REPORT

OF

THE ASTRONOMER ROYAL

TO THE

BOARD OF VISITORS

OF THE

ROYAL OBSERVATORY, GREENWICH,

Read at the Annual Visitation of the Royal Observatory, 1864, *June* 4.

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It has been my rule, in framing my Reports to the Board of Visitors for several years past, to adapt them to periods bounded at the beginning and at the end either by the beginning or by the middle of a lunation. The Report which I have the honour now to place before the Board applies to the period of twelve-and-a-half lunations, from 1863, May 17, to 1864, May 20.

I. Buildings and Grounds.—Only one change has been made in the Astronomical Buildings. It had long been remarked that the ventilation of the South Dome (in which the Altazimuth is mounted) was insufficient. I have therefore opened two windows into the room, one on the South and one on the East side. The south window is not often used, and is in fact at the present time blocked by a shutter; but the east window is almost perpetually open, partly by understood regulation and partly because the external thermometer is fixed without it; and the temperature of the room is now in an excellent state.

The North Dome (formerly called the East Dome or North-East Dome) does not exclude the rain so perfectly as it ought. Instructions have been given to the proper workmen for its examination, and it may possibly be made water-tight by the time of the Meeting of the Board.

Two piers have been built in the Front Court for the support of instruments which I expect Mr. Otto Struve to bring, to be used in observations connected with the Great Arc of Parallel. It was necessary to dig to the depth of 12 feet, to obtain a satisfactory foundation for the piers. A portable observatory is to be erected over them in some part of the approaching summer.

In a very heavy squall which occurred in the gale of December 2 of last year, the stay of the lofty iron pillar outside of the Park Rails, which carried our telegraph-wires, gave way, and the pillar and the whole system of wires fell. By permission of the Department of Her Majesty's Parks and Public Buildings, I was enabled to select a new position within the Park, and thus to attach the wires to a much shorter wooden mast. On the last day of the year, communication was again made perfect.

An important alteration has been made in the Magnetic Observatory. For several years past, various plans have been under consideration for preventing large changes of temperature in the room which contains the magnetic instruments. At length, I determined to excavate a subterraneous room or cellar under the original room. The work was begun in the last week of January, and in all important points it is now finished. The ground was cut down on all sides in the plane of the inner surface of the former walls, and within this space a 9-inch wall was built all round, so that the transverse dimensions of the room are less by 18 inches than those of the former room. Bricks were selected which were almost free from magnetism. The room is illuminated when necessary by three well-windows, facing the South; these can be covered by yellow glass, or by wooden shutters, and can otherwise be blocked. It can be warmed by a gas-stove, and lighted by gas-lights. Ventilation is provided by a large copper pipe leading to the ventilating-cowl of the upper room (no longer required for the upper room), through which pipe the warm stove-pipe is led nearly to the top. Drainage is effected by a pump in the ground outside of the building, about 20 feet distant from the eastern arm of the building. The building has been somewhat delayed by the illness of the Superintendent of Works, and also by the circumstance that the walls dry slowly. The reading of the atmospheric dew-point, at this season, is sometimes higher than the mean temperature of the ground, which is the temperature of the walls. It seems probable that the stove will be required more frequently in summer than in winter. On the erections for carrying the instruments, I shall speak hereafter.

The Map of the Grounds and Buildings has been engraved; it is accompanied by a description, with historic references, which might have been more complete if at the time of writing I had been possessed of the documents to which I shall soon allude. The whole is finished, but the circulation, with that of other parts of the Astronomical Volume, is delayed for a reason to be mentioned hereafter.

No steps, so far as I am aware, have been taken in the present year, for urging the proposal of a Railway through Greenwich Park.

II. Moveable Property.—With the exception of auxiliaries to instruments, which will be treated under a special head, no changes of the least importance have been made in the property serving for the active work of the Observatory. Its ornamental property has received a most valuable addition, in a bust of the highest merit, by Foley, of the Rev. R. Sheepshanks, many years a Member of the Board of Visitors; presented by Miss Sheepshanks.

The Visitors are aware that, under the provisions of the Standard Act, an official copy of each of the two fundamental Standards (that of length, and that of weight) is preserved in the Royal Observatory. In the late spring, some alarm was occasioned by the discovery that the Parliamentary Standard of the Pound Weight had become coated with an extraneous substance produced by the decomposition of the lining of the case in which it was preserved. The appearance was so grave that the Lords Commissioners of the Treasury decided immediately to follow the course prescribed by the Standard Act for cases of destruction or injury of the Parliamentary (National) Standard, namely, to compare it with the three Parliamentary Copies, of which that at the Observatory is one. The comparison was made by Professor Miller of Cambridge. It is satisfactory to know that the National Standard was found to be entirely uninjured. It is also interesting to know that the Observatory copy contributed its share to the evidence on this point. The occurrence seems to prove the propriety of the arrangement legalized by the Standard Act for restoration of the Standard in case of loss or injury, namely that of comparison with certain Official Copies. It would have been a most laborious business to test the Standard by reference to the weight of water, as was provided in the last preceding Standard Act.

III. Manuscripts.—The ancient Manuscripts are preserved with the usual care; and the current and accumulating Manuscripts are, in the first place, arranged and stitched together, on a peculiar plan which after many years' experience we have found to be very simple and satisfactory; and, in the next place, are bound as soon as the number of papers collected under each head requires it. The operations connected with this are generally intrusted to Mr. Carpenter. The Manuscripts are properly catalogued.

On the day of writing this Report, a packet of Bradley's MSS. relating principally to adjustments of the Greenwich Instruments, has been transferred by the Rev. H. O. Coxe, Librarian of the Bodleian Library, Oxford, to the Royal Observatory.

I adhere peremptorily to the rule of not permitting any original Manuscript to be taken out of the Observatory except by my own hands and to be kept under my own eye.

Lately, however, I have found the advantage of preserving duplicates which may be for a time lent from the Observatory. Several years ago (as was then notified to the Visitors), I was permitted, by the courtesy of the Vice-chancellor of the University of Oxford, to make accurate transcripts of Bradley's original Greenwich Observations, then preserved in the Bodleian Library. More lately (as the Visitors have been informed), the originals themselves have been transferred by the Senate in Convocation to the Royal Observatory. The copy is therefore free for use; and at the present time the copy of the observations from 1743 to 1749 (hitherto not printed) is in the hands of Mr. Hugh Breen for reduction of the observations (hitherto not reduced), and the copy of the observations from 1750 to 1762 is to be lent to Mr. Winnecke, for more complete reduction of the observations than was made by Bessel.

