Aug. 8, 1939. R. R. PITTMAN 2,169,110

REPULSION LIGHTNING ARRESTER

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Fig 1

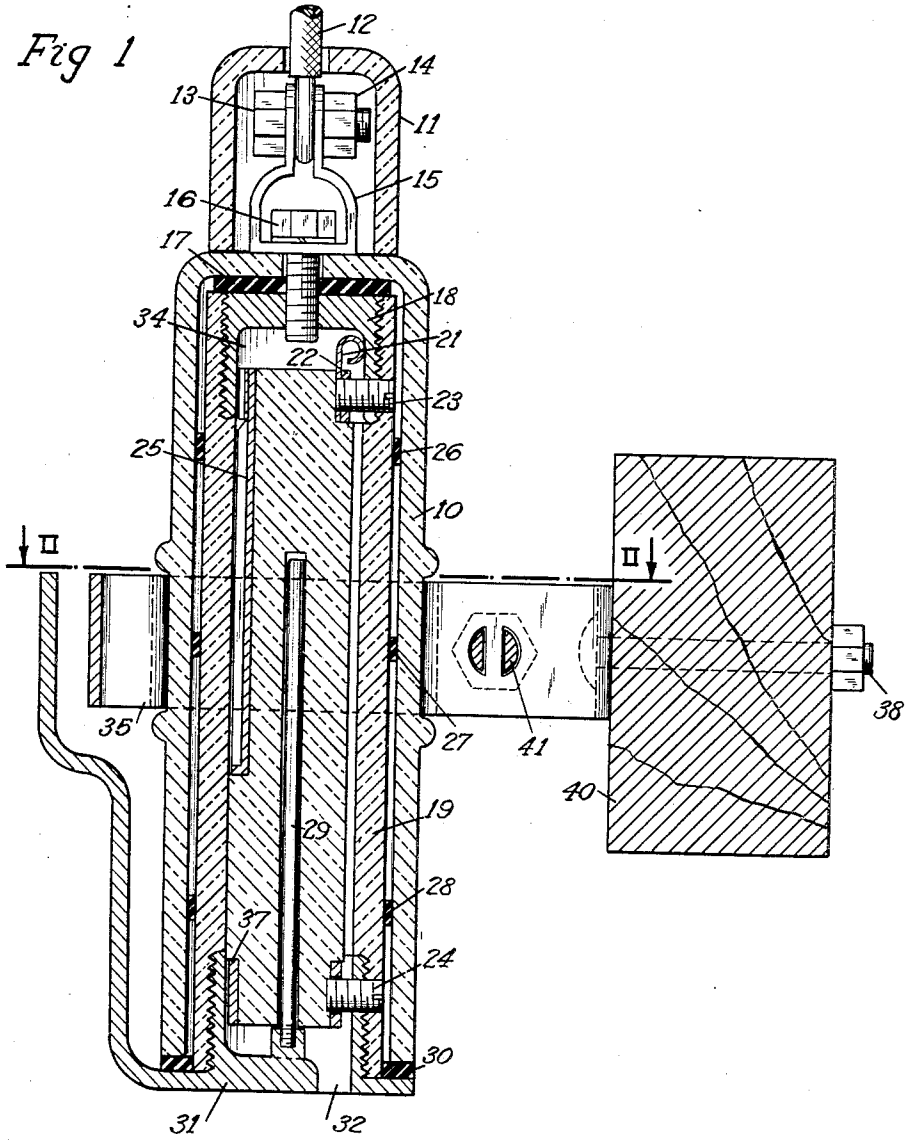
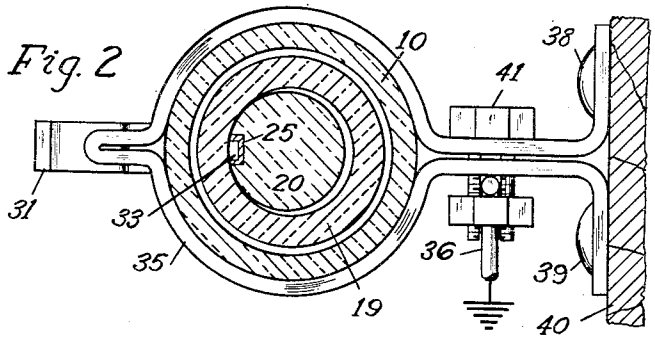


