

REPORT OF THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS,

Read at the Annual Visitation of the Royal Observatory, Greenwich, 1847, June 5.

THE Report on the State of the Royal Observatory, and the Proceedings during the last year, which I have now the honour to lay before the Board of Visitors, is arranged in the form which the experience of several years has shewn to be convenient.

1. Grounds and Buildings.—In the last Report to the Visitors, I adverted to a porch for the Magnetic Observatory, then in progress of construction. This porch was finished a short time after the last Visitation, and has been found to be a convenient addition to the Magnetic Building.

Besides this, no addition has been made to the buildings, and no alteration of the most trifling importance, except in the erection of a small wood-built and copper-fastened room attached to the north side of the Dip-house, now nearly completed. This room is intended for the reception of the Magnetic Theodolite; it being intended that a magnet, whose absolute declination is to be observed, shall be mounted (when required for use) in the adjoining Dip-house. I have undertaken the arrangement of the declination-apparatus in this form principally in deference to the strongly-expressed opinion of several of the magnetic observers who were present at the Magnetic Congress held at Cambridge: for my experience of the steadiness of neutral point of the torsion-circle in our magnet-suspension, warrants me in the belief that no important error has resulted from the use of the same magnet for absolute determinations and for occasional changes of declination.

The erection denominated the New South Dome, built on the walls of the ancient Advanced Building, has now, by the mounting of the Altitude and Azimuth Instrument, come into practical use; and it has been found to be generally convenient and well adapted to its purpose. The dome-shutters move very well; and the dome itself revolves so easily that it has been found necessary to attach an apparatus for stopping it in any required position.

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The Map of the Grounds and Buildings is now completed, exhibiting the state of the Observatory in December, 1846. A small map (reduced from the larger one) has been lithographed, and will be published in the Observations for 1845.

At the last Visitation of the Observatory, the attention of the Board of Visitors was called, by the Lords Commissioners of the Admiralty and by myself, to the plans then in agitation for the construction of a Railway to pass in a tunnel through the lower part of Greenwich Park. The formal history of the proceedings connected with this proposal, subsequent to the meeting of the Visitors, is, I believe, as follows. The Board of Admiralty, on consideration of the opinions laid before them, retracted the permission given to the Railway Company to prosecute their works through the Park; and the Legislature sanctioned a line, passing round the south side of Blackheath, and gaining the valley of the Thames by a tunnel under the neck of land which connects Blackheath with the heights that extend to Shooter's Hill. The first shaft for excavating this tunnel has very lately been sunk, on the Charlton road.

2. Moveable Property.—Our moveable property is entirely at home, with the following exceptions :—

One Journeyman Clock, and one Bar-Magnet—lent to the Observatory of Kew.

One volume of sheets of the Osler's Self-registering Anemometer (1842)—lent to Mr. Osler.

Two books, Reich's Experiments on the Density of the Earth, and Reich's Experiments on Falling Bodies—lent to Colonel Sabine.

A copy of Piazzi's Catalogue, 1814—lent to the Observatory of Durham.

Two Chronometers, by Massey, for measuring small portions of time—delivered, by instruction from the Admiralty, to Sir James South.

A Bar-Magnet—lent to Charles Brooke, Esq., for experiments on photographic self-registering magnetic apparatus.

I have the gratification of announcing to the Visitors that a very valuable present has been made to the Observatory. In the summer of last year it was notified to me by the Rev. Charles Turnor (in the first instance through Captain Smyth, R.N.), that he was desirous of presenting to the Royal Observatory an excellent clock, made by Mudge and Dutton. No present could be more acceptable to me, more especially at a time when I was contemplating the speedy mounting of a new instrument. I lost no time in stating this to Mr. Turnor; and the clock was very soon brought to the Observatory, and there mounted, without any expense to the Observatory. It appears to be going extremely well. I am confident that the Visitors will with me appreciate not only the value of the present, but also the manner in which it was made.

