

REPORT
OF
THE ASTRONOMER ROYAL
TO THE
BOARD OF VISITORS
OF THE
ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1872, June 1.

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IN accordance with the custom which has now been maintained so many years, and which I believe has received the approval not only of the Board of Visitors but also of the friends of Astronomy in general, I respectfully offer to the Board the following Report. In an Observatory in which the observation of the Moon occupies so much attention, the labours of the establishment are naturally divided by lunations; and for many years past I have therefore determined the epochs of my Reports by the most convenient New Moon or Full Moon. On the present occasion I offer the general history of the Observatory from the Full Moon of 1871, May 4, to the New Moon of 1872, May 7, including a period of twelve and a half lunations; and I report the state of the Observatory on the last-mentioned day. The subdivision of the Report adopted in previous years has been found convenient, and is adopted in the present Report.

I. Buildings and Grounds:—

In the Dwelling-house, the Octagon Room, the North Dome, and the principal range of buildings from the Quadrant Room to the South-east Dome, no alteration has been made which requires the slightest remark.

Two short open-air passages have been roofed with rough glass.

The iron curbs of the South Dome (Altazimuth) and South-east Dome (Great Equatoreal) have been cleansed from rust, and their motion is made much easier than formerly.

The galvanic wires from the Battery Basement under the North Dome to the large clock at the Entrance Gate, which formerly were led round by the iron rails of the Front Court, are now led with many others under the pavement and under the floors of the Observatory Rooms, and are thence carried underground to the clock.

In the Magnetic Observatory, guards have been fixed for the protection of the two telescopes adapted to eye-observation of the horizontal-force and vertical-force magnetometers; and a shade for protection from the Sun's radiation has been placed on the top of the naphthalizing-house. I am making preparations for fixing a platform on the roof of the Magnetic Observatory for the observation of meteors, auroras, &c. The Normal Sidereal Clock, for giving sidereal time by galvanic communication to the Astronomical Observatory, was established in the Magnetic Basement in 1871, June; that locality being adapted for it on account of the uniformity of temperature. Further mention of this clock will occur in a following Section.

On 1871, November 17, the box which carries the insulating glass pillar for the electrometer apparatus, at the top of a pole 80 feet high, was burnt. On the cause of this singular accident I am still in the dark; but it seems possible that, in the gusty weather and irregular burning of the inclosed gas-lamp, soot had been deposited, which had afterwards caught fire from the lamp. The abundant command of water prevented it from doing further mischief. A copper box is now substituted for the wooden box.

The front of the Telescope-Shed on the Magnetic Ground is now completely covered by four large doors. One of these is carried by hinges; the other three slide upon rollers. In this manner one fourth of the length of the shed can be opened at any part.

On 1871, December 1, the Watchman's Clock, upon which are registered the visits of the Night-Watchman, was moved from the Astronomical Observatory to the Magnetic Offices. As the Watchman, while not on beat, occupies the Gate Porter's Cabin, this arrangement insures the visits of the Watchman to every part of our now widely-extended premises. The clock-registers are read and entered in a book every morning.

The South Ground, at the present time, is much occupied with wooden erections, in preparation for the observations of the Transit of Venus in 1874. This occupation is only temporary. But the danger of fire would be so great that I have deemed it necessary to establish a third fire-plug in the South Ground (the two others being in the Front Court and the Magnetic Court) in communication with the Water Main, which is always charged with water at about 100 feet pressure.

The aspect of railway enterprise is at present favorable to the Park and the Observatory. The South-Eastern Railway Company has made an arrangement with the Metropolitan Board of Works for shifting the course of the great Southern Outfall Sewer. This enables the Company to trace a new line for the railway, passing on the north side of London Street, with much pecuniary advantage to the Company, and at such a distance from the Observatory as to remove all cause of alarm. I understand that the Bill, which was unopposed, has passed the Committee of the House of Commons. I trust that the contest, which has lasted thirty-seven years, is now terminated; and I shall be happy if it is closed on terms advantageous to the Company, from whom we have received important assistance in the arrangements for time-signals.

A line was contingently proposed for connecting the London, Chatham, and Dover Railway with the new line of the South-Eastern Railway. It has been suspended for the present, but will undoubtedly be taken up again. It will cause no inconvenience to the Observatory.

II. Moveable Property :—

No special remark is required on the state of the moveable articles of general character (the Manuscripts, Books, and Instruments being the subjects of separate Reports). The only addition deserving mention is the set of chairs in the Octagon Room in which the Board usually meet.

The Portable Transit, lent to Colonel Sir Henry James for observations in the North of Scotland, has been returned. Four telescopes about 4 inches aperture, of which three were lent to the British Association Committee for observation of the Eclipse of 1871, December 11-12, and one was lent to W. J. Lewis, Esq., of Oriel College, Oxford, for the same purpose, have been returned. A Simms' Equatoreal with 6-inch telescope, lent to the British Association Committee, is, I believe, completely returned, but its parts are in such a scattered state that I am not able positively to pronounce on it. The six chronometers which were lent to the British Association Committee are all returned.

I contemplate the employment of our Portable Altazimuth in one of the Stations for observation of the Transit of Venus, 1874.