Fig. 2



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Fig. 3

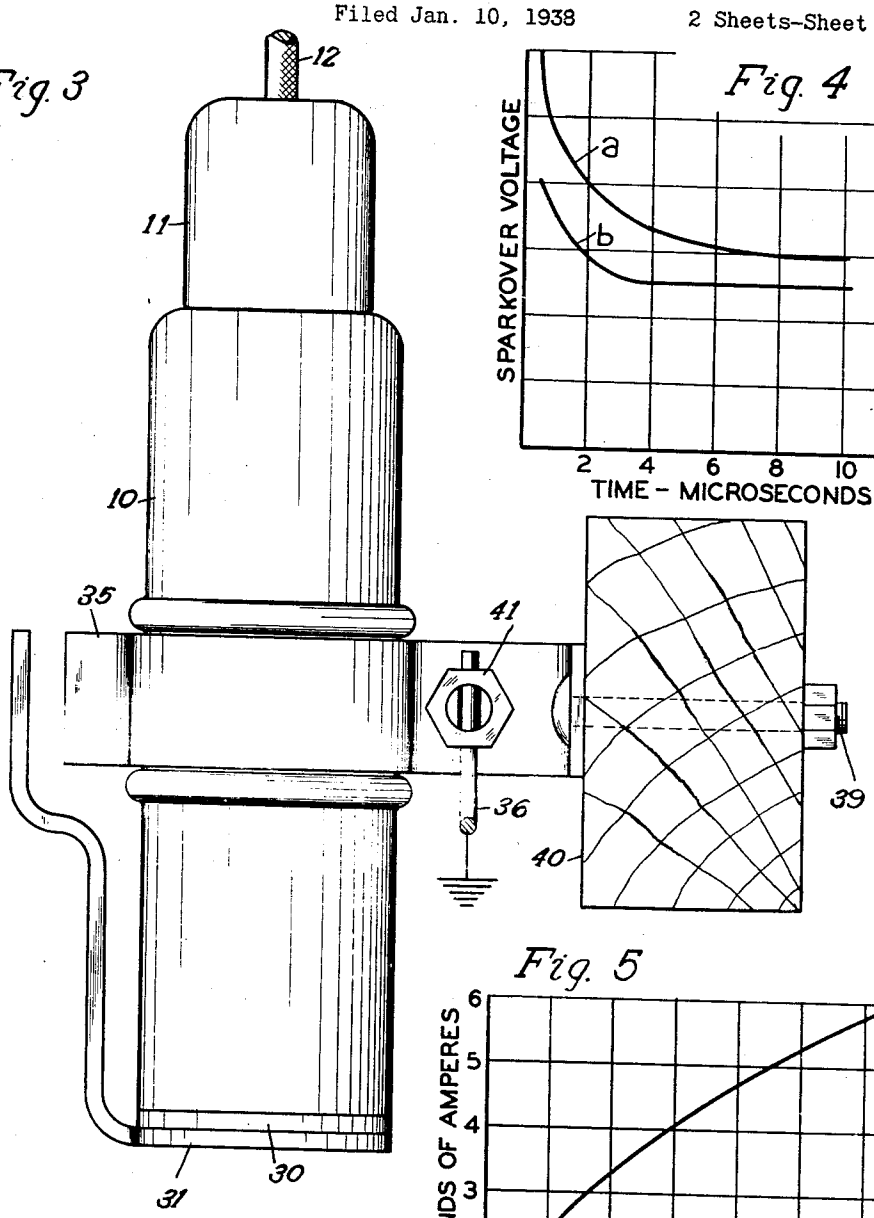
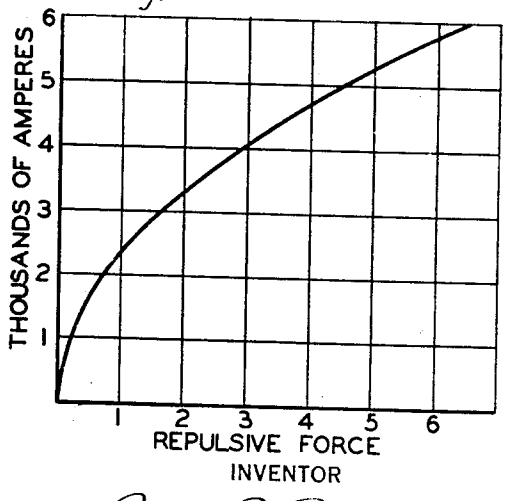


Fig. 4

Fig. 5



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REPULSION LIGHTNING ARRESTER

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Application January 10, 1938, Serial No. 184,269

11 Claims. (Cl. 175—30)

This invention relates to lightning arresters generally, and particularly to lightning arresters for the purpose of limiting the rise in voltage of a connected conductor by means of arcing gaps adapted to break down at a predetermined voltage, together with means for quickly extinguishing an arc which may attend break down of the gaps.

