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ARC PROTECTION MEANS

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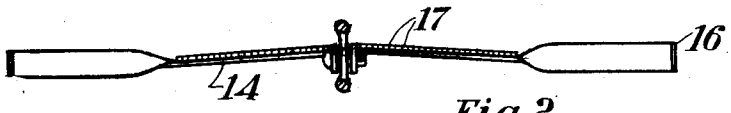


Fig. 2

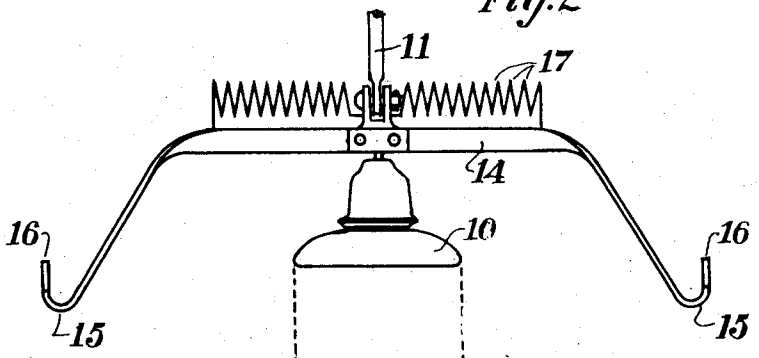


Fig. 1

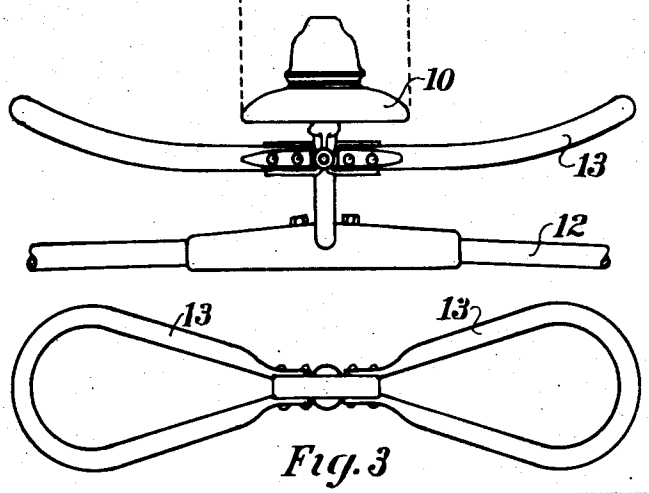


Fig. 3

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ARC PROTECTION MEANS

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4 Claims. (Cl. 173—318)

This invention relates generally to control gaps for protecting electrical apparatus against impulse voltages, and particularly to arcing guides for protecting insulators and their supported conductors or other electrical apparatus involving insulation from injury produced by electrical discharges caused by single impulses of unidirectional energy such as are produced by lightning strokes at or near the apparatus.

One object of the invention is to provide an arcing guide which will prevent the arc from striking the insulator or the supported conductor in case of discharge due to lightning or other abnormal surge voltage.

A further object of the invention is to provide a path of discharge parallel to the insulator which will serve as a safety gap to prevent the discharge from following the insulator itself.

A further object of the invention is to provide a parallel path of discharge having a shorter time lag than that of the discharge path over the insulator and yet having a sufficient time lag to prevent discharge into the string.

Other objects and advantages will appear from the following description.

The invention is exemplified by the combination and arrangement of parts shown in the accompanying drawing and described in the following specification, and it is more particularly pointed out in the appended claims.

In the drawing:

Fig. 1 is an elevation of an insulator string showing one embodiment of the present invention.

Fig. 2 is a top plan view of the upper arcing horn.

Fig. 3 is a plan view of the lower arcing horn.

In the construction of high potential transmission lines, it is of course necessary to insulate the line against flashover at normal voltages, but, generally, it is not feasible to insulate against abnormal voltages such as are produced by lightning. It is therefore desirable to provide a discharge path for such abnormal voltages such that the discharge will not injure the insulators nor the supported conductor.

Heretofore, various flux control devices have been attached to insulators for the alleged purpose of producing uniform distribution of the dielectric field surrounding the insulator or for producing a uniform voltage gradient in the insulator string or for other purposes related to the electrostatic field. It is doubtful if any of these devices produce the results that they are alleged to produce because of the time necessary, after the voltage is applied, to set up the conditions which they are said to establish. A grading ring, for instance, may materially affect the distribution of potential in the insulator string for normal operating voltages and frequency, but unequal distribution at normal voltage is not of serious consequence because it is not a very difficult matter to provide an insulator which will withstand the voltage to which it is subjected when the string is under normal voltage. When the string is subjected to abnormal voltage, time is required for charging the series of insulator units constituting the string, as each unit is a small condenser, and until they are charged, the grading ring or other device is ineffective to establish equal distribution among the various units. It is very probable that if the voltage is high enough to cause flashover, this will occur before equalization of voltage among the units can be established where the string is equipped with the usual grading ring.

