The Development of the Protector Block

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WITH the installation of the first commercial telephone circuits there arose the need of protecting the equipment against high extraneous voltages. To produce a protector is easy: a pair of conducting parts separated by a small air-gap will divert the high voltage to ground. But to produce a protector which is not likely to remain short-circuited as a result of a single discharge of relatively low current is more difficult. A tendency to permanently short-circuit is very troublesome, occasioning interruptions of service and the expense, often considerable at subscribers' stations, of removing and replacing the damaged protectors. It is the problem of their maintenance that has dictated most of the work on high-voltage protectors since the early days of the telephone.

One of the earliest protectors, in use about 1877, consisted merely of two pieces of silk-insulated wire twisted together, of which one was connected to the line and the other to ground. An excessive voltage punctured the insulation and thus formed for itself a by-pass to ground. Wire was soon displaced by variously formed metallic plates; in 1879 protectors were composed of two brass plates separated by a dielectric such as mica. In the following decade numerous minor changes were made in this general form, especially to the use of carbon instead of metal. Using this material a wider electrode spacing met the same breakdown voltage requirement. About 1890 the carbon-block protector with mica separator was standardized (Figure 1-A).

Thereafter occasional efforts were made to improve the maintenance characteristics of the protector. Various methods were devised for impregnation and cleaning the carbon faces to reduce the surface dust. A metal-block protector, for use where a higher breakdown voltage could be tolerated, also appeared (Figure 1-B). The essential features of the protector, however, remained the same: two parts, of conducting material, forming the electrodes, and a third part, of insulating material, separating the electrodes by the desired amount.

About 1913 an essentially different block appeared in experimental form, assembled of both insulating and conducting materials. In it the ends of one of the copper blocks then standard were equipped with insulating plugs (Figures 1-C and 1-D). This construction permitted the use of a metallic separator, or, by suitably depressing the parts of the conductors between the insulating plugs, the elimination of the separator entirely. Though it never advanced beyond the experimental stage, this block is interesting as one of the earliest embodiments of the basic principle of the present protector block.

By 1914 the telephone system had expanded to such proportions that

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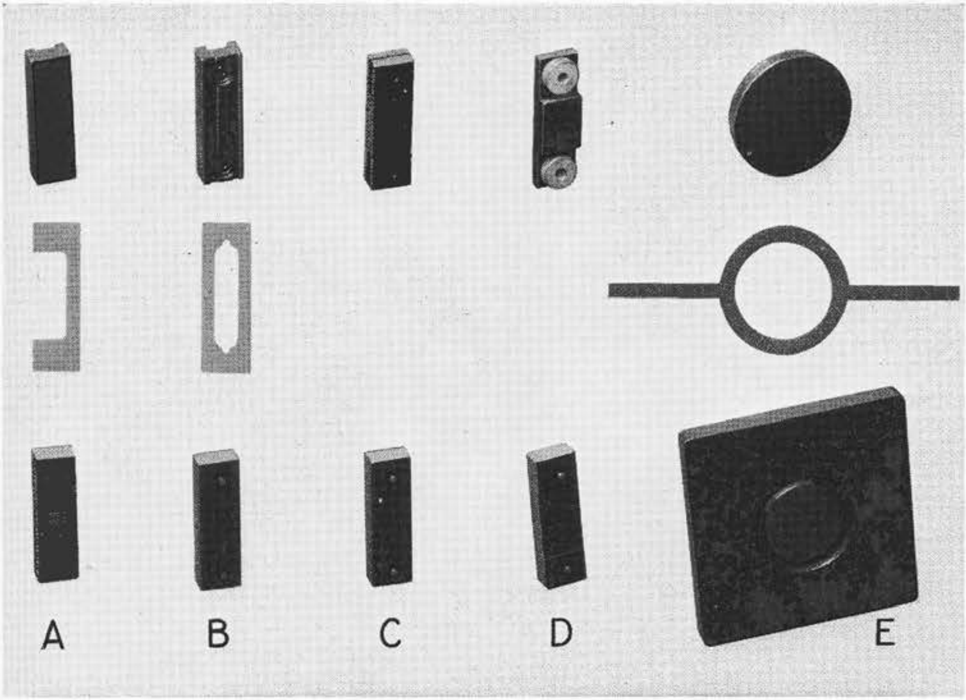

Fig. 1—Important steps in the development of the porcelain protector block. A—The formerly standard combination of the No. 1 and No. 2 protector blocks and the No. 3 mica. This was used for central office and sub-station protection. B—The formerly standard copper block protector, consisting of the No. 19 and No. 20 protector blocks and the No. 10 mica. C & D—The original bi-material protector blocks. In the type shown at C phenol plastic inserts were used; in the type shown at D lavite studs were employed. These blocks were associated with a block having the central portion depressed to give the desired separation. E—An early block wherein a conducting insert was used in an insulating frame. At the time this block was made, studies were in progress to determine whether increasing the size of the sparking surfaces would materially affect the breakdown voltage. This explains the large size of this protector. Separation was obtained by a gasket-like separator of metal

the high maintenance of protectors had become a serious concern. A vacuum arrestor was tried; but its high cost and excessive maintenance characteristics, due to breakage and loss of vacuum, made its use impracticable. Intensive work began, therefore, toward the development of an open-space cut-out with low maintenance.

