XVI. *On the Magnetism of Iron arising from its rotation. By* Samuel Hunter Christie, *Esq. M. A. of Trinity College, Cambridge; Fellow of the Cambridge Philosophical Society; of the Royal Military Academy. Communicated April* 20, 1825, *by* J. F. W. Herschel, *Esq. Sec. R. S.*

Read May 12, 1825.

As the principles on which phænomena depend can only be discovered by a careful investigation of the circumstances attending every new fact which presents itself, its importance must not, in the first instance, be estimated by the magnitude of the effects produced, but by their peculiarity. However minute may be the effects, an inquiry into the laws which govern them, if unattended by any other, will have this advantage, that these laws will serve as an additional test of the correctness of the principles advanced for the explanation of the more striking phænomena, firmly establishing their truth, if the consequences of those principles, or being incompatible with them, pointing out their fallacy. Thus the severest test that the principle of gravitation has been subjected to, is the explanation of the minute irregularities in the planetary motions; and the coincidence of the observed irregularities with those deduced from the application of this principle would have established its truth beyond dispute, had any doubt previously remained. In the experiments which I am about to detail, the effects produced are of this minute character; but as they point out a species of action not hitherto observed, they will not, I trust, be considered unimportant.

It has been stated that different effects will be produced on iron, as regards its polarity, when struck, twisted, filed, or scoured in different positions, with respect to the magnetic axis or line of the dip; but I am not aware that it has ever been suspected that the simple rotation of iron, in different directions, would have any effect on the manner in which the iron influenced a magnetic needle. This I have discovered to be the case; and that the laws which govern this peculiar action on the needle are so general and uniform, that I have no doubt their causes are as steady in their operation, as those to which the more striking phænomena of magnetism owe their origin. On observing these magnetical phænomena arising purely from rotation, it appeared to me that they might possibly indicate the cause of the earth's magnetism; and this was a further inducement to me thoroughly to investigate the circumstances connected with them. Before giving the particulars of these phænomena, it is necessary that I should mention how I was first led to observe them.

For some time previous I had been engaged in making several series of experiments, with a view to discover the precise manner in which unmagnetised iron acts upon a magnetic needle. For this purpose I had made use of an iron ball 13 inches in diameter, and likewise of a shell 18 inches in diameter, and observed their effects on the needle in various positions, as referred to certain planes passing through its centre. The shell and the needle were placed in the relative positions which I wished to give them, by determining a radius and an angle on an horizontal plane, and a vertical ordinate. The requisite computations being necessarily tedious, when I wished to pursue the subject further, I found them, from their number, so laborious, that I resolved, if possible, to supersede the necessity of them by the construction of an instrument, by which I could adjust the iron and the needle in their proper relative positions, without any previous computation. In this I succeeded; but as the iron was to be supported on an arm of brass, it became necessary to make use of a plate of iron instead of the heavy shell of nearly 500 lbs. weight; and in consequence of this, when I expected that I had overcome the principal difficulties, I found they had only commenced. It is well known that almost every mass of iron, but especially sheet iron, possesses polarity in a slight degree, and of a very variable nature in some parts of it, whatever care may have been taken in its manufacture; and I soon found, to my no small vexation, that the effects apparently produced by it in that which I made use of were so various, that they would for a long time baffle me in my investigations, if they did not ultimately frustrate all my attempts at drawing any conclusions from the experiments.

The instrument which I have mentioned is represented in Plate XXV. fig. 1. The principal part consists of two strong limbs of brass: one, SQN, a semicircle, 18 inches in diameter, 2.15 inches broad and .3 inch thick: the other consists of two semicircles joined together; SÆN, 1.2 inches broad and .22 thick, and its outer diameter 18 inches; *s æ n* .9 inch broad, .22 thick, and its inner diameter 9.2 inches. SÆN*n æ s* and SQN are attached to each other by strong brass pins passing from S to *s* and N to *n*; so that *s* Æ *n* will revolve about the axis S *s n* N, while S Q N is fixed. S Æ N and S Q N are graduated from Æ and Q towards S and N, as is likewise *s æ n* from *æ* towards *s* and *n*. The semicircle S Q N passes freely through an opening in the support G I, but may be clamped firmly in any position by means of two strong screws, working into the parts G, G′ from the back of the instrument. On the chamfered edge of the opening *g*, in the face of G G′, is an index showing the inclination of the axis S N to the horizon; and on the part K *k* at the foot of the pillar, and attached to it, is an index pointing out on the graduated circle L *l*, fixed on the table T *t*, the situation of the fixed limb S Q N with respect to the magnetic meridian. R *r* is another graduated circle, fixed to the moveable limb S Æ N; which, by the index at *x* on the fixed limb S Q N, shows the angle described by S Æ N from the plane of S Q N. A very strong brass pin, soldered to the foot of the pillar, passes through the table T *t* and a thick circle of wood, to which the legs are attached, and has below a clamping screw, to fix the whole firmly together in any position. The compass box N′ S′ is fitted on to a stand fixed to the support F *f*, which consists of two parts; *f* fitted to G, and F sliding on a tube attached to *f*; so that the compass may be elevated or depressed. An arm A B, to carry the circular plate of iron C *c*, is connected with the moveable limb S *æ* N. The part A *a* consists of two flat pieces, having the limb of the instrument between them, so that the arm may be moved into any position on it, and be fixed in that situation by means of a strong screw working into the face A *a*. On the cylindrical part B *b*, a short hollow cylinder slides freely, having a circular rim raised .6 inch from it, to support the iron plate

Cc at right angles to the axis of the cylinder. Over the plate of iron is a wooden washer D *d*, which is pressed on it by the screw *h* working on the short cylinder. The cylinder with the plate is fixed in any position on the arm by the clamp M *m*. In the part A*a* of the arm are two openings *o*, *o′*, on the chamfered edges of which are indexes in a line with the axis of the cylinder B *b*, so that when each points to the same arc on the semicircles S Æ N, *s æ n*, the axis of the cylinder B *b* is directed towards their centre, and every point in the edge of the plate is at the same distance from that centre. As the weight of the plate was a considerable strain on the instrument, a scale to contain a counter-weight, was suspended from the ceiling of the room, and the line from it passed through a moveable pulley, attached to the arm B *b*, so that the weight might easily be adjusted to relieve nearly altogether the strain of the plate on the arm in any position. The arm was also occasionally supported, and kept steady in its position, by a sliding rod resting on the table T *t*. The compass consists of a circular box, containing a circle 6 inches in diameter, very accurately divided into degrees, and again into thirds of a degree; and a very light needle, having an agate in its centre, and its point of suspension only .07 inch above the surface of the needle. The extremities of the needle are brought to very fine points; so that by a little practice, with the assistance of a convex lens, I could read off the deviations very correctly to two minutes, being the tenth of the divisions on the circle. To this compass I have another needle, which has a vernier at each end; but this being much larger and heavier, and consequently not so sensible, I greatly prefer the other for all delicate experiments. In the experiments which I had previously made, and in those which I proposed making with this apparatus, I conceived a sphere to be described about the centre of the needle, referring the situation of the iron to a plane, in which, according to the hypothesis I had adopted, it should equally affect the north and south ends of the needle. The line in which the needle would place itself, if freely suspended by its centre of gravity, I considered as the magnetic axis; the points where this axis cuts the sphere, the poles, the upper being the south, and the lower the north pole; and the great circle at right angles to the axis, the equator, being the plane above mentioned. The position of the iron was thus determined by its latitude and longitude; the longitude being always measured from the eastern intersection of the equator with the horizon. The angle which the axis makes with the horizon I considered to be, according to the most accurate observations, very nearly 70° 30′.*

As I shall have frequently to refer to different adjustments

* In 1818 Captains KATER and SABINE found the dip to be 70° 34 in the Regent's Park; and in 1819, in the same place, Captain SABINE found it to be 70° 33′.27. Since making the greater part of these experiments, I have had opportunities of observing the dip at this place. With a very good instrument, by T. JONES of Charing Cross, having a 7-inch needle, consisting of two circular arcs, on Captain KATER's construction, the mean of 40 observations, 10 with the face of the instrument east, 10 with the face west, and the same with the poles reversed, gave the dip 70° 15.25 on the 23d December, 1821, between the hours of 1 and 4 P.M. the observations being made in my garden. With another instrument, also by T. JONES, having an 8-inch rectangular needle, the mean of 40 observations made in my garden, (about a mile from the former place of observation) near noon on the 5th and 6th May, 1824, gave 70° 06.5 for the dip. With the same instrument, but using a needle on MEYER's construction, the mean of 40 observations near noon on the 8th May, 1824, gave the dip on the same spot 70° 10′.5.

of the instrument, I will here briefly notice their effects. The angle which the axis SN, fig. 1. makes with the horizon HO, being 70° 30′, if SQN is in the magnetic meridian, and the compass is adjusted, so as to have its centre in the centre of the instrument, SN will be the magnetic axis, and the centre of the plate, as there represented, would, by the rotation of the limb SÆN, describe a parallel of latitude, its longitude being indicated on the circle R*r*: and if the indexes at *o*, *o′* be brought to coincide with Æ, *æ*, the centre of the plate would then describe the equator. If the limb SQN be slided through GG′ until the index there coincide with 19° 30′, from Q towards S, and the indexes *o*, *o′* be made to coincide with Æ *æ*, as represented in Fig. 2, the centre of the plate, by the revolution of the limb, would describe a secondary both to the meridian and equator, and its latitude would be indicated on the circle R*r*. If the point Q, Fig. 1, or zero on the limb SQN, be brought to coincide with the index at *g*, and the instrument make a quarter of a revolution about GI, so that the index at K may point to 90°, the centre of the plate would describe the meridian when the indexes at *o*, *o′* coincide with Æ, *æ*; and the latitude would be determined from the degrees indicated on R*r*. This is represented Fig. 3, where the contrary side of the instrument to that seen in Fig. 1, 2, is placed in front, in order to show the situations of the screws, which clamp the arm AB and the limb SQN in their respective situations. Thus, by a proper adjustment of the indexes at K, *g*, *o*, *o′*, the centre of the plate may be made to describe any circle of the sphere.

After making a very few sets of experiments with this instrument, I found that it was necessary to attend very particularly to the situation of certain points on the iron plate with respect to the limb, since, with one point coinciding with it, the deviation of the needle, when the centre of the plate was on the meridian, would be easterly, and with another point coinciding, westerly; whereas had the iron possessed no partial magnetism, which was the case I wished to investigate, there would have been no deviation when its centre was on the meridian. My first object was to find what points on the plate must coincide with the limb, in order that the plate, when its centre was on the meridian, should cause no deviation in the needle; and it was in my attempts to effect this, which at first sight appears sufficiently easy, that I discovered the leading feature in all the phænomena which I am about to describe.

General description of the phænomena arising from the rotation of an iron plate.

In order to find the points which I have mentioned, I adjusted the instrument so that the plate of the fixed limb was exactly in the magnetic meridian, and then brought the other limb into the same plane: the centre of the plate was then on the magnetic meridian, and its plane perpendicular to that plane, as represented in Fig. 1. I now made the plate revolve in its own plane about the axis B *b*, and noted very carefully its effect on the needle. In doing this I found that if I placed the plate on the arm, so that a certain point, *c* for instance, coincided with the plane of the limb, the deviation was different when the same point, by the revolution of the plate, coincided with the limb again. As it appeared by this that the revolution of the plate had an effect

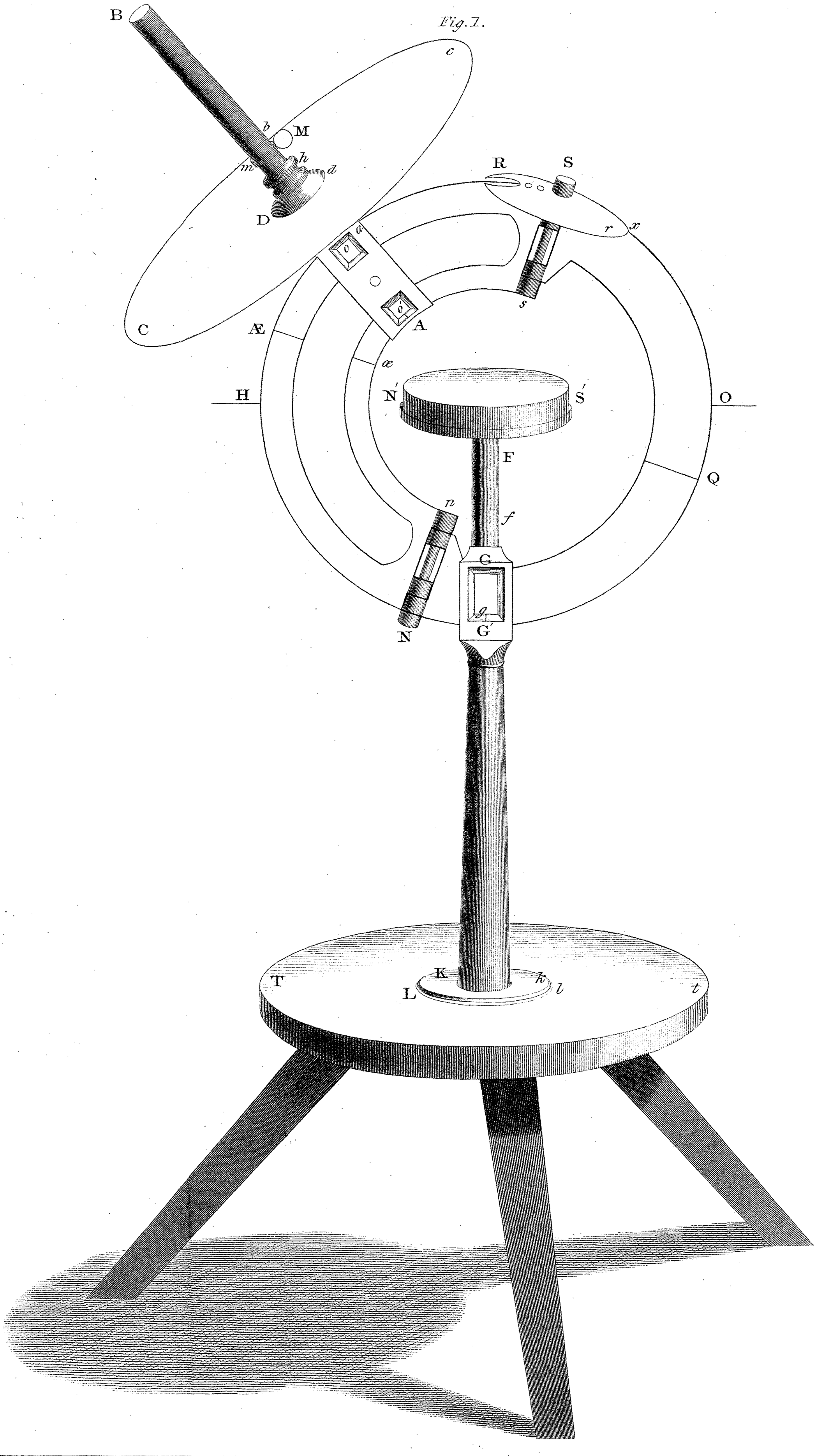

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Fig. 2.

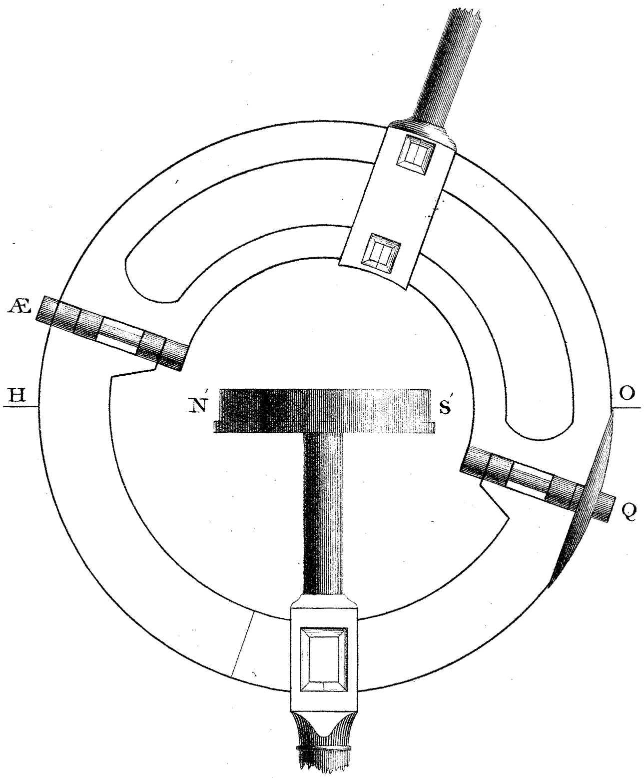


Fig. 3.

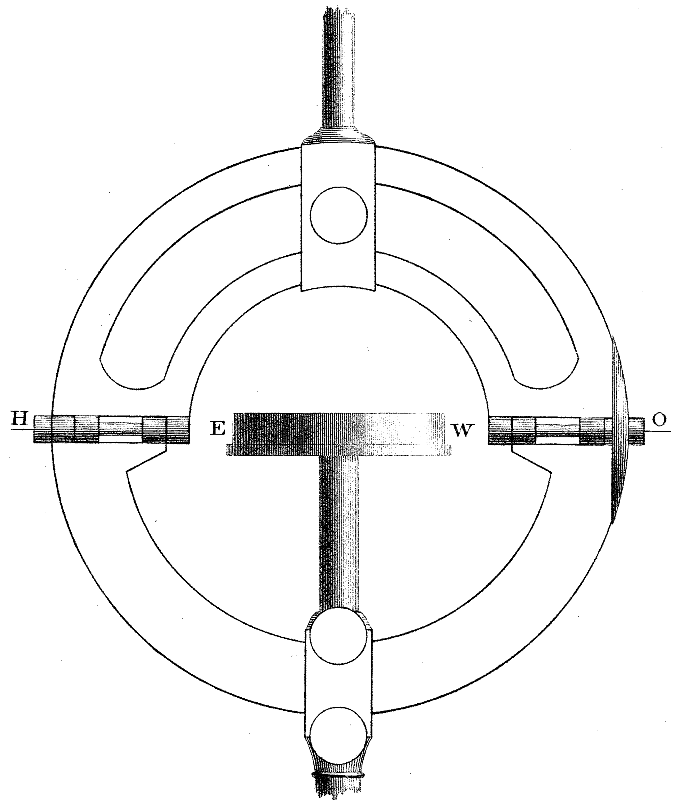


Fig. 4.

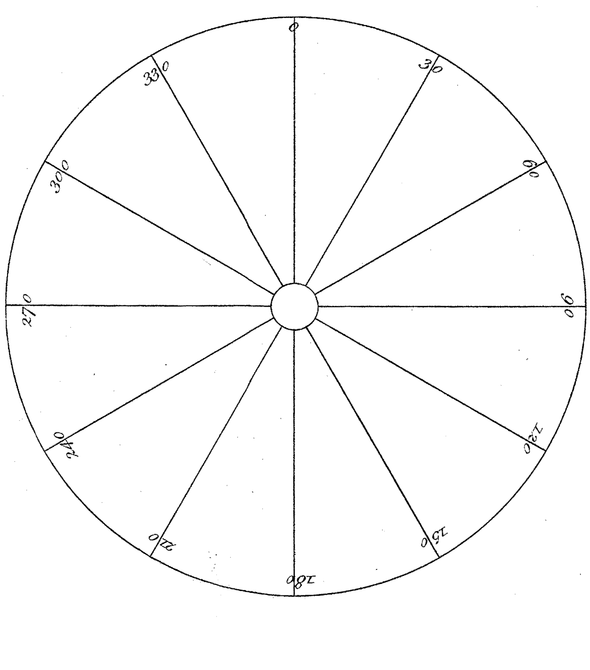


Fig. 5.

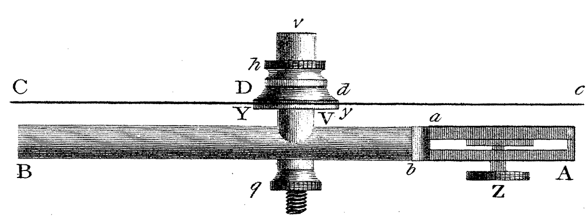
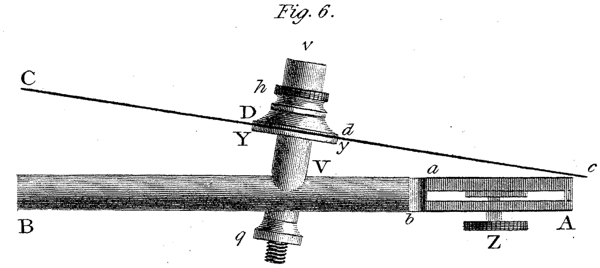


Fig. 6.



upon the needle, independent of the partial magnetism of particular points, I considered that if the plate were made to revolve the contrary way, the deviation ought to be on the opposite side, and this I found to be the case. I will illustrate this by the observations made when I first noticed the effect. The plate was divided at every 30° of its circumference (Fig. 4.) by lines drawn through the centre, and being placed on the arm, so that 0° coincided with the upper part of the limb, the north end of the needle pointed 10′ east; but when this point again coincided with the limb, by the upper edge of the plate revolving from *west* to *east*, the needle pointed 30′ east: making the plate revolve the contrary way, that is, its upper edge from *east* to *west*, when 0° coincided with the limb, the north end of the needle pointed 28′ west: so that there was a difference of 58′, when every point of the plate had the same position with respect to the needle, according as the plate was brought into that position by revolving from *west* to *east*, or from *east* to *west*. As this appeared extraordinary, I made repeated observations at the time, to ascertain that the effect was independent of any accidental circumstances, and found that the results always accorded with the first, the difference caused by the rotation of the plate being however greater or less according to the position of the plate.

Having fully satisfied myself that, in whatever manner the rotation of the plate might cause this difference, such was really the effect, I next endeavoured to ascertain the nature and degree of the difference, according to the different situations of the centre of the plate. For this purpose I made a great variety of experiments, of which I shall not however here give the details, as I afterwards repeated them in a more convenient manner, and with greater precision; but shall merely point out the nature of them in general, and the conclusions which I at the time drew from them. The instrument being adjusted, and the arm fixed so that the centre of the plate was in the position which I required, I made the plate revolve so that its upper edge moved from *west* to *east*, and noted the greatest and least deviation of the north end of the needle; I then made the corresponding observations when the plate revolved in the contrary direction: a mean of the differences between the two greatest and between the two least I considered as the effect produced on the needle by the rotation of the plate in opposite directions. Repeating these in a variety of positions, I found that when the centre of the plate was in the magnetic meridian, its plane being always a tangent to the sphere circumscribed about the centre of the needle, the deviation of the needle caused by the rotation of the plate in its plane was the greatest when the centre of the plate was in the equator, and that it decreased from there towards the poles, where it was nothing;* that when its centre was on the equator, this deviation was the greatest when the centre of the plate was on the meridian, or in longitude 90°, and decreased to nothing in the east and west points, or when the longitude of the plate was 0° or 180°; and that when the centre of the plate was in the

* I should here mention, that, from the nature of my instrument, I could not make observations at the *north* pole; but as the results, as far as I could observe, were of the same nature on this side of the equator as on the south side, I think I am warranted in concluding, that *at* the *north* pole the results would likewise be of the same nature as at the south pole.

secondary both to the equator and meridian, the rotation of the plate, whatever might be its latitude, caused no deviation of the needle. In these experiments, the plate which I made use of was a circular one 17.88 inches in diameter, and .099 inch in thickness, weighing 112 oz. The further I had pursued this inquiry, the more I was disposed to attribute the effects I have mentioned to a general magnetic action, arising in a peculiar manner from the *rotation* of the iron; and my next experiments were with the view of ascertaining how far this idea was correct. As similar results might not be obtained with any other plate, I next made use of a plate 12.13 inches in diameter and .075 inch in thickness, weighing 38.75 oz., and with it obtained results precisely of the same nature, though considerably less in quantity. Another objection which occurred to me was this—that the iron being evidently slightly polarised in particular points, the effect might be supposed to arise from an impulse given to the needle by the motion of these points in a particular direction, and that the directive power of the needle not immediately overcoming the slight friction on the pivot, a deviation might thus arise from the rotation of the plate. Had this, however, been the cause of the deviations, I should have expected that, when the centre of the plate was in the meridian, the greatest effect would be produced with the plate parallel to the horizon, and its centre vertical to that of the needle; but I had seen that the greatest deviation took place when the centre of the plate was in the equator, its plane being perpendicular to it; and the deviation arising from the *rotation*, when the plate was parallel to the horizon, was not a fifth of the deviation when the plate was perpendicular to that plane. Besides it was manifest that if this were the cause, any other impulse would have a similar effect. I therefore made the needle revolve first in one direction and then in that opposite, by means of a small bar magnet, and invariably found that it settled at the same point, in whichever direction the impulse was first given, and the results obtained by the rotation of the plate were in these cases of the same nature as before. It was also evident, that if the deviations I have mentioned arose from this circumstance, the needle being agitated after any particular point of the plate was brought to the limb of the instrument, it ought to settle in the same direction, whether that point were brought into this position by revolving from *east* to *west* or from *west* to *east;* but this, except in the cases I have mentioned, where the rotation produced no deviation, was not found to take place. In order wholly to obviate this objection, in all my future experiments, after any point had been brought to the limb of the instrument, I agitated the needle, and let it settle before I noted the deviation.

