ADDRESS

TO THE

INDIVIDUAL MEMBERS OF THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

BY THE

ASTRONOMER ROYAL:

AND

REPORT OF THE ASTRONOMER ROYAL,

Read at the Annual Visitation of the Royal Observatory, Greenwich, 1853, *June* 4.

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ASTRONOMER ROYAL.

THE Reduction of the Lunar Observations made at the Royal Observatory of Greenwich from 1750 to 1830, was conducted on principles which, I trust, gave it a value far superior to that of mere extent of period. The elements, by the use of which the clock-errors and instrumental errors were eliminated, were the same throughout. The mode of effecting the first reductions was as nearly uniform as the methods of observation permitted; and the same Lunar Theory was used through the whole time, for computing the tabular places with which the observed places must be compared, in order to render them really useful to Astronomy.

The date at which these Reductions closed was, in some degree, a matter of accident. The Reduction of the Planetary Observations was proposed at the meeting of the British Association in 1833; and the year 1830 was then a convenient limit for that work. When the Lunar Reductions were commenced, several years later, the same year was adopted for their termination, as indicating the general similarity of plan of the two works. Had not this consideration prevailed, it would undoubtedly have been thought desirable to extend the Lunar Reductions at least to the end of the year 1835.

From the end of 1830 to the end of 1835, the Greenwich observations of the Moon are reduced in the fifth Parts of the printed Observations, but the details of the reductions are not printed, and a close examination of them would be required before it could be asserted that they are fully deserving of confidence. From the beginning of 1836 to the present time, the observations have been reduced with great care, the reductions are published in detail, and it is presumed that they are in general worthy of confidence. Through the whole period, the places of the Moon, deduced from the observations, are compared with the places computed in the Nautical Almanac:

that is, with Burckhardt's tables, which have been used for many years past in computing the places of the Nautical Almanac.

During this time, I have uniformly cherished the intention of computing the places of the Moon on the same theory which was employed for the Reductions from 1750 to 1830, and of comparing the results of that theory with the results of Burckhardt's tables: by which means the comparisons which have been currently made of observed places with Burckhardt's places, would be at once converted into comparisons of observed places with the theory of the great Lunar Reductions. A motive only was wanting for deciding on the time at which this work should be undertaken. Such a motive has now presented itself.

The form of Burckhardt's tables was devised for the purpose of facilitating the computations of the Moon's place; and, as applied to Ephemerides, it is perhaps not absolutely unsuccessful. But this advantage is purchased at a very dear price. The artificial shape of the formulæ gives no direct indication of the shape of the formulæ of the Lunar Theory from which they are derived; and a very laborious process is necessary for bringing them to a state in which they can be referred to Mechanical Theory. Some years ago I did, at the instance of and in concert with Sir John Lubbock, effect this conversion for the longitude-formulæ; and Sir John Lubbock and others have done it (though without verification) for other formulæ. The conversion is troublesome, and the risk of error in the operation is great. On the whole, I was contented to trust to a future comparison of Burckhardt's numerical places of the Moon in Longitude and Latitude with places given by the theory to which I have alluded; and I tacitly assumed that there could be no sensible error in Burckhardt's Parallax, or in the Semidiameter which is deduced from the Parallax.

Very lately, however, Mr. Adams has shown that Burckhardt's Parallax is erroneous in formula and is numerically incorrect, sometimes to the amount of seven seconds. In consequence of this, every reduction of the observations of the Moon, from 1830 to the present time, is sensibly erroneous. And the error is of such a nature that it is not easy, in general, to introduce its correction by any simple process. From the year 1840, Mr. Adams has computed the numerical corrections to horizontal parallax, and it is possible that by means of the Greenwich Factors, P, Q, R, S, its effects in Longitude and Ecliptic Polar Distance may be found: but, before that year there is no course but to compute the parallax afresh.

This appears to me to indicate the present time as one at which the extension of the Greenwich Lunar Reductions may with propriety be taken up. There is, however, another reason. We may hope, before the completion of these reductions, to receive the Lunar Tables on which Professor Hansen is engaged. We should then have arrived at a time at which one good old theory may with propriety be abandoned, and another better new theory may be taken up. The connexion of one set of results with the other, when they are referred to theories which are presented in their natural form, is a matter of trifling difficulty.

It is to be remarked, that the amount of work to be done for each observation is very much less than was required for the more ancient Observations. From the beginning of 1836 no new reduction of the Observations, except for correction of parallax and semidiameter, is necessary. Before that time I trust that examination will shew that the results may be accepted almost without any other alteration. The principal labour will consist in the computation of the tabular places.

