# ADDRESS AND EXPLANATION

BY THE ASTRONOMER ROYAL,

PRESENTED TO THE BOARD OF VISITORS OF THE ROYAL OBSERVATORY, GREENWICH,

AT THEIR SPECIAL MEETING OF 1843, NOV. 10;

AND

# REPORT OF THE ASTRONOMER ROYAL,

READ AT THE ANNUAL VISITATION OF THE ROYAL OBSERVATORY,

1844, JUNE 1.

By order of the Board of Visitors, the Address of the Astronomer Royal, and the Explanation of the Construction of the proposed Altitude and Azimuth Instrument, &c., which were communicated to the Board of Visitors at their Special Meeting of 1843, Nov. 10, are printed with the Report, read at the Annual Visitation of 1844, June 1.

# ADDRESS

TO THE

# BOARD OF VISITORS OF THE ROYAL OBSERVATORY,

BY THE ASTRONOMER ROYAL.

*Read at the Special Meeting of the Visitors on* 1843, *November* 10.

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THE most important object in the institution and maintenance of the Royal Observatory has always been the Observations of the Moon. In this term I include the determination of the places of fixed stars which are necessary for ascertaining the instrumental errors applicable to the instrumental observations of the Moon. These, as regards the objects of the institution, were merely auxiliaries: the history of the circumstances which led the Government of the day to supply the funds for the construction of the Observatory shews that, but for the demands of accurate Lunar Determinations as aids to navigation, the erection of a National Observatory would never have been thought of. And this object has been steadily kept in view when others (necessary as fundamental auxiliaries) were passed by. Thus, during the latter part of Bradley's time, and Bliss's time (which two periods are the least efficient in the modern history of the Observatory), and during the latter part of Maskelyne's presidency (when, for years together, there is scarcely a single observation of the declination of a star), the Observations of the Moon were kept up with the utmost regularity. And the effect of this regularity, as regards its peculiar object, has been most honorable to the institution. The existing Theories and Tables of the Moon are founded entirely upon the Greenwich Observations; the Observatory of Greenwich has been looked to as that from which alone adequate observations can be expected, and from which they will not be expected in vain: and it is not perhaps venturing too much to predict that, unless some gross dereliction of duty by the managers of the Observatory should occur, the Lunar Tables will always be founded on Greenwich Observations.

With this impression, it has long been to me a matter of consideration whether means should not be taken for rendering the series of Observations of the Moon more complete than it can be made by the means at present recognised in our observatories. The interruptions of the regularity of the series are, at present, very numerous; and the uniform suppression of observations during the Moon's passage through entire portions of her orbit of great extent is, in reference to theory, extremely injurious. On examining the printed observations during seven years in which I have directed the Royal Observatory, I find that there are but two observations of the Moon within three hours of the Sun, one of which is imperfect. And the whole number of observations within six hours of the Sun is small as compared with the remainder. Thus one-fourth of the Moon's course is absolutely lost, and one-half is very imperfectly observed. It is needless for me to point out the influence of this deficiency upon the Variation, and several theoretical terms whose argument is related to the Variation. But, besides this, the loss of observations (sometimes from clouds beginning to obscure the Moon when it has actually entered the field of the meridional instrument) in those parts of the revolution which may be considered observable, is a most serious misfortune. For the Sun or a Planet, it is of little importance that the observations of one or several days are lost: for the Moon, it is of great importance, because the relation of sequence in its rapidly-changing Errors of Tables is thus entirely lost to the view.

If, now, we had the means of observing the Moon in any part of the sky, the deficiencies to which I have alluded would be, in a great measure, supplied. In fine weather, the Moon might perhaps be always observed within an hour and half of the Sun, and (when Cancer is near the meridian at the time of observation) probably nearer. In other parts of the lunation, the Moon might be observed almost every night: for there are very few nights when the Moon is above the horizon in which she cannot be seen pretty well at some time. The number of complete observations made at present is under one hundred in a year: I should expect that, with proper extra-meridional means, the number of nights of efficient observation might be made to exceed two hundred.

After careful consideration of the ways in which these observations might be made, I have come to the conclusion that there is but one instrument with which observations could certainly be made possessing the required accuracy, and that with it the observations certainly could be made. This instrument is the Altitude and Azimuth Instrument. No form, however, in which I have seen this instrument appears to me to be sufficiently firm for this purpose (in which the azimuths are as important as the altitudes). I should propose to construct a new instrument, with circles of three feet diameter, in general form resembling the Palermo or Dublin circle, but framed on the same principles of massiveness and strength, and with the same exclusion of adjusting power, which I have adopted in the Ordnance Zenith Sector.

