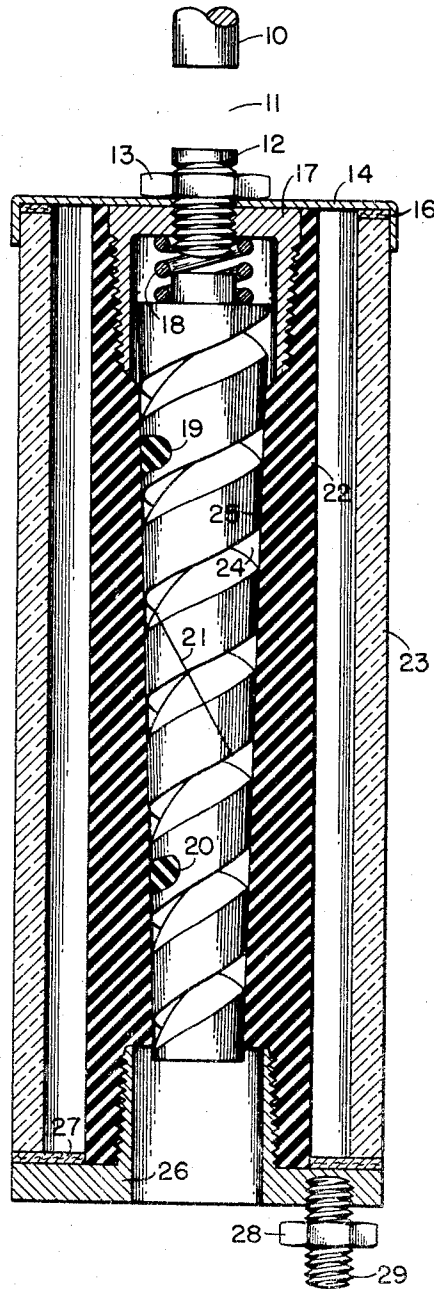


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LIGHTNING ARRESTER
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LIGHTNING ARRESTER

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This invention relates generally to lightning protective devices adapted for use with energized electrical circuits for the purpose of limiting the voltage rise of an associated conductor by discharging the abnormal or superimposed energy which may result from lightning strokes.

At this time there are in general use in connection with electrical distribution systems only two types of excess-voltage protective devices, sometimes called lightning arresters.

The first type is usually referred to as a "valve" type arrester, which consists of one or more spark gaps in series with a current-limiting resistance, the resistance material generally used being silicon carbide, this material having a resistance which varies exponentially with applied voltage. This device has good ability for limiting the power-follow current which tends to flow from the associated energized conductor to ground when the device sparks over in response to a predetermined voltage, but has serious practical limitations as to surge-current carrying capacity and further, the voltage drop across the resistance material is of course impressed upon the associated apparatus the device is intended to protect.

The second type is commonly called an "expulsion" type arrester, which is virtually the converse of the "valve" type, having relatively poor power-follow characteristics but practically unlimited surge-current ability with substantially no accompanying voltage drop impressed upon the apparatus protected. The desirability of the provision of an excess-voltage protective device having the surge-current carrying capacity inherent in the "expulsion" device along with the property of restricting the power-follow current to an insignificant amount is quite apparent, and the present invention relates specifically to such a device.

Many forms of lightning protective devices have been used, usually classified as "expulsion" arresters, which embody materials of construction similar to those found to be acceptable for use in the present invention.

Usually such devices depend for their operation upon (1) the establishment of a follow-current arc following the precursory discharge spark and (2) the evolution from the adjacent insulating material of copious quantities of arc-extinguishing gases to provide a relatively cool and de-ionizing environment for quenching the hot and therefore conducting arc-sustaining gases to effect arc extinguishment and interruption of the follow-current. Such a procedure necessarily consumes the materials of which the arc chamber is constructed, and the useful life of the device is a function of both the number of operations and the current available for contributing to the intensity of the arc.

Arc chambers of the devices mentioned generally consist of a filler member partially filling the hollow of an associated tube, the material of the filler and tube being formed of some gas-evolving material, such as hard fiber. Conventionally-used fillers have been either smooth-surfaced cylindrical members or cylindrical members provided with helical or circumferential grooves.