The number of Observations to the end of 1851 (after which time the parallax will be corrected in the current reductions) is about 2560. An expense approaching to £400 might be incurred in their reduction.

I have now to submit to the Visitors whether they may think fit to recommend to the Government to incur this expense.

G. B. AIRY.

Royal Observatory, Greenwich,
1853, *May* 3.

ADDENDUM.

I HAVE the satisfaction of stating to the Visitors, that the galvanic communications with Cambridge appear to have been perfectly successful, and the determination of its longitude most accurate. The atmosphere was in a dry state, which is important for insulation. The number of pairs of plates used at each end was 72. The signals were very strong and definite. On both nights, transits were obtained at both stations, both before and after the signals. The transits were reduced by two methods:—In Method A, the clock-stars of the Nautical Almanac were used; in Method B, a number of other stars (the same at both stations) were used. The result, as supplied to me this day by Professor Challis, is—

East Longitude of Cambridge.

Method A.

		s
May 17.	By 145 signals	22·953
May 18.	By 134 signals	22·978
	Mean	22·966

Method B.

May 17.	By 145 signals	22·903
May 18.	By 134 signals	22·988
	Mean	22·946

Concluded mean, giving equal weight to the two methods . . . . 22·956

The interchange of signals with Edinburgh also was perfectly successful: 216 pairs of plates were used at Greenwich against 144 at Edinburgh. I am not yet able to give the result for longitude, as there appears to have been an error in a chronometer at Edinburgh which is not yet completely corrected. I am able, however, to state the following result (which is not likely to be altered by correction of the chronometer): that the retardation in the time of observing a signal sent from Greenwich to Edinburgh or from Edinburgh to Greenwich, depending undoubtedly upon the two circumstances of gradual transmission of the galvanic current and more languid movement of the needle at the station furthest from the battery, is $\frac{1}{17}$ of a second of time.

G. B. AIRY.

1833, *June* 4.

REPORT OF THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS,

Read at the Annual Visitation of the Royal Observatory, Greenwich, 1853, *June* 4.

In my last Report to the Board of Visitors, I brought up the account of the Observatory to 1852, May 18. In the present Report I propose to exhibit the state of the Observatory on 1853, May 22, and to record generally the principal occurrences from 1852, May 18, to 1853, May 22.

I. Grounds and Buildings.—Within the inclosure of the Observatory, nothing has been done requiring the least notice, excepting the commencement of a new set of Plans of the Buildings, &c. Our wants for space, however, continue to increase; and I think that it will be found necessary, very shortly, to construct a new Fire-proof Room for Manuscripts, &c. I propose to erect a building of two stories in continuation of the Eastern Buildings, and to give it a front with pediments similar to those of other parts of the same range.

Beyond our own boundaries, however, there are two things worthy of mention to the Visitors.

The first of these is the repetition of the proposal, by the authorities of the South-Eastern Railway, for carrying a railway through the lower part of the Park. In the last autumn a plan was prepared by them, but there were in it so many points liable to serious objection, that it was withdrawn before it had been presented to Parliament. It is, however, understood that the South-Eastern Railway Company retain the desire of completing this line; and there are many large interests which would receive from it material benefit. The Board of Visitors have long ago been acquainted with my opinion, that, provided due care be taken in the plan of the Railway, the inconvenience which the Royal Observatory would suffer from it is altogether insignificant.

The second point is, the state of our galvanic communications. At the date of my last Report, the principal part of the work for carrying two wires to London Bridge (four having been laid in those parts in which the wires pass underground), was, by the kindness of the South-Eastern Railway Company and the Electric Telegraph Company, completed, but the wires were not so far connected as to be brought into use. Shortly after that time they were brought into daily use. Our prospective wants of galvanic connexions are increasing, and I have lately received the sanction of the Admiralty for the principal measures necessary to establish four complete galvanic lines from the Observatory to London Bridge.

