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EDITED

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Physical Science.

Description and Use of a Dipping Needle Deflector, invented by Robert Were Fox, Esq. *By* Mr. T. B. Jordan, *Philosophical Instrument Maker, Falmouth.*

The data for the accompanying paper having been kindly furnished by Mr. Fox, I now have the pleasure of forwarding it for insertion in your valuable Annals, in connexion with the description of the instrument which I have already sent you.   T. B. Jordan.

Description of the Instrument.

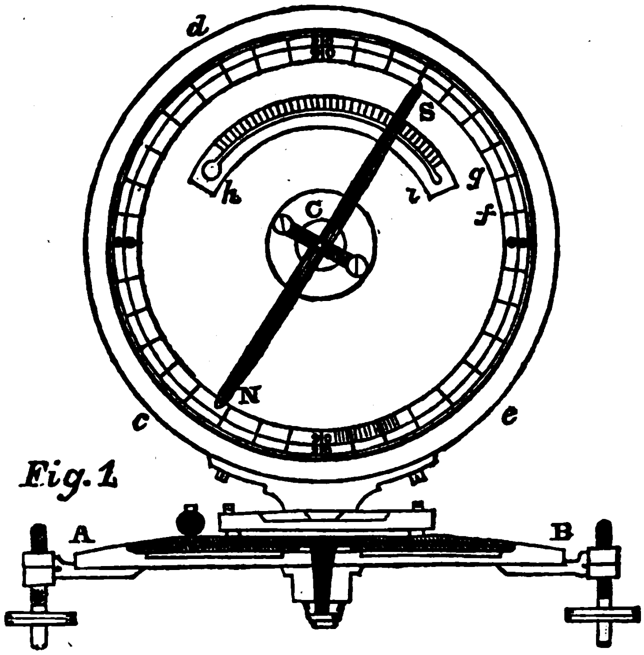

Fig. 1

Figs. 1 and 2 are front and back elevations of the instrument, and fig. 3, a transverse section with the deflectors screwed in. The same letters of reference are used in each figure. A, B, is the azimuth plate on which the vernier plate turns either in the same plane or with the usual beveled edge, as in theodolites. In the best instruments this limb is divided on silver or platina, and is read off by two verniers. The vernier plate is furnished with two levels, and the leveling screws are fixed to the foundation plate,

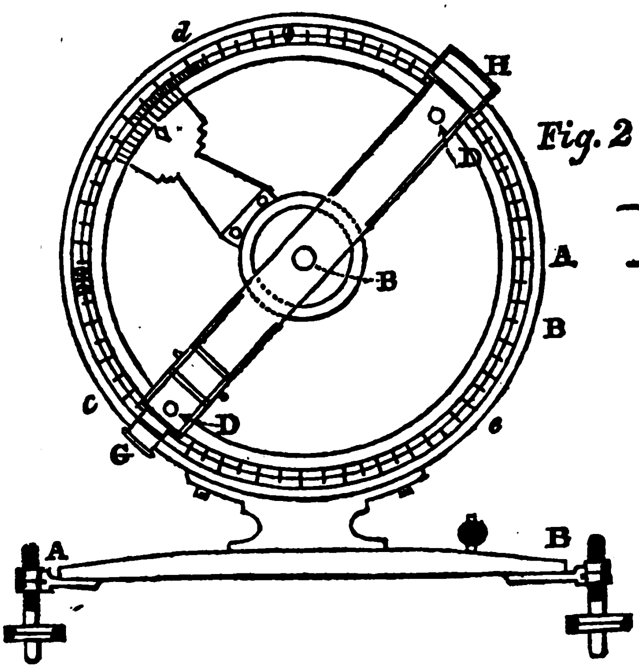

Fig. 2

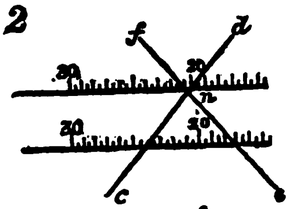

Fig. 2'

