REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1879, *June* 7.

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THE present Report refers to the period of thirteen lunations from the New Moon of 1878, May 2, to the New Moon of 1879, May 20, and presents the condition of the Observatory on the last-named day. The Report is arranged under the usual heads.

I. Buildings and Grounds:—

In the Octagon Room some troublesome repairs have been required. It was discovered that dry rot had attacked extensively the wood-work in the neighbourhood of the north window, and the whole of the wainscoting in this part has therefore been restored. At the same time it was found necessary to renew a beam which supported the brick-work over the window. The whole is now in a sound state.

The ceiling of the Octagon Room has been whitewashed (the first time since 1854). The walls will probably require painting before long.

Preparations have been made for the erection of the new Library near the Magnetic House. A sum has been placed on the estimates, and the general plan has been arranged with the Works Department of the Admiralty. The clearing of the ground is advancing.

II. Moveable Property :—

The instruments employed on the Transit of Venus remain as at the date of the last Report. The Transits, Altazimuths, Clocks, four Equatoreals, and one Photoheliograph, are stored in our shed. The Huts are lodged in the Reserve Ground of Greenwich Park.

One Equatoreal and one Photoheliograph, with their huts, are at the South Kensington Museum; one Photoheliograph is in daily use here, one is at the Observatory of the Cape of Good Hope, and one is lent to the Indian Government.

III. Manuscripts :—

The manuscripts of every kind, which are accumulated in the ordinary transactions of the Observatory, are preserved with the same care and arranged on the same system as heretofore. The bound volumes in which they are ultimately collected, are classified as follows :—

A.	Astronomical—chiefly Transit and Zenith Distance Reductions, and including the works of preceding Astronomers	1,160 vols.
B.	Astronomical—various Reductions, including also the Great Lunar and Planetary Reductions . .	584 „
C.	Astronomical—Star Catalogues, Correspondence, &c. .	400 „
D.	Standards, Tides, Railway, Gas, and other Commissions, &c.	190 „
E.	Scientific Societies	30 „
F.	Correspondence with Assistants, Computers, and Tradesmen	150 „
G.	Altazimuth Reductions	550 „
H.	Magnetism and Meteorology	400 „
I.	Meteorology	130 „
J.	Chronometers	340 „
K.	General Science	20 „
L.	General Science	115 „
M.	Administration	130 „

The total number of bound volumes exceeds 4,000.

Besides these there is the great mass of Transit of Venus Reductions and manuscripts, which when bound may be expected to form about 200 volumes.

All the bound volumes have been compared lately with the Catalogue. None were missing from the shelves, except a transcript of Bradley's Observations, lent to Dr. Auwers.

IV. Library :—

In regard to the Library, we endeavour to keep it in a standard state as regards our original subjects (Astronomy, Magnetism, Meteorology, and their accompanying instrumental subjects), and even more as regards the new subjects (Photography and Spectroscopy). In this we are greatly assisted by H. M. Government, acting through the Stationery Office.

The numbers of volumes of the various classes are :—

Astronomy	1,120
Mathematics, Mechanics, and Hydrostatics	520
Physics, Optics, and Electricity	430
Magnetism	100
Meteorology	650
Geodesy	330
Regular Observations, Astronomical, and Magnetical and Meteorological	630
Tables, General and Planetary	180
Ephemerides	700
Transactions	2,200
General Literature, Dictionaries, Statistics, and Geography	540

making a total of 7,400 volumes, exclusive of pamphlets.

The annual comparison of books with the Catalogue has been made, and all are found.

V. Astronomical Instruments :—

The object-glasses of the Transit-Circle and its Collimators have been taken out and cleaned; and the transit-wires, which had been accidentally broken, have been renewed. These are the only changes to record in the Transit-Circle, which is in good working order.

A determination of the flexure of the telescope has been made recently. The result has the opposite sign to that which has been found in every determination since the piercing of the central cube in 1866. The observations were made on two successive days last April. Those of April 22 give +0″·26, those of April 23 +0″·07, for the value of the horizontal astronomical flexure respectively. The value hitherto adopted, which has been confirmed by several determinations, is −0″·13; and, under these circumstances, it has been decided not to apply any correction for flexure. It is intended to make further observations of the flexure in the summer.