Description of particular experiments.

As I had found in my first experiments that I could obtain the nature of the deviation caused by the *rotation* by noting the greatest and least deviations when the plate was made to revolve in contrary directions, but that the quantity of that deviation could not by this means be determined with any degree of precision, I resolved to make my future observations differently. The method I adopted, when the change in the deviation from one point of the plate to another was considerable, was this: the plate being placed in any required position, I made it revolve once, for example, the upper edge from *east* to *west*, without noting the deviations, bringing the point marked 0° to coincide with the line indicating the position for observation; from hence I continued the revolution of the plate until the point marked 30° coincided with the same line, and, after slightly agitating the needle, noted the deviation; and in the same manner were the points 60°, 90°, 120°, 150°, 180°, 210°, 240°, 270°, 300°, 330°, 360° or 0° brought successively to coincide, and the deviations noted. I now made the plate revolve once from *west* to *east*, without noting the deviations, bringing 0° or 360° to coincide with the same line, and then brought in succession 330°, 300°, 270°, 240°, 210°, 180°, 150°, 120°, 90°, 60°, 30°, 0° to coincide, noting the deviations as before. The sum of the first set divided by 12, I considered as the mean deviation, when the plate revolved from *east* to *west;* and the sum of the others divided by 12, as the mean deviation, when the plate revolved from *west* to *east*: their difference was the mean effect of the *rotation* in contrary directions. This I call the *Deviation due to Rotation;* and to distinguish it from the deviation caused simply by the position of the iron, I call this last the *Absolute Deviation.* When the change in the deviation from one point of the plate to another was not so considerable, I made the observations only for the points 0°, 90°, 180°, 270° on the plate.

I now proceed to the detail of the experiments, and the conclusions I draw from them. In those which I shall first describe, the centre of the plate was always in the magnetic meridian; its plane was perpendicular to the meridian, and a tangent to the sphere, whose centre was the centre of the needle; and the plate revolved, as in all other cases, in its own plane: they are a repetition of those by which I first discovered several of the facts I have mentioned, but made for the purpose of determining more precisely the deviation caused by the rotation. In making these, the instrument was adjusted so that the index at *g*, fig. 1, pointed to 0°, that at K to 90°, and those at o, o′ to Zero; so that S N was horizontal and pointed east and west, as represented in fig. 3.

In the following table, the numbers in the first column indicate the points of the plate which coincided with the plane of the meridian nearest the south, or upper pole of the sphere, when the several directions of the north end of the needle in the same lines with them were observed; the latitudes and longitudes are those of the centre of the plate as referred to the centre of the needle, the longitudes being measured from *east through north;* the letters at the tops of the columns indicate the direction in which the edge of the plate, nearest the south pole of the sphere, moved; the mean deviation of the needle, when the plate revolved in this direction, is placed in the line below the other deviations; the direction in which the *deviation due to rotation* took place, in the following line; and the whole deviation, arising from making the plate revolve in opposite directions, below this: the deviations observed always refer to the north end of the needle. The distance of the centre of the plate from that of the needle was 9.75 inches; the diameter of the plate, 17.88 inches; thickness, .099 inch; weight, 112 oz.: so that its specific gravity appeared to be 7826. This plate I call No. I.

I. *Table of the deviations of a magnetic needle, caused by the rotation of a circular plate of iron, when its centre was in the magnetic meridian, and its plane a tangent to the sphere.* **Plate No. I.**

Points on the Plate.	Long. 90°. Lat. 0°.		Long. 90°. Lat. 19° 30′ S.		Long. 270°.* Lat. 19° 30′ S.		Long. 90°. Lat. 45° S.		Long. 270° Lat. 45° S.		Long. 90°.† Lat. 70° 30′ S.		Lat. 90° S.‡	
	E to W	W to E	E to W	W to E	W to E	E to W	E to W	W to E	W to E	E to W	E thro' S to W	W thro' S to E	S thro' S to W	W thro' S to E
0	0° 02′ E	1° 44′ E	0° 46′ W	0° 44′ E	0° 34′ E	1° 00′ W	0° 08′ E	0° 56′ E	0° 30′ W	1° 18′ W	0° 10′ E	0° 26′ E	0° 14′ E	0° 14′ E
90	2 10 W	0 34 W	2 06 W	0 32 W	1 34 E	0 04 E	1 54 W	1 04 W	1 12 E	0 22 E	1 22 W	1 06 W	1 08 W	1 06 W
180	1 40 W	0 04 E	0 40 W	0 54 E	0 16 E	1 16 W	1 14 W	0 24 W	0 48 E	0 08 W	1 02 W	0 44 W	0 54 W	0 54 W
270	0 20 W	1 20 E	0 06 W	1 30 E	0 12 W	1 42 W	0 10 E	0 58 E	0 26 W	1 16 W	0 16 E	0 36 E	0 28 E	0 26 E
Mean deviation -	1 02 W	0 38 E	0 56½ W	0 39 E	0 33 E	0 58½ W	0 42½ W	0 06½ E	0 16 E	0 35 W	0 29½ W	0 12 W	0 20 W	0 20 W
Direction of deviation -	N to W	N to E	N to W	N to E	N to E	N to W	N to W	N to E	N to E	N to W	N to W	N to E	Stationary.	
Deviation due to rotation	1° 40′½		1° 33′½		1° 31′½		0° 49′		0° 51′		0° 17′½		0° 0′	

Points on the Plate.	Long. 270°. Lat. 0°.		Long. 90°.* Lat. 19° 30′ N.		Long. 270°. Lat. 19° 30′ N.		Long. 90° Lat. 45° N.		Long. 90°. Lat. 39° 00′ N.		Long. 270°. Lat. 70° 30′ S.		Long. 90°. Lat. 31° 30′ S.	
	W to E	E to W	E to W	W to E	W to E	E to W	E to W	W to E	E to W	W to E	W to E	E to W	E to W	W to E
0	0° 12′ W	2° 00′ W	0° 54′ W	0° 34′ E	0° 44′ E	0° 50′ W	0° 14′ E	1° 00′ E	0° 44′ W	0° 14′ E	0° 42′ W	1° 00′ W	0° 22′ E	1° 38′ E
90	1 26 E	0 22 W	1 48 W	0 22 W	1 54 E	0 16 E	1 46 W	0 58 W	1 40 W	0 42 W	0 34 E	0 18 E	1 32 W	0 12 W
180	1 24 E	0 28 W	0 38 W	0 50 E	0 30 E	1 08 W	1 16 W	0 26 W	0 16 W	0 36 E	0 18 E	0 02 E	1 42 W	0 24 W
270	0 36 E	1 14 W	0 16 W	1 10 E	0 00	1 36 W	0 20 E	1 10 E	0 12 E	1 08 E	0 44 W	1 00 W	0 34 W	0 44 E
Mean deviation -	0 48½ E	1 01 W	0 54 W	0 33 E	0 47 E	0 49½ W	0 37 W	0 09¼ E	0 37 W	0 19 E	0 08½ W	0 25 W	0 51½ W	0 26½ E
Direction of deviation -	N to E	N to W	N to W	N to E	N to E	N to W	N to W	N to E	N to W	N to E	N to E	N to W	N to W	N to E
Deviation due to rotation	1° 49′½		1° 27′		1° 36′½		0° 46′¼		0° 56′		0° 16′½		1° 18′	

* In these positions the plane of the plate was vertical, and its centre in the same horizontal line as that of the needle.

† In this position the plane of the plate was horizontal, and its centre vertical to that of the needle.

‡ Here the deviations are those corresponding to the coincidence of the points on the plate with the southern meridian.

From these observations it appears, that when the centre of the plate was in the pole of the magnetic sphere, its plane being parallel to the equator, the position of the needle, for any situation of the several points of the plate, was the same whether they were brought into that situation by the plate revolving from *east* through *south* to *west*, or from *west* through *south* to *east*; that is, that the *deviation due to rotation* was nothing:

That the *deviation due to rotation* increased from this point towards the equator, where it was the greatest:

And that the horizontal needle was affected by the rotation of the plate, not according to the situation of the centre of the plate as regarded the poles and equator of the horizontal needle, but as regarded the poles and equator of an imaginary dipping needle passing through the centre of the horizontal needle.

This last is not so evident, from the circumstance of the deviation being nothing when the centre of the plate was in the pole of the dipping needle, and a maximum when in the equator, as from its being very nearly equal at equal distances on each side of the pole, and also of the equator, that is, at very unequal distances from the axis of the horizontal needle; and from the deviations at equal distances from the axis of the horizontal needle being very unequal. For if we compare the *deviation due to rotation* in lat. 70° 30′ S, long. 90°, with that in lat. 70° 30′ S, long. 270°, the difference is only 1′; in the first case, the centre of the plate was at the distance of 90° from the axis of the horizontal needle, and its plane parallel to it; and in the other at the distance of 51°, and its plane making an angle of 39° with this axis. Again, in the four corresponding situations of lat. 19° 30′, the mean *deviation due to rotation* is 1° 32′, and none of the deviations differ from this by more than 5′, although in two cases the centre of the plate was in the axis of the horizontal needle, and its plane perpendicular to it, and in the two others the centre of the plate was at the distance of 39° from this axis, and its plane made an angle of 51° with it. The mean of the *deviations due to rotation* in the three* corresponding situations of lat. 45° is 49′, from which none of the deviations differ by 3′, notwithstanding the difference in the situations of the centre and plane of the plate, in these cases, with respect to the axis of the horizontal needle. In long. 90° lat. 45° S, the centre of the plate was 64° 30′ above the horizontal axis, and its plane made an angle of 25° 30′ with it; in long. 90° lat. 45° N, it made an angle of 64° 30′ at 25° 30′ below it; and in long. 270° lat. 45° S, it was in a position above it similar to the last. Any doubt, however, on the subject will be removed, if we compare the deviation in long. 90° lat. 39° N with that in long. 270° lat. 0; the one deviation being nearly double of the other, although the centre of the plate was at the distance of 19° 30′ from the axis of the horizontal needle, and its plane made an angle of 70° 30′ with it in both cases. The difference is even more striking, if we compare the deviation in lat. 70° 30′ S, long. 270°, with that in lat. 31° 30′ S, long. 90°, the centre of the plate being in each case at the distance of 51° from the axis of the horizontal needle, and its plane making an angle of 39° with it.

* The nature of the instrument would not admit of observations being made so near to the north pole in long. 270° as lat. 45°, or so near as lat. 70° 30′ on the other side of the support G I.

The differences which we have noticed in the deviations observed at the same distance from the equator, is not more than I have found to arise from a slight change in the adjustment of the centre of the needle to the centre of the instrument, the plate remaining in the same position. These errors of adjustment I found it almost impossible to avoid, owing probably in a great measure to the magnetic centre of the needle not being in the centre of suspension; and it was to counteract their effects, that I generally made observations on contrary sides of the centre.

With respect to the direction in which the *deviation due to rotation* took place, it appears, that the rotation of the plate always caused the *north* end of the needle to move in the same direction as the edge of the plate nearest the *south* pole of the magnetic sphere: so that the deviation of the *north* end of the needle was in the direction in which the *south* edge of the plate moved, and that of the *south* end of the needle in the direction in which the *north* edge moved, referring the edges to the poles of the sphere.

Having ascertained, that when the centre of the plate was in the pole, and its plane *parallel to* the equator, the *deviation due to rotation* was nothing; and some of the first experiments which I had made having indicated that this was also the case when the centre of the plate was in the secondary to the equator and meridian, and its plane, as before, a tangent to the sphere, I wished to ascertain whether such were really the fact. The experiments, the results of which are given in the following table, left no doubt in my mind on the subject. In making them, the instrument was adjusted, so that the index at K (Fig. 1) pointed to zero, that at G to 19° 30′

from Q towards S, and those at o, o′ to zero on the limb S *æ* N, as in Fig. 2. The deviations for the several points of the plate are those observed when these points coincided with the southern or upper part of the secondary to the equator and meridian; and the direction of rotation is, as before, that of the edge of the plate nearest to the south pole of the sphere.

II. *Table of the deviations of a magnetic needle caused by the* rotation *of a circular plate of iron, when its centre was in the secondary to the equator and meridian, and its plane a tangent to the sphere: the distance as before* 9.75 *inches. Plate No. I.*

Points on the Plate.	Long. 0°. Lat. 0°.		Long. 180°. Lat. 0°.		Long. 0°. Lat. 45° S.		Long. 180°. Lat. 45° S.		Long. 0°. Lat. 45° N.		Long. 180°. Lat. 45° N.	
	S to N	N to S	N to S	S to N	S to N	N to S	N to S	S to N	S to N	N to S	N to S	S to N
0	0° 06′ E	0° 06′ E	0° 26′ W	0° 24′ W	7° 24′ W	7° 22′ W	6° 48′ E	6° 48′ E	7° 08′ E	7° 10′ E	7° 32′ W	7° 32′ W
90	0 14 E	0 14 E	0 40 W	0 40 W	7 40	7 40	6 58	6 56	7 18	7 20	8 00	7 58
180	0 04 E	0 04 E	0 32 W	0 32 W	6 52	6 54	5 58	6 00	6 26	6 26	6 52	6 52
270	0 04 W	0 04 W	0 20 W	0 20 W	6 28	6 28	5 48	5 48	6 08	6 08	6 30	6 28
Mean Deviations	0 5 E	0 05 E	0 29½ W	0 29 W	7 06 W	7 06 W	6 23 E	6 23 E	6 45 E	6 46 E	7 13½ W	7 12½ W
Deviation due to rotation	0° 00′		0° 00′ ½		0° 00′		0° 00′		0° 01′		0° 01′	

From these observations, combined with the preceding, we may infer, that if the centre of the plate were made to describe any parallel of latitude, the *deviation due to rotation* would be nothing when the longitude was 0° or 180°, and a maximum when the longitude was 90° or 270°, which is precisely the reverse of the *absolute deviations* that would be produced by the plate describing the parallel of latitude.

The next experiments which I made, were with the view of determining whether the *rotation* of the plate would produce any deviation, when its plane *coincided with the equator.* For this purpose an axis was fixed perpendicularly on the arm of the instrument in such a manner, that, when the plate revolved on it, its plane was parallel to the limb. This is represented in fig. 5: AB is the arm, on the cylindrical part of which, B *b*, is fixed perpendicularly to it the axis V *v*, on which the plate of iron, C *c*, here seen edgewise, revolves. A, *a*, are the two flat pieces, having an opening between them for the limb of the instrument; Z is the clamping screw, and Y *y* the circular rim to support the iron plate, which are not seen in fig. 1.

In order to make these observations, it was necessary to adjust the whole instrument twice; since the deviations for the longitudes 90° and 270° could not be observed with the same adjustment as those for the longitudes 0° and 180°. For the longitudes 90° and 270°, the axis of the instrument was horizontal and pointed east and west, as in fig. 3, and the moveable limb E AW revolved on the axis until its plane, and therefore also that of the iron plate, made an angle of 90° 30′ with the horizon, rising towards the north; so that the compass being elevated until the centre of the needle was in the plane of the plate, the plate was then in the equator. For the other longitudes, the axis of the instrument was inclined to the horizon at an angle of 19° 30′, and in the plane of the meridian, as in fig. 2, and the moveable limb adjusted at right angles to the fixed one: the compass was then elevated to coincide with the plane of the plate.

In these experiments the distance of the centre of the iron from the centre of the needle was 13.2 inches; but as its edge was only 4.26 inches distant, the differences between the deviations corresponding to the several points on the plate were greatly increased; and therefore, to obviate any inaccuracies that might arise, from the points not being brought into precisely the same situation when the plate revolved in the opposite directions, I increased the number of observations, making twenty-four for each position, namely, twelve points on the plate, as I have before described, the deviation for any point being observed when that point coincided with the line joining the centre of the plate and needle. The letters at the tops of the columns indicate the direction of rotation of the inner edge of the plate, or that nearest the centre of the needle.

III. *Table of the deviations of a magnetic needle, caused by the rotation of a circular plate of iron, when its centre was in the equator, and its plane in the plane of the equator. Plate No. I.*

Points on the Plate.	Long. 0°		Long. 45°		Long. 90°		Long. 135°		Long. 180°		Long. 225°		Long. 270°		Long. 315°	
	N to S	S to N	NW to SE	SE to NW	W to E	E to W	SW to NE	NE to SW	S to N	N to S	SE to NW	NW to SE	E to W	W to E	NE to SW	SW to NE
0	3° 00′ E	3° 00′ E	2° 40′ E	2° 40′ E	0° 30′ E	0° 30′ E	2° 00′ W	2° 00′ W	1° 28′ W	1° 28′ W	3° 06′ W	3° 00′ W	0° 26′ W	0° 32′ W	1° 22′ E	1° 22′ E
30	2 20 E	2 20 E	1 02 E	1 00 E	1 00 E	0 58 E	1 06 W	1 02 W	0 48 W	0 46 W	1 44 W	1 48 W	0 30 W	0 40 W	0 18 E	0 10 E
60	1 14 E	1 14 E	0 18 W	0 12 W	0 40 E	0 34 E	0 30 W	0 30 W	0 00	0 00	1 14 W	1 10 W	0 02 E	0 00	0 12 W	0 16 W
90	0 06 W	0 06 W	1 36 W	1 42 W	1 44 E	1 42 E	0 14 E	0 12 E	1 00 E	0 56 E	0 30 E	0 26 E	0 42 W	0 50 W	0 40 W	0 46 W
120	1 30 W	1 30 W	2 30 W	2 20 W	0 32 E	0 34 E	1 00 E	1 00 E	1 16 E	1 16 E	1 50 E	1 50 E	0 10 E	0 04 E	1 10 W	1 02 W
150	2 20 W	2 26 W	2 24 W	2 12 W	0 32 E	0 40 E	1 02 E	1 02 E	1 16 E	1 16 E	2 10 E	2 10 E	0 26 W	0 30 W	1 00 W	1 00 W
180	2 50 W	2 44 W	1 56 W	1 50 W	0 12 W	0 14 W	1 30 E	1 34 E	1 16 E	1 16 E	2 20 E	2 26 E	0 08 W	0 12 W	1 10 W	1 06 W
210	2 50 W	2 44 W	1 04 W	1 10 W	0 32 W	0 40 W	1 30 E	1 30 E	1 16 E	1 16 E	2 32 E	2 30 E	0 04 W	0 06 W	1 10 W	1 06 W
240	1 56 W	1 56 W	0 16 W	0 10 W	1 18 W	1 18 W	1 00 E	1 00 E	0 56 E	0 56 E	2 24 E	2 18 E	0 30 E	0 26 E	0 40 W	1 40 W
270	0 08 W	0 08 W	1 10 E	1 04 E	1 30 W	1 34 W	0 36 W	0 34 W	0 12 W	0 16 W	0 20 E	0 14 E	1 10 E	1 06 E	0 40 E	0 38 E
300	1 42 E	1 40 E	2 30 E	2 30 E	1 22 W	1 22 W	1 44 W	1 50 W	1 18 W	1 18 W	1 40 W	1 46 W	1 10 E	1 10 E	1 16 E	1 20 E
330	2 50 E	2 56 E	2 48 E	2 50 E	0 16 W	0 20 W	2 16 W	2 16 W	1 50 W	1 50 W	2 44 W	2 48 W	0 14 E	0 16 E	1 42 E	1 40 E
Mean Deviations.	0 02$\frac{5}{6}$ W	0 02 W	0 00$\frac{1}{2}$ E	0 02$\frac{1}{6}$ E	0 01 W	0 02$\frac{1}{2}$ W	0 09$\frac{2}{3}$ W	0 09$\frac{1}{2}$ W	0 07$\frac{2}{3}$ E	0 06$\frac{1}{2}$ E	0 08$\frac{2}{3}$ E	0 06$\frac{5}{6}$ E	0 05 E	0 01 E	0 03$\frac{2}{3}$ W	0 03$\frac{5}{6}$ W
Deviation due to rotation.	0° 00$\frac{5}{6}$′		0° 01$\frac{3}{4}$′		0° 01$\frac{1}{2}$′		0° 00$\frac{1}{6}$′		0° 01$\frac{1}{6}$′		0° 01$\frac{2}{3}$′		0° 04′		0° 00$\frac{1}{6}$′	

These observations show very clearly, that when the centre of the plate is in the equator, and its plane also coincides with the plane of the equator, the *deviation due to rotation* is always nothing, since the small differences to be observed here in the revolutions in opposite directions are only such as may justly be attributed to slight errors in the adjustments of the centre of the needle or of the plane of the plate, which are almost unavoidable. With regard to the several deviations in the different columns, I should notice, that they are not those actually observed, but derived from them by subtracting the same number from all the deviations observed in two corresponding columns, so that they indicate the same difference of deviations in the two revolutions as those actually observed, and therefore give the same *deviation due to rotation.* The necessity of this reduction arose from the circumstance of my having to adjust the compass to the proper height, so that its centre might be in the plane of the plate, while it was under the influence of the partial magnetism of particular points in the plate; and having done this, when zero of the compass was brought to coincide with the point of the needle it was not necessarily in the magnetic meridian, since the needle was under the influence of this partial magnetism; and as I wished the deviations to be those from the meridian, I reduced the observed deviations as I have mentioned.

Being convinced that the *rotation* of the plate *in* the plane of the equator caused no deviation of the needle, I proceeded to determine the effects produced by its rotation in other planes. In the first set of observations which I made, the centre of the plate was in the meridian, and its plane perpendicular to the plane of the meridian and passing through the centre of the needle. Before however making these, to avoid the necessity of moving the compass as in the last, I made a slight alteration in the instrument. Instead of having the axis on which the plate revolved perpendicular to the arm, and the plate consequently parallel to the limb, this axis was inclined in such a manner that the plane of the plate passed through the axis of the instrument, as represented fig. 6; so that the axis of the instrument being horizontal, and passing through the centre of the needle perpendicularly to the meridian, as in fig. 3, when the arm of the instrument was adjusted to zero on the limb, the revolution of the limb caused the centre of the plate to describe the magnetic meridian, and at the same time the plane of the plate always passed through the centre of the needle. The distance between the centre of the plate and that of the needle was as in the last 13.2 inches. The observations are given in the following table, where the letters above the columns indicate the direction of rotation of the plate's inner edge.

IV. *Table of the deviation of a magnetic needle, caused by the* rotation *of a circular plate of iro*
the meridian, and its plane in the plane of a secondary to the meridian.