In my Reports for some years past, I have alluded to the supposed loss of the Minutes of the Board of Visitors from 1784 to 1830. I now believe that there never was such a collection, in a separate form. The Board of Visitors was, in fact, a Committee of the Council of the Royal Society, and its Minutes are, I believe, contained in the Minutes of the Council. The volume which I possess, extending from the institution of the Board to 1784, consists of leaves inserted in a guard-book. Having learned that detailed minutes connected with the Royal Observatory exist in the Minutes of the Council of the Royal Society, I solicited of the President and Council permission to have those Minutes copied; the permission was immediately granted, and facilities given to my copyist; and the passages bearing upon the Royal Observatory were selected and marked by the Assistant Secretary of the Society. My best thanks are due to the President and Council of the Royal Society for the liberality and promptitude with which they acceded to my request. I am very glad to possess in the Royal Observatory a series of documents which illustrate so much (and in the latter part nearly the whole) of its official history.

IV. Library.—Some purchases are made by me, confined to the subjects which are followed in the active business of the Observatory; but the principal increase of books is derived from presents.

Preparations are made for the new Catalogue, but it is not yet begun. It is intended to adopt the method of moveable slips, now employed in the principal large libraries.

V. Astronomical Instruments:—

The Transit-Circle is in perfect condition. The index-pieces, to which in my last Report I alluded as being suspiciously near to the micrometer-heads, have been filed, and the micrometers have been put in good order.

A trifling want of steadiness has been discovered in the object-glass of the North Collimator, which may have produced some of the discordances that were attributed to instability of the ground. The fault has been corrected, but I am not yet able to say whether the discordances are removed.

A series of observations lately taken for determination of the astronomical flexure of the telescope has given a result of insensible amount of flexure. This differs from the results obtained in former years. The process is to be repeated; meantime, I may remark that, if the late deduction should be confirmed, I should attribute the difference to a difference in the firmness of fixation of the eye-end tube, which has once been taken off and replaced.

On November 16 of last year, the instrument narrowly escaped serious injury from an accident. Shortly after the operation of raising the Transit Circle (for comparison of the Collimators and cleaning the pivots) but when no person was near, the plate-chain which carries the large western counterpoise broke. The counterpoise fell upon the pier, destroying the massive gun-metal wheels of the lifting machinery, but was prevented from falling further by the iron stay of the gas-burner-flue. Had it forced this, it would probably have destroyed the microscopes, and might have injured the building by its ultimate shock on the ground. On examination it was found that many of the individual plates of the plate-chain were broken through. I lost no time in requesting the assistance of Messrs. Ransomes, to re-suspend the counterpoises from strong simple iron chains, and to prepare large pulley-wheels with grooves adapted to guide the links of the chains in their proper position. Subsequently, iron box-sides have been mounted, for so inclosing each counterpoise that, if it should fall, it will not fall from the top of the pier.

The Transit-Clock (lately cleaned) is in good order. To enable us to use another clock by the chronographic method when the transit-clock is temporarily dismounted, I have had seconds-contact-springs inserted in the North Dome Arnold. The Chronograph is in general good order, but I contemplate altering the form of its water-resistance mechanism to give it the same arrangement as that of the Large Equatoreal clock-work. The Reflex Zenith Tube is in good order.

The Altazimuth is in good order. The pinion-axis of the moderately-slow motion in azimuth lately broke, at a point where a screw-hole had been drilled through it: it has been repaired in a safer form. Much of the brass of the azimuthal microscopes had become rotten, and has been replaced. A similar operation is to be performed shortly on the vertical-circle microscopes.

The Apparatus of all kinds for Galvanic Signals is in good order. The Motor Clock has been lately cleaned, with much attention to the maintaining-mechanism,

and to the galvanic-contact-surfaces: ebonite has been substituted for ivory in some of the insulating parts; and, in order to diminish the mechanical interference with the motion of the pendulum, two pairs of pendulum-contact-springs have been removed, their circuits being completed by a multiple relay, which is worked by the springs that are left.

The Shuckburgh Equatoreal is imperfect as regards its hour-circle-microscopes, but in other respects is in good order. The Sheepshanks' Equatoreal (lately separated and cleaned by Mr. Carpenter) is in perfect efficiency.

The South-East Equatoreal has had no change since the last Meeting of the Board: it is in a perfect working state. An eye-piece with reflection from the surface of glass, for viewing the sun, has been provided for it: a construction which is very useful, where the whole aperture of the object-glass is desired for good definition, and where the accompanying heat is great. The water-clock-movement is most accurate; I propose to give it the last degree of exactness by the following arrangement. The arc of vibration of the conical pendulum will sometimes vary a little from variations in the height of the surface of the resisting water. To make the vibrations isochronous, the part which we have usually called the "spade-apparatus" requires to be loaded at the top so as to overtip a little. Some years ago I had computed the quantity necessary for perfect isochronism, and I propose soon to introduce the principle practically.

I have not had sufficient leisure to prepare for publication plans of the South-East Equatoreal.

The Prismatic Spectrum-Apparatus has been altered in the manner described in the last Report. Achromatic object-glasses are placed on both sides of the prism, so that each pencil of light through the prism consists of parallel rays; and breadth is given to the spectrum by a cylindrical lens. The spectral lines are seen straighter than before, and generally it is believed that their definition is improved.

Of the Ancient Instruments, the limbs of the Iron Quadrant and of the Brass Quadrant have been cleaned and covered with a rather hard varnish, under the superintendence of Mr. Simms. The other old instruments have been cleaned under Mr. Simms' eye, and the results of the examination have been interesting. One old instrument has, since the year 1835 at least, borne the repute of being one of Flamsteed's. On carefully examining it, we find that it is a perfect small equatoreal of the German form, with a steel polar axis, conical hole in the lower end for bearing on a conical pin, and brass ring near the upper end for bearing in a Y; above which are its telescope and declination-circle on one side. The oldest equatoreal with

which I am acquainted is Flamsteed's Equatoreal Sextant, of which we have an accurate drawing in a very rare engraving; its mounting was of the German form. From the style of workmanship as well as the general form, and from the circumstance that all Flamsteed's instruments are reported to have been taken away from the Observatory, I am inclined to believe that this old equatoreal is of Halley's time. Besides the coarse graduation on a small circle, by which the position of its declination-frame was registered, it has a better graduation by which the position of the telescope on the declination-frame was registered, and by which small differences of declination could be measured. Halley's unsymmetrical transit is in fair order: we remark on it a delicate screw-motion which might alter the error of collimation before certain parts were firmly fixed together. Bradley's transit appears to us to have been well put together, and not to have been liable to the flexure which Mr. Pond attributed to it, and which I conceive to have arisen from an error of collimation, not then perfectly understood by Mr. Pond. There seems to have been in it a ghost-apparatus, for determination of level-error. It was never strengthened by braces.

