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DISCHARGE GAP PROTECTIVE DEVICE

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Fig. 1.

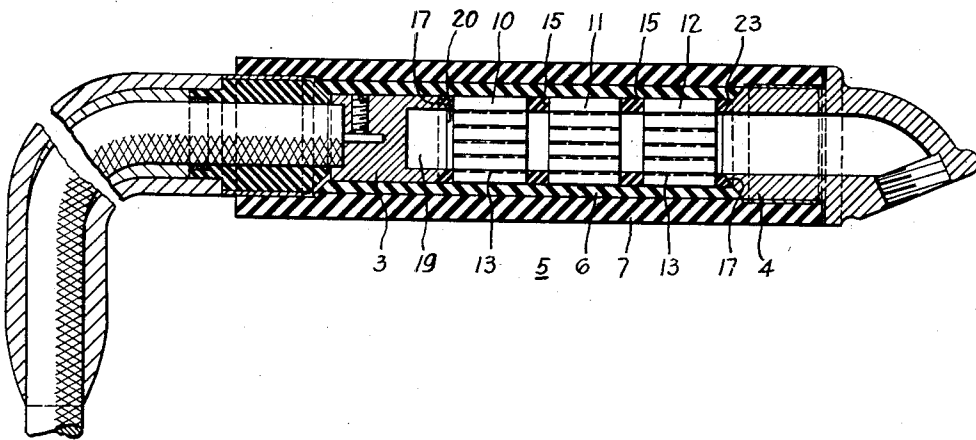
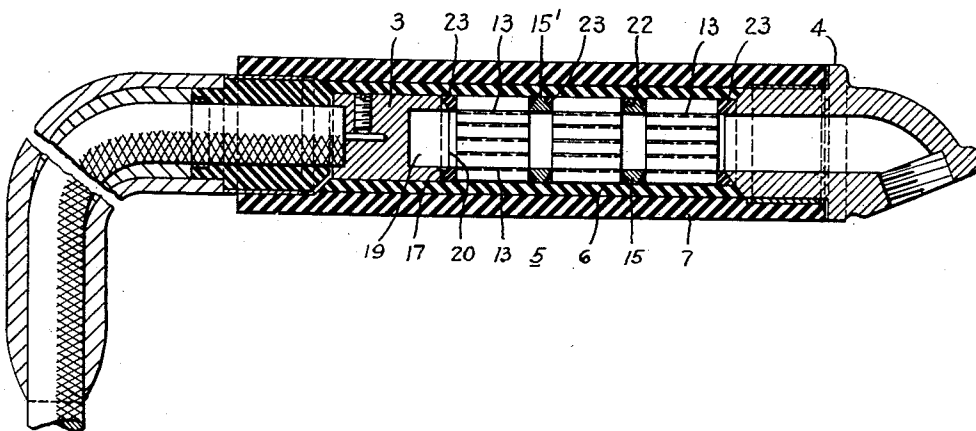


Fig. 2.



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DISCHARGE GAP PROTECTIVE DEVICE

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3 Claims. (Cl. 175—30)

Our invention relates to discharge-gap protective devices of the type in which an arc is formed between two spaced electrodes disposed inside of an insulating tube which is vented so that the resulting blast will extinguish the arc. Such devices are preferably provided with arc-responsive volatilizable insulating material which will liberate substantially non-ionized gas in the arcing chamber, to assist in extinguishing the arc. Our invention has more particular relation to such devices in which there is a slotted diffuser-plug fitting within the insulating tube, said diffuser-plug being provided with a plurality of slots extending from end to end, and being made of fibre or other arc-responsive volatilizable insulating material.

An object of our invention is to provide a combination and a construction whereby the gap-device is enabled to handle higher currents without destruction or serious damage to the device.

A more specific object of our invention is to provide one or more expansion chambers or spaces in which the discharged gases may expand and accumulate without developing too great a gaseous pressure until the gases have had time to be discharged through the vent in the gap-device.

A more specific object of our invention is to provide one or more of such expansion chambers disposed between a plurality of axially spaced diffuser-plugs, for purposes which will hereinafter be explained.

