REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1863, *June* 6.

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THE Report, which I had the honour last year to submit to the Board of Visitors, brought up the history of the Royal Observatory to 1862, May 13th. In the Report now offered, I propose to continue that history to 1863, May 17th.

I. Buildings and Grounds.—In the last Report I alluded to several changes of the buildings, as commenced or in contemplation. They have since been entirely carried out. Struve's Observatory, and the former Dip House and Deflexion House, have been taken down. A range of seven rooms has been built near the southern fence of the Observatory Grounds. Of these, No. 1 (reckoning from the East) is considered as an experiment-room; Nos. 2, 3, 4, 5, 6, are appropriated to various operations of photography; No. 7 contains the Deflexion-apparatus and the Dip-Instrument. On the south side of the range, at a small distance, is a long desk for supporting papers pressed between plate-glasses in the process of making photographic copies. Beyond this desk a piece of ground a few feet in breadth is left vacant.

The extension of the Magnetic Anteroom has been found extremely convenient. It enables me to place several computers under the immediate inspection of the Magnetic Superintendent. If this extension had been made a few years ago, the magnetic reductions 1848–1857 might have been effected with a great diminution of expense, and, in some respects, in a more satisfactory manner.

The exterior naphthalizing house has been completed, and is in constant use; and contributes to convenience and safety in the degree which was contemplated.

The stove in the lowest room of the S.E. Dome, whose flue was led by underground passage into the chimney of the Record Room, though perfectly successful as regarded draft, &c., did not give a sufficient volume of heated air to the middle room for the comfort of computers in cold weather. I have therefore had a stove planted in each room with rising flue; these flues are led through the wall of the staircase, and, scarcely remarked by the eye, pass to the roof of the Record Room. The stoves effect their purpose of warming the rooms extremely well.

A Map of the grounds and buildings in their present state has been nearly prepared for engraving, but I have not yet completed it sufficiently to place it in the engraver's hands.

The wires for observation of spontaneous magnetic earth-currents have been mounted, extending from the Royal Observatory along the poles of the South Eastern Railway, one to a point in the neighbourhood of Croydon, the other to a point in the neighbourhood of Dartford. They are insulated with great care. I shall in the course of this Report again allude to them.

The Visitors are aware that the project of carrying a Railway in a tunnel through the lower part of Greenwich Park has this year been revived. Three plans were proposed, by three different companies; two of them are withdrawn, but one (that of the London, Chatham, and Dover Railway Extension) is still pressed. On this subject I may say briefly that I believe that it would be possible to render such a railway innocuous to the Observatory; it would however be under restrictions which might be felt annoying to the authorities of the Railway, but whose relaxation would almost insure ruin to the Observatory. And it is to be remarked that, for this very reason, the communication between Woolwich and London was, some years ago, carried round in the detour by Lewisham; that, if connection between Woolwich and Blackfriars is required, a junction can easily be made either in the Ravensborne valley (which makes connexion both with Blackfriars and with the Crystal Palace) or at Gravel Lane; and that a very small expense would independently connect Woolwich with Greenwich. The passage through the Park is now therefore actually unnecessary.

II. Moveable Property.—The changes in our catalogue of the moveables of the Observatory during the last year will be most insignificant. I know of nothing which merits the special attention of the Visitors.

The Parliamentary Copies of the Yard Standard and the Pound Standard, which are deposited in the Royal Observatory under the provisions of the Standard Act, for official custody, are in good order.

III. Manuscripts.—The arrangement and cataloguing of the bound Manuscripts by Mr. Carpenter, one of the Assistants of the Royal Observatory, to which I alluded as in progress at the last Visitation, have been completed.

The current arrangement of Manuscripts, as they accumulate daily, is closely kept up, on a system which the experience of many years has shown to be very satisfactory; and volumes are bound from time to time, when the amount of collected papers on any special subject appears to make binding desirable.

The minutes of the Board of Visitors from 1784 to 1830 have not been found. I do not doubt of their safe preservation; but, after inquiring in many directions, I know not now where to look for them.

IV. Library.—The Library continues to increase, partly by moderate purchases, but principally by presents. As far as depends on the direction given by me, it is in great measure confined to the subjects which are actively pursued in the Observatory.

The system of arrangement and catalogue, which was planned many years ago, has been kept up with general regularity. It now appears to require change, and Mr. Carpenter is charged with the preparation of a new Catalogue.

V. Astronomical Instruments:—

The Transit-Circle is in an excellent state. The hemispherical bearings of the micrometer-screws have been somewhat worn, and the micrometer-heads are, in consequence, approaching suspiciously near to the index-pieces and other portions of the fixed frame. I intend to have these parts sufficiently filed to remove all fear of danger.

The Transit-Clock, the Chronograph, and the Reflex Zenith-Tube, are in good order, requiring no special notice.

