

# REPORT OF THE ASTRONOMER ROYAL

TO THE

## BOARD OF VISITORS,

*Read at the Annual Visitation of the Royal Observatory, Greenwich, 1846, June 6.*

I BEG leave to present my Annual Report to the Board of Visitors in the same form in which it has been offered to them for several years past.

1. Grounds and Buildings.—In regard to the Buildings of the Royal Observatory, very little alteration has been made in the last year. The external walls, coverings, and fences, remain in every respect in their former state. A few internal alterations have been made. A shed, which was built a few years since in the place that then appeared to be the cheapest for its purpose, has now been removed to a place which is much more convenient. The rails of my private garden have been shifted so as to inclose a narrow strip of broken ground which was never used for observations of any kind. The want of additional shelves becoming pressing, a considerable extent of slate shelves has been erected in the Safe Room, and of wooden shelves in the rooms under the New South Dome and in the Magnetic Building. At the present time a porch for the Magnetic Building is in the course of construction.

The Map of the Grounds and Buildings, to which allusion has formerly been made, having been long delayed by the illness and ultimate death of Mr. R. Harris, has been taken up by Mr. James Breen (one of the Computers usually employed on the Lunar Reductions), and is now nearly ready for engraving.

In regard to matters external to the Observatory Inclosure, although no step has been taken affecting the material walls and grounds surrounding us, yet discussions of a very important character have been for some time going forward which it is proper for me to lay before the Visitors. One of the railways proposed for the accommodation of the northern parts of Kent, promoted by the South Eastern Railway Company, is designed to pass through the lower part of Greenwich Park in a tunnel at a distance between 800 feet and 900 feet from the observing rooms of the Royal Observatory. Experiments were made by

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me in the spring of the present year to determine the probable effect of such a railway, more especially in regard to the sedative effect of the small covering of earth above the tunnel. Experiments on the general effect of a railway had been made by me about ten years since. The results of these experiments, though not very distinct, are yet, in my opinion, sufficiently distinct to enable us to decide on the course proper to be pursued in relation to the proposed railway through the Park. The experiments of every kind have been communicated to the Admiralty, and by that Department arrangements were made with the South Eastern Railway Company to the following effect (as is understood from the public newspapers), that the Lords Commissioners of the Admiralty consented to the passage of the Railway through the Park, on the introduction of a clause in the Railway Bill authorizing their Lordships from time to time to establish regulations for the speed and weight of the trains passing through the Park, or, if necessary, to stop the traffic entirely. With this understanding, the Bill received the sanction of the Railway Committee to whom it had been referred. Its progress through the House of Commons has, however, been for the present suspended; and I believe that the House of Commons have, by Order of the House, required the production of all papers illustrating the probable effect of the Railway upon the Observatory.

2. Moveable Property.—One of our journeyman clocks has been lent to the Observatory of Kew for use, and one magnet for experiments on the practicability of introducing self-registering apparatus for magnetometers. With these exceptions the whole of the moveable property belonging to the Royal Observatory is at home and in good order.

3. Manuscripts.—The manuscripts of Bradley's Observations, to which allusion has been made in the two last Reports, have now been returned to the University of Oxford, having been completely and accurately copied, with the exception of some papers of mere scribbling which could not be interpreted: and we have now a complete copy of every trustworthy observation made at the Royal Observatory since its foundation. I am confident that the Visitors will estimate, at the same value at which I do myself, the courtesy and the readiness to meet my views which have throughout been displayed by Dr. Wynter, Vice-Chancellor of the University, when the first application was made by me; by Dr. Bliss, Registrar of the University; and by Dr. Bandinel, Principal Librarian of the Bodleian Library, in whose custody the manuscripts were kept.

The manuscripts relating to the current operations of the Observatory, and also to the various business of different classes which are incidental to my own position, or on which the Government have a reasonable claim to my attention, accumulate now very rapidly. I consider it, therefore, an important matter to arrange for the temporary preservation of these papers in security and order by a peculiar method of stitching them together, and for their permanent preservation by binding. A large number of papers, forming about 40 volumes, have lately been bound.