The present invention relates to improvements in the lightning arrester illustrated in my copending application Serial No. 138,895, filed April 26, 1937, and has for one of its objects the embodiment of means for electromagnetically moving the arc from its initial path whereby to lengthen it and thus facilitate its extinguishment.

A further object is the provision of a device in which the electrodes of the arcing gaps are so related to each other and to the other elements of the device as to reduce the time lag of break down, to thereby provide a higher degree of protection to connected apparatus from overvoltages, and, at the same time, in a device having at least two arcing gaps in series circuit relation, to impress substantially all of the available voltage upon only one of the gaps, whereby to cause flashover of the serial arrangement at a lower voltage than would otherwise be required.

Another object is to provide, in an arc extinguishing device embodying spaced electrodes providing a restricted arc path between juxtaposed elements of insulating material, means for venting the electrodes to reduce the internal localized pressure due to an arc, and a further object is the provision of a chamber into which the gas resulting from the arc may be discharged.

These and other objects will be apparent from the following description taken in connection with the accompanying drawings and claims forming a part of this application, in which—

Fig. 1 is a side elevational view of the device, shown in section.

Fig. 2 is a section view on the line II—II of Fig. 1.

Fig. 3 is a view of the assembly.

Figs. 4 and 5 are characteristic performance curves of the device.

Referring first to Figs. 1, 2, and 3, a hollow tube of insulating material 19, preferably of hard fiber, is provided at its upper end with the cup-shaped metal closure 18, the latter being secured to the tube by means of external threads in cooperation with internal threads on the tube. In a similar manner, the flanged metal electrode 31 is secured at the lower end of the tube, and provided with the vent opening 32 in communication with the interior of the hollow tube 19.

The tube 19 contains the cylindrical element of insulating material 20, which may also be of hard fiber, and which has a diameter less than that of the hollow of the tube. The biasing screws 23 and 24 pass horizontally through threaded openings in the walls of the closure 18 and the electrode 31 respectively to engage the respective ends of the element 20 and support the latter in lateral abutting engagement with the inner vertical surface of the wall of the tube 19. A pair of metal reinforcing rings 22 and 37 encircle the respective ends of the element 20, and the metal line terminal electrode 25 extends downwardly along the line of abutment of the element 20 with the tube 19 from the upper ring 22 toward but in spaced insulated relation to the electrode 31, to provide an arcing gap therebetween along the line of abutment. A resilient contact 21 assures electrical contact of the closure 18 with the electrode 25.

The upper end of the cylindrical element 20 is spaced from the lower end of the closure 18 to provide an internal chamber 34 at the upper end of the tube 19, and a vertically extending groove 33, shown in Fig. 2, in the electrode 25 provides a passageway between the lower end of the latter and the chamber, for the purpose of preventing excessive pressure adjacent the lower end of the electrode.

A hollow tubular insulator 10 of porcelain or other ceramic insulating material is arranged to contain the tube 19, the latter being maintained in spaced relation with the former by means of the encircling bands of resilient insulating material 26, 27, and 28, which cushion the impact due to operation of the device and thus prevent breakage of the housing 10. For this same purpose, the resilient washer 30 is interposed between the flange of the metal electrode 31 and the lower end of the tubular insulator 10.

A cap screw 16 extends downwardly through a central aperture in the top of the tubular insulator 10, and threadedly engages the top of the closure 18, thereby supporting the assembly comprising the tube 19 and the element 20 within the insulator 10, and at the same time electrically connecting the closure 18 to the line conductor 12 through the terminal 15. The latter has a portion thereof clamped between the head of the screw 16 and the top of the insu-

lator 10, and is bent upwardly therefrom over the head of the screw 16, the conductor 12 being clamped between the upwardly extending portions by means of bolt 13, and the nut 14. A cup-shaped terminal shield 11, of porcelan or other suitable insulating material, and having an opening at its upper end through which the conductor 12 passes, is preferably provided to prevent accidental contact with the terminal elements. To complete the cushioning of the internal assembly, the washer of resilient material 17 is interposed between the top of the closure 18 and the bottom surface of the top of the tubular insulator 10.