The Altazimuth is in good order. It has lately been subjected to a special examination, for the following reason. In the operations for the determination of the longitude of Valencia (to which further allusion will be made), it was found that a

small Altazimuth used at Valencia gave the zenith-distances constantly too great. It was suspected therefore that there might be a constant error in the zenith-distances of the Greenwich Altazimuth. Observations have, in consequence, been made with the Altazimuth on a number of selected stars, on different parts of the meridian, from the neighbourhood of the north to that of the south horizon. The results agree most accurately with those of the Transit-Circle.

The Galvanic Signal-Apparatus is in good order; no change has been made in it.

The Shuckburgh Equatoreal is in the same state as during the last two years. No need for accurate reading of the graduations of the Hour-Circle has occurred, and the proposed alteration has not been made in the microscopes.

The Sheepshanks Equatoreal is in its usual state, and is perfectly efficient.

The South-East Equatoreal is in a perfectly good state. It has received no change since the last Visitation.

The Prismatic Spectrum-Apparatus has been completed, and is very efficient. It is constructed on the principle of giving breadth to the linear spectrum by allowing the conical pencil of light, that diverges from the image of a star, to fall in a diverging state upon the prism, which is placed in a position differing from that of minimum deviation. When both these conditions are secured, the light, on emergence from the prism, diverges differently in the two transverse planes; and the apparatus of lenses which then receives the pencil, and which gives complete convergence in the direction that produces purity of the spectrum, does not give complete convergence in the direction that produces narrowness of the spectum. The construction is the simplest that has been proposed for its purpose. Still I regard it as experimental; there may be some risk in the oblique refraction of conical pencils; and I propose soon to try the effect of the prism with parallel pencils of rays passing through it; breadth being given to the spectrum by a cylindrical lens.

The Ancient Instruments are apparently in their usual state, but have not been specially examined. It is my intention shortly to have them carefully examined and cleaned.

VI. Astronomical Observations.—From the establishment of the Observatory, a definite class of fundamental determinations has been regarded as its principal object; and, from the mounting of Bradley's newer instruments, these determinations have been effected nearly in the same manner as in later times. They are still regarded as

the subjects of observation which are to take precedence over all others. Their purpose is, to establish the places of the principal fixed stars, of the Sun, of the known bodies of the solar system, and of the Moon. For all except the Moon, meridional observations are considered sufficient; but for the Moon, extra-meridional as well as meridional observations are made available.

The stars observed on the meridian are; clock stars to the number of 189, and stars to the 5th magnitude generally; and some circumpolar stars; and also some stars connected with special observations, as conculminating with the Moon, occulted by the Moon, exhibiting proper motion, assisting to determine the laws of refraction, or used in comparison with Sirius or with planets; as well as some imperfectly determined in the Seven-year Catalogue. With these may be connected the observations of γ Draconis with the Reflex-Zenith-Tube, made at nearly every visible week-day transit of the star. Of the moveable bodies, the Moon only is observed on every day on which she is visible, without any exception; the Sun and inferior planets are observed on every week-day; the large superior planets every week-day when they pass before 15^h, or pass near to the morning Moon; the small superior planets when they pass before 14^h.

The number of meridional observations with the Transit-Circle from 1862, May 13, to 1863, May 17, is as follows:—

Transits (the 1 L. and 2 L. of the Sun, &c., being considered as two separate objects)	3,927
Pairs of observations of the Collimators by the Transit-Circle	304
Reflexion-observations of the transit-wires	296
Observations of Collimator by Collimator	54
Circle-observations of all kinds	3,960
Reflexion-observations of the zenith-distance-wire (included in the last number)	291
Reflexion-observations of stars	251
Circle-observations of Mars, for parallax, 1862, August 25 to Nov. 12	29

The observations of γ Draconis with the Reflex-Zenith-Tube are,

Pairs of observations (the instrument being reversed between)	41
Single observations	2

The observations with the Altazimuth are as follows:—

Azimuths of Moon and Stars	685
Azimuths of the Collimator	386
Zenith-distances of the Moon	375
Zenith-distances of the Collimator	386

The Moon was observed with the Altazimuth on every one of the 20 consecutive days from 1863, April 21 to May 10.

The number of altazimuth-observations of the Moon in both elements when near conjunction with the Sun is the following. The hours stated define the solar time of the Moon's transit over the meridian on the days of observation.

Between 21^h and 22^h	4
Between 22^h and 23^h	0
Between 23^h and 24^h	0
Between 0^h and 1^h	0
Between 1^h and 2^h	2
Between 2^h and 3^h	5

The whole number of days on which the Moon has been completely observed with both instruments is,—

With the Altazimuth, 190, or 15·2 per lunation.
With the Transit-Circle, 99, or 7·9 per lunation.

The South-east Equatoreal was used in observing Mars and neighbouring stars, East and West of the meridian on 11 days, and East or West of the meridian on 25 days; and stars for testing the adjustment of the instrument were observed on 5 days. It was also used on one day for observing Comet II. of 1862.

