Oct. 12, 1943. H. O. STOELTING 2,331,852

LIGHTNING ARRESTER

Filed Sept. 9, 1940

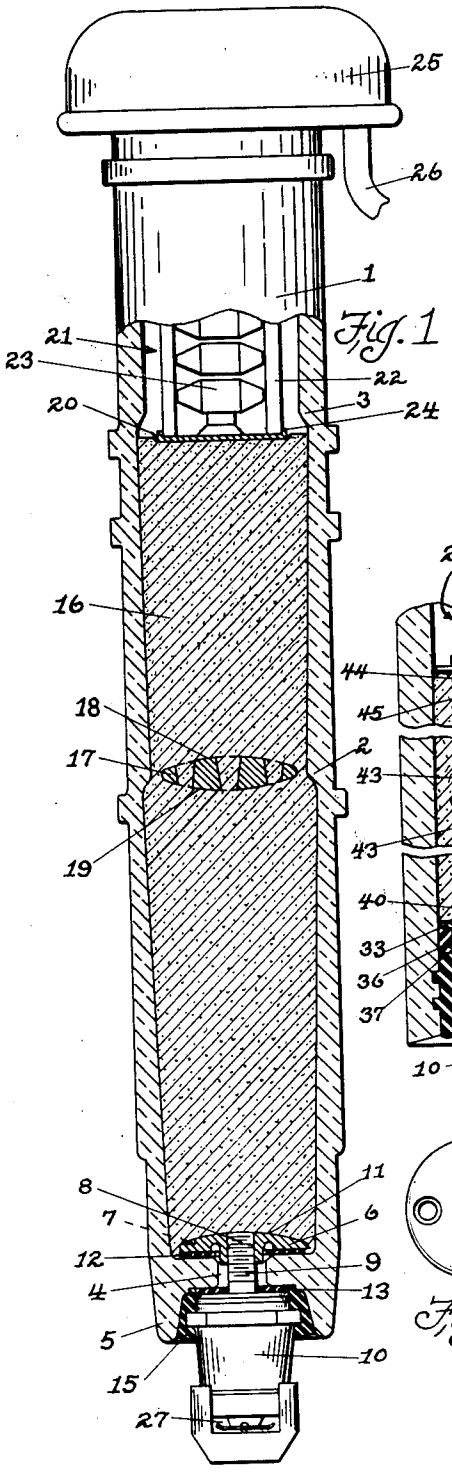


Fig. 1

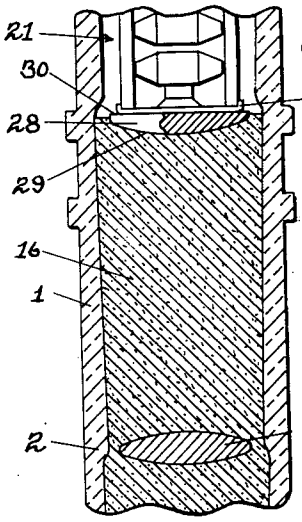


Fig. 4

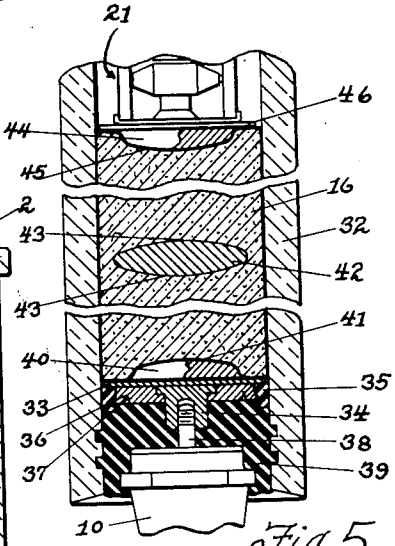


Fig. 5

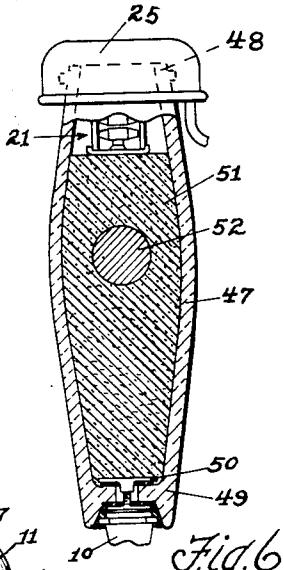


Fig. 6

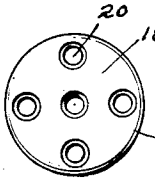


Fig. 2

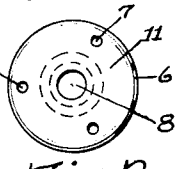


Fig. 3

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Patented Oct. 12, 1943 2,331,852

UNITED STATES PATENT OFFICE

2,331,852

LIGHTNING ARRESTER

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Application September 9, 1940, Serial No. 355,954

10 Claims. (201—76)

A lightning arrester for the protection of high voltage power lines customarily includes a spark gap in series with a resistor—which latter usually is a so-called valve element consisting of a mass of comminuted silicon carbide having characteristics which render it relatively highly conductive when subjected to surge voltages such as lightning discharges, but at the same time highly resistive at relatively low voltages such as those employed in the transmission of electric power. A lightning arrester so constituted provides a relatively low impedance path to ground for destructive surges, but operates promptly to interrupt the flow to ground of power current which would otherwise follow in the path of the surge current, once the spark gap barrier is broken down.

One of the difficult problems encountered in the development of efficient lightning arresters has been that of overcoming so-called "flashovers"—which expression pertains to the phenomenon of lightning flashes and follow-through power current bridging the resistor element along the surface thereof—thus effectively nullifying the resistor element as a means of suppressing power current flow and, in many instances, causing fracture or shattering of the glass or porcelain housing.