No further step has been taken for the arrangement of the papers of the Board of Longitude.

4. Library.—I have no remark of importance to make in relation to the Library. In keeping it up, attention has been given to the subjects of Astronomy, Magnetism, and Meteorology; but the number of books added in the last year is small.

The usual care is given to the classifying and cataloguing the books. The Library is accessible, under simple regulations, to all the Assistants; and is producing a marked effect upon their education.

5. Instruments.—The large instruments used for standard observations, namely, the Transit, the Circles, the North-East and South-East Equatorials, and the Zenith Tube, are in good order.

Of the Circles, Troughton's only has been used, and in the same way as that described in last year's Report, namely, without a fixed wire, the observations being made entirely on the moveable micrometer-wire. The eye-piece for viewing the wires by reflexion has been frequently used: the observations hitherto made with it seem to indicate that it gives a zenith point differing about two-fifths of a second from that given by stars: this must be due to some accidental cause which will probably be detected in time. We cannot now discover any systematic difference between the results derived from direct-observations and those derived from reflexion-observations.

I learnt some months since from Mr. Maclear that much inconvenience was sustained at the Observatory of the Cape of Good Hope from the want of a polar axis capable of carrying a telescope belonging to that establishment. As the West Equatorial of this Observatory has been for many years totally useless, I requested and obtained the sanction of the Lords Commissioners of the Admiralty for dismounting it, and for making such small changes in it as might seem to adapt it better to the wants of the Cape Observatory. The instrument has accordingly been prepared, and is at this time lying in Mr. Simms's shop, ready to be sent at the first opportunity that may present itself. The small telescope only which was formerly carried by it is detained at this Observatory.

The preparation of the Altitude and Azimuth Instrument has been delayed by a singular accident. The parts cast by Messrs. Ransome and May, namely, the lower fixed circle, the vertical axis in four parts (two ends and two sides), and the vertical circle and telescope, had been sent to Mr. Simms, and several fittings of micrometers and other small parts had been adapted to them. Some levels also having been adapted, I was much surprised to find that the end of the telescope would not pass them, although the calculations of height, &c., had been expressly arranged in order to permit it to pass. On examination it appeared that, in attaching some small portions of the pattern to the principal parts, these portions had been attached on the wrong side of the hole for the horizontal axis, so that, in the casting, what was intended for the upper part of the vertical axis became the lower part. The engineers, upon

B 2

hearing of this mistake, immediately undertook to prepare new sides without expense to the Observatory, and with as little delay as possible ; but as the completion of these parts requires not only skilful casting but also careful turning and planing, there is necessarily considerable delay. I hope, however, to receive them in a short time. When Mr. Simms' portion of the work shall be attached, the instrument will immediately come into regular use : for not only are the plans of operation arranged, but even the skeleton forms for the calculations are printed.

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

The three principal Magnetometers, the Magnetic Theodolite, and the Dipping Needle, are in the same state as at the last Report, and are in good order. The deflexion apparatus has been fitted with small magnets of 6 inches length, and the advantage gained by this alteration is very great. In its general form, &c., the apparatus is in the same condition as formerly.

No new magnets have been introduced for the absolute determination of declination.

The Barometer, the Standard Thermometer, the Wet and Dry-bulb Thermometers, and the Thermometers suspended in the Thames from the Dreadnought Hospital Ship, are in good order. The Radiation Thermometers are at present deranged, but will shortly be restored to their usual state.

Since the last winter, four Thermometers have been fixed in the ground at a short distance south of the Magnetic Observatory. The centers of their bulbs are at the distances of 3, 6, 12, and 24 French feet respectively, below the surface of the ground. These thermometers were constructed by Messrs. Adie and Son, of Edinburgh, under the immediate superintendence of Professor J. D. Forbes, and the graduation was made entirely by Professor Forbes. Observations of their readings have been regularly made, but no deduction has yet been drawn from them.

