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HIGH-VOLTAGE ARC-SPINNING ARRESTER

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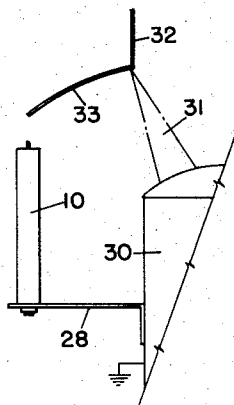


Fig. 7



Fig. 6

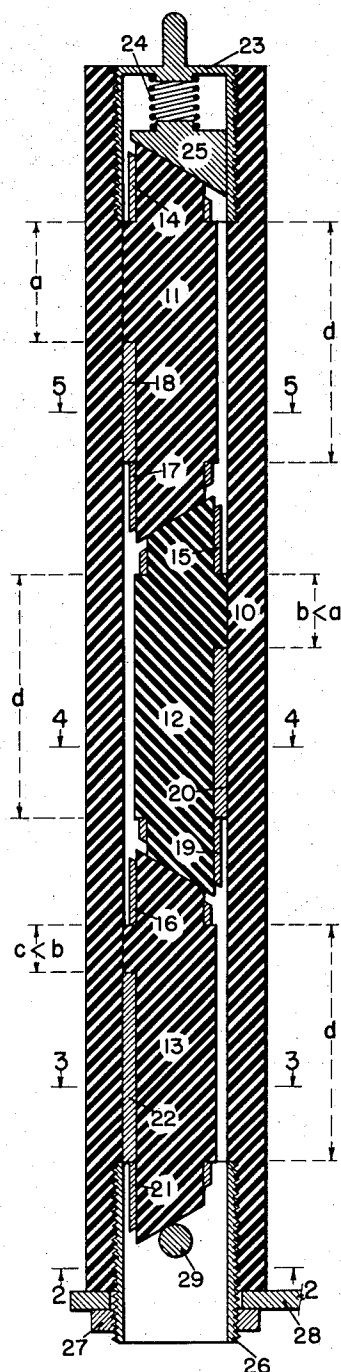


Fig. 1

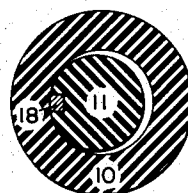


Fig. 5

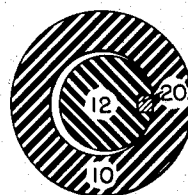


Fig. 4

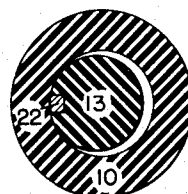


Fig. 3

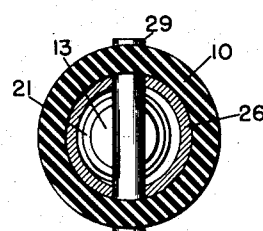


Fig. 2

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HIGH-VOLTAGE ARC-SPINNING ARRESTER

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3 Claims. (Cl. 175—30)

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The invention is a continuation in part of my application Serial No. 740,203, filed April 8, 1947, now abandoned, and relates to lightning arresters of the type adapted for the protection of electric power lines and connected apparatus from damaging effects of excessive superimposed voltages, such as may be caused by lightning or switching surges.

The objects of the invention include (a) the provision of a plural filler lightning arrester requiring at least two fillers in which the fillers may be made of the desired length to meet known operating conditions; (b) a construction in which the total filler length is not a design limitation in connection with high voltage circuits, as the number of fillers may be increased as may be necessary to meet circuit voltage conditions greatly in excess of the voltage which may be satisfactorily applied to a single filler device; and (c) the provision of a plural filler construction in which eccentrically positioned fillers are resiliently wedged against the inner surface of the tube along alternately peripherally spaced lines of abutment to provide an arc-spinning construction having a predetermined final arc position at extinguishment along each filler which differs both in length and position from the initiating sparkover path, the movement and elongation of the arc being facilitated by a favorable direction of movement of the conducting flame and gas from one filler to the next through the device so that greatly increased length of arc-extinguishing path per volt of protective voltage level is made available.