3. Manuscripts.—I have no special remark to make under this head. Care is taken for

the preservation and arrangement of original correspondence and original observations and computations of all kinds.

Attention is given, when opportunity offers, to the arrangement of Mr. Pond's papers; and the manuscripts of the Board of Longitude are still kept in sight.

4. Library.—The number of books added to the Library in the last year is not great; the usual attention, however, has been given to the subjects of Astronomy, Magnetism, and Meteorology. The books are classed and catalogued with the same regularity as in former years.

5. Instruments.—The Meridional Instruments (Transit, Circles, and Zenith Tube) and the Equatoreals (North-East or Shuckburgh's, and South-East or Sheepshanks') are in perfectly good order.

It is known to the Visitors that the Transit Instrument has been used (for many years I believe) without counterpoises of any kind; its whole weight resting upon its steel pivots. The mention of this practice excites much wonder among foreign astronomers, who conceive that such a continued bearing must necessarily injure the pivots, and who sometimes counterpoise their instruments within a few ounces. I am able to state, from regular and continued examination of these pivots, that they are not injured in the least, and that (strange as it may seem) they are apparently improved: some dark blotches, which apparently had been caused before the year 1835, by leaving the instrument too frequently in one position, having nearly disappeared. No irregularity of form is discoverable by the spirit-levels; but, as this trial does not negative the possibility of an oval shape, I cannot vouch further for their accuracy. The construction of their Y's does not admit of the application of a microscope in the way to which I shall shortly allude.

Troughton's Circle only has been used, and has been used with a micrometer-wire only, and without a fixed wire. The eye-piece for viewing the wires by reflexion has been occasionally used; the zenith-point which it gives agrees now nearly with that obtained from stars. This renders it probable that the discordance observed last year arose merely from an error of division; and it seems to shew that it is not so safe to rely upon observations of reflected wires as upon reflexion-observations of stars. The zenith points, deduced from north stars and from south stars, now agree very well.

The Zenith Tube is in good order. It seems so doubtful whether there really is any advantage in the continued use of this instrument (the irregularities of result, in some even of the late years, exceeding those of the Mural Circles) that, under the increased pressure of our general business, it may be prudent to contemplate laying it out of the system of ordinary observations.

The North-East Equatoreal requires no special remark.

The South-East Equatoreal (mounted in a form very nearly resembling that of the German Equatoreals) is in its usual condition. I believe that every person in the Obser-

vatory who has had the experience of an instrument like Shuckburgh's is heartily tired of this. The failure of slow-motion screws acting at so small a radius, and the impossibility of reading the circles accurately, are the principal difficulties. The clock-work, micro-meters, &c., are efficient.

The mounting of the North-West Equatoreal was sent to the Cape of Good Hope in the last summer.

The Altitude and Azimuth Instrument has been completed several weeks. This instrument has been constructed entirely in conformity with the principles which I explained to the Visitors at their meeting of 1843, November 10; the leading points of which are:—to construct the instrument in as few parts as possible (the bodies of the microscopes and the supports of the levels being cast in the same piece with the large parts of the frame that carry them); to make no connexion of important parts by small screws; and to have no adjusting screws whatever. The lower pivot rests upon the lower fixed circle, which is supported by three iron blocks on the pier. For the upper pivot, a support is thus constructed: below the floor, an iron triangle is based upon a three-rayed brick pier; upon each side of this triangle, a nearly vertical triangle is erected; the three upper points of these triangles are connected by a horizontal triangle; and the Y for the upper pivot is carried by the junction of three rods (which with the Y are all welded together) that are drawn by powerful screws to the angles of the upper triangle. This support of the revolving frame is exceedingly firm. The engineers' work (Messrs. Ransome and May's) is of the best quality: the casts are good and the fittings are close. The instrument-maker's work (Mr. Simms') is equally good. When it was necessary for me to decide on the method of graduating the circles, I adopted, without hesitation, the graduation by Mr. Simms' dividing engine, the principles of construction of which I regard as eminently judicious. When the instrument was mounted, and before the small parts were attached, my first care was to examine the graduations. This was done by a most careful process (many times repeated) of bisection and trisection, and the error of every 5° was ascertained. In no instance is the mean of the four microscopes of either circle half a second in error. I have in readiness the necessary apparatus for examining every division, but I shall probably not apply it without ground of suspicion, inasmuch as the construction of Mr. Simms' dividing engine gives great security for the accurate subdivision of small arcs. I have examined most severely the form of the pivots of the horizontal axis, by means of two micrometer-microscopes (attached by large cocks to the vertical revolving frame), which are used to view points planted upon the ends of the pivots, and by means of which (placing their micrometers alternately horizontal and vertical) the motions of the points are completely defined. The horizontal and vertical motions which are observed during a complete revolution of the vertical circle are cleared of micrometer-zero and excentricity of dot by an easy algebraical process, and then there remains only the effect of irregularity. This

