Aug. 2, 1960 A. C. WESTROM 2,947,903

CURRENT INTERRUPTING DEVICES

Filed Jan. 17, 1958

2 Sheets-Sheet 1

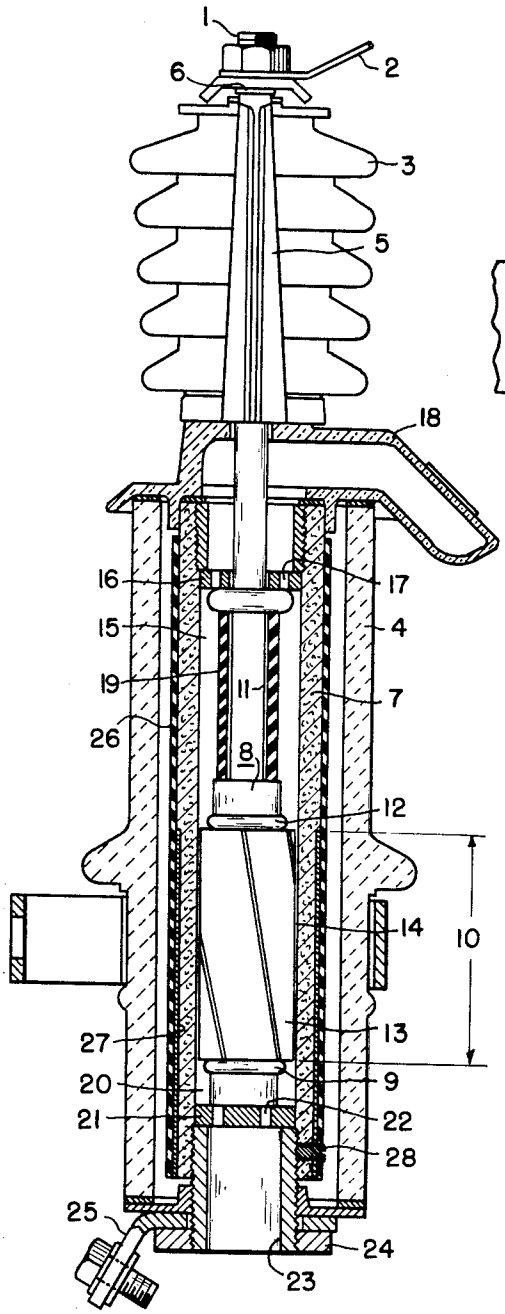


Fig. 1

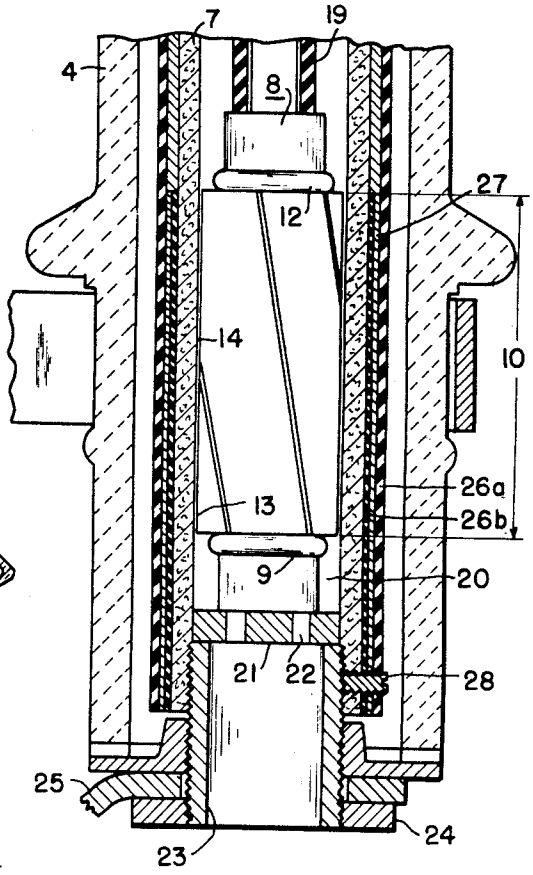


Fig. 2

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2 Sheets-Sheet 2

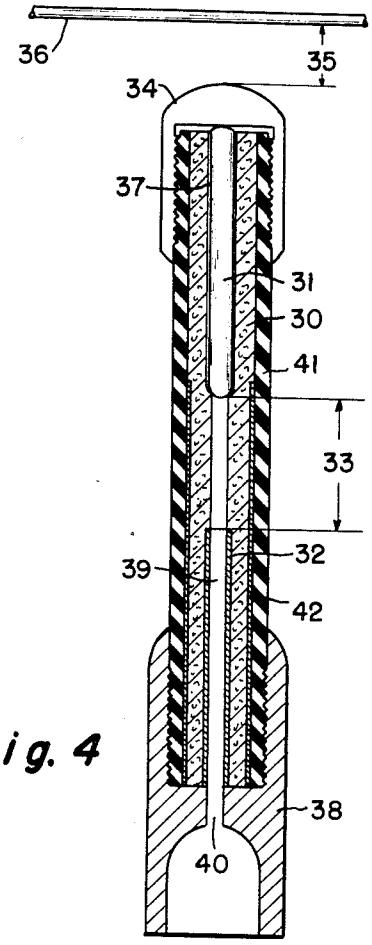


Fig. 4

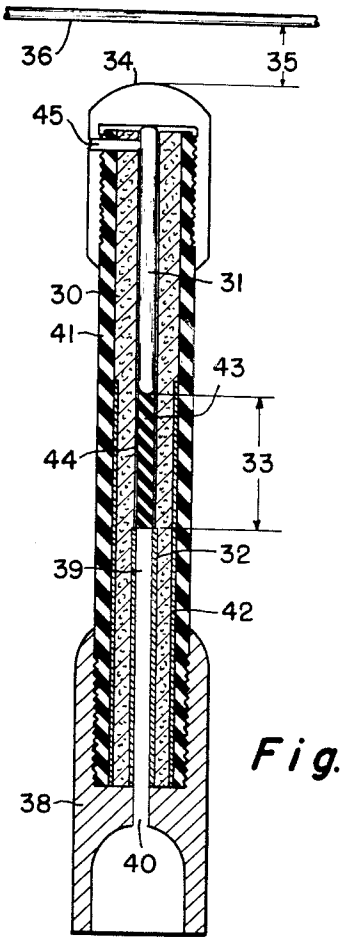


Fig. 5

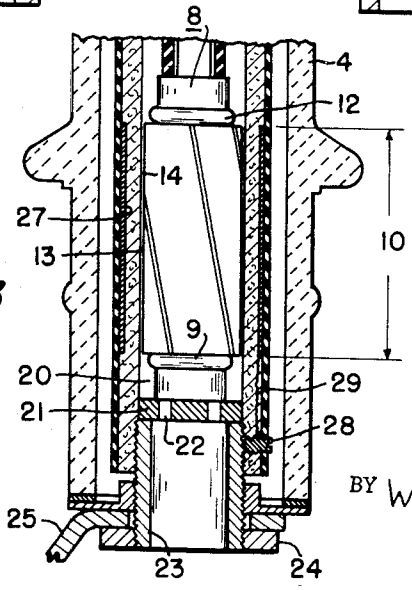


Fig. 3

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CURRENT INTERRUPTING DEVICES

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12 Claims. (Cl. 313—231)

This invention relates to devices for interrupting heavy current flow such as lightning current surges and particularly, to lightning arresters and line protector tubes.

An expulsion lightning arrester discharges lightning current over horn fiber surfaces in its path to ground. Generally, lightning arresters of the expulsion type have two air gaps arranged in series with the first air gap at a power line terminal and in free air. This first air gap isolates the arrester from the power system voltage except under current surge conditions. The second gap is through an air space in a horn fiber tube and frequently is an air space between a fiber plug disposed in the tube and the inner walls of the tube with the plug positioned to form a restricted passageway between it and the inner walls.