Generally, if not always, the spark gap and resistor or valve element of a lightning arrester is hermetically sealed within a housing of glass or porcelain and I have previously discovered that flash-overs can almost completely be prevented by bonding together the comminuted resistor material with a binder of sodium silicate and forming a firm sodium silicate bond between the resistor element and the interior of the housing—the sodium silicate binder being substantially desiccated by baking after assembly. A lightning arrester of that character may have either a porcelain or glass housing, but it has been found that although with porcelain housings the sodium silicate bond between resistor and housing is perfect, almost without exception, such is not the case where glass housings are concerned. In the latter instance the sodium silicate bond between resistor element and housing ruptures in about 20% of the arresters, upon being taken from the oven—due, no doubt, to difference in degree or rate of contraction on cooling and to the unavailability of a cheap enough glass having properties by virtue of which rupturing of the bond might be avoidable. A loss of that magnitude is of course intolerable and would to a considerable extent spell commercial impracticability of large glass housed arresters if the flashover problem could not otherwise be solved.

The primary object of the present invention is to obviate flashover by means applicable to lightning arresters having either porcelain or glass housings and, particularly, to render more feasible the use of glass housings by making it unnecessary to provide a bond between the resistor element and the interior of the housing—thus circumventing the aforementioned production losses resulting from bond ruptures—and, further, to accomplish that end without giving rise to excessive current density in any part of the resistor element such as would be apt to cause clinkering of the valve material and sequential ineffectiveness thereof with respect to interruption of power current through the arrester.

The resistor element of a lightning arrester, consisting usually of a mass of comminuted silicon carbide, must have a cross-sectional area large enough to ensure that the current density therethrough along any path will not be apt to attain a magnitude sufficient to cause sintering of the granules of silicon carbide or other transformation consequent upon excessive heating, which would render such path permanently so conductive as to prevent proper functioning of the resistor element thereafter.