The Double-Image-Micrometer had been adapted to the South-East-Equatoreal, and had been used for measures, before the date of the last Report. In the period now under record, its scale has been determined. It has also been used once for measures of the diameters of Saturn when his ring was nearly invisible the second time.

The appearance of Saturn was carefully examined during the edgewise position of the ring, and at a transit of the shadow of Titan; and two drawings of Saturn were made. Four drawings of Jupiter also have been made.

The Solar eclipse of 1863, May 17 was imperfectly observed.

The number of observed occultations of stars by the Moon is 12; 6 being disappearances and 6 reappearances. The number of phænomena of Jupiter's satellites is 21.

Fifty stars have been observed with the spectrum-apparatus. The following is the number of spectral lines whose positions have been measured with the micrometer:—

13 stars (principally of the 4th magnitude) have no measurable lines;
In 5 stars, 1 line has been measured in each spectrum,
In 20 stars, 2 lines „ „
In 7 stars, 3 lines „ „
In 5 stars, more than 3 lines „ „

Besides these, there are other lines not easily measurable.

VII. Reduction of Astronomical Observations.—For deducing the Right Ascensions of observed objects from the observations, the following progress has been made in computation; True Transits, corrected for all instrumental errors, are computed to 1863 April 19; Clock Errors and Rates to April 18; Apparent Right Ascensions of Center of Object to April 3; Stars' Corrections are computed to May 4, and applied to 1862 Dec. 31; Corrections for imperfect illumination of the Moon's Limbs, &c. to 1861 Dec. 31; Mean Solar Times to 1863 March 31. For deducing North Polar Distances from observation; True Zenith-Distances, corrected for zenith-point and refraction, are formed to April 4; Stars' Corrections are computed to May 2 and applied to 1862 Dec. 31; Corrections for imperfect illumination of Limb, to 1861 Dec. 31.

For the Ledgers, or collections of all results for each Star's Mean R.A. under one head and for each Star's Mean N.P.D. under one head, preparations are only commencing for 1862. The Star-Catalogue for 1862 is not begun. The number of stars will be about 525. The investigations for R — D and for Correction of Latitude, for 1862, are not yet begun.

In preparation for the comparisons of Right Ascensions and North Polar Distances of Sun, Moon, and Planets deduced from observations, with those computed from Tables, various numbers are entered, but nothing is finished for 1862. The investigations which usually follow, for determining the Position of the Ecliptic, the Errors of Tabular Places in Longitude and E.N.P.D. for the moveable bodies, and the Heliocentric Errors of Planets, are completed to the end of 1861; no steps are made in the computations for 1862.

The observations with the Reflex-Zenith-Tube are reduced to 1862 April 24. Their completion will be a short work.

The Altazimuth Observations are reduced to the following stages:—Observed Azimuths are corrected for all instrumental errors to 1863 February 14, Observed Zenith-Distances to May 10, Tabular Azimuths and Zenith-Distances to April 12, Errors of Tabular R.A. and N.P.D. of the Moon to 1862 December 14, and Errors of Tabular Longitude and E.N.P.D. to the same day.

The Equatoreal observations of Comet II. of 1862 are not yet reduced. For the observations of Mars east and west of the meridian, the corrections for refraction are applied, and the individual results of observation are obtained; an investigation however of such delicacy as the deductions of the Sun's parallax from the extra-meridional observations of Mars necessarily requires careful treatment.

The observations with the Double-Image-Micrometer are reduced to 1862, June 3.

The Occultations of Stars by the Moon are reduced to the end of 1861.

The measures of the lines in the spectra of stars are so reduced as to make them strictly comparable with the lines of the solar spectrum.

The discussion of the conclusions from these reductions exhibits the following results :—

The personal equations in transit-observations are insignificantly changed. Referring to Mr. Dunkin as standard, the greatest changes in the personal equations of the other observers, between 1861 and 1862, are $+ 0^s{\cdot}14$, $- 0^s{\cdot}07$, and $+ 0^s{\cdot}04$; but in these instances, the observers are assistants not often employed in transit-observations. Of the ordinary observers, only one shows a change so great as $0^s{\cdot}02$.

The azimuthal error of the Transit-Circle, as in former years, performs an annual oscillation of six or seven seconds; the error being zero in the month of September, the same month in which the instrument was erected with zero-error. I am not able to state whether, in this year, the collimators accompany it. The azimuthal zero of the Altazimuth, as determined from observations of stars, has irregular changes, while the reading for the collimator is nearly constant.

It has been remarked lately that the apparent errors in the Moon's Tabular N.P.D. given by the Altazimuth are less than those given by the Transit-Circle, by about $1''$ in the mean of comparisons. There is some reason to think that a part at least of this difference has arisen from an erroneous method of taking the readings of the barometer and thermometer for computing refraction; and steps will be taken to correct it.