Attempts to establish uniform flux distribution in the field to control flashover are probably of little or no avail under conditions where danger of flashover is greatest. Lightning of course occurs during stormy weather when the atmosphere is full of moisture so that the flux distribution is affected more by the drops of water in the air than it is by the flux control devices. The effect of a few drops of water on an electrostatic field is a well-known phenomenon. The operation of a sphere gap is, for instance, entirely changed by very little moisture in the air.

The present invention is directed to the protection of the insulator and the conductor in case of flashover, and no special attempt has been made to produce uniform grading in the string or to produce uniform flux distribution for the reason that these matters are regarded as of very minor consequence as compared with the protection of the insulators and the supported conductor.

In order to protect the conductor and the supporting string, there are three things that must be accomplished. A parallel path must be provided which will have a shorter time lag, i. e., elapsed time of application of flashover voltage before flashover occurs, than the path of discharge over the insulator. This of course is to prevent the arc from cascading over the insulator rather than from following the parallel path. Although an insulator string may stand one or more cascades without serious damage, there is always danger that the heat from the arc or the concussion caused by the discharge will injure

some of the insulator units. It is of course also important to prevent the arc from striking the conductor. The third condition which it is desirable to avoid is a partial cascade; that is, a condition in which the arc starts from the arcing horn and strikes into the string of insulator units.

All of these results can of course be produced by providing an arcing gap in parallel with the insulator string which is short enough that discharge over the gap, rather than over the string, is insured for all over-voltages. However, it is desirable that this parallel gap shall not be any shorter than is necessary for safety, because the insulation afforded by the string is expensive, not only for the insulators themselves but for the supporting structures necessary to secure clearance space for the insulators. It is therefore inexpedient to provide insulation and then cut out a material portion of that provided by means of a short arcing gap.

In order to insure a short time lag for the arcing gap, it would seem at first that the gap should be provided with a terminal of extensive area, such as a sphere gap or a broad plane, because a gap of this kind has less time lag than a needle gap or a gap having small terminals. Such a gap could be set to withstand the maximum voltage that the insulator string would withstand without flashover and could be relied upon to flashover ahead of the insulator string when the two were subjected to such voltage. For this reason, it might seem that arcing rings are preferable to arcing horns because the rings have a larger extent of discharge surface than the horns and consequently a shorter time lag. However, too short a time lag for protective devices of this kind has been found to produce another result which must be avoided, namely, arcing into the string. As previously stated, when the conductor is subjected to an impulse voltage, time is required to build up the potential gradient in the string and to permit streamers to build out from the arcing terminals and especially from the upper terminal, such that they will guide the discharge arc away from the string. This latter is particularly true when the conductor is positively charged, which is the condition of greatest severity.

If the time lag of the arcing device connected to the conductor is too short, discharge may occur before streamers have been built out from the upper terminal of sufficient length to guide the arc to that terminal and also before the ultimate potential gradient in the string, due to the abnormal voltage, has been established. Both of these conditions combine to cause the arc to strike into the string but if an arcing terminal of greater time lag characteristics is used, these conditions will be remedied before discharge occurs and the arc will strike free. In the case of a lightning stroke, there is usually a great excess of voltage over that required to flashover either the insulator or the gap so that the selection of the path is entirely controlled by the relative time lag. It is therefore of greatest importance that the time lag of the parallel path shall not be too great on the one hand so as to cause cascading of the insulator, or too small on the other hand so as to cause the arc to strike into the string.

It has been found that a discharge ring at the bottom of the string, unless it is too small to be effective or too large to be economical or set so high as to reduce materially the insulation, produces arcing into the string, while a discharge horn is apt to have too long a time lag, giving rise to cascading over the entire string. Applicant, therefore, employs a discharge member adjacent the conductor which has a time lag characteristic between that of a horn and a ring, and it is found that when a device of this kind is employed in conjunction with a horn at the top of the string, the parts may be properly proportioned and related without materially reducing the insulation of the string so that discharge will invariably take place over the path between the outer ends of the two discharge members and will never cascade over the string or strike into the string.

Devices of this kind have been subjected to impulses of approximately 3,000,000 volts time after time by means of an impulse generator, with the result that the arc invariably forms clear of the insulator string while with the same insulator equipped with a discharge device of greater extent at its lower end, the arc struck into the string and when equipped with discharge horns spaced for a similar voltage, the insulators were found to cascade. By the use of horns with comparatively restricted terminals at the top, in conjunction with horns at the bottom having proper time lag characteristics, streamers are caused to form at the discharge points which assist in guiding the arc clear of the insulator.