III. Manuscripts :—

In an establishment like that of the Royal Observatory, I consider it a most important duty to give especial regard to the preservation of Manuscripts. It is

obviously proper that care should be taken of those which relate to the original observations and calculations, and to the discipline of the Observatory; and as an instance of the necessity of continual attention, I may state that it came to my knowledge that, on the demise of an office closely connected with astronomy, very important manuscript calculations were sold for waste paper. But besides these records and computations, there is, in this Observatory, an astonishing amount of correspondence bearing upon the progress of most of the active sciences. The steps for the orderly preservation of all these papers have been reduced to a systematic form, and the daily action in it is carried out in a most satisfactory manner by Mr. Carpenter.

The bound volumes of manuscripts on the shelves have lately been compared with the Catalogue and found correct.

It will be necessary soon to provide additional shelving for the manuscripts.

A few papers of Mr. Baily's have lately been received; including some letters of De Zach, of great interest, I believe, for the history of science.

Some copy-manuscripts, formerly mentioned as lent out, are not returned.

IV. Library :—

The Library is in a satisfactory state. Much care is taken for the collection of pamphlets into the shape of books; for binding in all cases where it is necessary; for *raisonnée* arrangement on the shelves; and for cataloguing on the principle of moveable slips, now extensively adopted in large libraries. Mr. Carpenter takes charge of this department.

The annual comparison of producible books, or of books lent for a special purpose, with the Catalogue, was lately made; there was no deficiency.

It is considered that the standard subjects of the library are, astronomy with its cognate branches in chronology and geography, magnetism, meteorology, and optics, with several series of the best Academical Transactions; but other works are also admitted. The principal additions are made by presents; for some of these we are indebted to the Foreign and Colonial Offices. Small purchases, however, are made, principally through H. M. Stationery Office.

The shelves of the Library will soon require extension.

The books are lent, under ordinary library-regulations, to the assistants and computers. To them, as well as to the abstract institution, the Library is valuable.

V. Astronomical Instruments :—

The Transit-Circle is in an excellent state. Small repairs or alterations have sometimes been required; the spring acting upon one end of the axis to keep the other end in definite bearing against a fixed plate has been carefully cleaned; a new dew-cap has been provided; the annular reflector for illuminating the field of view has been regilded; at different times, five new transit wires have been inserted, replacing broken wires; a new declination wire, more nearly coinciding with the celestial parallel, has been mounted; new screws have been applied for fixation of the microscope-object-glasses, and greater range has been given to the adjustments of those glasses. Remarking the difficulty of access to the annular reflector, for regilding, &c., it appears to me not impossible that we may have occasion to separate the object-half of the telescope-tube, in order to arrange a more convenient mounting for the reflector.

In the months of June and July 1871, a new determination was made of the Errors of Division of the Circle. Upon laying down graphically the results, in juxtaposition with those of 1852 and 1856, the agreement is found to be surprisingly exact. It shows that the apparatus which was arranged in planning the instrument gives us perfect command of the graduation; it shows also that the division is admirable, and it testifies generally to the firmness of construction.

In January of the present year a new determination of the flexure of the telescope was made. It differs from the last preceding by $0''.13$.

Having heard of an instance in which the numerical reading for Zenith-point, as determined by observation of reflected wires, was affected by the previous position of the telescope, pointing N. or S., I have had an extensive series of observations made with the Transit-Circle-Telescope expressly to determine whether our Zenith-point is so affected. There is no discoverable difference between the Zenith-point determinations in the different circumstances.

We have sometimes thought that the steadiness of the reflected image is improved by a thin film of oil on the surface of the quicksilver. I am not so perfectly satisfied on this as to be willing to adopt it, at present, as a method for general use.

A quicksilver-trough has been placed on the ground (as was originally arranged in 1850) for observation of the wires by reflexion, instead of using the same moveable trough which is used for stars. I am not certain that anything is gained by the change.

The Zenith-point Correction used for each night has usually been determined, as is mentioned in the last Report, from the appropriate reflexion-observations of that night only. The weights given to the mean of a group of northern stars, to the mean of a group of southern stars, and to the mean of a group of wires are usually 2, 2, 1.

The practice of observing the Zenith Distance at several vertical wires has been somewhat extended.

The mechanical arrangements, as regards transits and time arrangements, have been completely modified by the introduction of the Normal Sidereal Clock. This clock is planted in the Magnetic Basement, as the locality in which the temperature is most uniform. Its escapement is one which I suggested many years ago in the Cambridge Transactions; a detached escapement, very closely analogous to the ordinary chronometer-escapement, the pendulum receiving an impulse only at alternate vibrations. The pendulum compensation is of steel and zinc. For adjustment of rate, I have placed a sliding-weight on the crutch-rod, where it can be moved by a nut at the level of the crutch-axis without disturbing the pendulum. I have also arranged upon the crutch-axis a peculiar apparatus (not yet tried) for adjusting the final rate of correction for temperature. At the middle of every vibration, a pin on the pendulum presses two light springs into contact, which complete a galvanic circuit; and a pin on the 60-seconds wheel interrupts the circuit once in each minute. The current thus put in motion, acting by relay, makes the seconds-punctures upon the chronograph-barrel, drives or regulates various sympathetic clocks, and in fact does all which the current from the Transit-Clock Hardy formerly did; but does it a great deal better. The steadiness of rate is very far superior to any that we have previously attained. One evidence of this is the regularity with which it indicates the barometric inequality.