One of the objects which it was proposed at first to effect by making a galvanic connexion with the London Bridge Railway Terminus was, to secure a communication with the Submarine Telegraph, and thus with the Continent of Europe generally, and with Paris in particular. There was reason

at that time to expect that the Dover Railway wires and the Submarine wires would be connected. The commercial relations of the companies, however, underwent some change; and ultimately an entire new line of wires has been laid underground from London to Dover, passing over Blackheath. Upon my communicating with Lord De Mauley and the Directors of the Submarine Company, I was assured by his Lordship that every facility would be given by that Company for communication with Paris, provided the connexions were made directly between the Royal Observatory and the wires of the Company. And the Officers of the Company with great courtesy acceded at once to the plan which I proposed, and which is now carried into execution. One of the Company's wires was cut where it crosses Blackheath, and the interrupted segments were continued by branches to a turn-plate which is contained in an iron box fixed in the south wall of the Park. From this turn-plate, a wire is led into the Transit-Circle-Room of the Royal Observatory. By different adjustments of the turn-plate, communications are made between London and Paris, between London and Greenwich, or between Greenwich and Paris. By a most liberal concession of the Company, the key of the iron box is preserved in my custody. The wire has not yet been used for the Greenwich-Paris communication, for reasons which will be explained shortly. In resuming, I may state that we have now the means of communicating with every part of Great Britain and of the Continent.

II. Moveable Property.—No change of the slightest importance has been made since the last meeting of the Board.

A Sextant is at present in my hands, borrowed from the Hydrographic Department of the Admiralty, for the purpose of trying some of the Horizons proposed for use at sea.

III. Manuscripts.—Professor De Morgan has transmitted to me, for preservation in the Observatory, a considerable number of letters found in the collection of correspondence of the late Mr. Baily. These cannot fail to contain matter which ultimately will prove very valuable for elucidation of the scientific history of the age now past; and I trust that I am supported by the approval of the Visitors in accepting this deposit.

I have borrowed from the Royal Society a manuscript book which appears to be an official copy of the Minutes of the Board of Visitors from their institution in 1710 to 1784. I have not yet had leisure to examine it with care.

The Visitors will remember that, some years past, I was enabled by the kindness of the Vice-Chancellor of the University of Oxford and the Librarian of the Bodleian Library to form a copy, approaching as closely as possible in character to a fac-simile, of Bradley's Observations. Very lately, I had the pleasure of receiving a hasty visit from M. Le Verrier, who had been carefully studying the printed Observations with reference to some investigations on which he is at this time engaged, and who brought with him a long list of apparent errors or inconsistencies. The whole or nearly the whole of these were removed by examination of the Manuscript Copy in the Observatory.

IV. Library.—No books of importance have been purchased in the last year. The Observatory is, however, deeply indebted to many of its friends for their presents to the Library. Among these, I am particularly bound to mention the Astronomische Nachrichten, the Comptes Rendus, the Observations of many Observatories, the Star Charts of Mr. Bishop, the collections of American books transmitted by the Smithsonian Society, the Transactions of many Societies, the Magnetical and Meteorological works edited by Colonel Sabine, and the Nautical Magazine by Captain Becher.

With the aid of donations of these kinds, and with ordinary care in keeping our sets of books perfect, our Library becomes almost a standard one for those subjects which particularly belong to the Royal Observatory.

V. Astronomical Instruments.—The Transit Circle is in an excellent state, and continues to maintain the most satisfactory character. In its reflexion-apparatus, two different changes are under contemplation.

The first relates to the method of emptying the quicksilver-trough. The Visitors are aware that, in its present state, the trough is a part of the parallel-motion-frame, and does not admit of being tilted; to discharge the quicksilver from the trough into the crane-reservoir, a tap is opened in the bottom of the trough; and in like manner to pour quicksilver from the reservoir into the trough (their relative positions being changed) a tap is opened in the bottom of the reservoir. This process is unobjectionable in regard to the discharge from the reservoir, because, generally speaking, the whole of the quicksilver is not run out of the cistern, and the dirt is left behind; but in discharging from the trough, every particle of quicksilver must be run out, and all the grit which it may carry passes through the tap; and in consequence, the tap is greatly injured. To obviate this, a new mounting is in preparation, in which the trough will not be a firmly connected part of the parallel-motion-frame; and then the discharge of quicksilver will be effected by tilting the trough.

The second change relates to the material of the trough. Several years ago, when I was at Hamburgh, my revered friend Professor Schumacher exhibited to me the pacifying effect of a copper dish whose surface had been previously amalgamated with quicksilver. It is well known that quicksilver in a vessel of glass, or iron, or copper not amalgamated, will preserve a continuous surface only when the depth of the quicksilver is considerable, and that its bounding edge is convex and bluff. But when the copper is amalgamated, the quicksilver will lie in a very thin sheet, and its bounding edge is slightly concave (like that of water on a wet dish), and in this state any accidental oscillation of the quicksilver comes to rest almost instantly. The Rev. Charles Pritchard has lately given much attention to this curious property of the metals, and has brought the practical operation of amalgamation to great perfection. Still it is not without difficulty, on account of a singular crystallization of the amalgam. I have hitherto tried the process very imperfectly; but I contemplate trying it with troughs of a better form than I possess at present.