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The undesirability of constructions which permit the flow of power-follow current has long been recognized, and some attempts have been made to solve this problem by means of some sort of a filler-tube construction having the ability to discharge the transient surge currents without initiating a dynamoelectric follow-current arc. These attempts are generally exemplified by a filler-tube arrangement in which a smooth cylindrical plug-type filler is driven tightly into the tube, depending upon the surge voltage to cause a discharge spark to pass through an extremely restricted path between the inner surface of the tube and the outer surface of the filler. There being no compensatory adjusting mechanism in such a construction the effectiveness of its operation is dependent upon a definite and critical precision of fit of the filler plug in the tube.

Since known insulating materials having suitable properties to withstand the mechanical stresses and temperatures attending operation and particularly that material most suitable, namely—vulcanized fiber—are subject to important changes in dimensions with changing humidity and temperature, the vital precise clearance between the members of the arcing chamber is more apt to be absent than not. Slightly too much clearance results in serious grooving by the follow-current arc initiated by a discharge spark, because this construction is a single discharge path device, and in the absence of any alternate path, no forces are brought into action to move or spread the discharge spark from the initial path. On the other hand, if adjacent surfaces of the filler and tube are pressed together so that all of the air is squeezed out of the space therebetween, then no air gap is available for the passage of the discharge spark, and the device will fail by external flashover, or alternately be protected by failure of the associated apparatus it is intended to protect.

The principal object of the present invention is the provision of an excess-voltage protective device, embodying a pair of separate paths, which is capable of (a) discharging a widely varying range of transient surge-currents, such surge-currents lasting only for a very small fraction of a cycle of a 60 cycle power system and (b) restraining the flow of power-follow current, which in conventional devices continues to flow from the 60-cycle power line through the path initiated by the discharge spark, to such an extent that the operation of the device causes no visible erosion of the insulating members bounding the discharge path, or indication of follow-current or 60 cycle voltage disturbance on the trace when the electrical operation of the device is recorded by a magnetic oscillograph.

Another object of the invention resides in the provision of means for compensating for dimensional changes of the insulating members bounding the discharge path, so that the ability of device to discharge surges without accepting follow-current as above described is unaffected by either weather conditions or discharge sparks.

Another object of the invention resides in the provision of a novel filler construction which renders the device capable of discharging high-current surge sparks without eroding a groove at the path followed by the surge current, such a filler being provided with a helical furrow forming a relatively narrow channel extending from one end of the filler to the other, with an intervening land between the convolutions of the narrow channel which is substantially wider than the channel.

Another object is an improved plural-part filler construction divided near its midpoint along abutting oblique end surfaces of the parts, which construction, in cooperation with resilient means urging the respective parts of the filler to mutual engagement at the abutting beveled ends, provides an essential unbalance of pressure along

the longitudinal adjacent surfaces of the filler and the tube into which it is fitted, thereby assuring presence of the necessary chain of air molecules to provide a relatively short air gap along the internal smooth surface of the tube and between conducting electrodes positioned at the respective ends thereof.

The particular embodiment shown in the drawing is a lightning arrester having a discharge chamber formed by tube or tubular structure 22 of insulating material, hard fiber being one suitable material. An upper electrode 17, here shown as an inverted cup-shaped metal member, is threaded into the upper end of the tube 22, and the metal stud 12 threadedly extends coaxially downward through the top portion and into the hollow of the upper electrode 17. In somewhat similar fashion, a lower metal electrode 26 extends upwardly from the bottom end of the tube 22 in threaded engagement therewith, the lower end of the lower electrode being open to provide a vent for the escape of gas which may be expanded or generated within the tube. The upper end of the lower electrode 26 is spaced from the lower end of the upper electrode 17 within the tube 22 to form a spark gap for a discharge spark. A lower terminal stud 29 is threaded upwardly into an outwardly extending flanged portion of the lower electrode 26, which, together with the terminal nut 28, provides means for connecting a ground wire thereto, and for use in mounting the device, if desired.