There is one position, within the precincts of the Royal Observatory, which appears to me well adapted for such an instrument. It is on the south side of the Chronometer Room and South Dome, and between the two windows of the former. Another position might be obtained by dismantling the Advanced Building and erecting a dome, &c., on its site. In either case it would be necessary to build a pier for the instrument and walls for the dome, to the height of two low stories. The former position would command a free horizon throughout the Moon's path, excepting that in the north-west (a part of little importance, because the air is thickened by the smoke of London) the erections at the top of the Octagon Room rise to the elevation of eight degrees above the horizon. The access to this place would be either through or by the side of the South Dome. In the latter position, the horizon would be somewhat less interrupted. I should propose to cover the instrument with a drum-dome, and should keep it at such a height as not to interrupt the view from the South Dome.

Upon all details connected with the construction of the building, the construction and mounting of the instrument, the method of observing with the instrument, and the method of computing the results, I am fully prepared to explain my views.

I think it probable, that the use of this instrument would in some shape occupy the time of one observer. Its running expense might thus be estimated at £150 per annum. Of the first expenses I can give no accurate estimate; but I should suppose that they would be £700 or £800. To give an idea of the relation of these sums to the importance of the object aimed at, I may state that I consider the Lunar Observations to be justly chargeable at present with one-third of the whole expenses of the Observatory, or with £1000 per annum; and that I have always considered one complete lunar observation to be worth £10.

I now beg leave to submit these suggestions to the consideration of the Board of Visitors, and to request their judgment as to the propriety of making a representation to the Board of Admiralty, with the view of carrying into effect the proposed scheme.

G. B. AIRY.

*Royal Observatory, Greenwich,* 1843, *Nov.* 4.

# EXPLANATION

OF

## THE MOUNTING AND CONSTRUCTION

OF THE

# ALTITUDE AND AZIMUTH INSTRUMENT,

WHICH IT IS PROPOSED TO ATTACH TO THE ROYAL OBSERVATORY;

AND OF

THE METHOD OF MAKING OBSERVATIONS OF THE MOON WITH THIS INSTRUMENT, AND THE METHOD OF REDUCING THE OBSERVATIONS.

ADDRESSED TO THE BOARD OF VISITORS OF THE ROYAL OBSERVATORY, GREENWICH,

BY THE ASTRONOMER ROYAL.

*Read at the Special Meeting of the Visitors on* 1843, *November* 10.

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WITHIN the circular wall which supports the Dome, I propose to build a cruciform pier on a separate foundation, having no connection with the circular wall from the ground, but approaching near to it at the extremities of its cross-arms. Instead of a cruciform pier, a three-rayed pier may be used: but as the same description, with small alterations, will apply to both, I shall confine my description to the cruciform shape. This cruciform pier I propose to raise to within a small distance (from one to two feet) of the floor of the dome, so that it will not be touched by the joists of the floor, which are to be supported entirely by the circular wall. The internal diameter of the circular wall needs not to exceed 10 feet (and may probably be less): the length of the arms of the cross may be about $9\frac{1}{2}$ feet. Upon the top of this cross I propose to plant an iron cross (or three iron rays, if the pier be three-rayed), the length of whose arms exceeds by a small quantity the length of the arms of the pier-cross, but so little that it does not touch the circular wall (its length may be $9\frac{3}{4}$ feet): the extremities of the four (or three) arms of this cross to be connected by four (or three) sides, welded in the same piece: thus the iron work would form a square (or triangle), whose sides are about 7 feet, and which has diagonals in the same piece of metal. Upon each side of the square, &c., I propose to erect an iron triangle, connected by screw-bolts to the angles of the square, and rising about 10 feet above the square. The four points forming the four vertices of these triangles would be four angles of a square to be attached to them, of the same dimensions as the lower square; but lying in such a position that its angles correspond to the sides of the lower square, and *vice versâ*. Of this upper square I propose that the sides be in one piece, but that the crossed diagonals be in another piece, and that they rest in forks at the angles of the square, their ends being cut with a screw-thread so that they can by means of nuts be drawn endways. This power of screw-motion is for the purpose of adjusting the place of the intersection or center. Every drawing-strain upon one of the arms will imply a bending of the transversal arm. At the intersection or centre will be the Y for the upper pivot of the azimuthal motion, into which Y the pivot will be forced by a long piece of iron or steel screwed upon it, whose spring will insure perfect bearing. In this manner I conceive that most perfect firmness would be given to the upper pivot of the azimuth motion. No adjustment nicer than that depending on the screws at the end of the cross is to be provided for it.