does not amount to half a second. I think it extremely creditable to the engineers that pivots which have not been touched by the tool of the instrument-maker should possess this accuracy. The engineers' process was particularly directed to making the pivots uniform of size in the different parts of their length; and I have no doubt of their perfect success in this. I attach great importance to the accuracy of these pivots, because it is the only maker's adjustment, in the whole instrument, of which the faults are not detected in the course of ordinary observation. No sensible variation is found in the position which the pivot takes as the circle is turned forwards or backwards. The level-scales have been determined by ourselves, with the aid of our mural circle (a level-prover lent by Mr. Simms having completely failed). In short, I am now possessed of an instrument of the firmest and best mechanical construction, in which all the parts subservient to measures have been examined by myself; and I have no doubt of accomplishing the difficult object to which I addressed myself, of making observations out of the meridian as accurate as observations in the meridian.

The ancient instruments remain in their former state. The small instruments and detached telescopes are in good order.

The three great Magnetometers are in the same general state as at the last Visitation. Preparations, however, are in progress, under the direction of Charles Brooke, Esq., for making these Magnetometers self-registering, by a photographic process. From the specimens furnished by Mr. Brooke, and from the facility with which one of the junior assistants (Mr. Humphreys) has acquired the command of the photographic part, I am satisfied of the practicability of this plan.

A small magnet, with collimator, has been lent to us by Colonel Sabine, for use in the Dip-house, in conjunction with the Theodolite when in the new adjoining house, for absolute determinations of declination; and a micrometer-telescope has been prepared for mounting in the Magnetic Observatory, in conjunction with the declination-magnetometer. But neither is yet brought into use.

The deflexion apparatus and vibrating magnet are in good order. One dipping-needle is under repair.

In alluding to the magnets, I think it proper to state that at the beginning of the present year a series of very careful observations was made for the determination of the temperature-correction of the Force-Magnetometers; and that, while it was found that the former determination was generally correct, it was also established beyond doubt that a modification of the received law is necessary. It is certain that the diminution of magnetic power for each degree of the mercurial thermometer is considerably greater at high temperatures than at low ones.

The Barometers and the Thermometers of all kinds (with the exception of one Radiation Thermometer, now under repair) are in good order. The deepest of the thermometers

sunk in the ground has nearly reached the level of reversed seasons : its maximum (uncorrected) reading occurring in December, and its minimum in June ; its range is about 4° .

The Osler's Anemometer is in fair working order. The Whewell's Anemometer is under repair.

The Electrical Apparatus and the Actinometer are in good order.

6. Observations.—No important change has been made in the plan of meridional observations. The Nautical Almanac Stars are observed, if possible, twenty times in any three successive years. The other star-observations have been directed to Stars of which one element was wanting in previous observations : Moon-culminating Stars ; Occultation Stars ; and small Stars that have been compared with Comets. The Sun, Moon, and Planets, are observed at all hours when they are visible on the meridian ; and on all days, except Sunday (when the Moon alone, with necessary stars, is observed), and except a monthly holiday. There has been great difficulty in obtaining the slightest glimpse of Astræa.