As eye-and-ear observations (of circumpolar stars, &c.) are recorded by means of the transit-clock in the transit-circle-room, it is necessary to possess some means of comparing the Normal Sidereal Clock with the Transit-Clock. This is done by the contact-springs in the Transit-Clock, which are placed in connexion with the wires by which, in ordinary transits, the finger-touch causes a puncture on the chronograph-barrel; the Normal Sidereal Clock at the same time making its punctures by its own wires.

This clock was constructed, under my direction, by Messrs. E. Dent & Co., and may be regarded, I think, as an excellent specimen of horology. It was brought into use on 1871, August 21.

Other clocks have had small repairs and cleanings, requiring no special notice.

The chronograph is in good order. A small alteration has been made in its break-contact apparatus. Since 1871, October, glycerine has been used instead of water for producing the small resistances to the pendulum-movement and to the movement of the friction-regulator which are required in Siemens' Chronometric Governor; and it possesses this advantage, that it does not cause rust in the steel-work. A trifling inconvenience is produced by the absorptive power of the glycerine, which sometimes fills the cistern more than is desired.

The Altazimuth is in an effective state. A small finder has been attached to the telescope, and is found to be convenient. One of the upper Azimuth levels was broken by a workman, but a new one has been supplied. The lenses connected with

the gas-illumination of the horizontal-circle-microscopes are constantly employed and are useful.

The Sheepshanks Equatoreal is in good order. The Shuckburgh Equatoreal is in its usual state. The South-East Equatoreal is in all respects in good condition. Two new eyepieces of high power have been prepared for it; and a bar-eyepiece is in hand. I think that it may be desirable to procure a good spectroscope, for occasional attachment to this telescope.

The Water-Telescope is in good order. With the view of making its results less dependent on level-values, it has been carefully adjusted to verticality. The micrometer has been cleaned in the course of the late series of observations. Plans of the instrument have been prepared, for publication in the Greenwich Observations.

The Reflex-Zenith-Tube, and the Ancient Instruments, are in their usual state.

VI. Astronomical Observations:—

In addition to the regular subjects of observation, great attention has been paid during the past year to determinations of R. A. of Circumpolar Stars, with polar distance up to 40° , both above and below the pole, with a view to supplying a check, on the general accuracy of the adopted Collimation Error, and on the steadiness of the Clock Rate for periods of twelve hours or more. To facilitate these observations, an extended Working Catalogue has been formed, in which all Circumpolar Stars down to the 6th magnitude have been included; but some time must elapse before the necessary data are accumulated.

In consequence of the change in the system of adopting Zenith-points for the Transit-Circle, I have judged it advisable to have four stars observed by reflexion on every evening that would permit it, two being North and two South of the Zenith. A special list has been formed containing about 850 Stars suitable for this purpose; and in order that satisfactory determinations of their places may be secured, they have been inserted in the Working Catalogue as requiring 5 observations in R. A. as well as in N.P.D.

Means have been taken to secure at least 15 observations in R.A. and 10 in N.P.D. of all the Nautical Almanac and Clock Stars for the next Catalogue, to be formed from several years' observations; some of these stars having been insufficiently observed in past years.

Dr. Auwers has recently called attention to some stars, which, having been observed by Bradley in one element only, had been omitted from our list of Bradley Stars for

observation; these have now been placed on the Working List and will be observed in due course.

In the observations with the Altazimuth, the only change to be recorded is the substitution of a Low Star for the Collimator, when practicable, whereby a much better determination is obtained of the Zero of Azimuth, the only instrumental constant which is not practically eliminated by reversing the instrument.

The Water-Telescope has been used for observations of γ Draconis, in the Autumn when the star passed between 8^h and 4^h, and in the Spring between 20^h and 17^h; at other seasons the observations have been made with the Reflex-Zenith-Tube.

The following is an analysis of the observations made from 1871, May 5, to 1872, May 7:—

With the Transit-Circle :

Transits, the separate limbs being counted as separate observations	3,961
Pairs of observations of the nearly vertical wires of the Reversed Telescopes	297
Reciprocal observations of the nearly vertical wires of the Reversed Telescopes	360
Reflexion-observations of the central wire	450
Circle-observations, each requiring a separate reading of the six microscope-micrometers	3,866
Reflexion-observations of zenith-distance wire (included in the circle-observations)	457
Reflexion-observations of stars (similarly included)	385

With the Reflex-Zenith-Tube :

Pairs of observations of γ Draconis, the instrument being reversed between the observations	23
Single observations	1

With the Water-Telescope :

Pairs of observations of γ Draconis, the instrument being reversed between the observations	27
Single observations	14

With the Altazimuth :

Azimuths of the Moon and stars	817
Azimuths of the Collimating-mark	212
Zenith distances of the Moon	401
Zenith distances of the Collimating-mark	264

The number of complete observations of the Moon near to her conjunction with the Sun, is :—

On days when the Moon passed between 21^h and 22^h Mean Solar

Time	.	.	.	.	.	.	.	.	.	.	4			
„	„										between 22 ^h and 23 ^h	.	.	2
„	„										between 23 ^h and 24 ^h	.	.	1
„	„										between 0 ^h and 1 ^h	.	.	0
„	„										between 1 ^h and 2 ^h	.	.	3
„	„										between 2 ^h and 3 ^h	.	.	5

The following comparison shows the number of places of the Moon observed with the Transit-Circle and Altazimuth respectively :—

With the Transit-Circle, 115, or 9·2 per lunation.

With the Altazimuth, 203, or 16·2 per lunation.