A still further object of our invention is to provide such an expansion chamber at the closed electrode of such a discharge-gap device, for purposes which will hereinafter be explained.

With the foregoing and other objects in view, our invention consists in the combinations, structures and methods hereinafter described and claimed and illustrated in the accompanying drawing, wherein:

Figure 1 is a longitudinal sectional view through one form of embodiment of our invention; and

Fig. 2 is a similar view of a modification.

As shown in Fig. 1, our gap-device consists of two electrodes 3 and 4 extending within an insulating tube 5 of a material having sufficient strength and insulating properties. In the particular protector illustrated, the tube 5 is made of arc-responsive volatilizable insulating material, such as fibre, sometimes known as hard fibre, which has the property of releasing large quantities of substantially non-ionized gases when subjected to the direct play of an electric arc. For

convenience in manufacture, and also for securing a greater mechanical strength, or resistance to bursting, for a given total thickness of fibre walls, the fibre tube 5 is preferably made in a plurality of tightly telescoped fibre parts 6 and 7, or only the inner tube 6 may be of fibre, the outer tube or tubes 7 being of a material chosen primarily for its strength or other qualities.

The arcing chamber between the electrodes 3 and 4 must be vented in order to discharge the resulting gases when there is an arc between the two electrodes. This venting is preferably obtained by making at least one of the electrodes 3 and 4 tubular, or vented in some other way, so that the blast of gases may be discharged there-through. In some applications of discharge-gap devices, it is necessary for the expelled blast to be discharged from only one end of the device, in which case, as shown in Fig. 1, one of the electrodes 3 is closed, while the other electrode 4 is vented.

In accordance with our invention, two or more axially displaced diffuser-plugs, such as 10, 11 and 12, are utilized, said diffuser-plugs being preferably constructed as shown and described and claimed in a patent to W. G. Roman, No. 1,923,748, granted August 22, 1933. Each plug consists of a gas-evolving body of stratified or laminated construction, having a plurality of slots 13 of about $\frac{3}{4}$ inch thickness extending axially therethrough, said slots being conveniently formed by grooves cut in the faces of the strata or laminations.

In previous designs of discharge gaps of this nature, the diffuser-plug has been made in a single section, being made long enough to interrupt the 60-cycle power-follow arc, following a lightning surge discharge, at the 60-cycle voltage on which the protective gap-device was to be used. The construction of the gap-device is such that the internal gap-spacing between the electrodes 3 and 4, inside of the tube 5, is sufficiently less than the external arcing path between the electrodes over the outer surface of the tube 5, so that any discharge which occurs will always occur inside of the tube, rather than externally thereof. When a high-current surge is passed through the gap-device, it has been found that the device might explode, or the diffuser-plates might be broken at a considerably lower surge-current, if the diffuser-plug is long in an axial direction, than if it is short. Nevertheless, for the higher voltage-ratings, it was necessary for the diffuser-plug, in the previously designed tube, 55

to be long in an axial direction, in order that the length of the plug might be sufficient to interrupt the power-follow arc at the 60-cycle voltage on which the arrester was being used.

5 Our present invention aims to overcome the above-mentioned difficulties with long diffuser-plugs, and we do this by dividing the diffuser-plug into a plurality of short sections which are spaced axially from each other, as by spacing-rings 15.

10 While we do not care to be limited to any particular theory of operation, we explain our improved result as follows. In any diffuser-plug, the amount of gas evolved, for a given surge, is proportional to the length of the slot 13 through 15 which the surge passes. This gas, formed by the surge, fills the slot and flows out of both ends thereof. At the end of the slot which is vented, the discharged gas passes out to the outer atmosphere. At the closed end of the tube, the discharged gas expands in the space at the end of the diffuser-plug and discharges back through the other slots which are not carrying an arc. We believe that, in general, a breakdown occurs 20 in only one of the slots at a time.