Points on the Plate.	Long. 90°. Lat. 0°.		Long. 90°. Lat. 19° 30′ S.		Long. 270°. Lat. 19° 30′ S.*		Long. 90°. Lat. 45° S.		Long. 270°. Lat. 45° S.		Long. 90°. Lat. 70° 30′	
	W to E	E to W	W so E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E
0	0° 14′W	0° 14′W	0° 12′W	0° 06′E	0° 12′W	0° 12′E	0° 54′W	0° 00′	0° 48′W	0° 02′E	0° 58′W	0
30	0 12E	0 08E	0 02W	0 14E	0 24W	0 00	0 56W	0 00	1 14W	0 18W	1 02W	0
60	0 20E	0 18E	0 06E	0 24E	0 24W	0 00	0 32W	0 24E	1 22W	0 24W	0 58W	0
90	1 04E	1 04E	0 48E	1 10E	0 50E	1 14E	0 22E	1 18E	0 20W	0 38E	0 10W	1
120	0 40E	0 38E	0 26E	0 48E	0 22E	0 48E	0 18E	1 14E	0 32W	0 28E	0 04E	1
150	1 16E	1 14E	0 56E	1 22E	1 00E	1 26E	0 50E	1 44E	0 10E	1 06E	0 20E	1
180	0 36E	0 38E	0 32E	0 58E	0 44E	1 08E	0 36E	1 32E	0 10E	1 08E	0 20E	1
210	0 14E	0 16E	0 02E	0 26E	0 28E	0 50E	0 04W	0 52E	0 00	0 56E	0 00	1
240	0 38W	0 40W	1 00W	0 38W	0 08W	0 12E	1 08W	0 10W	0 30W	0 28E	0 50W	0
270	1 30W	1 28W	1 40W	1 18W	0 46W	0 24W	1 46W	0 48W	0 56W	0 00	1 20W	0
300	1 04W	1 08W	1 20W	1 00W	0 40W	0 20W	1 54W	0 52W	0 56W	0 02E	1 22W	0
330	0 30W	0 26W	0 46W	0 26W	0 44W	0 18W	1 30W	0 36W	1 02W	0 06W	1 30W	0
Mean deviation - -	0 02 $\frac{1}{6}$ E	0 01 $\frac{2}{3}$ E	0 10 $\frac{5}{6}$ W	0 10 $\frac{1}{2}$ E	0 00 $\frac{1}{2}$ E	0 24 E	0 33 $\frac{1}{6}$ W	0 23 $\frac{1}{6}$ E	0 36 $\frac{2}{3}$ W	0 20 E	0 37 $\frac{1}{6}$ W	0
Direction of deviation	Stationary.		N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N
Deviation due to rotation	0° 00′ $\frac{1}{2}$		0° 21′ $\frac{1}{3}$		0° 23′ $\frac{1}{2}$		0° 56′ $\frac{1}{3}$		0° 56′ $\frac{2}{3}$		1° 21	

	Long. 270°. Lat. 0°.		Long. 90°. Lat. 19° 30′ N.*		Long. 270°. Lat. 19° 30′ N.		Long. 90°. Lat. 45° N.		Long. 270°. Lat. 45° N.		Long. 90° Lat. 70° 3	
	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E
0	0° 58′W	0° 58′W	0° 08′E	0° 14′W	0° 54′W	1° 20′W	0° 14′E	0° 40′W	0° 44′E	0° 12′W	0° 42′E	0
30	0 52W	0 52W	0 38E	0 16E	0 44W	1 06W	0 50E	0 00	0 54E	0 02E	1 20E	0
60	0 46W	0 46W	0 40E	0 16E	0 28W	0 48W	1 02E	0 14E	0 52E	0 02W	1 16E	0
90	0 46E	0 46E	1 06E	0 42E	0 36E	0 14E	1 18E	0 20E	0 54E	0 02W	1 26E	0
120	0 40E	0 38E	0 46E	0 22E	0 42E	0 18E	1 00E	0 12E	0 52E	0 04W	1 08E	0
150	1 36E	1 38E	1 08E	0 44E	1 16E	0 54E	1 18E	0 20E	1 02E	0 06W	1 16E	0
180	1 14E	1 16E	0 24E	0 00	0 58E	0 34E	0 44E	0 10W	0 40E	0 18W	0 38E	0
210	1 08E	1 08E	0 20E	0 02W	1 00E	0 36E	0 42E	0 12W	0 22E	0 38W	0 14E	1
240	0 24E	0 26E	0 22W	0 48W	0 18E	0 04W	0 08E	0 50W	0 12W	1 16W	0 14W	1
270	0 32W	0 32W	1 06W	1 30W	0 54W	1 16W	0 38W	1 30W	0 42W	1 36W	0 42W	2
300	0 46W	0 44W	0 40W	1 02W	1 06W	1 30W	0 28W	1 12W	0 12W	1 06W	0 16W	1

: of iron, when the centre of the plate was in
idian. Plate No. I.

ng. 90°. t. 70° 30′ S.†		Long. 270°. Lat. 70° 30′ S.		Lat. 90° S.	
to E	E to W	W to E	E to W	W to E	E to W
8W	0° 20′ E	1° 10′W	0° 08′ E	1° 10′W	0° 14′ E
2W	0 20 E	1 10W	0 00	1 12W	0 08 E
8W	0 32 E	1 10W	0 08 E	1 08W	0 20 E
0W	1 18 E	0 20W	1 00 E	0 22W	1 04 E
4 E	1 26 E	0 20W	1 02 E	0 16W	1 14 E
0 E	1 40 E	0 10 E	1 30 E	0 16 E	1 40 E
0 E	1 36 E	0 12 E	1 24 E	0 16 E	1 40 E
0	1 12 E	0 12W	1 02 E	0 04W	1 14 E
0W	0 22 E	0 52W	0 28 E	0 50W	0 30 E
0W	0 00	1 12W	0 00	1 20W	0 04 E
2W	0 00	1 20W	0 04W	1 22W	0 00
0W	0 00	1 26W	0 10W	1 30W	1 02W
7 1/6 W	0 43 5/6 E	0 44 1/6 W	0 32 1/3 E	0 43 1/2 W	0 40 1/2 E
to W	N to E	N to W	N to E	N to W	N to E
1° 21′		1° 16′ 1/2		1° 24′	

Long. 90°. Lat. 70° 30′ N.		Long. 270°. Lat. 70° 30′ N.	Lat. 90° N.	
to E	E to W		W to E	E to W
′ 42 E	0° 38′W	…instrument does not admit of observations …de in this position of the Plate.	0° 42′ E	0° 42′W
20 E	0 00		1 22 E	0 06W
16 E	0 04W		1 22 E	0 00
26 E	0 06 E		1 24 E	0 00
08 E	0 14W		1 18 E	0 10W
16 E	0 04W		1 26 E	0 04W
38 E	0 48W		0 52 E	0 38W
14 E	1 10W		0 28 E	0 56W
14W	1 36W		0 02W	1 24W
42W	2 02W		0 32W	2 00W
16W	1 40W		0 16W	1 44W

270	0 32W	0 32W	1 06W	1 30W	0 54W	1 16W	0 38W	1 30W	0 42W	1 36W	0 42W	2
300	0 46W	0 44W	0 40W	1 02W	1 06W	1 30W	0 28W	1 12W	0 12W	1 06W	0 16W	1
330	1 06W	1 02W	0 08 E	0 12W	0 56W	1 20W	0 10 E	0 46W	0 28 E	0 24W	0 40 E	0
Mean deviation - -	0 04 E	0 04 $\frac{5}{6}$ E	0 15 $\frac{5}{6}$ E	0 07 $\frac{1}{3}$ W	0 01W	0 24W	0 31 $\frac{2}{3}$ E	0 21 $\frac{1}{6}$ W	0 28 $\frac{1}{2}$ E	0 27 $\frac{1}{2}$ W	0 37 $\frac{1}{3}$ E	0
Direction of deviation	Stationary.		N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	
Deviation due to rotation	$0^{\circ}\ 00'\frac{5}{6}$		$0^{\circ}\ 23'\frac{1}{6}$		$0^{\circ}\ 23'$		$0^{\circ}\ 52'\frac{5}{6}$		$0^{\circ}\ 56'$		$1^{\circ}\ 2$	

* The plane of the plate was here horizontal.

† Here the plane of

42W	2 02W	The nature of the instrum being made in this	0 32W	2 00W
16W	1 40W		0 16W	1 44W
40 E	0 46W		0 32 E	1 00W
37 $\frac{1}{3}$ E	0 44 $\frac{2}{3}$ W		0 43 E	0 43 $\frac{2}{3}$ W
N to E	N to W		N to E	N to W
1° 22′			1° 26′ $\frac{2}{3}$	

plane of the plate was vertical.

Here we find, directly contrary to what took place when the plane of the plate was a tangent to the sphere, that the *deviation due to rotation* increases from the equator to the pole where it is a maximum. In this case, however, as in the other, the deviations are very nearly equal at equal distances on each side of the equator; so that, as before, it appears that the horizontal needle was affected by the rotation of the plate, not according to the situation of the centre of the plate with respect to the poles and equator of the horizontal needle, but with respect to the poles and equator of an imaginary dipping needle passing through the centre of the horizontal needle.

With regard to the direction of the *deviation due to rotation*, it appears, that when the centre of the plate had *north latitude*, the *north end* of the needle deviated *in the direction* of the motion of the plate's *inner edge;* and when it had *south latitude*, the *north end* deviated in a *contrary direction* to that of the *inner edge* of the plate, and therefore the *south end* deviated *in the direction* of the *inner edge*: so that, *the end of the needle of the same name as the latitude, always deviated in the direction of the motion of the plate's inner edge.*

Let us compare this with the inference we have drawn from the observations in Table I. viz. that when the centre of the plate is in the meridian, and its plane a tangent to the sphere, the north end of the needle, by the rotation of the plate, deviates in the direction of the motion of the south edge, and the south end in the direction of the north edge of the plate; that is, either end of the needle deviates in a direction contrary to that of the motion of the edge of the plate nearest to the pole of the sphere of the same name as that end. Now, if from the position which the plate had in the last experiments, namely, its plane passing through the centre of the needle, it be conceived to revolve about its diameter, which is perpendicular to the plane of the meridian, until its plane be a tangent to the sphere, the direction of the revolution about this diameter being of the inner edge towards the pole of the same name as the latitude of the plate's centre, the inner edge will become the edge of the same name as the end of the needle, which, in its first position, according to our inference from the last observations, deviated in the direction of its rotation; but according to the inference drawn from Table I. the end of the needle of the same name as this edge will, in the new position, deviate in a direction contrary to that of its rotation; so that the rotation of the plate being in the same direction in both positions, the deviations by rotation will be in contrary directions in the two cases: and consequently, between the two positions, the plane of the plate must have passed through one in which the rotation would produce no deviation. If we conceive the plate to come into the position of the tangent plane by revolving about its diameter in the opposite direction, that is, by the inner edge moving towards the pole of a contrary name to the latitude, the inner edge will become the edge of the contrary name to the end of the needle, which in the first position, deviated in the direction of its rotation; and therefore that end of the needle will still continue to deviate in the same direction; that is, the direction of the rotation being the same in the two positions, the deviation by rotation will be in the same direction in both cases; and consequently, between the two positions, either there is no position of the plane of the plate in which the rotation will produce no deviation, or there are two, or some even number of such positions.

I have not been able to determine in all cases experimentally the situation of the plane in which the *deviation due to rotation* vanishes, or whether there may be more than one plane in which this takes place; but all the observations which I have made, confirm me in the opinion which I formed on comparing the preceding results, that when the centre of the plate is in the meridian, there is only one plane between the tangent plane and the plane passing through the centre of the needle in which the deviation due to rotation vanishes, and that that plane is parallel to the equator.

Another conclusion which we may draw from these experiments compared with those in Table I. is this, that when the centre of the plate is in the meridian, and its plane perpendicular both to the meridian and equator, then, supposing the plate always to revolve in the same direction, the deviation will always be in one direction, in whatever point of the meridian the centre of the plate may be; for when the centre of the plate is in longitude 90°, latitude 0, Table I. the plane of the plate has this position, and also when in latitude 90° S. and 90° N. Table IV. and with the same direction of rotation, the deviation will be in one direction in these two cases.

As I had already found, that, when the centre of the plate was in the secondary to the equator and meridian, and its plane a tangent to the sphere, the rotation caused no deviation of the horizontal needle; it appeared to me, that there ought to be no *deviation due to rotation* when the plane of the plate was in any other plane perpendicular to this secondary.

To ascertain how far my views were correct, or otherwise, I adjusted the plate on the arm as in fig. 6. the same as in the last experiments, and the instrument as in fig. 2: so that the axis ÆQ being in the plane of the meridian and inclined to the horizon at an angle of 19° 30′, the centre and plane of the plate were, during the revolution of the limb, always in the position I required. The distance between the centres of the needle and plate was as before 13.2 inches. The following Table exhibits the observations which I made; the letters at the tops of the columns indicate the direction of rotation of the plate's inner edge; and the numbers in the first column, the points on the plate which coincided with the plane of the secondary, when the several directions of the north end of the needle in the same lines with them were observed. The observations were made at every 10° of latitude, as in some cases there was an indication of *deviation due to rotation.*

V. *Table of the deviations of a magnetic needle caused by the* rotation *of a circular plate of iron u*
and its plane perpendicular to this secondary, and passing through t

	Long. 0° Lat. 0°		Long. 0° Lat. 10° S.		Long. 0° Lat. 20° S.		Long. 0° Lat. 30° S		Long. 0° Lat. 40° S		Long. 0° Lat. 45° S		
	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S
0	1° 16′ E	1° 16′ E	6° 58′ W	6° 56′ W	11° 10′ W	11° 10′ W	16° 12′ W	16° 14′ W	17° 36′ W	17° 30′ W	17° 50′ W	17° 50′ W	16
30	1 24 E	1 22 E	5 30	5 30	10 24	10 24	15 16	15 10	16 52	16 50	17 02	17 00	16
60	1 18 E	1 20 E	3 44	3 42	9 22	9 24	13 32	13 32	15 42	15 38	15 56	15 52	15
90	0 54 E	0 52 E	3 00	2 58	9 26	9 24	13 14	13 10	15 40	15 40	15 44	15 40	15
120	0 20 E	0 18 E	2 56	2 52	9 32	9 32	13 18	13 20	15 48	15 48	16 00	15 58	15
150	0 18 W	0 22 W	3 38	3 40	10 22	10 24	14 10	14 16	16 18	16 20	26 38	16 38	15
180	1 00 W	1 04 W	4 56	4 52	11 26	11 22	15 30	15 30	17 18	17 22	17 36	17 40	16
210	1 44 W	1 42 W	6 24	6 24	12 30	12 30	17 10	17 10	18 18	18 20	18 46	18 42	17
240	1 54 W	1 54 W	7 44	7 42	13 04	13 00	18 08	18 06	18 56	18 54	19 24	19 20	18
270	1 04 W	1 02 W	8 04	8 04	12 40	12 34	18 00	17 58	18 38	18 36	19 16	19 12	18
300	0 04 W	0 02 W	8 06	8 06	12 00	11 56	17 40	17 38	18 24	18 20	19 02	19 02	17
330	0 38 E	0 42 E	7 44	7 44	11 34	11 32	16 52	16 52	17 50	17 48	18 26	18 22	17
Mean Deviations.	0 01 $\frac{1}{6}$ W	0 01 $\frac{1}{3}$ W	5 43 $\frac{2}{3}$	5 42 $\frac{1}{2}$	11 07 $\frac{1}{2}$	11 06	15 45 $\frac{1}{6}$	15 44 $\frac{2}{3}$	17 17	17 15 $\frac{1}{2}$	17 38 $\frac{1}{3}$	17 36	16
Deviations due to rotation.	0 00$\frac{1}{6}$′		0° 01$\frac{1}{6}$′		0° 01$\frac{1}{2}$′		0° 00$\frac{1}{2}$′		0° 01$\frac{1}{2}$′		0° 01$\frac{1}{2}$′		

f iron when its centre was in the secondary to the equator and meridian, rough the centre of the needle. ***Plate No.* I.**

0° 5° S	Long. 0° Lat. 50° S		Long. 0° Lat. 60° S.		Long. 0° Lat. 70° S.		Long. 0° Lat. 80° S		Lat. 90° S	
N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S
' 50W	16° 56' W	16° 58' W	13° 40' W	13° 38' W	10° 08' W	10° 02' W	5° 08' W	5° 08' W	0° 22' E	0° 22' E
' 00	16 20	16 20	13 32	13 26	10 00	9 54	5 06	5 04	0 20	0 20
52	15 24	15 22	12 58	12 52	9 32	9 26	4 50	4 50	0 24	0 22
40	15 14	15 08	12 52	12 48	9 24	9 20	4 50	4 50	0 20	0 22
58	15 20	15 20	12 56	12 54	9 32	9 30	4 50	4 48	0 18	0 22
38	15 52	15 50	13 04	13 02	9 46	9 42	4 50	4 48	0 20	0 24
' 40	16 40	16 40	13 24	13 24	10 08	10 10	4 52	4 54	0 24	0 28
42	17 36	17 36	14 00	13 56	10 32	10 30	5 02	5 04	0 22	0 26
20	18 16	18 12	14 18	14 12	10 46	10 40	5 08	5 08	0 26	0 24
12	18 02	18 20	14 06	14 00	10 36	10 36	5 10	5 10	0 24	0 24
02	17 52	17 52	14 00	13 58	10 32	10 30	5 10	5 10	0 22	0 22
22	17 20	17 16	13 42	13 42	10 18	10 16	5 08	5 08	0 20	0 20
36	16 44⅓	16 42⅚	13 32⅔	13 29⅓	10 06⅙	10 03	5 00⅓	5 00⅙	0 21⅚	0 23
½'	0° 01½'		0° 03⅓'		0° 03⅙'		0° 00⅙'		0° 01⅙'	

Although the *deviations due to rotation* are here in some cases greater than might perhaps on a first view be expected, if in the position in which I have supposed the plate, its rotation would really produce no deviation, yet the differences are not in any case more than may, I consider, be fairly attributed to errors in the adjustments. That the deviations, when the plate revolved from south to north, had a tendency most generally to be greater than when it revolved in a contrary direction, as is evident by referring to the Table, appears at first sight more unfavourable to my opinion than the magnitude of the difference; but on further consideration, I think that this will be allowed rather to point out the source of the errors in the results, than the incorrectness of my views, and that these errors arose from the plane of the plate not being in those cases perpendicular to the plane of the secondary to the equator and meridian. The proximity of the edge of the iron to the ends of the needle, varying from 5.16 inches to 4.27 inches at the south end, and from 5.16 inches to 5.92 inches at the north end, I considered to be another source of error; the inequalities arising from the effects of particular points near the edges of the iron on the ends of the needle being the more sensible when the distances are small. All my observations were made as near to the centre of the needle as the instrument would admit, in order that the effects of the rotation, since they were in many cases extremely small, might be the more sensible; and by this means I discovered the nature of the effects produced on the needle by the rotation of the plate; but I am fully convinced, that for the purpose of comparing the results of observation with the conclusions from theory, it is always desirable, that the observations should be made when the iron is at such a distance from the centre of the needle, that the effects of particular points, near its edges, on the ends of the needle are nearly insensible. Taking these circumstances into consideration, I was quite satisfied from these experiments, that, if the centre of the plate be in the secondary to the equator and meridian, and its plane perpendicular to the plane of that circle, the rotation of the plate will produce no effect on the absolute deviations caused by the mass.

In order to determine what effects would be produced by the rotation of the plate when its centre was in the secondary to the equator and meridian, and its plane in the plane of this circle, the instrument was adjusted as in fig. 1. the index at *g* pointing to 70° 30′; the limb SÆN was then placed at right angles to SQN, and the arm AB attached to it with the iron plate on the axis as in fig. 5; and that the centre of the needle might be in the plane of the plate, the compass box was moved in the direction of the meridian.

Some of my first observations were made with the centre of the plate in the equator, and I immediately found, that the *deviation due to rotation*, instead of being 0, as in the cases when the plate revolved in the planes at right angles to its present position, was here considerable; and also that, that of the south end of the needle was in the direction of the upper, or south edge of the plate, contrary to what had been observed in the same plane at the pole (Table IV. lat. 90°). This indicated that there must be, at least, one point in this circle on each side of the pole, where the *deviation due to rotation* was 0; and to determine nearly the latitude of this point, I made observations at every 10° degrees of latitude on each side of the south pole. Before, however, giving these observations, it is necessary that I should state the kind of reliance I place on them as forming a complete set. In order to make the observations near the pole, it was necessary to adjust the instrument as in fig. 3. and after having made the complete set, I suspected that, in the change from the one adjustment to the other, the centre of the plate had been nearer to that of the needle in making the observations near the equator, than those near the pole; and that consequently, the *deviations due to rotation* in the former case, were proportionally too great. I was confirmed in this suspicion on comparing these observations with those which I had, in the first instance, made in lat 0° and in lat. 90°; and still further on comparing them with others, which I subsequently made at the several distances 15, 17, 19, 20 inches; in the corresponding situations. For example, in my first observations, the *deviations due to rotation* in lat. 0°, long. 0°, and in lat. 0° long. 180° were 3° 10′, and 3° 14′, giving a mean 3° 12′ in lat 0; and in lat. 90 S, 1° 31′; when the centres of the plate and needle had been carefully adjusted to the same distance 13.2 inches, in the two cases; whereas the corresponding deviations in the table are 3° 43′ and 1° 29½′; and, by subsequent observations, I found the sum of the deviations at the distances 15, 17, 19 and 20 inches to be in these two cases, 7° 20′ and 3° 32′, to which 3° 12′ and 1° 31′ are very nearly proportional. As however these differences do not in the least affect the conclusions which I at the time drew from this set of observation, and they were all made immediately follow- each other, I prefer giving them as a complete set for the purpose of illustration; they are contained in the following Table. The numbers in the first column indicate the points on the plate which coincided with the line joining the centres of the plate and needle, when the several observations of the directions of the north end of the needle were made. Of the letters at the *tops* of the columns, the *upper* ones indicate the direction of rotation of the *south*, or *upper edge* of the plate, with respect to the points in the horizon; and the *lower* ones, the direction of the *inner edge*, or that nearest the axis, with regard to the poles of the sphere; the letters at the bottoms of the columns indicate the direction of the *deviation* of the south end of the needle *due to rotation*.

VI. *Table of the deviations of a magnetic needle, caused by the* rotation *of a circular plate of* *meridian, and its plane in the plane of this seconda*

	Long. 0°. Lat. 0°.		Long. 0°. Lat. 10° S.		Long. 0°. Lat. 20° S.		Long. 0°. Lat. 30° S.		Long. 0°. Lat. 40° S.		Long. 0°. Lat. 45° S.		Lo La
Upper Edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to
Inner Edge.	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to
0	° ′ 2 10 E	° ′ 1 24 W	° ′ 5 24W	° ′ 8 46W	° ′ 13 00W	° ′ 16 10W	° ′ 19 16W	° ′ 21 30W	° ′ 21 50W	° ′ 23 08W	° ′ 21 44W	° ′ 22 30W	° 21 5
30	1 54	1 50	5 40	9 28	13 10	16 44	19 22	21 50	21 54	23 20	21 50	22 40	21 5
60	1 46	1 58	6 34	9 44	13 16	16 50	19 22	21 54	21 56	23 20	21 48	22 40	21 3
90	0 54	2 38	7 20	11 06	14 14	17 24	20 40	23 06	23 18	24 38	23 20	23 58	22 4
120	0 00	3 40	8 30	12 20	15 12	18 32	21 20	23 38	23 40	24 56	23 38	24 16	22 4
150	0 30 W	4 20	9 34	13 08	15 52	19 10	21 54	24 22	24 16	25 26	23 58	24 36	23 2
180	0 30	4 40	9 36	13 34	15 50	19 30	21 46	24 30	24 04	25 24	24 00	24 38	23 1
210	0 08	4 30	9 10	13 20	15 32	19 02	21 36	24 30	23 38	25 08	23 36	24 20	22 5
240	0 30 E	3 38	8 00	11 38	14 06	17 44	20 04	22 28	22 44	24 04	22 20	23 10	22 0
270	1 46	1 54	6 16	9 48	12 26	16 04	18 20	20 46	20 58	22 24	20 56	21 46	21 2
300	2 44	1 20	4 46	8 28	11 48	15 18	17 50	20 20	20 22	21 40	20 36	21 20	21 0
330	2 38	1 20	4 50	8 28	12 06	15 20	18 16	20 26	20 58	22 08	20 48	21 26	21 1
Mean Deviations.	0 56 1/6 E	2 46 W	7 08 1/3	10 49*	13 52 2/3	17 19	19 58 5/6	22 26 2/3	22 28 1/6	23 48	22 22 5/6	23 06 2/3	22 0
Direction of Deviation by rotation.	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to
Deviation due to rotation.	3° 42′ 1/6		3° 40′ 2/3		3° 26′ 1/3		2° 27′ 5/6		1° 19′ 5/6		0° 43′ 5/6		

	Long. 180°. Lat. 0°.		Long. 180°. Lat. 10° S.		Long. 180°. Lat. 20° S.		Long. 180°. Lat. 30° S.		Long. 180°. Lat. 40′ S.		Long. 180°. Lat. 45° S.		Lo La
Upper Edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to
Inner Edge.	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to
0	° ′ 1 30W	° ′ 5 04 W	° ′ 6 48 E	° ′ 3 36 E	° ′ 14 06 E	° ′ 10 50 E	° ′ 19 50 E	° ′ 17 24 E	° ′ 21 44 E	° ′ 20 10 E	° ′ 21 36 E	° ′ 20 50 E	° ′ 20 5
30	0 32	4 18	7 38	4 30	14 52	11 50	20 42	18 18	22 10	20 40	21 46	21 00	21 0
60	0 38 E	2 52	8 42	5 20	15 44	12 42	20 00	19 34	22 38	21 30	22 10	21 22	21 1
90	2 14	1 20	9 46	6 18	16 48	13 38	23 00	20 22	22 42	21 40	22 12	21 30	21 0
120	3 16	0 22	10 48	7 32	18 00	15 00	24 20	21 44	24 02	22 58	23 40	23 00	22 1
150	3 12	0 26	10 40	7 12	18 00	15 00	24 10	21 34	24 08	22 50	23 54	23 10	22 2
180	3 12	0 26	10 46	7 16	17 58	14 58	24 20	21 36	24 34	23 16	24 30	23 48	22 5
210	3 40	0 12	11 30	7 58	19 20	15 54	25 00	22 14	25 24	23 56	25 26	24 34	23 4
240	3 38	0 10	11 48	8 16	19 22	15 58	24 50	22 08	25 54	24 38	25 52	25 10	24 1
270	2 24	1 12	10 40	7 06	17 48	14 40	23 00	20 28	25 08	23 38	25 04	24 20	23 4

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late of iron, when its centre was in the secondary to the equator and secondary. Plate No. I.