Such a resistor element can reasonably be considered as consisting of a very large number of electrically parallel conductive paths and it is convenient so to regard it for the purposes of this specification, even though it probably is not true that such paths exist as individual clearly defined entities comparable, for example, to the individually insulated conductors of a cable. If such individual paths, extending from end to end of the resistor element, be assumed—and they are here assumed—it will be apparent that the conductivity of all the paths should be of the same order if there is to be achieved something approaching a uniform current density. Otherwise, a major part of the total current might be restricted to a relatively small part of the cross-sectional area of the resistor, and excessive localized heating might occur with attendant formation of a clinker chain and resultant failure of the arrester. On the contrary, the present invention is predicated, in theory at least, upon bringing about a limited degree of non-uniformity in the conductivity of the several paths; but that non-uniformity, although apparently essential, must not be carried to excess because to do so would result, as above stated, in too much con-

centration of the current flow in paths of constricted cross-sectional area.

A theoretical consideration underlying the present invention is that by diverting the current flow through the resistor element as much as practicable away from the longitudinal exterior surface thereof the tendency for flashovers to occur is somewhat proportionately diminished; and with a view to achieving that end it was contemplated that the conductivity of the current paths running along and close to the longitudinal axis of the resistor should be greater than the conductivity of the paths at and adjacent the longitudinal exterior surface of the resistor, and that the paths intermediate of the longitudinal axis and the exterior surface should be of graduated intermediate conductivity. In addition, it was conceived that presently the most practicable way to realization of the aforementioned accomplishment, on a commercial scale, was to interpose in the resistor element, at one or more points intermediate of its length, portions of relatively high conductivity, so proportioned and so placed that the paths at and near the longitudinal axis would be of maximum conductivity whereas the remaining paths would be characterized by conductivity somewhat inversely proportional to their distances from the longitudinal axis. More specifically, the inventive concept comprehends embedding and enveloping in the resistor one or more or several pieces of metal of various lengths so placed as to produce the above described result.

In practice there need generally be provided only one slug of metal of suitable proportions and this ordinarily is embedded and enveloped in the mass of comminuted material at a point approximately midway of its length. Such is probably the most convenient way of carrying out the invention, and it seems most expedient to make the metal slug of lenticular form; but it will be self-evident to those who comprehend the underlying principle of operation that the invention is susceptible of a variety of embodiments.

In the drawing:

Fig. 1 is a view in side elevation, partly in section, showing an improved lightning arrester.

Fig. 2 is a top plan view of a surge directing element.

Fig. 3 is a top plan view of the lower lightning arrester electrode.

Figs. 4 and 5 are fragmentary sectional views illustrating modifications of the lightning arrester shown in Fig. 1.

Fig. 6 is an elevational view on a reduced scale, partly in section, illustrating a further modification of the lightning arrester shown in Fig. 1.

The arrester shown in Fig. 1 comprises a housing 1 made of glass, porcelain or any other suitable insulating material. It may be noted that the glass housing 1 is made up of a number of housing units joined together in any convenient manner as by welding at 2 and 3. It may be further noted that the bore of the housing is not uniform due to the welds at 2 and 3. Housings may also be provided having a uniform bore and made as a single unit.

It is necessary to provide a relatively long housing, as shown, when designing an arrester adapted to operate on a comparatively high voltage electric transmission system.

The lower end of the housing 1 apertured at 4 and having a depending skirt portion 5 is provided with a disc-like terminal member 6 notched at 7 to receive a holding tool, not shown, and threadedly apertured at 8 to receive the bolt portion 9 of the gap device 10. The gap device 10 is more fully disclosed in the application of Ralph H. Earle, Serial Number 269,065, filed April 21, 1939, for Isolator.

The terminal 6 is provided at the upper side with a convex contact surface 11 and at the under side with a flat surface which seats against an asbestos gasket 12. The gap device 10 is tightened into the terminal 6 and seated against a sealing gasket 13, thereby sealing the lower end of the housing against moisture.

An insulating compound 15 is placed within the depending skirt portion 5 and around the gap device 10 to provide a further moisture seal for the housing.

