Report to Francis Ronalds, *Esq., on the Performance of his three Magnetographs during the Experimental Trial at the Kew Observatory, April* 1 *till October* 1, 1851. *By* John Welsh, Esq.

In making a preliminary report on the performance of the three Magnetographs during the experimental trial of them which has just expired, I shall confine myself to a statement of—1st, the methods adopted for adjustment of the several instruments; 2nd, the means of preserving a record, numerical and graphical, of the photographic registers; and 3rd, the general capabilities of the instruments of affording data for magnetical investigation. The instruments having been already minutely described in your various reports on the Observatory, it is unnecessary to make any reference to their mechanical construction.

I. Adjustments, &c.

Declination Magnetograph.—This instrument was put into adjustment on March 27–29. The suspending thread, of untwisted silk, was examined throughout its whole extent, and found to have retained its original condition. The magnet having been removed, a brass bar of the same weight was inserted in its place, and the amount of torsion existing in the thread examined. This amounted to only 10° and was eliminated.

The value in arc corresponding to a given ordinate on the registering plate depends upon,—first, the distance from the centre of motion of the magnet and its appendages to the slit in the moveable shield; and second, the number of times by which the image of a certain motion of the slit is magnified when represented upon the registering plate. The first of these is obtained by direct measurement with a beam compass; for the determination of the second, the following contrivance was resorted to:—A scale divided on plane glass to $\frac{1}{30}$th of an inch was placed in such a position that the lines of the graduation were at the same distance from the lens as the slit in the moveable shield when the magnet is in full adjustment. A scale of the same value divided on ground glass was placed in the sliding plate-frame, and upon it the magnified image of the first scale was received at the proper focus. Both the scales were in this way visible on the same surface: the one magnified, and the other of the natural size. It was then easy to observe the value of the one in terms of the other; the number of divisions of the *real* scale corresponding to one division of the *apparent* scale representing the magnifying power of the lens. If a be the required arc value corresponding to an ordinate d on the plate, r the distance of the slit from the centre of motion of the magnet, and m the magnifying power of the lens, we have $a=\tan^{-1}\frac{d}{m.r}$, or when the angular motions are small, $a=\text{arc}^{-1}\frac{d}{m.r}$ very nearly. The value of r was found by measurement to be 18·0 inches; and that of m, by the process above-described, 6·706; whence we have the arc-value of an ordinate of one inch$=28'{\cdot}48$.

By turning the arms of the torsion-circle through different angles, it was found that a twist of 90° in the thread deflected the magnet through 44′; whence the value of the torsion coefficient $\left(1+\frac{\mathrm{H}}{\mathrm{F}}\right)=1{\cdot}008$.

This torsion effect being taken into account, the arc-value of one inch $=28'{\cdot}71$. The scale employed in the process of tabulation being divided to $\frac{1}{50}$th of an inch, the factor for converting the recorded numbers into minutes of arc is $0'{\cdot}574$.

The same observations which determine the magnifying power of the lens, afford also a means of estimating the amount of its spherical aberration. For this purpose we have merely to examine whether the value of the *apparent* scale in terms of the *real* scale remains constant at different portions of the field. Observations of this kind having been made for all the instruments, there is no reason to believe that, within the adopted range of motion, any irregularity of scale exists. The scale divided on ground glass, which is fixed permanently in each of the sliding plate-frames, supplies a means of observing the positions of the magnets when the photographic registration is not in action, and has been found of essential service in the preliminary adjustments of the instruments. The scales are of the same value as that employed in tabulating the numerical results: the zero division of the scale can also be adjusted to correspond with the edge of the spot of light which gives the zero-line on the plate; observations taken in this way are therefore at once comparable with the photographic measurements.

The length of time during which the light is allowed to act upon the plate when the instrument is in action, is found by measuring the width of the diaphragm at the image end of the camera; or more accurately by measuring the length of the impression produced by the light from the moveable slit when the plate is at rest. This was found to correspond to about $6\frac{1}{4}$ minutes.