The meridional observations of Mars in the autumn of 1862 have been compared with those made at the observatory of Williamstown near Melbourne, Australia, and they give for mean solar parallax the value $8''{\cdot}932$, exceeding the received value by about $\frac{1}{24}$ part. (A value nearly identical with this $8''{\cdot}93$ has also been found by comparing the Pulkowa and Cape of Good Hope observations.) The comparison of Greenwich observations east and west of meridian, though yet unfinished, appears likely to give a result of the same kind.

The drawings of Saturn show well the singular brown appearance of the ring when turned nearly edgewise. The ring never entirely disappeared.

In the measured star-spectra it is remaked that, of the 50 spectra measured, 28 have each a line corresponding exactly to the solar line F.

The principal work, less connected with the daily routine of reductions, is the preparation of the Seven-year Catalogue of 2021 stars, formed from observations in the years 1854–1860. The constants for reduction of star-places have been entirely computed anew: and a few errors have been found in former computations. Every part of the catalogue is prepared, with the exception of references to other catalogues which are not quite completed.

VIII. Printing and Distribution of Astronomical Observations.—The printing of the Tabular Part of the volume for 1861 is finished, and that of the Introduction is in hand. No part of the manuscript copy for 1862 has yet been sent to the Printer, but a large quantity is nearly prepared; and I expect shortly to send to him (besides the Seven-year Catalogue above-mentioned) a considerable portion of the Meridional R.A. and N.P.D., and of the Altazimuth Zenith-Distances, Azimuths, and Tabular Computations.

The volume for 1860 has been distributed to the same extent as in the great distribution of the preceding year. The number of copies remaining on hand is below 100; the whole impression being 350 copies.

IX. Magnetical and Meteorological Instruments.—The three magnetometers, whose positions are observed by eye about four times every day, and which register continuously by photographic impression the three fundamental magnetic elements, are in good order. The knife-edges of the vertical-force-magnetometer were reground by Mr. Simms at the end of last year. This instrument still exhibits occasionally those starts of position, accompanied by vibration, which produce "dislocations" in the photographic curve. Their magnitude is unimportant. Sometimes the curve is thrown out of position and in a short time returns gradually to its former track. They occur as frequently when the observatory is locked up as at any time. Every the smallest force of the nature of magnetic disturbance is beautifully registered.

In order to ascertain whether these dislocations depend on the magnitude of the apparatus, or upon the separation of its two bearing-edges, I have instructed Mr. Simms to construct a Vertical Force Instrument, with linear dimensions three-fourths of those of the instrument now in use, differing from it in no point of arrangement except that the ends of the needle may be pointed, and that (if possible) the knife-edge may be one continuous piece of steel. Hitherto the artist has not succeeded in finding a piece of steel which will bear hardening.

I have commenced the system of carefully closing the double glass-sashes and case-

ments and the wooden window shutters through the night, with the view of preserving greater uniformity of temperature in the magnetic observatory. It appears, as far as we can judge, that, for similar ranges of external temperature, the range within the magnet-boxes is diminished by a quantity between 1° and 2°.

The Kew deflexion-instrument is in good order. The circle-verniers have been removed to positions more convenient than their first places. There are some defects in the plan of this instrument, as used in a fixed observatory, which I shall endeavour by degrees to remove. One annoyance, arising from the necessity of making certain changes of mounting in order to observe the vibrations of the deflecting magnet, has been dismissed by the simple expedient of observing the vibrations upon a separate tripod stand. There is, still, more hooking and unhooking than I could wish, and I shall endeavour so to modify the instrument that these can be avoided as regards the deflecting magnet. But the greatest fault is the feebleness of mounting of the telescope. Upon its firmness of connexion, the accuracy of the observation entirely depends; yet the grasp by which it is held is the weakest that I ever saw. When these defects are removed, I do not doubt that the instrument will prove excellent.

The Dip-Instrument, as I mentioned in my last Report, was suspected to have a little iron in its base plate. Every part has been very carefully examined. Every part except a small bar near the base-plate is made of chosen gun-metal, and appears to be perfectly free from magnetism; that bar is of brass, and was found to be slightly magnetic. It is now removed. The observing-microscopes at first required to be shifted and screwed in order to change their adaptation from a needle of one length to a needle of another length; to avoid the insecurity and various troubles attending this, the microscopes and illuminators are now made in triplicate, and are always ready for any of the needles. The relieving apparatus has been a little altered; attention has been given to the needle-axes; and the whole is in a very fine state. And the result is, that the dips are no more consistent than they were formerly. At times when the needle has been vibrating most delicately in an arc of less than 2′, it has been carefully raised and lowered, and, vibrating with the same delicacy, it has settled in a position more than 30′ different from the former. I need not say that, after this experience, I entirely reject the idea of the probable error of a 3-inch needle not exceeding 1′·5 ($\frac{1}{1500}$ inch). The six means of results from the six unloaded needles, used through a period of several months, agree very closely; and the mean of the six, I doubt not, gives a mean determination excelling in accuracy and certainty any that has been made elsewhere. But the separate results of the same needle at different times are more discordant than I could wish.