The opening within the tubular structure 22 between the electrodes 17 and 26 is provided with a smooth inner conical surface, the conically-enlarged end being closed by the upper electrode 17, and the conically-reduced end vented through the coaxial opening in the lower electrode 26.

Within the tubular structure 22 is disposed and supported therein by tight slip-frictional engagement with the inner conical surface of the tube a filler of insulating material, such as hard fiber, this filler being divided along the plane indicated by the numeral 21 into an upper part 19 and a lower part 20. A helical spring 18 is centrally disposed between the upper electrode 17 and the upper end of the filler part 19, and arranged to continuously wedge both parts of the filler downwardly into the conical opening of the tubular structure 22.

The filler is preferably divided near its midpoint and along an oblique plane such that the angle of bevel is small with respect to the longitudinal axis of the filler, so that the resultant wedging together of the parts by the resilient downward and endwise urging, whether due to the spring 18, gas pressure, or both, of the upper portion 19 against the lower portion 20 will be effective to unbalance the pressure of the respective filler parts against the inner conical surface of the tube 22 along diametrically positioned vertical lines, thereby providing direct lines of relatively low contact pressure between the electrodes for the establishment of the shorter discharge path. The arrangement just described provides the necessary compensation for routine change in dimensions of the members of the arc chamber, and is an important feature of the arrester, because it enables the parts to maintain that preciseness of relationship essential to proper operation. If the filler becomes too tightly wedged, the protective ability of the device is destroyed; if too loose, power-follow current will be established in the path of the discharge spark, as in a conventional expulsion arrester.

A narrow channel 24, preferably in the form of a furrow generally triangular in section and having a flat top and a downwardly and outwardly sloping side, is cut helically in the surface of the filler from its upper to its lower end to provide a relatively long discharge path of relatively less restriction in parallel with the shorter discharge path above described. For best results, the channel 24 should be of substantially less width than the land 25 between its convolutions, and the pitch of the channel should be such that any gas moving therein will

move transversely with respect to the shorter discharge path.

The magnitude and relationship of certain dimensions are important. As an illustration, an arrester of the character herein described operates successfully in connection with a 60 cycle 8000 volt R.M.S. circuit with the shorter path about 5 inches in length, the longer path about 14 inches in length, a filler tapering from a 1" diameter at the top to a 3/4" diameter at the bottom, the longer path being formed by a flat-topped triangular furrow 3/16" deep and 1/4" wide, and a spiral pitch of 3/4", the filler being divided near its midpoint along a bevel of 30 degrees with the long axis of the filler. The drawing illustrates this construction in approximately actual size.

A housing 23, of porcelain or similar material, is provided to house the elements of the discharge chamber, being supported at its lower end by the outwardly extending flange of the lower electrode 26, and positioned and covered at its upper end by the metal cover 14, being fixed in position by the nut 13 of the stud 12, the latter extending downwardly through a central opening in the cover 14 and being threaded through the top electrode 17. Gaskets 16 and 27 may be provided to seal the joints at the respective ends of the housing 23.

In operation, the upper terminal 10 is connected, through an external series spark gap 11, to a terminal of a protected device or to a conductor associated therewith, the lower terminal 29 being usually connected to ground. Upon the occurrence of a predetermined excess voltage, such as might be caused by lightning, the gap 11 along with the internal shorter gap between the electrodes 17 and 26 sparks over along the internal surface of the tube 22, discharging the surge to ground. The heat of the discharge spark expands the air within the discharge chamber, and this expansion, along with any water vapor distilled from the fiber components, exerts a downward pressure tending to tightly wedge the filler parts in the tapered opening and thereby highly restrict the shorter and direct discharge path. The available power line voltage is unable to maintain continued flow of power-follow current over this shorter path, and at the same time the longer spiral path refuses to accept follow-current. Therefore no power-follow current follows the discharge spark, regardless of the polarity or instantaneous dynamoelectric voltage of the energized connected conductor at the time of discharge.