The Transit-Circle for the Cape Observatory is finished in all that relates to engineers' work; and it is a very beautiful instrument. Some optical and divisional work is yet to be completed, which Mr. Simms will supply as rapidly as the present pressure of business permits.

The Reflex Zenith Tube is in good order, and is efficient. It would be very desirable, if possible, to introduce with this instrument the amalgamated trough of quicksilver of which I have just spoken. There is, however, this difficulty: from the peculiar construction of the Reflex Zenith Tube, the focal adjustment can be effected only by a float on the quicksilver; and with the amalgamated trough, the shallowness and the nature of the surface do not admit of this.

In the Altazimuth, no change whatever has been made. I must remark that the construction of the friction-wheels of the horizontal axis (a single wheel partially supporting each pivot) is not quite satisfactory to me; and I contemplate changing it for a double friction-wheel.

The Barrel Apparatus for the American method of observing transits is not yet brought into use. In an apparatus, embodying much that is new (for the circumstances under which we have to try it differ much from those of the original experiments), there must be a great many small alterations; and

sometimes, from the demand for workmen competent to perform work of this kind, a single alteration has caused more than a month's delay. I have, however, brought it to it such a state that I am beginning to try whether the Barrel moves with sufficient uniformity to be itself used as the Transit Clock. This, if perfectly secured, would be a very great convenience; but I am not very sanguine on that point. Much convenience will, however, be gained by making the barrel to move with a speed approaching very near to uniformity, even though the barrel-clock be not quite accurate enough to be used as the best measurer of time in the Observatory, and, therefore, not accurate enough to be used for impressing the second-dots upon the barrel.

The galvanic apparatus for sending hourly signals to London; the sympathetic dial at the Entrance Gate; the sympathetic clocks in the chronometer-room, computing-room, and dwelling-house; and a sympathetic clock at the South-Eastern Railway Terminus, are all complete and in constant use.

In the employment of the galvanic wires in the Royal Observatory for the several purposes of making registers in the American manner, dropping our time-ball, sending hourly signals to London, dropping the ball in the Strand, passing occasional signals to or from London and stations beyond London, and passing occasional signals to or from Paris, a variety of communications of wires is required. These are effected by means of several turn-plates which are distributed in different parts of the buildings.

The Equatoreals, Micrometers, &c., are in their usual good state.

The old instruments of the Observatory are preserved in their usual order, without, however, being subjected to very special examination.

VI. Observations.—No alteration is made in the general system of Meridional Observations. The observation of standard stars is carefully maintained. Attention is given to the more extended list to which allusion was made in the last Report. There are also a few stars which have been observed with the Moon, &c., and a small list of stars observed at the request of R. C. Carrington, Esq., to enable him to complete the reduction of certain observations made at Durham. The observation of the Moon on the meridian is never omitted; that of the Sun and Planets, only on Sundays. The whole number of observations from 1852, May 18, to 1853, May 22, is nearly as follows:—In the Transit Department: Transits, 4037; Observations of Collimators, 312; Observations of Transit-wire by reflexion, 312; Observations of one Collimator by the other, 52. In the Meridian-Circle Department: Observations of all kinds, 4475.

Several sets of Collimator Observations have been made for the intervals of the transit-wires, and one for the flexure of the telescope.

The ordinary routine of Transit Adjustments is as follows:—Once in each week the instrument is raised, and the south collimator is adjusted upon the north collimator. Once every day the two collimators are observed with the transit instrument, for obtaining the line of collimation. Once every day the wire is observed by reflexion, to obtain the inclination of the axis. Circumpolar stars are observed above and below the pole when possible, in order to give the means, with the corresponding collimator observations, of obtaining the azimuth of the North Collimator; and the azimuth as determined serves to determine the azimuth of the transit instrument on any other days. It is unnecessary to state that clock stars are observed, and objects whose right ascensions are to be determined.

The routine of Circle Adjustments is this. The runs of the microscopes are observed once in each week. The wire is observed by reflexion every day. If the weather admits, a north star and a south

star are observed by reflexion every day. The errors of graduation determined in 1850 are still retained; I bear in mind, however, the propriety of repeating the examination of these errors, or at leats a part of the operation. The corresponding determinations of values of micrometer-screws are also retained. The observations for flexure have been repeated lately, and I shall shortly allude to the results.