A barometer with metallic scale, and graduation modified for change of mercury-surface in the cistern, by Horne and Thornthwaite, returned from the Transit of Venus Expedition, has been substituted for the barometer Newman hitherto used with the Transit-Circle; and a similar barometer has been provided for use in the Altazimuth Dome.

No change has been made in the Sidereal Standard Clock. Arrangements are begun for regulating a clock, which should give seconds' signals on the chronograph, as mentioned in the last Report; but under the great pressure of business, they have not yet been completed.

The clock "Hardy" since its recent repairs has gone very well, and is occasionally used to mark seconds on the chronograph in case of failure in the contact springs of the Sidereal Standard. The other clocks are in good order.

The Chronograph has not required any repairs during the past year. It is in excellent condition.

The object-glass of the Altazimuth has been cleaned, and the instrument has been kept in good working order. Last summer it was found that the azimuth-circle was slightly tilted; the paper formerly placed under two of the radii, to correct the tilt, having been destroyed by rust. Mr. Simms substituted thin slips of brass, and the circle appears now to be perfectly horizontal. The microscopes are now in fair focus for all parts of the circle.

The centering of the lenses in the object-glass of the Sheepshanks Equatoreal has been disturbed in course of years; this fault has been corrected by means of the adjusting screws provided for the purpose, and the definition is now very good. The Shuckburgh Equatoreal is in its usual state, and is but rarely used, its dome being very unfavourably situated.

Considerable alterations have been made in the Great Equatoreal. To make the instrument easy for use with the long Half-prism Spectroscope, the telescope-tube has been shifted longitudinally 30 inches in its cradle, bringing the eye-end nearer to the centre and allowing more room between it and the floor. The declination axis being meridionally excentric by 14 inches as regards the polar axis, the observing chair may be made available for eye-observations and for spectroscopic observations respectively, by reversing the instrument in hour-angle so as to take advantage of this excentricity. In consequence of the greater length of the object-glass-end, it has been necessary to apply a counterpoise of nearly two hundred-weight at the eye-end, and to make new arrangements for application, when necessary, of the object-glass separator.

The Single-prism Spectroscope is occasionally used in cases where small dispersion is desired. For all other observations Mr. Christie's Half-prism Spectroscope only is now in use, and with the change just mentioned it can be used for all parts of the sky. It has received some important improvements at Mr. Hilger's hands since the last Report. A new first prism, 2 inches square in cross-section, has been substituted for that originally used, the effective breadth of which had been reduced by an accident (whilst in the workman's hands) to $1^{in}\cdot3$ only. At the same time a third prism was added, so that a train of one, two, or three, half-prisms can be used at pleasure. Some improvements have been made in the spark-apparatus for comparison-spectra, and a plane glass at an angle of 45° has been substituted for the comparison-prism, the reflection from the front surface being less intense and therefore more suitable for comparison with star-spectra.

The Photoheliograph, it appears, was not planted accurately in the first instance, and had been subsequently disturbed by workmen in cleaning it. This produced error of reductions while the zero of the position-circle was determined by sweeping with the equatoreal motion. The error has been carefully measured, and all is perfectly corrected.

VI. Astronomical Observations:—

No change has been made in the usual course of observations carried out for so many years. The Moon is observed at every opportunity with the Altazimuth as well as with the Transit-Circle, and with the latter instrument the Sun and Planets on every week-day, when they transit before 15^h. Observations for the measure of the Diameters of the Sun and Moon are taken on all favorable occasions.

With merous group of Minor Planets, the Berlin authorities have mostention to my representation, and we have now a most admirablve Ephemeris. But the extreme faintness of the majority of these bpractically beyond the reach of our Meridian instrument, and the vation is in many cases further increased by the large errors of es.

Our mas of stars are directed primarily to the determination, with the accuracy, of the places of 215 fundamental stars observed throughout, and these are supplemented by observations of stars taken froalogue of about 2,500 stars. About 1,300 of these stars were obseing a larger annual catalogue than usual.