When the arrester begins its conduction of surge currents, the two gaps present a low impedance path which efficiently directs most of the surge current to the ground. The action of the current surge on the horn fiber surfaces generates gases sometimes under high pressure which gases are substantially nonconducting and which serve to deionize an arc path concurrent with and following passage of the surge current and thus prevent, limit or interrupt flow of power system follow current.

Line protector tubes function electrically like expulsion type arresters but have a more limited application. The line protector tubes are electrically connected to a power system through air gap and unlike the arrester, it is bracketed at its ground terminal to a crossarm or steel structure but is otherwise not physically connected to the power system. However, like the expulsion type arrester, it has a second air gap in a horn fiber tube. Previously, the protector tubes have not had porcelain jackets for weatherproofing but have used Bakelite jackets for weatherproofing. Also, protector tubes have had an unrestricted gap between the electrodes in the horn fiber tube and have not had an electrostatic shield surrounding the gap in the horn fiber tube.

Heretofore, many lightning arresters have had a steel reinforcing band surrounding the second air gap and electrically connected to the ground electrode of the arrester. The steel band must be insulated from one end of the arrester. The function of this steel band is to prevent the arrester from exploding as a result of the high gas pressures generated by a flow of heavy current surges. The steel band also serves as an electrostatic shield for stabilizing and lowering the arrester impulse sparkover characteristics.

The use of this steel reinforcing band has disadvantages and shortcomings such as a weight problem and wall thickness which necessarily increases the size of the arrester. Also, the material required to insulate the band from one end of the arrester increases its bulk. In addition, the steel band adds to the arrester a high electrical conductivity and, as a result thereof, almost unlimited current carrying capacity in the event of arrester failure. Where arrester failure occurs and the steel band is in the circuit of the lightning current surge, a power arc develops

which shorts the power system and continues uninterrupted until a line sectionalizing device functions to bring about an outage in the power system.

My invention in devices for interrupting heavy current flow is not subject to the shortcomings and disadvantages of arresters having a steel band reinforcement. In the event of arrester failure, my device has ability to interrupt a current arc or when a high current surge occurs, my device creates sufficient pressure to explode and blow itself free from the line and thus avoid a line outage. Specifically, my invention is in a device for discharging heavy current surges having a housing made from fibers and two electrodes disposed in the housing and spaced apart to form a gap therebetween with one of the electrodes being electrically connected to an air gap external of the device and with the other electrode being the ground electrode of the device. My invention comprises the combination of a sleeve made from ceramic fibers and fitting around the outside of the housing of fibers. Generally, the sleeve extends substantially the length of the housing. Interposed between the outside of the housing and the sleeve is a layer of conductive glaze which extends at least substantially the length of the gap in the housing between the electrodes so as to capacitatively couple same and which for this purpose is electrically connected to an electrode of the device, preferably the ground electrode whereas it is physically spaced from the other so as to be coupled thereto through capacitance only.

Included among the various ceramic materials from which the sleeve, which fits around the horn fiber tube, is made are glass, sodium, calcium silicates, calcium aluminates, aluminum silicates, calcium silicates and sodium silicates. The sleeve may comprise the ceramic fibers bonded together by a resin or they may be a cloth made from the fibers. Another form which the sleeve may take is a matte of ceramic fibers.

The conductive glaze of my invention is a thin layer of metallic material and functions as an electrostatic shield about the charged electrode to stabilize and lower a lightning arrester's or line protector tube's sparkover characteristics. In the event a lightning surge punctures the horn fiber tube from that electrode to the conductive glaze, it is highly desirable that the arrester either itself interrupt the current surge or blow itself free from the power circuits and avoid a line outage. The use of the conductive glaze enables a lightning arrester or line protector tube to interrupt the circuit as pointed out.

I minimize the thickness of the conductive glaze so that should the horn fiber tube be punctured, the power arc has a minimum amount of material to feed upon and thus would feed primarily upon exposed fibers of the horn fiber tube. Where the power arc feeds on the exposed fibers of the tube, the arrester or line protector then has ability to either interrupt the current surge or blow itself free from the circuit and prevent a line outage.