The Osler's Anemometer and the Whewell's Anemometer are efficient and in good order.

Considerable attention has been given to the apparatus for exhibiting Atmospheric Electricity, and I believe that it is now, relatively to its local situation, nearly perfect. It is now a very rare circumstance indeed to find no electricity indicated by any of the electrometers. Nevertheless its indications are far less vigorous than those of the electrometer at the Kew Observatory. After making various experiments, I am convinced that this difference arises principally or entirely from the necessity of employing a great length of wire to conduct the electricity from the lamp which attracts it to the electrometer which exhibits its energy. This necessity is, in the circumstances of our magnetic observatory, unavoidable.

Attempts have been made by us, but unsuccessfully, to procure a self-formed register of the kind and tension of the electricity by the charge given to a plate of glass coated with wax.

The Galvanometer and the Induction Ball have been used with better success than in former years.

The Actinometer is in good order.

6. Observations.—The general character of the observations with the Meridional Instruments is the same as in the last years. Besides the stars of the Nautical Almanac List, of each of which, if possible, twenty observations are made in every contiguous three years [a rule that can scarcely be maintained with circumpolar stars that require corresponding observations of Polaris, &c.], there have been stars observed for completing the deficient element (R. A. or N. P. D.) in the Catalogue of 1439 Stars, and in the observations of 1842, 1843, 1844, 1845; Moon-culminating Stars of the Nautical Almanac Lists; Stars whose occultations have been observed; Stars observed in the Trigonometrical Survey; and Stars which have been compared with some of the numerous Comets of late years. The Sun, Moon, and Planets, are observed at all hours when they are visible on the meridian; the Moon alone, with the necessary adjuncts, being observed on Sundays.

The Equatorials have been used for occultations, for phenomena of Jupiter's satellites, for the late eclipse of the Sun, for transits of the Moon's diameter, for comparisons of Mars with Stars, and for observations of Colla's, or Wilmot's, and Biela's Comets, De Vico's third and fourth, and Brorsen's first and second, and of Astræa.

The double-image Micrometer has been employed in measures of the planets' diameters, and in observations of  $\gamma$  Virginis.

The Zenith-tube has been used at every opportunity for observation of  $\gamma$  Draconis.

The Magnetical and Meteorological observations have been observed on the same system as in the last two or three years. The three principal magnetometers, the barometer, the dry and wet thermometers, and the electrometers, are observed at every two hours of the day and night except on Sundays; the dew-point four times every day; the dip twice every week. Once in each month the magnetic observations are made at every five minutes, and once also the barometrical observations are made at every hour. The deflexion-observations are made at intervals of about a fortnight. Observations of simple vibration of a magnet, however, at intervals of a week, have been lately introduced, and I intend to diminish the frequency of observations of deflexion as soon as the success of this method shall be established. Osler's and Whewell's Anemometers, Crosley's and another Rain-gauge, and the thermometers in the Thames, are read every day; a rain-gauge sunk in the ground, once every month. At my request, the Rev. George Fisher has planted a similar rain-gauge in his garden at the bottom of the Greenwich Hill, and the observations made every month are communicated to me. Actinometer and extraordinary observations are made when circumstances seem to require them.

The standing adjustments of instruments, in relation to all these observations, have received great attention.

I entertain strong hopes that the efforts which several gentlemen are now making for the introduction of self-registering apparatus will at length enable us to make the whole of the night observations in the Magnetic and Meteorological Department automatic. This would tend materially to diminish the expenses of that department.

7. Reduction of Observations.—The following is the state of the Astronomical Reductions:—For 1845, the star observations are entirely reduced, and the means of the separate determinations are taken; but their incorporation in the form of a Catalogue is not quite completed. Every individual planetary observation is reduced, but the errors are not yet grouped. The Equatoreal observations of De Vico's Second Comet, D'Arrest's, Colla's, and Biela's, and of Astræa, are in different stages, but none greatly advanced. The Zenith-tube reductions are completed. The computation of occultations is not begun. For 1846, the True Times of Transit are cleared of instrumental errors to March 12, and are nearly finished to April 30: the clock-errors are not yet formed. The circle readings are cleared of all small corrections to June 1; the zenith points are formed to April 6, but are not applied. The Zenith-tube reductions are not commenced—the observations having been somewhat interrupted by observations for the value of the micrometer screws.