	Long. 0°. Lat. 50° S.		Long. 0°. Lat. 60° S.		Long. 0°. Lat. 70° S.		Long. 0°. Lat. 80° S.		Lat. 90° S.	
o E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
o S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S		
' 30W	21° 52'W	22° 16'W	18° 18'W	18° 00'W	13° 22'W	12° 22'W	8° 20'W	6° 58'W	1° 46' W	0° 18' W
40	21 50	22 10	18 30	18 12	13 20	12 20	8 18	6 58	1 48	0 24
40	21 30	21 50	18 24	18 04	13 20	12 18	8 14	6 54	1 46	0 18
58	22 40	22 56	19 16	18 58	14 00	12 50	9 00	7 36	2 18	0 48
16	22 44	22 58	19 14	18 50	14 00	12 50	8 50	7 26	1 56	0 22
36	23 20	23 40	19 22	18 58	14 06	12 52	8 56	7 32	1 58	0 28
38	23 18	23 38	19 18	18 56	14 00	12 52	8 52	7 36	1 42	0 20
20	22 56	23 16	18 46	18 30	13 42	12 46	8 24	7 08	1 24	0 00
10	22 08	22 30	18 00	17 42	13 10	12 18	7 50	6 38	0 54	0 38 E
46	21 20	21 42	17 10	16 50	12 56	11 48	7 36	6 10	0 50	0 44
20	21 06	21 26	16 54	16 38	12 56	11 46	7 38	6 12	0 50	0 40
26	21 10	21 26	17 18	16 52	13 10	11 50	7 44	6 18	1 28	0 18
06 ⅔	22 09 ½	22 19	18 22 ½	18 02 ½	13 30 ⅙	12 24 ⅙	8 18 ½	6 57 ⅙	1 32 ⅔ W	0 03 ⅙ W
E	S to W	S to E	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W
	0° 19'½		—0° 20'		—1° 06'		—1° 21 ⅓		—1° 29'½	

.	Long. 180°. Lat. 50° S.		Long. 180°. Lat. 60° S.		Long. 180°. Lat. 70° S.		Long. 180°. Lat. 80° S.			
o E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E		
N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N		
o E	20° 58' E	20° 38' E	17° 26' E	17° 48' E	11° 42' E	12° 48' E	5° 34' E	6° 52' E		
o	21 00	20 40	17 26	17 46	11 42	12 48	5 36	6 50		
2	21 10	20 52	17 36	18 00	12 00	12 56	5 38	6 56		
o	21 00	20 42	17 22	17 48	11 32	12 34	5 08	5 28		
o	22 18	22 02	18 16	18 40	12 08	13 10	5 34	6 58		
o	22 24	22 08	18 16	18 40	12 04	13 08	5 30	6 50		
8	22 50	22 32	18 38	19 04	12 22	13 20	3 44	7 00		
4	23 40	23 20	19 12	19 36	12 50	13 58	6 08	7 20		
o	24 12	23 52	19 46	20 08	13 20	14 22	6 40	8 00		
o	23 42	23 22	19 22	19 50	13 12	14 18	6 38	8 00		

240	3 38	0 10	11 48	8 16	19 22	15 58	24 50	22 08	25 54	24 38	25 52	25 10	24 1
270	2 24	1 12	10 40	7 06	17 48	14 40	23 00	20 28	25 08	23 38	25 04	24 20	23 4
300	0 42	2 52	9 10	5 40	16 52	13 26	21 42	19 34	24 06	22 36	24 00	23 18	23 1
330	0 50 W	4 28 W	7 40	4 14	15 18	11 40	20 22	18 02	22 56	21 18	22 40	21 56	22 0
Mean Deviations.	1 45 $\frac{1}{3}$ E	1 58 $\frac{1}{2}$ W	9 39 $\frac{2}{3}$	6 14 $\frac{5}{6}$	17 00 $\frac{2}{3}$	13 48	22 46 $\frac{1}{3}$	20 14 $\frac{5}{6}$	23 47 $\frac{1}{6}$	22 25 $\frac{5}{6}$	23 34 $\frac{1}{6}$	22 49 $\frac{5}{6}$	22 2
Direction of Deviation by rotatiou.	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to
Deviation due to rotation.	3° 43′ $\frac{5}{6}$		3° 24′ $\frac{5}{6}$		3° 12′ $\frac{2}{3}$		2° 31′ $\frac{1}{2}$		1° 21′ $\frac{1}{3}$		0° 44′ $\frac{1}{3}$		

* In adjusting the compass for the observations in long. 0°, lat. 10° and lat. 0°, the north end of the needle pointed 50 westerly, and added to the easterly deviations. A similar error of 30′ W was made in the adjustment for lat. 80°, lon *rotation;* but the *absolute deviations* must be increased when east, and diminished when west.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]		
0	24 12	23 52	19 46	20 08	13 20	14 22	6 40	8 00		
0	23 42	23 22	19 22	19 50	13 12	14 18	6 38	8 00		
3	23 10	22 48	19 00	19 26	12 50	14 06	6 30	7 52		
5	22 00	21 38	18 18	18 40	12 28	13 36	6 14	7 34		
9 $\frac{5}{6}$	22 22	22 02 $\frac{5}{6}$	18 23 $\frac{1}{6}$	18 47 $\frac{1}{6}$	12 20 $\frac{5}{6}$	13 25 $\frac{1}{3}$	5 54 $\frac{1}{2}$	7 08 $\frac{1}{3}$*		
E	S to W	S to E	S to E	S to W	S to E	S to W	S to E	S to W		
	0° 19′ $\frac{1}{6}$		—0° 24′		—1° 04 $\frac{1}{2}$		—1° 13 $\frac{5}{6}$			

ointed 50′ W of zero in the box, and consequently 50′ should be subtracted from the 80°, long. 180° and long. 0°, and lat. 90°. These will not affect the *deviations due to*

It appears, from these observations, that, when the plate revolves in the plane of a secondary to the equator and meridian,

1st. The deviation due to rotation is a maximum when the centre of the plate is in the equator.

2d. It decreases as the plate approaches the pole, and is o between the latitudes 50° and 60°, apparently very nearly at 55°; and from this point it increases till it attains a maximum in a contrary direction at the pole.

3d. At the south pole and on each side down to the latitude 55°, the deviation of the *south* end of the needle, due to rotation, is in the direction of the *north*, or *lower* edge of the plate: or, from the *south pole* down to the latitude 55°, the *south* end of the needle moves *towards* the plate, when the *inner* edge of the plate moves *from* the *south* pole, and *from* the plate when the *inner* edge moves towards the *south* pole.

4th. From the equator towards either pole as far nearly as the latitude 55°, the *south* end of the needle moves in the direction of the *south* edge of the plate; that is, it moves *towards* the plate when the *inner* edge of the plate moves *towards* the *south* pole, and *from* the plate, when that edge moves *from* the *south* pole; also the *north* end of the needle moves *towards* the plate, when the *inner* edge moves *towards* the *north* pole, and *from* the plate, when that edge moves *from* the *north* pole. Consequently towards whichever pole the *inner* edge moves, the corresponding end of the needle will move *towards* the plate from the equator to the latitude of 55° nearly, and the contrary will take place from the latitude 55° to the pole.

The observations which I made with the plate on the north side of the equator, though not so multiplied as those on the south, were sufficient to show, that the deviations due to rotation observed the same laws on that side of the equator as I had noticed on the south side.

The *deviation due to the rotation of the plate*, when its centre is in the secondary to the equator and meridian, having a peculiar character, namely, two greater maxima when the centre is in the equator, two less maxima, in a contrary direction, when the centre is in either pole, and four points where it vanishes, I consider to be particularly well adapted for forming an estimate of the correctness of any theory which may be adopted for the explanation of the phænomena in general; since the theory must be perfectly compatible with these peculiarities, before it can be applied to the explanation of the less marked phænomena.

As it appeared from these observations, that the point where the deviation due to rotation vanishes, is not far from lat. 55°, the complement of which, 35°, is nearly half the angle of the dip, I wished to ascertain whether the deviation were really 0 in latitude 54° 45′, which I considered to be correctly the complement of half the dip 70° 30′, although I could not see how the angle which the plane makes with the horizon could have an influence on an angle in the plane itself. The following observations show, that in this instance the deviation due to rotation vanishes, or nearly so, when the polar distance of the centre of the plate is equal to half the angle which the dipping needle makes with the horizon. Whether this coincidence is purely accidental, or is a necessary consequence of the manner in which the effect is produced, must remain doubtful, until it can be shown how the action takes place; it, however, led me to ascertain precisely the point at which the deviation due to rotation vanishes

VII. *Table of the deviations of a magnetic needle caused by the* rotation *of a circular plate of iron when the centre and plane of the plate were in the secondary to the meridian and equator, and its centre in latitude* 54° 45′.

	Lat. 54° 45′ S.				Lat. 54° 45′ N.			
	Long. 180°.		Long. 0°		Long. 180°.		Long. 0°.	
Upper Edge.	E to W	W to E	W to E	E to W	W to E	E to W	E to W	W to E
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
0	20 42 E	20 42 E	20 44 W	20 44 W	21 36 W	21 40 W	19 56 E	19 56 E
30	20 30	20 32	19 50	19 50	21 10	21 10	20 18	20 20
60	19 54	19 56	19 30	19 28	20 50	20 50	20 44	20 44
90	19 18	19 20	20 26	20 24	20 16	20 18	20 56	20 58
120	19 50	19 52	20 50	20 46	20 24	20 22	20 48	20 50
150	19 38	19 38	21 42	21 46	19 52	19 50	20 34	20 36
180	20 16	20 16	22 22	22 24	19 46	19 44	19 50	19 50
210	21 30	21 26	22 22	22 20	19 24	19 20	19 40	19 40
240	22 32	22 32	21 34	21 34	19 28	19 28	19 09	19 08
270	22 26	22 28	20 42	20 42	20 28	20 30	19 58	19 00
300	22 02	22 04	20 30	20 30	21 10	21 10	19 38	19 38
330	21 26	21 26	20 36	20 36	21 12	21 18	20 00	20 02
Mean Deviations.	20 50 $\frac{1}{3}$	20 51	20 55 $\frac{2}{3}$	20 55 $\frac{1}{3}$	20 28	20 28 $\frac{1}{3}$	20 02 $\frac{1}{2}$	20 03 $\frac{1}{2}$
Deviation due to rotation.	— 0° 00$\frac{2}{3}$′		+ 0° 00′$\frac{1}{3}$		— 0° 00$\frac{1}{3}$′		— 0° 01′	

General law of the deviation due to rotation *deduced from the experiments.*

Having now ascertained the nature of the effects produced on the horizontal needle by the rotation of the plate in different planes, I endeavoured to discover some general law, according to which the direction of the deviation depended on the direction of the rotation of the plate; so that the situation of the centre of the plate, the plane in which it revolved, and the direction of rotation being given, we might point out immediately the direction in which the deviation would take place.

On comparing together all the facts which I have detailed, I found that this might be effected in the following manner. I refer the deviations of the horizontal needle to the deviations of magnetic particles in the direction of the dip, or to those of a dipping needle passing through its centre; so that, in whatever direction this imaginary dipping needle would deviate by the action of the iron, the horizontal needle would deviate in such a manner as to be in the same vertical plane with it: thus, when the north end of the horizontal needle deviates towards the west, and consequently the south end towards the east, I consider that it has obeyed the deviation of the axis of the imaginary dipping needle, whose northern extremity has deviated towards the west and its southern towards the east; so that the western side of the equator of this dipping needle has deviated towards the south pole of the sphere, and its eastern side towards the north pole. It would follow from this, that if the north and south sides of the equator of the dipping needle (referring to these points in the horizon) deviated towards the poles, no corresponding deviation would be observed in the horizontal needle; the effect, in this case, taking place in the meridian, would only be observable in the angle which the dipping needle made with the horizon. As it is not my intention at present to advance any hypothesis on the subject, I wish this to be considered only as a method of connecting all the phænomena under one general view. Assuming it then for this purpose, it will be found that the *deviations of the horizontal needle due* *to rotation* are always such as would be produced *by the sides of the equator of this imaginary dipping needle deviating in directions contrary to the directions in which the edges of the plate move*, that edge of the plate nearest to either edge of the equator producing the greatest effect on it. By referring to the particular laws which I deduced at the time of making the experiments in different planes, it will be seen that they are all comprised under this general law; but this will be rendered more evident by taking an instance.

When the centre of the plate is in the meridian, and its plane a tangent to the sphere, the eastern side of the equator of the imaginary dipping needle, according to the above law, will deviate in a direction contrary to that of the motion of the eastern edge of the plate, and consequently the northern extremity of the axis will deviate in a contrary direction to that of the motion of the plate's northern edge, or it will deviate in the direction in which the southern edge of the plate moves. Hence the horizontal needle obeying the deviations of this dipping needle, the deviations of its north end due to the rotation of the plate will be in the direction in which the south edge of the plate moves, which is the law deduced from the experiments, Table I.

Experiments with the dipping needle.

Having found, in all the experiments which I have described, that the effects produced on the horizontal needle depended on the situation of the plate with respect to the axis and equator of an imaginary dipping needle passing through the centre of the horizontal needle, my next experiments were undertaken with the view of ascertaining whether the effects produced by the rotation of the plate on the dipping needle itself corresponded with those which I had observed on the horizontal needle. In making these it was necessary to adjust the dipping needle on a stand detached from the instrument, on the arm of which the iron plate revolved, on account of the diameter of the case of the dipping needle being greater than the distance *s n* (fig. 1). It was therefore only in particular positions that I could observe the deviation caused by the rotation of the plate. This however was of the less importance, since, as I expected that the deviations of the dipping needle would be less than those of the horizontal needle nearly in the ratio of sin. 19° 30′ to 1, it was only in the cases in which they were the greatest that I was likely to have been able to observe them.

As the dipping needle, when in the position of the dip, could only vibrate in the plane of the meridian, no effect corresponding to the deviations of the horizontal needle could be observed, either when the centre of the plate was in the intersection of the meridian and equator, and its plane perpendicular to the planes of these circles, or when the centre of the plate was in the secondary to the meridian and equator, and its plane in the plane of this secondary. In order therefore to ascertain the deviations of a needle suspended freely by its centre of gravity, corresponding to those of an horizontal needle, when the plate had those positions, and which I considered to be the principal points to be determined, it was necessary to observe the effect produced on the dipping needle when the centre of the plate was in the equator and exactly east or west of the centre of the needle, and its plane parallel to the plane of vibration of the needle; and also when its centre and plane were in the plane of vibration.

In making these observations, the instrument was adjusted as in fig. 1, the compass being however removed; the indexes at o, o′ were brought to Æ, æ, on the moveable limb, and that limb was placed at right angles to the fixed limb, so that the plane of the plate was parallel to the magnetic meridian. The dipping needle was then placed as nearly as possible in the required position, and the levels being carefully adjusted, the needle was made to vibrate freely and left to settle. After the plate had been made to revolve several times in the same direction, the point marked o was brought to coincide with the upper part of a line parallel to the magnetic axis, and passing through the centre of the plate. The needle was then slightly agitated, or made to vibrate through a small arc; and when it settled, the dip was noted both at the upper and lower extremity, or the south and north end of the needle. This was repeated for the points marked 60, 120, 180, 240, 300. The plate was now made to revolve in the contrary direction, and similar observations made of the dip of the needle when the several points 300, 240, 180, 120, 60, o, coincided with the upper part of the line parallel to the magnetic axis. Continuing the revolution of the plate in this direction, a second set of observations of the dip were made for the several points from 300 to o. After this, the plate was again made to revolve in its first direction, and a second set of observations made of the dip for the points from o to 300. I considered the mean of all the observations in the two sets, when the plate revolved from o to 300, as the mean dip when the plate revolved in this direction; the mean of all the observations in the two sets, when the plate revolved from 300 to o, as the mean dip when the plate revolved in this direction; and the difference between these mean dips as the *deviation due to the rotation* of the plate.

As I had experienced that the dipping needle, even when of the best construction, was an instrument from which accurate results could only be obtained by taking a mean of a great number of observations, I was aware that, by making only two for each point of the plate, I was liable to an error in the observations for each point taken separately, but this I considered would be counteracted in taking the mean for all the points; so that the mean results could not err far from the truth. The dipping needle which I made use of was a very good instrument, by JONES, of Charing Cross: the needle, made according to Captain KATER's construction, consisted of two arcs of a circle; its length was 7 inches. The plate was the same I had used in the experiments with the horizontal needle.

For the better distinguishing of the edges of the plate and the direction of its rotation, I conceive two planes at right angles to each other to pass through its centre; one, the plane of the equator or a plane parallel to it, which I call the equatorial plane; the other, the plane of the secondary to the equator and meridian, or a plane parallel to this secondary, which I call the plane of or parallel to the axis. The intersections of the first plane with the edges of the plate, I call the equatorial north and south edges; and the intersections of the second, the polar north and south edges.

In the following table, the numbers in the first column indicate the point on the plate which was in the polar south; the inclinations of the needle corresponding to these positions of the plate are in the following columns, which are in pairs, the one showing the inclination indicated by the southern extremity of the needle, the other, that by the northern. Above the pairs of columns, is indicated the direction in which the upper or polar south edge of the plate revolved, with reference to the points in the equator, and also the direction in which the equatorial south edge of the plate revolved with reference to the polar points in the plane of the axis. Under the columns, are the mean inclinations of the needle when the plate revolved in opposite directions, and below these, the mean deviation due to rotation.

VIII. *Table of the inclinations of the dipping needle when the centre of the plate was in longitude 0°, latitude 0°, and its plane parallel to the meridian; so that the axis of rotation of the plate was the same as the axis of vibration of the needle: the distance of the centre of the plate from that of the needle being 9.5 inches.* ***Plate No.*** **I.**

Points on the Plate coinciding with the Polar South.	Polar South edge of the Plate to Equatorial North, or Equatorial South edge to Polar South.				Polar South edge of the Plate to Equatorial South, or Equatorial South edge to Polar North.			
	First Set.		Seeond Set.		First Set.		Second Set.	
	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.
	° '	° '	° '	° '	° '	° '	° '	° '
0	70 30	70 45	70 30	70 20	71 40	71 35	71 25	71 20
60	70 10	70 25	70 3c	70 20	71 45	71 40	71 05	71 00
120	70 45	71 00	70 25	70 15	71 25	71 20	71 05	71 00
180	70 40	70 55	70 25	70 20	71 00	70 55	72 00	70 55
240	70 55	71 10	70 40	70 30	71 30	71 20	71 20	71 15
300	71 05	71 20	70 45	70 35	71 30	72 00	71 05	71 00
Mean dip.	78° 38′				71° 18′			
Mean deviation due to rotation.	0° 40′							

From these observations it appears that, in this position of the plate, the *deviation* of the *upper*, or *south* end of the needle, *due to rotation*, was in the direction in which the *north* or *lower* edge of the plate revolved, and the deviation of the *north* or *lower* end of the needle, in the direction of the rotation of the *upper* or *south* edge of the plate. It would follow from this, that if a needle could be suspended freely by its centre of gravity, and the centre of the plate were in longitude 90°, latitude 0°, and its plane at right angles to the meridian; then also, the *deviation* of the *south* end of the needle *due to rotation*, would be in the direction of the *north* or *lower* edge of the plate, and the deviation of the *north* end, in the direction in which the *south* or *upper* edge revolved; which are precisely the directions of the deviations of the horizontal needle in this position of the plate. (See Table I.)

The law which I have shown to obtain in all the experiments on the horizontal needle, viz. that the sides of the equator of the imaginary dipping needle always deviated in directions contrary to those in which the corresponding edges of the plate moved, I had derived previously to having an opportunity of making any experiments with the dipping needle: a comparison of the above results with this law will more fully illustrate its nature, and at the same time show their perfect accordance. In making this comparison, it is necessary to notice that, an *increase* of the dip of the needle, corresponds to a deviation of the *southern* edge of its equator towards the *south* pole, and of the *northern* edge towards the *north* pole; and on the contrary, a *diminution* of the dip corresponds to a deviation of the *southern* edge of the equator towards the *north* pole, and of the *northern* edge towards the *south* pole. Now, when the equatorial *south* edge of the plate revolved towards the polar *south*, and consequently the equatorial *north* edge towards the *polar* north, the inclination of the needle was *diminished* by the rotation; that is, the *south* edge of its equator deviated towards the *north* pole, and the *north* edge of its equator towards the *south* pole; or *the edges of the equator, by the rotation of the plate, deviated in directions contrary to those in which the edges of the plate moved.* The same conclusion evidently follows from the observations when the equatorial south edge of the plate revolved towards the polar north, the dip being here increased by the rotation of the plate.

The next observations which I made, were of the inclinations of the dipping needle, when the plane of the plate was in the plane of the meridian or plane of vibration of the dipping needle.

IX. ***Table of the inclinations of the dipping needle, when the centre of the plate was in longitude 90°, latitude 0°, and its plane in the plane of the meridian, or plane of vibration of the dipping needle; the distance of the centre of the plate from that of the needle being 13.3 inches. Plate No. I.***

Points on the Plate coinciding with the Polar South.	Polar South edge of the Plate to Equatorial North, or Equatorial South edge to Polar South.				Polar South edge of the Plate to equatorial South, or Equatorial South edge to Polar North.			
	First Set.		Second Set.		First Set.		Second Set.	
	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
0	70 25	70 35	70 45	70 30	69 40	69 35	69 35	69 15
60	69 50	70 05	70 15	70 05	69 20	69 15	69 30	69 20
120	69 50	70 00	69 55	69 50	68 55	68 55	69 00	68 45
180	70 45	70 55	70 35	70 25	69 35	69 40	69 35	69 25
240	70 55	71 05	70 50	70 40	69 30	69 35	69 20	69 10
300	70 40	70 50	70 30	70 15	69 35	69 40	69 30	69 20
Mean dip	70° 26′ $\frac{1}{4}$				69° 22′ $\frac{1}{2}$			
Mean deviation due to rotation.	1° 04′							

From these observations it appears that, the plane of the plate being in the plane of vibration of the needle, and its centre in the equator, the *deviation* of the *upper* or *south* end of the needle, *due to rotation,* was in the direction of the rotation of the *upper* or *south* edge of the plate, and of the north end in that of the *north* edge; and we may therefore conclude, that if a needle could be freely suspended by its centre of gravity, and the centre of the plate were in the equator, and its plane in that of the secondary to the meridian and equator, the *deviation* of the *south* end, *due to rotation,* would be in the direction in which the *south* edge of the plate revolved, and of the *north* end, in that in which the *north* edge revolved; which, again are precisely the directions in which we have seen, that the horizontal needle deviated by the rotation of the plate in this position.

X. *Table of the inclinations of the dipping needle, when the centre of the plate was in latitude* 90° *South, and its plane in the plane of the meridian, or plane of vibration of the dipping needle; the distance of the centre of the plate from that of the needle being* 13.3 *inches. Plate No. I.*

Points on the Plate coinciding with the Polar South.	Polar South edge of the Plate to Equatorial North, or Equatorial South edge to Polar South.				Polar South edge of the Plate to Equatorial South, or Equatorial South edge to Polar North.			
	First Set.		Second Set.		First Set.		Second Set.	
	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.	S. end.	N. end.
	° ′	° ′	° ′	° ′	° ′	° ′	° ′	° ′
0	71 05	71 05	71 35	71 30	71 40	71 40	71 50	71 40
60	71 00	71 10	71 10	71 05	71 35	71 15	71 35	71 25
120	71 10	71 15	71 25	71 25	71 40	71 30	72 15	72 05
180	71 40	71 45	71 35	71 40	72 00	71 50	72 30	72 20
240	71 40	71 45	71 30	71 35	72 05	72 05	72 15	72 05
300	71 05	71 10	71 25	71 35	71 40	71 55	72 00	71 55
Mean dip.	71° 23′ 1/3*				71° 52′ 1/12			
Mean deviation due to rotation.	0° 29′							

* In these observations the edge of the iron plate was not an inch from the south end of the needle; so that a very small error in the position of the plate's centre will account for the dip in *both* directions of rotation being *greater* than 70° 15′, the true dip.

Here, contrary to what took place when the centre of the plate was in the equator, the deviation of the *south* end of the needle is in the direction in which the *lower* or *north* edge of the plate revolved; and we may therefore infer, that the same would be the case if a needle were suspended freely by its centre of gravity, and the plane of the plate were in the plane of the secondary to the meridian and equator, its centre being in latitude 90° S: which also agrees exactly with the directions of the deviation of the horizontal needle, due to rotation, in this position of the plate.

It is evident from these different experiments with the dipping needle, that whatever may be the peculiar effects produced on the iron by its rotation, the *deviations* of the horizontal needle, *due to the rotation,* are of the same nature as those that would arise by referring the deviations of the dipping needle to the horizontal plane.

Further observations with the horizontal needle.