Upon the centre of the brick cross, and covering the centre of the lower iron cross, I propose to plant a stone pier. In the top of this I would insert three metallic forks, very solidly made. These forks are to receive the three ribs of the lower fixed circle. This circle I propose to be a solid flat cone of iron or bell-metal, 3 feet in diameter, and 6 inches thick in the center, with a conical hole for the bearing of the lower azimuthal pivot, a racked ring for pinion-action, a smooth ring for clamp-action, and a graduated ring at its circumference. All these are to be turned at the same chucking on the lathe. The circle will be laid with its ribs in the forks, and then examined by the artist for horizontality, with a spirit level. As he finds it wrong, he will correct its position by filing the forks. When it is adjusted in a satisfactory way to horizontality, it will never be moved again. Thus the bearing of the lower azimuthal pivot, and the azimuthal graduated circle with its slow motion circle and clamp circle, are provided for.

For the lower part of the azimuthal frame, I propose to use a strongly-ribbed flat of cast iron or bell-metal (the ribs being on its lower side, and 3 inches or more deep), with a vertical pivot having a hemispherical end to work in the conical hollow of the lower circle. The whole of this should be cast in one piece. The upper surface should be planed. The length about 33 inches and the breadth 21 inches. This basis would carry no fine work, except the clamp-screw and the slow-motion pinion.

For the two uprights, I propose to use two trough-shaped pieces with their lower ends planed (the opening of the trough being covered as far as the insertion of the horizontal axis permits), each about 4 ft. 6 in. high, the breadth of its trough about 21 inches, and the depth $10\frac{1}{2}$. One of these uprights to carry two microscopes for reading the lower circle; the other to carry two miscroscopes for reading the lower circle, four for reading the vertical circle, and blocks for carrying the levels transversal to the horizontal axis. Each also to carry blocks for the levels parallel to the axis. Each vertical trough with the parts that I have mentioned to be cast in one piece, as in the Ordnance Zenith Sector. The vertical which does not carry the four microscopes will carry the semicircles in which the clamp-screw and slow-motion pinion act.

The upper connection of the upright troughs will be only a flat piece 9 inches broad, ribbed, and carrying the upper pivot.

By the sides of the upper connecting piece will be two levels parallel to the horizontal axis, resting on blocks which are near to the outside extremities of the vertical supports, and which are attached to those supports. Perhaps, however, they may be more conveniently placed at the bottom of the supports.

Two levels transversal to these and to the horizontal axis will be placed on the outside of the vertical which carries the four microscopes, resting on blocks which are attached as near as possible to these microscopes.

The Y's for the support of the horizontal axis will be cast in the trough pieces, and will be adjusted only by filing.

This completes the description of the azimuthal axis.

The part moveable in altitude is to consist of a double cone (each cone being widened to a flat at its base) with the telescope between the bases of the cones. If possible, one cone (carrying the graduated circle), its pivot, and the telescope, should be cast in one piece, and the rest in another piece. On the part opposite the graduated circle, and near to the eye end of the telescope, would be the clamp-screw and the head of the pinion for slow motion.

The telescope should have crossed wires in the field, six horizontal and six vertical. The plate containing them should be firmly fixed, their adjustment being effected as nearly as possible by the instrument-maker.

This completes the description of the instrument.

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The following would be the method of making observations with the instrument.

The observation, as regards the celestial body, would be entirely one of transits; whether the observation were for azimuth or for altitude.

For an observation of azimuth, the azimuth clamp-screw would be pinched, and the observer would at transit over every wire move the telescope and vertical circle by means of the pinion acting on the vertical racked semicircle, so that every transit should be observed over the middle part of each of the vertical wires. The four microscopes of the lower or horizontal circle would be read, and likewise the two levels which are parallel to the horizontal axis.

For an observation of altitude, the clamp-screw of the vertical circle would be pinched, and the observer would at transit over every horizontal wire move the azimuthal frame by means of the pinion acting on the lower racked circle, so that every transit should be observed over the middle part of each of the horizontal wires. The four microscopes of the vertical circle would be read, and also the two levels which are transversal to the horizontal axis.

Whichever observation be made, the instrument should be immediately reversed in azimuth, and a new observation of the same kind should be made. The clock should be immediately compared with the transit-clock, the comparison being made by the coincidence of beats of a half-second solar chronometer.

This completes the observation.

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The following would be the process of computation :—

By the comparisons of clocks, the clock-time of transit is to be reduced to transit-clock-time, to sidereal time, and (for the Moon) to mean solar time. The tabular R. A., N. P. D., and hour angle, of the objects observed (Stars and Moon) are to be prepared, and with these and the astronomical colatitude for the Stars and the geocentric colatitude for the Moon, the tabular azimuth and zenith distance of every object (Stars and Moon's centre) are to be computed.