Observations of 4 disappearances and 3 re-appearances of stars occulted by the Moon, and of 42 phenomena of Jupiter's satellites, have been registered. Rather more attention than usual has been given to these latter, pending the adoption of the suggestion I have made to devote a special observatory to them. The Great Equatoreal has generally been used for these observations, which has allowed of estimates of the phases of the eclipses, as well as of the occultations and transits, being made in several instances.

Drawings of Venus, Jupiter, Encke's Comet, and Saturn, have been made with the Great Equatoreal. Owing to the low altitude of the last, my eyepiece for the correction of atmospheric dispersion was absolutely necessary in order to obtain a satisfactory view of the planet.

VII. Reduction of Astronomical Observations :—

The following table shows the state of the various stages of the reductions on 1872, May 7 :—

For Meridional Transit Observations :

The observed transits are cleared of instrumental errors, and
clock-times of transit over the true meridian are exhibited, to . 1872, May 2.
Apparent right-ascensions from observation are formed by
application of clock-errors and rates, to May 2.
Stars' corrections are computed, to May 6.
Mean right ascensions of Stars from observation, reduced to
1872, January 1, are formed by combination of the two last-
mentioned elements, to May 2.

B 2

Mean solar times of observation of Sun, Moon, and Planets are prepared, to	April 26.
Corrections for deficient illumination of Moon's and Planets' limbs are applied, to	May 2.

The Personal Equations of the observers who have taken transits in the year 1871, have been investigated in the usual way. In nearly every instance they agree almost exactly with those found for the same observers in 1870; one only of the Assistants having changed his habit of observing to the extent of $0^s \cdot 07$.

It has been mentioned in a preceding Section that attention has been given, in observation, to the transits of circumpolar stars below the pole. This is a following out of a policy which I commenced many years ago at the Observatory of Cambridge. The ordinary system of reductions is unaltered, and the results will be published in precisely the same form as that hitherto adopted, but I anticipate that in the examination of those results I shall be able to pronounce positively upon that point which has often been a difficulty to astronomers, the accuracy of the relation of the R.A. of stars nearly opposed in R.A.

For Meridional Circle Observations:

Means of microscope-micrometers are taken, and corrected for telescope-micrometer, errors of graduation, flexure, inclination of wire, and zenith-point, exhibiting apparent zenith-distances, to	1872, April 28.
Refraction, parallax, and colatitude are applied to form true geocentric north polar distances, to	April 10.
Stars' corrections are applied, forming mean north polar distances on 1872, January 1, to	April 10.
Corrections for deficient illumination of Moon's and Planets' limbs are applied, to	April 10.

The refractions used are the same as those employed in 1870, namely Bessel's $\times 0.99797$.

The corrections for R—D and for error of assumed latitude, and the position of the Ecliptic, have been computed for the year 1871, but the calculations of the geocentric and heliocentric errors of planetary tables for last year are not yet complete.

The variable term in the R—D correction is almost identical in the two years 1870 and 1871, but the constant part has now become insensible owing to the adoption of a correction to the results of the Nadir-point observation. The result for co-latitude from the observations of 1871 is identical with that obtained for 1869, viz., $38^{\circ} 31' 21'' \cdot 61$, and differs but very slightly from last year's determination.

The Paris observations of the small planets have been received from M. Delaunay to the end of 1871, and the planet ledgers and the results based upon them will speedily be completed.

The observations of γ Draconis with the Reflex-Zenith-Tube in 1871 are completely reduced.

The observations of γ Draconis with the Water-Telescope, made in the Autumn of 1871 and the spring of 1872, are reduced, the latter only in their first steps. I delay the complete reduction for the following reason. The results for the autumn of 1871 depended sensibly on the value of the level-scales, and I have been desirous of verifying that value, and, if necessary, of correcting the reductions of 1871. I am provided by Mr. Simms with a portable level, which I propose to compare with the levels of the Water-Telescope and with the Transit-Circle. Meantime I have to state that, using the values of the level scales as determined by Mr. Simms, (which I have no reason to believe to be inaccurate) the spring and autumn observations of 1871 absolutely negative the idea of any effect being produced on the constant of aberration by the amount of refracting medium traversed by the light. If the observations in the autumn of 1872 shall be found to support the conclusions obtained in 1871, I propose to terminate the observations, and perhaps dismount the instrument.

The Altazimuth reductions are advanced to the following stages :—

In azimuth, the means of microscopes are corrected for level,	
collimation, and azimuthal zero (forming true azimuths,) to 1872, March 28.	
In zenith distance, true Greenwich zenith distances are formed,	
to	May 1.
Corresponding tabular azimuths and zenith distances are computed, to	April 24.
Apparent tabular errors of Moon's R.A. and N.P.D. are computed, to	March 28.
Apparent tabular errors of Moon's Longitude and E.N.P.D. to	March 28.

The Occultations of Stars by the Moon are completely reduced.

At the suggestion of some foreign astronomers, we have lately drawn up lists of the stars included in the late Greenwich Catalogues, but not observed by Flamsteed or Bradley.

VIII. Printing and Distribution of Astronomical Observations :—

The volume for 1870 is printed, but the binding is not completed. As soon as bound copies are received, the impression will be distributed as usual.

The number of copies is 350.

The arrangement is in every respect the same as in the volume for 1869.

The printer is supplied with an abundant quantity of manuscript for the year 1871, and several sheets are printed in various Sections.