Although, in order to point out the particular laws according to which the rotation of the iron causes the needle to deviate in particular situations of the plate, and to deduce a general law by which the direction of the deviation might in all cases be determined from the direction of rotation, I have been under the necessity of entering into such a detail of the experiments, as has already extended this paper beyond the limits to which I wished to confine it, I yet think it may not be uninteresting to enquire, how far the adoption of particular hypotheses may enable us to account for the several phænomena which I have observed.

I have already stated, that I considered that the deviations arising from the rotation of the plate, when its centre and plane are in the secondary to the equator and meridian, are those best adapted for forming a comparison with the results obtained from theory. In Table VI. I have given a series of such observed deviations; but as I was not quite satisfied that in making these observations there had not been some small inaccuracies in the different adjustments, when the centre of the plate was near the equator and when near the pole, I should not on this ground have considered a comparison with them as altogether conclusive with respect to the correctness of any theory. In repeating these experiments, I increased the distance of the centre of the plate from that of the needle, as, in order to simplify the calculations, it would be necessary to neglect certain terms, which would be the greater the less was this distance, and consequently if it were increased, the neglecting these terms would the less affect the results of the calculation as compared with the observations. The following Table contains a series of observations similar to those in Table VI, but having the centre of the plate removed to the distance 16 inches from the centre of the needle. In making them, the most scrupulous attention was paid to the different adjustments, so that I can place entire confidence in the results.

Table of the deviations of a magnetic needle, caused by a circular plate of iron, whose centre w in the plane of this secondary, the plate having revolved in opposite directions; the distance 16 *inches. Plate No. I.*

Latitude and Longitude of the plate's centre.		Lat. 0°.		Lat. 10° S.		Lat. 20° S.		Lat. 30° S.		Lat. 40° S.		Lat. 50° S.		La
		Long. 0°		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Lo
Direction of rotation of plate's upper edge.		W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W t
Points on the plate coinciding with the line joining the centres of the needle and the plate.	0	° ′ 1 02W	° ′ 0 32 E	° ′ 4 50W	° ′ 3 20W	° ′ 7 46W	° ′ 6 30W	° ′ 9 38W	° ′ 8 42W	° ′ 10 28W	° ′ 9 54W	° ′ 10 38W	° ′ 10 28W	° 10
	30	1 02	0 36	4 24	2 52	7 10	5 52	9 04	8 04	10 00	9 22	9 42	9 32	9
	60	0 58	0 40	4 04	2 32	6 38	5 22	8 38	7 38	9 38	9 00	8 56	8 46	8
	90	0 44	0 54	3 36	2 04	6 10	4 52	8 12	7 10	9 16	8 36	8 18	8 08	8
	120	0 46	0 52	3 32	2 02	6 12	4 56	8 18	7 18	9 22	8 42	8 18	8 06	8
	150	1 06	0 30	3 50	2 22	6 34	5 20	8 42	7 44	9 44	9 08	8 36	8 30	8
	180	1 14	0 26	4 06	2 34	6 58	5 40	9 04	8 02	10 04	9 30	9 02	8 52	9
	210	0 52	0 50	4 04	2 30	7 02	5 44	9 08	8 08	10 12	9 34	9 28	9 18	9
	240	0 34	1 04	4 02	2 30	7 10	5 52	9 16	8 14	10 16	9 38	9 58	9 52	9
	270	0 22	1 12	4 10	2 38	7 18	6 00	9 24	8 24	10 26	9 50	10 34	10 26	10
	300	0 26	1 06	4 26	2 56	7 34	6 20	9 40	8 38	10 36	10 00	11 04	10 56	10
	330	0 46	0 42	4 42	3 14	7 48	6 34	9 46	8 50	10 38	10 06	11 04	10 56	10
Mean deviations.		0 49⅓	0 47	4 08⅚	2 37⅚	7 01⅔	5 45⅙	9 04⅙	8 04⅓	10 03⅓	9 26⅔	9 38⅙	9 29⅙	9
Deviations due to rotation.		1° 36′⅓		1° 31′		1° 16′½		0° 59′⅚		0° 36′⅔		0° 09′		
		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		
Direction of rotation of plate's upper edge.		E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to
Points on the plate coinciding with the line joining the centres of the needle and the plate.	0	° ′ 1 20 E	° ′ 0 14W	° ′ 4 08 E	° ′ 2 38 E	° ′ 7 16 E	° ′ 5 58 E	° ′ 9 30 E	° ′ 8 30 E	° ′ 10 16 E	° ′ 9 38 E	° ′ 10 42 E	° ′ 10 32 E	° 10
	30	1 10	0 26	3 52	2 20	7 00	5 42	9 16	8 14	10 10	9 32	10 40	10 30	10
	60	0 58	0 40	3 38	2 06	6 46	5 26	9 00	8 00	9 54	9 16	10 12	10 02	10
	90	0 28	1 10	3 16	1 44	6 22	5 06	8 32	7 36	9 28	8 56	9 32	9 22	9
	120	0 12	1 22	3 06	1 36	6 10	4 56	8 18	7 20	9 14	8 40	8 46	8 38	8
	150	0 08	1 22	3 14	1 44	6 18	5 00	8 26	7 26	9 16	8 40	8 24	8 14	8
	180	0 18	1 18	3 28	1 56	6 30	5 14	8 44	7 42	9 32	8 52	8 20	8 08	7
	210	0 32	1 06	3 46	2 16	6 56	5 36	9 00	8 00	9 44	9 04	8 26	8 12	8
	240	0 52	0 46	4 02	2 30	7 10	5 52	9 18	8 18	9 56	9 18	8 42	8 30	8
	270	1 00	0 36	4 08	2 38	7 14	5 56	9 22	8 24	9 56	9 20	9 02	8 52	8
	300	1 18	0 18	4 18	2 50	7 24	6 06	9 32	8 32	10 08	9 32	9 44	8 32	9
	330	1 18	0 10	4 14	2 48	7 22	6 06	9 34	8 36	10 18	9 40	10 24	10 12	9

entre was in the secondary to the equator and meridian, and plane
istance of the centre of the plate from the centre of the needle being

	Lat. 54° 45′ S.		Lat. 60° S.		Lat. 70° S.		Lat. 80° S.		Lat. 90° S.	
	Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.			
W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W
′ 28W	° ′ 10 08W	° ′ 10 08W	° ′ 8 48W	° ′ 9 00W	° ′ 6 52W	° ′ 7 18W	° ′ 3 54W	° ′ 4 34W	° ′ 0 40 W	° ′ 1 24 W
32	9 18	9 18	7 56	8 06	6 54	7 20	3 48	4 26	0 24 W	1 08 W
46	8 46	8 46	7 24	7 32	6 50	7 16	3 44	4 18	0 18 W	0 56 W
08	8 20	8 20	6 52	7 02	6 36	7 02	3 20	4 02	0 08 E	0 36 W
06	8 26	8 24	6 58	7 12	6 20	6 48	3 02	3 48	0 26 E	0 24 W
30	8 40	8 42	7 22	7 36	5 56	6 28	2 40	3 24	0 46 E	0 02 W
52	9 00	9 02	7 48	8 00	5 26	5 56	2 18	2 58	1 08 E	0 22 E
18	9 18	9 16	8 10	8 24	5 00	5 26	2 00	2 38	1 16 E	0 28 E
52	9 42	9 42	8 36	8 48	4 48	5 18	2 02	2 40	1 08 E	0 22 E
26	10 14	10 14	9 06	9 18	5 00	5 28	2 20	3 00	0 42 E	0 06 W
56	10 36	10 40	9 28	9 38	5 32	6 02	2 54	3 34	0 06 E	0 38 W
56	10 34	10 36	9 16	9 30	6 14	6 42	3 28	4 06	0 24 W	1 04 W
29 $\frac{1}{6}$	9 25 $\frac{1}{6}$	9 25 $\frac{2}{3}$	8 08 $\frac{2}{8}$	8 20 $\frac{1}{2}$	5 57 $\frac{1}{3}$	6 25 $\frac{1}{3}$	2 57 $\frac{1}{2}$	3 37 $\frac{1}{3}$	0 19 $\frac{1}{2}$ E	0 25 $\frac{1}{2}$ W
	— 0° 00′ $\frac{1}{2}$		— 0° 11′ $\frac{5}{6}$		— 0° 28′		— 0° 39′ $\frac{5}{6}$		— 0 45	

.	Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Lat. 90° N.	
E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
′ 52 E	° ′ 10 06 E	° ′ 10 06 E	° ′ 9 06 E	° ′ 9 18 E	° ′ 4 46 E	° ′ 5 12 E	° ′ 1 44 E	° ′ 2 24 E	° ′ 0 16W	° ′ 0 26 E
0	10 06	10 06	9 14	9 24	5 16	5 40	2 08	2 44	0 14	0 30
2	10 40	9 40	8 52	9 04	5 42	6 10	2 28	3 06	0 10	0 34
2	9 02	9 02	8 20	8 32	6 08	6 38	2 50	3 24	0 16	0 30
8	8 20	8 20	7 38	7 50	6 24	6 56	3 04	3 50	0 06	0 42
4	8 00	7 58	7 14	7 24	6 36	7 06	3 24	4 06	0 14	0 32
8	7 56	7 54	7 08	7 16	6 40	7 08	3 38	4 18	0 32	0 14
2	8 02	7 58	7 10	7 18	6 32	6 58	3 38	4 16	0 34	0 10
0	8 12	8 12	7 20	7 28	6 04	6 32	3 18	3 58	0 32	0 10
2	8 28	8 28	7 32	7 42	5 26	5 56	2 46	3 26	0 34	0 12
2	9 04	9 04	8 04	8 14	4 56	5 24	2 14	2 54	0 26	0 18
2	9 44	9 42	8 44	8 54	4 40	5 08	1 52	2 32	0 16	0 28

Poi	300	1 18	0 18	4 18	2 50	7 24	6 06	9 32	8 32	10 08	9 32	9 44	8 32	9
	330	1 18	0 10	4 14	2 48	7 22	6 06	9 34	8 36	10 18	9 40	10 24	10 12	9 4
Mean deviations.		0 47 $\frac{5}{6}$	0 47 $\frac{1}{3}$	3 45 $\frac{5}{6}$	2 15 $\frac{1}{2}$	6 52 $\frac{1}{3}$	5 34 $\frac{5}{6}$	9 02 $\frac{2}{3}$	8 03 $\frac{1}{6}$	9 49 $\frac{1}{3}$	9 12 $\frac{1}{3}$	9 24 $\frac{1}{2}$	9 13 $\frac{2}{3}$	8 5
Deviation due to rotation.		1° 35′ $\frac{1}{6}$		1° 30′ $\frac{1}{3}$		1° 17′ $\frac{1}{2}$		0° 59′ $\frac{1}{2}$		0° 37′		0° 10′ $\frac{5}{6}$		

2	9 04	9 04	8 04	8 14	4 50	5 24	2 14	2 54	0 20	0 1[illegible]
2	9 44	9 42	8 44	8 54	4 40	5 08	1 52	2 32	0 16	0 28
3 $\frac{2}{3}$	8 53 $\frac{1}{3}$	8 52 $\frac{1}{2}$	8 01 $\frac{5}{6}$	8 12	5 45 $\frac{5}{6}$	6 14	2 45 $\frac{1}{3}$	3 25 $\frac{2}{3}$	0 20 $\frac{5}{6}$	0 23 $\frac{5}{6}$
	+ 0° 00′ $\frac{5}{6}$		− 0° 10′ $\frac{1}{6}$		− 0° 28′ $\frac{1}{6}$		− 0° 40′ $\frac{1}{3}$		− 0 44 $\frac{2}{3}$	

Considering the centre of the plate to have been in longitude 180°, and consequently the
of the deviations in the several latitudes, I obtain the following.

A. *Table of the easterly deviations of the needle, when the centre of the plate was in long*
in opposite directions.

Latitude of the plate's centre.	0°		10°		20°		30°		40°		50°	
Direction of rotation of plate's upper edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W t
Deviation East.	+47′ 55″	−47′ 55″	3° 57′ 20″	2° 26′ 40″	6° 57′ 00″	5° 40′ 00″	9° 03′ 25″	8° 03′ 45″	9° 56′ 20″	9° 19′ 30″	9° 31′ 20″	9° 2
Deviation due to rotation.	1° 35′ 50″		1° 30′ 40″		1° 17′ 00		0° 59′ 40″		0° 36′ 50″		0° 09′ 55″	

Two sets of observations which I had made more than two years before, had given me t
deviations might have been affected by the proximity of a mass of iron, of which I was not
to repeat them in a situation where no such influence could be exerted, although I did not

B. *Table of the mean easterly deviations of the needle, when the centre of the plate was in longitu*
directions; deduced from two sets of observations made in

Latitude of the plate's centre.	0°		10°		20°		30°		40°		50°	
Direction of rotation of plate's upper edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W
Deviation East. 1st Set.	+50′ 25″	−50′ 25″	4° 35′ 55″	3° 00′ 55″	7° 39′ 25″	6° 19′ 00″	10° 07′ 10″	9° 04′ 20″	11° 11′ 15″	10° 33′ 00″	10° 48′ 55″	10° 3
Deviation East. 2d Set.	+50 32	−50 32	4 25 45	2 48 50	7 36 45	6 11 55	10 08 30	9 02 05	10 53 10	10 14 15	10 40 55	10 2
Mean deviation East.	+50 28	−50 28	4 30 50	2 54 32	7 38 05	6 15 27	10 07 50	9 03 12	11 02 12	10 23 37	10 44 55	10 3
Mean deviation due to rotation.	1° 40′ 56″		1° 35′ 58″		1° 22′ 38″		1° 04′ 38″		0° 38′ 35		0° 12′ 20′	

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ıtly the deviations easterly in all the observations, and thus taking a mean

; in longitude 180°, *or to the west of the needle, the plate having revolved*
ctions.

50°		54° 45′		60°		70°		80°		90°	
›W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
′ ″ 1 20	° ′ ″ 9 21 25	° ′ ″ 9 09 15	° ′ ″ 9 09 05	° ′ ″ 8 05 15	° ′ ″ 8 16 15	° ′ ″ 5 51 35	° ′ ″ 6 19 40	° ′ ″ 2 51 25	° ′ ″ 3 31 30	′ ″ −22 25	′ ″ +22 25
₎° 09′ 55″		0° 00′ 10″		−0° 11′ 00″		−0° 28′ 05″		−0° 40′ 05″		−0° 44′ 50″	

en me the following results; but as I afterwards suspected that the absolute
vas not aware at the time of making the observations, I considered it better
lid not conceive that this would materially affect the conclusions.

longitude 180°, *or to the west of the needle, the plate having revolved in opposite*
ıade in November 1822 and February 1823.

50°		54° 45′		60°		70°		80°		90°	
› W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
′ ″ 8 55 0 55	° ′ ″ 10 36 55 10 28 15	No observation. 9 53 35	 9 53 05	° ′ ″ 9 13 05 9 11 15	° ′ ″ 9 25 30 9 23 50	° ′ ″ 6 32 15 6 35 30	° ′ ″ 7 04 55 7 07 45	° ′ ″ 3 14 55 3 06 45	° ′ ″ 4 00 35 3 51 25	′ ″ −25 00 −24 38	′ ″ +25 00 +24 38
4 55	10 32 35	9 53 35	9 53 05	9 12 10	9 24 40	6 33 52	7 06 20	3 10 50	3 56 00	−24 49	+24 49
0° 12′ 20″		0° 00′ 30′		−0° 12′ 30″		−0° 32′ 28″		−0° 45′ 108		−0° 49′ 38″	

Theoretical Investigations.

It has in general been considered that the different deviations of the horizontal needle, arising from the action of soft iron on it in different positions, can only be accounted for on the supposition, that the iron is polarised by position, the upper part being a north pole, and the lower a south one, each pole of the iron attracting the pole of the needle of the same name, and repelling that of a contrary name: but if we suppose that each particle of the iron simply attracts indifferently either pole of a magnetic particle, and refer the attraction of the iron to its centre, then if the angular deviations of a magnetic particle in the centre of the needle and in the line of the dip, arising from such attraction, be reduced to the horizontal plane, these reduced deviations will agree with the actual deviations of the horizontal needle. In investigating theoretically the effects that are produced by the *rotation* of a plate of iron, I will first suppose, that, independently of *rotation*, the iron acts in this manner, and that by the *rotation* it becomes polarised in a direction, making a certain angle with the magnetic axis, since from such a polarising of the iron, the law which I have shown to include all the phænomena, would evidently result. On this supposition, each pole of a magnetic particle in the centre of the needle would be urged by an attractive force towards *the centre* of the iron plate, by an attractive force towards the pole of a contrary name, and by a repulsive force from the pole of the same name in the iron.

Suppose now that the centre and plane of the plate are in the secondary to the meridian and equator, that its centre is to the west of the needle, or in longitude 180° ; and in south latitude, as in the observed deviations in Tables A and B, and that its upper edge revolves from east to west. Take the centre of the needle as the origin of the rectangular co-ordinates, the axis x being horizontal, and towards the west, that of z upwards, in the direction of the magnetic axis. We will indicate the north end of the magnetic particle, in the centre of the needle, on which the iron is supposed to act, by N, its south end by S; the north end of the line joining the poles in the plate by ν, its south end by σ, its centre by γ. Let the co-ordinates to the centre of this line be a, b; to its north end a_ν, b_ν; to its south end a_σ, b_σ; and let ψ be the angle which this line makes with a line passing through its centre, and parallel to the axis z. Also let r be half the length of the magnetic particle in the centre of the needle.

Since the effect of any force to turn the particle SN will be the same, whether it be supposed to act on N in a given direction, or on S in the contrary one, we may refer the action of the mass of the iron, and likewise the actions of its poles, wholly to the end S. Calling then m, the magnetic force of the earth acting in the direction of the dip; F the force of the mass of the iron, and f that of one of its poles on S, at the unity of distance; also the sum of all the forces on S resolved in the directions x and z, X and Z, we shall have

$$\left.\begin{array}{l} \mathrm{F}a \cdot \left(\frac{1}{\mathrm{S}\gamma^3} - \frac{1}{\mathrm{N}\gamma^3}\right) \\ + f \cdot \left\{a_\nu \cdot \left(\frac{1}{\mathrm{S}\nu^3} + \frac{1}{\mathrm{N}\nu^3}\right) - a_\sigma \cdot \left(\frac{1}{\mathrm{S}\sigma^3} + \frac{1}{\mathrm{N}\sigma^3}\right)\right\} \end{array}\right\} = \mathrm{X}$$

$$\left.\begin{array}{l} 2m + \mathrm{F} \cdot \left(\frac{b-r}{\mathrm{S}\gamma^3} - \frac{b+r}{\mathrm{N}\gamma^3}\right) \\ + f \cdot \left(\frac{b_\nu - r}{\mathrm{S}\nu^3} + \frac{b_\nu + r}{\mathrm{N}\nu^3} - \frac{b_\sigma - r}{\mathrm{S}\sigma^3} - \frac{b_\sigma + r}{\mathrm{N}\sigma^3}\right) \end{array}\right\} = \mathrm{Z}$$

If φ' be the angle which, in consequence of these forces, the magnetic particle makes with the axis z, or line of the dip, that is, its angle of deviation towards the west, we shall have

$$\text{Tan. } \varphi' = \frac{X}{Z} \qquad (1)$$

Let now λ be the latitude of the plate's centre; R the radius of the circle in which the centre of the plate is made to move, that is, its distance from the centre of the needle; ρ, half the distance between the poles in the iron plate: then

$$a = R \cos. \lambda, \qquad b = R \sin. \lambda;$$
$$a_\sigma = R \cos. \lambda + \rho \sin. \psi, \qquad b_\sigma = R \sin. \lambda + \rho \cos. \psi;$$
$$a_\nu = R \cos. \lambda - \rho \sin. \psi, \qquad b_\nu = R \sin. \lambda - \rho \cos. \psi;$$
$$S\gamma^2 = R^2 + r^2 - 2 R r \sin. \lambda, \quad N\gamma^2 = R^2 + r^2 + 2 R r \sin. \lambda;$$
$$S\nu^2 = R^2 + r^2 + \rho^2 - 2 R\rho \sin. (\psi + \lambda) - 2 r (R \sin. \lambda - \rho \cos. \psi);$$
$$N\nu^2 = R^2 + r^2 + \rho^2 - 2 R\rho \sin. (\psi + \lambda) + 2 r (R \sin. \lambda - \rho \cos. \psi);$$
$$S\sigma^2 = R^2 + r^2 + \rho^2 + 2 R\rho \sin. (\psi + \lambda) - 2 r (R \sin. \lambda + \rho \cos. \psi);$$
$$N\sigma^2 = R^2 + r^2 + \rho^2 + 2 R\rho \sin. (\psi + \lambda) + 2 r (R \sin. \lambda + \rho \cos. \psi).$$

Substituting these values in the expressions for X and Z, expanding the several fractions, and neglecting the terms in the series after the third, on account of r and ρ being small compared with R, the equation (1) will become,

$$\text{Tan. } \varphi' = \frac{3 \sin. \lambda \cos. \lambda + \frac{2 f \rho}{F r} \left\{ 3 \sin. (\psi + \lambda) . \cos. \lambda - \sin. \psi \right\}}{\frac{m R^3}{F r} + 3 \sin.^2 \lambda - 1 + \frac{2 f \rho}{F r} \left\{ 3 \sin. (\psi + \lambda) . \sin. \lambda - \cos. \psi \right\}} \qquad (2)$$

If we call $\varphi_{,}$ the angle of deviation of the magnetic particle when the plate revolves in the opposite direction, that is, its upper edge from west to east, we shall have

$$\text{Tan. } \varphi_{,} = \frac{3 \sin. \lambda \cos. \lambda - \frac{2 f \rho}{F r} . \left\{ 3 \sin. (\psi - \lambda) . \cos. \lambda - \sin. \psi \right\}}{\frac{m R^3}{F r} + 3 \sin.^2 \lambda - 1 - \frac{2 f \rho}{F r} \left\{ 3 \sin. (\psi - \lambda) . \sin. \lambda + \cos. \psi \right\}} \qquad (3)$$

Also if φ is the angle of deviation of the magnetic particle due to the mass alone of the iron, then

$$\tan \varphi = \frac{3 \sin. \lambda \cos. \lambda}{\frac{m R^3}{F r} + 3 \sin.^2 \lambda - 1} \quad (4),$$

Since when the *rotation* of the iron produces no effect, $\varphi' = \varphi = \varphi_{,}$ we must have in this case,

$$\frac{3 \sin. (\psi + \lambda) . \cos. \lambda - \sin. \psi}{3 \sin. (\psi + \lambda) . \sin. \lambda - \cos. \psi} = \frac{3 \sin. (\psi - \lambda) . \cos. \lambda - \sin. \psi}{3 \sin. (\psi - \lambda) . \sin. \lambda + \cos. \psi}.$$

whence

$$\sin. \psi . \cos. \psi = 0.$$

The value of ψ which satisfy this equation are 0°, 90°, 180°, 270°; and since 0° and 180° would in all cases give $\varphi' = \varphi_{,}$ these must be excluded; also $\psi = 270°$ would merely give the same value for φ' which $\psi = 90°$ would give for $\varphi_{,}$, and *vice versâ*; consequently we have $\psi = 90°$.

If now we reduce the deviations φ', φ, $\varphi_{,}$, of the magnetic particle in the line of the dip, to the horizontal plane, and call the corresponding horizontal deviations θ', θ, $\theta_{,}$, and the angle of the dip δ; then since tan. $\varphi = \cos. \delta \tan. \theta$, and $\psi = 90°$, the equations (2), (3), (4) will become

$$\text{Tan. } \theta' = \frac{1}{\cos. \delta} \cdot \frac{3 \sin. 2\lambda + \frac{2 f \rho}{F r} \cdot (3 \cos. 2\lambda + 1)}{\frac{2 m R^3}{F r} - (3 \cos. 2\lambda - 1) + \frac{2 f \rho}{F r} . 3 \sin. 2\lambda} \quad (5),$$

$$\text{Tan. } \theta_{,} = \frac{1}{\cos. \delta} \cdot \frac{3 \sin. 2\lambda - \frac{2 f \rho}{F r} . (3 \cos. 2\lambda + 1)}{\frac{2 m R^3}{F r} - (3 \cos. 2\lambda - 1) - \frac{2 f \rho}{F r} . 3 \sin. 2\lambda} \quad (6),$$

$$\text{Tan. } \theta = \frac{1}{\cos. \delta} \cdot \frac{3 \sin. 2\lambda}{\frac{2 m R^3}{F r} - (3 \cos. 2\lambda - 1)} \quad (7),$$

The angles θ' θ, θ, are the horizontal angles of deviation of the *south* end of the magnetic particle towards the *west*; so that the centre of the plate being to the *west* of the needle or in longitude 180°, the deviation of the *north* end of the horizontal needle ought to be towards the *east*, which agrees with the observations.