As regards the Moon, this azimuth and zenith distance are at present referred to the geocentric zenith, and are therefore in a state fit for the application of parallax. Therefore, applying first the geocentric semidiameter, the geocentric Z.D. of the limb from the geocentric zenith is found; and, correcting this for parallax, the Greenwich Z. D. of the limb from the geocentric zenith is found, which, by an easy computation, is changed to Greenwich Z. D. of the limb from the astronomical zenith. Also, with the geocentric Z.D. of the center from the geocentric zenith, and the geocentric semidiameter, the geocentric azimuth of the limb is found, and this is easily converted into astronomical azimuth of the limb.

Thus all the tabular places in zenith distance and azimuth, for comparison with observations, are found.

Now for the observed place:—

1. In Altitude.—An approximate zenith point being known, the zenith distance of a Star can be expressed from observation in the usual way (from the microscope readings of the vertical circle and level readings.) Every single observation of a Star, corrected for refraction, will give a zenith distance comparable with the tabular zenith distance, and will thus give a correction of the zenith point. But it will be prudent to take the correction from observations in reversed positions, because the zero of the levels will be eliminated, and, when the clock-time is suspicious, it may be corrected from this observation.

The corrected zenith point thus found is to be used for the Moon's limb, and, after correction for refraction, the true zenith distance is found, which will be comparable with the tabular zenith distance.

2. In Azimuth.—Before a zero of azimuth can be found, corrections are requisite—For the readings of the levels parallel to the horizontal axis—For the inclination of the horizontal axis—And for the error of collimation of the mean of the vertical wires in the telescope.

The first is easily computed.

The third may be found by observation of a distant object in the horizon, taking the lower circle readings when each of the wires is brought on it Face Right, and, again, when each wire is brought on it Face Left.

The second may be found by observation of a tolerably high Star, Face Right and Face Left, correcting for the first and third, and determining the second so that the difference of azimuth-readings Face Right and Face Left shall be the same as the difference of the tabular azimuths.

Or the second and third may be found together, by observations Face Right and Face Left, of a high Star and a low Star.

Every observation of a Star is then to be corrected for these three elements, and then it will give an azimuthal zero.

By applying this, with corrections for the three elements, to the observation of the Moon, the true azimuth of the Moon would be found.

In this manner there would be found a series of errors of the Moon's place in zenith distance and in azimuth, at times not exactly the same. From these it will be easy to infer the errors at one instant; and then there are two courses open. Either to apply these errors to the Moon's tabular Z.D. and azimuth computed for that instant, and (reversing the computation) to infer from them the R.A. and N.P.D. at that instant, which will be compared with the tabular R.A. and N.P.D. Or, from the errors in Z.D. and azimuth, to find the errors in R.A. and N.P.D. by the use of factors similar to P, Q, R, S, in the Appendix to the Greenwich Observations, 1836. I prefer this latter course.

The duty imposed upon the observer would be, in every fine night to observe at least two well-determined Stars, and to observe each of these in altitude and in azimuth, Face Right and Face Left: making in all at least eight observations.

And, whenever the Moon is visible, to observe at least one altitude and one azimuth, and, if possible, two altitudes and two azimuths.

And, in order to be certain about the Moon's diameter, it is necessary that he should be prepared beforehand with calculations of the time when the Moon's horns are vertical; and at such times he must observe repeated zenith distances of the Moon, upper limb and lower limb alternately.

It is indispensable that the observer be prepared to watch from Moon-rise to an hour or more after Sun-rise, or from an hour or more before Sun-setting to Moon-setting, as the case may be.

G. B. AIRY.

1843, *November* 4.

# REPORT OF THE ASTRONOMER ROYAL

TO THE

# BOARD OF VISITORS,

*Read at the Annual Visitation of the Royal Observatory, Greenwich,* 1844, *June* 1.

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I BEG leave to present to the Board of Visitors the following Report, on the general condition of the Royal Observatory, and on the operations which have been carried on there during the year which has elapsed since their last meeting in this place. And I trust that, with the additional information which the Visitors will obtain from their personal inspection of the Observatory, and with reference to the Printed Observations for the results of our labours as presented to the public, it will give them a reasonably complete view of the state and usual course of everything in the Observatory.