The only special addition which I propose to make to it, is a description, illustrated by plans, of the Water-Telescope.

IX. Magnetical and Meteorological Instruments :—

The usual care has been given to the maintenance of such a uniformity of temperature in the Magnetic Basement as will insure absolute accuracy in the comparison of the registers of magnetic force through all the hours of every day, and almost absolute accuracy in the comparison through all the months of the year. The daily changes rarely exceed 1° Fahrenheit; on a very few days they have amounted to 3° . Through the greater part of the year the temperature is maintained with great steadiness about 62° , the gas-stove enabling us to face the winter cold; but in the summer it is sometimes impracticable to keep the temperature down, and it has, very rarely, risen to 70° .

The Upper Declination-Magnet is in perfect order. On 1871, October 7, its supporting skein, which had been in use from 1865, January 20, suddenly broke. A new one was mounted on October 24, and the necessary experiments of adjustment were made on October 25. Advantage was taken of the interruption for making a change in the mode of attaching the upper end of the skein; it is now connected with a flat strap passing over a long-axis roller, which insures the constancy of the azimuthal position of the upper end of the skein. At the same time I procured from Mr. Gaddum, by the kind offices of Professor Roscoe, a stock of silk skeins which may be expected to last a very long time. My best thanks are due to Mr. Gaddum for his immediate attention to my request, and for the exertions made to procure silk of a proper quality from a distant factory.

The lower Declination-Magnetometer and the Horizontal-Force-Magnetometer (both photographic) are in perfect order. The Vertical Force Photographic Magnetometer was examined by Mr. Simms in December 1871, and was found in a most satisfactory state. The subsidiary and connected apparatus are quite efficient.

The earth-current apparatus is in a very good state. A small alteration has been made in its box for facilitating the adjustments. I am endeavoring to make its recorded traces a little more delicate. On account of the shortened distance between the points of connexion with the earth, while the length of the circuitous wires is still very considerable, it has been found necessary to increase the number of folds of wires

in the galvanic coils. One wire was lately interrupted by being rusted-through, the only instance of that failure, I believe, which we have had. The courses of the four wires were identified in 1871, June. I propose shortly, however, to repeat this identification, upon which the value of the records entirely depends.

The action of the apparatus for photographic impression of hour-lines is quite satisfactory.

The dip-instrument was revised by Mr. Simms in December 1871, and the deflexion apparatus has been examined; both are in the best possible order.

The meteorological instruments are all in a good state. The action of Robinson's Anemometer was rather unsatisfactory; some parts of it have been replaced. In the register given by Osler's Anemometer there has been a suspicion (I cannot yet say whether well founded) that in stormy weather the records of high pressure have been unjustly great, in consequence of the inertia of the weight which pulls the pressure-string, and the inertia of the weight with which the pencil was loaded; both are now replaced by springs. All the other instruments (barometers, thermometers with dry bulb and wet bulb, pluviometers, deep sunk thermometers, and thermometers plunged in the Thames) are in good order. I have mentioned that the insulating box of the electrical wire was burnt; no other mischief was done by the accident. Means have been arranged for easily lighting the gas-burner which warms the insulating glass pillar, so that few electrical indications are lost from the failure of the lamp; but the electrical apparatus is not satisfactory.

The public barometer, fixed in the outside wall of the Observatory inclosure, and exhibiting the principal barometric fluctuations on a large scale, is in good order.

X. Magnetical and Meteorological Observations :—

Every class of instruments has been kept in constant action; the photographic, the eye-observing (principally used as giving zeros for the photographic), the maximum-and-minimum, and the instruments for accumulation. Usually, the theodolite for Upper Declination-Magnet, and the telescopes for the other Magnetometers, are read four times a day; maximum-and-minimum instruments and rain-accumulators, every day; circumpolar stars for magnetic theodolite, and magnetic deflexions, once or twice in a month; magnetic dips, two or three times in a week.

The periodical meteor-shower of 1871, August, was well observed; that of November, on November 12 and 13 only.

The great Aurora of 1872, February 4, was well observed. On this occasion, the term Borealis would have been a misnomer, for the phenomenon began in the South and was most conspicuous in the South. Three times in the evening it exhibited that umbrella-like appearance which has been called (perhaps inaccurately) a corona. Brilliant displays of aurora were seen in many parts of the world, and in equatorial and southern latitudes, on the same evening and about the same time.

XI. Reduction of Magnetical and Meteorological Observations :—

The theodolite-observations of stars, giving astronomical zeros for the Declination Magnet, are reduced to the last observation. The theodolite readings of the Declination Magnet, and the telescope-observations of the Horizontal Force Magnet, to the present time; those of the Vertical Force Magnet to the end of 1871. These are the primary determinations by which the measures of the photographic ordinates are converted into absolute measures of their respective elements.

The time-scales and new base-lines are laid down upon the corresponding photographic sheets, and the ordinates of the curves are measured, to the end of 1871.

The number of days selected in the year 1871, as presenting the same general amount of disturbance as that which I have used in Memoirs in the "Philosophical Transactions" for 'disturbed days,' is 13. For these days the measures of the ordinates are taken for all the salient points of the curves; no further reduction of those numbers is made at present, and none has been made since 1857. For the other days pencil curves have been drawn smoothing down the principal inequalities, and their ordinates have been measured for every hour; these measures have been used to form tables of diurnal and other inequalities to the end of 1871.

