points are called the "poles," and may be in any position. While there may be a number of these poles, there are usually only two, **but never less than two,** and if the magnet is in the form of a bar these two will usually be very near the ends of the bar.

If a two-pole magnet is brought near a pole of a second magnet, it will be observed that this pole attracts one pole of the magnet and repels the other, which indicates that the poles are not alike. The different poles are distinguished as "positive" and "negative."

If we balance a two-pole magnet on a pivot, we find that it will turn on the pivot so that one pole points north and the other south. For this reason the poles are often distinguished as "north" and "south" poles. The

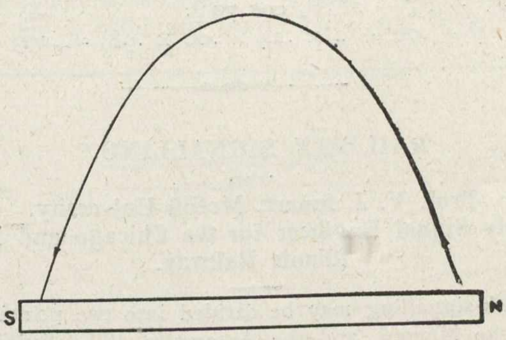

FIG. 12

north pole of a magnet may be easily distinguished from the south pole in this way. (A small magnet suspended in this way is known as a "mariner's compass," or a "compass needle.")

Laws of Attraction and Repulsion.—A few simple experiments will suffice to indicate the laws which govern the force exerted by a magnet.

If the north poles of two magnets, A and B, are brought together as in Fig. 10 they will repel each other, while if a south pole and a north pole are brought together, they will attract. This proves the first law, that **like poles repel and unlike poles attract.**

If these two magnets are made of long pieces of steel wire, and placed as in Fig. 10, the effect of the south pole of magnet A on the north pole of magnet B will be very small compared to the effect of the north pole of A, because the former is relatively far away. For the same reason the effect of the south pole of magnet B will be very small. The force exerted between the two magnets will, therefore, represent very closely the influence of one north pole on another.

To deal with this force quantitatively it is necessary to first adopt some unit to express the strength of the poles, since all poles do not exert the same force. Such a unit may be selected arbitrarily, but the selection might not lead to simple mathematical expressions. For the present, however, it will serve the purpose to express the pole strength by a symbol. It may also be decided to adopt the C.G.S. system of fundamental units.

Let m be the symbol for pole strength.
Let m_1 = pole strength of magnet A.
Let m_2 = pole strength of magnet B.
Let d = distance between the two north poles.
Let F = force exerted between the poles, in dynes.

If the force F is measured for different values of d, it is found that **this force varies inversely as the square of the distance d;** i.e., if the distance is doubled, the force is reduced to one-quarter, and if the distance is trebled, the force is reduced to one-ninth, etc.

The variation of this force with variation of pole strength may be determined by placing beside the magnet A (Fig. 2) another magnet exactly the same, so that together the two magnets form one magnet whose pole strength is double that of A. By varying the strength of m_1 of the poles of A in this way, and measuring the corresponding change in the force, we find that the force varies directly as the pole strength m_1. A similar experiment will show that the force varies directly as the pole strength m_2 of the magnet B. It thus follows that

$$F \propto 1/d^2;\ F \propto m_1;\ F \propto m_2.$$

Combining these into an equation we have—

$$F = Km_1m_2/d^2 \quad \ldots\ldots\ldots\ldots \quad (7)$$

K being a constant.

Having obtained a mathematical expression for the force exerted between two poles, a unit of pole strength may now be selected, which will make this expression as simple as possible. This is done by making K unity. In this case, if $m_1 = m_2$, these must each be unity when F and d are each unity. In other words, if F is one dyne and d is one cm., m_1 and m_2 must each be unity. This gives a simple unit of pole strength, and the one which has been adopted by international agreement. It may be defined as follows: **A unit pole is one such that, if placed one centimeter from another unit pole, the mutual force exerted is one dyne.**

Equation (7) now becomes—

$$F = m_1m_2/d^2 \quad \ldots\ldots\ldots\ldots \quad (7a)$$

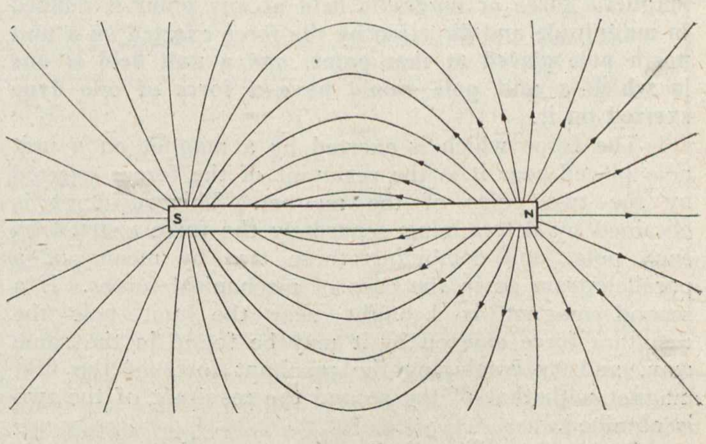

FIG. 13

Problem 4.—A north pole of strength 10 is placed 4 cms. from another north pole of strength 5 to determine the mutual force exerted.

$$F = m_1m_2/d^2 = 10 \times 5/4^2 = 3.12 \text{ dynes.}$$

Distribution of Magnetic Force.—The influence of a magnet pervades the whole space surrounding it, for it exerts a force on a magnetic substance placed at any point near it. This space is known as the "field" of the magnet, and is often referred to as a "field of force." The magnitude of the force exerted is greatest near the poles, and becomes less as the distance from the poles increases, as shown by equation (7). If a very small magnet is balanced on a pivot so that it is free to turn about a vertical axis, and then placed near a large magnet so that both are in the same horizontal plane,