Betweed 1879, May 20, the following observations were made:—

With t

The limbs being counted as separate observa-	
. . . . .	4284
Pons of the nearly vertical wires of the	
. . . . .	321
Rions of the nearly vertical wires of the	
. . . . .	386
Rns of the central wire . . .	296
Cieach requiring a separate reading of the six	
meters	3704
Rns of the zenith-distance wire (included in	
cle-observations)	288
Rns of stars (similarly included) . .	369

With Tube:

Pons of γ Draconis, the instrument being	
the observations	35
S	1

With

Aon and Stars	733
Allimating-mark	268
Z the Moon	368
Z the Collimating-mark . . .	260

In reference to the number of complete observations of the Moon in both elements, as depending on the Mean Solar Time of the Moon's Transit:—

Between 21^h and 22^h	there were	4	observations.
Between 22^h and 23^h	„	1	„
Between 23^h and 24^h	„	0	„
Between 0^h and 1^h	„	0	„
Between 1^h and 2^h	„	1	„
Between 2^h and 3^h	„	3	„

The whole number of places of the Moon observed with the two instruments were:—

With the Transit-Circle, 90, or 6·9 per lunation.
With the Altazimuth, 162, or 12·5 per lunation.

The Moon's diameter has been measured:—

With the Transit-Circle, once in R.A., 7 times in N.P.D.
With the Altazimuth, 13 times in Azimuth, 39 times in Z.D.

Observations of 9 occultations of stars by the Moon (8 disappearances and one reappearance), and of 26 phænomena of Jupiter's satellites, have been made during the period to which this Report refers. The Great Equatoreal, the Sheepshanks Equatoreal, and the Altazimuth, have been employed, sometimes simultaneously, in these observations.

After a fine autumn, the weather in the past winter and spring has been remarkably bad. More than an entire lunation was lost with the Transit-Circle, no observation of the Moon on the meridian having been possible between January 8 and March 1, a period of more than seven weeks. Neither Sun nor stars were visible for eleven days, during which period the clock-times were carried on entirely by the preceding rate of the clock. The accumulated error at the end of this time did not exceed $0^s{\cdot}3$.

Independently of cloudy weather, the observations with the Great Equatoreal have been interrupted by the work on the instrument above mentioned.

VII. Reduction of Astronomical Observations:—

The following Report exhibits the various stages of Reductions on May 20:—

For Meridional Transits:

Clock-times of transit over the true meridian after all corrections for instrumental errors, &c. are prepared, to . . 1879, May 16

Clock-errors and rates are determined, and corrections are applied to form apparent right-ascensions from observation, to	1879, May 15
Star-reductions are computed and applied to the apparent right ascensions of stars, so as to exhibit the mean right ascension on 1879, January 1, to	May 15
For transits of the Sun, Moon, and Planets, mean solar times are prepared, to	May 15
Corrections for defective illumination are computed and applied to	May 15

The Personal Equations in observations of transits during the year 1878 have been investigated.

For Meridional Circle-Observations:

The means of micrometer-readings are taken, and the usual corrections are applied, forming apparent zenith-distances, to	1879, May 18
Refraction, parallax, and co-latitude, are applied to . .	May 11
Star-reductions are computed and applied so as to form mean N. P. D. for 1879, January 1, to	May 1
Corrections for defective illumination are computed and applied to	May 11

The refractions used to the end of last year (1878) are the same as those employed since the beginning of 1868, on the authority of an investigation by Mr. Stone; namely, those of Bessel's *Tabulæ Regiomontanæ* × 0·99469. The result of investigations made in connexion with the Nine-Year Catalogue, to be mentioned shortly, shows that these refractions are too small; and from the beginning of this year (1879) those of Bessel's *Tabulæ Regiomontanæ* have therefore been used unaltered. The results of the two preceding years have also been corrected as far as was practicable, to reduce them to Bessel's refractions of the *Tabulæ Regiomontanæ*. For 1877, the printing of the Greenwich Observations was too far advanced to allow of any correction of the Planetary Results, for which Stone's refractions with the corresponding Co-latitude 38°. 31′. 21″·40 (deduced from circumpolar stars in the Nine-Year Catalogue) had been used. In the Annual Star Catalogue, however, the N. P. D.'s are reduced to Bessel's refractions and to Co-latitude 38°. 31′. 21″·90, by the application of the corresponding corrections. Two determinations have been made of the Co-latitude for 1877. With Bessel's refractions the result is 38°. 31′. 21″·80; with Stone's, 38°. 31′. 21″·51.