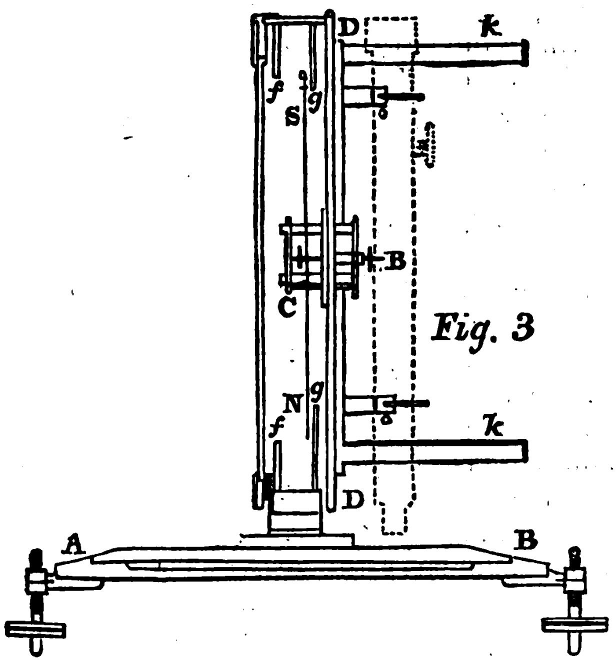

Fig. 3

as in the figures; or the instrument is made to screw on a stand similar to that used for field theodolites. *c*, *d*, *e*, is a circular brass box containing the needle N, S, two graduated circles *f*, *g*, and a thermometer *h*, *i*. The axis of the needle is terminated by exceedingly fine and short cylindrical pivots which work in jewelled holes. It may readily be removed from its bearings by releasing the screw B, at the back of the instrument, which admits of the front jewel coming forward sufficiently to remove the needle. The small grooved wheel C, on the axis, is intended to receive a thread of unspun silk, furnished with hooks for hanging the weights on in taking intensity observations, and the thermometer *h*, *i*, is intended to note the temperature at the same time.

The graduated circles, *f* and *g*, are adjusted to a perfect coincidence: the front one serves to direct the line of vision, and answers the purpose of a vernier.

At the back of the instrument (Fig. 2) there is another graduated circle adjusted to coincide with those in the box: but the zeros are generally placed on the vertical instead of the horizontal line, for the convenience of having the vernier arm independent of those carrying the deflectors.

The deflectors, *k*, *k'*, fig, 3, are two small cylindrical magnets, having their poles terminated by cones. After being magnetized and reduced to a standard intensity by heat, they are carefully packed in brass tubes; the outer tube of each is furnished with a screw, by which it can be fixed to the arms, D or D', at pleasure.

G, H, fig. 2, is an acromatic telescope fitted with webs, similar to a transit. Its use is to determine the true meridian for the variation of the needle; but as it has a vertical movement about the centre of the needle box, and a horizontal one on the vertical axis of the instrument, of course it may be used for measuring angles in either direction. It may be removed from its Ys when not in use.

The whole instrument is packed in a neat mahogany case, with magnetic armature, arranged so as to preserve the power of the different magnets. In addition to the parts described, the box contains a set of decimal weights for intensities, a pair of plyers, a rubber for producing friction on the back screw or pin, a screw driver, &c. &c.

The dotted lines in fig. 3 show the place of the telescope when in use.

Use of the Instrument.

Reading off, by means of two parallel graduated Circles.

The graduations on the parallel circles being coincident, they serve to direct the line of sight, and to prevent parallax in determining the position of the needle.

This arrangement also answers the purpose of a *vernier:* thus suppose the outer graduated circle to be *fifteen times* further from the points of the needle than the inner circle, the lines of sight, of which the points of the needle form the respective pivots, must pass over *fifteen* divisions on the former, to cause the needle to appear to pass over *one* equal division on the latter. If the relative distances of the two graduated surfaces from the points of the needle are unknown, it is evident that they may be readily ascertained by the same method.

To make this more clear, let the lines, A, B, fig. 2′, represent portions of parallel circles divided to half degrees; *n*, the point of the needle, and *c*, *d*, and *e*, *f*, visual rays; then by inspection of the figure, it becomes evident that the eye must, in passing from *c* to *e*, run over fifteen divisions on the outer circle before it can make the point *n*, appear to pass over one on the inner circle, so that the value of each division on the outer circle is two minutes, or of each degree four minutes. In reading off an instrument with this adjustment, we first observe the division which the needle has passed, (in the figure this is 21°) and then carry the eye on until we find some division which will fall in the same line with it and the needle point; in the figure this line is *c*, *d*, and the number of divisions passed over from 21° is 7, or 3° 30′, which makes the reading 21° 14′.

To find the magnetic declination.

Level the instrument by means of its screws, and ascertain the true meridian by the telescope, or sights, at the back, as the case may be, these being parallel to the plane of the needle, and note the angle indicated by the vernier on the horizontal limb. Turn the box round till the needle stands perfectly vertical, gentle friction* having been several times employed to cause the needle to take its true position.