From the outset of this work it appeared desirable to avoid the use of the dielectric separator, which was not only inconvenient to manufacture but also, at least in the forms previously employed, contributive to high maintenance. Attention naturally focussed on the part-insulating, part-conducting block of 1913. The first step was to reverse the two materials: to make an insulating block with a conducting insert forming the electrode, instead of a conducting block with insulating inserts. Various forms, and many materials such as glass and phenol plastic (Figure 2-F), were embodied

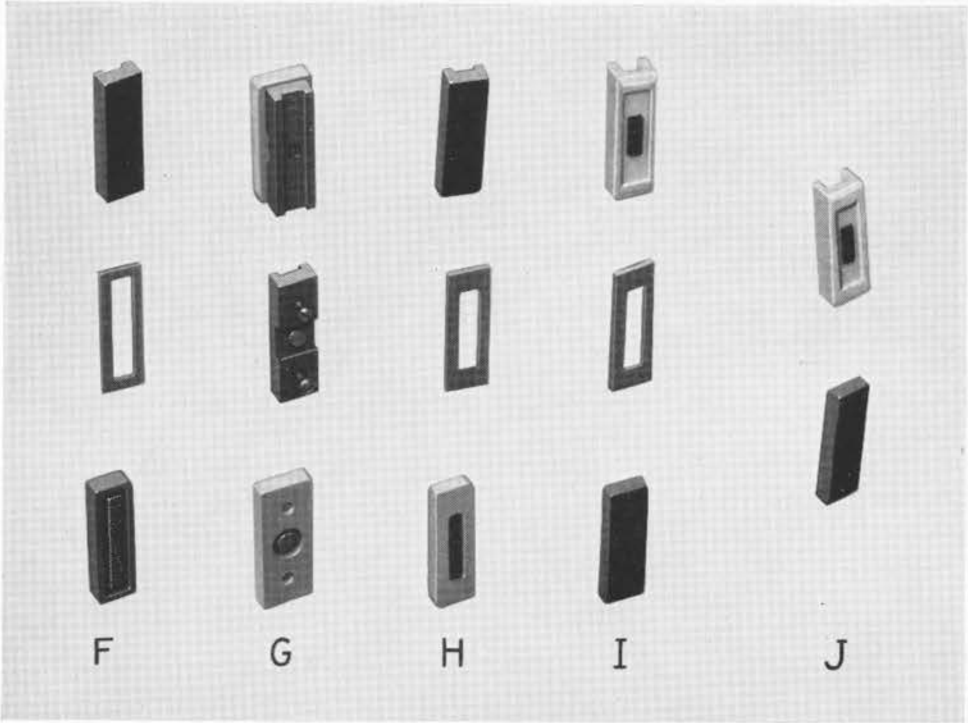

Fig. 2—Further steps in the development of the porcelain protector block. F—The first experimental protector submitted to trial installation. This consists of a phenol plastic frame carrying a copper electrode and separated from another copper electrode by means of a metallic separator. G—A construction employing tungsten-faced electrodes. A porcelain frame carries a small tungsten-faced tack. The two are assembled as a unit, opposed to a metal block carrying another tungsten-faced tack. Separation is secured in assembly, without the use of an individual separator. H—An early hard-carbon porcelain-frame combination. This employs a plane carbon block as a line electrode and the carbon-equipped porcelain frame as a ground block. A metal separator is used. I—A combination similar to C except that the carbon-equipped porcelain frame is used as the line block. J—The final step in development, wherein the separator is omitted and proper separation is secured by depressing the carbon insert

in experimental insulating blocks. The most satisfactory proved to be a porcelain frame, resembling in shape the No. 2 carbon block, and carrying at its center a rectangular block of conducting material.

Work on the electrode material started with metals, since these seemed most likely to free the protector from the dust troubles theretofore experienced. Many metals, variously combined, were tested in the laboratory, and the more promising were given trial installation to determine their behavior toward lightning (Figure 2-G). The results were discouraging; nine of these protectors showed less tendency to ground than did the carbon blocks standard at that time. Lightning discharges produced eruptions of metal sufficiently high to bridge the small gap between the electrodes. Fortunately during the latter part of the work on metals further work was done on carbon—not the former soft carbon, but a hard dense material with but little free surface dust. Promising results in the laboratory led to trial installations, which confirmed the conclusion that the long sought reduction in maintenance could, in a measure at least, be obtained with dense carbon.

