

April 26, 1966

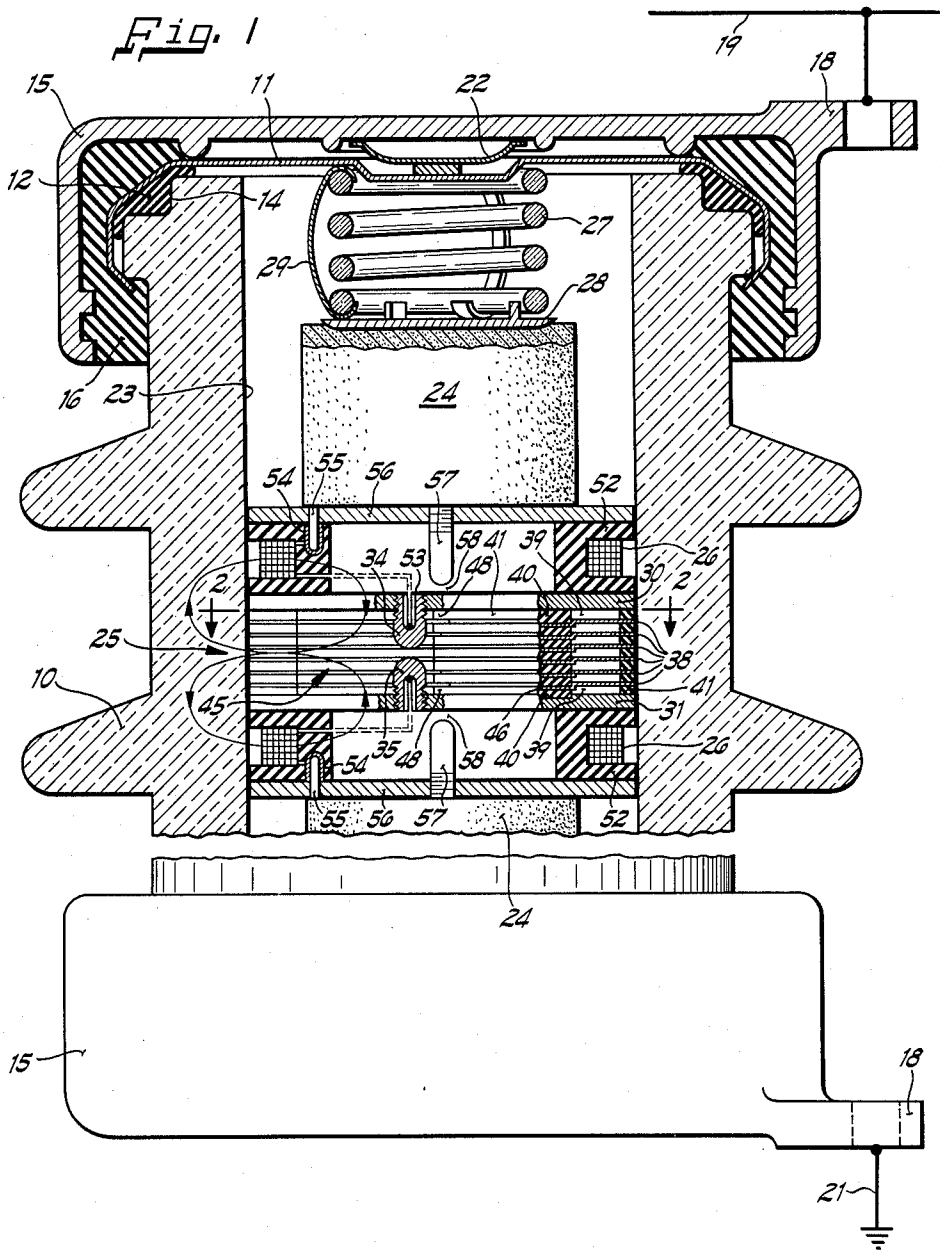
E. L. SANKEY ETAL

3,248,600

LIGHTNING ARRESTER WITH ARC SPLITTER

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Fig. 3

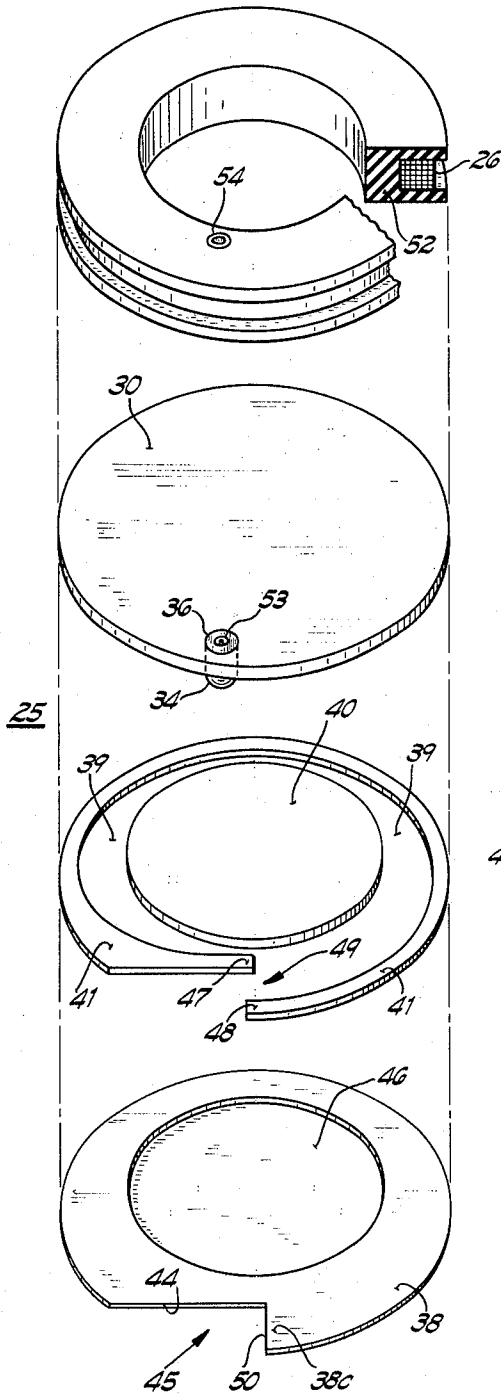


Fig. 2