The Reflex Zenith Tube was used for observations in the last autumn till October 20. Between May 18 and that day, 106 single observations were obtained. In the winter, a copper mercury trough was prepared with amalgamated surface, and the focal adjustment was made by the use of a 7-feet telescope as collimator. By some mischance, in afterwards cleaning the quicksilver, the adjustment was disturbed, and (as has been explained) it could not be easily recovered; and in consequence the star was lost till it became so bright in the morning that its confused broad disc was seen. The ancient form of quicksilver trough has now been restored; and six observations have been obtained since April 1. Some, perhaps, have been lost, from the necessity, during the illness of Assistants, of employing unskilled Supernumeraries.

The Altazimuth has been used in precisely the same manner as in the preceding years. The number of days of complete observations of the Moon is 224, or 18 per lunation, against 106 with the Transit Circle, or $8\frac{1}{2}$ per lunation. Of the Altazimuth observations, 0 are when the Moon passed between 0^h and 1^h, 4 between 1^h and 2^h, 8 between 2^h and 3^h, 8 between 3^h and 4^h, 6 between 20^h and 21^h, 0 between 21^h and 22^h, 1 between 22^h and 23^h, 1 between 23^h and 24^h. In none of these positions, except on a single occasion between 20^h and 21^h, was the Moon observed on the Meridian. The whole number of separate observations of Moon and Stars with the Altazimuth is 1003; and the whole number of separate observations of its Collimator, 712.

The South Equatoreal has been used only for images of the Solar Spots. Of these, 30 have been obtained to October 2, and one in the spring. The narrow dimensions of the South Dome make it difficult to observe in the winter; and in the spring we have had very little leisure.

The Double-image Micrometer has been used for measures of Venus, Saturn and his rings, and γ Virginis.

No observation of unusual character has been made, except a series of experiments for examination of the region immediately surrounding the Sun's limb (by throwing the image of the Sunthrough a circular hole in a white card) in order to ascertain whether any red projections like those seen in total eclipses could be discovered. The results were simply negative: nothing was seen; nor do I now conceive it possible that anything can be seen through a fully illuminated atmosphere of full density.

VII. Reduction of Observations.—The reductions are not so close as they have usually been; but for this there has been ample cause. The illness of one Assistant (Mr. Rogerson) has terminated in death; and it is only after some delay that his place has been filled up. Another Assistant (Mr. Glaisher) has been unable to attend to business from the beginning of February to the present time; and, though his occupation is not in the Astronomical department, yet his absence has drawn away and will continue to draw away some strength from the astronomical computations. A third Assistant (Mr. Breen), whose time is entirely devoted to calculations, has been long absent in consequence of illness, and is still very feeble. With this deprivation of strength, nothing but the order and energy of Mr. Main (assisted in some measure by the tardiness of the Printers, who have not troubled us with proof-sheets) could have kept our computations in a creditable state.

For Transits at this time (May 22) the instrumental errors are applied, and Clock Time of true Transits

formed to May 14; and apparent right ascensions from observation are formed to May 5. The corrections for reducing the places of the stars to the first day of the year are inserted in the Transit Books as far as May 7, but are not yet actually applied. For the Circle observations, refractions are applied, and North Polar Distances at observation are formed, to March 31; the stars' places to the first day of the year are formed only as far as Feb. 16. The Apparent Zenith Distances are computed to April 17, and the Concluded Circle Readings are complete to the present time. A set of observations for the flexure of the telescope was made in the beginning of this year; the combination of the results of this set, with those of other observations of the same kind in 1850 and 1851, gives exactly the same coefficient for flexure with that which was inferred from star-sbservations by reflexion in 1851.

The observations with the Reflex Zenith Tube are nearly reduced. The results are accordant, but not so close as I had expected.

The Zenith Distances observed with the Altazimuth are reduced to April 26; the Azimuths, to March 3; the Tabular Computations, to April 26; the conversion of Errors of Azimuth and Zenith Distance into Errors of Right Ascension and North Polar Distance is made as far as March 3. The results, generally speaking, are very good.

The observations with the Double-image Micrometer are reduced. The observations of Sun-spots are reduced to the same stage as was mentioned in the last Report.