While I am not certain as to the correct explanation of the improved operating results, it seems likely that the sudden transverse movement of air and water vapor attending the discharge spark quickly moves at differing rates various longitudinal segments of the discharge spark, thereby keeping the temperature of all available follow-current paths too low to effect the necessary reduction in arc-arresting resistance to enable the kindling of a power-follow arc. Since the device operates with no apparent thermal degradation of the fiber members, it is certain that no large volume of decomposition gases are evolved, such as are commonly generated in conventional devices, and this conclusion is further evidenced by observation of the relatively small quantities of incandescent gases vented when the arrester operates in circuits having available follow-current of 10,000 or more amperes. The initial spark always follows the highly but least restricted path established by unbalanced wedging of the filler parts against the inner surface of the tube, and it is apparent that any transverse movement of the discharge spark as it may be driven by the moving gas necessarily moves the discharge spark into an even more restricted area of the shorter path.

It will be apparent from the foregoing description that modifications and variations of the present invention are possible. It is, therefore, to be understood that the invention is not limited in its application to all of the details of construction specifically described and illustrated, and that within the scope of the appended claims,

it may be practiced otherwise than as specifically described and illustrated.

I claim:

1. A lightning arrester subject to follow-current in response to a precursory discharge spark therein, comprising a hollow insulator body forming a housing for a plurality of normally insulated conducting electrodes positioned in spaced relationship to provide an air gap, and a dielectric structure formed of insulating material and confining said gap, said dielectric structure including a tubular structure vented at one end, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end, and an elongated conical filler of insulating material having a convoluted surface fitted therein between said electrodes in tight slip-frictional engagement with the inner surface of said tubular structure, said convoluted surface cooperating with said smooth surface to define one of a pair of separate intersecting gas paths bridging the confined gap, the other of said paths extending along the smooth inner surface and forming a shorter path, the relative movement of gas in said paths cooperating in response to the occurrence of a discharge spark in said shorter path to preclude the ignition of a follow-current arc within the device.

2. A lightning arrester subject to follow-current in response to a precursory discharge spark therein, comprising a hollow insulator body forming a housing for a plurality of normally insulated conducting electrodes positioned in spaced relationship to provide an air gap, and a dielectric structure formed of insulating material and confining said gap, said dielectric structure including a tubular structure vented at one end, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end, and an elongated conical filler of insulating material fitted therein between said electrodes in tight slip-frictional engagement with the inner surface of said tubular structure, said filler member comprising at least two parts disposed in beveled end-to-end relationship and having a convoluted surface, said convoluted surface cooperating with said smooth surface to define one of a pair of separate paths bridging the confined air gap, the other of said pair extending along said inner surface and forming a shorter path, the relative movement of gas in said paths cooperating in response to the occurrence of a discharge spark in said shorter path to preclude the ignition of a follow-current arc within the device.

3. A lightning arrester subject to follow-current in response to a precursory discharge spark therein, comprising a hollow insulator body forming a housing for a plurality of normally insulated conducting electrodes positioned in spaced relationship to provide an air gap, and a dielectric structure formed of insulating material and confining said gap, said dielectric structure including a tubular structure vented at one end, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end, and an elongated conical filler of insulating material fitted therein between said electrodes in tight slip-frictional engagement with the inner surface of said tubular structure, said filler having a furrow extending helically from one electrode member to the other, the width of the land between adjacent convolutions of said furrow being substantially greater than the width of said furrow, the convoluted furrow cooperating with said smooth surface to define one of a pair of separate intersecting gas paths bridging the confined gap, the other of said paths extending along the inner smooth surface and forming a shorter path, the relative movement of gas in said paths cooperating in response to the occurrence of a discharge spark in said shorter path to preclude the ignition of a follow-current arc within the device.

4. A lightning arrester subject to follow-current in response to a precursory discharge spark therein, comprising a hollow insulator body forming a housing for a plurality of normally insulated conducting electrodes positioned

in spaced relationship to provide an air gap, and a dielectric structure formed of insulating material and confining said gap, said dielectric structure including a tubular structure vented at one end, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end, and a segmented conical filler of insulating material fitted therein between said electrodes in tight slip-frictional engagement with the inner surface of said tubular structure, said convoluted surface cooperating with said smooth surface to define one of a pair of separate intersecting gas paths bridging the confined gap, the other of said paths extending along the inner smooth surface and forming a shorter path, the relative movement of gas in said paths cooperating in response to the occurrence of a discharge spark in said shorter path to preclude the ignition of a follow-current arc within the device.

5. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure and one end of said tubular structure being vented, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end, and an elongated conical filler member of insulating material fitted within said tubular structure between said electrode members in tight slip-frictional engagement with the inner surface of said tubular structure, said filler member having a furrow extending helically from one electrode member to the other electrode member, the width of the land between adjacent convolutions of said furrow being substantially greater than the width of said furrow.

6. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure and at least one end of said tubular structure being vented, said tubular structure having a smooth inner surface and an opening conically reduced at the vented end and a segmented filler member of insulating material snugly fitted within said tubular structure between said electrode members, said filler member having a furrow extending helically from one electrode member to the other electrode member, the width of the land between adjacent convolutions of said furrow being at least equal to the width of said furrow, the segments of said filler abutting in beveled-end engagement.

7. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure and one end of said tubular structure being vented, said tubular structure having a smooth inner conical surface, the conically-reduced opening being at the lower end and vented end, and an elongated conical filler member of insulating material fitted within said tubular structure between said electrode members and supported therein solely by frictional engagement with the smooth inner conical surface of said tubular structure, said filler member having a furrow extending helically from one electrode member to the other electrode member, the width of the land between adjacent convolutions of said furrow being at least equal to the width of said furrow.

8. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure, said tubular structure having a smooth inner conical surface and being vented at the conically-reduced end, and a segmented conical filler of insulating material fitted within said tubular structure between said electrode members and supported therein solely by frictional engagement with the smooth inner conical surface of said tubular structure, said filler having a furrow extending helically from one electrode member to the other electrode member, the width of the land between adja-

cent convolutions of said furrow being substantially greater than the width of said furrow, the segments of said filler extending in end-to-end relationship and engaging one another along matching beveled-end surfaces.

9. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure, said tubular structure having a smooth inner conical surface and being vented at the conically-reduced lower end, and a segmented conical filler of insulating material disposed within said tubular structure between said electrode members and supported therein solely by frictional engagement with the smooth inner conical surface of said tubular structure, said filler having a furrow formed in the surface thereof extending helically from one electrode member to the other electrode member, the width of the land between adjacent convolutions of said furrow being substantially greater than the width of said furrow, the segments of said filler extending in end-to-end relationship and engaging one another along matching beveled-end surfaces, and resilient means urging said segments to engagement and toward the vented end of said tubular structure.

10. A lightning arrester comprising a tubular structure of insulating material, spaced electrode members disposed at the respective ends of said tubular structure, at least one of said electrode members extending into said tubular structure, said tubular structure having a smooth inner conical surface and being closed at the conically-enlarged end and vented at the conically-reduced end, and a segmented conical filler of insulating material extending longitudinally within said tubular structure between said electrode members and supported therein solely by frictional engagement with the smooth inner conical surface of said tubular structure, said filler having a furrow formed in the surface thereof extending helically from one electrode member to the other electrode

member, the width of the land between adjacent convolutions of said furrow being substantially greater than the width of said furrow, the segments of said filler extending in end-to-end relationship and engaging one another along matching beveled-end surfaces, and resilient means at the conically-enlarged end of said tubular structure for urging said segments to engagement and toward the vented end of said tubular structure.

11. A lightning arrester comprising a tubular structure of insulating material having a smooth inner conical surface tapering uniformly from a conically-enlarged end to a conically-reduced end, said tubular structure being closed at the conically-enlarged end and vented at the conically-reduced end, spaced conducting electrodes disposed at the respective ends of said tubular structure, at least one of said electrodes extending into said tubular structure to assure that a discharge spark between said electrodes occurs within said tubular structure, an elongated conical filler disposed between said electrodes and within said tubular structure in tight slip-frictional engagement with the inner conical surface thereof, and structural means for limiting the dielectric strength of the discharge path along the engaged surfaces of said filler with said tubular structure, said means including the division between said electrodes of said filler into at least two parts along an oblique plane defining matching beveled end surfaces, and resilient means at the conically-enlarged end of said tubular structure longitudinally urging said parts to abutting end-to-end engagement.

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