VI. Astronomical Observations.—By long tradition, which I trust will always be maintained in this Observatory, the first place in importance is ascribed to regular observation of the principal fixed stars, rather than of the small ones; to observations of the Sun, including the annual determination of equinox and obliquity, as well as of the Sun's place in its apparent orbit; to observations of the known bodies of the Solar System; and to observations of the Moon. Meridional observations only are employed for all determinations, except those of the Moon's place; but for the Moon, (whose tables, containing many rapidly-changing inequalities, can scarcely be sufficiently compared with her observed places in the heavens, as liable to the interruptions, both systematic and irregular, to which meridional observations are exposed,) extra-meridional observations with the Altazimuth are also used. It was mainly for observations of the Moon that the Observatory was founded; at no other Observatory has the Moon been followed in the same way, through more than a century, at every hour of the night-transit; and at the present time, when the claims of different observations conflict, the preference is always given to the Moon.

The stars observed on the meridian are principally of the following classes (the same as in 1863): 189 stars for clock-error; all stars not smaller than the 5th magnitude; circumpolar stars; stars in the Nautical Almanac lists conculminating with the Moon or occulted by the Moon; stars assisting in inquiries relating to proper motion or refraction, or serving as standards of reference for the motion of Sirius; a few supplemental to the Seven-Year Catalogue. Among these observations ought also to be included the zenith-distances of γ Draconis, determined with the Reflex-Zenith-Tube at nearly every practicable opportunity. A list of the whole of Bradley's stars is in preparation for re-observation.

The Sun, Mercury, and Venus are observed on the meridian on every week-day, when visible. The large superior planets are observed on week days when they pass before 14^h, or when they pass near the morning moon. The Moon is observed on every day when she is visible on the meridian, without any exception.

For observation of the small planets, a convention has been made with M. Le Verrier, founded on the following considerations :—No relief would be gained by dividing the observations of special planets among special observatories. The seasons at which it is particularly desired that this Observatory should be spared the labour of observing the small planets are the times when the observers are oppressed with the duty of observing the morning moon. These remarks sufficiently explain the motive for proposing to M. Le Verrier the following system, to which he has acceded with the utmost liberality. From new moon to full moon, all the small planets visible to 13^h are observed at the Royal Observatory of Greenwich. From full moon to new moon, all are observed at the Imperial Observatory of Paris. All ephemerides, results of observations, &c. are communicated freely from each Superintendent of Observatory to the other. The relief gained in this way is very considerable, principally because I am not compelled to provide observers both for the early morning and for the late night, partly also because the hours of night-observation of these bodies are made to cease at 13^h. The corresponding diminution of computation, though not so great, is very sensible.

The number of meridional observations with the Transit-Circle from 1863, May 17, to 1864, May 20, is as follows :—

Transits (the two limbs being considered as two objects)	3,729
Pairs of observations of the Collimators by the Transit-Circle	304
Reflexion-observations of the transit-wires	295
Observations of Collimator by Collimator	61
Circle-observations of all kinds	3,999
Reflexion-observations of the zenith-distance-wire	309
Reflexion-observations of stars	260

(The two last classes of observations are included in that which precedes them.)

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

Pairs of observations (the instrument being reversed between)	64
Single observations	11

In taking the observations with the altazimuth, the reading of the barometer has been corrected for the small error which was found to exist in it, and the thermometer

has been read more frequently, and at smaller interval from the observations. The numbers of observations with the Altazimuth, in their various classes, are,—

Azimuths of Moon and Stars	672
Azimuths of the Collimator	356
Zenith-distances of the Moon	364
Zenith-distances of the Collimator	356

The following is the number of complete altazimuth-observations of the Moon when near conjunction with the Sun. The time of the Moon's meridian transit on the days of altazimuth-observation, will sufficiently define the distance of the Moon from the Sun.

Between 21^h and 22^h	3
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	2
Between 2^h and 3^h	4

The whole number of days on which complete determinations of the Moon's place have been obtained with both instruments is,—

With the Altazimuth, 190, or 15·2 per lunation.
With the Transit-Circle, 111, or 8·9 per lunation.

The Earthquake of 1863, October 5, $15^h.\ 23^m.$ was seen with the Altazimuth Telescope by Mr. Ellis, who happened to be observing the Collimator. The mark appeared to descend, to rise rather more, and to descend a little to its original position.

With the South-east Equatoreal, no observations of numerical character have been made. The solar reflecting eye-piece has occasionally been used for examination of the inequalities of light on the sun's surface, and the spectrum apparatus has been employed for view of spectra of some stars. A drawing of the nebula of Orion (still in pencil) has been made with much care by Mr. Carpenter. No observations have been made with the double-image or wire micrometer.

The number of observed Occultations of Stars by the Moon is 12, of which 7 were disappearances and 5 were reappearances. The number of Phenomena of Jupiter's Satellites observed is 11.

VII. Reduction of Astronomical Observations.—The following progress has been made in the various steps by which the Right Ascensions of objects observed with the Transit-Circle are inferred from the observations: Transits are corrected for instrumental errors, and reduced to the state of Clock-time-transits over the true meridian, as far as May 15; Clock Errors and Clock Rates are computed to May 14; Apparent Right Ascensions of the object's center are found to May 14; Stars' corrections are

computed as far as May 15 (except those not previously observed, whose constants are not yet prepared), and are actually applied to the apparent right ascensions as far as 1863, December 31; Corrections for imperfect illumination of limbs to 1863, December 31; Mean Solar Times are prepared to 1863, December 31. For inferring Geocentric North Polar Distances from observations: True Zenith Distances corrected for instrumental flexure, zenith point, and refraction, are formed to May 12; Stars' corrections (limited as above) are computed to February 16, and are applied as far as 1863, December 31; Lunar Parallaxes are computed and applied to April 12, other Parallaxes are computed and applied to March 12; Corrections for imperfect illumination of limbs are applied to 1863, December 31.