1. Grounds and Buildings.—At the time of the last Visitation, there was erected on the Magnetic Ground a small framed Observatory, which had been constructed by Captain Fitzroy for use during his voyage round the world in the Beagle, and which, on his return to England, he had lent to the Royal Observatory. This small building was used here for the observation of the Magnetic Dip. On Captain Fitzroy's departure to assume the government of New Zealand, he was desirous of taking with him the same building, for the prosecution of the magnetic observations which he intended to continue there. It was necessary therefore immediately to provide a new building: and a small wooden erection, which the Visitors may have seen in the extreme southern part of the Magnetic Ground, was constructed for the observation of Dips and for other observations which could not be carried on in the neighbourhood of the great magnets. Its roof is double, with a free passage for air between the two coverings. It is found to be generally well adapted for its purpose.

The Visitors will remember the tenor and urgency of their representations to the Board of Admiralty, agreed on at their meeting of November last, regarding the proposal of erecting a proper Altitude and Azimuth Instrument for extension of the series of observations of the Moon, in conformity with the plan which I had the honour then to submit to them. The Board of Admiralty at once sanctioned the principle of this proposal; and, on their application, the Lords Commissioners of the Treasury without hesitation sanctioned the estimated expense. In the paper which I had laid before the Visitors, I pointed out two sites, either of which appeared well adapted for such an instrument. One was a little in the rear of the

Chronometer-room and South Dome: the other was the Advanced Building (formerly the place of Flamsteed's Equatoreal Sector). I at length determined on adopting the latter. The walls have accordingly been erected on the walls of the Advanced Buildings, and the structure, though not yet complete, is in such a state of forwardness that the Visitors can examine the arrangement of every part. The preparation for mounting the Instrument is made, but the flat dome for covering it, though in progress, is not yet completed. The Deputy Ranger of the Park consented, on my application, to cut off the top of the only tree which interfered materially with our view near the horizon; and the command of the sky is now almost complete. I may mention here that, in stripping the old walls of the Advanced Building, traces were found of windows or doors in each of its three sides (the fourth side being that which joins to the observing buildings). These windows are not represented in Flamsteed's plans: it seems very unlikely that they were opened since his time; and on the whole I should suppose that they were walls of some outbuilding of the old Greenwich Castle. It is to be remarked, however, that the western wall, which contains one of these unexplained windows, ranges due north and south (the others being inclined to the cardinal points); but as Flamsteed's arc was attached to its outside surface, and as the window does not pass through the whole thickness, which is 28 inches, it seems certainly anterior to Flamsteed's time. It can hardly be conjectured that it was made for anything like a meridian line. In the centre of the building, under the paved floor, was a pier of later date, covered with a massive block of stone.

The Visitors may have remarked, also, a small building containing a pier of brick and stone, adapted for observations with a portable transit, which is now erected on the Magnetic Ground. This has been erected for the observations which Mr. Struve is about to make, for determining, by transmission of chronometers, the difference of longitude between Greenwich and Altona, as part of the difference of longitude between Greenwich and Pulkowa. Mr. Struve's plan, of interchanging the observers at the two ends for the elimination of personal equation, makes it almost necessary that he should have the complete command of a transit instrument; but the combination of the observations made at this instrument with those made by our own observers with our own transit will be extremely easy. Mr. Otto Struve has already arrived to make the first preparations, and to conduct the first half of the observations; and I expect to be honoured with a visit from Mr. Struve himself, as soon as the regular interchange of chronometers shall have commenced.

2. Moveable Property in General.—Under this head I have nothing to remark, except what may, with greater propriety, be treated under the head of Instruments, &c. Our property is safe and in good order.

3. Manuscripts.—The system of binding, marking, and arranging our manuscripts has still been carefully kept up.

In my Report of last year, I stated that I had been in communication with the authorities of the University of Oxford, and that I had received their permission to bring hither, for the purpose of copying, the manuscripts of Bradley's observations. I am happy to state that this work has gone on, and has now arrived at a very advanced stage. The whole of the Transits are copied, and considerable progress is made with the Quadrant Observations. The manuscripts are copied, page for page, line for line, letter for letter, and erasure for erasure. These volumes commence with Bradley's earliest observations at Greenwich in 1743, several years earlier than the first of those printed in the folio edition of his Observations.

4. Library.—On the library I have only to remark, as in the last years, that attention is given to the procuring of books applying to physical and mathematical science generally, especially to astronomy, magnetism, and meteorology; to the binding and arrangement of the books; and, generally, to the rendering the library truly efficient and useful.

5. Instruments.—Alluding, in the first place, to some of the subjects mentioned in last year's Report, I may state as follows:—

No alteration has been made in the micrometer of Troughton's Circle.

No use has been made of Jones's Circle; the use of one circle, in the method first introduced by me at the Cambridge Observatory, being found at least as accurate as the combination of the two circles.