The series of registrations by this instrument has been on several occasions interrupted by derangements in the adjustments: these have been shown in alterations of the relative positions of the fixed and moveable shields. The moveable shield ought always to overlap, by a small quantity, the fixed one, so as to stop all light except such as passes through the slits. It has several times occurred that the shields have become so far separated as to allow the light to spread across the plate and thus to prevent the appearance of the curves. At other times the contrary has happened, the moveable shield so much overlapping the fixed one as to obliterate the light from the slit which produces the zero-line, the curve line being however still recorded. On one occasion, about the end of July, it was found that the fixed shield had become too high relatively to the image-diaphragm. For some days previous to this being discovered, the registers were very faint, owing to the great loss of light arising from this cause. These errors were always removed by opening up the instrument and readjusting the parts deranged—an operation which always renders doubtful the connexion between the observations before and after the adjustments. The derangements now stated have been ascribed to alterations in the condition of the wooden supports of the instrument, arising from changes of temperature or humidity. They may also be partly owing to the expansion and contraction of the very long suspending string.

Horizontal-Force Magnetograph.—The value in arc of the ordinates for this instrument was found in the manner already described for the declination. The radius of the moveable shield $=9{\cdot}08$ inches, and the magnifying power of the lens $=3{\cdot}46$; whence the arc-value of $\frac{1}{30}$th of an inch$=2'{\cdot}188$. The arc-value was also determined on September 20th, 1850, by a different process, as follows. The magnet having been removed, an equal weight was suspended from the stirrup. There being then no magnetic directive force, and the torsion-force of the bifilar suspension being considerable, when the arms of the torsion-circle are turned through any angle, the arm carrying the shield should move through the same angle. The image of the slit being observed upon a divided scale placed at the focus, its motions corresponding to certain changes of the circle reading were observed. From the mean of several observations it was found that the ordinate of $\frac{1}{30}$th of an inch $=2'\cdot192$, agreeing very closely with the value obtained by the other method. The optical value for $\frac{1}{30}$th of an inch$=2'\cdot19$.

The value of the angle of torsion of the suspending wires was determined by a method quite similar to that described in the 'Report of the Committee of the Royal Society.' The arm carrying the moveable shield has a motion in azimuth similar to that of the collimator in Dr. Lloyd's form of the bifilar magnetometer; the position of the image of the slit, with reference to the divisions of the ground-glass scale, serving all the purposes of the telescope and scale. The angle of torsion in the present adjustment was found to be $64° 45'$. By the usual formula, we find the value, in parts of the whole horizontal force, of an ordinate of $\frac{1}{30}$th of an inch$=0\cdot000300$.

The effect of temperature upon the magnetic moment of the bar was examined in December 1850 by the usual method of deflections. The results were—At temperature $55°\cdot3$, the effect of one degree$=0\cdot000312$; and at temperature $76°\cdot7$, the effect of one degree$=0\cdot000344$.

The temperature of the magnet is obtained by a thermometer whose bulb is within the box. Observations of the thermometer were taken generally every three hours, rather more frequently during the day, and not so often at night. They were taken usually by myself during the day and until midnight; whilst Mr. Nicklin, whom I had instructed so as to observe the thermometer with accuracy, took them at early morning or during my occasional absence.

The effect of the illuminating lamp in heating the air within the magnet box has been found to be rather considerable. At the commencement of the series, when no precautions had been adopted to prevent this effect, the thermometer showed that the air was heated about 4 or 5 degrees above what it would have been had the lamp been away; wooden screens were afterwards interposed for the purpose of preventing radiation from the lamp, but the effect was still about 2 or 2¼ degrees.

The effect of the new copper damper in checking mechanical oscillation was found to be very striking, a large arc of vibration being reduced to nothing in four or five swings.

The length of time during which the light of the registering image acts upon the plate is about 1¾ minute.

Vertical-Force Magnetograph.—The agate planes, upon which the knife-edges of the magnet rest, were made horizontal by means of a level supplied for the purpose by Mr. Barrow, and the instrument brought into approximate adjustment. The distance from the centre of motion (the knife-edge) to that portion of the slit in the moveable shield which produces the image on the plate, was thus obtained:—a brass rod carrying a shield, with a slit similar to that attached to the magnet, was made to rest, in an upright position, upon the agate planes, by means of a cross piece having a flat base which occupied the same position as the knife-edge of the magnet when in adjustment. The image of a portion of the slit is formed upon the focus glass: a fine point was then moved slowly along the slit by one person until another observed the image of the slit bisected by that of the point. A mark was there made on the shield. The distance of this point from the base is equal to the distance from the centre of motion to the effective portion of the slit in the moveable shield, and may readily be determined by a scale and square. It was found to be 11·93 inches. The magnifying power of the lens was found by the method already described to be 3·78. From these quantities we have the value in arc corresponding to an ordinate of $\frac{1}{30}$th of an inch$=1'\cdot525$.