Having determined from observation the value of λ when the *rotation* of the plate produces no effect, and the corresponding value of θ, we may determine the value of $\frac{2\,m\,R^3}{F\,r}$, independently of $f\rho$; and the value of $\frac{2f\rho}{F\,r}$ may then be determined from the observed values of θ' and $\theta_{,}$ when $\lambda = 0$ or 90°. Substituting these numerical values for $\frac{2\,R\,m^3}{F\,r}$ and $\frac{2f\rho}{F\,r}$ in the equations (5) and (6), we may deduce the values of θ' and $\theta_{,}$ corresponding to different values of λ, and compare them with those actually observed.

From Tables A, B, and also Table VII, it appears that the *deviation due to the rotation* of the plate vanishes when the latitude of its centre is very nearly 54° 45′, or as nearly as can be determined when $3 \cos. 2\,\lambda + 1 = 0$, in which case $\lambda = 54° \, 44' \, 08''$. We shall therefore have from Table A,

$$\text{Tan. } 9° \, 09' \, 10'' = \frac{1}{\cos. 70° \, 15'} \cdot \frac{3 \sin. 109° \, 28' \, 16''}{\frac{2\,m\,R^3}{F\,r} - 2}.$$

Whence $\frac{2\,m\,R^3}{F\,r} = 49.9504 = 50$ very nearly.

When $\lambda = 0$, $\tan. \theta' = \frac{1}{\cos. \delta} \cdot \frac{4 \cdot \frac{2f\rho}{F\,r}}{\frac{2\,m\,R^3}{F\,r} - 2}$; and since $\theta = 47' \, 55''$ and $\delta = 70° \, 15'$, we obtain $\frac{2f\rho}{F\,r} = .056524$.

Also when $\lambda = 90°$, $\tan. \theta' = \frac{1}{\cos. \delta} \cdot \frac{-2 \cdot \frac{2f\rho}{F\,r}}{\frac{2\,m\,R^3}{F\,r} + 4}$; where $\theta' = -22' \, 25''$; so that, $\frac{2f\rho}{F\,r} = .059494$.

Taking a mean of the two values, we shall have,

$$\frac{2f\rho}{Fr} = .058009 = .058 \text{ very nearly.}$$

The equations (5) and (6) therefore become,

$$\text{Tan. } \theta' = \frac{1}{\cos. 70^\circ\ 15'} \cdot \frac{3 \sin. 2\lambda + .058 \times (3 \cos. 2\lambda + 1)}{51 - 3 \cos. 2\lambda + .058 \times 3 \sin. 2\lambda} \qquad (5_a),$$

$$\text{Tan. } \theta_{,} = \frac{1}{\cos. 70^\circ\ 15'} \cdot \frac{3 \sin. 2\lambda - .058 \times (3 \cos. 2\lambda + 1)}{51 - 3 \cos. 2\lambda + .058 \times 3 \sin. 2\lambda} \qquad (6_a).$$

From Table B, we shall in the same manner obtain

$$\frac{2mR^3}{Fr} = 46.0278 = 46 \text{ very nearly ;}$$

$\frac{2f\rho}{Fr} = .054571$, when $\lambda = 0$, and $\frac{2f\rho}{Fr} = .060986$, when $\lambda = 90$; so that the mean value of $\frac{2f\rho}{Fr}$ is 0.57778 or .058 nearly, the same as before.

The equations (5) and (6) in this case become,

$$\text{Tan. } \theta' = \frac{1}{\cos. 70^\circ\ 15'} \times \frac{3 \sin. 2\lambda + .058 \times (3 \cos. 2\lambda + 1)}{47 - 3 \cos. 2\lambda + .058 \times 3 \sin. 2\lambda} \qquad (5_b),$$

$$\text{Tan. } \theta_{,} = \frac{1}{\cos. 70^\circ\ 15'} \times \frac{3 \sin. 2\lambda - .058 \times (3 \cos. 2\lambda + 1)}{47 - 3 \cos. 2\lambda - .058 \times 3 \sin. 2\lambda} \qquad (6_b).$$

We will first compare the situations of the points where the *deviation due to rotation* vanishes, as deduced from these equations, with the situation as determined by actual observation.

When the deviation due to rotation vanishes $\theta' = \theta = \theta_{,}$; we shall therefore have from equations (5_a) and (6_a)

$$\frac{3 \sin. 2\lambda}{51 - 3 \cos. 2\lambda} = \frac{3 \cos. 2\lambda + 1}{3 \sin. 2\lambda};$$

whence cos. $2\lambda = -.2800000$ and $\lambda = 53^\circ\ 07'\ 48''$.

The equations (5_b) and (6_b) give

$$\frac{3 \sin. 2\lambda}{47 - 3 \cos. 2\lambda} = \frac{3 \cos. 2\lambda + 1}{3 \sin. 2\lambda};$$

whence cos. $2\lambda = -.2753623$ and $\lambda = 52^\circ\ 59'\ 30''$.

Now I have uniformly found, in repeated observations which I have made at different distances, that when the centre of the plate was in latitude 54° 45′, the *rotation* produced so little effect, that only in one instance did the mean values of θ' and $\theta_{,}$ differ by a minute; and therefore cannot but conclude that 54° 45 is, as nearly as can be ascertained by observation, the true value of λ when $\theta' = \theta_{,}$, and that the value of λ as determined by the theory differs from its value derived from observatien by $1\frac{1}{2}°$ or $1\frac{3}{4}°$.

Let us now compare the values of θ', $\theta_{,}$ and $\theta' - \theta_{,}$, deduced from the equations (5_a), (6_a), (5_b) (6_b), for different values of λ, with those actually observed. This comparison is made in the following tables, where I have computed the values of θ' and $\theta_{,}$ to seconds, not that either the observed or computed values can be determined to such a degree of accuracy, but because the omission of the seconds might in some cases affect the value of $\theta' - \theta_{,}$ by more than a minute.

Table of the values of θ', $\theta_{,}$ and $\theta' - \theta_{,}$, computed from the equations (5_a), (6_a) compared with their mean observed values in Table A.

λ	θ'			$\theta_{,}$			$\theta' - \theta_{,}$		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
°	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″
0	+ 47 55	+ 49 10	+ 1 15	— 47 55	— 49 10	+ 1 15	1 35 50	1 38 50	+ 2 30
10	3 57 20	4 22 35	+ 25 15	2 26 40	2 49 57	+ 23 17	1 30 40	1 32 28	+ 1 58
20	6 57 00	7 19 21	+ 22 21	5 40 00	6 02 21	+ 22 21	1 17 00	1 17 00	0 00
30	9 03 25	9 17 07	+ 13 18	8 03 45	8 22 06	+ 18 21	59 40	55 01	— 4 39
40	9 56 20	10 04 49	+ 8 29	9 19 30	9 34 13	+ 14 31	36 50	30 48	— 6 02
50	9 31 20	9 41 19	+ 9 59	9 21 25	9 34 25	+ 13 00	09 55	06 54	— 3 01
60	8 05 15	8 13 00	+ 7 45	8 16 15	8 26 50	+ 10 35	— 11 00	— 13 50	— 2 50
70	5 51 35	5 51 44	+ 0 09	6 19 40	6 21 41	+ 2 01	— 28 05	— 29 57	— 1 52
80	2 51 25	2 53 40	+ 2 15	3 31 30	3 33 52	+ 2 22	— 40 05	— 40 12	— 0 07
90	— 22 25	— 21 51	+ 0 34	+ 22 15	+ 21 51	— 0 34	— 44 50	— 43 42	+ 1 08

Table of the values of θ', $\theta_{,}$ and $\theta' - \theta_{,}$ computed from the equations (5_b), (6_b) compared with their mean observed values in Table **B.**

λ	θ'			$\theta_{,}$			$\theta' - \theta_{,}$		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
°	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″	′ ″
0	+ 50 28	+ 53 38	+ 3 10	— 50 28	— 53 38	— 3 10	1 40 56	1 47 16	+ 6 20
10	4 30 50	4 46 12	+ 15 23	2 54 52	3 05 20	+ 10 28	1 35 58	1 40 53	+ 4 55
20	7 38 05	7 59 10	+ 21 05	6 15 27	6 35 29	+ 20 02	1 22 38	1 23 41	+ 1 03
30	10 07 50	10 06 20	— 1 30	9 03 12	9 05 40	+ 2 28	1 04 38	1 00 40	— 3 58
40	11 02 12	10 55 28	— 6 44	10 23 37	10 22 47	— 0 50	38 35	32 41	— 5 54
50	10 44 55	10 29 02	— 15 53	10 32 35	10 21 56	— 10 39	12 20	07 06	— 5 14
60	9 12 10	8 52 55	— 19 15	9 24 40	9 08 05	— 16 35	— 12 30	— 15 10	— 2 40
70	6 33 52	6 19 59	— 13 53	7 06 20	6 52 26	— 13 54	— 32 28	— 32 27	+ 0 01
80	3 10 50	3 07 34	— 3 16	3 56 00	3 51 32	— 4 28	— 45 10	— 43 58	+ 1 12
90	— 24 49	— 23 36	+ 1 13	+ 24 49	+ 23 36	— 1 13	— 49 38	— 47 12	+ 2 26

The differences here between the observed and computed values of θ' and $\theta_{,}$ are not greater than might possibly arise from slight errors in the adjustments of the plate and compass in the several positions, and their agreement is I think sufficiently near to prove that the principle which I have assumed, namely, that the attraction of the mass of the iron may be referred to its centre, and on which the most considerable of the terms in the formulæ depend, will account for the phænomena independent of the *rotation* of the iron. Although the differences between the observed and computed values of $\theta' - \theta_{,}$, or of the *deviation due to rotation*, are absolutely less, yet they are relatively greater; but their general agreement is such, that we can have little doubt of the *deviations due to the rotation* of the iron being, in all cases, nearly the same as would arise from such a polarising of the iron, as we have supposed. We shall however form a better estimate of the agreement between the results of the theory and observation, by eliminating $\frac{2mR^3}{Fr}$ from the equations (5) and

(6), and deducing the value of $\frac{F r}{2 f \rho}$ in terms of θ' and $\theta_{,}$, and depending principally on $\theta' - \theta_{,}$, or the *deviation due to rotation*, on the accuracy of the values of which in Table B, I place much greater reliance than on those of the absolute values of θ' and $\theta_{,}$. In this manner we obtain

$$\frac{F r}{2 f \rho} = \frac{1}{\sin.(\theta' - \theta_{,})} \cdot \left\{ \frac{3 \cos. 2\lambda + 1}{3 \sin. 2\lambda} . \sin.(\theta' + \theta_{,}) - 2 \cos. \delta \sin. \theta' \sin. \theta_{,} \right\} \quad (8);$$

in which the observed values of θ' and $\theta_{,}$ corresponding to any value of λ, being substituted, ought in all cases to give the same, or very nearly the same numerical value for $\frac{F r}{2 f \rho}$.

Table of the values of $\frac{F r}{2 f \rho}$ *computed from the several observed values of* θ' *and* $\theta_{,}$, *in Tables* A *and* B, *corresponding to different latitudes.*

λ	Observed values in Table A.		Computed value of $\frac{F r}{2 f \rho}$	Observed values in Table B.		Computed value of $\frac{F r}{2 f \rho}$
	θ'	$\theta_{,}$		θ'	$\theta_{,}$	
	° ′ ″	° ′ ″		° ′ ″	° ′ ″	
0	+ 47 55	− 47 55	17.692	+ 50 28	− 50 28	18.325
10	3 57 20	2 26 40	15.658	4 30 50	2 54 52	17.144
20	6 57 00	5 40 00	16.320	7 38 05	6 15 27	16.678
30	9 03 25	8 03 45	15.461	10 07 50	9 03 12	15.824
40	9 56 20	9 19 30	14.088	11 02 12	10 23 37	14.680
50	9 31 20	9 21 25	11.886	10 44 55	10 32 35	9.983
60	8 05 15	8 16 15	21.214	9 12 10	9 24 40	21.755
70	5 51 35	6 19 40	18.328	6 33 52	7 06 20	17.858
80	2 51 25	3 31 30	17.080	3 10 50	3 56 00	16.907
90	− 22 25	+ 22 25	16.808	− 24 49	+ 24 49	16.397
	Mean value		16.454	Mean value		16.555

The values of $\frac{F r}{2 f \rho}$ which differ most from the mean, are, in both cases, those corresponding to the values of λ, 50° and 60°; that is nearest to and on contrary sides of the point where $\theta' - \theta_{,} = 0$, which again shows clearly, that the theoretical determination of this point does not agree with the observations: and although the results of the theory agree in general very nearly with the observations, and the differences in the other values of $\frac{Fr}{2f\rho}$ are not greater than might possibly be attributed to errors of adjustment or observation, however little I may be disposed to admit the existence of errors to this extent, yet the uniform manner in which these values decrease, indicates that the effects are not produced in precisely the manner we have supposed. In one point our theory is unquestionably at variance with the actual circumstances of the case; for we have supposed that no partial magnetism exists in the iron, or that every part of it taken separately would equally affect the needle. It is, I believe, scarcely possible to procure iron that shall possess this uniformity of action, and it is evident that this was not the case with the plate of iron which I made use of. This species of polarity in iron is of so variable a nature, since by an accidental blow it will be transferred from one point to another, that it does not appear possible in any manner to submit its effects to calculation. It was to prevent these effects embarrassing the results, that I took the mean of twelve observations for each position of the plate; still it is possible that some of the differences between the observations and the results of the theory may have arisen from this cause.

As the results of the hypothesis which I have advanced do not precisely agree with the observations, it will be proper to enquire whether we shall obtain a more perfect agreement by means of the hypothesis commonly assumed, in order to account for the effects produced on the needle by a mass of soft iron, viz. that the upper part of every mass of iron acts as a north pole and the lower part as a south pole. Let us then suppose such poles to exist in the iron plate, in the diameter in the direction of the dip, and that the rotation causes the line joining them to describe in the iron an angle ψ from this diameter. The whole effect being now produced by the action of these poles, F being equal to o in the equations (2) and (3), we shall, on this supposition, have,

$$\text{Tan.}\ \varphi' = \frac{3\ \sin.(\lambda+\psi)\ .\ \cos.\lambda - \sin.\psi}{\frac{MR^3}{2f'\rho} + 3\ \sin.(\lambda+\psi)\ .\ \sin.\lambda - \cos.\psi} \qquad (2'),$$

$$\text{Tan.}\ \varphi_{,} = \frac{3\ \sin.(\lambda-\psi)\ .\ \cos.\lambda + \sin.\psi}{\frac{mR^3}{2f'\rho} + 3\ \sin.(\lambda-\psi)\ .\ \sin.\lambda - \cos.\psi} \qquad (3'),$$

$$\text{Tan.}\ \varphi = \frac{3\ \sin.\lambda\ \cos.\lambda}{\frac{mR^3}{2f'\rho} + 3\ \sin.^2\lambda - 1} \qquad (4').$$

These equations being reduced, give,

$$\text{Tan.}\ \theta' = \frac{1}{\cos\delta} \cdot \frac{3\ \sin.2\lambda + \tan.\psi(3\cos.2\lambda+1)}{\frac{mR^3}{f'\rho\cos.\psi} - (3\cos.2\lambda-1) + \tan\psi\ .\ 3\sin.2\lambda} \qquad (5'),$$

$$\text{Tan.}\ \theta' = \frac{1}{\cos.\delta} \cdot \frac{3\ \sin.2\lambda - \tan.\psi(3\cos.2\lambda+1)}{\frac{mR^3}{f'\rho\cos.\psi} - (3\cos.2\lambda-1) - \tan.\psi\ .\ 3\sin.2\lambda} \qquad (6'),$$

$$\text{Tan.}\ \theta = \frac{1}{\cos.\delta} \cdot \frac{3\ \sin.2\lambda}{\frac{mR^3}{f'\rho} - (3\cos.2\lambda-1)} \qquad (7'),$$

which will be precisely the same as ths equations (5), (6), (7), if $\tan.\psi = \frac{2fr}{Fr}$ and $f'\rho\cos.\psi = \frac{1}{2}Fr$.

The numerical values which we should obtain for θ' and $\theta_{,}$, from these equations, would, in all cases, be exactly the same as those which we have already obtained from the equations (5) and (6): so that the agreement between the observations and the results from this theory would not be greater than in the former case.

In the explanation of the phænomena which take place on presenting the different ends of a mass of iron to the poles of a magnetic needle, in addition to the hypothesis, that the upper part becomes a north, and the lower a south pole, by position, it is necessary to suppose also, that in every change of position of the iron there is a corresponding and immediate change of its poles; that is, the upper end becoming the lower, it also immediately becomes a south pole. Now it appears to me, that if we attempt to explain, on this hypothesis, the phænomena arising from the rotation of the iron, we shall find that there are circumstances which are wholly incompatible with it. If on turning a mass of iron end for end, the poles are immediately transferred from one end to the other, how can we suppose that the revolution of the iron will cause these poles to move forwards, so that the line joining them shall describe an angle from the line of the dip? or even granting that during the revolution of the iron they may be carried forward, they must, as soon as the iron ceases to revolve, resume their original position in the line of the dip, if they are so immediately transferred from one end of the iron to the other, as it is necessary to suppose in order to account for the phænomena which take place of attraction and repulsion, as they have been called. Immediately, then, that the iron becomes stationary in any position, the deviation of the needle ought, on this hypothesis, to become the same, whether the iron has been brought into that position by revolving in one direction, or in the contrary. It is hardly necessary for me to say that this would not be the case, since I have stated, that, in all the preceding observations, the iron was stationary previous to the observation being made.

Whatever are the effects produced on the iron by its revolution, so far from these effects being of the transient nature which we must suppose them to be on this hypothesis, they appear to have been quite permanent, that is, so long as the iron remained in the same position. The following observation will show the small changes which took place during 12 hours.

In order that the needle might be quite free to move, it was suspended in a balance of torsion by a brass wire, of the same diameter as the finest gold wire used for transits, free from torsion, 21.15 inches long. The plane of the plate was in the plane of the secondary to the equator and meridian, its centre in latitude 0° longitude 180°; and it was fixed to a wooden axis passing through its centre perpendicular to its plane: the ends of this axis, which revolved with the plate, being made of brass, that I might ascertain whether the effect was independent of friction on the plate itself. The plate was made to revolve in contrary directions, as usual, and the direction of the north end of the needle noted, when the point 180° on the plate coincided with the upper part of a plane parallel to the meridian, and passing through the plate's centre. After having made the plate revolve so that its upper edge moved from west to east, and noted the direction of the north end of the needle when 180° coincided with the above plane, it was made to revolve from east to west, and 180° being again brought to coincide with this plane, the direction of the north end of the needle was noted at different times for more than 12 hours, the plate remaining stationary during that time.

Direction of rotation of plate's upper edge.	W to E	E to W	Time of observation.	
	° ′	° ′	h m	
The several directions of the north end of the needle were observed when the point 180° on the plate coincided, above the centre, with the plane parallel to the meridian.	0 04W	2 50E	9 35	During this time the plate was kept perfectly stationary, and care was taken that the apparatus should not be in the least disturbed.
		2 50	10 05	
		2 46	11 10	
		2 44	20 35	
		2 42	21 48	
	0 02 E		22 01	After $21^h\ 48^m$ the plate was made to revolve slowly once from W to E.
	0 02 E		22 17	After making the plate revolve several times and more rapidly.
		2 46	22 28	Making the plate revolve several times from E to W.
	0 04W		22 40	Making the plate revolve once so slowly that the time of rotation was $3^m\ 26''$.
	0 06W		24 05	The plate kept perfectly stationary since $22^h\ 40^m$.
	0 08W		25 35	
		1 22		Making the plate revolve through 30° from W to E, and then bringing it back 30° from E to W.
		2 42		Making the plate revolve through 90° from W to E, and then bringing it back 90° from E to W.
		2 42		Making the plate revolve repeatedly and rapidly.

From these investigations it appears, that the effect produced on the iron by its *rotation* is permanent, so long as the plate remains stationary; that it is independent of friction; that it is so far independent of velocity, that the iron can scarcely be moved so slowly that the whole effect shall not be produced; and that the whole effect is produced by making it perform only one fourth of a revolution.

Shortly after I had discovered these pecular effects to be produced by the rotation of iron, I pointed out the general nature of the phænomena and exhibited some of them to Mr. BARLOW, and he has since made some experiments on the rotation of spherical shells, in which he has found that phænomena somewhat analogous take place, but they appear to be dependent on the velocity with which the shell is made to revolve.

On computing the several values of $\frac{F r}{2 f \rho}$ from the equation (8), I found that if the term 2 cos. δ sin. θ' sin. $\theta_{,}$ were neglected; that is, if $\frac{F r}{2 f \rho}$ were equal to $\frac{3 \cos. 2 \lambda + 1}{3 \sin. 2 \lambda} \cdot \frac{\sin. (\theta' + \theta_{,})}{\sin. (\theta' - \theta_{,})}$ its numerical values, so determined, would agree very nearly with each other. I was in consequence led to expect that equations from which this value of $\frac{F r}{2 f \rho}$ might arise, would give values of $\theta' - \theta_{,}$ agreeing more nearly with the observations; and the result fully answered my expections.

If $$\text{Tan. } \theta' = \frac{3 \sin. 2 \lambda + \frac{2 f \rho}{F r} \cdot (3 \cos. 2 \lambda + 1)}{\frac{2 m R^3}{F r} \cdot \cos. \delta} \qquad (9),$$

and $$\text{Tan. } \theta_{,} = \frac{3 \sin. 2 \lambda - \frac{2 f \rho}{F r} \cdot (3 \cos. 2 \lambda + 1)}{\frac{2 m R^3}{F r} \cdot \cos. \delta} \qquad (10),$$

then we shall have
$$\frac{F r}{2 f \rho} = \frac{3 \cos. 2 \lambda + 1}{3 \sin. 2 \lambda} \cdot \frac{\sin. (\theta' + \theta_{,})}{\sin. (\theta' - \theta_{,})} \qquad (11).$$

When the *deviation due to rotation* vanishes or $\theta' = \theta_{,}$ the equations (9) and (10) give $3 \cos. 2 \lambda + 1 = 0$ and $\lambda = 54° 44'$, which agrees perfectly with the observations.

From the observations in Table A, we have in this case,
$$\text{Tan. } 9° 09' 20'' = \frac{3 \sin. 109° 28' 16''}{\frac{2 m R^3}{F r} \cdot \cos. 70° 15'}$$
whence $\frac{2 m R^3}{F r} = 51.9504 = 52$ very nearly.

When $\lambda = 0$, $\frac{2 f \rho}{F r} = \frac{1}{4} \cdot \frac{2 m R^3}{F r} \cdot \cos. \delta \tan. \theta' = .061234$;

and when $\lambda = 90$, $\frac{2 f \rho}{F r} = -\frac{1}{2} \cdot \frac{2 m R^3}{F r} \cdot \cos. \delta \tan. \theta' = .057291$:

so that the mean value of $\frac{2 f \rho}{F r}$ is .059262, or nearly .059.

The equations (9) and (10) therefore become

$$\text{Tan. } \theta' = \frac{3 \sin. 2\lambda + .059 \times (3 \cos. 2\lambda + 1)}{52 \cos. 70^\circ 15'} \qquad (9_a);$$

$$\text{Tan. } \theta_, = \frac{3 \sin. 2\lambda - .059 \times (3 \cos. 2\lambda + 1)}{52 \cos. 70^\circ 15'} \qquad (10_a).$$

In the same manner the observations in Table B give, $\frac{2\,m\,R^3}{F\,r} = 48.0278 = 48$ nearly, and $\frac{2\,f\,\rho}{F\,r} = .059039 = .059$ nearly.

The equations (9) and (10), in this case, become,

$$\text{Tan. } \theta' = \frac{3 \sin. 2\lambda + .059 \times (3 \cos. 2\lambda + 1)}{48} \qquad (9_b);$$

$$\text{Tan. } \theta_, = \frac{3 \sin. 2\lambda - .059 \times (3 \cos. 2\lambda + 1)}{48} \qquad (10_b).$$

Table of the values of θ′, θ,, and θ′ — θ, computed from the equations (9_a), (10_a) *compared with their observed values in Table A.*

λ	θ′			θ,			θ′—θ,		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
°	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	′ ″	° ′ ″	° ′ ″
0	+ 47 55	+ 46 10	— 1 45	— 47 55	— 46 10	+ 1 45	1 35 50	1 32 20	— 3 30
10	3 57 20	4 04 26	+ 7 06	2 26 40	2 36 30	+ 9 50	1 30 40	1 27 56	— 2 44
20	6 57 00	6 53 20	— 3 40	5 40 00	5 38 06	— 1 54	1 17 00	1 15 14	— 1 46
30	9 03 25	8 52 50	— 10 35	8 03 45	7 56 22	— 7 23	59 40	56 28	— 3 12
40	9 56 20	9 49 43	— 6 37	9 19 30	9 15 34	— 3 56	36 50	34 09	— 2 41
50	9 31 20	9 38 02	+ 6 42	9 21 25	9 27 16	+ 5 51	09 55	10 46	+ 0 51
60	8 05 15	8 18 59	+ 13 44	8 16 15	8 30 17	+ 14 02	— 11 00	— 11 18	— 0 18
70	5 51 35	6 00 57	+ 9 22	6 19 40	6 30 34	+ 10 54	— 28 05	— 29 37	— 1 32
80	2 51 25	2 59 35	+ 8 10	3 31 0	3 41 26	+ 9 56	— 40 05	— 41 51	— 1 46
90	— 22 25	— 23 05	— 0 40	+ 22 25	+ 23 05	+ 0 40	— 44 50	— 46 10	— 1 20

Table of the values of θ', $\theta_{,}$ *and* $\theta' - \theta_{,}$ *computed from the equations* (9_b) (10_b) *compared with their observed values in Table* B.