Materials which I have found satisfactory for the conductive glaze or the thin layer of metallic material are those which have relatively high electrical conductivity and include aluminum paint, fine copper mesh or screen, fine aluminum mesh or screen, fine brass mesh or screen, perforated aluminum foil, perforated copper foil, perforated tin foil, perforated brass foil, and foil made from aluminum, copper, tin, brass and screen, mesh or foil made from steel or iron. In addition, I have used thin copper screen bonded to perforations assisting to effect a good bond. Preferably, the thickness of the conductive glaze ranges from about 0.000005" to about 1/32".

In the accompanying drawings, I have shown my invention in which:

Figure 1 is a side elevation view partly in section showing my invention incorporated in a lightning arrester of the expulsion type;

Figure 2 is an enlarged view of a part of Figure 1 showing a modification of my invention;

Figure 3 is a view of a part of Figure 1 showing a second modification of my invention;

Figure 4 is a side elevation view partly in section showing my invention incorporated in a line protector tube; and

Figure 5 is a side elevation view similar to Figure 4 showing a second embodiment of my invention incorporated in a line protector tube.

The lightning arrester shown in Figure 1 comprises a line terminal **1** to which is connected one end of a lead wire **2** whose other end is joined to an electric power line (not shown). This line terminal **1** is located atop a heavy-duty porcelain insulator **3** which is mounted on the upper end of a heavy-duty porcelain tube **4**.

Also mounted on the upper part of the heavy-duty porcelain tube is an arcing horn **5**. Between the upper end of the heavy-duty porcelain tube **4** and the line terminal **1** is a first air gap or isolating air gap **6**. The base of the arcing horn is directly beneath the heavy-duty porcelain insulator **3** with the horn extending upwardly along the heavy-duty insulator but spaced therefrom.

Inside the heavy-duty porcelain tube is a horn fiber housing or tube **7** which houses an upper electrode **8** and a lower electrode **9**, sometimes called the ground electrode, spaced apart to form a second air gap **10** therebetween. This second air gap **10** is electrically in series with the first air gap **6**. As shown in Figure 1, the upper electrode is electrically connected to the arcing horn **5** and comprises a stud **11** which connects the arcing horn to the electrode head **12**.

Between the upper and lower electrodes and disposed in the second air gap in the horn fiber tube is a barrier plug **13** made from fibers which substantially fills the air gap. However, between the inside side walls of the horn fiber tube **7** and the side walls of the plug **13** is a restricted passageway **14** extending the length of the air gap **10**. This restricted passageway connects the upper electrode and the lower electrode and comprises the path of lightning surge current from the upper electrode to the lower electrode.

The upper electrode is located in an upper expansion chamber **15** formed by the inside walls of the horn fiber tube and the top of the fiber plug **13**. The top of the upper expansion chamber is a spider **16** having large vents **17** for free passage of exhaust gases to be discussed hereinafter. Connected to the upper expansion chamber is an exhaust conduit **18** which opens to the atmosphere. Between the electrode head **12** and the spider **16** is a fiber exhaust sleeve **19** surrounding that portion of the stud **11** disposed in the upper exhaust chamber **15**.

Correspondingly, the lower electrode **9** is positioned in a lower expansion chamber **20** formed by the bottom of the barrier plug **13**, the inner side walls of the horn fiber tube **7**, and a retaining spider **21** upon which the bottom of the lower electrode sits. This retaining spider, like the previously mentioned spider **16**, has large vents **22** for free passage of exhaust gases to a bottom exhaust conduit **23** which opens to the atmosphere. The bottom exhaust conduit supports the retaining spider **21**.

As previously explained, lightning current surges in their paths to the ground generate gases when they contact or engage the horn fiber tube surfaces. The barrier plug **13** is highly useful in assisting to generate relatively high pressures of gas caused by contact of the electric current surge with the horn fiber tube surfaces. Since the gas generated is substantially nonconducting, it deionizes the arc path following the current surge and thereby prevents or limits system power follow current. By using the barrier plug, the pressure of the gases generated is increased, thereby effecting more efficient deionization of the arc path especially during discharge of low current surges.