It has always been the practice to adopt the mean of readings mentally formed after raising and dropping the needle two or three times. In future, every number used in

the dip-formula will be the mean of several recorded readings obtained by repeatedly raising and lowering the needle.

I have sometimes suspected that the location of magnetism in the needle is inconstant; and, in order to try a case where such inconstancy would produce no bad effect, I am preparing to try a needle whose broad dimension, instead of being transversal to the axis, contains the axis in its plane.

This, perhaps, will be a proper place for adverting to the history of the two most difficult instruments, the Photographic Vertical Force Magnetometer and the Dip-Instrument, from the beginning of their use to the present time.

Vertical Force.—Although the habitual movements of this instrument are well known to me from inspection in the continuous routine of observations, yet I have lately thought it desirable to examine in a mass the whole of the daily photographic sheets in the 14 years from 1849 to 1862, and to classify my remarks on them.

First, with regard to the Dislocations of the photographic curve.

The only appearance of sluggishness in the motion of the Vertical Force Magnet is presented by the instances in which, after the curve has for a short time been straight or nearly straight, the magnet has sprung off in a state of vibration, its place in the mean of the vibration being dislocated from the preceding place. This occurs, on the average, less than four times in each year. It has nearly ceased since Mr. Simms re-ground the knife-edges and re-adjusted the agate planes.

The evidence that these are really instances of sluggishness is much weakened by the following considerations:—There are repeated instances in which the photographic trace is nearly straight for a whole day, while it is bold on the day preceding and on the day following; and there are numerous instances, about two in each year, in which a similar dislocation has occurred when the magnet was rapidly changing its position, and when the idea of sluggishness is entirely inadmissible.

Occasionally, dislocations occur very close to the record of vibrations or of petty disturbances, when there can be no doubt of the sensibility of the magnet. Sometimes the presence of workmen or of unskilled assistants has produced dislocations; though there is no mechanical connexion of the instrument with the building or its floors. And there are some petty dislocations not classified. These, as well as those last-mentioned, are more numerous in later years. It might almost be suspected that, by the yielding of timber, some contact has occurred which I cannot trace.

I am as much as ever in the dark as to the cause of the dislocations. The last idea which has suggested itself is, that they arise from a start in the connexions of the

parts of the vibrating needle, possibly where different metals are pressed together. They seem specially to occur when a current of air is thrown upon the magnet-box; in these cases, the length of one-half of the magnet may be suddenly altered.

Besides the dislocations with vibrations, there occur a few dislocations without vibrations (almost two in a year). These have more the air of real changes of magnetism, and less that of instrumental starts, than the others.

Before Mr. Simms' rearrangement of the knife-edges and agate planes, there was frequently a sharp bend at the vertex of the photographic trace, which does not often show itself now.

Second, with regard to the register of perturbations.

Perturbations of a very violent character are registered on the following days; 3 days in 1848, 2 days in 1851, 3 in 1852, 1 in 1857, 2 in 1858, 5 in 1859.

Perturbations of considerable magnitude, but more moderate, are recorded in the following numbers; 6 days in 1848, 5 days in 1849, 2 in 1850, 7 in 1851, 13 in 1852, 17 in 1853, 4 in 1854, 3 in 1855, none in 1856, 3 in 1857, 14 in 1858, 12 in 1859, 22 in 1860, 13 in 1861, 9 in 1862.

Perturbations of the smallest class, or "fretting," occur in the following numbers; 1848, half year, 9; 1849, 7; 1850, 8; 1851, 5; 1852, 4; 1853, 3; 1854, 5; 1855, 3; 1856, 1; 1857, 11; 1858, 9; 1859, 4; 1860, 10; 1861, 9; 1862, 15.

The whole of these are recorded without dislocation or instrumental interruption of any kind.

The only published photographic curves with which I have been able to compare the Greenwich curves are those of Mr. Balfour Stewart in his papers in the Philosophical Transactions 1861 and 1862. In the first of these are given the curves traced by the Vertical-Force Instrument at Kew from 1859 August 28 to September 9. During the whole of this period, the curves correspond in every the minutest bend, as far as they can be compared; but the Kew Instrument has failed to record the great and characteristic disturbances, even where they are certainly contained in the field of the paper, while the Greenwich Instrument has registered the whole. It is the most magnificent perturbation on record. In Mr. Stewart's second paper are given the perturbations (of a very small class) on a part of 1860 August 11; they coincide to the minutest particular with those at Greenwich.