25 When the slots are long, as heretofore was the case for high-voltage gap-devices, the gas in the slot wherein breakdown occurred was not only greater in volume than in a shorter slot, but had to travel further in the narrow restricted slot, in which it originated, before it could be vented into the open, or before it could expand into the space back of the plug and be allowed to divide among the several remaining slots in order to reach the open. Thus, very considerable gaseous pressures were developed in the particular slot through which the surge-discharge originated, thus tending to break the diffuser-plates bounding this particular slot, and also tending 30 to burst the enclosing insulating tube 5 of the arcing chamber.

35 According to our new construction, the gas which is generated in the slot through which the surge passes has to travel only a short distance to one of the spaces between the diffuser-sections or plugs, where the gas can then divide among the several slots of the next plug, and thus escape into the open. This action primarily saves the diffuser-plates from breaking 40 as a result of excessive differences in gas-pressure between the various slots of the plugs. In addition, gas-storage spaces are provided, in the spaces between the plugs, thus providing more volume in which a predetermined amount of generated gas may expand, thus reducing the average gaseous pressure inside of the gap-device, for a given surge-current, or conversely making it possible for a higher surge-current to be carried without destruction or damage to the gap-devices. 45

50 In the older designs of gap-devices with slotted diffuser-plugs in accordance with the Roman invention, some difficulty was experienced as a result of burning of the closed electrode 3. It was known to be desirable for the arc-terminal surface of the electrode 3 to be beveled, as indicated at 17, so as to reduce the breakdown voltage of the gap and also to direct the arc away from the junction between the diffuser-plug and the insulating tube 5, thus tending to cause the arc to form within one of the slots 13 of the diffuser-plug. However, it was found to be necessary to make the arcing tip of this electrode rather blunt, in order that it might stand the burning caused by the 60-cycle power-follow cur- 55

rent, without being burned away. This blunt construction caused the gap to have a higher breakdown-voltage than it would otherwise have had, and even this blunt type of construction would sometimes burn so much, on a very high 60-cycle power-follow current, that the shape of the electrode, and even the total length between the two electrodes, would be changed, thus affecting the breakdown-voltage, so that the performance of the tube would not be constant. 60

65 According to our present invention, we provide a deep central depression 19 in the arc-terminal end of the closed electrode 4, and we retain the beveled construction 17 which had previously been found to be desirable, but for the burning. In our new construction, we not only bevel the outer rim of the arc-terminal end of the closed electrode 3, but, by reason of our central depression 19, the combination of bevel and depression produces a sharp tip 20 of the electrode 3, giving the gap device a particularly low breakdown-voltage, because of the high voltage-gradient at the sharp tip, especially when the closed electrode 3 has a positive potential with respect to the other gap-electrode 4. 70

75 Once the gap is broken down, by an excess-voltage surge, the blast of gases coming from the slot of the diffuser in which the discharge occurs blows the terminal of the arc down from the sharp tip 20 to the bottom portions of the hollow depression 19 in the electrode 3, and practically all of the burning caused by the power-follow current takes place on the side walls at the bottom or back portions of this depression 19, where it will not affect the subsequent breakdown-voltage of the gap-device, even this burning being relatively small because of the continuous movement of the arc-terminal as the gas-pressure varies. 80

85 In addition to the foregoing advantages, the deep depression 19 in the closed gap-electrode 3 provides an additional expansion-chamber or space in which the gas generated by a very high-current surge can be temporarily stored at a pressure low enough to prevent explosion of the tube until the gas can be vented into the open. 90

95 In the form of our invention which is shown in Fig. 1, the spacing-rings 15 which separate the axially spaced diffuser-plugs 10, 11 and 12 are made of insulating material. This has the effect of somewhat increasing the breakdown-voltage of the gap-device over what it would have been if the diffuser-plugs 10, 11 and 12 had been brought together without any spacing therebetween or made in a single piece. 100

105 The effect of a shorter spacing between the terminal electrodes 3 and 4, so as to produce a lower breakdown-voltage, can be obtained, as shown in Fig. 2, by making the spacing rings 15 of metal or other conducting material, as indicated at 15' in Fig. 2. With this type of construction, the breakdown-voltage of the gap-device is made practically the same as though the gap-device had not been lengthened out by the provision of the spacers 15 or 15', and the other advantages of our multiple diffuser-plug construction are retained. 110