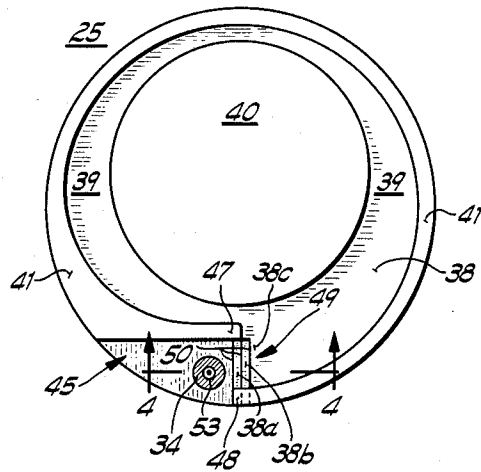
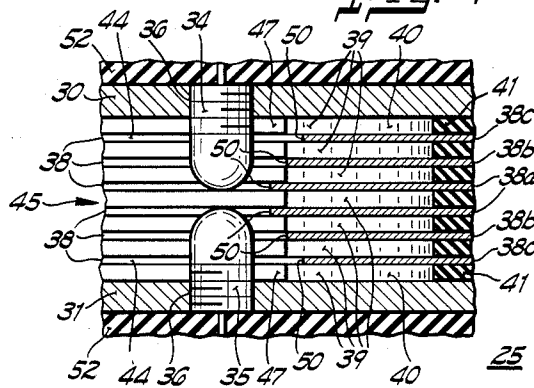


Fig. 4



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Fig. 8

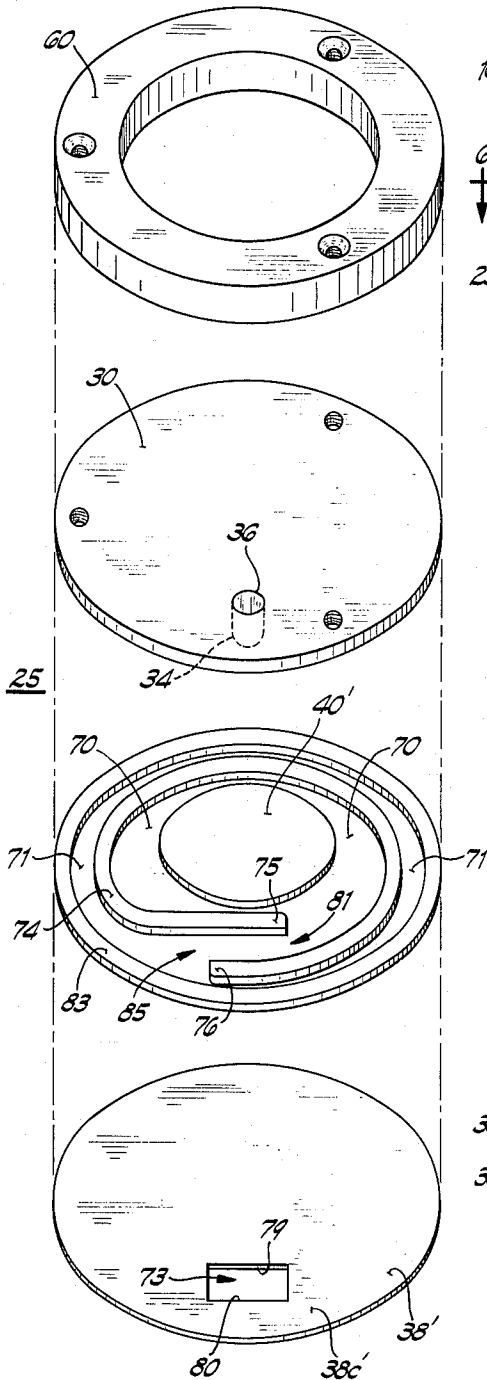
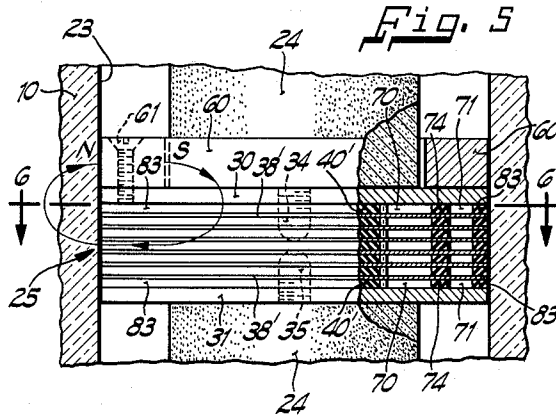


