Dec. 29, 1953 T. I. ELDRIDGE, JR., ET AL 2,664,518

EXPULSION TYPE LIGHTNING ARRESTER

Filed April 26, 1951

Fig. 1.

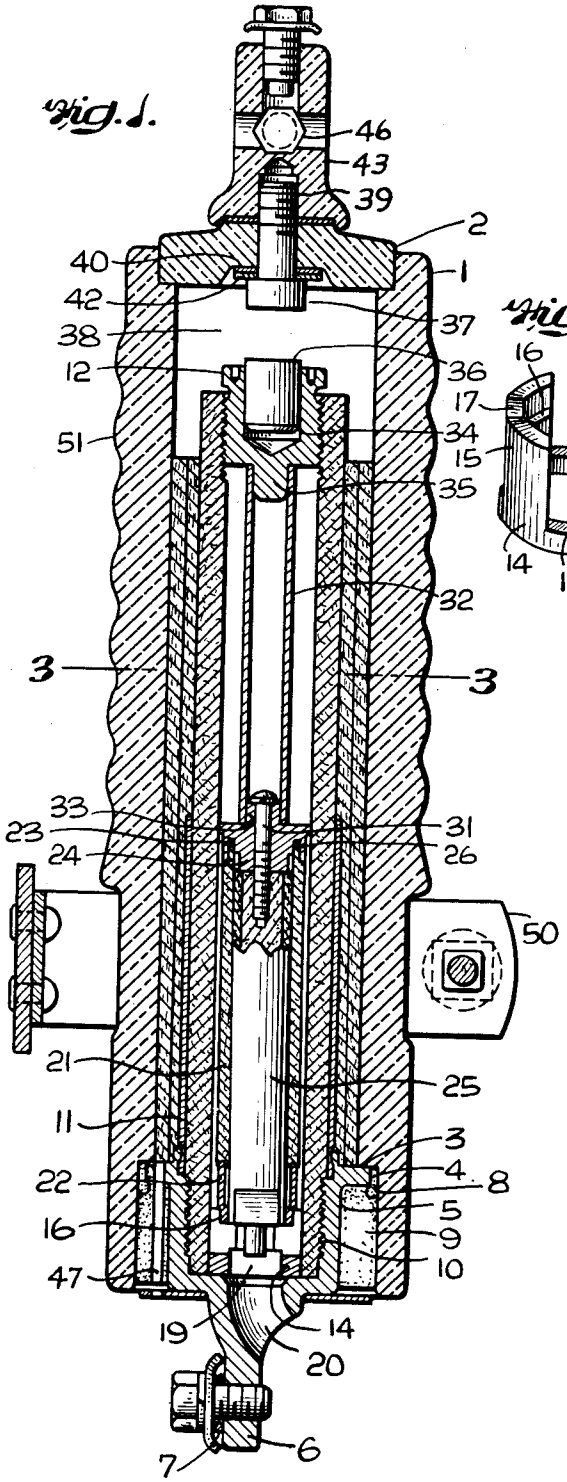


Fig. 5.

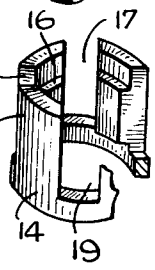


Fig. 2.

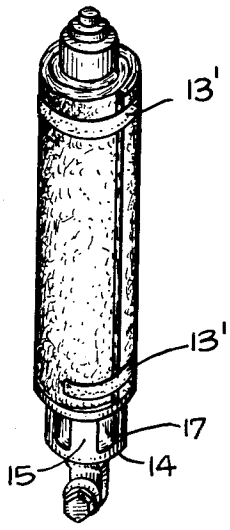


Fig. 3.

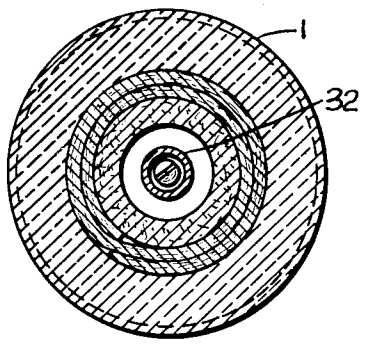


Fig. 4.