Dip-Instrument.—I have examined all the readings in many of the observations whose results appear anomalous, but I have not found anything to which I could object, and,

guided by late experience, I am satisfied that the observations are good, and subject to no greater error than is incident to every dip instrument when it is fairly used. I have laid down graphically every annual mean result given by all the dipping-needles employed, from 1843 to 1862. From this exhibition the following conclusions may be drawn:—

It will be remembered by the Visitors that some alarm was excited by the apparent increase of dip to the year 1854 or 1855; and that I conjectured that it might have been occasioned by an injudicious use of the instrument, and provisionally suppressed the observations of 1856. The graphical representation shows clearly that these inferences and suppression were without foundation. In the run of chance, the dips to 1851 had diminished too rapidly, and in another turn of chance they rose again. The results of 1856 agree well with those of 1857, &c., in which it is certain that there was none of the supposed injudicious treatment. I have, therefore, in the volume now under press, restored the results of 1856, as entirely worthy of credit.

In the year 1858, six 3-inch needles, made by Barrow, furnished with microscopes on the Kew pattern, were brought here, after having been at the Kew Observatory, and were observed here, and gave tolerably accordant results. The mean of all these appears, from the graphical representation, to be about 10′ in error.

The results of the new Dip-Instrument in 1861 and 1862 appear to give a firm foundation for speculations on the state and change of the dip.

As a general result, I may state as probable that the value of dip in the middle of 1843 was about 69° 1′, and in the middle of 1862 about 68° 11′. The decrease of dip appears to be more rapid in the second half of this interval than in the first; the dip at beginning of 1853 being about 68° 44′.

Returning now to the present state of instruments, I have to remark that:—

The earth-current wires are furnished each with a galvanometer, for eye-observations. This imperfect arrangement is only temporary: I have already instructed Mr. Simms to proceed with the construction of a self-registering apparatus, and have supplied the plans. I propose to make trial of ebonite for the material of the revolving photographic cylinders, as admitting of being turned to a more accurate form than the glass cylinders which we have hitherto employed.

The meteorological apparatus is in an efficient state. Besides the barometer, dry and wet thermometers, pluviometer, and anemometer, which automatically register their respective phenomena, and can also be observed by eye, there are thermometers in the air and in the River Thames which record maxima and minima and require to be read every day, and electrometers which can only be observed by eye.

Many of the Constants of Adjustment of the Magnetical and Meteorological Instruments were redetermined at the beginning of this year.

X. Magnetical and Meteorological Observations.—The instruments mentioned in the last chapter are all fully employed in their respective functions. The magnetometers, barometers, and dry and wet thermometers, are read by eye several times every day, in order to give zeros for their continuous photographic registers; the magnet-thermometers every day as often as appears necessary. Maximum and minimum instruments once every day. It has been the rule to observe magnetic dips twice in a week, and since the beginning of 1863 to make observations for absolute measure of magnetic force, twice in a month; but the rule with respect to the dip has been a little disturbed by the repairs, &c. of the instrument. It is possible that, as our intended more elaborate observations of the dip will each occupy more time than before, the number of observations will in future be somewhat diminished.

The readings of barometer and thermometer, and the state of wind and weather, are observed every morning, and telegraphed to M. Le Verrier, for publication in his Bulletin. We are indebted to the London District Telegraph Company and the Submarine Telegraph Company for the gratuitous daily transmission of these telegrams to Paris.

XI. Reduction of Magnetical and Meteorological Observations.—The equivalents, for eye-observations of the Declination-Magnetometer, are completed to the present time, and those for the Horizontal Force and Vertical-Force Magnetometers, to the end of 1862: but temperature-corrections for both are entered to the present time. The reading for Astronomical Meridian, as determined by star-observations with the same theodolite that is used for observing the declination-magnet, is computed to 1863, April, and applied to the end of 1862.

The time-scales for the photographic registers formed by the three instruments are laid down to 1862, August 31, August 31, and September 30, respectively. The new base-lines are laid down only to the end of 1861, but several steps of preparation are made for 1862. The Deflexion-observations are reduced to 1862, April. The Dip-observations to the present time.

The mean magnetic declination for 1862 is about 20°.52′; the diminution in the year appears to be 13′. The mean dip for 1862, as has been stated, is about 68°.11′; at the present time it appears to be about 68°.4′.

The photographic sheets for the barometer and thermometers are in the same state as those for the Vertical Force.

The vane of Osler's anemometer made, in the year 1862, about + 14 revolutions.

The following calculations, related generally to our Magnetical observations, but not included in the routine of daily work, have been made in the last year.

The monthly means of the indications of the three Magnetometers at different hours of the day, during the exclusive use of eye-observations (1841 to 1847), had been taken for every day, whether the day was or was not included in those which I consider as stormy or difficult days. The use of such observations taken at a precise moment, without reference to the preceding and following states of the magnet, if on a disturbed day, is actually injurious to the mean; and, moreover, the reductions are not homogeneous with those which embrace the succeeding period (1848 to 1857). I have therefore had the means taken anew, excluding those disturbed days.

I remarked in the last Report the strangeness in the variations of the mean magnetic forces at each hour of the day from year to year. I have lately taken the differences between these quantities as exhibited at each hour of the day for two extreme years, and I think I see a prospect of referring them, not very distantly, to a change in the direct action of the sun. But I have nothing yet in a state which I can exhibit clearly.