The Equatorials have been used for occultations, for phænomena of Jupiter's satellites, for transits of the Moon's diameter, and for observations of Neptune, of De Vico's fifth Comet, and of Hind's second Comet. In addition to these occasional objects, Shuckburgh's Equatorial is employed on a special object. It was announced last year by M. Faye (of the Paris Observatory), that there was reason to think that the star Groombridge 1830, which was known to have enormous proper motion, has also sensible parallax. I, therefore, determined on observing the star, in reference to this question, for at least a year ; and, a convenient comparison-star within micrometer-range having been found, the two stars have been observed with the North-East Equatorial since the beginning of this year with great regularity. No results can yet be deduced.

The double-image Micrometer has been used for measures of the planets and of γ Virginis. It may be mentioned as one result of the former, which is almost free from doubt, that the ellipticity of Jupiter is found to be considerably less than that determined by Struve some years ago (Mem. Ast. Soc., vol. iii.). It is proper to add that our measures have been made with an instrument moved by clock-work, and that Struve had not for his measures the advantage of clock-work movement.

The Zenith-tube has been used at every opportunity for γ Draconis. It has lately been the practice to observe the star at the same time with the Mural Circle.

The Altitude and Azimuth Instrument was brought into use at the beginning of the present lunation. Intensely cloudy weather prevented the observation of the Moon when one day old ; but she was observed when two days old. The very bad weather when the Moon was young, and the very fine weather from her first quarter, are exceedingly unfavourable for displaying the advantages of an extra-meridional instrument. The following list of days, however, will shew what has been done :—

(7)

Days of Observation with the
Altitude and Azimuth Instrument.

1847.... May 16

19

20

21

22

23

24

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26

27

28

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June 1

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4

Days of Observation with the
Meridional Instruments.

1847.

May 21

22

25

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27

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29

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31

June 1

2

The Magnetical and Meteorological Observations are continued with no alteration of plan. Two-hourly observations, day and night (except on Sundays), of all the principal instruments; six-hourly observations of the dew-point; two observations of the dip every week; a magnetical term-day and a meteorological term-day every month; deflexion-observations about once in six weeks, and vibration-observations about once in a fortnight. The self-registering thermometers in the air, for radiation, and in the Thames, and the anemometers and three rain-gauges, are read once in a day; one rain-gauge in the ground, and a similar rain-gauge in the garden of the Rev. G. Fisher, once a month. The continuance of the latter observations shews steadily the same fact: that while a depression of 50 feet, from the top of the highest building to the ground, nearly doubles the quantity of rain,—a depression of about 100 feet, from the ground at the top of the hill to the ground at the bottom of the hill, scarcely increases it in a sensible degree.

7. Reduction of Observations. — The following is the state of the Astronomical Reductions:—For 1846, the Apparent R.A. from Observations are formed only to the end of June; but, as the Clock-Errors and Rates are entered throughout, very little is necessary for the completion of the R.A. The Star Corrections to Mean R.A. are prepared nearly to the same time. No Mean Times are formed for 1846. The Circle Observations are entirely reduced to the stage of Apparent N.P.D. for 1846, and to that of Mean N.P.D.

of Stars to the end of May. The Zenith-Tube Observations are reduced partially to the end of the year, and entirely to July, 1846. No Equatoreal Observations are reduced, and no Occultations, &c. For the present year, 1847:—The instrumental corrections are applied, and the True Transits formed, to the present time; and the Clock-Errors and Clock-Rates are completed (but not applied) to within a few days of the present time. The Apparent Zenith Distances are completed to the end of April; the instrumental corrections are applied and the Zenith Points prepared to the end of May. I consider all these reductions as being in a most healthy state, which for years we have been struggling to reach. The Equatoreal Observations of Groombridge 1830 are partially reduced, and a beginning is made in the reduction of the observations with the Altitude and Azimuth Instrument.