λ	θ′			θ,			θ′ — θ,		
	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.	Observed.	Computed.	Difference.
°	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0	+ 50 28	+ 50 01	— 0 27	— 50 28	— 50 01	+ 0 27	1 40 56	1 40 02	— 0 54
10	4 30 50	4 24 43	— 6 07	2 54 52	2 49 34	— 5 18	1 35 58	1 35 09	— 0 49
20	7 38 05	7 27 24	— 10 41	6 15 27	6 06 04	— 9 23	1 22 38	1 21 20	— 1 18
30	10 07 50	9 36 27	— 31 23	9 03 12	8 35 29	— 27 43	1 04 38	1 00 58	— 3 40
40	11 02 12	10 37 47	— 24 25	10 23 37	10 00 58	— 22 39	38 35	36 49	— 1 46
50	10 44 55	10 25 11	— 19 44	10 32 35	10 13 35	— 19 00	12 20	11 36	— 0 44
60	9 12 10	8 59 55	— 12 15	9 24 40	9 12 06	— 12 34	— 12 30	— 12 11	+ 0 19
70	6 33 52	6 30 47	— 3 05	7 06 20	7 02 48	— 3 32	— 32 28	— 32 01	+ 0 27
80	3 10 50	3 14 31	+ 3 41	3 56 00	3 59 50	+ 3 50	— 45 10	— 45 19	— 0 09
90	— 24 49	— 25 01	— 0 12	+ 24 49	+ 25 01	+ 0 12	— 49 38	— 50 02	— 0 24

The agreement between the computed and observed values of $\theta' - \theta_{,}$ also of θ' and $\theta_{,}$ in the first table is such, that had I been assured of the correctness of the formulæ, I should certainly not have expected it to be more perfect. In the second table, the agreement between the computed and observed values of $\theta' - \theta_{,}$ is equally close, but there is a greater difference between those values of the angles θ', $\theta_{,}$ themselves. In determining the value of $\frac{2mR^3}{Fr}$ from the observation when $\lambda = 54° 45'$, and $\theta' = \theta_{,}$, I had in the first instance in consequence of an error in computation, found it 47 instead of 48, and having computed the several values of θ' and $\theta_{,}$ from this value of $\frac{2mR^3}{Fr}$, I found that the difference between these and the observed values was less than 8′, except in two instances, in one of which it amounted to 11′ and in the other to 19′. Now the observations when $\lambda = 50°$ and $\lambda = 60°$ would give the value of $\frac{2mR^3}{Fr}$ even less than 47°, as will be seen when we compute it for these values of λ, which would still further diminish these differences. I have therefore no doubt that the differences between the computed and observed values of θ' and $\theta_{,}$ in this table are to be attributed to an error of about 15′ in the observed value of θ' when $\lambda = 54° 45'$. The best criterion, however, of the correctness of the formulæ is in the agreement of the values of the constants derived from them by means of the observations.

If we eliminate $\frac{2 f \rho}{F r}$ from the equations (9) and (10), we shall obtain

$$\frac{2 m R^3}{F r} = \frac{6 \sin. 2 \lambda}{\cos. \delta} \cdot \frac{\cos. \theta' . \cos. \theta_{,}}{\sin. (\theta' + \theta_{,})} \qquad (12).$$

Substituting in the equations (11) and (12) the several observed values of θ' and $\theta_{,}$ in tables A and B, we obtain the values of $\frac{2 F r}{f \rho}$ and $\frac{2 m R^3}{F r}$ contained in the following table.

Table of the values of the constants $\frac{2 m R^3}{F r}$ *and* $\frac{2 F r}{f \rho}$ *computed from the several observed values of* θ' *and* $\theta_{,}$ *in tables* A *and* B, *by means of the equations* (12) *and* (11).

λ	Observed values in Table A.		Computed values.		Observed values in Table B.		Computed values.	
	θ'	$\theta_{,}$	$\frac{2 m R^3}{F r}$	$\frac{2 F r}{f \rho}$	θ'	θ'	$\frac{2 m R^3}{F r}$	$\frac{2 F r}{f \rho}$
°	° ′ ″	° ′ ″			° ′ ″	° ′ ″		
0	+ 47 55	− 47 55	50.103	16.331	+ 50 28	− 50 28	47.571	16.798
10	3 57 20	2 26 40	54.301	15.733	4 30 50	2 54 52	46.767	17.240
20	6 57 00	5 40 00	51.615	16.681	7 38 05	6 15 27	46.834	17.085
30	9 03 25	8 03 45	51.077	16.321	10 07 50	9 03 12	45.492	16.819
40	9 56 20	9 19 30	51.516	15.852	11 02 12	10 23 37	46.203	16.759
50	9 31 20	9 21 25	52.587	18.188	10 44 55	10 32 35	46.512	16.412
60	8 05 15	8 16 15	53.492	16.939	9 12 10	9 24 40	46.915	16.894
70	5 51 35	6 19 40	53.452	17.397	6 33 52	7 06 20	47.609	16.849
80	2 51 25	3 31 30	54.463	16.902	3 10 50	3 56 00	48.846	16.712
90	— 22 25	+ 22 25	53.551	17.455	— 24 49	+ 24 49	48.372	17.081
	Mean values		52.616	16.780		Mean values	47.112	16.865

On comparing together the several values of $\frac{2mR^3}{Fr}$ and also of $\frac{2Fr}{f\rho}$, contained in this table, there can, I think, be no doubt that if the formulæ (9) and (10), on which these values depend, be not absolutely correct, they will, at least, give in all cases, as close approximations to the values of θ' and $\theta_{,}$ that would be obtained by actual observation, as the nature of the case appears to admit of. It is very possible that some modification in the theory which I have examined might lead to the omission of the terms $2 \cos. \lambda - 1 \pm \frac{2f\rho}{Fr} . 3 \sin. 2\lambda$ in the formulæ (5) and (6); and should this be the case, that the formulæ (9) and (10) were to be derived from the theory so modified, it would, I think, be a very strong presumption in favour of the truth of such a theory.

Since it appears from all the observations which I have detailed, that the direction of the magnetic polarity, which iron acquires by *rotation about an axis*, whether it be at right angles to the line of the dip, as would follow from the theory which I have investigated, or not, has always reference to the direction of the terrestrial magnetic forces, we must infer that this magnetism is communicated to it from the earth. It does not therefore appear from this, that a body can become polarised by rotation alone, independently of the action of another body: so that if from these experiments we might be led to attribute the magnetic polarity of the earth to its rotation, we must at the same time suppose a source from which magnetic influence is derived. Is it not then possible that the sun may be the centre of such influence, as well as the source of light and heat, and that by their rotation, the earth and other planets may receive polarity from it? If so, further experiments and observations on the magnetic effects produced by the rotation of bodies may indicate the cause of the situations of the earth's magnetic poles, and of their progressive movements or oscillations.

Comparison of the magnetical effects produced by slow and by rapid rotation.

With the view of ascertaining how far the effects produced on a magnetic needle by a plate of iron during its rapid rotation, corresponded with those that I have described as nearly independent of the velocity of rotation, and as continuing after the rotation had ceased, I placed the same plate of iron, which I had used in my former experiments, in the plane of the magnetic meridian, on an axis perpendicular to its plane, and about which it could be made to revolve with any velocity, not exceeding 10 revolutions in a second. I then placed a small compass, with a light needle delicately suspended, on a platform wholly detached from the iron plate, in certain positions opposite to the edge of the plate, both to the east and to the west of it, as near to the surface as the compass box would admit. The compass being adjusted, the plate was made to revolve once, slowly, so that its upper edge moved from north to south, and the point o coinciding with the plane perpendicular to the plane of the plate, and passing through its centre and that of the needle, the direction of the north end of the needle was observed; and also when 180 coincided with the plane, the same observation was made. The plate was now made to revolve rapidly in the same direction, about 8 times in a second; and when the needle became stationary during the rotation, the direction of its north end was observed. The point o on the plate was again made to coincide as quickly after the rapid rotation as possible, and the direction of the needle observed, in order to see if that rotation had produced any permanent change in the iron; the same was done when the point 180 again coincided. Observations precisely similar to these were made when the upper edge of the plate revolved from south to north.

Although the centre of the plate was stationary, and the needle was placed in certain positions with respect to it, I consider, as before, the situation of the centre of the plate with reference to the plane passing through the centre of the needle perpendicular to the dip; and its angular distance from this plane, the equator, was measured on a circle of 9 inches radius parallel to the meridian, passing through the centre of the needle, and at the distance 1.45 inches from it, so that the centre of the needle was always at this distance from the edge of the plate, east or west. As the needle was only two inches in length, and the rim of the compass divided into degrees, the direction of the needle could not be observed nearer than to 5′, and indeed scarcely to that degree of accuracy. The mode which I was under the necessity of adopting in adjusting the compass to the several positions did not admit of extreme accuracy, so that these positions may be considered as liable to errors amounting to 1°, or perhaps rather more, in angular distance from the equator; but as my principal object was the comparison of the deviation due to the slow and rapid rotation of the plate, when its centre was in precisely the same position with respect to that of the needle, this was not very material: it will however account for any disagreements that may be noticed in the absolute deviations in corresponding positions, as the greatest accuracy of adjustment would be requisite for their perfect agreement, when the plate is so near to the poles of the needle.

Having ascertained, by the observations when the plate was to the west of the needle, that the rapid rotation produced no permanent change in the iron beyond that arising from the slow rotation, the deviations when any particular points of the plate were opposite to the needle being, as near as could be expected, the same after the rapid rotation as they were after the slow rotation in the first instance, the errors being sometimes in excess, sometimes in defect, as will appear by inspection of the first table, I did not repeat the observations on the effects of the slow rotation after the rapid, when the plate was to the east of the needle.

The following tables contain the observations. The first four columns of deviations, are those which were observed when the plate was stationary, after having very slowly revolved, and also those when the needle pointed steadily during the rapid rotations. The deviations in the 5th and 6th columns are obtained by taking half the difference between those in the 1st and 2nd, and between those in the 3rd and 4th columns, as the deviation due to the rotation when the plate's upper edge revolved from north to south.

Tables of the deviations of a magnetic needle, caused by the rapid rotation of a plate of iron, observed during rotation, compared with the deviations due to the slow rotation of the plate, and permanent after the rotation had ceased.

1*st. The iron plate,* 18 *inches in diameter, to the west of the compass.*

Angular distance of the plate's centre from the equator. (Measured from the north when plate's centre in north lat. and from south when in south lat.)	Angular velocity of the plate, and points opposite to the needle when plate stationary.	Direction of the N. end of the needle when plate stationary after slow rotation, and also while the plate was rapidly revolving.				Deviation due to the rotation of the plate's upper edge from N to S, when plate's centre was	
		Plate's centre in N. lat.		Plate's centre in S. lat.			
		Upper edge of the plate revolving.					
		N to S	S to N	N to S	S to N	in N. lat.	in S. lat.
		° ′	° ′	° ′	° ′	° ′	° ′
0	Slow 0	2 45W	14 25 E	6 40 E	8 10W	8 59W	6 54 E
	Slow 180	4 55 E	23 40 E	14 15	2 05 E		
	8 rev. per sec.	3 55W	19 25 E	14 30	4 40W	11 40W	9 35 E
	Slow 0	2 55W	13 55 E	6 40	7 50W	8 45W	6 49 E
	Slow 180	6 30 E	24 40 E	14 50	2 05 E		
20	Slow 0	32 50W	27 30W	40 55	33 20	2 25	3 15
	Slow 180	27 40	23 00	42 25	37 00		
	8 rev. per sec.	30 55	24 35	41 25	32 40	3 10	4 22
	Slow 0	32 50	27 35	40 40	33 35	2 34	3 22
	Slow 180	28 00	22 40	42 25	36 45		
50	Slow 0	43 50	41 25	54 00	51 00	1 14	1 21
	Slow 180	40 30	38 00	53 05	50 40		
	8 rev. per sec.	42 25	39 15	53 30	49 00	1 35	2 15
	Slow 0	43 45	41 25	54 10	51 20	1 09	1 15
	Slow 180	40 15	38 00	53 10	51 00		
70	Slow 0	52 30	51 00	59 25	57 20	0 55	1 06
	Slow 180	49 10	47 00	59 00	56 40		
	8 rev. per sec.	51 05	48 20	57 40	54 40	1 23	1 30
	Slow 0	52 30	50 50	59 40	57 25	0 55	1 04
	Slow 180	48 55	46 55	58 40	56 40		
90	Slow 0	62 00	60 20	68 30	66 40	0 50	0 51
	Slow 180	57 40	56 00	67 45	66 10		
	8 rev. per sec.	60 35	57 25	66 55	64 20	1 35	1 17
	Slow 0	62 25	60 25	68 50	66 25	0 55	1 01
	Slow 180	58 00	56 20	67 55	66 15		
110	Slow 0	72 25	71 25	75 25	74 00	0 34	0 35
	Slow 180	68 10	66 55	76 00	75 05		
	8 rev. per sec.	70 20	68 15	74 40	72 40	1 02	1 00
	Slow 0	72 35	71 25	75 35	74 25	0 38	0 32
	Slow 180	68 00	66 40	76 00	75 00		
130	Slow 0	84 05	84 10	83 55	83 30	0 06	0 11
	Slow 180	80 50	80 20	85 00	84 40		
	8 rev. per sec.	82 20	81 00	83 00	81 45	0 40	0 37
	Slow 0	84 20	84 10	84 00	83 10	0 09	0 14
	Slow 180	80 40	80 15	85 00	84 55		
140	Slow 0	86 20	87 00	86 00	86 15	0 33 E	0 10W
	Slow 180	82 15	83 45	87 40	88 05		
	8 rev. per sec.	83 40	85 00	84 40	85 15	0 40 E	0 18W
	Slow 0	86 00	87 20	85 40	86 20	0 39 E	0 16W
	Slow 180	82 40	83 55	87 35	88 00		
160	Slow 0	75 20	83 55	76 00	83 00	7 05 E	3 18
	Slow 180	54 00	73 45	78 15	84 25		
	8 rev. per sec.	57 55	78 20	69 40	80 30	10 12 E	5 25
	Slow 0	76 10	83 40	76 05	82 00	6 45	3 01
	Slow 180	53 20	72 50	78 10	84 20		

2nd. The same iron plate to the east of the compass.

Angular distance of the plate's centre from the equator.	Angular velocity of the plate, and points opposite to the needle when plate stationary.	Direction of the N. end of the needle when plate stationary after slow rotation, and also while the plate was rapidly revolving. Plate's centre in N. lat. Upper edge of the plate revolving. N to S	S to N	Plate's centre in S. lat. N to S	S to N	Deviation due to the rotation of the plate's upper edge from N to S, when plate's centre was in N. lat.	in S. lat.
Measured from north when the plate's centre in north lat. and from south when in south lat.		° ′	° ′	° ′	° ′	° ′	° ′
0	Slow 0	9 55 E	1 25W	8 50W	5 20 E	5 56 E	6 29W
	Slow 180	5 00 E	7 25W	16 30	4 45W		
	8 rev. per sec.	11 05	4 25W	16 35	1 35 E	7 45 E	0 05W
20	Slow 0	35 15	29 25 E	39 40	33 30W	2 50	2 45
	Slow 180	31 55	26 25	42 20	37 30		
	8 rev. per sec.	34 50	27 25	42 25	34 55	3 43	3 45
50	Slow 0	42 30	40 05	53 45	50 50	1 09	1 16
	Slow 180	39 50	37 30	54 25	52 15		
	8 rev. per sec.	42 10	38 50	53 20	49 10	1 40	2 05
70	Slow 0	48 55	47 50	59 15	56 20	0 40	1 18
	Slow 180	45 30	43 55	59 30	57 15		
	8 rev. per sec.	48 35	45 45	58 50	55 40	1 25	1 35
90	Slow 0	59 45	57 55	66 35	64 40	0 50	0 57
	Slow 180	56 00	54 30	66 50	65 00		
	8 rev. per sec.	58 25	55 40	66 25	63 35	1 23	1 25
110	Slow 0	71 00	69 30	75 10	73 40	0 43	0 41
	Slow 180	67 10	65 50	75 10	73 55		
	8 rev. per sec.	70 40	68 30	74 20	72 10	1 05	1 05
130	Slow 0	83 25	83 30	81 10	80 45	0 00	0 06
	Slow 180	80 20	80 15	83 00	83 00		
	8 rev. per sec.	82 20	81 45	81 15	80 15	0 18	0 30
140	Slow 0	86 35	87 30	81 30	82 20	0 35W	0 20 E
	Slow 180	83 00	84 25	84 50	85 20		
	8 rev. per sec.	85 50	86 40	82 20	82 40	0 25W	0 10 E
160	Slow 0	77 00	85 20	68 00	77 20	8 31W	4 30
	Slow 180	47 30	73 15	72 35	81 15		
	8 rev. per sec.	51 40	81 40	67 10	79 40	15 00	6 15

From the inspection of these tables, it appears that the forces which are exerted on the needle during the rapid rotation of the plate, are always in the same direction as the forces which are derived from the slowest rotation, and which continue to act after the rotation has ceased; but that the former forces are greater than the latter, there being only one instance of the contrary, and that in a position where the effects are so small, that a trifling error of observation would account for the difference. Taking a mean of all the observations, these forces appear to be in the ratio of 19 to 13, or very nearly 3 to 2. It is evident then that the polarising of the iron in the same direction will account for the phænomena in both cases, but that the intensity of the polarity during the rapid rotation is greater than of that which appears to be permanent after the rotation, whether slow or rapid, has ceased; and that the phænomena observed during rapid rotation are such as we should expect from those which I have so fully described as arising from rotation, without regard to its velocity.

IV. *Table of the deviation of a magnetic needle, caused by the rotation of a circular plate of iron, when the centre of the plate was in the meridian, and its plane in the plane of a secondary to the meridian. Plate No. I.*

Points on the Plate.	Long. 90°. Lat. 0°.		Long. 90°. Lat. 19° 30′ S.		Long. 270°. Lat. 19° 30′ S.*		Long. 90°. Lat. 45° S.		Long. 270°. Lat. 45° S.		Long. 90°. Lat. 70° 30′ S.†		Long. 270°. Lat. 70° 30′ S.		Lat. 90° S.	
	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W
0	0° 14′W	0° 14′W	0° 12′W	0° 06′E	0° 12′W	0° 12′E	0° 54′W	0° 00′	0° 48′W	0° 02′E	0° 58′W	0° 20′E	1° 10′W	0° 08′E	1° 10′W	0° 14′E
30	0 12E	0 08E	0 02W	0 14E	0 24W	0 00	0 56W	0 00	1 14W	0 18W	1 02W	0 20E	1 10W	0 00	1 12W	0 08E
60	0 20E	0 18E	0 06E	0 24E	0 24W	0 00	0 32W	0 24E	1 22W	0 24W	0 58W	0 32E	1 10W	0 08E	1 08W	0 20E
90	1 04E	1 04E	0 48E	1 10E	0 50E	1 14E	0 22E	1 18E	0 20W	0 38E	0 10W	1 18E	0 20W	1 00E	0 22W	1 04E
120	0 40E	0 38E	0 26E	0 48E	0 22E	0 48E	0 18E	1 14E	0 32W	0 28E	0 04E	1 26E	0 20W	1 02E	0 16W	1 14E
150	1 16E	1 14E	0 56E	1 22E	1 00E	1 26E	0 50E	1 44E	0 10E	1 06E	0 20E	1 40E	0 10E	1 30E	0 16E	1 40E
180	0 36E	0 38E	0 32E	0 58E	0 44E	1 08E	0 36E	1 32E	0 10E	1 08E	0 20E	1 36E	0 12E	1 24E	0 16E	1 40E
210	0 14E	0 16E	0 02E	0 26E	0 28E	0 50E	0 04W	0 52E	0 00	0 56E	0 00	1 12E	0 12W	1 02E	0 04W	1 14E
240	0 38W	0 40W	1 00W	0 38W	0 08W	0 12E	1 08W	0 10W	0 30W	0 28E	0 50W	0 22E	0 52W	0 28E	0 50W	0 30E
270	1 30W	1 28W	1 40W	1 18W	0 46W	0 24W	1 46W	0 48W	0 56W	0 00	1 20W	0 00	1 12W	0 00	1 20W	0 04E
300	1 04W	1 08W	1 20W	1 00W	0 40W	0 20W	1 54W	0 52W	0 56W	0 02E	1 22W	0 00	1 20W	0 04W	1 22W	0 00
330	0 30W	0 26W	0 46W	0 26W	0 44W	0 18W	1 30W	0 36W	1 02W	0 06W	1 30W	0 00	1 26W	0 10W	1 30W	1 02W
Mean deviation - -	0 02 5/6 E	0 01 2/3 E	0 10 5/6 W	0 10 5/6 E	0 00 1/3 E	0 24 E	0 33 1/2 W	0 23 1/6 E	0 36 2/3 W	0 20 E	0 37 1/6 W	0 43 5/6 E	0 44 1/6 W	0 32 1/3 E	0 43 1/3 W	0 40 1/2 E
Direction of deviation	Stationary.		N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E
Deviation due to rotation	0° 00′ 5/6		0° 21′ 1/3		0° 23′ 1/2		0° 56′ 1/3		0° 56′ 2/3		1° 21′		1° 16′ 1/2		1° 24′	

	Long. 270°. Lat. 0°.		Long. 90°. Lat. 19° 30′ N.*		Long. 270°. Lat. 19° 30′ N.		Long. 90°. Lat. 45° N.		Long. 270°. Lat. 45° N.		Long. 90°. Lat. 70° 30′ N.		Long. 270°. Lat. 70° 30′ N.	Lat. 90° N.	
	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	The nature of the instrument does not admit of observations being made in this position of the Plate.	W to E	E to W
0	0° 58′W	0° 58′W	0° 08′E	0° 14′W	0° 54′W	1° 20′W	0° 14′E	0° 40′W	0° 44′E	0° 12′W	0° 42′E	0° 38′W		0° 42′E	0° 42′W
30	0 52W	0 52W	0 38E	0 16E	0 44W	1 06W	0 50E	0 00	0 54E	0 02E	1 20E	0 00		1 22E	0 06W
60	0 46W	0 46W	0 40E	0 16E	0 28W	0 48W	1 02E	0 14E	0 52E	0 02W	1 16E	0 04W		1 22E	0 00
90	0 46E	0 46E	1 06E	0 42E	0 36E	0 14E	1 18E	0 20E	0 54E	0 02W	1 26E	0 06E		1 24E	0 00
120	0 40E	0 38E	0 46E	0 22E	0 42E	0 18E	1 00E	0 12E	0 52E	0 04W	1 08E	0 14W		1 18E	0 10W
150	1 36E	1 38E	1 08E	0 44E	1 16E	0 54E	1 18E	0 20E	1 02E	0 06W	1 16E	0 04W		1 26E	0 04W
180	1 14E	1 16E	0 24E	0 00	0 58E	0 34E	0 44E	0 10W	0 40E	0 18W	0 38E	0 48W		0 52E	0 38W
210	1 08E	1 08E	0 20E	0 02W	1 00E	0 36E	0 42E	0 12W	0 22E	0 38W	0 14E	1 10W		0 28E	0 56W
240	0 24E	0 26E	0 22W	0 48W	0 18E	0 04W	0 08E	0 50W	0 12W	1 16W	0 14W	1 36W		0 02W	1 24W
270	0 32W	0 32W	1 06W	1 30W	0 54W	1 16W	0 38W	1 30W	0 42W	1 36W	0 42W	2 02W		0 32W	2 00W
300	0 46W	0 44W	0 40W	1 02W	1 06W	1 30W	0 28W	1 12W	0 12W	1 06W	0 16W	1 40W		0 16W	1 44W
330	1 06W	1 02W	0 08E	0 12W	0 56W	1 20W	0 10E	0 46W	0 28E	0 24W	0 40E	0 46W		0 32E	1 00W
Mean deviation - -	0 04 E	0 04 5/6 E	0 15 5/6 E	0 07 1/3 W	0 01W	0 24W	0 31 2/3 E	0 21 1/6 W	0 28 5/6 E	0 27 1/2 W	0 37 1/3 E	0 44 2/3 W		0 43 E	0 43 2/3 W
Direction of deviation	Stationary.		N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W	N to E	N to W		N to E	N to W
Deviation due to rotation	0° 00′ 5/6		0° 23′ 1/6		0° 23′		0° 52′ 5/6		0° 56′		1° 22′			1° 26′ 2/3	

* The plane of the plate was here horizontal.