Perhaps this may be a proper place for stating that the system of reductions for the observations to be made with the Altitude and Azimuth Instrument has been thoroughly digested, and that in one respect a departure has been made from the method which I explained in a former Address to the Visitors: a departure which in itself may seem trivial, but which in the facility of operations which it produces is very important. It consists in referring the Moon's place, not to the center of the Earth, but to the point at which the Greenwich normal meets the Earth's axis. The consideration of angle of the vertical is thus entirely banished: a small correction only is required for the Moon's north polar distance, and a small correction to horizontal parallax. I am not aware that this method has ever been suggested before; and I consider it likely to give considerable facilities for reduction of observations of the Moon in general.

In regard to the reduction of Magnetic and Meteorological observations, I have to state to the Visitors that a great effort has been made, and is still made, to place the reductions in a satisfactory state. In the beginning of the existence of a new department, the reductions must necessarily be in arrear: and indeed in our Magnetical and Meteorological department, the personal establishment as first planned was not sufficient to keep up the computations. After a time, the establishment was increased to a scale sufficient perhaps to keep up the current work, but not sufficient to bring up the arrears. On my representing this to the Lords Commissioners of the Admiralty, their Lordships were pleased to sanction the employment of additional force; and the calculations are at present going on collaterally for three different years, 1844, 1845, and 1846. The state for each year is

nearly as follows:—For 1844, all the Magnetical Abstracts (except of the Dip) are in the printers' hands, and all the Meteorological Abstracts are very nearly ready for press. For 1845, the Daily and Term-day magnetic observations, and part of the Extraordinary observations, are completely reduced, the Daily observations to the end of May being in the printers' hands; the daily meteorological observations are prepared generally to October. A portion of the Abstracts, magnetic and meteorological, is prepared to June. For 1846 (excepting a short time at the beginning of the year), almost every part which can yet be done is finished to the end of April, and a portion to the end of May: in this statement are included those portions of the Abstracts which can be collected before the completion of the year.

8. Printing.—The Astronomical volume for 1844 has been finished some time since, and is distributed in the same manner as in the last year. Of the volume for 1845, six sheets are printed. The number of copies struck off is 350.

Of the Magnetical and Meteorological volume for 1844, ten sheets are printed. A greater advance would have been made, but for the necessity of again composing the five first sheets, in consequence of an uncertainty as to the number of copies required. The number now struck off is 500.

I expect that the printing of the Magnetical and Meteorological volume for 1845 will shortly be commenced.

9. Chronometers.—The number of Chronometers in the last year has been about the average. As before, they are usually compared twice each day, and their rates are reported to the Hydrographer. An Abstract of the Rates of Chronometers on Trial for Purchase is attached to each annual volume of Astronomical Observations.

The repairs of Government Chronometers are superintended by myself. A Digest of the sanctioned Estimates is kept in manuscript.

The Signal Ball is dropped by an Assistant at one o'clock precisely every day. Its fall is always observed by another Assistant. The error of time does not usually exceed one-tenth of a second, and does not amount to three-tenths of a second oftener than once in six weeks.

10. Personal Establishment.—The personal establishment now consists of the following gentlemen:—First Assistant, Mr. Main. Attached to the Astronomical Department, Mr. Henry, Mr. Ellis, Mr. Rogerson, Mr. Dunkin. Attached to the Magnetical and Meteorological Department, Mr. Glaisher, Mr. H. Breen, jun., Mr. Lovelace, Mr. Downs. The Astronomical Assistants take charge of Stores, Chronometers, and Signal Ball: the Magnetic Assistants are charged with the Manuscripts and Library. The First Assistant is not attached to either department, and takes a share sometimes in the work related to one, sometimes in that of the other.