The coefficient, for converting the angular motions of the magnet into variations of the whole vertical force, has been obtained by the usual method of vibration in the horizontal and vertical planes. The magnet, with its appendages, having been first brought into approximate adjustment, was removed and slung horizontally by a slight loop of thread attached to a silk suspension. It was defended from currents of air by being enclosed in a cylindrical box with lids, the thread being alone exposed. A microscope with cross wires was fixed to one side of this box, and so adjusted that a mark on the shield carried by the magnet was visible. A vibration of about 2° was given to the magnet, and the times of transit of the mark across the wire noted by a chronometer. On March 31st the time of one oscillation was found to be 17·90 seconds, the temperature being 52°. The time of vibration in the vertical plane was observed by watching the motion of the image on the ground-glass scale, the initial arc being generally nearly 2°.

Owing to the arrangement of the stone pier upon which the apparatus rests, and the position of the window from which light was obtained, the magnet could not be conveniently mounted either in the magnetic meridian or at right angles to it. It was in fact mounted at right angles to the astronomical meridian, the north end being directed to about 67° west of the magnetic north. The mode of adjusting the horizontality of the magnet was the same as in Dr. Lloyd's original balance-magnets, namely, a screw attached near the south end working horizontally.

The adjustment for the height of the centre of gravity was effected at first by altering the position of the weight which counterpoises the vertical arm carrying the moveable shield. After August 8th this adjustment was made by a screw working vertically in the same frame as the horizontal adjusting screw, the former method having been found very inconvenient.

In the beginning of August, the instrument, having been for some weeks performing very indifferently, was returned to Mr. Barrow for alteration. He stated that the knife-edges had become much deteriorated and even somewhat rusted; they were therefore re-ground: he was desired at the same time to alter the mode of adjusting for the position of the centre of gravity. The counterpoise weight below was permanently fixed; and a screw working vertically attached to the south end, an equal weight being added at the north end. On the magnet being returned it was again vibrated horizontally; and the time of one oscillation found to be 18·52 seconds, the temperature being 72°.

The temperature correction for this magnet was determined at the same time as that for the horizontal force. The results were—At temperature 50°·4, the effect of one degree=0·000283; at temperature 71°·5, the effect of one degree=0·000319.

The thermometer for this instrument was observed at the same time as that of the horizontal force. The effect of the lamp in heating the air in the magnet box was very trifling.

Several circumstances have tended to prevent the satisfactory performance of this instrument. When it was first put into action, the marble slab which carries the magnet and its supports was *suspended* from the upper slab, upon which were placed the camera, the lens, and the clock apparatus. This upper slab again was merely *laid* upon the corbel supports, and not fastened down to them. It was almost constantly noticed, during the month of April, that the photographic trace exhibited sudden breaks or dislocations in the curve, accompanied by oscillation of the magnet. These breaks could nearly always be referred to periods when something was done in connexion with the instrument, especially about sunset and sunrise, when the lamp was placed or removed; and also at noon and midnight, when the registering plates were changed or reversed. It having been noticed on one or two occasions with certainty, that a disturbance of the magnet occurred at the times of changing the plates, it was conjectured that these anomalous motions might be due to concussions generated in the apparatus by the necessary manipulations, and that those at sunset and sunrise might arise from a similar cause. In the end of April the instrument was fixed more securely to its supports. The four brass columns which connected the lower slab to the upper were removed, and the slab cemented to an additional massive corbel: the upper slab was at the same time cemented to its supporting corbels. Care was taken to preserve as nearly as possible the previous relative positions of the different parts. The effect of this change was at once to remove the disturbances which had occurred about noon and midnight; those at the placing and removal of the lamp, however, still remained. Whilst making a more careful trial, as to whether there was any magnetic action connected with the lamp, the real cause of this particular class of disturbance occurred to me; and in a few minutes it was traced to the different positions of the iron bars of the window-shutters, when these were closed or opened. It had, in fact, been remarked previously, that the disturbances at sunrise and sunset occurred always in opposite directions. This source of error having been discovered, it was remedied by the immediate removal of all the shutter-bars to the basement story. These anomalous dislocations in the curves were after this time scarcely ever experienced.