These remarks apply to the reduction of the observations of the year 1853. For 1852, every thing is completely reduced, with only the following exceptions. The Star-Catalogue is not absolutely finished, though all the means are ready. The Solar and Planetary Observations are nearly finished, but are not written out for press. The Lunar Meridional Reductions were nearly complete (wanting only the exhibition of errors in Longitude and Latitude), when, in the spring of the present year, Mr. Adams's corrections of the Lunar Parallax were published. It became necessary at once to make the corresponding alterations in the reduction of all the observations of the Moon for 1852. The alterations to N.P.D. are now finished; but those to Longitude and Latitude are not quite ready. The Altazimuth Reductions were completed to the very last stage, when it became necessary to alter all for the same reason: this alteration is not entirely completed.

I have not examined the results of adjustment-observations sufficiently to judge whether the appearances which I described last year, suggesting a movement of the solid ground, are or are not supported by the observations of the present year.

VIII. Printing of Astronomical Observations.—The Observations of 1851 have long since been printed, and the volume would have been distributed some time ago, but for the following arrangement. I had intended to attach to it a description of the Transit Circle: but the draftsman who was employed delayed his work so long, that the engravings could not possibly be prepared in time. Mr. Main had nearly revised for press the Ledgers of Dr. Maskelynes's star-results, to which I have on several preceding occasions called the attention of the Visitors. In order to prevent the volume for 1852 from being too much loaded, I thought it desirable at once to prepare Dr. Maskelyne's reductions for press, and to attach them to the volume for 1851. Seven sheets of this Appendix are now printed.

No part of the volume for 1852 is actually printed: this, however, is no fault of the Observatory. By new arrangements of her Majesty's Stationery Office, the printing of our Observations has been transferred from Messrs. Palmer and Clayton to Messrs. Eyre and Spottiswoode. A large quantity of manuscript of almost every section of the Observations has been placed by me in their hands,

but it is only at the moment of writing that I have received the first proof-sheet. The undertaking of a new contract of very great magnitude has undoubtedly caused some confusion in their offices; but I do not doubt that the work will now progress with reasonable speed.

IX. Magnetical and Meteorological Instruments.—With occasional repairs, our instruments of this class remain in every respect in the same state as last year, except in regard to the Electrometer-apparatus. A wire for the collection of atmospheric electricity is now stretched from a chimney on the north-west angle of the leads of the Octagon Room to the Electrometer Pole. At each end it is attached to a glass tube: the tube on the chimney is kept hot and dry by a small jet of gas; for that on the pole, which would not be conveniently accessible if fixed, and which is, therefore, mounted on the travelling frame, an oil lamp is used. From this wire, another wire is led down to the electrometers. There appears to be no doubt that a greater amount of electricity is collected by this apparatus than by that formerly in use.

X. Magnetical and Meteorological Observations.—The system remains in every respect as in the last year. The Photographic instruments register the indications of the Magnetometers, the Barometer, and the Dry and Wet Thermometers. Osler's, Whewell's, and Crosley's instruments register in different ways the direction and pressure of the wind and the rain. Eye-observations are made, as is necessary, for zero-points to these instruments. Magnetic Dip (thrice on one day in each week), deflexions for absolute measure of magnetic force (about once a month), magnetic vibrations, and indications of thermometers sunk in the ground, are observed by the eye. Captain Sanders, R.N., with great zeal for the prosecution of an important meteorological inquiry, under circumstances frequently of an uninviting kind, reads daily a maximum and a minimum thermometer suspended from the Dreadnought Hospital Ship in the Thames. And the Rev. G. Fisher registers every month the accumulation of water in a rain-gauge at the Hospital Schools.

XI. Reduction of Magnetical and Meteorological Observations.—The formation and combination of equivalents for the daily observations of the Declination and Horizontal Force Magnetometers are completed to the present time. The Theodolite Zero, however, is prepared only to the end of 1852. The Vertical Force observations are reduced only to the end of 1851. The Dip observations are reduced to the present time. The Deflexion observations to the end of 1851. The daily Meteorological observations are prepared, as far as appears necessary, to the present time.

The Photographic Sheets of Declination, Horizontal Force, Vertical Force, and Barometer, have their time-scales laid down to the end of 1852; those for the Thermometers are not completed. For the Declination, the base-line readings are inferred from comparison with eye-observations to 1852, Nov. 30; but the new base-lines are not drawn. In the other sheets, every thing is finished to the end of 1851, and considerable progress is made in the insertion of equivalents of eye-observations (for comparison with the photographs) to the end of 1852, but no part is finished.