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EXPULSION TYPE LIGHTNING ARRESTER

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7 Claims. (Cl. 313—231)

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Our invention is an improved electric protective device or lightning arrester having a housing containing an electrode which, in use, is at line potential; an electrode, which, in use, is normally at ground potential; and an intermediate electrode: the latter being air spaced from the line electrode to form an isolating gap, and spaced from the grounded electrode by a constricted arc slot or slots formed by walls of a protector tube. Such walls generate the deionizing gases when subjected to the action of an arc and constitute the characteristic element of the arrester for suppressing the flow of follow current to ground after the discharge of a surge due to lightning or transient abnormal voltage.

The stresses to which such devices are subjected in operation usually render desirable the encirclement of the protector tube with a metal sleeve connected electrically with the grounded electrode and which acts as an electrostatic shield to provide low spark over of the discharge paths through the arc slot between the intermediate electrode and the grounded electrode.

We have found that failures of such arresters occasionally occur after the interruption of a discharge of surge current as a result of flashover of dynamic or system current through a shunt air path from the line electrode, around the protector tube to the grounded electrode or the conducting sleeve connected therewith. Such flashovers occur despite the fact that such shunt air path is considerably longer than the total of the arcing distances between the isolating gaps and through the arc slot and that dynamic or system current does not arc across either of such arcing distances excepting when the air between the electrodes has been ionized by a discharge of surge current. The dynamic or system current does not flashover through the shunt air path excepting during a discharge to ground initiated by a surge current or during the cycles immediately following the suppression of a discharge initiated by a surge current.

Discharges of dynamic current to ground through the characteristic element are satisfactorily suppressed by the deionizing effect and pressure of the gases generated by the action of the arc on the walls of the characteristic element. But the flashover through the shunt air path around the characteristic element is not always suppressed, particularly when the shunt flashover occurs immediately after the suppression of the flow through the characteristic element at or about a current zero.

We have found that shunt flashovers or "restrikes" are particularly likely to occur under circuit conditions which develop high magnitudes of short circuit current, especially at low power factor, and where voltage conditions are such that a relatively high voltage may exist at a time of current zero and upon the suppression of the flow through the characteristic element.

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Our observations indicate that such shunt flashovers or "restrikes" result from a continued emanation of ions from metallic parts within the housing, and particularly from the electrode at line potential, even after arcing over the isolating gap and through the arc slot of the characteristic element has ceased. Such continued emanation of ions appear to result from either thermal or electrostatic conditions during or following the suppression of the arc across the isolating gap and across the arc slot of the characteristic element, and when such ions are sufficiently concentrated they form a conducting path between an element or elements at line potential and an element or elements at ground potential, with a resultant flow of dynamic current to ground and explosion of the arrester.

In accordance with our invention, we preclude the formation of a conducting path of concentrated ions, in the space surrounding the characteristic element, between any conducting element at line potential and any conducting element at ground potential. The interruption of any such path of concentrated ions may be effected in various ways, as, for instance, by venting, cooling and obstructing such ions and completely shielding therefrom by insulation all grounded conducting elements in the space between the insulating wall of the characteristic element and the insulating wall of the housing. Preferably, however, the ionized gases are subdivided and deionized by the interposition of fibrous strands between the region of the isolating air gap and any conducting element connected with the ground terminal, and the deionized gases are then discharged from the housing through a vent. Such fibrous strands are preferably of vitreous material matted or interlaced together to form a porous resilient fabric or bat containing a multitude of restricted tortuous paths in which the ionized gases may diffuse and in which they are cooled and deionized before contacting any grounded member and before their discharge from the arrester housing.

The vitreous fibres are preferably matted together in layers to form a bat which may be wrapped around the outer wall of the protector

tube so as to cover and insulate all grounded conducting parts and fill the space between the protector tube and the arrester housing with a compressible resilient mass permitting any requisite slight expansion of the protector tube during a heavy discharge.