Considerable labour has been given to a numerical discussion of the Magnetic Storms in all the three elements, from 1841 to 1857. Each storm-day has been treated separately. Availing myself of the printed measures of the values of ordinates of photographic curves in the published Results of Magnetic Observations, I have applied to all a simple process, within the power of the youngest computer but admitting of easy checks, for resolving every storm into its successive swells, and at the same time for displaying the irregularities or smaller swells riding upon these principal swells. The mass of reductions is at present waiting for my inspection; but the general character of appearance of results has suggested ideas to me which are in some measure confirmed by another reduction which I proceed to mention.

On 1862, Dec. 14, a splendid aurora was seen. The Assistant (Mr. Ellis) in charge of galvanic observations immediately came to the Observatory and carefully noted the indications of the galvanometers on the two earth-current wires. From these we were enabled, by easy reductions, to obtain the numerical values of the currents in the magnetic N. and W. directions, and to construct curves for them. The photographic sheet of records of Declination and Horizontal Force at Greenwich, unfortunately, failed totally (from a chemical fault); but the Kew Committee, on my application, courteously allowed me the use of their photographs. They were perfectly good, with the exception of one part where the motion was very violent, a case for which the arrangements at Kew are not well adapted. There remained, however, enough to enable me to institute a comparison. And the result, supposing the sign of the interpretations of the Kew

curves to be correct (which I have no reason to doubt, but upon which all will depend) is very remarkable. The action of the earth-currents upon the magnet is in the same direction in which the earth-currents flow, and not transverse to the current-direction as is usual with galvanic currents.

If this should be confirmed, then, viewing the rarity of disturbances in the vertical direction as produced by magnetic storms, and their great violence when they do occur in the vertical direction, I shall have no hesitation in suggesting, as a general theory of Magnetic Sorms, that the idea of attraction is to be abandoned, and that they are to be referred to currents of a Magnetic Ether whose movements are closely analogous to that of air, the vertical movement of which occurs but in few places, but in these places is excessively violent. Much, however, must be done, before such a theory can be established.

XII. Printing of Magnetical and Meteorological Observations.—The Results of Observations for 1861 are completely printed, in the form which has been followed without interruption since the termination in 1847 of the system of printing independent volumes containing all the meteorological details. The ordinates of the three photographic curves, which record the positions of the three principal magnetometers, are measured, each by its proper scale, at the points of the curves; and the numerical values of the measures are printed. For other magnetic observations, the separate results are given in greater or less detail. Of the meteorological results, an abstract only is given, in different degrees of detail for different observations. There are added, the Dip observations of 1856 to which I have already adverted, and a few corrections of numbers wrongly printed in preceding volumes. The extent of impression is 600 copies; of which 350 are bound with the Astronomical volume, and 250 are circulated separately.

Two copies of each of the photographic curves for Declination and Horizontal Force have been taken to 1861 September, and two for Vertical Force to 1860 December.

None of the Magnetic Results for 1862 are yet prepared for press, but the Meteorological Results are very nearly complete.

In a communication to the Royal Society, I have presented the results, in the shape of curves, for the mean diurnal inequalities of magnetic force; the means being taken on two systems of grouping; one, supposing that all the observations at the same hour through each year, 1841–1857, are grouped together; the other, supposing that all the observations at the same hour in each month of the same name through a period of years are grouped together. This second grouping is effected separately for the period 1841–1847, and for the period 1848–1857.

XIII. Chronometers, Communications of Time, Longitudes, &c.—The number of Chronometers on hand at this time is 132; of these, 82 are compared with a standard clock every day, and the others are compared on one day in every week. The standard clock is one of a series of galvanic clocks whose movements are necessarily synchronous with that of the Motor Clock; which is accurately adjusted to Mean Solar Time by means of a galvanic action upon its pendulum, that can be used for any arbitrary length of time to accelerate or retard the clock by slow degrees during that time. Every chronometer, whatever be the reason of its lodgment at the Royal Observatory, is tried during some part of its stay in the heated Chronometer Oven.

When it is necessary to decide on the merits of chronometers, either as affecting their price for purchase, or as deciding their place in the published Order of Merit, the decision is made by me. The repairs of Chronometers the property of the Government are entirely managed by me.

The drop of the Time-Signal-Ball at Deal, by a galvanic current from this Observatory which is automatically given by the corrected Motor Clock, is perfectly efficient, no failures occurring except from the defects of adjustment of the Clock at the London Bridge Station which changes the connexions of wires. Time-Signals are sent daily along the principal lines of railway, the most distant points (I believe) being Glasgow and Cardiff. I have also heard that the companies, through whose offices the wires pass, have begun to distribute branch signals to private factories.