In a late communication to the Royal Astronomical Society, I proposed a new form for the computation of Star-reductions, which would avoid the use of algebraical signs incidental to Bessel's method. I am at present making preparations for the introduction of this method for the calculations of the present year at the Royal Observatory.

The Reductions of the Magnetical and Meteorological Observations are in the following state:—The theodolite reading for the declination-magnet is formed to the present time, but converted into declination only to the end of 1846. The horizontal forces are reduced, and the vertical forces nearly reduced, to the present time. The term-day observations are reduced, some to the end of 1846 and some to the present time. The deflexion and vibration observations are partially reduced to the present time, but none completely reduced. The dip observations to the present time. The daily meteorological observations to the present time. The hygrometric calculations are not finished for 1845, though much advanced for 1846. The Magnetic Abstracts are complete for 1845, and nearly so for 1846: the Meteorological Abstracts are not complete for 1845, though far advanced for 1846. When a comparatively small quantity of back-work shall be brought up, the Reductions will be in a very satisfactory state.

8. Printing.—The Astronomical volume for 1845 is not yet completed, although very near its termination. This unusual circumstance has arisen principally from the mass of printing in the Account of the Operations for determining the Longitude of Valentia, which has much exceeded my expectations. Of the volume for 1846, two sheets are printed. The number of copies is 350.

The Magnetical and Meteorological volume for 1844 has been finished some time. Of the volume for 1845, twenty-six sheets are printed. The number of copies is 500.

The Printing is on the whole somewhat advanced; and I trust, as the printers' powers are increased, will yet advance more.

9. Chronometers.—The number of Chronometers during the last year has been nearly the average. At this time the number is large: in the present week the number rated was

117. The rating and reporting on these, the management of repairs, and other business relating to them, occupy a portion of our energies, for which the Observatory does not receive sufficient credit. I consider that, on the whole, the computing time of more than one assistant is absorbed in this work.

The Abstract of the Rates is printed, the manuscript Digest of Estimates is kept up, and the affairs of the Signal Ball are managed as in the last year.

10. Personal Establishment. — The following is the actual personal establishment:— First Assistant, Mr. Main. In the Astronomical Department, Mr. Henry, Mr. Ellis, Mr. Rogerson, Mr. Dunkin, Mr. H. Breen, Jun. In the Magnetical and Meteorological Department, Mr. Glaisher, Mr. Lovelace, Mr. Downs, Mr. Humphreys. Mr. H. Breen is considered as additional Assistant required in consequence of the mounting of the Altitude and Azimuth Instrument; and Mr. Humphreys is introduced in his place in the Magnetical Department; but neither of these appointments is yet formally recognized.

I have solicited from the Government authority to employ occasional Computers, to the amount of £180 per annum.

11. Reduction of Ancient Observations. — The printing of the Lunar Reductions has not advanced so rapidly as I could wish. The First Section (the Reductions of Transits) is completed to the end of 1808. The Second Section (the Reduction of Zenith Distances) to the middle of 1817. The Third Section (Comparison of Observed and Theoretical Places) to the end of 1802.

The deduction of the correction of elements from these reductions is essentially finished; and I defer the public exhibition of them only because they are liable to small corrections occasionally presenting themselves in the revision of the proof-sheets. The corrections of the epochs at different times are, however, scarcely subject to error. In the last summer, I had the pleasure of visiting Professor Hansen, at Gotha, and I was so fortunate as to exhibit these corrections to him, and strongly to call his attention to their certainty, the peculiarity of their fluctuations, and the necessity of seeking for some physical explanation. I have much pleasure in indulging in the thought, that it was mainly owing to this representation that Professor Hansen undertook that quest, which has terminated in the discovery of his two new lunar inequalities, the most remarkable discovery, I think, in Physical Astronomy.