The absolute measures of horizontal magnetic force, as calculated by Gauss's method, are prepared to the end of 1871; the dips, as usual, are reduced to the last day of observation.

The following are the principal results for 1871 :—

Mean westerly declination		19°. 45' nearly.
Mean horizontal force		{ 3.871 (in English units).
		{ 1.785 (in Metrical units).
Mean dip		{ 67. 49. 20 (by 9-inch needles).
		{ 67. 50. 0 (by 6-inch needles).
		{ 67. 51. 24 (by 3-inch needles).

I alluded in the last Report to the computation of the diurnal inequality of dip from the diurnal inequalities of horizontal force and vertical force. We have made calcula-

tions of this for our own information, but have made no further use of it. The comparison of results for different years appears to show that little confidence can be placed in the diurnal inequalities of vertical force except in those years in which the temperature has been maintained sensibly uniform.

The dip-observations whose results are given above have most frequently been obtained about 2^h p.m.

The ordinates of the photographic curves given by the earth-current-wires in their present position have not been measured.

As regards the meteorological results; the eye-observations are corrected for recognized errors of the instruments, and the dewpoint and degree of moisture are computed, to the present time; and time-scales and new base-lines are laid down where required, to the end of 1871. The anemometers and the photographic thermometers require no base-lines, and the anemometers require no new time-scales.

The vane of Osler's Anemometer revolved in the year 1871, through — 2·4 complete rotations.

I have very carefully compared the momentary phenomena of the aurora of 1872, February 4, with the corresponding movements of the magnetometers. In some of the most critical times, the comparison fails on account of the violent movements and consequent faint traces of the magnetometers. I have not been able to connect the phases of aurora and those of magnetic disturbance very distinctly. Preceding comparisons had led me to expect that the umbrella-shaped corona would be accompanied with a very violent disturbance of vertical force, but I can hardly say that the expectation was borne out in the three coronæ of the evening of February 4. I intend to repeat these comparisons in a different way at the next aurora which we may be privileged to witness.

The reductions of the photographic records of thermometers from 1848 to 1868 have been advancing. The diurnal laws of the dry-bulb thermometer, as depending on the month, on the temperature-waves, and on the barometric waves, have been taken for the whole period; the two former have been examined through twelve years, and the last through three years. The similar computations for the wet-bulb thermometer are commenced.

I could wish to receive powers for making a similar investigation of the diurnal laws of temperature as referred to the prevalence of different winds; with that I think that the examination of temperatures from 1848 to 1868 may appropriately close.

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XII. Printing of Magnetical and Meteorological Observations :—

The magnetical and meteorological work of 1870 is entirely printed.

The section of Magnetism contains the detailed measures of ordinates of the photographic curves on sixteen disturbed days, without further computation of them; the diurnal inequalities of the three magnetic elements in each month; the observations and reductions for Gauss's absolute measure of horizontal magnetic force; and the result of every observation of dip.

The Meteorological section contains, in monthly arrangement, various particulars and results of daily barometric and thermometric readings, temperature of the Thames water, winds, electricity, clouds, and weather. These are followed by tables of various monthly means, barometric waves, daily readings of deep-sunk thermometers and their means, change of direction of wind through each month and through the year, rainfall, and luminous meteors.

The number of copies printed is 600, of which 350 are bound in the general volume of "Greenwich Observations," leaving 250 for separate distribution.

The meteor shower of August 1871 was so well observed here that it appeared desirable to print at once so much of the 1871 Magnetical and Meteorological part of the Observations as would include that meteor shower, and to take off an extra number of copies for immediate circulation. No other part of the volume for 1871 is printed, but nearly the whole of the manuscript is ready for press.

Under the friendly relations of the Post Office and the Royal Observatory, an arrangement was made, commencing with 1871, November 3, for the daily transmission of a simple meteorological report to the Paris Observatory at small expense: the assistance of the British Post Office is in fact given gratuitously, but over a portion of the Submarine-Telegraph expense the Post Office has no control. Abbreviated meteorological results are communicated every week to the Registrar General of Births, Deaths, and Marriages, for publication in his weekly Reports. A short report is sent every day to the Greenwich Post Office, and I contemplate distributing it more extensively.

XIII.—Chronometers, Communications of Time, &c. :—

At the present time, the number of chronometers lodged in the chronometer-room is 177. Of these, 137 are the property of the Government, namely, 93 box-chrono-

meters, 26 pocket-chronometers, and 18 deck-watches; 40 are the property of chronometer-makers, undergoing the annual competitive trial. All chronometers are compared with a Mean Solar Clock, which is sympathetic with the Normal Mean Solar Clock; some (including, among others, the chronometers on competitive trial) are compared every day, some only once in a week; all are rated for a limited time in different magnetic positions, and all occasionally in high temperatures.

Six of our chronometers were lent to the Expedition for observing the Eclipse of 1871; all are now returned.

The average excellence of the first six of the chronometers whose competitive trial terminated in August 1871 is slightly superior to that for 1870 and comparable to that for 1869.

Some time since, an accident happened to a chronometer from the weakness of the bottom of its wooden case. To prevent a repetition of this, I have had that part strengthened in all instances where it appeared advisable.

At the request of M. Quetelet, a chronometer belonging to M. Briart has been rated for several weeks. A Mean-time clock for hourly galvanic signals is now being tested preparatory to its being sent out to the Cape of Good Hope Observatory.