The clocks of the General Post Office are connected as formerly with the Observatory, each of four clocks being adjusted by current from our Motor Clock once every day, and reporting itself to us twice every day. The clock of Westminster Palace has also been brought into connexion, the attendant receiving a signal from us once every hour, and the clock reporting its state to us twice every day. As far as I have yet observed, the rate of this clock may be considered certain to much less than one second per week.

The various operations, connected with Chronometers and Galvanic Signals, including the Chronograph, occupy pretty fully the office-time of two assistants and one computer.

The operations for the redetermination of the longitude of Valencia in Ireland were effected shortly after the last Visitation of the Royal Observatory. The distance (nearly 800 miles by the indirect course of the wires) was not too great for very good exhibition of galvanic signals when the air was not very damp. The principal trouble in the reductions arose from the circumstance that the small altazimuth used at Valencia for the determination of local time, from some peculiarity whose cause I have

not been able to trace, gave all zenith-distances too great. The observations, however, were so arranged that this leaves no uncertainty in the result. The concluded longitude agrees almost exactly with that determined by the transmission of chronometers in 1844; and entitles us to believe that the longitudes of Kingstown and Liverpool, steps in the chronometer-conveyance, were determined with equal accuracy.

The proposal for the establishment of Time-Signals on the Start Point, introduced by my last Report to the notice of the Visitors, and by them recommended to the attention of His Grace the First Lord of the Admiralty, has been, as I understand, under the consideration of the Government; and some communication on that subject will probably be made to the Board of Visitors.

XIV. Personal Establishment.—The positions of First and Confidential Assistant, of Superintendant of Altazimuth, of Superintendant of Time-Communications and Chronometers, and of Superintendant of Equatoreal, are held (as at the last Report), by Mr. Edward James Stone, M.A., Fellow of Queens' College, Cambridge, Mr. Dunkin, Mr. Ellis assisted by Mr. Criswick, and Mr. Carpenter. The meridional and altazimuth observations are principally divided among the four gentlemen last mentioned; Mr. Stone sometimes taking a part; and the services of supernumeraries being also occasionally employed. Mr. Lynn, B.A. Univer. London, directs the supernumerary computers, by whom in fact the largest portion of the mechanical calculations in the ordinary routine is effected. Seven supernumeraries have, till lately, been employed, partly on the ordinary work, partly on the Seven-Year-Catalogue and other exceptional works.

Mr. James Glaisher, F.R.S., ranks as Second Assistant of the Observatory, and is charged with the superintendance of the Magnetical and Meteorological Department. One Assistant, Mr. Downs, is attached to that Department; and five supernumeraries have lately been employed, partly on the ordinary operations, partly on the reduction of Magnetic Storm observations.

The final responsibility for every part of the work executed at the Observatory rests on myself.

XV. Extraneous Works.—With the assistance of a grant from the Admiralty, sufficient for the conclusion of the operations, the computations, for inferring the direction and amount of movement of the Solar System in space from the observed proper motions of 1167 stars, have been completed. The result is, that the Sun is moving towards a point, R.A. 264°, N.P.D. 65°, (not very different from Sir W. Herschel's, but depending much in N.P.D. on the accuracy of Bradley's quadrant-observations), and

that its annual motion subtends, at the distance of a star of the first magnitude, the angle 0″·4. But the comparison, of the sum of squares of apparent proper motions uncorrected, with the sum of squares of apparent proper motions corrected for motion of Sun, shows so small an advance in the explanation of the stars' apparent movements as to throw great doubt on the certainty of results; the sum of squares being diminished by only one twenty-fifth part.

No steps have been taken for discussion of the Total Eclipse of the Sun in 1860, except in the collection of a few outstanding accounts of observations.

At present, I have no unusual work on hand, with the exception of the Seven-Year Catalogue and the discussion of Magnetic Storms, which have probably ceased to oppress the establishment; and I shall be anxious to avoid taking up any new work.

XVI. General Remarks. — In the last Report, I did by anticipation solicit the indulgence of the Visitors for anything that might be considered as shortcomings in the Reductions of the year then beginning. From the present Report it will appear that my fears have been in some degree realized. Every part of our Reductions is somewhat (though not very much) in arrear. This is sufficiently explained by the observations and computations of the Valencia Longitude and the Parallax of Mars; the computations of Seven-Year Catalogue and Magnetic Reductions; and the superintendance, by a skilled assistant, of the computation of Solar Movement. An accidental error, of small amount but of systematic character, in some fundamental numbers of calculations, has also thrown us back a little. I trust, however, that all may be brought to the ordinary state before an opportunity of reporting on them to the Visitors shall again occur.

The approaching completion of certain points in the instrumental equipment of the Observatory of Paris induces me to hope that I may be able to arrange with M. Le Verrier for a division of the labour of observing the small planets; a division which would be felt as a considerable relief to the Royal Observatory.

G. B. AIRY.

Royal Observatory, Greenwich,
1863, *May* 22.

NOTE.—Since the first part of this Report was prepared, I have learned that the proposal for a Railway, to which allusion is made in page 4, is withdrawn for the present.