The principles of our invention, and the best mode in which we have contemplated applying such principles will further appear from the following description and the accompanying drawings illustrating a preferred embodiment of our invention.

In the drawings, Fig. 1 is a longitudinal sectional view of an illustrative form of lightning arrester or protective device embodying our invention; Fig. 2 is a detached, fragmentary perspective view of the characteristic element for suppressing a normal follow current arc and preventing formation of a shunt arc around the characteristic element; Fig. 3 is a transverse sectional view taken on the line 3—3 of Fig. 1; Fig. 4 is a plan view of a fragmentary section of the porous, fibrous bat preferably used to trap, interrupt and deionize gases otherwise tending to facilitate the formation of a shunt arc around the characteristic element; and Fig. 5 is an enlarged, partly broken away, perspective view of the cylindrical conductor shown at the bottom of Fig. 2.

The lightning arrester shown in the drawings as an embodiment of our invention, comprises an external housing composed of a hollow, cylindrical, wet-process porcelain body 1 and a porcelain plug 2 glazed into the top of the body. The bottom of the housing is countersunk to form a seat 3 for the flanged edge 4 of a conducting cup 5 which may be provided with a hollow depending terminal boss 6 for the attachment of a ground 7. The cup 5 is secured against the seat 3 by a plastic seal 8 and non-plastic cement 9.

A characteristic element or a protector tube is operatively associated with the ground terminal and includes a cylindrical shell 10 having its end threaded into the threaded cup 5. The shell 10 is encircled, exteriorly, by a steel, seamless, reinforcing sleeve or shield 11 which may be staked to the cup 5 and is therethrough connected to the ground. The sleeve 11 projects along the shell 10 part way to the top 12 of an intermediate electrode extending downward within, and sealing the top of the tube 10.

In accordance with our invention, the space between the inner wall of the body 1 and the outer walls of the conducting sleeve 11 and most of the length of the non-conducting hard fibre shell 10 is filled by a porous, non-hygroscopic, non-absorbent, compressible, fibrous fabric 13 which is lapped around the sleeve and shell above the flanged edge 4 of the cup 5 and effectively traps ionized gases and prevents their passage toward the grounded members 5 and 11.

The fabric 13 preferably comprises a bat composed of loosely matter layers of resin-impregnated glass fibers, known commercially as "Aerocor," and forming a multitude of restricted, tortuous pores or passages which trap and retard the movements of ionized gases while they are cooled and deionized by contact to the glass fibres. The porosity and compressibility of the bat 13 permits slight expansion of the shell 10 under the pressures built up therein and allow for expansion of such gases as may be formed within the housing.

The lapped bat may be prevented from unwrapping by the adhesive tapes 13'.

A cylindrical conductor 14 is seated and grounded on the cup 5 within the shell 10 and has a peripheral wall 15 containing the countersink 16 at the upper end thereof and diametral slots 17 which communicate, through an aperture 19 in the bottom of the electrode, with a discharge passage 20 through the terminal boss 6.

A hard fibre tube 21 is mounted on the knife edge of an annular electrode 22 seated in the countersink 16 of the ring 14 and is centered thereby in spaced relation to the inner wall of the shell 10.

A rubber gasket is seated on top of the tube 21 and supports the flanged top 26 of the element 24 of the intermediate electrode. A hard fibre core 25 is suspended by a screw 31 from the member 24 concentrically within the tube 21 and slightly spaced from the inner wall thereof.

The tubes 10 and 21 and the core 25, or some of these parts, are formed of hard fibre or horn fibre or contain boric acid or other suitable gas generating substances activated by arcs between the respective electrode members 24 and 26 and the grounded electrode 22.