A properly prepared valve material 16, commonly comprising silicon carbide or any other suitable material, is placed within the housing 1 approximately level with the first weld at 2.

At this point in the filling operation a lenticular conductive disc 17 having upper and lower convex surfaces 18 and 19 respectively is centered within the housing 1 in contact with the valve material 16 for purposes hereinafter described.

Additional valve material 16 is filled in around the disc 17 and within a predetermined distance from the upper end of the housing 1.

It may be noted that the upper end of the column of valve material 16 is sprayed with a film of copper, not shown, in a well known manner and is recessed a short distance at 20 to facilitate centering the spark gap 21 commonly used on lightning arresters of this type. The spark gap comprises a pair of spaced parallel ceramic supports 22 supporting a number of spaced cylindrical electrodes 23, the lower one of which is connected by a screw, not shown, to the electrode disc 24 which seats against the copper film within the recess 20.

The upper end of the housing 1 is sealed against moisture by means of a cap 25 in a manner more fully described in the above noted application.

The arrester is connected to an electric circuit by connecting a line conductor, not shown, to the conductor 25 which is electrically connected to the spark gap 21; and connecting a ground wire, not shown, to the gap device 10 at 27. When a lightning surge or other overvoltage condition exists on the system connected at 26, the spark gap breaks down electrically and the valve material 16 assumes a low resistance, thereby allowing the surge current to pass through the valve material 16 between the upper electrode 24 and the lower electrode 6 through the gap device 10 to ground.

By providing the lenticular electrode 17 intermediate the electrodes 24 and 6 and adjacent the constricted portion of the housing at the weld 2, the surge current passing through the valve material seeks paths away from the wall of the housing and centrally of the electrode 17. This is observed by noting that a shorter distance is provided in a path extending between the central portions of the electrodes 6 and 17, and the central portion of the electrode 17 and the electrode 24 than is provided between the peripheral surfaces of the electrodes adjacent the housing.

The mass of valve material 16, together with the lenticular disc 17 embedded and and enveloped therein, constitutes an elongated conductive medium electrically interconnecting upper

electrode 24 with lower electrode 6; and it may for all practical purposes be considered that the aforementioned conductive medium presents a large number of electrically parallel conductive paths bridging the space between said electrodes. Manifestly, those paths are not clearly defined isolated entities, but the effect apparently is the same as if such were the fact, and it will serve well, for purposes of description and claim terminology, to assume the presence of many individual geometrically parallel conductive paths extending longitudinally through the conductive medium and distributed uniformly throughout the cross section thereof. Assuming absence of the lenticular disc, the aforementioned paths would, for the most part, be of substantially equal conductivity and it follows that the current density through the conductive medium would be substantially uniform. Such is the condition which obtains in lightning arresters of the prior art wherein many failures have in the past been experienced due to flashovers occurring along the inner surface of the housing bore.

As stated at the beginning of this specification, I have been able, practically, to overcome flashover troubles by mixing the comminuted silicon carbide with sodium silicate (water glass) and bonding the mass to the inside of the housing with sodium silicate as a bonding agent—the wet mass of silicon carbide and sodium silicate binder being baked until substantially desiccate and solid. And, as previously indicated, that method is applicable to both porcelain and glass housed arresters, but it is commercially uneconomical at present with respect to large glass housings because of excessive production losses —due to unavailability of a glass which is both sufficiently cheap and capable of preventing rupture of the bond during the cooling off period after baking.

According to one theory which I have adopted as a plausible explanation of the operativeness of the present invention, the lenticular disc 17 introduces a sufficient differentiation in the conductivity of the several parallel paths extending longitudinally through the conductive medium to cause the current flow therethrough to tend toward the longitudinal axis. That is to say, the paths along and near the axis are of slightly greater conductivity than the paths more remote from the axis—and particularly the paths closely adjacent the inner surface of the housing where destructive flashovers are prone to occur; and it follows that there would be, in consequence, a greater current density along the axis of the conductive medium than at points remote therefrom. If the foregoing theory is correct, it is obvious that there is nothing particularly critical about the shape of disc 17 so long as it is appropriately designed to create a suitable degree of concentration of current along the axis and a concomitant diversion of current away from the inner surface of the housing.