The metal band 35 embraces the tubular insulator 10 at a position intermediate its ends, and above the lower end of the terminal electrode 25. Portions of the band 35 extend first outwardly from the insulator 10 in parallel relation to one another, and the outer ends are bent away from each other, to provide means for attaching the band 35 to a supporting structure 40, by the bolts 38 and 39. A ground terminal bolt 41 extends through the parallel outwardly extending portions of the band 35, and a ground conductor 36 is electrically connected therewith to maintain the band 35 at ground potential. The band 35 also has a continuous portion thereof extended first outwardly and then inwardly along a diameter extending between the parallel mounting portions, and a portion of the intermediate electrode 31 extends upwardly along the outside of the tubular insulator 10, in spaced parallel relationship with the internal arcing gap between the terminal electrode 25 and the intermediate electrode 31, to a point horizontally spaced from the outwardly bent continuous portion of the band 35, thereby forming an external arcing gap between the intermediate electrode 31 and the band or ground terminal electrode 35.

A portion of the intermediate electrode 31 extends under the lower end of the cylindrical element 20 to provide a support therefor, and a flux control conducting member 29, in electrical contact at its lower end with the intermediate electrode 31, extends upwardly within the element 20 to a point substantially above the lower end of the line terminal electrode 25, but not entirely through the element 20, so that the distance separating the line terminal electrode 25 and the conducting member 29 is substantially less than the distance separating the former and the intermediate electrode 31. It may be mentioned that the electrical strength of the air per unit of length between the electrode 25 and the intermediate electrode 31 is substantially less than that of the insulating material between the electrode 25 and the conducting member 29, so that breakdown always occurs over the air path.

The series arrangement of the internal and external arcing gaps has an electrical strength which is so coordinated with the insulating elements of the device that the weakest electrical path from conductor to ground is through the series arrangement of these gaps, and electrical breakdown therefore includes the arcing gap between the line terminal electrode 25 and the intermediate electrode 31, and the arcing gap between the latter electrode and the ground terminal electrode 35.

It may now be observed that the ground terminal electrode 35 encircles the line terminal electrode 25, and may be nearer thereto than the intermediate electrode 31, and that, with this arrangement the larger portion of the electrostatic flux prior to breakdown of the gaps will pass from the line terminal electrode 25 through the walls of the insulating members to the ground terminal electrode 35. It may also be observed that whatever flux is not shunted away from the series arrangement of gaps will be greatly unbalanced in the respective gaps, for the reason that the flux from the lower end of the line terminal electrode 25 is diverted away from the internal arcing gap by the flux control member 29, but that no equivalent shunting flux path is available with respect to the external gap, and the flux is therefore concentrated in the latter gap.

The conditions before breakdown may therefore be regarded as similar to one large capacitor (25—29) in series with one small capacitor (31—35), this series arrangement being shunted by another relatively large capacitor (25—31). Since the voltage applied to such a series arrangement divides inversely in accordance with the relative electrical capacities, it may be seen that cascade breakdown will occur at a voltage which may approach that required to breakdown only the longer of the two gaps, and in this manner the low initial breakdown voltage desired to provide a high degree of protection is accomplished. It may be noted that cascade breakdown in an arrangement of this kind is controlled by relative values of flux concentration, rather than absolute values. It may be further observed that the effect of the proximity of the line terminal electrode 25 with respect to the ground terminal electrode 35 forms a capacitor which must be charged before voltage can build up to flash the gaps, thus reducing the time required to flash the arrester.

The curve *b* of Fig. 4 illustrates a volt-time characteristic of the invention, in comparison with that (curve *a*) of a device embodying gaps of the same length, but without the flux control features of the present invention, as before described. It may be noticed that not only do the improvements herein set forth reduce the magnitude of the sparkover voltage for all times shown, but also that the characteristic curve is much flatter as zero time is approached, both of which are important considerations relating to overvoltage protection of electrical apparatus from lightning disturbances.

Following breakdown of the gaps in response to an overvoltage with respect to ground on a connected conductor, the initial path of current which may follow from an energized alternating current conductor through the device is downwardly through the electrode 25, downwardly in an arc along the line of abutment of the element 20 with the tube 19, thence upwardly through the electrode 31 along the outside of the tubular insulator 10 in close spaced parallel relation with the arc, thence across the external gap as an arc to the ground terminal electrode 35.