On 10 days, the violence of the wind has prevented the raising of the time-signal-ball; but no failure has occurred from other causes.

The clock used at Deal in case of failure of the Greenwich time signal was cleaned in November last, and has performed well since. The ball was dropped by the current on 90·7 per cent. of days since the last report; on 4·9 per cent. the assistance of the attendant's hand was required; on one day the ball was not raised on account of high wind; on two occasions it was dropped a few seconds before 1^h accidentally (by signals from telegraph clerks), which is notified to the public by the exhibition of a black flag; and on 3·6 per cent. communication was interrupted. In the two latter cases the ball is dropped by hand at 2^h instead of 1^h.

Some further correspondence with reference to the proposed establishment of a system of hourly time signals at the Start Point has resulted in a determination on the part of both the Admiralty and the Board of Trade to adhere to their former decision adverse to the proposal.

I am informed by the Engineer of the Post Office Telegraph Department that the distribution of time-signals is becoming more extensive; and a greater battery-power has become necessary at the Royal Observatory for working the additional relays at Telegraph Street.

The automatic report of the clock of the Westminster Palace shows that 60 per cent. of its errors are below 1^s, 91 per cent. under 2^s, and 98 per cent. under 3^s.

Some of the members of the European Geodetic Association have proposed a redetermination, by galvanic signals, of the difference of longitude between the Observatories of Paris and Greenwich. I have stated my opinion that this is not desirable until chronographic registration shall be established at the Paris Observatory.

XIV.—Personal Establishment :—

The establishment of Assistants recognized in the books of the Admiralty is the same as at the last Report. The following are their names and offices :—

Mr. Christie, Chief Assistant.

Mr. Glaisher, Superintendent of the Magnetical and Meteorological Department.

Mr. Dunkin, Superintendent of Supernumerary Computers in the Astronomical Department, and specially charged with the Meridional Transits.

Mr. Ellis, Superintendent of the Time Department, and of the Money Accounts and the Stationery Stores.

Mr. Criswick, Superintendent of the Meridional Zenith Distance Reductions.

Mr. Lynn, Superintendent of the Altazimuth.

Mr. Carpenter, Superintendent of the Equatoreals, the Library, the Manuscripts, and the printed works for distribution.

Mr. Nash, General Assistant in the Magnetical and Meteorological Department, subordinate to Mr. Glaisher.

All these gentlemen, except Mr. Glaisher and Mr. Nash, make observations with all the astronomical instruments; Mr. Dunkin, however, as Senior Assistant, is almost entirely relieved from that labour.

It had long been remarked that the scale of salaries of the Assistants (which had originally been settled when the position of the Assistants was really very humble, and the education and acquirements expected were of the lowest class) was far too low for the talent and education now required, and for the important services rendered by them, not merely in their own persons, but also as directing younger computers. An able representation made by the Assistants through me to the Lords Commissioners of the Admiralty received their Lordships' liberal attention; and a new scale was established which appears to be entirely satisfactory. The Visitors, I am confident, will be gratified at this announcement of a change in the position of the Assistants, which insures their cheerful and cordial devotion to the interests of the Observatory.

Funds are provided by the Government for the employment of six Supernumerary Computers in the Astronomical Department and three in the Magnetical and Meteorological Department. Their stipends are not fixed; they are revised by me every month. Nearly the whole of the routine calculations are made by them. These computers are allowed to practise themselves in the use of the instruments; and when they can make

observations in a manner which is satisfactory to the Chief Assistant and another Assistant who has more particularly examined their work, a written certificate is presented to me, and a written approval of their employment for observations is issued by me. It is usual then to make a small addition to their stipends, and to call on them, when the pressure of business requires it, to take part in the observations.

I am convinced by very long experience that no office system is so efficient and so inexpensive as the combination of warrant-officers and supernumeraries nearly in the way which I have described.

There are also attached to the Observatory a labourer, a gate-porter, and a watchman; care is taken that there be always at least one man on the premises. The principal carpenter in employ is virtually Clerk of Works, almost in the position of an established officer.

The Astronomer Royal is publicly responsible for everything and for every transaction in the Observatory. The effective supervision is partly maintained by a system of Reports, daily, weekly, monthly, or occasionally, which are arranged to bring every matter under his view.

XV.—Extraneous Work:—

Our connexion with the Cape Observatory subsists, as I trust it will continue to subsist. I have been called on to make a Report on proposed instruments for the Cape, and I am charged with the distribution of Mr. Stone's reduction of some of Sir T. Maclear's observations, which will be effected with the distribution of our 1870 volume.

In the summer of last year it was arranged, after much correspondence, that the Royal Astronomical Society would undertake the expense of printing the account of the Eclipse of 1870, December, with some additional notes on the Eclipse of 1860, July; and I assented to the request that I would generally superintend the preparation, provided that some competent astronomer would manage the principal details. I was very happy to find that A. C. Ranyard, Esq., was at liberty to undertake the detail work. The demand on my time is thus very inconsiderable.

The Total Eclipse of 1871, December, has caused no further trouble to this Observatory than that of lending instruments (sometimes requiring modifications) and chronometers, and of recovering them after use.