For 1878, the observed N. P. D.'s of Stars and Planets in the section of Results have been corrected for R—D and for reduction to Bessel's refractions, and computed with Co-latitude 38°. 31′. 21″·90. As in 1877, two investigations of Co-latitude have been made. With Bessel's refractions the result is 38°. 31′. 21″·91, with Stone's, 38°. 31′. 21″·59. The position of the Ecliptic has been investigated. The discordance between the results for obliquity from the summer and winter solstices respectively, is much smaller than in preceding years, being +0″·31 for 1878, whilst in 1877 it was +1″·13. The correction to the obliquity adopted in the Nautical Almanac has changed from −0″·25 in 1877, to +0″·23 in 1878. The changes in these corrections appear to be due to the alteration in the refractions and Co-latitude.

In connection with this question of refraction, a thermometer has been mounted on a post in the Front Court, as far as possible from any buildings, and freely exposed to the air, and its readings are taken simultaneously with those of the Transit-Circle exterior thermometer and of the Meteorological standard. Three thermometers in the Transit-Circle room, mounted respectively north, south, and in the shutter-opening over the centre of the instrument, are also read simultaneously, with a view of determining the curves of equal temperature in the immediate neighbourhood of the instrument. The readings taken up to the present time seem to show that these curves are approximately semi-circles, and that the temperature of the observing room has no sensible influence on the amount of refraction.

Before issuing the Nine-Year Catalogue, some discussions were made of its N. P. D.'s as compared with the two last preceding Greenwich Catalogues, the Cape Catalogue (1860), and the Melbourne Catalogue (1870). From these it appears that while the First and Second Seven-Year Catalogues, in which Bessel's refractions are used, accord well with the Southern Catalogues, the Nine-Year Catalogue, in which Stone's refractions are used, shows discordances increasing progressively with the zenith distance, and amounting to 2″·5 at Z.D. 80°. The results of the Ecliptic investigations support this, as they show that the mean of the observed N. P. D.'s of the Sun throughout the year is systematically too small for the years since 1868, in which Stone's refractions were used. The comparisons of the several catalogues, and the corrections required to reduce the N. P. D.'s to Bessel's refractions and to Co-latitude 38°. 31′. 21″·90, are given in an Addendum to the Introduction to the Nine-Year Catalogue.

The whole of the Planetary Results, exhibiting geocentric and heliocentric errors in the tabular places of the Sun, Moon, and Planets, are complete.

The observations of γ Draconis with the Reflex-Zenith-Tube are completely reduced to the present time.

The following is the state of reduction of the Altazimuth-observations :—

For azimuths, true azimuths are formed by combination of mean of microscopes, correction for level, collimation, and azimuth-zero, to	1879, April 21
For zenith-distances, true Greenwich zenith-distances, corrected for refraction, are formed, to	May 12
Corresponding tabular azimuths and zenith-distances are formed, to	April 21
Apparent errors of Moon's tabular R. A. and N. P. D. are computed, to	April 21
Apparent errors of Moon's tabular Longitude and Ecliptic N. P. D. are computed, to	April 21

In 1878 the errors of Hansen's Lunar Tables, as indicated by both instruments, appear to be smaller on the whole than in 1876 and 1877.

The observations of Occultations of Stars by the Moon are completely reduced.

VIII. Spectroscopic and Photographic Observations :—

During the past year, Spectroscopic observations have been almost entirely suspended, in order that the reductions of accumulated Photographic observations might proceed more rapidly. The Sun's chromosphere has been examined on seven days only, and, on five of these, prominences were seen. Two measures of the displacement of the F line in the spectrum of α Virginis, and 26 of the b lines in the spectra of 6 stars (3 of them not previously examined), as compared with the corresponding lines of hydrogen and magnesium, have been made. In five of these, though the stars were of the second magnitude only, a dispersive power equivalent to fifteen prisms of 60° was used. These observations were checked by reference to the F or b lines in the spectrum of the Moon or of the Sky.

The spectrum of Brorsen's comet has been examined with the Half-prism Spectroscope, and that of the Eclipsed Moon on 1878, August 12, with the Single-prism Spectroscope.

The Solar spectrum in the neighbourhood of G has been examined with reference to the existence of bright lines in this region, and several photographs of this part of the spectrum have been taken.