In the photographic curves of the Vertical Force Magnet there are still occasional dislocations. Some time since, on collecting in a tabular form the times and directions of these dislocations, it appeared that they almost always correspond to the time of commencement of diurnal change of movement in that direction in which the dislocation took place. I am inclined, therefore, to think that they are not so purely accidental as I had imagined; and I propose in future to insert the transcript of photograph readings in our printed book without the retracing which has hitherto been

used, but with such an exhibition of the double reading at the time of dislocation as will fully convey to the reader its amount.

The Visitors, at their last meeting, expressed a wish that some attempt should be made to proceed further in the reduction or digest of the magnetical results, if any satisfactory plan could be devised. I cannot say that I have yet satisfied myself on the propriety of any special plan that I have examined. As regards the mean result of any number of indications obtained at definite hours of the day, I am by no means disposed to take simply the indications read off from the sheets precisely at these hours. The treatment of the curves in the way which I should be disposed to adopt, as preliminary to any process of taking means, would require greater labour than we have been able (with our diminished personal strength) to give to them in the past year. I must, however, confess that, in viewing the capricious forms of the photographic curves, my mind is entirely bewildered, and I sometimes doubt the possibility of extracting from them anything whatever which can be considered trustworthy.

XII. Printing of Magnetical and Metcorological Observations.—The printing for 1851, as I have mentioned, was finished some time since. No part of the manuscript for 1852 has been delivered to the Printer; its preparation having been interrupted by Mr. Glaisher's serious illness.

XIII. Chronometers, Communications of Time, and Operations for Longitude.—The number of Chronometers now on hand is 120. The system of rating the chronometers daily or weekly as the case appears to require, of reporting the rates to the Admiralty, of rating the trial-chronometers in extremes of heat and cold, of abstracting their rates, of superintending repairs, and of dropping the signal-ball, remains unaltered. In the mechanical part of the operation of rating an alteration has been made, which contributes greatly to convenience, and in some measure to accuracy. At the time of the Vistors' last meeting, a Normal Clock had been erected by Mr. Shepherd, furnished with a small apparatus suggested by myself (an auxiliary pendulum, which can be made very long or very short, and can in either state be connected with the clock-pendulum), by means of which the indication of the clock can be increased or diminished by any required quantity above $0^s \cdot 01$. The error of this clock being ascertained every day, by means of another clock close to its side which has been compared with the Transit-clock, there is no difficulty (with the use of the auxiliary apparatus above mentioned) in making it sensibly correct. This clock keeps in motion a sympathetic galvanic clock in the Chronometer-room, which, therefore, is sensibly correct; and thus the chronometers are compared with a clock which requires no numerical correction. I need not insist on the facility, and the freedom from a fruitful source of errors, which are thus obtained.

The same Normal Clock maintains in sympathetic movement the large clock at the entrance-gate, two other clocks in the Observatory, and a clock at the London-bridge Terminus of the South-Eastern Railway (first tried with the assistance of C. V. Walker, Esq., as an experiment, but now to be used for automatically making and unmaking certain connexions of our galvanic wires). It sends galvanic signals every day along all the principal railways diverging from London. It drops the Greenwich Ball and the Ball on the Offices of the Electric Telegraph Company in the Strand; and the correctness of the last of these operations is tested by means of a galvanic signal-needle upon the case of our transit-clock. All these various effects are produced without sensible error of time; and I cannot but feel a satisfaction in thinking that the Royal Observatory is thus quietly contributing to the punctuality of business through a large portion of this busy country.

I have the satisfaction of stating to the Visitors that the Lords Commissioners of the Admiralty

have decided on the erection of a Time-Signal Ball at Deal, for the use of the shipping in the Downs, to be dropped every day by a galvanic current from the Royal Observatory. The construction of the apparatus is intrusted to me. Probably there is no roadstead in the world in which the knowledge of true time is so important; and I anticipate that this decision of the Admiralty will be highly agreeable to the Visitors.

One of the objects, for which the galvanic communications between the Royal Observatory and the principal lines of telegraph were recommended, was the determination of differences of longitude, for British and Continental Observatories. I am happy to state that a step has been made in carrying out this intention. On the nights of May 17 and 18, excellent series of signals were passed backwards and forwards between the Royal Observatory and the Railway Station at Cambridge. No wires have been led to the Cambridge Observatory; and Professor Challis was therefore compelled to carry chronometers, previously compared with the transit-clock, to the station. The observers were interchanged on May 18 for the elimination of personal equation. At the moment of my writing, the observations are not fully reduced; but I shall probably be able to state verbally to the Visitors the result of this operation. I anticipate from it a most accurate determination of the difference of longitude. It is perhaps worthy of mention that all the Greenwich signals were given by the contact-apparatus on the Transit Circle, adapted to the American method of observation; and that many of them corresponded to the transits of stars over the wires, as observed by the eye.