Other errors have exhibited themselves, the causes of which we have not yet discovered; one of these is,—a tendency of the magnet to change its mean position from day to day, and always in one direction, showing an apparent gradual diminution of the vertical force. This change has generally been to an extent which quite precludes the idea of its being due, either to a real magnetic change, or to a loss of magnetism in the needle. That the latter is not the cause, we have only to refer to the two observations of the time of oscillation in the horizontal plane given above: from these we see that, considering the higher temperature at the time of the second observation, and the fact that an additional weight had in the interim been put on the magnet, the loss of magnetism has been trifling.

Another, and perhaps a more serious error is the inconstancy of the height of the centre of gravity, as shown by variation of the time of vibration in a vertical plane. In nearly every case of adjustment during the six months, it has been found that, after some days, the time of one vibration has diminished to a very large extent. The following are a few of the cases in which this has been shown:—

April 1.	At adjustment, the time of vibration was			20 secs.
... 29.	28 days after,	...	...	11 ...
May 5.	At adjustment,	...	...	25 ...
June 4.	30 days after,	...	...	13 ...
... 5.	At adjustment,	...	...	25 ...
... 20.	15 days after,	...	...	17 ...
... 26.	At adjustment,	...	...	23½ ...
July 11.	15 days after,	...	...	11 ...

Again, the knife-edges having been in the interim re-ground:—

Aug. 14.	At adjustment, the time of vibration was			23·1 secs.
... 25.	11 days after,	...	...	22·4 ...
Sept. 9.	26 days after,	...	...	16·2 ...

Very remarkable changes of this nature have been previously observed in balance-magnets, but in no case that I am aware of, has the variation been to such an extent as is shown above. Observations have been taken of the time of vibration for different inclinations of the magnet, with the view of ascertaining whether this diminution could be owing to variations in the bearing-points of the knife-edges. These differences have in some cases been considerable, but not nearly so great as to account for such excessive changes. I cannot venture as yet to give any opinion as to the probable cause. With the occasionally excellent performance of the magnet (as shown, for example, in the magnetic disturbance of Sept. 3–4) before us, it is difficult to conceive that it can be wholly due to imperfection of the knife-edges *.

II. Tabulation of Numerical Results, &c.

In preserving a numerical record of the changes as shown by the magnetographs, the objects kept in view have been,—1st, to obtain data for deducing mean results, such as the diurnal changes, daily and monthly means, &c.; 2nd, to record all the changes which can be said to come under the class of disturbances; and 3rd, generally, to possess in a numerical form, as far as is practicable, the means of producing the complete curves, either as originally recorded photographically, or in the true form of declination, inclination, and total magnetic force.

The positions of all the magnets have been measured for every hour of Greenwich time during which we have had records; in almost all cases the position for each half-hour has also been noted. Whenever the fluctuation has been at all marked, the turning-points of the fluctuation with the corresponding epochs have been measured; very few motions exceeding two scale divisions will be found omitted. Attention has been paid, as far as possible, to have simultaneous measurements of all the instruments, but especially of the two components of force. Both edges of the photographic trace have always been measured, and the mean of the two entered; by this means the effects of mechanical oscillation and of variable breadth of the trace from whatever cause, are eliminated. The number of measurements for each instrument during twenty-four hours has of course varied very much; it may be said, however, that the lowest number is 48, whilst in some cases of great disturbance as many as 150 measurements have been taken; the average is probably somewhat more than 60. Any unusual appearance in the curves, such as small and rapid fluctuation with little change of mean position, has been mentioned. The attempt has been made throughout to leave no phænomenon of any consequence unrepresented.