12. General Remarks.—In the step lately taken by me, with the sanction and official assistance of the Visitors, for the erection of the Altitude and Azimuth Instrument, with the professed intention of securing, with whatever labour, observations of the Moon, whenever she can be seen, I conceive that an important indication is given of the nature of the objects to be followed in the future conduct of the Astronomical Department of the Observatory. The observations of the Moon (including, as a necessary part of them, the observation of the Sun and of a very considerable number of stars,) are the first object;

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next, in reference to the wants of science, come the regular observations of planets; and below these, the observation of extensive catalogues of stars, the observation of Comets, &c., and the measures of double stars, &c. I am confident that this general plan is justified by the history of the Observatory, and by an examination of the present state of astronomical institutions. Greenwich Observatory was built mainly for observation of the Moon, and of stars regarded as accessories to Lunar observations; and at Greenwich Observatory alone can a continuous series of observations of the Moon be found. Planets are now observed at other observatories more extensively than they were a few years ago; but, unless when the interest of observers is stimulated by the discovery of a new planet, they are scarcely observed, except at Greenwich, in the transits of early morning. Extensive catalogues of stars are observed at Oxford, at Hamburg, and many other places. Comets are well observed at some public observatories and at many private ones: and the instruments in the last-mentioned establishments are now so good, and the methods of observing and reducing in several of them are so accurate, that it is almost lost labour to repeat these observations at Greenwich Observatory. Double stars are followed as the most important objects of the Cambridge and Pulkowa Observatories.

In discriminating between the degrees of importance which I am inclined to ascribe to the different classes of observations, it will not, I trust, be supposed that I wish absolutely to neglect any. But where want of power, or any other cause, shall make it impossible for us to follow all completely, I wish to establish a rule as to the class of observations which is to be secured at every risk.

Other observations will be required, from time to time, in connexion with the observations made in other scientific operations, either under the direction of our Government or in foreign countries; and these must claim our careful attention.

The mere observations, however, are but a trifling part of the labours of an observatory occupying a position like that of the Greenwich Observatory. The observations must be reduced, promptly, completely, on a uniform system, and with the utmost exactness. And the observations and reductions must then be printed, in sufficient fulness to permit the verification of every part.

Occasional employments, suggested by the wants of Government, or of the scientific institutions of Government, will occasionally require the abstraction of a small part of my own time. At present, however, I have no engagement of this kind, except in the preparation for press of a portion of the operations of the Cape Survey.

The selection of classes of observation which I have indicated guides me in the proposals which I submit to the Visitors, regarding the selection of instruments. In explanation, I beg leave to recall to the Visitors, that since their last meeting an offer was made to me, by the agents of M. Lerebours, of the largest refracting telescope in existence, and that I thought it my duty to communicate this offer to the President of the Board. I now state

that, however flattering it might be to our feelings that we could claim as our own the finest telescope in the world, I do not recommend such a purchase. Setting aside all considerations of expense, locality, &c., it would, by the distraction of our attention, seriously endanger our success in the plan of operations which I have described. On the other hand, I think it worthy the careful consideration of the Visitors, whether meridional instruments carrying larger telescopes should not be substituted for those which we possess. Whatever we do, we ought to do well. Our present instruments were, at the time of their erection, the best in the world; but they are not so now: and we actually feel this in our observations. It is with the utmost difficulty that we have observed *Astræa* a few times, though she has been observed repeatedly on the Continent. We frequently are unable to observe, on the meridian, stars which have been compared with Comets in equatorial observations.

I have no special remark to make in reference to the Magnetical and Meteorological Department. At the next Visitation it will be necessary for the Visitors seriously to consider the course to be recommended for its future maintenance.

I propose these subjects entirely in deference to the judgment of the Visitors, and with the full assurance that if they are worthy of consideration they will be duly entertained by them. The experience of nearly twelve years has taught me to rely fully upon the prudence and liberality of the Government, upon the support of the Visitors, and upon the zeal and activity of my Assistants; and I should be unwilling to press upon either of these bodies any proposal which was not almost anticipated by themselves.

G. B. AIRY.

*Royal Observatory, Greenwich,
1847, June 5.*