The different results for each star's Mean Right Ascension, and for each star's North Polar Distance are collected in what is usually called the "Ledger" form for the year 1863. The Star Catalogue for 1863 is completed; the number of stars is 765. The investigation for R − D is made for 1863, and gives a value, nearly according (at the zenith distances at which the observations are most frequent) with that of the last years. The investigation for correction of colatitude for 1862 gives the smallest colatitude that we have yet obtained, namely 38°. 31′. 21″·58. That for 1863, lately finished, gives 38°. 31′. 21″·79.

Right Ascensions and North Polar Distances of Sun, Moon, and Planets, deduced from observations, are compared with those computed from tables, to the end of 1863. The conversion of errors of R.A. and N.P.D. (taking the mean of groups) into errors of Longitude and E.N.P.D., and other deductions from them, are completed for 1862, but are only commenced for 1863.

The observations with the Reflex-Zenith-Tube are reduced to 1863, December 31.

The Altazimuth Observations are reduced, in different parts of the chain of calculation, to the following states:—Observed Azimuths are corrected for instrumental errors and zero of azimuth, to April 25; Observed Zenith Distances are corrected for zenith point and refraction, to April 25; Tabular Azimuths and Zenith Distances, to the same date; Errors of Moon's Tabular R.A. and N.P.D., and Errors of Moon's Tabular Longitude and Ecliptic N.P.D., to April 1.

The reduction of the Equatoreal observations of 1862, to which allusion was made in the last Report, and which was then unfinished, is now complete.

The Occultations of Stars by the Moon are reduced to the end of 1862; no important step is yet made for those of 1863.

It appears from the transit-reductions, that the personal equations of the observers have changed very little. Three observers, not often employed on transits, have

changed, with reference to Mr. Dunkin, by + 0^s·12, − 0^s·09, and + 0^s·08; but four Assistants more frequently employed have changed by only 0^s·00, − 0^s·01, + 0^s·01, and − 0^s·01.

The azimuthal error of the Transit-Circle continues to make its annual oscillation; the error always being very small in the month of September. The azimuthal zero of the Altazimuth is still liable to irregular changes.

I am not yet able to exhibit such a comparison of Moon's N.P.D. derived from Altazimuth observations, with Moon's N.P.D. obtained by use of the Transit-Circle, as will authorize me to say whether the small discordance which appeared to exist in former years is removed by the alteration of the Altazimuth Dome and the improved practice of observation of its barometer and thermometer.

The Seven-Year Catalogue of 2021 stars from observations in the years 1854–1860, which was mentioned in the last Report as nearly finished, has been completed.

I request the attention of the Visitors to a white Globe, on which we have laid down all the stars observed from 1836 to 1860.

VIII. Printing and Distribution of Astronomical Observations.—The Astronomical printing for 1862 is somewhat increased by the addition of the Appendixes containing the redetermination of the Longitude of Valencia and the Seven-Year Catalogue. And the Magnetical and Meteorological printing, for reasons which will shortly be mentioned, is unusually large. I have therefore thought it desirable, for 1862, to separate the printing into two parts. The Astronomical volume for 1862 has been printed some time since; but, to prevent the confusion which might arise from distributing this, the first part, alone, I have thought it expedient to wait for the completion of the second or Magnetical and Meteorological Part. Separate copies of the Seven-Year Catalogue have been received, but I have not had leisure to attend to their distribution.

Nearly the whole of the manuscript of the principal sections of the observational part for 1863 (Transits and Zenith Distances with Transit-Circle, Azimuths and Zenith Distances with Altazimuth, and comparison of Altazimuth determinations with Tables) is in the printer's hands. The following is the number of sheets already printed:—Transits, 4; Circle Observations, 2; Azimuths with Altazimuth, 1; Zenith-Distances with Altazimuth, 1; Comparisons of Observed and Tabular Places for Altazimuth, 1.

In the section containing the Results of Observations of the Small Planets, I propose to incorporate with our own results the results of the observations made at the

Paris Observatory under the convention which I have described. This combination is approved by M. Le Verrier.

The whole impression of the volumes for 1861 and 1862 is 350 copies. The volume for 1861 has been distributed, and that for 1862 is to be distributed, to the same extent as that for 1860.

IX. Magnetical and Meteorological Instruments.—I have stated above that the excavation for the new Magnetic Basement was begun on January 25 of the present year. It is unnecessary to say that the observations of Declination, Horizontal Force, and Vertical Force were at once suspended; and my remarks on the operation of the instruments apply only as far as January 25. All have been in excellent order. The vertical-force-magnetometer still exhibits sometimes the "dislocations" in the photographic trace. There is no evidence, I believe, that these dislocations do not exist in the curves of every vertical-force instrument, for they are always accompanied with vibration; and no vertical-force instrument, I believe, except that of Greenwich, gives a trace strong enough to exhibit vibrations; and the dislocations, therefore, with any other instrument would appear merely as interruptions of the trace, and would not attract much attention.

In the preparations for mounting the instruments in their new location, the following points are worthy of remark :—

The declination-magnet in the Magnetic Basement (a new 2-feet magnet by Mr. Simms) is carried by a pier built of brick and slate, whose upper part or suspension-piece protrudes through the floor of the upper room, for the sake of giving greater length to the suspending-wire, and for making the suspension-piece more accessible. This instrument is used for photographic self-registration only.

Upon the superstructure of this pier is planted the original framed wooden stand, for carrying the original 2-feet magnet vertically above the photographic magnet. Hitherto, this magnet has been so mounted that its attached collimator was right or left of it; it is now so mounted that the collimator is above or below it; and with this arrangement, on reversing the collimator and giving the necessary movement for making the collimator-axis coincide with the axis of the theodolite-telescope, the magnet is still vertically above the photographic magnet in the basement.

The theodolite, with which the magnet-collimator is viewed, and with which circumpolar stars are also viewed, is in the same position as formerly; a brick pier being built up from the ground below the floor of the Magnetic Basement, through the basement, and through the floor of the upper room, to carry the theodolite.

For the support of the horizontal-force-magnet, a pier is built of brick, stone, and slate, which, like that of the declination-photographic-magnet, projects through the upper floor into the upper room.

The suspending cords of these three instruments are of steel wire. I have seen no practical reason for objecting to the silk skeins; yet, on theoretical grounds, I have long since determined, when opportunity shall present itself, to make this change.

The new vertical-force instrument differs from the old one in the following points:— First, the length of the magnet is 18 inches instead of 2 feet. Secondly, its ends are pointed; a construction indicated by Lamont as giving great magnetic power; which, however, is not successful in the present instance. Third, the knife-edge is one continuous piece of steel. Fourth, the whole of the frame which connects the knife-edge with the magnet is of iron. I am not able yet to say whether any practical advantage attends these modifications.