In taking these measurements, the edge of the scale is brought very near to the surface of the plate, in order, as much as possible, to prevent error from parallax; a compound magnifying lens with a flat field being used in reading off. From my own experience, supported by the opinions of several gentlemen accustomed to observation, I estimate the accuracy with which the better defined traces can be measured at about $\frac{1}{500}$th of an inch, or one-tenth of a division of the measuring scale. In the case of the declination, the trace not being so distinct, probably $\frac{1}{250}$th of an inch should be considered as the extent of accuracy. These estimates give for the probable error of a measurement of the declination about 0′·1, and for the horizontal force about 0·00003 of the whole force. The adjustments of the vertical force in-

* Shortly after the date of this report it was discovered that a spot of rust had formed upon one of the knife-edges: this had not been perceived when the magnet was examined about the beginning of October; although it may have been already in operation, but to so small an extent as to be imperceptible to the eye. It seems highly probable that a considerable share of the irregularities complained of may be ascribed to this cause.

strument having been so variable, no constant estimate can be given for it; in an average adjustment, however, it is believed that the probable error of a measurement will not exceed 0·000015 of the whole vertical force.

Failures in the registration have been mentioned whenever they have occurred, and a note taken of the cause when such is known. On examination of these records, I find that, in the case of the declination, there are about seventy-five hours in the six months during which no registrations have been obtained, owing to insufficiency of the photographic process; in the horizontal force there are about fifty hours. No failures whatever have taken place in the photographic process during the last ten weeks of the trial. Failures have occasionally occurred from causes purely accidental, such as omitting to wind the clocks, not properly adjusting the sliding plate-frames, forgetting to open the valve of the declination lamp, and such like. These, however, must be considered rather as personal than instrumental errors.

All the photographic registrations have been copied upon gelatine tracing-paper. I am not yet prepared to give any estimate as to the accuracy with which these copies are made.

III. General Remarks on the Capabilities of the Instruments.

In forming an opinion as to the powers of the instruments, it is necessary to take into consideration the circumstances connected with their construction. The declination magnetograph was the first instrument constructed according to your design, and consequently cannot be expected to equal in accuracy or convenience those afterwards made. From the essential portions of its structure being altogether of wood, it would be too much to expect from it a long-continued series of trustworthy records, where steadiness and permanency of adjustment are so necessary. The large dimensions of the magnet and its appendages would, on any system of observation, present great difficulties whenever the more rapid magnetic changes occur. A considerable loss of light is sustained by the position of the instrument requiring the daylight to be reflected, and the photographic difficulties are accordingly increased. The want of a copper damper sufficiently powerful to eliminate the mechanical oscillation of the magnet, by permitting an almost continuous minute vibration, tends to diminish the sharpness of outline in the trace. It has accordingly been found that, owing to changes taking place in the framework of the apparatus, a series of more than a few weeks cannot be obtained without some slight adjustments of the instrument. When the magnetic changes become very rapid and extensive, it fails to afford all the information which is desirable. Instances of failure in this respect will be found in some of the larger disturbances which have occurred during the trial, as, for example, in those of the 3rd and 29th of September, when, from the excessive abruptness of the magnetic motions, and the want of delicacy in what may be styled the registering-pencil, the interpretation of the photographic records becomes very difficult and uncertain. Notwithstanding the defects which I have alluded to, it is, however, certain that the instrument is capable of affording a large amount of information. It exhibits with much exactness all the common fluctuations; and there can be no doubt that very trustworthy results, as to the mean diurnal movements, could be obtained from it. Even disturbances of considerable amount, especially those which, although of large extent, are not of an abrupt character, are recorded with as much accuracy as seems to be desirable. In short, the instrument, even in its present state, is capable of providing a very great porportion of the data required for magnetical investigation.

In the horizontal-force magnetograph, the defects of construction in the declination have been in a great degree remedied. All the essential parts of the apparatus being of metal or stone, the permanency of the adjustments is secured. The light being admitted directly to the instrument, and the optical power not being so great, the photographic means are increased. The dimensions of the magnet and its appendages being much smaller, the mechanical inertia is diminished; and by the use of a very powerful copper damper, the inconvenience arising from vibration is almost wholly got rid of. The results of these improvements are such as might be expected. It has been found that a long series of registrations can be obtained without the occurrence of a single case of mechanical derangement requiring re-adjustment of any portion of the apparatus. The instrument has been found capable of recording, in a perfectly distinct manner, almost all the magnetic changes which occur, and with a delicacy of scale quite sufficient to represent even the most minute movement. In only one instance during the six months has it been unable to overtake the most rapid motions. In the disturbance of September 29, it certainly has been found deficient in power to represent with distinctness those very violent and extensive changes which occasionally do occur. This deficiency seems to have arisen—1st, from the length of time during which the plate is exposed to the action of the light being sufficient for more than one motion to take place; and 2nd, from the mechanical inertia being still so great, as in some instances to carry the magnet farther in the direction of a sudden magnetic change than is strictly due to such change. These defects seem to point to the desirability of further improvements in the same direction as those already made, namely, greater photographic power and less mechanical inertia. It should be remarked also, that in the larger disturbances the extent of scale adopted for all the instruments has been insufficient to contain the extreme excursions.

