number 4 Brown & Sharpe copper wire. This wire should be solidly connected and soldered to a galvanized iron plate at least ⅛ inch thick and having an area of at least ten square feet on each side. If a pipe is used instead of a plate, the external area is not to be considered, but twenty square feet of external area is necessary. This earth plate should be sunk so deeply in the earth that even during a dry season it will always be in moist ground. A well or a stream of water is preferable. The earth wire should also be connected to water pipes or gas pipes if they are near by. Such a connection, however, is not a substitute for the earth plate, which is a necessity under any circumstances.

The conductor of the lightning rod of a building must not be connected with the earth wire of a lightning arrester.

All connections underground must be soldered and then painted with asphaltum to prevent corrosion and poor contacts. Poor connections with the earth are very often the cause of the unsatisfactory working of lightning arresters.

It should be borne in mind that no lightning arrester is an absolute safeguard against the freaks of lightning. Very long circuits, especially those not protected by tall buildings or trees, are very liable to be struck by lightning. In such cases extra devices at some points along the line must be put up as an additional protection.

The jaws of the lightning arrester should be kept clean and at a proper distance. It is advisable to run a cardboard between the plates every day to make sure that the jaws are at a proper distance from each other.

GROUND DETECTOR.—It is absolutely necessary to test electric light circuits frequently, and this means at least once a day, for grounds. In incandescent light installations which run

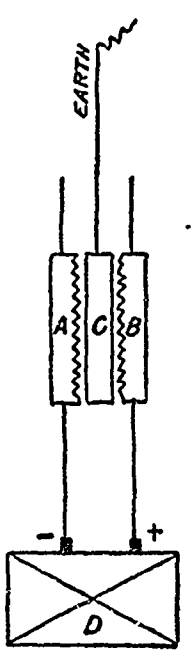

FIG. 6.

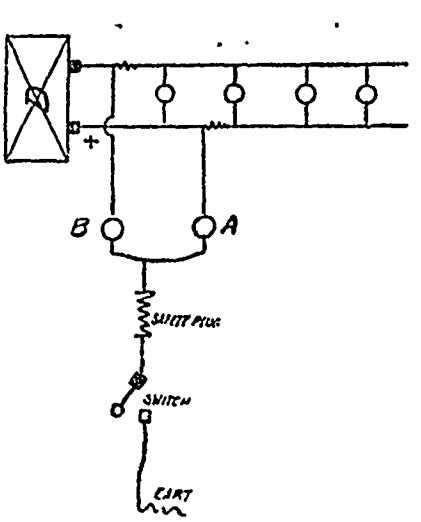

FIG. 7.

continuously, arrangements to indicate a ground while the dynamo is running should be made. A simple form of ground detector is shown in Fig. 7. Two lamps are connected in series between the mains near the dynamo. A wire leading to earth is connected between the two lamps or a safety plug and a switch are put into the earth wire. If there is no ground on the line the two lamps will burn very very dimly but at equal candle power. If a ground should occur anywhere in the circuit, say on the positive pole, the earth wire and the ground will form a shunt of low resistance to the lamp nearest the positive wire; the result will be that lamp *A* will dim down and lamp *B* will brighten up. Sometimes it may occur that both poles of a circuit are grounded and that the grounds are of about equal resistance. In such a case the two lamps will burn equally dimly. By switching out one lamp, however, it can be seen whether the lines are grounded or not. If the other lamp also goes out the lines are not grounded, but if the other lamp continues to burn the lines are grounded on both poles. To make this test one lamp should be provided with a socket with key.

Instead of two lamps a galvanometer with two coils connected in the same manner as the two lamps may be used. The needle will stand at zero when there is no ground on the line and deflect as soon as the wire gets grounded. Any grade of sensitiveness may be given such an instrument.

SWITCH-BOARD.—A switch-board is used in larger plants to connect any dynamo with any circuit. Of course only dynamos of the same kind can be made interchangeable. For arc lamp plants, plug switch-boards are generally employed. Short cables with a plug on each end can be inserted in the different

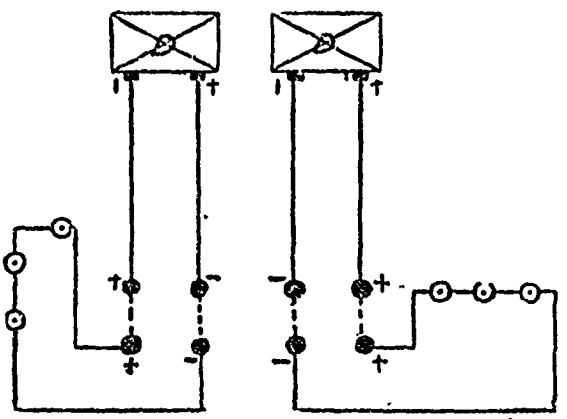

FIG. 8.

sockets. The latter are marked with + or −, and with *D* (dynamo), *C* (circuit). In addition, they are marked with a number. For instance, *D*1 (meaning dynamo number 1) can be connected to *C* 2 (circuit number 2), and so on. Fig. 8 is a diagram showing the arrangement of a switch-board.

In incandescent plants large lever switches are generally used, as large enough plugs could not be conveniently made to carry the heavy currents of incandescent circuits.

CIRCUITS OR LEADS.*

OUTDOOR LEADS FOR ARC LIGHTING.—The wire used for outdoor circuits is mostly what is called underwriters' standard. It consists of a copper wire which is braided with cotton and painted with asbestos to make it uninflammable. This wire is fastened to glass insulators on poles or houses in a way similar to that in which telegraph wires are usually run. Insulated wire, and not bare wire, should be used for tie wire, as the common non-insulated tie wire will cut the insulation of the line wire and possibly cause leaks. The size of arc light conductors varies between numbers 6 and 4, Brown & Sharpe gauge, number 6 being the smallest wire which can be used, according to the rules of the National Board of Fire Underwriters. If the return wire is fastened on the same poles, the positive and negative wires should be kept sufficiently far apart so they can not touch each other when swung by wind. It must be understood that the insulation called underwriters' standard is only an insulation when perfectly dry, and when wet is hardly any insulation at all. If, therefore, the positive and negative wires exposed to rain or moisture of any kind should come in contact with each other or with the ground, a short circuit would be caused. This may cut a number of lamps suddenly out and cause damage to the dynamo. Such an accident, for instance, may burn out the armature or throw off the belt. In very cold weather such occurrences are rare, as frost may make out of a circuit of the poorest insulation one of very high insulation, while on the other hand a thaw or rain may cause all kinds of disturbances. If these disturbances occur during a thunder storm accompanied by rain, lightning is often unjustly accused of having done the mischief, while in fact the poor insulation of the wires is the prime cause.

Accidents from poor insulation of lines are more frequent than damages caused by lightning, though the latter will always be a ready excuse for anything that may have happened. Recently weather and water-proof insulation have come in vogue, and they are much safer than underwriters' standard wire.

In conducting wires into houses, great care must be taken to prevent rain following the wires. The wire should be fastened to the insulator below the point where it is intended to be led through the wall or a window frame, so the rain would have to run up hill in order to follow the wire, Fig. 1.

Fig. 2 shows a wood pin and glass insulator, such as are used on cross-arms. The latter are fastened to poles by means of

* From "Dynamo Tenders' Hand-Book"