According to another plausible explanation, direct current conductivity and slight differences of direct current conductivity have little or no bearing on the operation of the lenticular disc so far as prevention of flashovers is concerned because what is being dealt with primarily is high voltage, high frequency lightning flashes which are attracted to and concentrate upon the conductor which is closest to the point of origin and included in an easy path to ground—subject to the exception that lightning will strike a pointed conductor, such as the tip of a lightning rod, in preference to an unpointed conductive surface.

Fig. 4 shows fragmentarily an arrester similar to the one described with reference to Fig. 1, but showing the upper end of the valve material 16 provided with a disc-like electrode 28 having a convex contact surface 29 embedded a predetermined distance into the valve material, and a flat contact surface 30 against which the electrode 24 of the spark gap 21 makes electrical contact. A disc-like electrode 31 is embedded in the valve material adjacent the weld 2 for reasons cited in reference to Fig. 1.

It may be noted that in providing the upper end of the valve material 16 with an electrode curved in a manner similar to the electrodes 6 and 17, the surge current is directed centrally of the valve material and away from the housing in a positive manner.

Fig. 5 shows an arrester comprising a housing 32 made of porcelain or other suitable insulating material and having a uniform bore throughout its length. Intermediate portions of the arrester are cut away, indicating that the housing may be provided in any predetermined length, depending upon the voltage under which the arrester is to operate.

The lower end of the housing 32 is provided with a circular electrode 33, an anchor nut 34 mounted against the electrode 33 and a sealing washer 35 positioned about the electrode. A lead alloy 36 is poured around the nut 34 within the sealing washer 35. The peripheral portion of the alloy is forced outwardly at 37, against the washer 35 by means of a circular wedging tool, not shown, thereby providing a positive moisture seal. The gap device 10 is secured to the nut 34 by means of a bolt 38 and the housing further sealed against moisture by a sealing compound 39.

A disc-like electrode 40 curved at the upper side to provide a convex contact surface 41 is mounted against the electrode 33 and a predetermined amount of valve material 16 is packed within the housing and around the electrode 40 as shown. A disc-like electrode 42 having upper and lower convex surfaces 43 is embedded centrally and intermediate the ends of the valve material 16 for reasons described with reference to the electrode 17 in Fig. 1. A disc-like electrode 44 provided with a convex contact surface 45 is embedded in the valve material adjacent the upper end thereof. An electrode 46 is positioned in contact against the electrode 44 and the spark gap 21, mounted on the electrode 46 as shown. The upper end of the housing 32 is sealed against moisture in the manner described with reference to Fig. 1.

It may be noted that a minimum conductive path is provided between the central portions of the electrodes 44, 42, and 40 and a maximum distance established between the same electrodes adjacent the housing 32, thereby causing the surge current to seek paths centrally of the valve material, preventing current concentration adjacent the housing.

Fig. 6 shows an arrester having a housing 47 made of glass, or other suitable material, formed, as shown, with the intermediate portion of its length diametrically enlarged and gradually tapering off in opposite directions toward the diametrically smaller end portions 48 and 49.

The lower end of the housing 47 is assembled with an electrode 50, the gap device 10, and the assembled parts sealed therein in the manner described with reference to Fig. 1.

A predetermined amount of valve material 51 is placed within the housing as shown and a spark gap 21 positioned on the upper end of the material which is provided with a film of copper, not shown. It may be noted that the film of copper provides more uniform electrical contact between the spark gap 21 and the valve material 51. The upper end of the housing is sealed against moisture by means of the cap 25 in the manner described with reference to Fig. 1.