The preparation for the Transit of Venus, 1874, has occupied much attention. The wooden buildings for the transit-instruments and altazimuths are completed; for the altazimuths I judged it necessary to provide revolving domes. The buildings for the 6-inch equatorials are advancing; for one of these, formerly Admiral Smyth's instru-

ment, which I propose to plant at Alexandria, a special building is prepared, adapted to the latitude of Alexandria; for the others, hexagonal buildings are planned, without revolving domes, but admitting of removal, to a great extent, of separate portions of the roofs. The transit-instruments and the altazimuths are all ready; of the 6-inch equatorials, three are ready in most points, one requires attention after its loan to the last Eclipse, and one has not yet been delivered complete. Two 4-inch telescopes (which, with three that we possess, will complete the required number) are expected from Mr. Simms. The first-class clocks are complete, two of the Observatory clocks being fitted with zinc and steel pendulums; nine second-class clocks are in hand, and the Observatory can furnish one. A special frame has been mounted in the lower South-East Room for attachment of the numerous clocks during their rating. We have begun to prepare skeleton forms for the calculations.

I was made aware of the assent of the Government to the wish of the Board of Visitors, as expressed at their last meeting, that provision should be made for the application of photography to the observation of the Transit of Venus. It is unnecessary for me to remark that our hope of success is founded entirely on our confidence in Mr. De La Rue. Under his direction, Mr. Dallmeyer has advanced far in the preparation of five photoheliographs, improved upon that which has acquired so much reputation at Kew; and I am waiting Mr. De La Rue's final instructions for preparation of the huts. The subject is recognized by many astronomers as not wholly free from difficulties, but it is generally believed that these difficulties may be overcome, and Mr. De La Rue is giving careful attention to the most important of them.

One officer of the Royal Artillery, and one gentleman not connected with the service of Government, have commenced practice in astronomical observations, such as will be required for the Transit; and I am in daily expectation of being joined by two Naval Officers.

Some labour has been expended in examining the bearings of our magnetic observations on a supposed discovery of a magnetic period of $26\frac{1}{3}$ days, and in investigating the distribution of magnetism in bar-magnets and galvanic coils. I understand also that Mr. Glaisher has made important use of our older records in investigating the relation between sun-spots and temperature. The duties connected with the Presidency of the Royal Society, though very imperfectly discharged, have occupied a portion of my time.

I take this opportunity of reporting to the Board that the Observatory was honored by a visit of His Majesty the Emperor of Brazil, who minutely examined every part.

XVI.—General Remarks:—

In the last Report to the Board of Visitors, I indicated, as subjects which might require additional grants of money, and which therefore I submitted to the approval of

the Board, the continued prosecution of the Reductions of the Photographic Meteorological Registers from 1848 to 1868;—the combination of Magnetic Results on undisturbed days, from 1864;—the examination of Magnetic Storms, from 1858;—and possibly other magnetical and meteorological reductions. The expression of the opinion of the Board on these matters would doubtless contribute very much to assist the carrying them out, or to justify me in laying them aside.

I have now to offer to the notice of the Board another subject, not less important.

The tendency of late discoveries and consequent discussions in astronomy has been, not to withdraw attention from the exact departments of astronomy, but to add greatly to the public interest in those which are less severely definite. And this has become so strong, that I think it may well be a subject of consideration by the Board of Visitors whether observations bearing upon some of those trains of discovery should not be included in the ordinary system of the Royal Observatory.

The criteria which, as appears to me, may be properly adopted in the selection or rejection of subjects of observation, are these. Observations which can be made at any convenient times, which do not require telescopes of the largest size, and which do not imply constant expense, ought to be left to private observers. Observations which demand larger telescopes, and especially observations which must be carried on in continual routine and with considerable expense, can only be maintained at a public observatory. The claims of each subject must be separately considered; but there can be no doubt that a very powerful demand for attention is made, when private persons have been induced to continue observations for a long time at considerable current expense, and when plausible evidence is given of the connexion of results thus obtained with other cosmical elements.

I think that these considerations exclude measures of double stars at the Royal Observatory, but they leave an opening for the scrutiny of nebulae, planets, &c., and possibly (but I speak in doubt) of solar spectroscopy. But I have no doubt that they fully sanction the undertaking a continued series of observations of solar spots.

If the Board of Visitors should judge that these observations ought to be taken up, I would request them to observe that another assistant must be added to the Observatory Establishment. For the present, little would be required in the nature of instruments.

The character of the Observatory would be somewhat changed by this innovation, but not, as I imagine, in a direction to which any objection can be made. It would become, *pro tanto*, a physical Observatory; and possibly in time its operations might be extended still further in a physical direction. There would be no difficulty in maintaining its efficiency under the present system of superintendence.

Indeed, the Observatory has long been a physical Observatory, by virtue of its Magnetical and Meteorological Department; the systematic observations in which are,

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as I believe, the best in the world. In my opinion, they remove all necessity of subvention by the Government to any other magnetical or meteorological observatory in this part of Britain.

The consideration of possible changes in the future of the Observatory leads me to the recollection of actual changes in the past. In my Annual Reports to the Visitors I have endeavoured to chronicle these; but still there will be many circumstances which at present are known only to myself, but which ought not to be beyond the reach of history. I have therefore lately employed some time in drawing up a series of skeleton annals of the Observatory (which unavoidably partakes in some measure of the form of biography), and have carried it through the critical period, 1836-1851. If I should command sufficient leisure to bring it down to 1861, I think that I might then very well stop.

G. B. AIRY.

Royal Observatory,
1872, May 10.