clusion, city track should be well built, on solid foundation, with paving substantial, durable and pleasing to the eye, and laid with all possible economies to reduce costs, provided the economy is not carried to such an extent as to mitigate in the least the good-will and sufferance of the public.

ELEMENTARY ELECTRICAL ENGINEERING.

L. W. Gill, M.Sc.

This series of articles will be continued for some months. They will be of particular interest to the student of electrical work and the civil engineer anxious to secure some knowledge of the simpler electrical problems.

The Earth a Magnet.—If a two-pole magnet is balanced horizontally so that it is free to turn about a vertical axis it will assume a position such that a line joining its poles will point nearly, if not exactly, north and south, the north or positive pole pointing toward the north. This indicates that there is a magnetic field all over the earth's surface, and that its direction is from south to north, for the north pole of the magnet tends to move to the north. The geographical north pole of the earth thus acts as the south or negative pole of a magnet, and the south pole of the earth acts as the north or positive pole of a magnet. The earth is, therefore, a huge magnet, with its north or positive pole at the south.

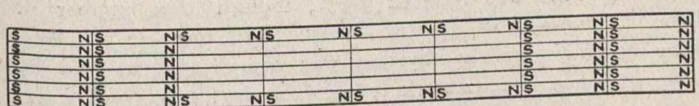

FIG. 14

If the material of the earth were homogeneous and its magnetic poles coincided with its geographical poles, the direction of the magnetic force would be exactly from south to north, but on account of the large and irregularly distributed bodies of magnetic material in the earth's crust the magnetic poles do not coincide with the geographical poles, and the direction of the magnetic force is not exactly from south to north. The angle between the magnetic meridian at any point (a line representing the direction of the magnetic force as indicated by a compass needle) and the geographical meridian is known as the "magnetic declination" at that point. This varies from 0° to 30°, depending on the locality, being in some cases to the east and in other places to the west.

Up to this point the horizontal direction only of the earth's magnetic force has been considered. The compass needle being free to turn only in a horizontal plane indicates only the horizontal direction of the earth's force. If a second magnet is suspended so that it is free to turn about a horizontal axis, and this axis is placed at right angles to the magnet meridian, the magnet will then be free to point in the direction of the resultant force of the earth. The inclination of the latter to the horizontal is known as the "dip" of the earth's field, and varies considerably with the locality. The magnitude or intensity of the earth's field varies roughly from .3 to .6 dyne on the habitable portion of the earth.

In addition to the variations in the strength of the earth's field, declination, and dip, depending on locality, there is also a variation in each of these, depending on time. Some of these variations are cyclic, passing through a series of changes in periods of a few days, months or years, while other variations are more or less permanent.

Subdivision of Magnets.—If a bar magnet with a pole at each end is cut at right angles to its length, it is found that each piece is a magnet with two poles. The two additional poles have appeared at the point of section, one in each piece, so that each piece has a positive and negative pole the same as the original magnet. If each piece of the original magnet is now cut, four magnets are obtained, each with two poles. If the parts are put together, each part being put in its proper place, all the new poles apparently disappear. In reality they do not disappear, but simply neutralize each other, thus proving that a positive pole will exactly neutralize a negative pole of equal strength.

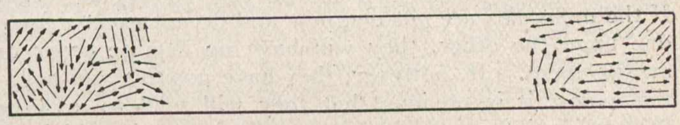

FIG. 15

If the magnet is divided in the direction of its length, a similar result is obtained. It is thus obvious that it is possible to subdivide a magnet into an infinite number of small magnets, each having two poles. A magnet may, therefore, be regarded as being made up of an infinite number of small magnets, with their north poles all pointing in one direction. Within the magnet the poles of these small magnets neutralize each other. At the ends of the magnet one pole of each of the small magnets is not neutralized, and these form the poles of the large magnet. Such an arrangement of small magnets is shown in Fig. 14.

If an attempt is made to subdivide a magnet, the parts soon become so small that it is mechanically impossible to carry the subdivision further. Theoretically, however, it can be continued until each part is a molecule. The conclusion is thus reached that each molecule of a magnetic substance is a magnet. When any considerable number of these molecular magnets point in one direction, there is a resultant external effect, and the substance is said to be magnetized; while, if the molecules as a whole do not point in any particular direction, their

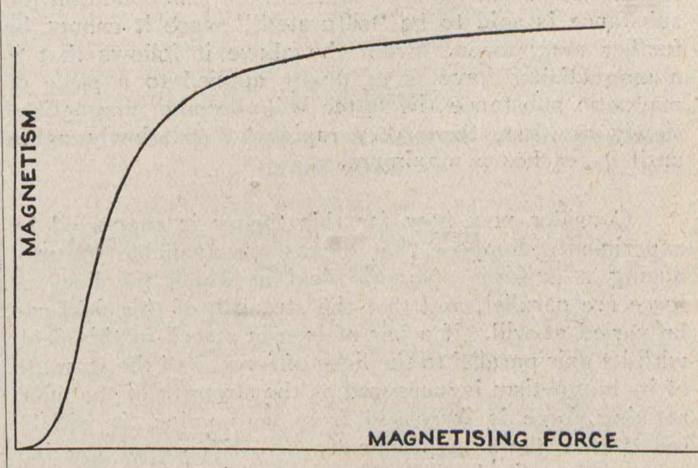

FIG. 16

poles neutralize each other, and the resultant magnetic effect is zero.

In addition to the above it will be clear that when the molecules are forced to point in one direction, as in