I have also made every arrangement with Professor C. Piazzi Smyth for the interchange of signals on the night of May 25, and trust to be able to state to the Visitors the result.

I believe that wires are nearly completed for connecting the Oxford Observatory with the Railway Station at Oxford, and I may soon anticipate the galvanic determination of the longitude of Oxford Observatory.

In these operations I am gradually acquiring the experience which will be necessary for undertaking an enterprise of somewhat greater difficulty and greater delicacy, namely, the determination of the difference of longitude between the Observatory of Paris and that of Greenwich.

XIV. Personal Establishment.—The numerical strength of the establishment is the same as it has been for some years past. The officers of the establishment are:—First Assistant, Rev. R. Main. Astronomical Assistants: Mr. Henry, Mr. Dunkin, Mr. Breen, Mr. Henderson, Mr. W. Ellis. Magnetical and Meteorological Assistants: Mr. Glaisher, Mr. Downs. Three or four supernumeraries also have usually been employed.

Mr. Breen superintends the computations which are carried on by the supernumerary computers, and is not usually employed in observing; but when need requires, any one of the Assistants or Computers is called on to make observations.

As before, a Labourer, Gate Porter, and Watchman, are attached to the establishment; and a Carpenter, who acts upon occasion as Clerk of Works, is almost constantly employed.

XV. Extraneous Computations, or Computations not connected with the Current Observations.—The revision of Dr. Maskelyne's Ledgers of Star Results is terminated; and I trust it will be found that the publication of these deductions will give most valuable information on the state of the sidereal heavens from 1765 to 1807. Another work of greater magnitude now presents itself for the consideration of the Visitors.

The great Lunar Reductions terminate with the end of the year 1830: an epoch adopted to corre-

spond with that of the termination of the Planetary Reductions. There was obviously no reason for definitively closing the reductions at that time, and there was strong reason for continuing them, inasmuch as Burckhardt's Tables (to which, through the intermediation of the Nautical Almanac, all later observations have been referred) are constructed on the dangerous principle of altering the mathematical form of the tables, by contrivances extremely difficult to verify, in order to give small facilities to the computers of lunar places. It was supposed, however, by me, that a mere examination of the differences in Longitude and Latitude between Burckhardt's Tables and the Tables used in the Lunar Reductions would suffice, in order to effect a reference of the Greenwich Observations to the Tables of the Lunar Reductions. But Mr. Adams has lately ascertained that there is a serious error in Burckhardt's Parallax, and, in consequence of this, the whole of the reductions of the observations to the end of 1851 are, to some extent, erroneous. I have now to propose for the consideration of the Visitors, whether it would not be desirable at once to complete the reduction of the observations and their comparison with tables, from 1831 to 1851; using, as far as possible, in all respects the same bases of reduction of observations, and the same elements of tables, as in the former Lunar Reductions. The quantity of calculation to be made for each individual observation would be considerably less than before; still it is not to be supposed that such a series of computations could be effected at a less expense than £400.

XVI. General Remarks.—In spite of the considerable diminution of strength in our personal establishment to which I have alluded, I have the satisfaction of believing that the Observatory is in a thoroughly efficient state. The support of the Government has never been denied, when application has been made on well-considered grounds. The characteristics of our Astronomical duties are well understood by every Assistant connected with the establishment. It is known that we are confined to observations of a standard class, and that even our galvanic and other novelties are subjected to that restriction; but in that restricted class it is known that our observations must be unimpeachably good. With this feeling, and with the command of instruments superbly adapted to their purposes, I have no doubt that our observations may challenge comparison with any in the world. Our adjustments and reductions are in a healthy state. The system of combining the labour of unattached computers with that of attached Assistants tends materially to strengthen our powers in everything relating to computation. We find also, among the young persons who are engaged merely to serve us as computers, a most laudable ambition to distinguish themselves as observers; and thus we are always prepared to undertake any observations which may be required, although necessarily by an expenditure of strength which would usually be employed on some other work.

Several matters connected with the formation of national standards, and the consideration of systems of measures, weights, and coinage, have occupied much of my own time. I do not doubt the feeling of the Visitors, that these employments are perfectly proper to my position; and that my occasional attention to these subjects does, in fact, contribute to the utility and the credit of the Observatory.

G. B. AIRY.

Royal Observatory, Greenwich,
1853, *May* 28.