Fig. 6

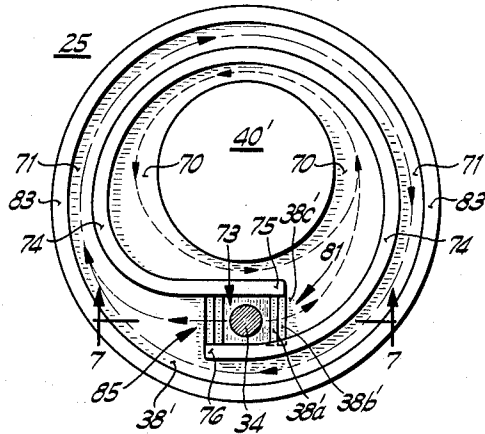
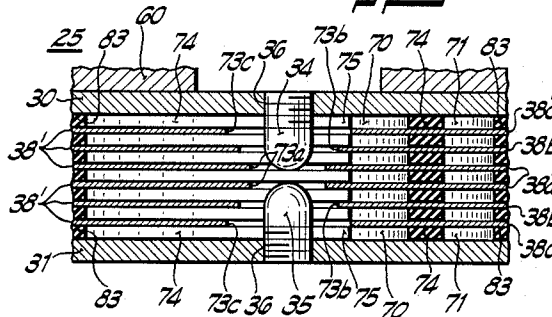


Fig. 7



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LIGHTNING ARRESTER WITH ARC SPLITTER
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This invention relates to lightning arresters and more particularly to lightning arresters having an arc splitter gap for interrupting power follow current.

A conventional lightning arrester has a spark gap and a current limiting resistor connected in series between an electrical power line conductor and ground. The length of the gap is such that the voltage between the power line conductor and ground is normally insufficient to spark-over the gap and permit current to flow through the current limiting resistor to ground. The gap becomes conducting by sparking when lightning strikes the power line conductor and a high frequency transient voltage of a magnitude greater than the sparkover potential of the gap appears on the power line, thereby providing a path to ground for the lightning current through the current limiting resistor. The current limiting resistor has a high apparent resistance at low voltage and a sharply reduced resistance under a predetermined overvoltage, thereby permitting the lightning surge to be discharged to ground with low discharge voltage. Sixty cycle power current follows the lightning current, and the resistor limits the follow current to a magnitude that the spark gap can interrupt.

It is desirable to utilize a current limiting resistor having a low value of resistance to assure that the high amperage lightning current surge does not produce a large voltage drop across the resistor and thereby impress a high voltage across the apparatus being protected by the arrester. However, such a resistor of low resistance allows such a high amperage follow current to flow that interruption of follow current becomes difficult. Increasing the length of the air gap improves follow current interrupting ability, but it also increases the sparkover voltage to an excessively high magnitude. Lightning arresters having arc splitter spark gaps are known wherein the initial arc is broken up into a plurality of smaller arcs, or arclets, by magnetic means which elongate the arc and move it between a plurality of spaced auxiliary electrodes. In such arresters further movement of the arc within the arc splitter auxiliary electrodes is usually restrained, or arrested, either by a portion of the field produced by the magnetic means reacting in a reverse direction or by additional magnetic means providing a field acting in a reverse direction. As a consequence of restraining further movement of the arc, heating and burning of the electrodes often occurs and the arc voltage drop is limited to the range of 20 to 50 volt per arclet which is characteristic of a stationary arc. Consequently, a large number of auxiliary electrodes is required to provide adequate follow current interrupting ability. Further, the heating or burning may raise the temperature of the brass electrodes above the melting temperature thereof and cause deformation of the electrodes with possible change in the gap spacing and increased tendency for the arc to restrike after a current zero.

It is an object of the invention to provide a lightning arrester having an arc splitter spark gap of minimum size and increased follow current interrupting ability in comparison to prior art arresters.

It is a further object of the invention to provide a lightning arrester having a spark gap provided with means to break the arc up into a plurality of smaller

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arcs and wherein the voltage drop per smaller arc is substantially greater than in prior art devices, whereby the follow current interrupting ability is improved. It is a still further object to provide such a lightning arrester wherein burning and overheating of the electrodes of the spark gap is substantially eliminated. Another object is to provide a lightning arrester having an arc splitter gap wherein a small number of auxiliary electrodes in series may provide a total cathode anode drop which exceeds the peak voltage of the power system, thereby assuring interruption of follow current at the first current zero.