Photographs of the Sun have been taken on 150 days, and 228 of these have been selected for preservation. The photographs show a complete absence of spots on 121 days out of 150; and on comparing them with those of the preceding year, when there was an absence of spots on 66 days out of 156, it appears that we have not yet passed the minimum.

IX. Reduction of Spectroscopic and Photographic Observations:—

The Spectroscopic observations of all kinds have been completely reduced.

The areas, position-angles, and distances from the Sun's centre, of Sun-spots and faculæ, have been measured in duplicate up to the present time, and the measures completely reduced, so as to exhibit areas in millionths of the Sun's visible surface, and Heliographic longitudes and latitudes. Great efforts have been made to bring up these reductions, and they have now been perfectly corrected for an instrumental error above mentioned.

X. Magnetical and Meteorological Instruments:—

As regards the magnetical instruments, there is very little to record. New thermometers have been mounted to give the temperature within the cases of the Horizontal and Vertical Force Magnetometers, and the stand carrying the cylinder for the Vertical Force and Barometer traces has been more firmly fixed.

The identity and insulation of the Earth-Current wires were tested last January. The abnormal fluctuations in the indication of one of the wires, noticed in the last Report, have much diminished of late, and I believe that the real indication can be traced.

Some difficulty was at first experienced with the Thomson Electrometer, which was traced to want of insulation. This has been mastered by the use of glass supporters, which carry some sulphuric acid. The instrument is now in excellent order, and the photographic registers have been perfectly satisfactory since 1879,

February, when the new insulators were applied. To facilitate comparison with the Anemometer records, the clock-train has been slightly altered, so as to make the time-scales of the Electrometer and of the two Anemometers exactly equal. I have not yet made the same arrangement for the thermometers and barometer.

The photographic barometer apparatus was thoroughly cleaned by Messrs. Negretti & Zambra at the beginning of this year, and a new cistern-float was supplied. The whole barometer has been raised, so that in the normal position the long arm should be horizontal.

New photographic thermometers were supplied last summer by Messrs. Negretti & Zambra, and some improvements were made in the driving clock by Messrs. E. Dent & Co. in the spring of this year. The Standard Thermometers have been screened from the radiation of the ground, by a circular table fixed below their bulbs, and some further small alterations of the same character have been carried out.

A rain-gauge on the roof of the Magnetic House has been substituted for that hitherto placed on the Library leads, which is somewhat overshadowed by neighbouring parts of the buildings. The elevation of the new gauge is sensibly the same.

All the thermometers in ordinary use were compared with the Standard in February last. A comparison was also made of the thermometers in use in the Astronomical department.

XI. Magnetical and Meteorological Observations:—

The photographic sheets giving a continuous record of the magnetometers, barometer, thermometers, and electrometer, are in excellent state, the indications of the last-named instrument being specially interesting. The zeros of the photographic curves are determined by readings of the magnetometers and electrometer taken four times a day; and occasional observations of dip, deflexion, and zero of the declination-theodolite give the absolute values of the magnetic elements.

Our former arrangements were adapted only to reductions by monthly means. We are now endeavouring to make them more available for single-day exhibition, in which state the results can be compared more easily with those of other observatories.

XII. Reduction of Magnetical and Meteorological Observations:—

The theodolite readings of the Upper Declination Magnet, giving absolute declinations, and the eye-observations of scale of Horizontal and Vertical-Force Magnetometers, are reduced to the end of 1878. On the photographic sheets the time-scales for Declination, Horizontal and Vertical Force, and Earth-Currents, are complete to the end of 1878. The base-line values for the Declination and Horizontal Force are formed for 1878, but not yet laid down on the sheets. The Dip-observations are reduced to the present time, and the Deflexion-determinations of absolute Horizontal Force to the end of 1878.

The following are the principal results for magnetic elements in the year 1878:—

Approximate mean westerly declination . .	18°. 49′.
Mean horizontal force	3·905 (in English units). 1·801 (in Metric units).
Mean dip	67°. 37′. 10″ (by 9-inch needles). 67. 38. 12 (by 6-inch needles). 67. 38. 59 (by 3-inch needles).