The arrangement for the use of the Zenith Tube, so as to obtain a double observation at one transit of a zenithal star, appears to be successful. The results of observation are much more consistent since that mode of observation was introduced than they were before.

The engravings of Bradley's sector have been completed.

The escapement of Hardy's clock has been returned by the Secretary of the Admiralty.

The Declination Magnetometer, Horizontal Force Magnetometer, Vertical Force Magnetometer, and Dipping Needle, appear to be in the most perfect order, and competent to the most delicate observations.

The deflecting apparatus (in Lamont's method) is in an efficient state.

In the autumn of last year I had an opportunity of examining the beautiful arrangements of the Atmospheric Electrometer at the Kew Observatory, which have been made under the superintendance of Professor Wheatstone and Francis Ronalds, Esq. It was impossible to see these without perceiving that considerable improvements might be made in our own, by following the same plan, with such alterations as the difference of local circumstances rendered necessary. The form which I have adopted may be generally described as follows. Two iron rods are extended from the top of the mast to the ground, and are kept in a state of tension by weights hung in a pit. These rods serve as guides to a travelling frame, which carries a copper rod supported on a glass cone. A lamp is placed below the glass cone to keep it warm and dry; and another lamp is attached to the top of the copper rod to collect atmospheric electricity. The frame is lowered twice every day for trimming the lamp, and is then raised again; this operation is effected with a windlass and rope. The wire by which the electricity is conducted from the copper rod to the electrometers within the building is kept in tension by a lever with a weight at one end, which also serves for the electric conduction. During the operation of lowering or raising the frame, a self-acting reel (driven by a weight) coils up or delivers the wire, which is then detached from the lever. The metallic apparatus within the building is supported by a glass rod, whose ends are maintained in a state of warmth and dryness by small lamps. The electrometers are, the dry-pile apparatus (mentioned in the Report of last year), three expansion electrometers, and one Henley's electrometer; there is also an apparatus for measuring the length of sparks. Judging from the long time through which the apparatus will preserve a trifling charge of atmospheric electricity, I conceive that its insulation is nearly perfect; yet, from some unknown cause (not improbably the proximity of lofty trees) the indications are much less constant than those at the Kew Observatory.

The Galvanometer seems to be affected not more than once or twice in a year. The induction copper ball gives no certain results.

The Osler's Anemometer performs well, except in the registration of the pressures of ordinary light winds.

At the last Visitation, the Board of Visitors recommended to the Board of Admiralty the erection of a Whewell's Anemometer. The Lords of the Admiralty immediately assented to this, and an instrument of this class was mounted in the last summer. With some small refittings it has worked extremely well. In the heavy wind of March 12, the small theodolite house on which it is mounted (which had stood more than twenty years) was blown over. Fortunately some parts of the Anemometer were at that time in Mr. Simms' hands for repair: all that remained on the theodolite house were nearly destroyed. The instrument is at present in an efficient state.

In addition to the usual thermometers, self-registering thermometers have lately been procured for ascertaining the temperature of the water of the Thames: they are suspended from the side of the Dreadnought Hospital Ship. The object of these observations will be stated presently.

The construction of the new Altitude and Azimuth Instrument, which is to be mounted in the new building, is intrusted to Mr. Simms as instrument-maker, and to Messrs. Ransome, of Ipswich, as engineers. No part of it, I believe, is yet cast.

6. Observations.—The Astronomical observations with the meridional instruments have been directed principally to the following objects. The Stars of the Nautical Almanac List are considered to have the first claim: the rule that each star should be observed at least twenty times in any three years, both in right ascension and in polar distance, being adhered to as strictly as possible. A few low stars have been observed for refraction. Besides these, there have been observations of stars selected for the Moon-culminating List of the Nautical Almanac, of stars which had been compared with comets, and of stars which had been observed, in the course of the Trigonometrical Survey, with the Ordnance Zenith Sector. The Sun, Moon, and Planets, have been observed at every practicable opportunity (the latter through all hours of the night) except on Sundays, when the Moon only, with accompanying stars, is observed. The equatoreals have been used for measuring the Moon's diameter and for observations of Mauvais' and Faye's Comets: as well as for Occultations of Stars by the Moon, and for the Eclipses, &c., of Jupiter's Satellites. The Zenith Tube has been regularly employed for the observation of $\gamma$ Draconis. With the double-image Micrometer, measures of the diameters of the Planets, and of the distances and positions of some Double Stars have been made.