The new positions of the vertical-force and horizontal-force magnets are vertically below their former positions. That of the declination-magnet is about 10 inches north of its former position.

I have now to mention a result of late observations which has given me great anxiety.

The variations in the power of the horizontal-force and vertical-force magnets depending on temperature were determined several years ago with very great care by experiments in which the magnet was immersed in water of various temperatures. It is evident, however, that this form of experiment does not exactly reproduce the circumstances of a magnet whose temperature depends on that of the external atmosphere; and I have long contemplated experiments in which the magnet should be heated, not by water, but by air.

Opportunity seemed to be given by the command of the hot-air stove, constructed entirely of copper, and heated by gas, which was provided for the warming of the Magnetic Basement. I had a copper box prepared to fix on the top of this stove, containing facilities for the placing of the magnet (to be tried) in a definite position, for the distribution of the heated air over its length, and for reading three thermometers in different parts of its length. The degree of heat was regulated merely by turning the tap of the gaspipe at the floor; a manipulation which could not affect any part of the apparatus. The stove was placed in a position convenient for pro-

ducing deviation, by the magnet inclosed in the copper box, on the needle of the Kew Unifilar.

The result of these experiments is, to give a coefficient for temperature-correction four or five times as great as that given by the water-heatings. And this applies to both the magnets (Horizontal Force and Old Vertical Force), in which I am able to compare the two systems of experiment. A large coefficient is also given for the New Vertical Force Magnet, though much smaller than that for the old one, when tried in the same manner.

I cannot discover any peculiarity in the apparatus which can produce the smallest error. The only differences between the modes of action in the two experiments are, that in the former or water-experiments the magnet was "end-on" to the deflected magnet, while in the latter or air-experiments it was "broadside-on;" and that in the former experiments the magnet travelled round to a position definite with regard to the axis of the deflected magnet (in which case its power is measured by the sine of deviation), whereas in the latter it was stationary (in which case its power is measured by the tangent of deviation).

For the rotating cylinders upon which the photographic paper is placed, and which have hitherto been of glass, being merely glass shades selected with great care from the large stock of a vender of glass ornaments, I propose to try ebonite. This material is very light, but is firm; it turns well in the lathe, and presents a very smooth surface. I expect that a little accuracy will thus be gained in the sub-divisions of the time-scale on the photographic sheets.

The Kew deflexion-instrument is in good order, but with the same defect of plan which I described in my last Report, and which I have not had time to remedy.

The Dip-Instrument, and all its needles, are in good order. With regard to its needles, and to dipping-needles in general, and the change in the position which they take upon being merely raised and lowered, I suggested in my last Report that there appeared to be a small wandering of the magnetic axis (produced, I suppose, by the infinitesimal jar of raising and lowering the needle), and that the injurious effects of this might be removed if the breadth of the needle, instead of being in the plane transverse to the axis of rotation, were in the plane passing through the axis of rotation. I have accordingly had three needles prepared by Mr. Simms in this form, of the lengths 3 inches, 6 inches, 9 inches, respectively (the same lengths as those of the other systems of needles), with the same dimensions of axle and the same workmanship as in the other needles. And very lately I have had a numerical comparison made between the extreme discordances of the field-of-view-readings of the needle-

points (the microscopes remaining unmoved) produced by raising and lowering the needle usually 5 times, sometimes 4 or 3 times, but as nearly as possible the same number of times in each class. The results are as follows:—

		Largest Values of Daily mean of extreme Value of Discordances, in Groups of 5, &c.	General Mean of extreme Discordances, in Groups of 5, &c.
		′ ″	′ ″
9-inch needles	B_1 ordinary	19 14	8 45
	B_2 ordinary	12 14	8 45
	B_4 new flat	4 5	2 20
6-inch needles	C_1 ordinary	48 32	27 52
	C_2 ordinary	21 35	9 53
	C_4 new flat	7 12	3 36
3-inch needles	D_1 ordinary	12 21	7 56
	D_2 ordinary	14 6	7 24
	D_4 new flat	8 49	4 26;

and, combining the needles of different lengths but of the same class, the means of extreme discordances are,—

	′ ″
For an ordinary needle	11 45
For a flat needle	3 27

It appears here that the greater part of the discordance is owing to a cause peculiar to ordinary needles, as distinguished from flat needles, (which cause I still attribute to inconstancy in the position of the magnetic axis) whose action cannot be annihilated. After this I need not say that I consider it certain that the small probable errors which have been attributed to ordinary needles are a pure delusion. I know no instrumental determination in which, without any breach of faith, the wish for uniformity of results will be so certainly followed by uniformity of results, as in the determination of dip. I am proud to offer to the world the long series extending from 1843 to 1864, as one in which this wish has nowhere prevailed, and which I believe exhibits the genuine results of unbiassed observations made with the most accurate instruments that anxious care and the best mechanical skill could produce.

The self-registering apparatus for the record of results of the earth-current wires is ready in all important points, but its mounting is delayed for the completion of the Magnetic Basement.

The meteorological apparatus is in good order. Some of the instruments,—the barometer, the dry and wet thermometers, the anemometers, and a pluviometer,—are adapted (like the three Magnetometers) to automatic continuous register as well as to occasional eye-observation. Other instruments—as several pluviometers at different

elevations—exhibit accumulations, to be occasionally read by eye. Others—as the maximum and minimum thermometers in the air and in the Thames—register extremes only, and require to be read every day. The electrometers (which communicate with a wire that extends from a warmed glass pillar upon the Electrometer Mast to a warmed glass pillar upon the north-west turret of the Octagon Room) are only useful when the eye is turned towards them; until satisfactory means of self-registration can be arranged, these instruments are nearly useless.

I am preparing to erect, near the entrance gate of the Observatory, a barometer, for public information. Only the graduated face will be exposed. Upon this, the scale of graduations will be much enlarged. Indexes are arranged for exhibiting the present state of the barometer, the last maximum, and the last minimum.

X. Magnetical and Meteorological Observations.—The barometer and dry and wet thermometers are read several times every day, and the maximum and minimum thermometers once every day, to the present time. The eye-observations and the photographic record of the three magnetometers have necessarily been suspended since January 25, but the photographic record of the barometer has been continued to May 10, and that of the thermometers is still maintained. Dips have been observed twice each week, or oftener. Observations for absolute measure of horizontal magnetic force about three times in a month.

In the present year, commencing with January 1864, 60 series of observations on 23 day shave been made with the Actinometer.