† Here the plane of the plate was vertical.

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V. *Table of the deviations of a magnetic needle caused by the rotation of a circular plate of iron when its centre was in the secondary to the equator and meridian, and its plane perpendicular to this secondary, and passing through the centre of the needle.* **Plate No. I.**

	Long. 0° Lat. 0°		Long. 0° Lat. 10° S.		Long. 0° Lat. 20° S.		Long. 0° Lat. 30° S		Long. 0° Lat. 40° S		Long. 0° Lat. 45° S		Long. 0° Lat. 50° S		Long. 0° Lat. 60° S.		Long. 0° Lat. 70° S.		Long. 0° Lat. 80° S		Lat. 90° S	
	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S
0	1° 16′ E	1° 16′ E	6° 58′ W	6° 56′ W	11° 10′ W	11° 10′ W	16° 12′ W	16° 14′ W	17° 36′ W	17° 30′ W	17° 50′ W	17° 50′ W	16° 56′ W	16° 58′ W	13° 40′ W	13° 38′ W	10° 08′ W	10° 02′ W	5° 08′ W	5° 08′ W	0° 22′ E	0° 22′ E
30	1 24 E	1 22 E	5 30	5 30	10 24	10 24	15 16	15 10	16 52	16 50	17 02	17 00	16 20	16 20	13 32	13 26	10 00	9 54	5 06	5 04	0 20	0 20
60	1 18 E	1 20 E	3 44	3 42	9 22	9 24	13 32	13 32	15 42	15 38	15 56	15 52	15 24	15 22	12 58	12 52	9 32	9 26	4 50	4 50	0 24	0 22
90	0 54 E	0 52 E	3 00	2 58	9 26	9 24	13 14	13 10	15 40	15 40	15 44	15 40	15 14	15 08	12 52	12 48	9 24	9 20	4 50	4 50	0 20	0 22
120	0 20 E	0 18 E	2 56	2 52	9 32	9 32	13 18	13 20	15 48	15 48	16 00	15 58	15 20	15 20	12 56	12 54	9 32	9 30	4 50	4 48	0 18	0 22
150	0 18 W	0 22 W	3 38	3 40	10 22	10 24	14 10	14 16	16 18	16 20	26 38	16 38	15 52	15 50	13 04	13 02	9 46	9 42	4 50	4 48	0 20	0 24
180	1 00 W	1 04 W	4 56	4 52	11 26	11 22	15 30	15 30	17 18	17 22	17 36	17 40	16 40	16 40	13 24	13 24	10 08	10 10	4 52	4 54	0 24	0 28
210	1 44 W	1 42 W	6 24	6 24	12 30	12 30	17 10	17 10	18 18	18 20	18 46	18 42	17 36	17 36	14 00	13 56	10 32	10 30	5 02	5 04	0 22	0 26
240	1 54 W	1 54 W	7 44	7 42	13 04	13 00	18 08	18 06	18 56	18 54	19 24	19 20	18 16	18 12	14 18	14 12	10 46	10 40	5 08	5 08	0 26	0 24
270	1 04 W	1 02 W	8 04	8 04	12 40	12 34	18 00	17 58	18 38	18 36	19 16	19 12	18 02	18 20	14 06	14 00	10 36	10 36	5 10	5 10	0 24	0 24
300	0 04 W	0 02 W	8 06	8 06	12 00	11 56	17 40	17 38	18 24	18 20	19 02	19 02	17 52	17 52	14 00	13 58	10 32	10 30	5 10	5 10	0 22	0 22
330	0 38 E	0 42 E	7 44	7 44	11 34	11 32	16 52	16 52	17 50	17 48	18 26	18 22	17 20	17 16	13 42	13 42	10 18	10 16	5 08	5 08	0 20	0 20
Mean Deviations.	0 01½ W	0 01⅓ W	5 43⅔	5 42½	11 07½	11 06	15 45⅓	15 44⅔	17 17	17 15½	17 38⅓	17 36	16 44⅓	16 42⅝	13 32⅔	13 29⅓	10 06¼	10 03	5 00⅓	5 00⅙	0 21⅝	0 23
Deviations due to rotation.	0 00⅛′		0° 01⅙′		0° 01½′		0° 00⅓′		0° 01⅞′		0° 01½′		0° 01⅓′		0° 03⅓′		0° 03⅜′		0° 00⅙′		0° 01⅛′	

VI. *Table of the deviations of a magnetic needle, caused by the rotation of a circular plate of iron, when its centre was in the secondary to the equator and meridian, and its plane in the plane of this secondary.* Plate No. I.

	Long. 0°. Lat. 0°.		Long. 0°. Lat. 10° S.		Long. 0°. Lat. 20° S.		Long. 0°. Lat. 30° S.		Long. 0°. Lat. 40° S.		Long. 0°. Lat. 45° S.		Long. 0°. Lat. 50° S.		Long. 0°. Lat. 60° S.		Long. 0°. Lat. 70° S.		Long. 0°. Lat. 80° S.		Lat. 90° S.	
Upper Edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
Inner Edge.	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S		
0	2° 10′ E	1° 24′ W	5° 24′ W	8° 46′ W	13° 00′ W	16° 10′ W	19° 16′ W	21° 30′ W	21° 50′ W	23° 08′ W	21° 44′ W	22° 30′ W	21° 52′ W	22° 16′ W	18° 18′ W	18° 00′ W	13° 22′ W	12° 22′ W	8° 20′ W	6° 58′ W	1° 46′ W	0° 18′ W
30	1 54	1 50	5 40	9 28	13 10	16 44	19 22	21 50	21 54	23 20	21 50	22 40	21 50	22 10	18 30	18 12	13 20	12 20	8 18	6 58	1 48	0 24
60	1 46	1 58	6 34	9 44	13 16	16 50	19 22	21 54	21 56	23 20	21 48	22 40	21 30	21 50	18 24	18 04	13 20	12 18	8 14	6 54	1 46	0 18
90	0 54	2 38	7 20	11 06	14 14	17 24	20 40	23 06	23 18	24 38	23 20	23 58	22 40	22 56	19 16	18 58	14 00	12 50	9 00	7 36	2 18	0 48
120	0 00	3 40	8 30	12 20	15 12	18 32	21 20	23 38	23 40	24 56	23 38	24 16	22 44	22 58	19 14	18 50	14 00	12 50	8 50	7 26	1 56	0 22
150	0 30 W	4 20	9 34	13 08	15 52	19 10	21 54	24 22	24 16	25 26	23 58	24 36	23 20	23 40	19 22	18 58	14 06	12 52	8 56	7 32	1 58	0 28
180	0 30	4 40	9 36	13 34	15 50	19 30	21 46	24 30	24 04	25 24	24 00	24 38	23 18	23 38	19 18	18 56	14 00	12 52	8 52	7 36	1 42	0 20
210	0 08	4 30	9 10	13 20	15 32	19 02	21 36	24 30	23 38	25 08	23 36	24 20	22 56	23 16	18 46	18 30	13 42	12 46	8 24	7 08	1 24	0 00
240	0 30 E	3 38	8 00	11 38	14 06	17 44	20 04	22 28	22 44	24 04	22 20	23 10	22 08	22 30	18 00	17 42	13 10	12 18	7 50	6 38	0 54	0 38 E
270	1 46	1 54	6 16	9 48	12 26	16 04	18 20	20 46	20 58	22 24	20 56	21 46	21 20	21 42	17 10	16 50	12 56	11 48	7 36	6 10	0 50	0 44
300	2 44	1 20	4 46	8 28	11 48	15 18	17 50	20 20	20 22	21 40	20 36	21 20	21 06	21 26	16 54	16 38	12 56	11 46	7 38	6 12	0 50	0 40
330	2 38	1 20	4 50	8 28	12 06	15 20	18 16	20 26	20 58	22 08	20 48	21 26	21 10	21 26	17 18	16 52	13 10	11 50	7 44	6 18	1 28	0 18
Mean Deviations.	0 56 1/6 E	2 46 W	7 08 1/3	10 49*	13 52 2/3	17 19	19 58 5/6	22 26 2/3	22 28 1/6	23 48	22 22 1/2	23 06 5/6	22 09 1/2	22 19	18 22 1/2	18 02 1/2	13 30 1/6	12 24 1/6	8 18 1/2	6 57 1/6	1 32 5/6 W	0 03 1/6 W
Direction of Deviation by rotation.	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W
Deviation due to rotation.	3° 42′ 1/2		3° 40′ 2/3		3° 26′ 1/3		2° 27′ 1/2		1° 19′ 2/3		0° 43′ 5/6		0° 19′ 1/2		−0° 20′		−1° 06′		−1° 21 1/2		−1° 29′ 1/2	

	Long. 180°. Lat. 0°.		Long. 180°. Lat. 10° S.		Long. 180°. Lat. 20° S.		Long. 180°. Lat. 30° S.		Long. 180°. Lat. 40′ S.		Long. 180°. Lat. 45° S.		Long. 180°. Lat. 50° S.		Long. 180°. Lat. 60° S.		Long. 180°. Lat. 70° S.		Long. 180°. Lat. 80° S.	
Upper Edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
Inner Edge.	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N	N to S	S to N
0	1° 30′ W	5° 04′ W	6° 48′ E	3° 36′ E	14° 06′ E	10° 50′ E	19° 50′ E	17° 24′ E	21° 44′ E	20° 10′ E	21° 36′ E	20° 50′ E	20° 58′ E	20° 38′ E	17° 26′ E	17° 48′ E	11° 42′ E	12° 48′ E	5° 34′ E	6° 52′ E
30	0 32	4 18	7 38	4 30	14 52	11 50	20 42	18 18	22 10	20 40	21 46	21 00	21 00	20 40	17 26	17 46	11 42	12 48	5 36	6 50
60	0 38 E	2 52	8 42	5 20	15 44	12 42	20 00	19 34	22 38	21 30	22 10	21 22	21 10	20 52	17 36	18 00	12 00	12 56	5 38	6 56
90	2 14	1 20	9 46	6 18	16 48	13 38	23 00	20 22	22 42	21 40	22 12	21 30	21 00	20 42	17 22	17 48	11 32	12 34	5 08	5 28
120	3 16	0 22	10 48	7 32	18 00	15 00	24 20	21 44	24 02	22 58	23 40	23 00	22 18	22 02	18 16	18 40	12 08	13 10	5 34	6 58
150	3 12	0 26	10 40	7 12	18 00	15 00	24 10	21 34	24 08	22 50	23 54	23 10	22 24	22 08	18 16	18 40	12 04	13 08	5 30	6 50
180	3 12	0 26	10 46	7 16	17 58	14 58	24 20	21 36	24 34	23 16	24 30	23 48	22 50	22 32	18 38	19 04	12 22	13 20	3 44	7 00
210	3 40	0 12	11 30	7 58	19 20	15 54	25 00	22 14	25 24	23 56	25 26	24 34	23 40	23 20	19 12	19 36	12 50	13 58	6 08	7 20
240	3 38	0 10	11 48	8 16	19 22	15 58	24 50	22 08	25 54	24 38	25 52	25 10	24 12	23 52	19 46	20 08	13 20	14 22	6 40	8 00
270	2 24	1 12	10 40	7 06	17 48	14 40	23 00	20 28	25 08	23 38	25 04	24 20	23 42	23 22	19 22	19 50	13 12	14 18	6 38	8 00
300	0 42	2 52	9 10	5 40	16 52	13 26	21 42	19 34	24 06	22 36	24 00	23 18	23 10	22 48	19 00	19 26	12 50	14 06	6 30	7 52
330	0 50 W	4 28 W	7 40	4 14	15 18	11 40	20 22	18 02	22 56	21 18	22 40	21 56	22 00	21 38	18 18	18 40	12 28	13 36	6 14	7 34
Mean Deviations.	1 45 1/3 E	1 58 1/3 W	9 39 2/3	6 14 5/6	17 00 2/3	13 48	22 46 1/3	20 14 5/6	23 47 1/6	22 25 5/6	23 34 1/6	22 49 5/6	22 22	22 02 5/6	18 23 1/6	18 47 1/6	12 20 5/6	13 25 1/3	5 54 1/2	7 08 1/3*
Direction of Deviation by rotation.	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to W	S to E	S to E	S to W	S to E	S to W	S to E	S to W
Deviation due to rotation.	3° 43′ 1/6		3° 24′ 5/6		3° 12′ 2/3		2° 31′ 1/3		1° 21′ 1/3		0° 44′ 1/3		0° 19′ 1/6		−0° 24′		−1° 04 5/6		−1° 13 5/6	

* In adjusting the compass for the observations in long. 0°, lat. 10° and lat. 0°, the north end of the needle pointed 50′ W of zero in the box, and consequently 50′ should be subtracted from the westerly, and added to the easterly deviations. A similar error of 30′ W was made in the adjustment for lat. 80°, long. 180° and long. 0°, and lat. 90°. These will not affect the *deviations due to rotation*; but the *absolute deviations* must be increased when east, and diminished when west.

Table of the deviations of a magnetic needle, caused by a circular plate of iron, whose centre was in the secondary to the equator and meridian, and plane in the plane of this secondary, the plate having revolved in opposite directions; the distance of the centre of the plate from the centre of the needle being 16 inches. Plate No. I.

Latitude and Longitude of the plate's centre.		Lat. 0°.		Lat. 10° S.		Lat. 20° S.		Lat. 30° S.		Lat. 40° S.		Lat. 50° S.		Lat. 54° 45′ S.		Lat. 60° S.		Lat. 70° S.		Lat. 80° S.		Lat. 90° S.	
		Long. 0°		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.		Long. 0°.			
Direction of rotation of plate's upper edge.		W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W
Points on the plate coinciding with the line joining the centres of the needle and the plate.	0	1° 02′ W	0° 32′ E	4° 50′ W	3° 20′ W	7° 46′ W	6° 30′ W	9° 38′ W	8° 42′ W	10° 28′ W	9° 54′ W	10° 38′ W	10° 28′ W	10° 08′ W	10° 08′ W	8° 48′ W	9° 00′ W	6° 52′ W	7° 18′ W	3° 54′ W	4° 34′ W	0° 40′ W	1° 24′ W
	30	1 02	0 36	4 24	2 52	7 10	5 52	9 04	8 04	10 00	9 22	9 42	9 32	9 18	9 18	7 56	8 06	6 54	7 20	3 48	4 26	0 24 W	1 08 W
	60	0 58	0 40	4 04	2 32	6 38	5 22	8 38	7 38	9 38	9 00	8 56	8 46	8 46	8 46	7 24	7 32	6 50	7 16	3 44	4 18	0 18 W	0 56 W
	90	0 44	0 54	3 36	2 04	6 10	4 52	8 12	7 10	9 16	8 36	8 18	8 08	8 20	8 20	6 52	7 02	6 36	7 02	3 20	4 02	0 08 E	0 36 W
	120	0 46	0 52	3 32	2 02	6 12	4 56	8 18	7 18	9 22	8 42	8 18	8 06	8 26	8 24	5 58	7 12	6 20	5 48	3 02	3 48	0 26 E	0 24 W
	150	1 06	0 30	3 50	2 22	6 34	5 20	8 42	7 44	9 44	9 08	8 36	8 30	8 40	8 42	7 22	7 36	5 56	6 28	2 40	3 24	0 46 E	0 02 W
	180	1 14	0 26	4 06	2 34	6 58	5 40	9 04	8 02	10 04	9 30	9 02	8 52	9 00	9 02	7 48	8 00	5 26	5 56	2 18	2 58	1 08 E	0 22 E
	210	0 52	0 50	4 04	2 30	7 02	5 44	9 08	8 08	10 12	9 34	9 28	9 18	9 18	9 16	8 10	8 24	5 00	5 26	2 00	2 38	1 16 E	0 28 E
	240	0 34	1 04	4 02	2 30	7 10	5 52	9 16	8 14	10 16	9 38	9 58	9 52	9 42	9 42	8 36	8 48	4 48	5 18	2 02	2 40	1 08 E	0 22 E
	270	0 22	1 12	4 10	2 38	7 18	6 00	9 24	8 24	10 26	9 50	10 34	10 26	10 14	10 14	9 06	9 18	5 00	5 28	2 20	3 00	0 42 E	0 06 W
	300	0 26	1 06	4 26	2 56	7 34	6 20	9 40	8 38	10 36	10 00	11 04	10 56	10 36	10 40	9 28	9 38	5 32	6 02	2 54	3 34	0 06 E	0 38 W
	330	0 46	0 42	4 42	3 14	7 48	6 34	9 46	8 50	10 38	10 06	11 04	10 56	10 34	10 36	9 16	9 30	6 14	6 42	3 28	4 06	0 24 W	1 04 W
Mean deviations.		0 49 1/3	0 47	4 08 1/6	2 37 5/6	7 01 2/3	5 45 1/6	9 04 1/2	8 04 1/2	10 03 1/3	9 26 2/3	9 38 1/6	9 29 1/6	9 25 1/6	9 25 2/3	8 08 2/3	8 20 1/2	5 57 1/3	6 25 1/3	2 57 5/6	3 37 1/3	0 19 1/2 E	0 25 1/2 W
Deviations due to rotation.		1° 36′ 1/3		1° 31′		1° 16′ 1/2		0° 59′ 5/6		0° 36′ 2/3		0° 09′		—0° 00′ 1/2		—0° 11′ 1/6		—0° 28′		—0° 39′ 5/6		—0 45	
		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Long. 180°.		Lat. 90° N.	
Direction of rotation of plate's upper edge.		E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
Points on the plate coinciding with the line joining the centres of the needle and the plate.	0	1° 20′ E	0° 14′ W	4° 08′ E	2° 38′ E	7° 16′ E	5° 58′ E	9° 30′ E	8° 30′ E	10° 16′ E	9° 38′ E	10° 42′ E	10° 32′ E	10° 06′ E	10° 06′ E	9° 06′ E	9° 18′ E	4° 46′ E	5° 12′ E	1° 44′ E	2° 24′ E	0° 16′ W	0° 26′ E
	30	1 10	0 26	3 52	2 20	7 00	5 42	9 16	8 14	10 10	9 32	10 40	10 30	10 06	10 06	9 14	9 24	5 16	5 40	2 08	2 44	0 14	0 30
	60	0 58	0 40	3 38	2 06	6 46	5 26	9 00	8 00	9 54	9 16	10 12	10 02	10 40	9 40	8 52	9 04	5 42	6 10	2 28	3 06	0 10	0 34
	90	0 28	1 10	3 16	1 44	6 22	5 06	8 32	7 36	9 28	8 56	9 32	9 22	9 02	9 02	8 20	8 32	6 08	6 38	2 50	3 24	0 16	0 30
	120	0 12	1 22	3 06	1 36	5 10	4 56	8 18	7 20	9 14	8 40	8 46	8 38	8 20	8 20	7 38	7 50	6 24	6 56	3 04	3 50	0 06	0 42
	150	0 08	1 22	3 14	1 44	6 18	5 00	8 26	7 26	9 16	8 40	8 24	8 14	8 00	7 58	7 14	7 24	6 36	7 06	3 24	4 06	0 14	0 32
	180	0 18	1 18	3 28	1 56	6 30	5 14	8 44	7 42	9 32	8 52	8 20	8 08	7 56	7 54	7 08	7 16	6 40	7 08	3 38	4 18	0 32	0 14
	210	0 32	1 06	3 46	2 16	6 56	5 36	9 00	8 00	9 44	9 04	8 26	8 12	8 02	7 58	7 10	7 18	6 32	6 58	3 38	4 16	0 34	0 10
	240	0 52	0 46	4 02	2 30	7 10	5 52	9 18	8 18	9 56	9 18	8 42	8 30	8 12	8 12	7 20	7 28	6 04	6 32	3 18	3 58	0 32	0 10
	270	1 00	0 36	4 08	2 38	7 14	5 56	9 22	8 24	9 56	9 20	9 02	8 52	8 28	8 28	7 32	7 42	5 26	5 56	2 46	3 26	0 34	0 12
	300	1 18	0 18	4 18	2 50	7 24	6 06	9 32	8 32	10 08	9 32	9 44	8 32	9 04	9 04	8 04	8 14	4 56	5 24	2 14	2 54	0 26	0 18
	330	1 18	0 10	4 14	2 48	7 22	6 06	9 34	8 36	10 18	9 40	10 24	10 12	9 44	9 42	8 44	8 54	4 40	5 08	1 52	2 32	0 16	0 28
Mean deviations.		0 47 5/6	0 47 1/2	3 45 5/6	2 15 1/2	6 52 1/2	5 34 5/6	9 02 2/3	8 03 1/6	9 49 1/2	9 12 2/3	9 24 1/2	9 13 2/3	8 53 1/3	8 52 1/2	8 01 5/6	8 12	5 45 5/6	6 14	2 45 1/3	3 25 2/3	0 20 5/6	0 23 1/6
Deviation due to rotation.		1° 35′ 5/6		1° 30′ 1/3		1° 17′ 1/2		0° 59′ 1/2		0° 37′		0° 10′ 5/6		+ 0° 00′ 1/6		— 0° 10′ 1/6		—0° 28′ 1/6		— 0° 40′ 1/3		—0 44 2/3	

Considering the centre of the plate to have been in longitude 180°, and consequently the deviations easterly in all the observations, and thus taking a mean of the deviations in the several latitudes, I obtain the following.

A. *Table of the easterly deviations of the needle, when the centre of the plate was in longitude 180°, or to the west of the needle, the plate having revolved in opposite directions.*

Latitude of the plate's centre.	0°		10°		20°		30°		40°		50°		54° 45′		60°		70°		80°		90°	
Direction of rotation of plate's upper edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
Deviation East.	+47′ 55″	−47′ 55″	3° 57′ 20″	2° 26′ 40″	6° 57′ 00″	5° 40′ 00″	9° 03′ 25″	8° 03′ 45″	9° 56′ 20″	9° 19′ 30″	9° 31′ 20″	9° 21′ 25″	9° 09′ 15″	9° 09′ 05″	8° 05′ 15″	8° 16′ 15″	5° 51′ 35″	6° 19′ 40″	2° 51′ 25″	3° 31′ 30″	−22′ 25″	+22′ 25″
Deviation due to rotation.	1° 35′ 50″		1° 30′ 40″		1° 17′ 00		0° 59′ 40″		0° 36′ 50″		0° 09′ 35″		0° 00′ 10″		—0° 11′ 00″		—0° 28′ 05″		—0° 40′ 05″		—0° 44′ 50″	

Two sets of observations which I had made more than two years before, had given me the following results; but as I afterwards suspected that the absolute deviations might have been affected by the proximity of a mass of iron, of which I was not aware at the time of making the observations, I considered it better to repeat them in a situation where no such influence could be exerted, although I did not conceive that this would materially affect the conclusions.

B. *Table of the mean easterly deviations of the needle, when the centre of the plate was in longitude 180°, or to the west of the needle, the plate having revolved in opposite directions;* deduced from two sets of observations made in November 1822 and February 1823.

Latitude of the plate's centre.	0°		10°		20°		30°		40°		50°		54° 45′		60°		70°		80°		90°	
Direction of rotation of plate's upper edge.	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E	E to W	W to E
Deviation East. 1st Set.	+50′ 25″	−50′ 25″	4° 35′ 55″	3° 00′ 55″	7° 39′ 25″	6° 19′ 00″	10° 07′ 10″	9° 04′ 20″	11° 11′ 15″	10° 33′ 00″	10° 48′ 55″	10° 36′ 55″	No observation.		9° 13′ 05″	9° 25′ 30″	6° 32′ 15″	7° 04′ 55″	3° 14′ 55″	4° 00′ 35″	−25′ 00″	+25′ 00″
Deviation East. 2d Set.	+50 32	−50 32	4 25 45	2 48 50	7 36 45	6 11 55	10 08 30	9 02 05	10 53 10	10 14 15	10 40 55	10 28 15	9 53 35	9 53 05	9 11 15	9 23 50	6 35 30	7 07 45	3 06 45	3 51 25	−24 38	+24 38
Mean deviation East.	+50 28	−50 28	4 30 50	2 54 32	7 38 05	6 15 27	10 07 50	9 03 12	11 02 12	10 23 37	10 44 55	10 32 35	9 53 35	9 53 05	9 12 10	9 24 40	6 33 52	7 06 20	3 10 50	3 56 00	−24 49	+24 49
Mean deviation due to rotation.	1° 40′ 56″		1° 35′ 58″		1° 22′ 38″		1° 04′ 38″		0° 38′ 35		0° 12′ 20″		0° 00′ 30′		—0° 12′ 30″		—0° 32′ 28″		—0° 45′ 108		—0° 49′ 38″	