The Magnetical and Meteorological observations have been made nearly in the same manner as in the two last years. The three magnetometers, the barometer, and the wet and dry thermometers, are observed at every two hours day and night (except on Sundays); the dew point four times every day; the magnetic dip is observed on the forenoon and afternoon of each of two days in every week; on one term day in every month magnetic observations are made at every five minutes; on one day in each month hourly observations of the barometer are made; observations with the actinometer are made when circumstances are favourable; electrical observations and extraordinary observations of any kind when circumstances require them. The indications of the self-registering instruments are regularly preserved or read off: the rain-gauges, &c., which are cumulative but not self-registering, are read some once in a day, some once in a month.

7. Reduction of Observations.—The reduction of our Astronomical observations is nearly as forward as is desirable or practicable. To the end of 1843 everything is completed and in the hands of the printer, with the exception of a small portion of the computations of Occultations, and a small portion of the computations of Comet observations. In the present year, the Transits are cleared off to the end of February, and great progress is made with the remainder: in the Circle observations, all the important parts are finished to March 5 (though not quite reduced to North Polar Distances), and the other parts are very much advanced: the Zenith-tube observations and the Comet observations are completely reduced. The great Catalogue of 1439 stars has been finished long since.

In the Magnetical and Meteorological department, the following is nearly the state of reductions. For 1842 everything is finished, and in the printers' hands. The first steps of reduction and conversion of values of all the instruments, with the exception of temperature corrections, are completed and examined to the end of April 1844. Westerly variations are computed to the end of May 1843. Term observations with the Declination Magnetometer are nearly finished for 1843: means of many kinds are taken to the end of April 1843. No progress further than that stated above is made with the Horizontal Force and Vertical Force Magnetometers. Extraordinary observations are reduced to the end of May 1843. Observations of Dip are reduced to the present time. Some examination is yet required before passing several of these calculations. All observations for adjustment (including all the determinations of the Astronomical meridian on the Theodolite) are thoroughly reduced and examined to the present time. The results for all the meteorological instruments are completed to the end of 1843, and nearly all are completed from 1 January, 1844, to the present time: this latter step has been made in order to enable us to furnish the Registrar-General with certain results to be published in his weekly reports.

The arrears of computation in this department, as measured by the time and labour necessary to bring them up, are not so great as might at first sight appear. They have been caused chiefly by the devotion of much time and attention to the Abstracts for 1843. These are now completely finished and in the printers' hands: and I have no doubt that when published they will be regarded as creditable to the Observatory, and to Mr. Glaisher, by whom, almost entirely, they have been planned and superintended.

8. Printing.—The Astronomical volume for 1842 is lately finished; its form is precisely the same as that of the volume for 1841, excepting that it has, as Appendix, the Catalogue of 1439 stars. The volume contains, as usual, the results of rating the Chronometers on trial, and the last Report of the Astronomer Royal. The number of copies struck off is 350: and, in addition, 400 separate copies of the Appendix have been printed. No part of the volume for 1843 has yet been received from the printer.

Of the Magnetical and Meteorological volume for 1842, forty-two sheets are printed. They consist of daily, term-day, and extraordinary observations, both of the magnetical and of the meteorological instruments. The Introduction is begun, but the Abstracts are not begun. The number of copies struck off is 350.

It appears therefore that the printing of the Astronomical volume has dropped behind considerably since the Visitation of last year: that of the Magnetical and Meteorological volume has in some degree advanced. In consideration of the great amount of work of the same class now occupying the attention of the printers, I have been unwilling strongly to urge them to keep the Astronomical volume to the state of forwardness which is perfectly practicable.

9. Chronometers.—The number of chronometers on trial during the last year has not been excessively great. At present there is a considerable number (about one hundred and ten); many Government chronometers having been returned from ships paid off, and about thirty chronometers being rated in preparation for the determination of the longitude of Valentia in Ireland.

The Digest of the Estimates of Expense of Repairs to Government Chronometers is still kept up.

10. Personal Establishment.—The establishment of regular Assistants consists of the same number and the same persons as at the time of the last Visitation. Five Assistants are attached to the Astronomical Department, and four to the Magnetic and Meteorological Department. In addition to the services of these gentlemen, I am authorized by the Treasury to employ additional computers to the amount of £120 per annum. The establishment in this form is extremely efficient in proportion to its expense.

11. Reduction of Ancient Observations.—Of the Reductions of the Greenwich Planetary Observations four sections out of five have been printed; the fifth is begun. The four sections include all the laborious part of deduction from observations and computations from planetary tables; the fifth section contains the comparison of the deduction with the tabular computation.