A spherical electrode 52 may be embedded centrally of the valve material as shown.

By providing the housing 47 in the manner just described, a shorter conductive path is established between the spark gap and the electrode 50 through the central portion of the valve material than is provided adjacent the housing. The electrode 52 further tends to direct the surge current centrally of the valve material.

From the foregoing description it is apparent that the objects of this invention have been attained by providing for a lighting arrester comprising a housing, a valve material, including conductive means adapted to direct the flow of surge current through the arrester away from the housing.

Further objects have been attained by providing a valve material formed in a predetermined manner, whereby a minimum distance between contact surfaces is maintained centrally thereof.

I claim:

1. In a lightning arrester, a pair of spaced electrodes and an elongate conductive medium interconnecting said electrodes, said medium comprising principally a mass of comminuted non-metallic material, said medium also including a slug of highly conductive material embedded and enveloped in said comminuted material and situated intermediately of said electrodes and remote from both said electrodes, said slug being electrically connected with said electrodes through said comminuted material and not otherwise, and having opposite surfaces individually in face-to-face spaced relation to said electrodes respectively, at least one of said surfaces being so shaped as to provide shortened electrical paths through said comminuted material between its co-operating one of said electrodes and said slug along lines contiguous to the longitudinal axis of said medium, the shortness of said shortened paths being so distinguished by comparison with the lengths of other electrical paths through said comminuted material between said co-operating electrode and said slug in shunt to said shortened paths and more remote from said longitudinal axis than said shortened paths, said conductive medium affording many parallel electrical paths between said electrode and said slug in shunt to said shortened paths and of somewhat greater lengths than said shortened paths and more remote from said longitudinal axis than said shortened paths, both said slug surfaces being so formed that the thickness of said slug, measured longitudinally of said medium, is greatest along and contiguous to the longitudinal axis of said medium and approximately a minimum at points most remote from said axis, said thickness being graduated approximately in inverse proportion to the distance from said longitudinal axis of the points at which the measurements of said thickness are taken.

2. In a lightning arrester, a housing of insulating material having an elongate bore, an elongate conductive medium occupying said bore and interconnecting said electrodes, said conductive medium comprising principally a mass of comminuted non-metallic conductive material and a slug of highly conductive material embedded and enveloped in said comminuted material at a point intermediate of said electrodes and remote from both said electrodes, said slug having opposite surfaces individually in face-to-face spaced relation to said electrodes respectively, at least one of said surfaces being convex and having a portion adjacent or coincident with the longitudinal axis of said medium, which portion is spaced least remotely from the electrode facing said convex surface.

3. In a lightning arrester, a housing of insulating material having an elongate bore, an elongate conductive medium occupying said bore and consisting principally of valve material having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes contacting respectively the extremities of said conductive medium, and a highly conductive lenticular disc completely embedded and enclosed in said conductive medium at an intermediate point therein remote from both said electrodes, the opposite convex surfaces of said disc being disposed individually in spaced face-to-face relation with said electrodes respectively and individually.

4. In a lightning arrester, a housing of insulating material having an elongate bore, an elongate conductive medium occupying said bore and consisting principally of valve material having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes contacting respectively the extremities of said conductive medium, and a highly conductive lenticular disc completely embedded and enveloped in and coaxial with said conductive medium, the opposite convex surfaces of said disc being disposed individually in spaced face-to-face relation with said electrodes respectively and individually, said disc being situated intermediately of and remote from both said electrodes.