With the gratuitous assistance of the London District Telegraph Company, and the Submarine Telegraph Company, we every morning communicate to M. Le Verrier the state of weather and the readings of barometer and thermometer, which, with those from other parts of Europe, are published in the Bulletin.

XI. Reduction of Magnetical and Meteorological Observations.—The equivalents for eye-observations of the three Magnetometers, and the temperature-corrections for two, are applied as far as the suspension of photographic records on January 25: the reading for astronomical meridian is reduced and applied to 1863, December 31. The time-scales are attached to the photographs as far as 1863, December 31; the new baselines for the declination and horizontal force to 1863, June 30, for the vertical force to 1863, December 31. The deflexion-observations are reduced to 1863, December 31. The dip-observations are reduced to the present time.

The mean magnetic declination for 1863 is about 20°. 46′.; the diminution from the preceding year about 6′. The mean dip for 1863 is about 68°. 4′. The diminution

from 1862 appears to be about 7′. The dip at the present time appears to be 68°. 2′; but this depends partly on C_1, which always gives a large result. It is remarkable that this is the needle whose magnetism, as above stated, appears to be so unsteady.

The barometer-photographs are in the same state as the vertical-force-photographs upon the same sheet, to the end of 1863. No step of reduction is taken for 1864.

The thermometer-photographs are nearly in the same state.

The vane of Osler's anemometer made about +28·5 complete revolutions in the year 1863; the largest number that we have yet observed.

In the last Report, I alluded to the numerical discussion of the Magnetic Storms, one hundred and seventy-seven in number, registered from 1841 to 1857; the treatment of which was then far advanced. In the last autumn, I finished the discussion of these: the results have been placed before the Royal Society, and are printed as a memoir in the Philosophical Transactions. They appear to me entirely to support the idea that storm-disturbances cannot be explained by sudden magnetic attractions or sudden galvanic currents, but require the supposition of currents, like air-currents or water-currents, upon the surface of the earth.

XII. Printing of Magnetical and Meteorological Observations.—I have thought it desirable to commence the printed record of the observations of 1862 with an Introduction written at considerable length. The last detailed Introduction is that in the volume for 1847 (the last separate volume of detailed magnetic and meteorological observations); and, though changes in instruments and methods have been noted in the briefer Introductions preceding the "Results of Magnetic and Meteorological "Observations" attached to the Astronomical Observations, yet it appeared advantageous now to collect the results of all, and to exhibit fully the present state of the Magnetical and Meteorological Establishment. The manuscript is in the printer's hands, and the printing is in progress.

The Indications of the Magnetometers are printed in the same form as in preceding volumes commencing with 1847; exhibiting the numerical values, expressed each by its proper scale, of the ordinates of all the salient or conspicuous points of each photographic curve. The printing of these is very nearly finished for 1862. The other magnetic observations are prepared for printing in different degrees of detail; the manuscript is in the hands of the printer. An appendix contains the Abstract of the Reduction of the observations of Magnetic Storms (to which I have alluded above) in form intermediate between the exhibition of Instrumental Indications and the

Analysis in the Philosophical Transactions; the printing is far advanced. The Meteorological Observations for 1862, in Abstract only, are printed.

As the long Introduction, and the Storm Abstracts, increased the size of this portion of our printing, I have deemed it expedient, for 1862, to direct that it be bound in a separate volume. The number of copies is 600, of which I propose that 350 be considered as a Second Part of the Astronomical Volume, and that 250 be circulated separately as heretofore.

For 1863, the Indications of Declination Magnetometer are prepared to Feb. 26, those of Horizontal Force to May 31, and those of Vertical Force to July 31. The Meteorological Abstract is more than half finished; the following tables nearly complete.

It is known to the Visitors that I have every year prepared Photographic Copies of the Photographic Curves, for future use or communication to others. These copies can only be formed by the transmission of sun-light through the originals; and, in order to give the desired vigour and clearness to the copies, it is often necessary to touch the originals with sepia or other dark pigment. It has been matter of great regret to me that the delicacy of the original is frequently much injured by this process. I have at length devised a method which removes all difficulties. An apparatus is constructed, consisting of a horizontal looking-glass and a sheet of clear glass erected over it in the position of a desk. The photographic sheet is laid upon this desk with its face downwards; the photographic curve is seen in the utmost perfection by light reflected from the looking-glass and transmitted through the paper; and the sepia is laid on the back of the paper, without touching the original photographic trace at all.

Two copies of each of the photographic curves for Declination and Horizontal Force have been taken to 1861, December 31, and two for Vertical Force to 1862, April 30.

XIII. Chronometers, Communications of Time, Longitudes, &c.—The number of chronometers on hand at the date of this Report is 168; of these, 101 are the property of Government, and 67 are on the Annual Competitive Trial. The whole of the latter and a portion of the former are compared every day with one of the galvanic clocks, sympathetic with the Normal Mean-Time-Clock; the remainder are compared with it once every week. Every Chronometer is tried for some weeks in the heat of the Chronometer Oven.

All decisions on the merits of chronometers offered to the Government for purchase, and on the merits of chronometers rated in the Annual Competitive Trial, are referred

to me; and the repairs of chronometers belonging to the Government are effected entirely through me.

The system of galvanic clocks (containing among others the Normal Clock, the Chronometer Clock, and the large clock at the Entrance Gate), are all simultaneously adjusted to time by the use, when required, of a galvanic force, which may be kept in action during any arbitrary time, to accelerate or retard the vibrations of the pendulum of the Normal Clock. Another common clock has lately been fitted with contact springs, to enable it to give the currents at every second when the Normal Clock is for a time disabled.

The Time-Signal-Ball at Deal is dropped daily by a galvanic current automatically given by the Normal Clock; and from the first, very few failures have arisen from defect in the Observatory Apparatus. Failures have usually arisen (and, in the late disturbed state of the South Eastern Station, more frequently than usual) from defects in the connexions of the Railway Telegraph. Time-signals are sent daily to great distances, as Glasgow and Cardiff, and on the principal railways in various directions. Time-signal-guns are fired daily at Newcastle and Shields. The Post-Office Clocks are regulated mechanically, and signals are sent for regulating the Westminster Clock; and all these, as well as the Deal Ball, automatically report to us the success of the effect of the current which left the Greenwich clock. I shall advert below to the failure of my proposal for hourly time-signals on the Start Point.