The following is nearly the state of the Lunar Reductions. The Right Ascensions and North Polar Distances from observation, cleared, not only of all instrumental and clock errors, but also of semidiameters, are computed throughout (from 1750 to 1830). The Tabular Longitudes and Ecliptic Polar Distances are computed throughout. The Longitudes and Ecliptic Polar Distances from observation are computed completely for more than 3000 observations, and in great part for all the observations. The copying of results, in the form in which I propose ultimately to print them, has been begun: I trust that it will be found to be so arranged as to give great facilities for the correction of the elements of the Lunar Tables.

12. General Remarks.—On former occasions I have avowed without scruple that I do not consider the Royal Observatory as a mere isolated place for the conduct of astronomical observations. I consider it as a part, perhaps the most important part, of the scientific institutions of this country, but still as only a part of them; and under this impression I consider it as my duty to lend its assistance and mine to any department, either of the State generally, or of the scientific institutions in particular, to which our powers or habits enable us to give any aid. I am confident that the preceding part of this Report will shew that the original and

standard interests of the Observatory have in no way suffered from this interpretation of my duties. But at the same time it will be gathered that, in the occasional employments of myself and my assistants, many things are included, occupying much time, which cannot be expressed in any regularly arranged statement like that which I have just terminated. The following heads of employment may, however, be stated:—Official superintendance, as Chairman of Committee, of the restoration of the National Standards (of which the immediate superintendance is intrusted to Mr. Baily and Professor Miller). Reduction of the Irish Tidal Observations. Printing the account of Mr. Maclear's Verification and Extension of La Caille's Arc. Assisting the Registrar-General in regard to the Meteorological Report affixed to his weekly Sanatory Report. Aiding Mr. Struve in his proposed determination of the longitude of Pulkowa. Arranging an enterprise to determine the longitude of Valentia in Ireland, for the measure of an arc of parallel, and for the fixing of a nautical zero. For several of these purposes I have had to ask the assistance of other persons or establishments. Thus, for the Registrar-General's Report, I have requested the co-operation of Lieutenant Sanders, Superintendant of the Dreadnought Hospital Ship, to determine the temperature of the waters of the Thames; for ascertaining the difference of the quantity of rain which falls at the top and at the bottom of Greenwich Hill, I have solicited the assistance of the Rev. George Fisher; for the transmission of chronometers to Ireland, I have asked help from the Birmingham and Grand Junction Railways, from the Liverpool Observatory, from the City of Dublin Steam Company, and from the Irish Post-Office. I conceive that by this extension of friendly relation we shall all be ultimately gainers.

I may, perhaps, be allowed here to give the history of the result of one of the aids which I have been able to offer to another Department of Government (the account of which reached me but two days ago). In my last Report I stated that the officers of the Corps of Royal Engineers, who were to trace the Canadian Boundary, had been placed here for instruction and practice in the use of instruments under my eye. The most difficult partof the Boundary was a straight line of nearly 70 miles in length to join two defined points. The country through which this line was to pass is described as surpassing in its difficulties the conception of any European. It consists of impervious forests, steep ravines, and dismal swamps. A survey for the line was impossible; and a tentative process would have broken the spirit of the best men. I therefore arranged a plan of operations founded on a determination of the absolute latitudes and the difference of longitudes of the two extremities. The difference of longitudes was determined by the transfer of chronometers by the very circuitous route from one extremity to the other; and it was necessary to divide the whole arc into four parts, and to add small part by measure and bearing. When this was finished, the azimuths of the line for the two ends were computed, and marks were laid off for starting with the line from both ends. One party, after cutting more than forty-two miles through the woods, were agreeably surprised, on the brow of a hill, at seeing directly before them a gap in the woods on the next line of hill; it opened gradually, and proved to be the line of the opposite party. On continuing the lines till they passed abreast of each other, their distance was found to be 341 feet. To form an estimate of the magnitude of this error, it is to be observed that it implies an error of only a quarter of a second of time in the difference of longitudes; and that it is only one-third (or nearly so) of the error which would have been committed if the spheroidal form of the earth had been neglected. I think that I may here assume that the aid of this institution has been beneficial to another department of the State. But, in once departing from a bare statement of facts, it is imperative on me to point out the extraordinary merit of the officers who effected this operation. Transits were observed and chronometers were interchanged when the temperature was lower than 19° below zero; and when the native assistants, though paid highly, deserted on account of the severity of the weather, the British Officers still continued the observations upon whose delicacy everything depended.

In concluding this long Report, I have only to say that I have been uniformly supported by the confidence of the Government, and uniformly aided by the spirit and the subordination of my Assistants. And without the aid thus cheerfully given on both sides, it would have been impossible to go through the work which has been successfully completed.

G. B. AIRY.

*Royal Observatory, Greenwich*, 1844, *June* 1.