The concentric cylindrical arc slots formed between the spaced members 11, 12 and 25 are preferably of unequal lengths: the inner slot being of smaller cross-sectional area and being the shorter. This tends to divert impulses of steep wave fronts to the outer and longer arc slot and to divert heavy currents of slower rising steepness to the inner, shorter arc slot. The concentricity of the walls forming the concentric arc slots results in gas generating areas which are large relatively to the lengths of the slots of the arrester. The diffusion of the arc or arcs over a large area minimizes the charring or pitting of the gas generating surfaces, and is of particular value in preventing self destruction under discharges involving current magnitudes of very high order because of the multiple paths principle.

The constricted slots and gas generating walls form effective means within the shell 10 for suppressing an arc formed by the discharge of a surge and the flow of follow current thereafter.

The member 26 of the intermediate electrode is conductively connected with the member 12 thereof by a conducting tube 32 which is telescoped over the boss 33 of the member 26 and over the boss 35 of the member 12 within the tube 10. There is no communication permitting the movement of gas from within the tube 10 to the space between this tube and the interior of the housing 1 or vice versa.

A conducting plug 36, seated in the member 12, and an electrode 37, carried by the end closure 2, form an isolating gap 38 normally isolating the arc suppressing elements of the arrester from line but providing a path to ground for impulse surges due to lightning or other transient abnormal voltages.

The electrode 37 has a threaded shank 39 which passes through an aperture in the closure 2 and the joint between the shank and closure is sealed by the washers 40, 42 which are squeezed by the head of the electrode 37 and line terminal 43 when the line terminal is screwed onto the shank.

A wire clamp 45 may be provided for gripping the line conductor inserted into the aperture 46.

The space between the interior of the housing 1 and the protector tube 10 is ventilated through ventilating apertures 47 through the flange 4 and the cement 8 and 9.

The arrester may be mounted in any suitable position adjacent to a circuit to be protected by a metal bracket 50 encircling the housing 1 intermediate the ends of the reinforcing sleeve 11; the bracket 50 being spaced from the line terminal of the arrester by the corrugated area 51 of the surface of the housing 1 to avoid external flashovers.

When a surge of lightning or other transient high potential electric disturbance reaches the section of the line with which the line terminal 43 is connected, it is discharged across the isolating gap 33, through the member 12, conductor 32, electrodes 26 and 24, through one or both of the arc slots, electrode 22, cup 5 and ground terminal 6 to ground. The arcs through the arc slots quickly generates large volumes of deionizing gas, which extinguishes the arc maintained by follow current, generally at or before the next zero point of the cycle of the alternating dynamic current. The generated gas is expelled from the arc slots through the slots 17 and passages 19 and 20, away from the ground conductor 7.

Air in the upper or line end of the housing, ionized by electrical and thermal conditions accompanying and immediately following the operation of the arrester, is diffused through the ion trap formed by the long and tortuous paths of the bat 13 before contacting any grounded conducting element. The air in such paths is normally of low ionic content and of high electrical resistivity. Movement of ionized air from the interior of the line and of the housing to any other area is delayed; as it diffuses through the trap it is mixed with the un-ionized air therein and its ion concentration is reduced, and further deionization is effected by processes of cooling and recombination. The final result of these three actions is that as equalization of air pressures within the housing proceeds, deionized non-conductive air replaces relatively highly ionized conductive air that otherwise would flow along the path between the line and ground elements and to the vent 47. There is thus no tendency for external flashovers between the members 36 or 37 and the grounded shield 14 and complete cut off by the arrester is maintained after the suppression of the follow current arc through the arc slot.

While the loosely matted, porous bat of glass fibres constitutes the best mode in which we have contemplated applying the principle of our invention of interposing an effective barrier to any path of concentrated ions from an element at line potential to any element at ground potential, our invention is not necessarily limited to such specific embodiment as a barrier may be formed by completely covering all exposed surfaces of grounded elements within the space between the tubes 1 and 11 with insulation, or by housing all ion emanating elements within a fine metallic screen acting on the Davy lamp principle to cool and deionize the ionized gases before they have traveled far from the ion emanating elements, or by venting ionized gases adjacent to the ion emanating elements and interposing a non-conducting diaphragm between all ion emanating elements and all grounded conducting elements which have exposed surfaces in the space between the tubes 1 and 11. Such modifications are, however, deemed by us less desirable for general use than the glass fibre bat hereinbefore described.