High voltage lightning arresters now available consist of a stacked series arrangement of separately housed units, structurally difficult to mount on apparatus. At the present time there are available no plural-filler lightning arresters of the arc-elongating expulsion type, to which the present invention is related. The voltage limitation in the application of this type of expulsion arresters has been principally a matter of maximum satisfactory length of filler. Single fillers are limited in length for several reasons; one is a material limitation, since long fiber fillers are susceptible to warping, either the filler or the associated tube may warp out of the initial position and cause failure of the arrester. Another reason for the limitation is strength of the insulating material when used as a long thin column. If too long with respect to diameter, lightning impacts may fracture the filler; if of sufficient diameter to withstand shock, cost of all the other elements increases too rapidly to

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enable devices so built to compete with other means of lightning protection. That the difficulties heretofore encountered in the construction of high voltage expulsion arresters of the arc-elongating type, which are inherent in long filler design, are overcome by the plural-filler design of the present invention will be apparent as the description proceeds.

With these and other objects in view which will appear from the description, my invention resides in the novel form, combination and construction of the parts of the device, and the scope of the invention will be indicated by the appended claims.

Fig. 1 of the drawing shows an elevational view of an embodiment of the invention, shown partly in section; Figs. 2, 3, 4 and 5 are respectively sectional views along the lines 2—2, 3—3, 4—4 and 5—5 of Fig. 1; Fig. 6 shows an elevation of a single filler and Fig. 7 illustrates an application of the invention to a piece of electrical apparatus.

Referring to Figs. 1 through 6, a hollow cylindrical tube of insulating material 10 is provided at its lower end with the conducting terminal electrode 26, the latter being hollow for the purpose of venting the tube to the atmosphere. The lower conducting rod 29 only partially closes the bore of the tube 10 and extends transversely across the lower portion of the tube 10 to provide a lower support for the stack of fillers within the tube.

The embodiment here presented illustrates a construction utilizing three fillers, 11, 12 and 13. From the description to follow, it will be apparent that two fillers is the minimum required to realize the advantages of the construction, and some number greater than two may be desired, depending upon the voltage of the circuit upon which the device is to be used. The fillers 11, 12 and 13 are conveniently formed from cylinders of insulating material of a diameter less than the internal diameter of the tube 10. The respective end portions of each filler is reduced in diameter, and the conducting ferrules 14 and 17 are press-fitted on the respective end portions of the upper filler 11, the conducting ferrules 15 and 19 are press-fitted on the respective end portions of the intermediate filler 12, and the conducting ferrules 16 and 21 are press-fitted on the respective end portions of the lower filler 13.

The upper and closed end filler 11 normally engages the vertical inner surface of the tube 10 along a vertical abutment line, and the conduct-

ing initiating electrode 18, in contact with the electrode 17, extends upwardly from the latter over a portion of the abutment line. Similarly, the initiating electrode 20 extends upwardly from the electrode 19 of the intermediate filler, and the initiating electrode 22 from the electrode 21 of the lower and exhaust end filler. From the initiating-electrode sides of the respective fillers, the respective upper ends of the fillers are bevelled to slope outwardly and downwardly, and the respective lower ends are bevelled to slope outwardly and upwardly, so that when the separate fillers are sequentially dropped into the upper end of the tube with the initiating electrodes alternately peripherally spaced 180 degrees, the fillers naturally assume the positions shown in Fig. 1.

The upper end of the tube 10 is closed by threaded engagement with the end closure and line electrode 23. A spring 24 continuously and resiliently urges the stack of fillers in endwise direction against the lower terminal member 29, through the bevelled guide block 25, to normally maintain the desired end-to-end relationship, as well as the desired axial offset to provide the respective abutment line engagement, and maximum spacing from the inner wall along a line diametrically opposite the respective abutment lines. To provide a continuous gas passageway from the upper filler to the exhaust end of the tube, the fillers are preferably extended slightly beyond the associated end ferrules, which construction also avoids undesired welding of metal parts under conditions of heavy current discharge.