The performance of the vertical force instrument has unfortunately been so little satisfactory, from causes apparently unconnected with the means necessary to adapt it to photographic registration, that it is impossible to come to a distinct conclusion as to its value. Its performance for some time after being repaired by the maker was, however, so good, and its power of exhibiting such great and sudden motions as occurred during the disturbance of September 3–4 so considerable, as to hold out the expectation that, whenever the source of the errors already noticed shall have been discovered, it may be found to be a really efficient and trustworthy instrument.

JOHN WELSH.

Kew Observatory, October 23, 1851.

Report concerning the Observatory of the British Association at Kew, from August 1, 1850 *to July* 1, 1851. *By* FRANCIS RONALDS, *Esq., F.R.S., Honorary Superintendent.*

IT is hoped that this eighth annual summary relative to the status and proceedings of the Kew Observatory will evince our sincere desire to promote the liberal views of the British Association, and that our diligence has been commensurate with the augmented funds which have been kindly granted by Her Majesty's Government and the Royal Society, and with the increased interest which gentlemen of the highest scientific acquirements and reputation, both at home and abroad, have manifested in the success of the Establishment.

The principal means which I have employed in its composition have been references to my former Reports of a like kind; examinations of the various instruments, &c. spoken of; descriptions, &c. from my own portfolios; the Electro-meteorological Journal; the tabulations and tracings of the magnetic curves, &c., and the Kew Diary.

The materials which I have used for supplying some omissions in our Diary have been three manuscripts concerning the Meteorological Journal, the Barometrograph, and the Hygrometers, drawn up by Mr. Welsh (our observer). In making use of the Diary and all other documents, endeavours have constantly been made to record shortly only such facts as may be, or may become useful, and to do this in the words themselves of those documents whenever a due regard to brevity permitted.

The subjects are arranged under four heads:—1st, those which relate to the Building, Instruments, &c.; 2ndly, those referable to the Observations; 3rdly, experimental (and analogous) subjects; and lastly, those which do not properly belong to any of the former.

I. THE BUILDING, INSTRUMENTS, &c.

*The edifice** has undergone no change of importance this year. The annexation of three new corbels to the wall of the great mural quadrant, for the support of a new Vertical-force Magnetograph, is probably a temporary expedient. The custody of a large quantity of apparatus, consigned to our care by the Royal Society, and of which a portion is highly valued, from the circumstances of its having been invented, or made, or even possessed by such men as Boyle, Huygens, Newton, Cook, Cavendish, Coulomb, Le Roy, Sabine, Kater, &c., renders a little reparation (of damage by dry rot) and painting very desirable (a long time has elapsed since any interior painting has been done); and it has frequently been thought advisable that the wall of the great quadrant, which instrument has long since been dismantled, and will never be again employed, should be converted into piers, pedestals, &c. for the support of experimental instruments requiring scrupulous regard to immutability of position and exemption from extraneous vibration†.

In speaking of the Instruments, I refer principally to those which have been more or less used in this year.

Electrical Apparatus.

The Principal Conductor, &c. on, and in, the Dome, and all the electrical apparatus which has been employed for the observations of atmospheric electricity, are in working order. The *Rod*, *Lantern*, &c., the *Volta-Electrometers*, *Henley-Electrometer*, *Discharger* and *Distinguisher*, retain the forms described at p. 123 (*et seq.*) of the Report for 1844. The *Observer's Clock and its scale* remain as described at p. 178 of the Report for 1850.

The Galvanometer of M. Goujon gives strong indications when connected with the conductor, in times of violent rain, &c., but is not to be depended upon as to measures.

* Described at p. 120, Report for 1844.

† Two of the magnetographs, although solidly, are inconveniently placed. The photo-barometrograph requires a much better foundation than boards and joists can afford (as will be seen); and for the due prosecution of projected observations of standard and other barometers, pendulums, &c., extremely solid bases cannot (obviously) be dispensed with.