In these various operations, about one-fourth of the strength of the Observatory is employed. Viewing the close dependence of Nautical Astronomy upon accurate knowledge of time, there is perhaps no department of the Observatory which answers more completely to the original utilitarian intentions of the founder of the Royal Observatory.

I expect that, in the latter part of the summer, steps will be taken by Mr. Otto Struve for the telegraphic determination of the differences of longitude, between Greenwich and some station on the Continent, and between Greenwich and some point near Milford, as portions of the great Arc of Parallel which is to extend from Orsk on the river Oural to Valencia. The initiation of this enterprise was made by Mr. Struve, and much of the primary work was done by Mr. O. Struve. I hold it to be my duty therefore in no way to interfere with Mr. O. Struve's plans; but to place the Observatory, and myself, and the influence which I may command among the telegraphic or other institutions of the country, entirely at his service; and, as a zealous subordinate, to take every possible measure for carrying out his design.

XIV. Personal Establishment.—The persons employed as Assistants are the same, and with the same ranks, as at the last Report; Mr. Edward James Stone, M.A., Fellow

of Queen's College, Cambridge, is Confidential Assistant; Mr. Dunkin is charged with the Altazimuth; Mr. Ellis and Mr. Criswick with the Chronometers and Time-work; Mr. Carpenter with the Equatoreal and with the care of Manuscripts, Library, Distribution of Observations, &c. Mr. Lynn, B.A. Univer. London has the control of the supernumerary computers. Four or five computers are usually attached to the Astronomical Department. Mr. James Glaisher F.R.S., Second Assistant of the Observatory, superintends the Magnetical and Meteorological Department, aided by one Assistant, now Mr. Nash, and by three or four supernumeraries.

I am ultimately responsible for every part of the work performed at or for the Observatory.

XV. Extraneous Work.—I have not, in the past year, sought for the Observatory any extraneous work, although in my own person I have found it difficult to avoid devoting a portion of my time to the assistance of the Government in some small matters applying to Standards of Measures and Weight.

This however may be a proper place for referring to other works connected with the Greenwich observations. Mr. H. Breen, formerly Assistant, but who had retired from the Observatory, desired to complete certain numerical investigations; and the Admiralty, after calling for my opinion on some points, have sanctioned the expense. The first was a redetermination of the Moon's Parallax, by comparison of the observations of Declination made at the Cape of Good Hope, principally with those made at Greenwich, but partly with those of other British observatories; the results of this are printed in the Memoirs of the Royal Astronomical Society. The second was a determination of the Moon's Diameter as inferred from Occultations at Greenwich and Cambridge; the manuscript computations are still in my hands, for revision as soon as I can find leisure for that purpose. The third is a general reduction of Bradley's unpublished Greenwich Observations from 1743 to 1750; the attested copy of the manuscript is lent to Mr. Breen for this purpose, and preparations for the calculations are begun, but no part except perhaps some auxiliary tables is yet actually computed.

XVI. General Remarks.—The Visitors will doubtless have remarked that the hope which I expressed in my last Report, of shortly bringing up the Reductions to their usual state, has not been disappointed. The Astronomical reductions have been brought up to a state more advanced than usual; the Magnetical reductions are not quite so forward. This considerable advance upon the state of things in 1863 has been gained principally in consequence of our having no large extraneous work.

Observations have been restricted where it could be done without loss of any thing essential, yet the whole number of observations scarcely differs from that of the preceding year. The Assistants have honorably used their best efforts to urge the work in an orderly and rapid course.

The whole amount of labour in the year can scarcely be gathered even from such a detailed Report as that which I have offered. The time consumed in reductions or comparisons connecting the past of Greenwich with the present; the correspondence with contemporaneous institutions; the responses to applications or inquiries of irregular character, by no means confined to astronomical, magnetical, or meteorological subjects; the preparations of new Introductions, Descriptions, or Memoirs; the arrangements of manuscripts, books, and money-accounts; and the general administration; occupy a far larger proportion of our time than could be conjectured by any person who has not had the experience of an establishment, old, active, and widely connected. The part of these labours which falls on myself has been felt in the past year as heavier than usual.

Before closing this Report, I take the opportunity of placing on record some plans of proposed action, which I am unable to carry out at present; but which, as I trust, with such modifications as experience may suggest, will be adopted for effectual use at some future time. They relate to the system of hourly time-signals proposed for exhibition at the Start Point.

It will be remembered by the Board of Visitors that, after consideration of the reasons which I adduced and the methods of galvanic communication and manipulation which I explained, the Board, at their Visitation of 1862, deputed a selection of their Members, accompanied by myself, to wait on His Grace the First Lord of the Admiralty, and to request his favorable attention to the proposal; and that in the course of the summer of 1862, an answer was received, conveying the substance of communications referring to this proposal which had passed between the Board of Admiralty and the Board of Trade, of which the conclusion was, that the Board of Trade possessed no funds applicable to the defraying of the expenses attending the execution of the scheme. This answer was not laid before the Board of Visitors or known to myself till the Visitation of 1863. As it did not fully explain the intentions of the Board of Admiralty, I applied to them in the autumn of 1863, requesting to be informed whether the Admiralty considered as possible the establishment of these time-signals under their own authority; and I received their reply that they do not at present contemplate that measure.

Trusting that the establishment of these signals is only deferred for a few years, and thinking it probable that advantage may result to the system which will hereafter be adopted, from a publication of some details of the plan on which I had proposed to act now, I will here state the general principles of the arrangement on which I had provisionally decided.

The Admiralty possess telegraphic wires passing underground from the Admiralty Telegraph-Office in Whitehall through the principal street of Deptford, towards Deptford Dockyard, Woolwich, and more distant places. The Royal Observatory possess telegraphic wires passing from the Observatory to a house in Deptford called Gothic House, through which one of the Admiralty wires is led; and here, at any moment, such communications of wires can be made, that the galvanic currents from the Admiralty will all pass to the Observatory and back to Gothic House (by what is technically called "a loop"), and thence proceed towards Deptford Dockyard and Woolwich.

When an interruption is made at the Observatory, then currents can be sent direct from the Observatory to the Admiralty-Telegraph-Office.

The wire of the Deptford-speaking-instrument in the Admiralty-Telegraph-Office can be joined with a wire of the Devonport-speaking-instrument in the same office. The wire from the Telegraph-Office to Devonport is continuous, and is good, liable only to some interruptions from occasionally receiving the spray of the sea beyond Exeter.