The Magnetic Reductions for the years 1865 to 1876 are nearly completed. The results are exhibited in the form of annual and monthly mean curves of diurnal inequality, as in preceding investigations; the abscissæ showing the variation of magnetic declination, and the ordinates that of horizontal force, throughout the 24 hours. The annual curves of diurnal inequality are now complete for the period of 36 years, from 1841 to 1876; and from the great length of this series of observations, all made on the same system and with similar instruments, most important inferences may be drawn, both as to the laws of diurnal inequality in general and its changes in different years and seasons, and as to the connexion between magnetic phenomena and sun-spots. These annual curves show a well-marked change in close correspondence with the number of sun-spots. About the epoch of maximum of sun-spots they are large and nearly circular, having the same character as the curves for the summer months; whilst about the time of sun-spot minimum they are small and lemniscate-shaped, with a striking resemblance to the curves for the winter months. It may be worthy the consideration of the Board whether the whole of these results, with any modifications that experience suggests, should not be printed and circulated as a separate volume.

The monthly curves, 1865–1876, have been formed for three periods of four years each, corresponding roughly to periods of minimum, maximum, and mean of sun-

spots, and the whole series stands thus (the general character of the curves being added):—1841–1847, (curves) mean; 1848–1857, small; 1858–1863, large in summer, small in winter; 1865–1868, small; 1869–1872, very large; 1873–1876, mean. The maxima of sun-spots occurred in 1848, 1860, and 1870, and the minima in 1844, 1856, and probably in 1879.

The connexion between changes of terrestrial magnetism and sun-spots is shown in a still more striking manner by a comparison which Mr. Ellis has made between the monthly means of the diurnal range of declination and horizontal force, and Dr. R. Wolf's "relative numbers" for frequency of sun-spots. It appears from this that not only is there a general correspondence in the two sets of phenomena, but that the minor irregularities of the sun-spot curve are reproduced in the curves of diurnal magnetic range; and further that the well-marked annual inequality in the latter is itself variable, being greatest at the time of maximum of sun-spots and least at that of minimum.

It will be an interesting inquiry, when sun-spots become more numerous, to determine whether the present paucity of earth-currents is connected with the fewness of spots.

The following is the state of the meteorological results:—The eye-observations of barometer, dry and wet-bulb thermometers, anemometers, and rain-gauges, are corrected, where necessary, for instrumental errors, and a summary of results is communicated weekly to the Registrar-General for publication in his "Weekly Return." On the photographic sheets, time scales and new base-lines are laid down to the end of 1878 for the barometer-traces, and the corresponding work for the thermometer-curves is in progress. The Photographic Meteorological Records for 1877 are completely reduced, and the results will be included in the volume of Greenwich Observations for 1877, now in the press.

The mean temperature of the year 1878 was 49°·6, being 0°·2 above the average of the preceding 37 years; the months of greatest deviation were February and May, respectively 2°·9 and 2°·5 above the average, and November and December, respectively 3°·3 and 6°·5 below. The mean temperature was above the average in every month except September, November, and December. The highest temperature was 85°·8 on June 26, and the lowest 12°·2 on December 25.

The mean daily motion of the air in 1878 was 268 miles, being 11 miles less than the average. In February the movement was 99 miles below the average. The greatest daily motion was 839 miles on December 31, and the least 34 miles on December 20.

The vane of Osler's anemometer made, in the year 1878, thirty-four complete revolutions in the positive direction N, E, S, W, N.

The records of sunshine with Campbell's Registering Sun-dial are preserved in a form easily accessible for reference, and the results are communicated weekly to the Agricultural Gazette.

XIII. Printing and Distribution of the Volume of Greenwich Observations:—

The printing of the Astronomical part of the volume for 1877 is nearly complete, with the exception of the Introduction, and the Spectroscopic and Photographic Results. The manuscript of the latter has been much delayed by the necessity for correction, alluded to in a former part of this Report, and for careful revision of the results in this new department of the Observatory, leading in many cases to the re-measurement of photographs in which errors were suspected. The manuscript is quite complete to the end of 1878.

With regard to the Numerical Lunar Theory, I have already found that my printing was too rapid, and that a portion must be cancelled. I am now, therefore, delaying the printing.

The Magnetical Results for 1877 are printed, and the Meteorological Results are in the press; the manuscript of the Introduction is in preparation.

With regard to the volume for 1878, the whole of the manuscript of the three principal sections of the Astronomical part has been recently sent to the printer, and a proof sheet has been received.

