessary frequently to rely on the assistance of the supernumeraries for maintaining due regularity in the observations. And in the original appropriation of supernumeraries to the Magnetic and Meteorological Department, it was intended that their services should be mainly confined to writing and computing; but it has been found expedient to employ them in the chemical and photographic operations, especially in those of multiplying copies of photographs.

There are also attached to the Observatory, by appointment or by custom, a labourer, a gate-porter, a night-watchman, and a carpenter, who superintends workmen.

XV. Extraneous Works.—The most serious work, not included in the general business of the Observatory, which has partly occupied the personal strength of the Establishment during the last year, is a series of Pendulum Experiments undertaken in the Harton Colliery, for ascertaining the variation of gravity on descending to the bottom of a deep mine. It is not necessary for me to describe at length the laborious but unsuccessful attempts made by two Members of this Board and myself nearly thirty years ago for the same purpose. It will be sufficient to state that, in the last summer and autumn, finding several circumstances favourable for again attempting the experiment, and supported by a grant of money from the Admiralty which defrayed the greater part of the incidental expenses, I borrowed the necessary apparatus from the Royal Society, and sought and obtained personal assistance from the Observatories of Cambridge, Oxford, Durham, and Red Hill. Two Observers (Messrs. Dunkin and Ellis) were sent from this Observatory. The experiments occupied about a month. The abstraction of so much valuable strength from the establishments which I have mentioned must have

been strongly felt; but I trust that it will be recompensed by the understanding that the experiments appear to have been in every point successful, showing beyond doubt that gravity is increased at the depth of 1,260 feet by $\frac{1}{19000}$ part. I trust also that this combination may prove a valuable precedent for future associations of the different Observatories of the kingdom, when objects requiring extensive personal organization shall present themselves.

No other extraordinary work has been performed beyond the occasional undertaking of investigations or furnishing of copies of observations for which strangers have made application.

I have commenced examination of observations and preparation of skeleton forms for the extension of Lunar Reductions.

XVI.—General Remarks.—A fair examination of the statements already made will show how much our real disposable force has been weakened, by accidental circumstances, during the last year. Two Assistants were absent for a month on the Pendulum expedition, and the whole of the extensive calculations which followed were made in the Observatory. One Assistant was employed for some time at Deal, another being at the same time partially occupied in London. The longitude of Paris required the absence of an Assistant for some weeks, and threw a great mass of calculation upon us. For mounting the Model of the Transit-Circle at the Exhibition in Paris, one Assistant has been employed in Paris (with four workmen) for a month. It is under these pressures that I have been obliged to require the assistance of supernumeraries for observations—an assistance which I have been compelled to purchase by the sacrifice of part of their time, otherwise available for computation.

At the same time, I view the progress of our ordinary work cheerfully. We have effectually maintained the mastery over it, and, if no special cause interrupts us, we shall in a few months have brought everything to the most forward condition in which it is practicable to keep it.

For the rest, the general policy of the Astronomical Observatory has been the same as during the last twenty years; to leave the Equatoreal and Scrutinizing Departments of Astronomy to other Observatories, but to spare no expense in instruments, no pains in observation, and no labour in reduction, on standard meridional observations generally, and on meridional and extrameridional observations of the Moon in particular. And I would fain hope that the Greenwich Observations have assumed such a shape, that the Astronomer who may desire to find fundamental determinations of the Sun's path, of the places of an extensive Catalogue of Stars, and of the varying positions of

(14)

all the moving bodies of the Solar System, presented in the utmost extent and fulness and accuracy, may meet with all that he desires in those volumes.

Of the Magnetical and Meteorological Observations I cannot make the same assertion; but this is not caused by any defect in the instruments or observations. I would willingly believe that these are at least as complete and as accurate as those of any Observatory in the world. But after having obtained the immediate results of observation with the utmost completeness and exactitude, we are absolutely stopped from making further progress by the total absence of even empirical theory. Whenever any extended view of the cosmical causes or laws of magnetism and meteorology shall render an accurate discussion of observations practicable and useful, the Magnetical and Meteorological Observations made at Greenwich, I am confident, will be found to present such materials for the discussion as can scarcely be obtained from any other Observatory.

G. B. AIRY.

*Royal Observatory, Greenwich,
1855, May 19.*