In addition to this establishment, I am authorized to employ Computers to the amount

of £120 per annum, which sum in the present year is increased to £240, for the acceleration of the Magnetic and Meteorological Reductions. The staff of extra computers is organized with Captains of Division and Subordinates, and is now working with the utmost regularity.

The Board of Visitors having, at their last meeting, expressed a desire that an additional Assistant should be appointed for working the intended Altitude and Azimuth Instrument, the Lords Commissioners of the Admiralty were pleased immediately to intimate to me that I was authorized to nominate an Assistant. In consequence, however, of the delay in the construction of the instrument, I have not yet made a nomination.

I beg to remark to the Visitors that the appointment of a Permanent Assistant cannot properly be made without the sanction of an Order in Council; and that it will be desirable when this shall be obtained to make at the same time a permanent arrangement regarding the Magnetic and Meteorological Establishment. I submit to the Visitors, therefore, whether it would be desirable for them again to express an opinion upon the scale on which the Magnetic and Meteorological Department should be kept up as a permanent establishment.

11. Reduction of Ancient Observations. — Since the last meeting of the Board, the printed Reductions of the Greenwich Planetary Observations, from 1750 to 1830, have been published. Upon the character of this work, which is in the hands of the Visitors, I shall make no lengthened remark; but it may be satisfactory to the British Association by whom the work was first recommended, and to the Government who have defrayed the expense, to know, that the illustrious Bessel, in the last letter which I received from him, and Professor Hansen, in a late review of the work in the “*Astronomische Nachrichten*,” have expressed very strong opinions on its importance.

The Lunar Reductions are now entirely completed, and the printing is going on. Of the First Section, which contains all particulars of the reductions of Transits, eighteen sheets are printed, extending from 1750 to 1774. Of the Second Section, which contains everything relating to the Reductions of Zenith Distances, seventeen sheets are printed, extending from 1750 to 1786. Of the Third Section, containing the comparison of Observed Places with Tabular Places, three sheets are printed, from 1750 to 1756. This comparison, it is to be observed, does not contain a simple comparison of places, but contains also the coefficients of the various changes in the Moon's place depending on changes in the elements. Thus, for longitude, there are also the Elliptic Inequality, the change produced by a change in its argument, the Parallaxic Inequality, the Variation, the change produced by change in its argument, the Annual Equation, the Evection, and the change produced by change in its argument. For the Ecliptic Polar Distance, there are also the Effect of Mean Inclination, the change produced by change in its argument, and the Evection in E. N. P. D. All these quantities are made positive by the addition of constants.

The process for the correction of the elements by means of these comparisons is now going on: and the extent of this work, even after so much has been prepared, almost exceeds belief. For the longitude, ten columns are added in groups, formed in thirteen different ways, each different way having on the average about nine hundred groups. For the ecliptic polar distance, five columns are added in groups, formed in seven different ways, each different way having on the average about nine hundred groups. Thus it will appear that there are not fewer than 150,000 additions of columns of figures. This part of the work is not only completed but is verified, so that the books of comparison of Observed and Tabular Places are, as regards this work, completely cleared out. The next step is to take the means of these groups, a process which is now in hand: it will be followed by the formation and solution of the equations on which the corrections of the elements depend.

I take this opportunity of remarking that if any person interested in the Lunar Theory should be desirous of investigating from observations the value of the coefficients of any specific inequalities not included in the list which I have given, I can effect this investigation with comparative facility. I may observe, that those which depend on the place of the Moon's node will be obtained simply by collecting the equations in groups for several years determined by the positions of the Moon's node.

I have lately caused the Ledgers of Maskelyne's Reductions of Star-observations to be examined, with a view to the printing of them. It appears that there are about one hundred and fifty pages of manuscript, which would probably occupy fifty pages of printing. If the Visitors should judge that the publication of these ledgers (as tending to illustrate the inequalities of proper motion of the stars) is desirable, I will soon take measures for preparing them for press.