When these connexions are made, there is unbroken metallic communication from the Royal Observatory to the Admiralty-Office at Devonport; sufficiently good to insure the transmission of Greenwich signals with the regularity required for giving the information by which the Devonport Superintendent can adjust his clock; and also sufficiently good to insure the transmission of automatic signals from the Devonport clock to Greenwich, by which the officers of the Royal Observatory will see the error of the Devonport clock; but not sufficiently good to insure the regular dropping of a time-signal at the Start, if wires should be continued from any part of the Devonport telegraph-wire to the Start.

The distance, however, from Devonport to the Start, is so much less, that it may be expected that no difficulty will be experienced in dropping a time-signal at the Start by the agency of a galvanic battery and automatic clock at Devonport.

The first section then of the proposed operations must consist in such arrangements as will secure the accuracy of a clock at Devonport, and the second section must

consist in such arrangements as will secure the accuracy, (by automatic action of that clock), of the signal-drop at the Start, and will also secure a register at Devonport (by automatic action of the Start mechanism) of the actual success of the signal-drop, in a form which will admit of convenient transmission to the Royal Observatory of Greenwich.

For the first section, three arrangements are to be made. (1.) About the time of each of the proposed communications from Greenwich to Devonport or from Devonport to Greenwich (in all, three times or four times every day), for a few minutes at each time, an automatic clock at Greenwich must interrupt the Greenwich loop, and must connect the Greenwich Motor Clock with the Deptford wire to the Admiralty; and an automatic clock at the Admiralty must interrupt the communications of that Deptford wire with its speaking-instrument, and of one Devonport wire with its speaking-instrument, and must connect the Deptford wire with the Devonport wire. (2). At the times arranged for signals from Greenwich to Devonport, the Motor Clock at Greenwich must for an instant automatically take its wire from earth and connect it with a galvanic battery. (3). At the times arranged for signals from Devonport to Greenwich, the Devonport Clock must for an instant automatically take its wire from earth and connect it with a battery. All these arrangements are very easy, and their action is practically infallible.

The Devonport Clock would probably require a small mechanical correction every day (to remove the error, arising from unsteadiness of rate; which error the attendant would ascertain by observation of the Greenwich signals.) This is best done, as at Greenwich, by fixing on the pendulum a magnet, of which one pole swings above a galvanic coil; a galvanic current, sent at pleasure through the coil, produces attraction or repulsion, according to the nature of the current sent; and the clock is accelerated or retarded. The current must be kept in action till the clock-error is perfectly corrected.

In this manner, it was presumed, accuracy would be insured in the state of the Devonport clock sensibly equal to that of the Greenwich Motor Clock; and thus Devonport might be adopted as basis for the operations by which the Start time-signal would be actually dropped.

For the second section, the arrangements would be the same as those between Greenwich and Deal. There must be a clock at the Start, by which the resident at the Start would be guided in order to raise the Start signal at the proper time before each hour; there must be a relay and a local battery; the Devonport clock, by mechanism similar to that of the Greenwich Motor Clock, must automatically send a current accurately at every hour, which will work the relay and put the local battery

in connexion; and the action of the local battery must withdraw the detent on which the time-signal is lodged, and thus drop the signal; and the signal, shortly before reaching its lowest point, must (by what is called a "tapper-apparatus") so change the connexions of the battery that an instantaneous current will be sent to Devonport. These arrangements are found, in practice, to work without failure.

It was proposed that the time-signal at the Start should be a skeleton-ball about 8 feet in diameter, dropped through a space of 12 or 16 feet. The locality selected for it is a rock behind the Start lighthouse, called "The Boy." The height of the mast on which it should be raised would be determined after inspection from the sea; but no great height would in any case be necessary. It was proposed to commence with day-signals only; but night-signals would be given by a mere change of galvanic communications at the Start, which would enable the galvanic current to drop a small weight, whose fall would fire a quantity of gunpowder sufficient to produce a flash visible at the distance of several miles.

For the Devonport record of the currents sent by the action of the tapper-apparatus at the Start, the following mechanism was proposed. The Devonport clock was to give rotation to a small barrel, perhaps 3 inches long and 3 inches in diameter, covered with paper. This barrel was to revolve in a time differing from 1^h by a small quantity, say by $\frac{1}{900}$ part, which would easily be given by the 60-minute spindle of the clock, carrying a wheel of 30 teeth acting in one of 29 teeth, the latter wheel being fixed to one of 30 teeth acting in the barrel-wheel of 31 teeth. The Devonport clock also was to give slow motion by a screw to the frame carrying an indicator which would be made to travel nearly from one end of the barrel to the other in 24 hours. That indicator would be made to impress a point on the barrel by the instantaneous current from the tapper-apparatus. It will be seen that the 24 signals given in the course of one day, if at perfectly uniform intervals, describe on the barrel a spiral very little inclined to the axis. Any departure from uniformity to the extent of 3 seconds of time would immediately be visible to the eye; and this would be sufficient to give evidence on the correctness of management of the ball. At the end of 24 hours exactly, the barrel would have performed $24 + \frac{24}{900}$ revolutions. In preparation for the commencement of a second day, the attendant must draw back the travelling indicator-frame to the beginning of the screw, and then the indicator would in the course of the second day describe another spiral at the distance $\frac{24}{900} \times$ circumference of barrel from the former. This retraction of the indicator-frame is the only daily operation, referring to the register, which is required from the attendant. At the end of each month, the barrel must be removed and replaced by another; the paper covering is then to be taken off and sent to the Astronomer Royal. For the indicator I proposed to use a mechanism (suggested to me by Professor Wheatstone) in which the bottom of a small cistern of

ink is perforated with a single hole too small to permit the escape of the fluid ink; the action of the galvanic current thrusts a small wire through this hole, and the end of the wire carries a small film of ink which impresses a dot upon the barrel-paper.

In selecting a course for the telegraph-wires from Devonport to the Start, it was proposed, under the advice of the best Telegraph-Engineers, not to take the shortest line (which would be, to return towards London as far as the Kingsbridge Road Station, and then to pass by an inland road directly towards Kingsbridge, and the Start Point), but to make use of existing poles to Newtown Junction, Torquay, and Dartmouth, from which place the extent of telegraph line upon new poles would be small.

The following collateral advantages would attend the establishment of this system of signals. Accurate time-currents would be given at Devonport, which could be made subservient to the public exhibition of time-signals, either at Mount Wise, or on the Devonport Column. A commencement would be made of coast-telegraph, available for military purposes. Facilities would be given for a commercial telegraph from the Start Point to Dartmouth, much desired by persons connected with the mercantile marine.

G. B. AIRY.

1864, *May* 23.