Other objects and advantages of the invention will be more readily apparent from the following detailed description of the invention when taken in conjunction with the accompanying drawing wherein:

FIG. 1 is a partial sectional view through a lightning arrester incorporating a preferred embodiment of the invention;

FIG. 2 is a view taken on line 2—2 of FIG. 1;

FIG. 3 is an exploded perspective view of the elements which are stacked to form the spark gap of the lightning arrester of FIG. 1;

FIG. 4 is a view taken on line 4—4 of FIG. 2;

FIG. 5 is a partial vertical section view through an alternative embodiment of the invention;

FIG. 6 is a view taken on line 6—6 of FIG. 5;

FIG. 7 is a view taken on line 7—7 of FIG. 6; and

FIG. 8 is an exploded view of the elements which are stacked to form the spark gap of the embodiment of FIGS. 5—7.

Referring to FIG. 1 of the drawing, the invention is illustrated as incorporated in a hermetically sealed, valve type lightning arrester having a housing 10 which may be of a suitable insulating material such as porcelain. The ends of porcelain housing 10 may be sealed by metallic caps 11 which are spun thereon and hold annular gaskets 12 of suitable resilient material such as synthetic rubber against annular seats 14 provided in the outer periphery adjacent the ends of housing 10. Cup-shaped metallic castings 15 of suitable material such as aluminum alloy are secured to the ends of housing 10 by suitable means such as cement 16. End castings 15 are provided with metallic terminals 18 for electrical connection of the upper end of the arrester to a conductor 19 of the power system to be protected and the lower end to ground 21. Spring members 22 electrically connect the end castings 15 and the metallic caps 11.

The axial compartment 23 in porcelain housing 10 contains a column of alternate current limiting, valve block nonlinear resistors 24, spark gaps 25, and electrical coils 26 maintained in series relation between upper and lower end caps 11 by a metallic compression spring 27 which at its upper end engages the upper end cap 11 and at its lower end engages a metallic plate 28 disposed against the upper valve block resistor 24. A conductor shunt 29 is disposed between the upper closure cap 11 and the metallic plate 28 to eliminate any inductive reactance voltage drop in spring 27 and to relieve spring 27 of undesirable current flow. The valve block resistors 24 are cylindrical in configuration and are preferably composed of granulated valve material such as silicon carbide and an essentially non-conducting binding material.

Each spark gap 25 includes circular upper and lower discs 30 and 31 of conductive material, preferably brass, which function as auxiliary electrodes as explained herein-after. Opposed main electrodes 34 and 35 of suitable conductive material such as brass are secured at their ends to the discs 30 and 31 respectively and extend toward each other between the discs 30 and 31 parallel to the axis of housing 10 to form a main spark gap therebetween. The electrodes 34 and 35 may be brazed to discs 30 and

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31 or, as shown in the drawing, may have external threads which are engaged within tapped holes 36 in the discs 30 and 31 adjacent the peripheral margin thereof.

A plurality of thin, circular, auxiliary electrode plates 38 of suitable conductive material such as brass are arranged transverse to the axis of tubular housing 10 in spaced apart relation in a stack between discs 30 and 31 with insulating means interleaved between adjacent auxiliary plates 38 defining endless, or loop, arc chambers 39 therebetween of spiral, or annular, configuration, and in the preferred embodiment such insulating means includes a centrally disposed insulating disc 40 (see FIGS. 2 and 3) of suitable material such as mica coplanar with and surrounded by a split insulating ring 41 of suitable material such as mica to define an arc chamber 39 between each pair of adjacent auxiliary electrode plates 38. The auxiliary electrode plates 38 have aligned, generally triangular-shaped cutout portions 44 adjacent the outer margin thereof forming an axially extending opening 45 in which the main electrodes 34 and 35 are disposed. The auxiliary electrode plates 38 also have shallow circular indentations 46 with their center offset from the axis of the housing 10 which receive the circular insulating discs 40 in the planes of the split insulating rings 41.

The split insulating rings 41 and the auxiliary electrode plates 38 are of slightly smaller diameter than axial compartment 23 in porcelain housing 10 and are thus prevented from moving laterally. Inasmuch as circular insulating discs 40 are disposed within the shallow depressions 46 and are held therein by the axial force of compression spring 27, lateral movement of insulating discs 40 is prevented, and the stack of end plates 30 and 31, insulating split rings 41, insulating discs 40, and auxiliary electrode plates 38 may be held together by suitable means such as cement to provide an integral assembly.

One end 47 of each split insulating ring 41 is straight and extends generally along a chord of a circle parallel to an edge of the triangular cutout portion 44 in the auxiliary electrode plates 38 and restricts communication between the passage 45 and the annular arc chambers 39, thereby isolating the main air gap between electrodes 34 and 35 from the loop arc chambers 39. This end 47 of split insulating ring 41 is spaced radially from the other end 48 thereof to form an opening 49 into each arc chamber 39 extending generally tangential of the annular arc chamber and opposite the main air gap between electrodes 34 and 35. The endless arc chambers 39 may thus be alternatively described as spiral in configuration.