The friction is produced by an ivory, or brass, surface being rubbed against the extremity of a pin which projects from the back of the extremity of the jewel plate, and again note the angle on the horizontal limb. The face of the instrument should then be turned round to the opposite quarter till the needle again becomes vertical, and if it required more, or less, than 180° to effect this, half the difference will indicate the true magnetic meridian, the face of the instrument being at right angles to it.

To ascertain the dip.

The face of the instrument having been made to coincide with the plane of the magnetic meridian, by turning it 90° from its last position, and vibration produced as before, the mean indications of both poles of the needle should be carefully observed and noted. The face should then be turned round 180°, so as to be again in the plane of the magnetic meridian, and the observations repeated and noted; the mean of the whole will indicate the dip.

To correct the observed dip.

The instrument being still in the plane of the magnetic meridian, screw on the deflectors, *k*, *k*, at right angles from the back, as shown in figure 3, so as to *repel* the ends of the needle which are nearest to them: adjust the deflectors at a given angle from the supposed or observed dip, say at 45° or at 50° from it, as shown by the vernier or verniers at the back.

Suppose after vibration, that the lower end of the needle settles at 115°

* This must in no case be omitted previous to reading off the place of the needle.

from the o on the north side of the instrument. Then turn the deflectors back to an equal angle from the observed dip, say 45°, or 50° as the case may be, on the opposite side of it, which suppose to be 69° 20′, and that the poles of the needle stand at 23° 30′. Then 23° 30′ + 115°=138° 30′, which divided by 2, gives 69° 15′. Turn the instrument round 180° in azimuth and repeat the process, and if the result should be 69° 13′ the mean or corrected dip will be 69° 14′. Similar observations may be multiplied at pleasure by varying the angles of the deflectors from the observed dip, but generally three sets of observations will be perfectly satisfactory.

Mr. Fox generally employs one deflector to ascertain the true dip, as small angles seem often to give more uniform results than large ones. The following may be considered as fair specimens of the results obtained by this method, even with a four inch needle.* They were recently observed at Westbourne Green, Paddington, near London, by Mr. Fox, in company with Capt. Ross, R. N.

The deflector which repelled the north end of the needle having been screwed into the lower arm at the back, and adjusted at 40° from the apparent dip of 69° 20′ first on one side and then on the other.

First Observation.

Instrument facing East needle repelled to	87°	10′		
On altering the deflector to 40° on the other side, needle stood at	51	20		
Sum	138	30;	which ÷2=69° 15′	Mean 69° 17′ .5
Facing west needle repelled to	86°	58′		
And afterwards to	51	42		
Sum	138	40;	which ÷2=69° 20′	

Second Observation

Deflector adjusted at 50° from apparent dip of 69° 20′ facing east	85°	20′		
And afterwards	53	8		
Sum	138	28;	which ÷2=69° 14′	Mean 69° 16′ .5
Facing west	85°	2′		
And afterwards	53	36		
Sum	138	38;	which ÷2=69° 19′	
General Mean,	.	.	. .	69° 17′

If the apparent dip had been taken at 69° 14′ or 69° 15′, the corrected dip would probably have been reduced to 69° 16′ or 1′ less, an original error of 5′ or 6′ in the apparent dip being reduced to 1′ by this method of correction. It may here be observed, that in this way the bearings of the

* Satisfactory as these observations are, a longer and heavier needle is found to give still more uniform and consistent results.

axle of the needle are changed, and by turning the jewel plate the resting places in the jewels are also changed, and under all these circumstances the results have been found most satisfactorily and remarkably uniform.

To ascertain the terrestrial magnetic intensity by means of weights.

Take off the deflector or deflectors and place the fine silk, with the hooks attached, on the grooved wheel, and suspend weights to one of the hooks so as to coerce the needle to a given distance, say 50°, from the actual dip at the station; and after applying friction as usual at the back, note the weights required; then change the weights to the other hook till the needle is coerced 50° on the opposite side. The weights required will indicate the magnetic intensity at the place of observation as compared with that ascertained in the same manner at any other place. Instead of having *given angles* to which the needle is to be deflected, it is more easy and practical to employ *given weights*, and the inverse ratio of the sines of the angles of deflection will give the intensity; corrections having been applied for differences of temperature at the different stations.

