A UNIPOLAR MAGNETIC COMPASS

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The purpose of this paper is to suggest the possibilities in the polar pivoting of magnets, which in the opinion of the writer greatly clarifies and simplifies the demonstration of the First and Second Law of Magnets.

By pivoting a magnetic needle at one of its poles, a unipolar magnetic compass is designed as shown in Fig. 1. Such a polar-pivoted needle can be used to demonstrate the law of magnetic attraction and repulsion. When a bar magnet is presented to the free end of the compass needle so that unlike poles are near, attraction takes place as indicated by the movement of the needle; or, when like poles are near, repulsion likewise takes place. The advantage of such a polar-pivoted needle is that when it is desired to demonstrate attraction, attraction alone can be demonstrated; and when it is desired to demonstrate repulsion, repulsion alone can be demonstrated, because the pole which is located at the pivot point has a zero lever arm and hence contributes nothing to the magnetic moment. In the case of the ordinary magnetic needle, which is pivoted between the poles, magnetic attraction or repulsion is always accompanied by repulsion or attraction, and these two effects form a couple which causes the needle to orient itself with respect to a magnetic field, a point that is not always obvious to the pupil.

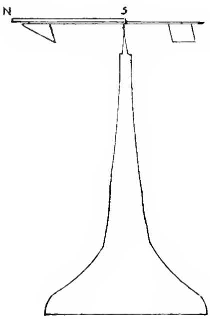

FIG. 1

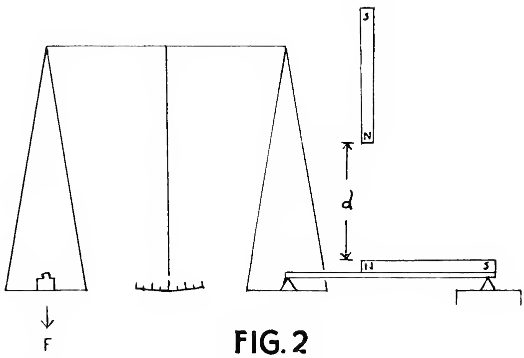

FIG. 2

A demonstration in either attraction or repulsion can be made conspicuously conservative by adjusting the magnetic needle so that both poles are on the same side of the pivot point and also in line with it. It can thus be shown, by presenting a magnetic field, that the predominant movement of the needle takes place as a result of the moment of the pole at the greater distance from the pivot, while the other pole, which has the shorter lever arm, tends to produce motion in an opposite direction, as indicated by bringing a bar magnet very near it, which then produces motion in the opposite direction. Thus attraction can be demonstrated in spite of repulsion, and repulsion can be demonstrated in spite of attraction, a point that will surely be obvious to the pupil.

The apparatus used in the demonstration for this paper was constructed for the writer by Mr. Robert Rice. It consists of a ten-inch aluminum bar which carries a bar magnet made from a clock spring. The magnet is adjustable so that it can be extended along the aluminum bar, making it possible to place it in any desired location with respect to the pivot point. A slide-adjustable copper weight counterbalances the system. A twelve-inch pedestal bearing a needle point furnishes the base for the aluminum bar. Various sized apparatus were made, giving in each case the same results.

In order to test the possibilities of using the polar-pivoted magnet in the demonstration of the Second Law of Magnets, which states that the force of attraction or repulsion between two poles varies inversely as the square of the distance between the poles, several hookups were used. The simplest and most satisfactory was to place a six-inch magnet upon a ten-inch hardwood bar, which was supported at either end by knife-edge supports such that one pole (South) of the magnet rested over one knife-edge support, while the other end of the bar extended and rested upon the knife-edge which was supported by one pan of a chemical balance. Above the free pole (North) of the magnet, and at right angles to it, was placed vertically, at measured distances, another magnet which produced the repulsing force. The relative forces were measured by the balance, while the distances between the poles were measured by a meter stick. Fig. 2 shows a schematic drawing of the assembly.

One apparent advantage in this set-up is that the earth's field produces no effect that can vary the readings, as the position of the polar-pivoted magnet never changes. For a practical demonstration the writer believes that it may be assumed without too much error that the upper or far-away pole of the vertical magnet has no effect upon the readings.

The following data are here submitted showing a high school student's results, using the above described set-up of apparatus:

F equals the relative chemical balance readings.

d equals the distance between like poles in cm.

Fd^2 should be a constant if our data have any significance in proving the law of inverse squares for magnets.

d (cm.)	F (g.)	Fd^2
24	.012	6.912
20	.019	7.600
18	.023	7.452
16	.033	8.488
15	.032	7.200
12	.059	8.496
10	.085	8.500
8	.131	8.384
6	.215	7.740

In submitting this sample of the various data taken, there is no intention of making claims, but rather to suggest possibilities of interesting research with polar-pivoted magnets.