The publication of the volume for 1876 was somewhat delayed, in order that the discussion of the corrections required to the Nine-Year Catalogue on account of refraction and latitude, as previously explained, might be included. The volume of Observations for 1876, the Results, the Nine-Year Catalogue, and the Great Meteorological Reductions have now been distributed. The "Introduction," which contains discussions and explanations of general interest to astronomers, is this year included in the Astronomical Results and widely distributed.

I have prepared for printing an Index to the detached observations, not included in the regular series which recur every year, but printed in the "Greenwich Observations."

XIV. Chronometers, Time-Signals, Regulation of External Clocks, Operations for Longitude:—

We have now in the Chronometer-room 167 chronometers, which are regularly rated once a week, or, in some cases, once a day. Of these 137 (93 box-chronometers, 20 pocket-chronometers, and 24 deck-watches) belong to the Government; the remaining 30 are the property of various chronometer-makers, who have placed them here for the annual competitive trial. Of the 30 competitive chronometers, 23 are fitted with my supplementary compensation.

The first six chronometers in the competitive trial of last year, show a falling off as compared with those in any of the preceding 16 years, the average "trial numbers" being taken as the test of merit.

In regard to the Greenwich Time-ball, there has been only one failure from accident in the automatic drop; on 6 days the ball was not raised on account of high wind; and on 1 day the mast was so thickly coated with ice that the ball could not be moved. The Deal ball was not dropped at 1^h on 7 days, through failure in the telegraphic connexion; on 2 days the ball was accidentally dropped about 2^s too soon by telegraph signals; on 17 days the current was weak, and the trigger was released by the attendant, without appreciable loss of accuracy; on the 9 days of failure of the ball-drop at 1^h, a black flag was hoisted, and the ball was dropped again at 2^h.

The Westminster Clock has not been quite so well regulated as usual. During the period to which this Report refers, its error exceeded 1^s on 77 days; on 15 of these it was between 2^s and 3^s, on 4 between 3^s and 4^s, and on 1 day it exceeded 4^s.

Prof. Oppolzer's results for the determination of the longitudes of Vienna and Berlin, made in 1877, have now been made public. They show a remarkable agreement of the Chronometric determinations formerly made with the Telegraphic. It may be of interest to recall the fact that a similar agreement was found between the Chronometric and Telegraphic determinations of the longitude of Valentia.

XV. Personal Establishment:—

The personal appointments and duties remain as at the date of the last Report: Mr. Christie, with the full powers and important labours of First Assistant;

Mr. Dunkin, superintending the Supernumerary Computers, and directing the greater part of routine calculations and of arrangements for printing; Mr. Lynn, in charge of the Altazimuth; Mr. Criswick, engaged on chronometers, time signals, quarterly accounts, and stationery; Mr. Downing on library, manuscripts, affairs with the Stationery Office, and distribution of publications; Mr. Thackeray, with the Chronograph and Meridional Zenith Distances. Usually also, six Supernumerary Computers are employed in the Astronomical Department.

From severe illness, my excellent and zealous Assistant Mr. Lynn was unable for several months to take any part in the daily work of the Observatory; and even now cannot share in the severer labours. I have therefore been obliged to rely more than formerly on the assistance of the Supernumeraries, especially for observations. These young gentlemen are not thus employed until their ability has been formally certified to me by Mr. Christie and Mr. Dunkin, and formally recognized by me. They are then considered as having risen to a higher grade in the Observatory. It seems not improbable that we shall be compelled to strengthen this part of our Personal Establishment.

Mr. Ellis and Mr. Nash, with Supernumeraries, still control the Magnetical and Meteorological Department. As the reduction of the diurnal magnetic inequalities 1865–1876 is nearly completed, their staff of four supernumeraries may perhaps be shortly diminished. Mr. Maunder, with one or two supernumeraries, manages the Spectroscopic and Photographic department.

A gate-porter, a labourer, a night-watchman, and a clerk of works, are practically attached to the Observatory.

In the ordinary discipline of the Observatory, every transaction in every department is reported to me, periodically or occasionally, by the proper Officer of each department.