Mr. Fox has lately obtained many results of intensity, as well as of dip, at various places on the continent and in this country, with a small portable dipping needle deflector, having a 4-inch needle; and on this needle 1° of the Centigrade scale produces an effect on the angles of deflection equal to 2′ to 2′. 4. An example will show the method pursued.

Suppose two grains to be the given weight employed in one of his experiments, the instrument facing east, and that the needle counting from 0° was stationary at . . . 118° 8′ and afterwards on putting the 2 grains on the other hook at 20° 40′

Included angle	97 28; which ÷ 2 =	48° 44′
The same observations repeated facing west .		= 48 38
Mean, instrument facing east and west		48 41
Temperature 17° centigrade, or taking 14° as the the standard, there would be 3° in excess, for which deduct		0 7
Corrected mean angle . .		48 34

the inverse ratio of the sine of which will show the intensity in relation to other results similarly made, and with the same weights.

Similar experiments may be made with other given weights, 2.1 grs., 2.2 grs., 2.3 grs., &c. for instance, and the number of observations multiplied at pleasure, and the mean of the whole taken.

The following are a few of the results which Mr. Fox has obtained, which may serve to show the working of the method in question. The needle used was only 4 inches long, and, consequently, did not give such uniform results as a larger needle would have done.

Mean results obtained at different stations near London.

Corrected angle, the instrument facing east and west.

Grs.		Intensity.
2.0	= 48° 36′ .7 =	1.0000
2.1	= 51 55 .3 =	1.0000
2.2	= 55 33 .0 =	1.0000

Eastbourne, in Sussex, Grounds of Davies Gilbert, Esq.

(Chalk.)

Grs.			Intensity.
2·0	= 48° 57′	=	0.9938
2·1	= 52 19	=	0·9921
2.2	= 55 57	=	0·9952
	Mean		0·9937

Eastwick Park, near Leatherhead, Grounds of David Barclay, Esq.

(Chalk.)

Grs.			Intensity.
2·0	= 48° 35′	=	0·9997
2.1	= 51 57	=	0·9996
2.2	= 55 40	=	0·9986
	Mean		0·9993

Grounds of Combe House, near Bristol, George Hilhouse, Esq.

(Limestone.)

Grs.			Intensity.
2·0	= 48° 25′	=	1·0023
2·1	= 51 45	=	1·0024
2·2	= 55 18	=	1·0031
	Mean		1·0026

Grounds of R. W. Fox, Esq., near Falmouth.

(Clay Slate.)

Grs.			Intensity.
2.0	= 48° 29′	=	1.0013
2.1	= 51 48	=	1.0017
2.2	= 55 20	=	1.0026
	Mean		1.0018

The intensity of the earth's magnetism may also be ascertained by means of the deflectors. For this purpose the latter should be screwed into the sockets in the arms at the back of the instrument, and adjusted to the dip at the station, so as to repel the needle from it, first on one side and then on the other.* Half the sum of the included angles will represent the force of the earth's magnetism in relation to that of the deflectors on a needle thus circumstanced; that is, at the angles which the latter makes with them respectively. The value of the sines of angles thus taken at different stations and with the instrument facing east and west, may be ascertained by means of small weights. For this purpose the deflectors should be placed *at the angle* of which the value is to be ascertained, the same to be calculated from *the actual dip at the place of observation where the weights are to be employed.* The weights required to coerce the needle back to the dip, against the force of the deflectors, will give that of the earth's magnetism on the needle, at the angle, the value of which is required, and in comparing the value of

* The position of the needle may be readily changed from one side of the dip to the other, by turning the jewel plate and its bracket by means of the knobs at the back.

different angles the sines of which will be greater or less in proportion as the terrestrial magnetic intensity is less or more, corrections must be applied according to the sines of such angles in an inverse ratio. Such observations, in order to be quite satisfactory, should be made with the deflectors adjusted on each side of the dip, and, when convenient, with the instrument facing the east and west, the mean of the whole being taken. Upon the whole, however, Mr. Fox prefers using the weights alone for ascertaining the intensity, if time should not admit of both methods being employed, which he finds they will do with a remarkable degree of uniformity and precision. It may here be observed, that if the needle should have sustained any diminution of force, it will settle at a *less* angle from the deflectors when in the dip at a given station, and at a *greater* angle when deflected by given weights only; whereas, if the force of the earth's magnetism should only be diminished by a change of station, the angles will be increased by both methods.