The tube and fillers should preferably be of some mechanically strong arc-resistive material; for example, hard fiber.

The path of lowest electrical strength through the device, as established by the relation of the conducting members, is from the line electrode 23 to the upper ferrule 14 of the closed end filler, thence along the abutment line from the ferrule 14 to the initiating electrode 18 and lower ferrule 17, thence from the latter to the upper ferrule 15 of the intermediate filler, thence along the abutment line from the ferrule 15 to the initiating electrode 20 and lower ferrule 19, thence from the latter to the upper ferrule 16 of the exhaust end filler, thence along the abutment line from the ferrule 16 to the initiating electrode 22 and ferrule 21, and thence to the lower or exhaust end electrode 26.

In operation, when a surge voltage of sufficient magnitude is expressed between the electrodes 23 and 26, sparkover occurs along the respective offset line-of-abutment gaps between the respective upper filler ferrules and the respective initiating electrodes, since the device is so constructed that the weakest electrical path is along the line-of-abutment gaps. The impact resulting from sparkover of the line-of-abutment gaps tends to drive each of the fillers away from its respective abutment line, and thereby lengthen the column of fillers. Any such tendency to lengthen is resisted by the spring 24, which immediately drives the fillers back to their original position when the surge is discharged. The gas accompanying surge discharge is initially conducting, and immediately upon formation discharges from the respective abutment lines endwise into the less restricted arc space of the offset and adjacent filler.

The initially conducting gas, in a three filler

construction as here illustrated, which passes the closed end filler en route to the exhaust vent is less than that passing along any other filler. More conducting gas passes the intermediate filler than passes the closed end filler, and more conducting gas passes the exhaust end filler than passes the intermediate filler. Applicant believes that this is the explanation for the very favorable results obtained by his construction in actual practice, which makes possible the use of progressively shorter initiating gaps from the closed end to the open end of the device, while still retaining the desired spinning of the power arcs around each filler alternately from left to right and right to left, to thereby elongate and cool them to extinguishment by passing them over the relatively cold surfaces of the fillers and tube as they move to and elongate along the path of least restriction.

Whatever the explanation may be, I have found it possible with the construction illustrated to obtain a much higher ratio of final arc length to initial sparkover length than is possible in any single filler device, such as that described in Patent 2,164,720, dated July 4, 1939, and issued to the inventor herein. To illustrate, a construction suitable for extinguishing arcs on a 35,000 volt 60 cycle circuit operates satisfactorily with $1\frac{1}{2}$ " initial abutment-line sparkover gap at the closed end filler, 1" initial abutment-line sparkover gap at the intermediate filler, and $\frac{3}{4}$ " abutment-line sparkover gap at the exhaust end filler. The length of the least restricted path along which arc extinguishment occurs is 3" for each filler, yielding an elongation ratio at the closed end filler of 2 to 1, an elongation ratio at the intermediate filler of 3 to 1, and an elongation ratio at the exhaust end filler of 4 to 1. These results were obtained with a tube having as internal diameter of $1\frac{1}{2}$ " and a filler diameter of $1\frac{3}{8}$ ". With the same tube and filler diameters, I have found that under actual service conditions, a construction is suitable for a 35,000 volt 60 cycle circuit, from the standpoint of arc spin and extinguishment, which employs 4 fillers having $1\frac{1}{2}$ " initial at the upper two fillers and $\frac{3}{4}$ " initial at the lower two fillers, the length of the final and least restricted path in each case being 3".

It is also likely that the evolved gas, as it moves from closed to open end, more tightly seals the abutment lines of the fillers adjacent to the exhaust end, thus better shielding the initiating electrodes, and preventing the retention of an arc along the initial sparkover path despite the fact that the voltage gradient becomes higher as the length of the initial sparkover path is decreased. In this connection, I have found the bevel at the filler ends is preferably not less than 30 degrees from the horizontal, and if desired may be at an angle greater than 30 degrees.