The radially extending edges 50 of the auxiliary electrode plates 38 (which edges partially define the cutout portions 44) are staggered circumferentially so that the number of auxiliary gaps in series progressively increases as the distance from the main gap between electrodes 34 and 35 is increased. The edges 50 of the pair of plates 38a (see FIG. 4) at the center of the stack are nearer the electrodes 34-35 than the edges 50 of the two plates 38b disposed above and below plates 38a. The edges 50 of the two auxiliary electrode plates 38c disposed above and below the plates 38b are still further removed from the main air gap. Thus, as the distance from the main gap is increased, one auxiliary gap is first defined between the pair of electrode plates 38a; then three auxiliary gaps in series between electrode plates 38b-38a-38a-38b; then five gaps in series between electrode plates 38c-38b-38a-38a-38b-38c; and finally seven auxiliary gaps in series between members 30-38c-38b-38a-38b-38c-31.

In alternative embodiments the edges 50 of all auxiliary electrode plates are in the same plane and thus all auxiliary gaps are equidistant from the main electrodes.

Magnetic means are provided for moving an arc drawn between main electrodes 34 and 35 through openings 49 into the auxiliary electrode structure to thus form arclets between the auxiliary electrode plates 38 and to spin the arclets continuously within the endless arc chambers 39.

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In the preferred embodiment illustrated in FIGS. 1-4, the magnetic means includes annular electrical coils 26 disposed above and below the spark gap structure 25 and which generate a generally radially extending magnetic field (see FIG. 1) transverse to the arc in the main arc gap between electrodes 34 and 35 and also transverse to the endless arc chambers 39 throughout their entire length. The coils 26 may be wound on annular spools 52 of suitable insulating material. The threaded end of main electrodes 34 and 35 may have axial openings 53 in which one electrical lead from the coil 26 is affixed by suitable means such as solder. The other lead from coil 26 may be connected to a suitable metallic jack 54 molded within spool 52 and adapted to receive a metallic plug 55 secured to a metallic disc 56 disposed between valve block 24 and insulating spool 52. It will thus be appreciated that the coils 26 are connected in series with the main air gap and the valve blocks 24 between the end caps 11. The lines of force of the magnetic field generated by coils 26 describe closed loops in any radial cross section through the coils 26 and have a major, generally radially extending component transverse to the main air gap and also transverse to the arclets in the endless arc chambers 39 throughout the length of the arc chambers.

In the radial cross section including the main electrodes 34 and 35, the magnetic field traverses the arc in the main air gap in a direction transverse thereto, and consequently the magnetic field of the arc reacts with the magnetic field of the coils 52 to move the arc through openings 49 into the auxiliary electrode plate structure and form arclets within the annular arc chambers 39.

The lightning arrester of the invention is connected between power line conductor 19 and ground 21 and normally presents a high impedance to the flow of sixty cycle current. Under normal operating conditions the voltage between conductor 19 and ground 21 is insufficient to cause the air dielectric between the electrodes 34 and 35 to become conductive. When a large high frequency surge appears on power line conductor 19 incident to a lightning stroke, the gap between the electrodes 34 and 35 sparks over and a comparatively low impedance path is provided from line 19 through the valve block resistors 24 and spark gaps 25 to ground.

Threadedly mounted on the conductive discs 56 are adjustable conductive studs 57 having the end thereof spaced from the brass plates 30 and 31 to define air gaps 58 therewith. If lightning striking power line 19 contains high frequency components, the air gaps 58 spark over and permit the current to flow therethrough rather than through coils 26. After the transient has been dissipated, the sixty cycle follow current will take the path of lower impedance through the coils 26 rather than through the gaps 58, and the arcs across these gaps 58 are rapidly extinguished.

As soon as the lightning surge has passed, it is desired to have the lightning arrester again present a high impedance to the power line. The nonlinear resistor blocks 24 are voltage sensitive and increase in resistance when the voltage applied thereto is decreased so that after the voltage surge has passed, the valve blocks 24 return to their initial resistance, but the power line voltage will maintain the arc conductive between electrodes 34 and 35.

The magnetic field created by coils 26 is transverse to the follow current arc between electrodes 34 and 35 and reacts with the magnetic field created by the arc, in accordance with the well known electric motor principle, to cause the arc to move generally parallel to the annular face of coils 26 through the openings 49 into the annular arc chambers 39. After the arc enters the arc splitter formed by the auxiliary electrode plates 38, it divides into a series of arclets between adjacent auxiliary electrodes 38 and which move in the annular path provided by the arc chambers 39, since an arc always moves at right angles to the magnetic field and the arclets are re-

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stricted from moving out of the annular arc chambers 39 by the confining wall portions of the split insulating rings 41 and the insulating discs 40. The arclets are spun in the annular arc chambers 39 at a sufficiently high velocity to prevent heating and burning of the auxiliary electrode plates 38. Further, the arclets are spun at a sufficiently high velocity, by the reaction between the magnetic fields of coils 26 and the field of the sixty cycle follow current arc, to develop a voltage drop of from 200 to 500 volts per arclet, in contrast to the cathode anode drop in the range of from 20 to 50 volts which is characteristic of a stationary arc.