The gases generated by the flow of a current surge escape into the expansion chambers **15** and **20**, then pass through the vents of the spiders to the exhaust conduits and thence to the atmosphere. Such flow of the gases is essential to preserve the arrester and to prevent its being blown apart by excessive gas pressure. However, it is highly desirable to generate this gas and to generate it under pressure for the purpose previously explained.

A nut **24** threaded upon the outlet end of the lower exhaust conduit **23** affixes a ground terminal **25** to the bottom exhaust conduit so that the ground terminal is electrically connected to the lower electrode **9** through the retaining spider **21** and the bottom exhaust conduit.

A sleeve **26** made from ceramic fibers fits substantially completely around the outside of the horn fiber tube and extends substantially the length of the tube. It is not essential that the sleeve **26** extend substantially the length of the horn fiber tube but it may extend for just a part of the length of the tube. It is preferable that the sleeve extend the length of the tube for it has good strength and accordingly, strengthens the arrester throughout the length of the horn fiber tube. Interposed between the outside of the tube and the sleeve **26** is a layer of conductive glaze **27** which extends the length of the second air gap **10** between the upper and lower electrodes **8** and **9** and also extends down to the bottom of the sleeve **26**. This layer of conductive glaze surrounds the outside of the horn fiber tube. A set screw **28** extends through the sleeve of ceramic fibers, through the layer of conductive glaze and through the horn fiber tube where it engages the bottom exhaust conduit and thus, effects an electrical connection between the layer of conductive glaze and the lower electrode **9**.

The ceramic fibers give the sleeve **26** both high strength and excellent electrical insulating properties.

The sleeve **26** insulates the layer of conductive glaze from the top of the arrester and particularly the arcing horn and the upper electrode. In addition, it forms a good backing and support for the layer of conductive glaze.

This sleeve of ceramic fibers increases the discharge capacity of lightning arresters from about 65,000 amperes, the capacity of arresters heretofore used, to about 150,000 amperes and higher. The high strength and excellent insulation properties of the ceramic fibers brings about this increase in capacity without requiring additional insulation. Furthermore, use of the sleeve of ceramic fibers and the layer of conductive glaze materially reduces the weight of lightning arresters. As a result, production costs of arresters embodying the sleeve of ceramic fibers and the layer of conductive glaze are reduced for the arrester requires fewer and more compact materials.

The conductive glaze functions as an electrostatic shield and has distinct advantages over the steel band heretofore used. Where a lightning current surge punctures a defective or eroded or carbonized horn fiber tube from the top electrode to the electrostatic shield and where the shield is a steel band, a power arc results and shorts the power system. Due to the small gap between the top electrode and the steel band, the power arc is only interrupted when a circuit breaker, line sectionalizing device or other similar unit functions to cause a line outage. With the layer of conductive glaze, when the horn fiber tube is punctured by a lightning surge, the power arc primarily feeds on the exposed fibers of the horn fiber tube, thus enabling the arrester to either interrupt the power arc or to explode itself free from the line and avoid a line outage.

The modification of my invention shown in Figure 2 has the layer **27** of conductive glaze sandwiched between two layers **26***a* and **26***b* of ceramic fibers with the sandwich surrounding the outside surface of the horn fiber tube. As shown, the layer of conductive glaze extends

the length of the gap between the upper and lower electrodes 8 and 9 and down to the bottom of the sleeve 26. This sandwich of the two layers of ceramic fibers efficiently insulates the shield, the layer 27, from one end of the arrester.

The second modification of my invention shown in Figure 3 has the layer of conductive glaze 27 extending only the length of the air gap between the upper and lower electrodes 8 and 9 with a thin wire 29 connecting the lower end of the conductive glaze to the bottom exhaust conduit. This use of the thin wire to connect the conductive glaze to the bottom exhaust conduit provides a minimum of conducting material for a power arc which has punctured the horn fiber tube to feed upon.

The path of travel of a surge of lightning current through the arrester of Figure 1 is as follows: from the lead wire 2 to the line terminal 1, across the first air gap 6 to the arcing horn 5, to the upper electrode 8, across the air gap 10 via the restricted passageway 14, to the lower electrode 9, to the retaining spider 21, thence to the bottom exhaust conduit 23 and then to the ground terminal 25.

