Mr. Earle Bernard Phelps' statements were open to criticism, and as he had mentioned my name in connection with the Digby process I thought it well to take the matter up. My connection with this particular process, however, is limited to having written a paper dealing with it, jointly with Mr. W. Pollard Digby, some years ago, to which paper Mr. Phelps referred in his report.

Yours truly,

H. C. H. Shenton.

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.

Magnetic Flux (continued).—The symbol for magnetic flux is "ϕ," and the unit is the "maxwell." A circuit with a flux of 1,000 maxwells will thus have 1,000 unit streams of flux and 1,000 lines of force.

The number of unit streams of flux, lines of force, or maxwells per unit area, is known as the "flux density," the unit of which is the "gauss," and the symbol "B." At any point where the flux density is one gauss the sectional area of a unit stream is one sq. cm. If **a** represents the area of any circuit over which the flux density is uniform, it is obvious that $\phi = Ba$. In the case of a magnetic flux in air, the symbol "H" is usually adopted to represent flux density instead of B.

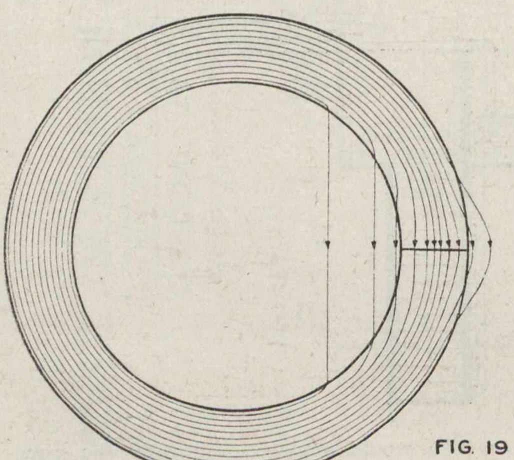

FIG. 19

Magnetomotive Force.—Since by hypothesis magnetic force is caused by a motion or flow of some fluid, it follows that there must be some motive force causing this flow. In the case of the mechanical analogy shown in Fig. 17, the propeller is the seat of a motive force which causes a difference of pressure between its two sides, and as a result of this difference of pressure there is a flow of fluid from the point of higher pressure to the point of lower pressure. In the case of the magnet there is a "magnetomotive force" which sets up a difference of magnetic pressure or potential, and the result is a flow of fluid from points of higher to points of lower magnetic potential. Regarding the nature of magnetomotive force or the mechanism which causes it nothing is known except that each molecule is the seat of such force, since each molecule is a magnet. Each part of a magnet is, therefore, the seat of a magnetomotive force. It is also found that an electric current is the seat of a magnetomotive force. (See section on Electro-magnetism for a full discussion). The unit of magnetomotive force is the "gilbert," the symbol "M," and the abbreviation "m.m.f."

Magnetic Reluctance.—When a difference of pressure causes any fluid to move from one point to another, the motive is opposed by frictional forces. In the case of the electric current this opposition to the flow is known as the "resistance" of the conducting medium. In the case of magnetic flux it is known as "reluctance." The reluctance of any path will vary directly as its sectional area and inversely as its length. It will also depend on the physical nature and condition of the conducting medium. Under given conditions one substance is found to be more permeable to magnetic flux than another, i.e., it will allow more flux to pass per unit of area.

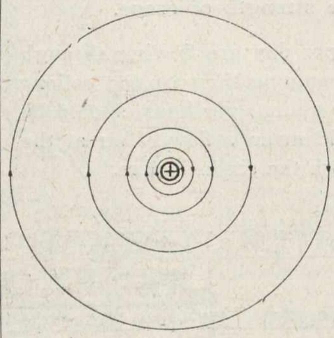

FIG. 20

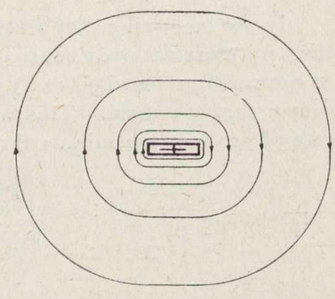

FIG. 20a

The capacity of any substance to conduct magnetic flux in comparison with a vacuum taken as unity, is known as its "permeability." This is represented by the Greek letter "μ." Since the conductivity of air is the same as that of a vacuum, the permeability of a substance may be defined as its magnetic conductivity relative to air. The unit of reluctance is the "oersted," and the symbol "R."

As the permeability increases the flux increases; consequently the reluctance will vary inversely with the permeability. It thus follows that if the sectional area of any magnetic path is represented by **a** and the length by **l**, the expression for reluctance will be

$$R = \frac{kl}{a\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

k being a constant, the value of which will depend on the unit selected for reluctance. By selecting a suitable unit for the latter the value of **k** is made unity, and the above expression becomes

$$R = \frac{l}{a\mu} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (8a)$$

From the above it is seen that magnetic permeability is analogous to electric conductivity. The former, however, varies greatly with the quantity of flow, while the latter is independent of the flow. This fact makes it much more difficult to deal with magnetic flux than with the flow of electricity. On the other hand, permeability varies very little with change of temperature (except at higher values of temperature), while conductivity varies considerably with temperature.

The Magnetic Circuit.—It has been shown in a previous section that wherever there is magnetism there is a magnetic circuit, around which there is a magnetic flux. This flux is represented symbolically by "lines of force," which always form closed loops. Consider now the whole of any magnetic circuit. Since the flow of any fluid in a