It will be appreciated that the plurality of arclets between auxiliary electrode plates 38, each of which develops a voltage drop of approximately 300 volts, greatly improves the follow current interrupting ability of the lightning arrester. In fact, in the disclosed arrester a total cathode anode potential drop may be developed across the series auxiliary gaps of greater magnitude than the peak voltage of the power system, thereby assuring follow current interruption at or before the first current zero. Further, in the lightning arrester of the invention the arclets are not restrained by magnetic means from further movement within the auxiliary electrodes in a position wherein the hot cathode spot can heat and burn the electrodes as in prior art arresters, but rather the arclets are spun continuously at a sufficiently high velocity within the endless arc chambers 39 to assure that no burning of the auxiliary electrode plates 38 occurs. Normally the cathode anode drop of an arc between hot cathodes is in the order of 20 volts, but if the electrodes can be kept cool, the cathode anode drop rises to approximately 300 volts. The velocity of the arclets in the present invention is sufficiently high to cool the arc by extracting energy therefrom and to obtain cathode anode drops near current zero in the range of from 200 to 500 volts.

The velocity of arc movement is a function of the strength of the field of the magnetic means and of the magnitude of the arc current, and in accordance with the invention the strength of the magnetic field of the coils 26 is sufficiently high so that the arclets spin at velocities of from 1,000 to 30,000 centimeters per second, and an arclet may complete as high as ten to twelve revolutions within the annular arc chambers 39 before being interrupted at the first current zero. It will be appreciated that the straight portions 47 of the split insulating rings 41 form obstructing wall portions for the annular arc chambers 39 which prevent the spinning arclets from re-igniting the main gap between the electrodes 34 and 35.

In the embodiment of FIGS. 5-8, the magnetic means for elongating the arc and moving it into the auxiliary electrode structure to spin arclets in the continuous arc chambers comprises an annular permanent magnet 60 disposed against upper circular disc 30 in surrounding relation to valve block 24 and secured to disc 30 by suitable means such as screws 61. The permanent magnet 60 may be of any suitable magnetic material, although it preferably is a ceramic material such as barium ferrite ($\text{BaFe}_{12}\text{O}_{19}$) which is an excellent insulator and has great resistance to demagnetization by magnetic fields or by heat or shock. If desired, the permanent magnet 60 may be enclosed within suitable insulating housing members (not shown). The permanent magnet 60 is polarized to generate a generally radially extending magnetic field transverse to the arc formed between the main electrodes 34 and 35 and also transverse to the arclets formed between adjacent auxiliary electrode plates 38' throughout the entire length of the annular arc chambers. Permanent magnet 60 may be polarized with a north pole N adjacent its outer periphery and a south pole S adjacent its inner periphery so that the lines of force in any radial cross section through annular magnet 60, as schematically illustrated in FIG. 5, emerge from the inner periphery

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of magnet 60 and intersect the auxiliary electrode plates 38' with a component transverse to the arclets formed between auxiliary electrode plates 38'. Inasmuch as the magnet 60 is annular, the magnetic field will be generally radial and transverse to the arclets throughout the entire length of the annular arc chambers.

In the embodiment of FIGS. 5-8, an inner continuous arc chamber 70 and an outer endless arc chamber 71 are provided between each pair of adjacent auxiliary electrode plates 38' within which the arclets are spun, depending upon the polarity of the cycle of follow current. The inner and outer arc chambers 70 and 71 are generally spiral in configuration and concentric. The inner arc chamber 70 is disposed radially inward from the main gap defined by main electrodes 34 and 35, and the outer arc chamber 71 is disposed radially outward from the main gap. Rectangular openings 73 are provided in the auxiliary electrode plates 38' for receiving the main electrodes 34 and 35. The inner annular continuous arc chambers 70 are defined between the auxiliary electrode plates 38' by insulating discs 40' of suitable insulating material such as mica coplanar with and surrounded by split insulating rings 74 of suitable insulating material such as mica. The radially inner end 75 and the radially outer end 76 of each split insulating ring 74 are straight and extend generally along chords of a circle parallel to the radially inner and radially outer edges 79 and 80 of the rectangular openings 73 in the auxiliary electrode plates 38'. The ends 75 and 76 of the split annular insulating rings 74 are spaced apart radially and define generally tangentially extendible openings 81 into the inner annular arc chambers 70, and the inner end 75 restricts communication between the inner loop arc chamber 70 and the main gap between electrodes 34-35 to prevent the spinning arclets from re-igniting the main gap. Alternatively, the inner arc chambers 70 may be described as spiral in configuration with their open end in communication with the main gap.