In line protector tubes the sleeve of ceramic fibers and the layer of conductive glaze perform the same function as in the lightning arresters and accordingly, impart to line protector tubes substantially the same advantages. In addition, this combination of the sleeve of ceramic fiber and the layer of conductive glaze materially extends the operating range of line protector tubes by making it feasible especially from an economic and weight standpoint to incorporate a barrier plug in the tube. Furthermore, the sleeve of ceramic fibers without the layer of conductive glaze adds to the operating range of protector tubes but, of course, not to the same extent as the combination of the sleeve and the layer of conductive glaze.

The sleeve of ceramic fibers weatherproofs line protector tubes and thereby replaces the Bakelite jacket heretofore used for weatherproofing. The ceramic fibers of the sleeve materially strengthen the tube and thus render it superior to those tubes using Bakelite jackets.

Figures 4 and 5 show my invention applied to line protector tubes. Referring to Figure 4, the line protector tube shown therein comprises a vulcanized fiber jacket or housing 30 with an upper electrode 31 and a lower or ground electrode 32 disposed therein and spaced apart to form a gap 33 therebetween. The upper electrode is a metal rod which extends to the top of the jacket 30 where it engages a metal head 34, the top of the line protector tube. As shown in Figure 4, there is an external air gap 35 between the head of the tube and a line conductor 36. Thus, like the lightning arrester, the line protector has two gaps in series with the tube being electrically connected to a power system across the external air gap 35.

Between the upper electrode 31 and the inner walls of the jacket 30 is an expansion chamber 37 where gases generated during a current surge may expand.

The lower electrode 32 is a hollow metal cylinder which extends to the bottom of the jacket where it engages the bottom member 38 of the tube. The bottom member is the ground terminal of the tube and has a ground wire (not shown) connected thereto.

The lower electrode 32 forms a lower expansion chamber 39 connected to the atmosphere by a vent 40 located in the bottom member. Gases generated by a current surge through the tube escape to the atmosphere out through the vent.

Fitting around the fiber jacket and extending the length thereof is a sleeve 41 made from ceramic fibers. Interposed between the outside of the fiber jacket 30 and the ceramic fiber sleeve 41 is a layer 42 of conductive glaze which runs the length of the internal gap 33 down to the lower end of the fiber jacket where it engages the bottom

member 38 and is thereby electrically connected to the ground.

The path of travel through the line protector tube of Figure 4 is as follows: From the line conductor 36 across the external air gap 35, to the metal head 34, then to the upper electrode 31 across the air gap 33, to the lower electrode 32, thence to the bottom member 38 and to the ground wire (not shown).

Figure 5 shows the line protector tube of Figure 4 with a fiber plug 43 disposed in the gap 33 between the upper electrode 31 and the lower electrode 32. The fiber plug sits upon the lower electrode 32 and forms with the side walls of the fiber jacket a restricted passageway 44 connecting the upper electrode with the lower electrode. The restricted passageway 44 and the barrier plug 43 of the line protector tube perform the same function as the barrier plug and the restricted passageway of the lightning arrester. The upper expansion chamber of the line protector tube of Figure 5 exhausts to the atmosphere through a vent 45.

Each of the line protector tubes of Figures 4 and 5 may have the layer of conductive glaze sandwiched between two layers of ceramic fiber as shown in Figure 2. In addition, each line protector tube may have the layer of conductive glaze extend only the length of the air gap between the upper and lower electrode with a thin wire to connect the layer to the ground terminal as shown in Figure 3.

While certain present preferred embodiments and modifications of my invention have been shown and described, it will be understood that the invention may be otherwise embodied within the scope of the appended claims.

I claim:

1. In a device for discharging heavy current surges having a housing made from fibers, two electrodes disposed in said housing and spaced apart to form a gap therebetween, one of said electrodes being electrically connected to an air gap connected to the line side of said device and the other electrode being the ground electrode of said device, the combination comprising a sleeve made from ceramic fibers fitting around the outside of said housing, a thin layer of metallic material interposed between the outside of said housing and said sleeve of ceramic fibers, said thin layer of metallic material extending at least substantially the length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected solely to one of said two electrodes.