It is evident that if the deflectors are fixed at a constant angle from the dip, *at any given station*, and the needle is coerced, as before, into the line of dip, the weights required will be constant if no change has taken place in the magnetism of the deflectors, or the needle; and they will detect the amount of such change should it occur at any time or place.

In order to ascertain whether or not the needle itself has varied in intensity, remove the deflectors and screw the tube containing the second needle, which call number 2, into one of the arms at the back, so as for it to repel the suspended needle number 1. Adjust number 2 at any given angle, suppose 45° from the line of dip at the station, and coerce number 1 by weights into the dip. Repeat the operation with the opposite end of number 2, or rather screw the tube into the other socket. Half the sum of the weights required in both cases will indicate the repulsive forces of the needles with respect to each other under these circumstances at the angle of 45°. Remove number 2 from the back, and deflect number 1 to any given angle, say 45° from the dip, by means of weights only, and note the weight required to effect this. Change the needles, placing number 1 in the tube, and suspending number 2, and go through precisely the same operations as before. If, under these circumstances, there should appear to be any difference from the previous results in the reciprocal action of the needles, take the mean of both.

It is highly desirable that the deflections should always be made on *both sides* of the line of dip to ensure accuracy, and the process will be still more complete if done with the instrument facing both east and west.

In this manner the reciprocal force of the needles on each other may be ascertained, and their respective forces in relation to that of the earth's magnetism, under the circumstances described; and, therefore, approximately at least, the influence of any change in the former in relation to the latter, and vice versa.

These relations may be ascertained by experiments and varying the force of the needles at a given station where the terrestrial magnetic intensity is, for the time of their duration at least, presumed to be constant. And it can scarcely be doubted that this method furnishes the means of obtaining a true standard measure of the force of the earth's magnetism, at any time or place on given needles; or at least of approximating very closely to it.

In the course of such experiments it may, moreover, be found desirable to adjust the deflecting needle parallel to the arms at the back, (for which provision is made in the large instruments) and under such circumstances to repeat the operations which have already been described, with the deflecting needle at right angles to the arms; and in both cases the given angles may be multiplied at pleasure; thus 40° and 50° may be taken as well as 45°, and the deflecting needle may be likewise fixed in the line of dip so as to repel the suspended needle from it, instead of using the weights alone for this purpose, and in this way the relation of the needles with respect to the earth's magnetism, may be ascertained by applying the weights as described in the case of deflectors.

It will not be requisite, at any time, to employ extremely minute weights; as the value of small difference in the angles may easily be estimated in weights; thus if $\frac{1}{20}$ of a grain should cause the needle, under given circumstances, to pass through 30′ $\frac{1}{200}$ of a grain, will be represented by 3′.

In all observations on the magnetic intensity, the temperature should be noted, and the needful corrections applied, the amount of which may be readily ascertained by experiments, such as covering the instrument with a heated vessel inverted, or admitting heated air under it, &c. In one instrument, a needle, when deflected by weights 50° from the dip, had the angle increased more than one minute, by every degree (Fah.) of augmented temperature: in other needles of weaker intensity, the influence of temperature has been less considerable; the *ratio* appears to be nearly uniform within the ordinary range of changes in this climate.

If the needles are tempered very hard throughout, and, after having been magnetised, heated to 180° or 200°, Mr. Fox has found that they sometimes retain their force without any appreciable change for a long period of time, although he has continually observed that the magnetic axis* of a given needle, is liable to frequent variation, even without its having been retouched.

This is shown by its having at one time uniformly an excess of dip, when facing east for instance, and at another, when facing west, and this without affecting the mean results on either occasion. He also finds that needles attain their maximum force after having been rubbed by a magnet or magnets two or three times only. Annals Electricity.

Notices from the French Journals, translated for the Journal of the Franklin Institute, by J. Griscom.

Turbines.

M. Savary read a report (to the Academy of Sciences, Paris,) in his own name, and those of M. M. Prony, Arago and Gambey, on a memoir of M. Morin, containing the result of experiments on the turbines of M. Fourneyron.

Under the general name of turbines is understood water wheels which have scarcely any thing more in common than that of turning on a vertical axis. Those which an engineer, M. Bardin, invented and first made known under this appellation, receive the water at the top of a vertical cylinder or drum, and discharge it at the bottom. The water enters and issues near the circumference, and runs along spiral channels bent round the surface of the drum, which must be half as high as the whole disposable fall of the water.

* This fact suggests the expediency of having the wide part of a horizontal variation needle vertical and not horizontal, to ensure the greatest degree of uniformity in its indications.