The arrangement just described is such that the current through the upwardly extending portion of the electrode 31 produces an electro-magnetic field about the upwardly extending portion which reacts with the electromagnetic field about the arc, and results in a force which repels one from the other. Since the electrode is mechanically fixed in place, and further since the arc has little weight and is therefore easily deflected, the arc is driven from its initial path to successively longer paths in the space between the tube and the element of insulating material. The elongation of the arc in this manner greatly as-

sists in its extinguishment, and this is one of the important features of the present invention.

In Fig. 5 is illustrated the relation of the repulsive force to the current in the arc. This relation is a parabola, since the force is a square function of the current. This characteristic is particularly desirable in the present invention, since the force increases geometrically instead of linearly with increasing currents, and it is the high short-circuit currents of the order indicated in Fig. 5 which are the most difficult to interrupt.

The shape of the ground electrode **35**, together with its position with respect to the other elements constituting the arrester, is an important consideration in the construction of an arrester having the advantages herein set forth. It will be apparent from the above description that the ground electrode **35**, in addition to serving as an electrode for the external arcing gap, is also a common means for supporting the arrester and controlling the flux prior to breakdown. It will also be apparent that the intermediate electrode **31** not only is an arcing electrode common to both the internal and external gaps, but also a conductor so positioned as to drive the arc from the initial arcing path in response to current therethrough.

Although the invention has been shown in but one form, it will be evident to those skilled in the art that many other forms and modifications may be employed without departing from the spirit of this invention as described above or as set forth in the appended claims.

What is claimed is:

1. A lightning arrester comprising a hollow tube of insulating material, normally insulated conducting electrodes associated with said tube, said electrodes being so related as to cause an arc responsive to spark over which extends between said electrodes and longitudinally along the internal surface of said hollow tube, one of said electrodes having an externally positioned juxtaposed portion in series circuit relation with the arc and so positioned with respect thereto as to drive the arc away from the initial path, said portion extending longitudinally along one side only of said initial path.

2. A lightning arrester comprising a hollow tube of insulating material, normally insulated conducting electrodes associated with said tube, said electrodes being so related as to cause an arc responsive to spark over which extends between said electrodes and longitudinally along the internal surface of said hollow tube, one of said electrodes having an externally positioned juxtaposed portion associated and in series circuit relation with the arc and so positioned with respect thereto that the arc is electromagnetically repelled from said portion, said portion extending longitudinally along one side only of said arc.

3. In a lightning arrester adapted for connection between a conductor and ground, spaced insulated conducting electrodes forming an arcing gap in the circuit between conductor and ground, a tube of insulating material housing said arcing gap, structural means for causing an arc following sparkover of said gap to occur over an initial path along the internal surface of said tube, one of said electrodes having a portion thereof extending along one side only of said arcing gap in spaced insulated parallel relation therewith, said portion extending longitudinally along the outside of said tube and forming a part of the circuit between conductor and ground and being so related to said arcing gap that the electromagnetic fluxes about said portion and gap interact to move said arc from said initial path.

4. A lightning arrester adapted for connection between a conductor and ground comprising a hollow tube of insulating material, having an opening at one end thereof, a substantially cylindrical element of insulating material having a diameter less than that of the hollow extending therein, means holding said element of insulating material in lateral abutting engagement with the inner surface of said tube, and electrically conducting structural means for causing sparkover between conductor and ground to occur over an arc path along the line of abutment of said tube with said insulating element, said conducting means including a conducting member adjacent to and extending along said arc path in spaced relation thereto, said conducting member extending longitudinally along the outside of the tube and being arranged to conduct current in a direction opposite that of the direction of current through said arc path, whereby the arc is electromagnetically driven from its initial path.

5. A lightning arrester adapted for connection between a conductor and ground comprising a hollow tube of insulating material, having an opening at one end thereof, a substantally cylindrical element of insulating material having a diameter less than that of the hollow extending therein, means holding said element of insulating material in lateral abutting engagement with the inner surface of said tube, and electrically conducting structural means for causing sparkover between conductor and ground to occur over a predetermined initial arc path parallel to the axis of the tube and in the space between the tube and the cylindrical element, said structural means including an externally positioned conductor juxtaposed with respect to said arc path and conducting current in a direction to electromagnetically repel said arc from said conductor whereby said arc is driven away from the predetermined initial path.