115 In the particular embodiment of our invention shown in Fig. 2, the metal spacing-rings 15' are beveled at their ends, as indicated at 22, so as to increase the voltage-gradient (reducing the breakdown-voltage) and to place the initial sparkover terminal of the arc close to the bores or holes of the spacing-rings, although the beveled construction of the metal rings 15' is by 120

no means necessary. Preferably, beveled insulating rings 23 are disposed at all of the beveled metal surfaces such as 17 and 22 in both forms of embodiment of our invention.

5 Preferably, our gap-electrodes are made of steel or other low-resistance material suitable for constituting the terminal of an arc without excessive burning, and having a reasonably good arc-quenching property, or power of interrupting an arc after it is once formed. Our invention should
10 not be confused with glow-discharge devices in which a definite arc does not form.

15 The distinction between a glow-discharge and an arc is as follows. In both, the discharge initiates, in general, by ionization-by-collision in the discharge-space, or by the propagation of so-called streamers which are practically chains of ionized particles. It will be recalled that the voltage of flashover is a function of the product
20 of the gaseous pressure times the distance between the electrodes. In a glow-discharge, this product of pressure times distance is so small, or the resistivities of the electrode materials are so great, or both, or the other characteristics of the cathode materials are such, that a cathode-spot does not form on either one of the electrodes. A cathode-spot is a source of violent or copious electron-emission, so that the ionization-by-collision in the discharge-path is enormously
30 aided by the delivery of large numbers of electrons from the cathode spot. In an arc, such a cathode-spot forms, and the result is a very tenacious discharge, called an arc, which is characterized by having a high discharge-current, and a discharge-voltage which is of a very much lower
35 order of magnitude than the voltage necessary to initiate the discharge. Such an arc is very hard to extinguish, when impressed within a voltage anywhere near high enough to initiate the discharge in the first place: hence the necessity for
40 means for creating a powerful blast to extinguish the arc.

45 While we have illustrated our invention in two preferred forms of embodiment, it is obvious that we are not limited to the precise forms of construction shown, at least in the broader aspects of our invention. We desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language and
50 the prior art.

We claim as our invention:

1. A lightning arrester having an enclosing tubular insulating member defining a diffuser chamber, terminal electrodes at the respective
5 ends of the diffuser chamber, means for venting the diffuser chamber, and arc-responsive gas-evolving means for evolving a blast of substantially non-ionized gas in the diffuser chamber, at least one of said electrodes having a deep, closed,
10 central depression in its arc-terminal end, and a beveled annular rim-portion surrounding said depression for tending to place the initial spark-over terminal of the arc close to said depression, the side walls of said depression being altogether
15 of conducting material.

2. An arc-extinguishing gap-device for use on an electrical supply-line for affording protection against excess-voltage surges, comprising an enclosing tubular insulating member defining a
20 diffuser-chamber, terminal electrodes at the respective ends of said diffuser-chamber, and a multi-slotted diffuser-element of insulating gas-evolving arc-responsive material fitting within said enclosing tubular insulating member, where-
25 by a gaseous blast is provided in said diffuser chamber in response to an arc, at least one of said electrodes having a deep, closed, central depression in its arc-terminal end, and a beveled
30 annular rim-portion surrounding said depression for tending to place the initial sparkover terminal of the arc close to said depression, the side walls of said depression being altogether of conducting material.

3. An arc-extinguishing gap-device for use on an electrical supply-line for affording protection against excess-voltage surges, comprising an enclosing tubular insulating member having imperforate side walls defining a diffuser-chamber,
35 electrodes disposed only at the respective ends of said diffuser-chamber, and a plurality of axially spaced, multi-slotted diffuser-elements of insulating gas-evolving arc-responsive material fitting within said enclosing tubular insulating
40 member, successive diffuser elements being separated by an expansion chamber extending substantially across the entire bore of the tubular insulating member.
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