Having described our invention, we claim:

1. A lightning arrester comprising an insulating housing; a line terminal assembly including an electrode in said housing and at line potential when in use; an intermediate assembly including a fiber tube within and spaced from the interior periphery of said housing and also including an electrode co-acting with the first named electrode to form an isolating gap; a ground terminal assembly including an electrode complementary to and spaced from said second named electrode and also including a grounded conductor in the space between said fiber tube and the interior periphery of said housing and reenforcing said tube; said second named electrode projecting into said tube such distance that the sum of the flash-over distances across said isolating gap and between said second and third named electrodes is less than the flash-over distance through said space from said first named electrode to the nearest part of the ground terminal assembly, and said housing having an aperture venting said space without passage through said tube of ions emanating from said gap electrodes; and a barrier to the formation of any ion path connecting either of said gap electrodes with said ground terminal assembly through said space.

2. A lightning arrester comprising an insulating housing; a line terminal assembly including a gap electrode in said housing; an intermediate assembly including a tube within and spaced from said housing and having an electrode in operative relation to said electrode first named; a ground terminal assembly having an electrode in operative relation to said intermediate assembly and a grounded conducting sleeve encircling said tube in the space between said tube and housing; and a barrier to the formation of an ion path through said space between said sleeve and gap electrodes and comprising a porous, insulating fibrous filler.

3. A lightning arrester comprising a housing having a line terminal and a ground terminal, an intermediate assembly including a protector tube operatively associated with said ground terminal and having walls forming a restricted arc slot and electrodes positioned to permit arcing through said slot, electrodes forming an isolating air gap between said protector tube and said line terminal, and strands interposed between said isolating air gap and said ground terminal and co-acting to sub-divide and deionize gases ionized by an arc across said isolating gap and by emanations from the electrodes thereof.

4. A lightning arrester comprising a housing having a line terminal and a ground terminal, an intermediate assembly including a protector tube operatively associated with said ground terminal and having walls forming a restricted arc slot and electrodes positioned to permit arcing through said slot, a metallic sleeve encircling said protector tube and electrically connected with said ground terminal, electrodes forming an isolating air gap between said protector tube and line terminal, a porous fabric interposed between said isolating air gap and said sleeve and subdividing and deionizing gases ionized by an arc across isolating air gap and by emanations from the electrodes thereof.

5. A lightning arrester comprising a housing having a line terminal and a ground terminal and containing a vent, an intermediate assembly including a protector tube operatively associated with said ground terminal and comprising walls forming restricted arc slot and electrodes posi-

tioned to permit arcing through said slot, electrodes forming an isolating air gap between said protector tube and said line terminal, and a porous fabric interposed between said isolating air gap and said vent and sub-dividing and deionizing gases ionized by an arc across said isolating gap and by emanations from the electrodes thereof and flowing toward said vent.

6. A lightning arrester comprising a housing having a line terminal and a ground terminal, an intermediate assembly including a protector tube operatively associated with said ground terminal and having walls forming a restricted arc slot and electrodes positioned to permit arcing through said slot, electrodes forming an isolating air gap between said protector tube and said line terminal, and a bat of vitreous fibres surrounding said protector tube and deionizing gases ionized by an arc across said isolating gap and by emanations from the electrodes thereof.

7. A lightning arrester comprising an insulating housing containing an electrode member which, in use, is normally at line potential; conducting members, including a second electrode, which, in use, are normally at ground potential; a third electrode intermediate said electrodes and having a portion forming, with the first electrode member, an isolating gap; an arc suppressive element operatively associated with said second electrode and with a portion of said third electrode and spaced from the interior of said housing; and a barrier to the formation of a concentrated ion path around said element from any member at line potential to any member at ground potential.

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