In the embodiment illustrated, the letter *d* shows the length of the final or least restricted arc paths along each filler, which in this case is the same for each filler. For proper operation of a single filler device, an initial sparkover path at the first filler may require a length designated by the dimension *a*. But when additional fillers are added between the closed end filler and the open end of the tube, the initial sparkover at these fillers may be progressively shortened, as indicated at *b* and *c*, without any adverse effect upon the operation of the device. In this manner the degree of protective margin is increased, because of the lower sparkover voltages made possible by

the shorter initiating gaps, without any sacrifice of arc-extinguishing ability.

A method of applying the device is shown in Fig. 7. An electrode 33 extends to a point near the upper electrode of the device from the top of the insulating bushing 31 of the transformer 30, the line conductor 32 being connected to the top of the bushing. The device may be mounted upon a bracket 28, of conducting material, and fastened thereto by means of the nut 27. The metal tank of the transformer 30 is a grounded member, in accordance with common practice.

It will be apparent that the construction shown may be readily modified by simple changes to adapt the construction for use in protecting equipment operating at various circuit voltages, and it is intended that the drawing and description of the invention as here presented will be regarded as illustrative rather than limiting.

I claim, as my invention:

1. A lightning arrester construction comprising a tube of insulating material closed at one end and vented at the other end, normally insulated conducting electrodes mounted at the respective ends of said tube, a plurality of alternately axially-offset fillers of insulating material disposed within said tube in end-to-end abutting relationship, each of said fillers having a diameter less than the internal diameter of said tube, resilient means holding said fillers in alternately axially-offset positions to provide alternate diametrically opposed line-of-abutment engagement of alternate fillers with the inner surface of said tube, and structural means for causing sparkover between said conducting electrodes to occur within said tube and along a predetermined path which includes serially the diametrically opposed lines of abutment between said fillers and said tube, said structural means including a conducting member mounted on each filler and extending along the associated line of abutment for a distance less than the total length of said associated line of abutment, the conducting member associated with the filler adjacent to the closed end of said tube being shorter than the conducting members associated with any other filler.

2. A lightning arrester construction comprising a tube of insulating material closed at one end and vented at the other end, normally insulated conducting electrodes mounted at the respective ends of said tube, at least two alternately axially-offset fillers of insulating material, each having a diameter less than the internal diameter of said tube, positioned within said tube in end-to-end abutting relationship and in alternate diametrically opposed line-of-abutment engagement longitudinally along the inner surface of said tube, each of said fillers having an upper end surface sloping downwardly and outwardly and a lower end surface sloping upwardly and outwardly from its associated longitudinally extend-

ing line-of-abutment engagement, resilient means continuously urging said fillers in said end-to-end abutting engagement, and structural means for establishing within said tube and along the respective lines of abutment the path of lowest dielectric strength between said conducting electrodes, said structural means including a conducting member extending along the associated line of abutment of each filler for a distance less than the total length of said associated line of abutment, the length of said conducting members being such that the dielectric strength of the filler-tube abutment line associated with the filler at the closed end of said tube is greater than that of the other filler.

3. A lightning arrester construction comprising a tube of insulating material closed at one end and vented at the other end, normally insulated conducting electrodes mounted at the respective ends of said tube, a column of unjoined fillers of insulating material within said tube in end-to-end abutting engagement, each of said fillers having a diameter less than the internal diameter of said tube, said fillers being disposed in eccentric position with respect to the bore of said tube in engagement with the inner wall thereof along alternately peripherally spaced, longitudinally extending lines of abutment therewith, and providing a plurality of misaligned crescent-shaped, longitudinally extending discharge spaces originating at the abutment line of each filler and extending around each filler from one end to the other and between the outer surface of each filler and the inner surface of said tube, means including said electrodes for holding said fillers in said eccentric position, and structural means for causing sparkover between said electrodes to occur within said tube along a predetermined path which includes the peripherally spaced lines of abutment, said structural means including conducting members extending along a portion of the abutment line associated with each filler, the length of said conducting members being such that the ratio of the length of the dielectric portion of the abutment line of the filler adjacent to the closed end of said tube to the total length of said last-named filler is greater than said ratio with respect to any other filler.

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