place, the surface of the commutator must be smoothed first with coarse and then with fine emery cloth.

In most systems it is advisable to put a little oil on the commutator just after starting the dynamo. Very little oil, however, must be used. Dip the point of one finger in one drop of oil, distribute it by rubbing it on the inner surface of the hand and apply what oil remains on the finger tip to the commutator, and take it off with another finger. This will do for at least three hours run.

If it should become necessary at any time to replace the commutator by a new one, it should be done in the following manner: Take the armature out of the dynamo and put the two ends of the shaft on two wooden horses. Mark the wires leading from the armature to the commutator by attaching little tags with numbers, to make sure of the proper place of each wire after taking off the commutator. Then disconnect these wires from the corresponding copper bars of the commutator, either by unscrewing the set screw, or in commutators which have solid connections, by unsoldering them by means of a hot soldering iron. Take the commutator off, clean the shaft and connections and put the new commutator carefully in its proper position and connect the wires in proper turn to the corresponding copper bars of the commutator by means of set screws, or soldering with hard solder. The greatest care must be observed not to short-circuit any parts of the commutator with drops of molten solder.

In most cases repairs to the armature are necessitated by injuries to the insulation of the wire from external mechanical sources or by excessive heat generated in the armature. The first is very often caused by little particles of material dropping in the spaces between armature and pole pieces for instance, little balls of cotton waste being caught from the end of the dynamo and pressed between armature and pole pieces, thus scaling off the insulation of the wires in some places, or bursting the metal bands. Such injuries can have two different results, either short circuiting some of the coils or bringing different parts of the wire coils in contact with the iron core. These injuries hardly ever extend below the first layer of wire. In most cases it will be possible to carefully lift one wire at a time just high enough to wrap it with silk tape, and thus insulate it. After having wrapped and insulated all the injured parts, drive the wires back into their position by means of a small hard wood block and hammer, and give them two or three good coatings of shellac varnish. If the injuries are below the first layer of the armature, it will be necessary in most cases to have it sent to the factory to have it re-wound.

Excessive heat in the armature will very often char the insulation of one or more coils of wire entirely. These coils, of course, must be taken out and replaced with new wire. In most armatures of the so-called Gramme pattern this can be easily done. In armatures of the Siemens drum pattern it will necessitate a re-winding of the whole armature. The over-heating of one or more coils of an armature is very often caused by the short-circuiting of two or more segments of the commutator by means of copper dust which has been allowed to settle back of the commutator, or by excessive sparking of the brushes, forming little bridges of metal across to adjacent commutator segments.

The faults which mostly occur in field magnets consist in short-circuiting coils, or in getting parts of the field wire in contact with the iron core. The field wire should be unwound until the damaged part is reached, and after insulating it properly as described before, it should be wound back on the core. If it should be necessary to take a considerable amount of wire off the field in this way it will be advisable to put the damaged field magnet in a lathe and do the unwinding and re-winding by means of the lathe.

The iron frame of each dynamo must be well insulated from the wire coils of the field, the armature and also from any connection with the earth. If one of these wire coils should get in contact with the iron frame of the dynamo and the latter should be in connection with the earth by means of foundation bolts, etc., it would cause what is called a ground. The ground must be considered the worst enemy of electric light apparatus, and should never be allowed to exist. In testing for contact between field wire coils or armature coils and the iron, any wires leading to the circuits or other apparatus should be disconnected from the dynamo in order to make sure that the fault really lies in the dynamo itself. Another fault sometimes found in the field of the armature is called a short circuit.

A short circuit is a shunt of little resistance between two points of a conductor. Suppose the points *A* and *B*, in Fig. 7, are set in some way in connection. It is clear that the main part of the current will pass through *A*, *B*, and but very little of the current will pass through the coil. If this should occur in the armature, the coil thus short-circuited in itself will generate currents of great strength, which will destroy the insulation of this coil in a very

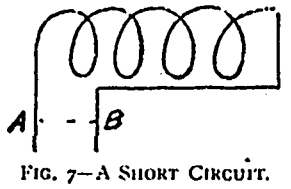

FIG. 7—A SHORT CIRCUIT.

short time. Generally the dynamo tender will be warned by a smell of burnt cotton and shellac. If this fault should occur in a field magnet it would decrease its power, and thus cause the different magnets of the field to be of unequal strength. It may cause heating of the field in shunt and compound dynamos, while in series dynamos it will simply decrease the current strength generated by the dynamo. In order to test for a short circuit in an armature coil, or a field magnet, it is necessary to disconnect each field coil, or each armature coil, and measure by proper instruments the resistance of each coil. If any magnet coil shows a resistance below the others, it is short circuited. The use of the necessary testing apparatus can not be described here, as it would go beyond the limits of our space.

The short circuits in field coils, however, can very often be found without the use of finer testing instruments, simply by the use of the dector galvanometer and the cell. By connecting each field coil in series with galvanometer and cell, and marking the deflection of the galvanometer, the coil which will show the least deflection is the one which is short circuited. A short-circuited field magnet will heat less than a sound magnet when the dynamo is generating current. A break of the fire can very easily be found by means of the galvanometer, as no deflection would be obtained at all through the broken coil. A break in a wire coil of the armature could only be found by disconnecting all wire coils from the commutator and from each other, and

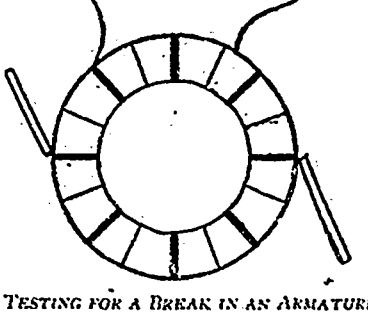

FIG 8.—TESTING FOR A BREAK IN AN ARMATURE COIL.

then testing each coil separately in the manner described. This, however, would involve considerable work and delay, and a quicker method may be employed: Set the dynamo in operation; then take a short piece of wire and touch the commutator with the two ends of this wire at a distance of three or four segments apart, Fig. 8. If the machine should commence to generate current, an electric arc will be formed on the commutator between the two ends of this wire, and indicate there is a break in the armature wire. The machine must be shut down quickly, as otherwise it would cause damage in the commutator and armature. The coil of the armature in which the fault lies can be easily recognized by the burns on the corresponding segments of the commutator. Faults of this kind are very often found in poor contacts between two coils, or between a coil and the corresponding copper bar of the commutator. Poor contacts will cause more trouble than actual breakage of the wire. Such faults will often destroy certain commutator segments, caused by increased sparking of the brushes when passing these points. Hence, if only one or two commutator segments should show