6. A lightning arrester subject to a voltage from a conductor and to ground, comprising insulating means supporting a plurality of normally insulated conducting electrodes to provide a first arcing gap and a second arcing gap in series relation from conductor to ground, a tube of insulating material housing said first arcing gap, said electrodes being related to control the electrostatic fields about said gaps prior to breakdown thereof so as to concurrently reduce the time of flashover of said gaps and impress substantially all of said voltage on said second arcing gap and said electrodes being also related to control the electromagnetic fields about said gaps following breakdown thereof so as to move the arc of said first arcing gap away from its initial path.

7. A lightning arrester subject to a voltage from a conductor and to ground, comprising insulating means supporting a plurality of normally insulated conducting electrodes to provide a first arcing gap and a second arcing gap in series relation from conductor to ground, insulating elements defining an annular arc space housing said first arcing gap, said electrodes being related to control the electrostatic fields about said gaps prior to breakdown thereof so as to concurrently reduce the time of flashover of said gaps and impress substantially all of said voltage on said second arcing gap and said electrodes being also related to control the electromagnetic fields about said gaps following breakdown thereof so as to

elongate the arc of said first arcing gap within said annular space whereby to extinguish it.

8. A lightning arrester comprising a tube of fibrous gas evolving insulating material, having one end thereof closed a substantially cylindrical element of insulating material having diameter less than that of the tube supported therein in lateral abutting engagement with the inner surface thereof, a tubular insulator of ceramic insulating material, means supporting said tube within said tubular insulator, vent means for said tube at the other end thereof, normally insulated conducting electrodes including a first terminal electrode at the closed end of said tube, an intermediate electrode at the vented end of said tube, and a second terminal electrode positioned externally of said tube, said first terminal electrode extending along the line of abutment of said element with said tube toward said intermediate electrode in spaced relation therewith to provide a preferential internal arcing gap therebetween, and said second terminal electrode encircling said ceramic insulator and forming supporting means for mounting the arrester, said first terminal electrode extending through said second terminal electrode to thereby increase the electrical capacity of the arrester.

9. A lightning arrester comprising a tube of organic gas evolving insulating material having a closure at one end and vent means at the other end, a substantially cylindrical element of insulating material having a diameter less than that of the tube supported therein in lateral abutting engagement with the inner surface thereof, a hollow tubular insulator of inorganic material, means supporting said tube within said tubular insulator, normally insulated conducting electrodes including a first terminal electrode at the closed end of said tube, a second terminal electrode encircling said tubular insulator between the ends thereof, and an intermediate electrode at the vented end of said tube, said electrodes being related to provide the weakest electrical path between the terminal electrodes, said first terminal electrode extending through said second terminal electrode along the line of abutment of said element with said tube toward the intermediate electrode to provide a first arcing gap there between, whereby to increase the electrical capacity of the device, and said intermediate electrode extending externally of said tube along said first arcing gap toward said second terminal electrode to provide a second arcing gap and being magnetically coupled to said first arcing gap so as to cause movement of the arc spanning said first arcing gap between said element and said tube in response to electrical breakdown of said gaps.

10. In a lightning arrester, a hollow tube of gas evolving insulating material having a closure at one end and vent means at the other end, a substantially cylindrical element of insulating material having a diameter less than that of the hollow of said tube supported therein in lateral abutting engagement with the inner surface thereof, said element extending toward but in spaced relation with said closure whereby to provide a chamber therebetween, normally insulated conducting electrodes at the respective ends of said tube, one electrode extending along the line of abutment of said element with said tube, said one electrode having a grooved passageway extending from the extended end thereof in communication with said chamber.

11. In a lightning arrester adapted for connection between a conductor and ground, spaced insulated conducting electrodes forming an arcing gap in the circuit between conductor and ground, a wall of insulating material enclosing said arcing gap, said electrodes being arranged for causing an arc following sparkover of said gap to occur over an initial path along the internal surface of said wall of insulating material, one of said electrodes having a conducting portion thereof extending along one side only of said arcing gap in spaced insulated parallel relation therewith, said conducting portion forming a part of the circuit between conductor and ground and being arranged to conduct current in a direction opposite that of the direction of current through said arc path, whereby the arc is electromagnetically driven from its initial path.

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