5. In a lightning arrester, a pair of spaced electrodes and an elongate conductive medium interconnecting said electrodes, said medium comprising principally valve material having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, said medium also including a slug of highly conductive material embedded and enveloped in said valve material and situated intermediately of said electrodes and remote from both said electrodes, said slug being electrically connected with said electrodes through said valve material and nct otherwise, and having opposite surfaces individually in face-to-face spaced relation to said electrodes respectively, at least one of said surfaces being so shaped as to effect shortened electrical paths through said valve material between its co-operating one of said electrodes and said slug along lines contiguous to the longitudinal axis of said medium, the shortness of said shortened paths being so distinguished by comparison with the lengths of other electrical paths through said valve material between said co-operating electrode and said slug in shunt to said shortened paths and more re-

mote from said longitudinal axis than said shortened paths, said conductive medium affording many parallel electrical paths between said electrode and said slug in shunt to said shortened paths and of somewhat greater lengths than said shortened paths and more remote from said longitudinal axis than said shortened paths, both said slug surfaces being so formed that the thickness of said slug, measured longitudinally of said medium, is greatest along and contiguous to the longitudinal axis of said medium and approximately a minimum at points most remote from said axis, said thickness being graduated approximately in inverse proportion to the distance from said longitudinal axis of the points at which the measurements of said thickness are taken.

6. In a lightning arrester an elongate conductive medium having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes individual to and contacting the respective ends of said medium, and a third electrode embedded within said medium and connected with said spaced electrodes via said medium and not otherwise, said third electrode being situated intermediately of and remotely from both said spaced electrodes, said third electrode being enveloped entirely within and spaced, at all peripheral points thereon, a substantial distance from the proximate external peripheral surface of said medium, but otherwise having an area, transversely of said medium, which is substantially coextensive with the coplanar cross-sectional area of said medium.

7. In a lightning arrester, an elongate conductive medium having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes individual to and contacting the respective ends of said medium, the contacting surface of at least one of said electrodes being convexly protrudent toward the other, and a third electrode embedded within said medium and connected with said spaced electrodes via said medium and not otherwise, said third electrode being situated intermediately of and remotely from both said spaced electrodes, said third electrode being enveloped entirely within and spaced, at all peripheral points thereon, a substantial distance from the proximate external peripheral surface of said medium, but otherwise having an area, transversely of said medium, which is substantially coextensive with the coplanar cross-sectional area of said medium.

8. In a lightning arrester, an elongate conductive medium having the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes individual to and contacting the respective ends of said medium, the contacting surfaces of said electrodes each being convexly protrudent toward the other, and a third electrode embedded within said medium and connected with said spaced electrodes via said medium and not otherwise, said third electrode being situated intermediately of and remotely from both said spaced electrodes, said third electrode being enveloped entirely within and spaced, at all peripheral points thereon, a substantial distance from the proximate external peripheral surface of said medium, but otherwise having an area, transversely of said medium, which is substantially coextensive with the coplanar cross-sectional area of said medium.

9. In a lightning arrester, a housing having an elongate bore, an elongate conductive medium occupying said bore and endued with the properties of relatively low impedance to high voltage surges in the nature of lightning and relatively high impedance to lower voltages of the order commonly employed for power transmission, a pair of spaced electrodes within said housing and contacting the two ends of said conductive medium individually, said conductive medium being characterized by somewhat greater lengthwise conductivity per unit of cross-section along paths embraced within the cross-sectional mid-portion thereof than along paths outside said mid-portion and constituting the cross-sectional peripheral portion thereof, the above-specified greater conductivity being obtained by the interposition of localized metal in said mid-portion, said metal being embedded within and enveloped by said conductive medium and situated intermediately of said spaced electrodes and remotely from both said electrodes, said medium being further characterized in that no path therethrough interconnecting said electrodes is so conductively predominant over other parallel paths, unit for unit of cross-section, as to create a condition likely to give rise to excessive localized heating and clinker formation.

10. Lightning arrester structure in accordance with claim 9 and further characterized in that the interposed localized metal is so distributed cross-sectionally of the conductive medium that the lengthwise conductivity of said medium is thereby caused to be of a maximum value along the center-most portions thereof and of approximately proportionately decreased conductivity along portions displaced radially from said center-most portion, so that the current density at any cross-sectional portion of said medium is inversely related to the distance of the last-mentioned portion from the longitudinal axis of said medium.

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