2. The combination of claim 1 characterized by said thin layer of metallic material being about .000005" to about 1/32" in thickness.

3. In a device for discharging heavy current surges having a housing made from fibers, two electrodes disposed in said housing and spaced apart to form a gap therebetween, one of said electrodes being electrically connected to an air gap external of said device and the other electrode being the ground electrode of said device, the combination comprising a sleeve made from ceramic fibers enveloping the outside of said housing, a thin layer of metallic material interposed between the outside of said housing and said sleeve of ceramic fibers, said thin layer of metallic material extending at least substantially the length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected to the ground electrode of said device.

4. In a device for discharging heavy current surges having a housing made from fibers, two electrodes disposed in said housing and spaced apart to form a gap therebetween, one of said electrodes being electrically connected to an air gap external of said device and the other electrode being the ground electrode of said device, the combination comprising a sleeve made from ceramic fibers, said sleeve fitting around the outside of said housing, a thin layer of metallic material sandwiched between at least two layers of ceramic fibers of said sleeve, said thin layer of metallic material extending at least substantially the

length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected solely to one of said two electrodes.

5. The combination of claim 4 characterized by said thin layer of metallic material being about 0.000005" to about 1/32" in thickness.

6. The combination of claim 1 characterized by said sleeve of ceramic fibers extending substantially the length of the housing.

7. The combination of claim 4 characterized by said sleeve made from at least two layers of ceramic fibers extending substantially the length of said housing.

8. In a line protector tube having a housing, two electrodes disposed in said housing and spaced apart to form a a gap therebetween, one of said electrodes being electrically connected to an air gap connected to the line side of said protector tube and the other electrode being the ground electrode of said protector tube, the combination comprising a sleeve made from ceramic fibers fitting around the outside of said housing and extending substantially the length of said housing, a thin layer of metallic material interposed between the outside of said housing and said sleeve of ceramic fibers, said thin layer of metallic material extending at least substantially the length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected solely to one of said two electrodes, a plug made from fibers disposed in said air gap between said two electrodes, said plug substantially filling said air gap and forming with the inner walls of said housing a restricted passageway connecting said two electrodes.

9. In a line protector tube having a housing, two electrodes disposed in said housing and spaced apart to form a gap therebetween, one of said electrodes being electrically connected to an air gap external of said protector tube and the other electrode being the ground electrode of said protector tube, the combination comprising a sleeve made from ceramic fibers fitting around the outside of said housing and extending substantially the length of said housing, a thin layer of metallic material interposed between the outside of said housing and said sleeve of ceramic fibers, said thin layer of metallic material extending at least substantially the length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected to one of said two electrodes, a plug made from fibers disposed in said air gap between said two electrodes, said plug substantially filling said air gap and forming with the inner walls of said housing a restricted passageway connecting said two electrodes, and an expansible chamber located in said housing and connected to said air gap so that gases generated during a surge of current flow through said tube escape into said chamber and an exhaust open to the atmosphere and connected to said expansion chamber for escape of said gases therefrom.

10. In a line protector tube having a housing, two electrodes disposed in said housing and spaced apart to form a gap therebetween, one of said electrodes being electrically connected to an air gap external of said protector tube and the other electrode being the ground electrode of said protector tube, the combination comprising a sleeve made from ceramic fibers fitting around the outside of said housing and extending substantially the length of said housing, a thin layer of metallic material sandwiched between at least two layers of ceramic fibers of said sleeve, thin layer of metallic material extending at least substantially the length of said gap in said housing between the two electrodes, said thin layer of metallic material being electrically connected solely to one of said two electrodes, a plug made from fibers disposed in said air gap between said two electrodes, said plug substantially filling said air gap and forming with the inner walls of said housing a restricted passageway connecting said two electrodes.

11. The combination of claim 8 characterized by said thin layer of metallic material being about 0.000005" to about 1/32" in thickness.

12. The combination of claim 10 characterized by said thin layer of metallic material being about 0.000005" to about 1/32" in thickness.

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