12. General Remarks.—In entering upon the second decade of my connexion with the Royal Observatory, it may not be improper for me to say a few words upon the late history and present condition of the Observatory, as compared with those of preceding times; and to speculate a little upon its necessities for the future. In regard to the quality of Observations, my immediate predecessor (whom I regard as the principal improver of modern practical astronomy) left little to be done: some few small changes, which I hope are improvements, have however been made. In regard to the selection of subjects of observation, the system of almost exclusive observation of stars has been modified, and, without neglecting them, I have introduced an extensive system of observation of planets; regarding the establishment of good grounds for planetary theories as an object worthy of a national institution, and as one which can scarcely be attained at any other place. Of the importance of keeping up and extending the observations of the Moon, as the original and distinctive object for the Royal Observatory of Greenwich, I have in a sufficiently practical manner expressed my sense, by the proposal of the new Altitude and Azimuth Instrument.

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In the observation of double stars, and in scrutinizing astronomy generally, little has been done ; not because I regard it unimportant, but because it may be done as well, or perhaps better, at smaller or private establishments. In the extent of Reductions, a very great advance has been made, and I think that every reduction has been completed, which it is possible to complete for current observations. This work has been accompanied with what is, as I firmly believe, the greatest work in astronomy, namely, the Reduction of the Ancient Planetary and Lunar Observations. In thus giving attention to the completeness of Astronomical Reductions, from the beginning of accurate astronomy to the present time, I trust it will appear that other important matters have not been neglected. By the system which has been here introduced of combining the labour of permanent Assistants and occasional Computers working under my own eye, the expense of these calculations has been most materially diminished. By holding myself at liberty to give attention to the Correction of the Compass, the tracing of the Canadian Boundary, the partial superintendence of the construction of National Standards, the investigation of the Longitude of Valentia, the concerting of instrumental and observing plans with the Director of the Ordnance Survey, the giving opinions on the subjects of Railways and other mechanical matters referred to me by the Government, it has appeared that our energies are not wholly absorbed in the mere astronomy of the Observatory.

For the plan of Observations which has been pursued, and which I regard as being in general sufficiently extensive, the present personal establishment, aided by the labour of occasional computers, is sufficient. The addition of any new instruments which are to be regularly used will require an increase of the number of Assistants.

Our principal instruments having now been erected more than thirty years—a period in which the German school of instrument-makers has arisen, and in which many new constructions have been introduced—it has often been a subject of consideration with me, whether these instruments are fairly equal to the best instruments intended for the same purposes in other places. And I am well persuaded that in soundness of mechanical principle, in firmness, and in accuracy, they are equal to any instruments in the world. The one point in which they may be considered defective, in comparison with some other large instruments, is in the size of their object-glasses. The inconvenience which this defect produces is not wholly speculative ; for we sometimes find it impossible to observe, on the meridian, stars which have been compared with comets, &c., and we have some difficulty in following the small planets. The utmost change, therefore, which I contemplate as likely to occur in many years, in regard to our meridional instruments, is the substitution of instruments of the same class carrying telescopes of larger aperture.

Among the novel constructions which have been introduced on the Continent, there is but one on which I set the smallest value, namely, the large divided object-glass, or heliometer. The applications of this instrument are, however, so rare (for it is certain that

small measures may be made as conveniently by simpler instruments), that I have no doubt that the heliometer to be mounted at Oxford will suffice for the wants of England.

The only instrument which, as I think, may possibly be called for by the demands of the astronomer or the astronomical public, is a telescope of the largest size, for the observation of faint nebulae and minute double stars. Whether the addition of such an instrument to our apparatus would be an advantage, is, in my opinion, not free from doubt. The line of conduct for the Observatory is sufficiently well traced; there can be no doubt that our primary objects ought to be the accurate determination of places of the fundamental Stars, the Sun, the Planets, and, above all, the Moon. Any addition whatever to our powers or our instrumental luxuries, which should tend to withdraw our energies from these objects, would be a misfortune to the Observatory.

G. B. AIRY.

*Royal Observatory, Greenwich,  
1846, June 5.*