THE ELECTRIC CIRCUIT.*

THE electric circuit is the path or paths by which the current passes, and it must be complete from any given point, say the positive pole of the generator, through the wires, cables, etc., forming the external circuit, back to the negative pole of the generator, and through that to the positive pole from which it started. If any portion of the circuit be wanting; that is to say, if there be any place, or any body present in the path of the current, where the available E.M.F. cannot force any current through, then no current passes in any part of the circuit; and the apparatus which should have been actuated by the current does not work. A complete electrical circuit is sometimes spoken of as a *closed circuit*, and the operation of causing the current to cease is referred to as *breaking circuit*, or *opening circuit;* and again, a circuit in which no current is passing is sometimes called an *open circuit*. Thus, a dynamo machine is spoken of as being run on *open circuit*, when no work is being done in the circuit external to the machine. The same current—that is, the same strength of current in *Amperes*—passes in every part of a closed electric circuit; so that if a body whose resistance is comparatively high form part of the circuit, it will weaken the current passing in every part, in accordance with Ohm's law; and conversely, lowering the resistance of any part of the circuit will raise the current strength.

Though it has been stated that for all electrical action, or rather for the working of all apparatus requiring the passage of electrical currents, a complete electric circuit is necessary, it does not follow that there may not be more than one electric circuit; in fact, there may be as many of them as you like, and they may be arranged all to emanate from one source, or to branch out from other circuits. But no matter how many there are, the same rules hold good, viz., that no current will pass in any circuit—whether it be one of a number of circuits, a branch from another circuit, or a simple circuit by itself—unless that individual circuit is complete; and it follows, of course, that in the case of branches from a larger circuit the main circuit and the individual branch must be complete. Further, when a main circuit is divided into a number of branches, technically called derivations, the current in the main circuit divides between the branch circuits in the inverse ratio of their resistances, the branch having the highest resistance taking the smallest current, and *vice versa*. This again is strictly in accordance with Ohm's law.

A simple method of grasping the idea of an electric circuit, which the author has been accustomed to place before the pupils

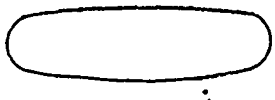

Fig. 1.

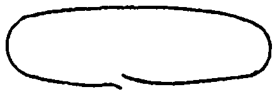

Fig. 2.

of his firm in the early days of their articles, is the following:—

Imagine a complete ring or hoop of wire, as shown in Fig. 1; and that an electro-motive force arises at some point in the ring of sufficient magnitude to generate a current. This current will go on circulating round the ring as long as the E.M.F. exists, and the wire remains intact. For simplicity, it is assumed that the ring is perfectly insulated from every other conductor, and that there are no branch circuits.

Now, suppose that we cut the ring of wire with a pair of pliers, at any convenient point, as Fig. 2. The current will no longer pass. Now, let us take a galvanic cell and connect its two poles—that is, the points at which the current can be taken from it—to the ends of the wire we have just cut, as Fig. 3. We have in the galvanic battery the source of electricity we require, and the current from it will continue to circulate through our ring of wire and our cell—which it must not be forgotten forms part of our circuit—as long as the cell continues to create an E.M.F., and there is no break in any part of the circuit, either in the wire loop or in the cell itself. But how are we to know that we have a current passing? Well, in some cases the action visible in the battery cell tell us, but not always; and, as we shall see later on, a battery may be consuming materials when no useful work is being done. Cut the wire in a second place and connect to the ends some apparatus that will denote the presence of the current furnished by one cell, against the resistance of our loop of wire, say an electric trembling bell, as Fig. 4. The current that will pass will be as the E.M.F. created by the cell, divided by the resistance of the circuit, that is, the combined resistance of the cell, the bell, and the connecting wire. If our bell is constructed to work with the current passing in our circuit, it will commence ringing, and will go on until either the battery ceases to create an E.M.F., there is a break in the circuit as before, or the resistance of some part of the circuit—say that of the cell itself rises sufficiently to reduce the current below the strength at which the bell will work.

The question of the increase of the resistance of the battery will be dealt with later on; at present we will only consider actual breaks in the circuit. Cut the wire in a third place, and, this time, insert a push, as shown in Fig. 5, such as are to be seen in every optician or electrical apparatus dealer's window,

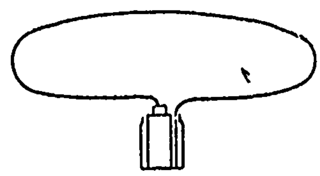

Fig. 3.

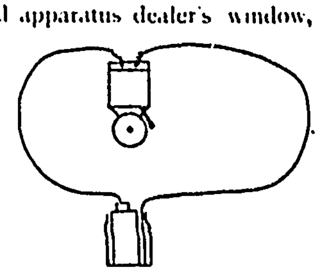

Fig. 4.

and which consist simply of two springs mounted on a board, and so arranged that the ivory button facing them, when pressed by the thumb, brings them into metallic contact; the ends of the two wires being connected to the two springs.

If we have carried out the above experiment carefully, the bell will now ring whenever we press the button of our push; and we have control of the bell as long as we have no other break in our circuit. It is obvious, of course, that the wire connecting the push, bell, and battery may be of any convenient length, provided that the battery, wire, and bell be so proportioned that the latter will ring with the current that passes. The reader will recognize the arrangement as that of an ordinary domestic electric bell.

But now cut our wire in a fourth place, and we shall find that we have lost the control of our bell, because we have another break in the circuit besides the one at push. (Fig. 6.)

Let us suppose, also, that our wire is covered with gutta-percha which we know has a very high resistance, and is, for most practical purposes, an insulator. Suppose that in any one of the connections we have made—to battery, bell, or push—we neglected to remove this covering before making our connection, we should find that we had no current passing; and the reason would again be, because, in accordance with Ohm's law, the resistance offered by the two thicknesses of gutta-percha was so great in proportion to the E.M.F. created by the cell, that no appreciable current could pass. Therefore, in all connections between wire and wire, or between wires and terminals or other

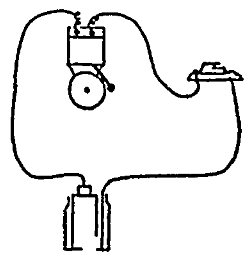

Fig. 5.

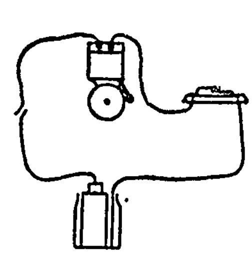

Fig. 6.

connecting pieces, we always first remove whatever insulating covering may be present, and we also scrape the wire bright, as dirt offers a higher resistance than copper. The reader must not imagine that gutta-percha offers an impassable resistance under all conditions; each case works out in exact accordance with Ohm's law. It was only because the E.M.F. of the cell was low, that the gutta-percha barred the passage of the current; if a high tension generator had been used, some current might have passed through the covering.

Let us attach wires to the bell and battery, and lead them to a second push, as shown in Fig. 7. We have now a circuit with two branches, the bell and battery being included in each, and we therefore control the action of the bell from either push, so long as there is no other break in the circuit. If there should

*Walker's "Electricity in Homes and Workshops."