In the embodiment of the invention shown in the drawing, the numeral **10** designates the units of an insulator string carried by a grounded structure **11** and supporting a conductor **12**. Attached to the support for the conductor **12** is a pair of oblong loop shaped members **13**, the axes of which extend in the direction of the conductor **12** above the conductor, the members being slightly curved upwardly at their outer ends to insure discharge from the outer ends. These members **13** have sufficient lateral extent to screen effectively the conductor **12** against discharge and are so arranged and proportioned relative to the insulator string and the upper horn **14** that they form an arcing gap parallel to the insulator string having a time lag for lightning surges less than that of the insulator string but sufficient to permit a surge to establish a potential gradient in the string and also to permit the formation of corona streamers from the ends of the horn **14** prior to discharge from the lower member, so as to prevent the arc from striking into the string. The upper member **14**, as shown in the drawing, is secured to the grounded support **11** and extends outwardly in the vertical plane of the conductor and is provided with downwardly extending discharge points **15**. The extremities of the arcing horn **14** may be turned upwardly and pointed, as shown at **16**, and the horizontal portion of the horn may be provided with upwardly extending points **17** to prevent birds from perching on this member.

The exact shape and proportion of the lower member **13** is of course controlled by the conditions of each installation. For a string of twenty-four insulators having a height of 6 inches each and a maximum diameter of 10½ inches designed for a 220 kv. line, it has been found that lower discharge members of the shape shown, having a total spread of 3 feet 4 inches and a maximum breadth of 10 inches, can be used with a horn **14** having the same length as the lower member **13** and will prevent cascading or striking into the string with a spacing that will not materially reduce the insulation afforded by the string. In the particular installation referred to, the tips of the lower members **13** were spaced approximately 2 inches above the bottom of the lower insulator and the tips of the upper members **14** were spaced

approximately 3 inches below the bottom face of the upper insulator, giving a discharge voltage to the arcing gap approximately that of the discharge voltage of the insulator string but providing a time lag for the gap less than that of the string but sufficient to permit the establishment of a potential gradient in the string produced by a surge impulse and the formation of streamers on the tips 15 before discharge occurs, so as to prevent the arc from striking into the string.

It will of course be necessary to proportion the parts of each installation to suit the particular conditions but if it is kept in mind that the time lag of the arcing path is the controlling factor and that this can be adjusted by varying the size of the loops 13, the proper proportions for any installation can readily be ascertained by using the above relative proportions as a guide and making a few tests to facilitate adjustments. Flashover tests can be made to determine when proper relations have been established by use of an impulse generator set similar to that described in Patent Number 1,997,064, dated April 9, 1935. Care should be taken to employ a set having sufficient power capacity as a set in which the capacity is too limited to produce conditions approximating those produced by actual lightning conditions is apt to be misleading. It is believed that the use in the past of inadequate impulse generator sets has given rise to a great many erroneous conceptions relative to the behavior of arcing devices under lightning conditions.

I claim:

1. The combination with an insulator comprising a plurality of capacitance members connected together in series, of a conductor supported by said insulator and a pair of discharge members connected to the terminals of said insulator respectively, the discharge member adjacent said conductor being of greater lateral extent than the other discharge member while the discharge member away from said conductor has a more restricted area adjacent its discharge point, said discharge members being disposed and related to each other and to said conductor and insulator so that the time lag of discharge between them, when subjected to a lightning charge, is less than the time lag of discharge across said insulator but as great as the time required to establish the potential gradient in said insulators due to said charge and to produce a streamer from the initial flashover point of said discharge member away from said conductor so that the arc between said discharge members will not strike into the insulator.

2. The combination with electrical apparatus to be protected, of an arcing gap connected in parallel with said apparatus and having substantially the same discharge voltage rating as said apparatus but having a shorter time lag of discharge than that of said apparatus, the time lag of said gap being sufficiently great, however, to permit the building up, prior to discharge, of a streamer from at least one terminal of said gap sufficient to direct the discharge arc between said terminals away from said apparatus.

3. The combination with electrical apparatus to be protected, of an arcing gap connected in parallel with said apparatus and comprising two discharge terminals, one of said terminals being shaped to produce, when subjected to over-potential, a concentration of electrostatic flux sufficient to cause a discharge streamer prior to flashover at the point where initial flashover occurs, the other of said discharge terminals being shaped to produce a more even distribution of electrostatic flux, the time lag of said gap being shorter than that of the protected apparatus but being sufficient to permit the formation of a streamer from said first mentioned terminal of sufficient length to guide the flashover arc away from said apparatus.

4. The combination with electrical apparatus to be protected, of an arcing gap connected in parallel with said apparatus and comprising two discharge terminals, one of which is grounded, said grounded terminal having a more restricted surface area than the other terminal to cause sufficient concentration of electrostatic stress to produce a discharge streamer from said terminal prior to arc-over of said gap, the ungrounded terminal having sufficient surface area to impart to said gap a time lag of discharge after discharge voltage has been impressed on said gap and apparatus which is less than that of said apparatus but great enough to permit building up of a streamer from said grounded terminal sufficient to guide the flashover arc between said terminals.

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