XVI. Extraneous Work:—

First, on operations connected with the Transit of Venus:—

The principal part of the work which I have here to report is not strictly that of the Observatory, but that of Captain (now Major) Tupman, who has voluntarily devoted his whole time to the Transit, labouring every day at the Observatory with

the same regularity and vigour as one of the Assistants. After the exhibition of first results from observation, under a hasty call from the Legislature, there necessarily remained much to be done in more carefully working up, both the observations which first came to hand, and those which subsequently were brought to our knowledge; and after this, considerable labour was necessary to put reports and calculations in a shape adapted to eventual printing of the account of the whole enterprise. The former of these labours had been in a great measure accomplished at the date of the last Report; the year now terminating has been occupied chiefly with the latter. The copy for press of the observations and reductions for the three stations in the Hawaiian Islands is now ready; those for Egypt (Mokattam), Rodriguez, and New Zealand, are nearly ready. The observations at Kerguelen have been finally examined, but the copy for press is not prepared.

We are naturally looking to the Transit of 1882; and the general impression appears to be that it will be best to confine our observations to simple telescopic observations or micrometer-observations at Ingress and Egress, if possible at places whose longitudes are known. For the first phænomenon (accelerated ingress) the choice of stations is not good; but for the other phænomena (retarded ingress, accelerated egress, retarded egress), there appears to be no difficulty. The adoption of a south-polar station seems to be practically abandoned.

Secondly, on the Numerical Lunar Theory.

The incessant pressure of the business of the Observatory has prevented my advancing so rapidly as I had hoped. The Solar Perturbing Forces are all computed to 10^{-7} in all cases, and to 10^{-8} and 10^{-9} in those cases in which large factors are introduced by theory as necessary for obtaining the correction to tabular coefficients from discordance of computed deductions (Lunar Places on one side, with Solar Forces on the other side). The Lunar Places with the same arguments, first computed to 10^{-7}, are now extended to 10^{-8} or 10^{-9}, for the powers of radius vector. The computations of the same kind for the other assumed elements (longitude and latitude) are not begun. In regard to the discordance of Annual Equation, to which I called attention in the last Report, I suspend my judgment. I have now discussed the theory completely; and, in going into details of secular changes, I am at this time engaged on that which is the foundation of all, namely, the change of excentricity of the Solar Orbit, and its result in producing Lunar Acceleration.

An important error in the theoretical formulæ for Variations of Radius Vector, Longitude, and Latitude, was discovered; some calculations depending on them are cancelled.

XVII. General Remarks:—

At the last Meeting of the Board, I called their attention to the magnitude of the printed volume of "Greenwich Observations," and I was invited to communicate with certain Members of the Board (each on a definite subject), as to the practicability of reducing the extent of the volume. The answers received by me are not quite complete, but they seem to lead to a distinct conclusion, upon which however, I trust, the Board will officially decide. In regard to the Introduction, it has been suggested for consideration whether, without omitting any part, some portions recurring every year might be maintained in stereotype, for reduction of compositor's charges. In regard to the detail of Meridional and Altazimuth observations (the most important point of possible diminution of press-work), the severe and long-enduring illness of the Member of the Board to whom this question was intrusted has prevented the transmission of any extended Report; but the more brief statement of his views, communicated by him to me, appears to imply his opinion that no reduction ought to be made. A strong appeal has been made for extension of the spectroscopic observation of stars, in reference to their motion in the line of sight, (to which I have given a tacit response by the modification of the S. E. Equatoreal, so as to facilitate that extension). The tendency of external scientific movement is to give great attention to the phænomena of the Solar disk (in which this Observatory ought undoubtedly to bear its part). And I personally am most unwilling to recede from the existing course of magnetical and meteorological observations. All these, however, are inferior in importance, with regard to the question now before us, to the extent of printing the original details of astronomical observations.

(As connected with the subject of printing, I may here state that the Treasury precept, cited in the last Report, which forbad the commencement of printing until the entire manuscript should be communicated to the Stationery Office, was entirely withdrawn so far as it affected the Greenwich Observations.)

The general tendency of these considerations is, to increase the annual expenses of the Observatory. And so it has been, almost continuously, for the last 42 years. The annual ordinary expenses are now between $2\frac{1}{2}$ and 3 times as great as in my first years at the Royal Observatory. I would fain flatter myself that the value of its results has increased in a greater degree.

G. B. AIRY.

Royal Observatory, Greenwich,
1879, *May* 21.