Need had early been recognized for a means of short-circuiting the protector blocks when an arc persisted longer than a few seconds. Overheated blocks and mountings would otherwise constitute a fire hazard. In the protector formerly standard, with No. 1 and No. 2 carbon blocks, this need was filled by inserting in one of the blocks a plug of metal with a low melting point which would melt to bridge the gap between the blocks. This construction was not feasible for the new combination of hard carbon and porcelain. Several low-melting cements for attaching the carbon insert to the porcelain frame were tried, therefore, and a lead borate glass was finally selected. This does not cold-flow, but softens at a comparatively low temperature and allows the pressure of the clamping spring in the protector mounting to move the insert into contact with the ground-block.

In most of the trials, the operating surface of the electrode was ground flush with the insulating frame, and the separation was secured by a metallic separator (Figure 2-H and 2-I). In considering commercial manufacture of the new protector, it developed that this construction imposed very close dimensional limits, not only on the separator but also on the porcelain block, for insurance against accidental short-circuit of the electrodes. This difficulty was avoided by omitting the separator and depressing the sparking surface of the carbon electrode the proper distance below the plane surface of the porcelain frame as in the block shown in Figure 2-J.

Starting production of the new piece of apparatus required thousands of tests to establish the various limits necessary to its proper operation and cooperation with associated apparatus. The protector block, consisting of but two piece-parts, is one of the System's smallest pieces of coded apparatus. Nevertheless, in the assembly and piece-part drawings, eleven dimensions have plus-and-minus tolerances. Some of these requirements are very exacting; their insurance demands one hundred per cent check of the product. Especially precise must be the depression of the sparking surface of the electrode below the plane of the porcelain block. The normal depression of the No. 27 block is twenty-eight ten-thousandths inch and variations of but four ten-thousandths inch above and below this value are allowed. To gauge to such dimensions the several million protectors manufactured annually, required the development by the Western Electric Company of elaborate means of automatic gauging.*

Because of its superior maintenance characteristics, the porcelain block soon outgrew the original restriction of this use to station protection and thenceforth provided central-office protection as well. That the porcelain type of block might be associated with all types of main-frame protectors, some of which require their blocks to be mounted on three-eighths inch centers, there was developed the No. 29 block, electrically identical with the No. 27 and differing only in the dimensions of the porcelain frame. For cable protection, to replace the old copper blocks, the No. 30 block was developed, mechanically identical with the No. 27 and differing only in

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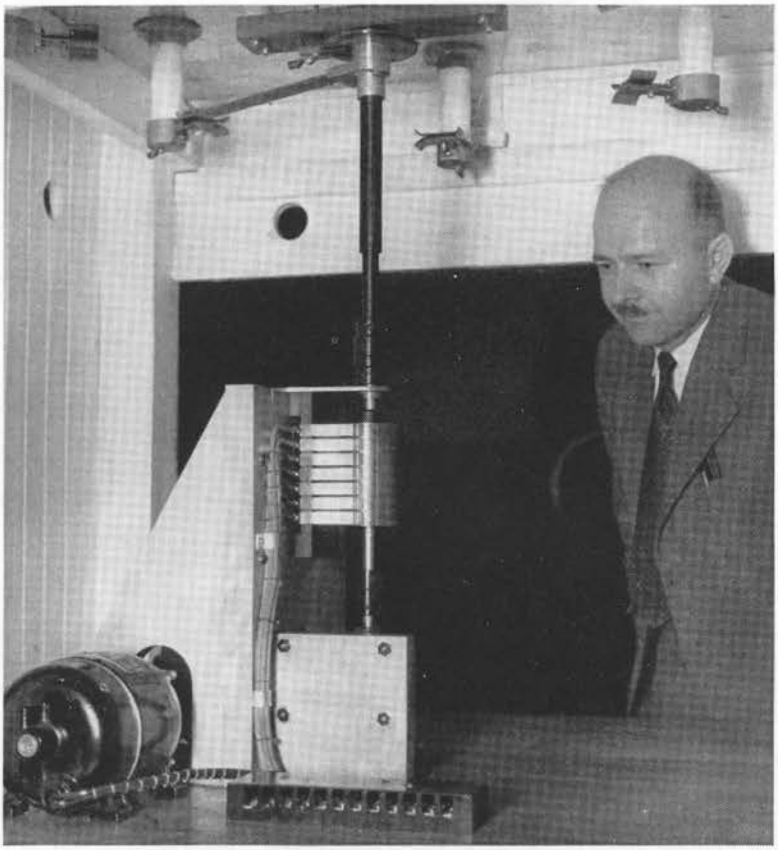
a greater depression of the insert, and in the dark blue color of the porcelain frame, distinguishing it from the lower-breakdown blocks. The decreased maintenance of these three porcelain blocks is saving the Bell System hundreds of thousands of dollars annually.



A final inspection of an antenna switch before it is shipped to Miami. The switch, housed outdoors and remotely controlled from the transmitter room, will connect a two-wire line from a short-wave transmitter to the lines to any one of six directive antennas. Contacts for one side of the lines can be seen fastened to the ceiling. Those to the other side are in the compartment above. It will be used in radiotelephone links between the United States and points bordering the Caribbean Sea. The inspection is being made on the Laboratories' shipping platform by J. L. Mathison, of the Radio Research group.