Outer continuous arc chambers 71 between the auxiliary electrode plates 38' are defined by the split insulating rings 74 and outer annular insulating rings 83 in surrounding relation to the split insulating rings 74. It will be appreciated that the radially spaced ends 75 and 76 of split rings 74 also define openings 85 into the outer spiral arc chambers 71 and which are disposed on the opposite side of the main electrodes 34-35 from the openings 81 into the inner arc chambers 70. The outer end 76 of split rings 74 restricts communication between the outer annular arc chambers 71 and the main electrodes 34-35 and prevents the arclets being spun in the outer arc chambers 71 from re-igniting the main gap. In this embodiment the shallow depressions in the auxiliary electrode plates for receiving the discs 40', split rings 74, and annular outer rings 83 are omitted from the drawing in order to simplify the drawing and facilitate the understanding of the invention, and it will be appreciated that these members may be held together with the auxiliary electrode plates 38' by suitable means such as cement to provide an integral assembly.

As shown in FIGS. 6 and 7, the rectangular openings 73b in auxiliary electrode plates 38b' are preferably longer than the similar openings 73a in the innermost auxiliary plates 38a', and such openings 73c in the top and bottom auxiliary electrode plates 38c' are preferably still longer than the openings 73b in auxiliary electrode plates 38b' so that the number of auxiliary gaps in series progressively increases in both directions as the distance from the main gap between electrodes 34 and 35 is increased. In alternative embodiments, the openings 73 in all auxiliary electrode plates are of the same size and all auxiliary gaps are equidistant from the main electrodes 34 and 35.

The valve blocks 24 abut against the metallic end plates 30 and 31 in this embodiment to connect the valve elements in series with the gap structures 25. When the

cycle of follow current is of one polarity, for example, positive, the magnetic field of the arc reacts with the generally radially extending field of the permanent magnet 60 to move the arc in one direction, for example, counterclockwise, into the auxiliary electrode structure and form arclets between electrode plates 38' which are spun continuously within the inner endless arm chambers 70 as shown in dotted lines in FIG. 6. When the follow current is of the opposite polarity, i.e., negative, the magnetic field of the arc reacts with the magnetic field of the permanent magnet 60 to move the arc in the opposite, i.e., clockwise, direction between the auxiliary electrode plates 38' and form arclets therebetween which are spun continuously in the outer annular arc chambers 71 as shown in dot-dash lines in FIG. 6.

While only a few embodiments of the invention have been illustrated and described, many modifications and variations thereof will be readily apparent to those skilled in the art, and consequently it is intended in the appended claims to cover all such modifications and variations which fall within the true spirit and scope of the invention. For example, it will be apparent that the main electrodes may alternatively be disposed axially of the tubular housing and the arc moved outwardly into the endless arc chambers.

We claim:

1. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, nonlinear resistance material within said housing, a pair of main electrodes within said housing defining a main air gap connected in series with said resistance material between said terminals, a stack of spaced apart auxiliary electrode plates within said housing, insulator means between adjacent auxiliary electrode plates defining annular arc chambers therebetween each having an opening extending generally tangential of said annular chambers, said insulator means engaging both said adjacent auxiliary electrode plates and defining the inner and outer peripheral sidewalls of said annular arc chamber between said auxiliary electrode plate and confining the arclets between said auxiliary electrode plates within said annular arc chamber, said pair of main electrodes having communication with said arc chambers through said openings, and annular magnetic means within said housing defining a generally radially extending magnetic field transverse to said main air gap and transverse to the gaps between adjacent auxiliary electrode plates throughout the length of said arc chambers for moving an arc formed between said main electrodes through said openings and spinning the resulting arclets formed between said auxiliary electrode plates in said annular arc chambers.

2. A lightning arrester in accordance with claim 1 wherein said magnetic means includes a coil generally coaxial with said annular arc chambers and connected in series with said resistance material and said main air gap.

3. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, nonlinear resistance means within said housing, a pair of main electrodes within said housing defining a main air gap in series with said nonlinear resistance means between said terminals, a plurality of spaced auxiliary electrode plates within said housing, insulating means between adjacent auxiliary electrode plates defining loop arc chambers therebetween each having an opening therein, said main electrodes being disposed in a radial direction away from said insulating means and said arc chambers and opposite said openings, and magnetic means within said housing for defining a magnetic field transverse to said main air gap and also transverse to the gaps between said adjacent auxiliary plates throughout the length of said arc chambers.

4. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, a nonlinear resistance valve block within said housing, a pair of main electrodes within said housing defin-

ing a main air gap connected in series with said valve block between said terminals, a plurality of spaced auxiliary electrode plates within said housing defining a plurality of auxiliary air gaps therebetween in a direction substantially parallel to said main air gap, means between adjacent electrode plates including an insulating disc and a split insulating ring surrounding said disc for defining loop closed arc chambers therebetween each having an opening therein between the ends of said split ring extending generally tangentially of said loop, said main electrodes being disposed in a radial direction away from said split rings and opposite said openings, and magnetic means within said housing having a configuration generally conforming to said loop arc chambers for generating a magnetic field which traverses said main air gap in a direction transverse thereto and also traverses said auxiliary gaps in a direction transverse thereto throughout the length of said loop arc chambers.

5. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, nonlinear resistance means within said housing, a pair of electrodes defining a main air gap within said housing connected in series with said resistance between said terminals, a plurality of spaced auxiliary electrode plates within said housing defining a plurality of auxiliary air gaps therebetween, insulator means between pairs of adjacent auxiliary plates defining loop arc chambers therebetween each having an opening adjacent said main air gap, each said loop arc chamber between adjacent auxiliary electrode plates being closed throughout the entire length of the closed curve of the loop except at said opening and confining the arc between said adjacent auxiliary electrode plates within said loop arc chamber, and magnetic means for defining a magnetic field which traverses said main air gap in a direction transverse thereto and also traverses said auxiliary gaps in a direction transverse thereto throughout the length of said loop arc chambers.

6. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, a nonlinear resistance valve element within said housing, a pair of main electrodes within said housing defining a main air gap in series with said valve element between said terminals, a plurality of spaced auxiliary electrode plates within said housing, means between adjacent auxiliary electrode plates including an insulating disc and a split insulating ring surrounding said disc for defining annular arc chambers between said auxiliary electrode plates each having an opening between the ends of said split ring extending generally tangentially of said annular arc chambers, said main electrodes being disposed radially outward from said split insulating rings and opposite said opening, and annular magnetic means within said housing for generating a magnetic field transverse to said main air gap and also transverse to the gaps between said auxiliary plates throughout the length of said arc chambers.

7. A lightning arrester comprising, in combination, an insulating housing, a nonlinear resistance valve block within said housing, spaced apart terminals on each housing, a pair of main electrodes within said housing defining a main air gap in series with said valve block between said terminals, a plurality of spaced apart auxiliary electrode plates in a stack within said housing, an insulating disc and a split insulating ring surrounding said disc interleaved between each pair of adjacent auxiliary electrode plates and defining an endless annular arc chamber therebetween, said auxiliary electrode plates having a cutout portion adjacent the outer margin thereof defining a passage parallel to the axis thereof, said split insulating rings restricting communication between said passage and said arc chambers and the ends of said split rings being spaced apart radially adjacent said passage and providing openings between said passage and said annular chambers extending generally

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tangentially of said annular arc chambers, said main electrodes extending parallel to the axis of said stack within said passage and being opposite said openings, and annular magnetic means disposed within said housing adjacent one end of said stack for generating a generally radially extending magnetic field transverse to said main air gap and also transverse to the auxiliary gaps between said auxiliary plates throughout the length of said arc chambers.

8. A lightning arrester comprising, in combination, an insulating housing, spaced apart terminals on said housing, nonlinear resistance valve block means within said housing, a pair of main electrodes defining a main air gap electrically connected in series with said valve block means between said terminals, a plurality of spaced auxiliary electrode plates within said housing defining a plurality of auxiliary air gaps therebetween, insulating means between adjacent auxiliary electrode plates defining spiral shaped passages open at one end and forming endless arc chambers between said auxiliary electrode plates, said main electrodes being disposed opposite said open end of said passages, and magnetic means for generating a magnetic field transverse to said main air gap and also transverse to the auxiliary gaps between said auxiliary electrode plates throughout the length of said endless arc chambers.

9. A lightning arrester comprising, in combination, a tubular insulating housing, terminals on the ends of said housing, a nonlinear resistance within said housing, a stack of auxiliary electrode plates within said housing extending transverse to the axis thereof and each having an opening therethrough and the openings in said plates being in alignment and defining a passage parallel to the axis of said housing, a pair of main electrodes within said passages defining a main air gap connected in series with said nonlinear resistance between said terminals, insulating means between pairs of adjacent auxiliary electrode plate defining inner and outer endless spiral arc chambers each having an inner end communicating with said passage, and an annular permanent magnet within said housing disposed adjacent one end of said stack and being polarized to generate a generally radially extending magnetic field transverse to said inner and outer spiral arc chambers throughout the length thereof, whereby an arc of one polarity formed between said

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main electrodes reacts with the field of said permanent magnet and moves through said openings into said inner arc chambers and forms arclets between said auxiliary electrodes which are spun in said endless inner arc chambers and an arc of the opposite polarity moves into said outer spiral endless arc chambers.

10. An arrester in accordance with claim 9 wherein said insulating means between each pair of adjacent auxiliary electrode plates includes a centrally disposed disc, a split annular ring surrounding and spaced from said disc and having its end spaced apart radially, and an annular ring surrounding and spaced from said split ring.

11. A lightning arrester comprising, in combination, a tubular insulating housing, terminals on the ends of said housing, a nonlinear resistance within said housing, a stack of auxiliary electrode plates within said housing transverse to the axis thereof, each of said plates having an opening therethrough and the openings in said plates being in alignment and defining a passage parallel to the axis of said housing, a pair of main electrodes disposed within said passage defining a main arc gap connected in series with said resistance between said terminals, insulating means including a split annular ring between each pair of adjacent electrode plates defining an endless spiral chamber therebetween having an opening registering with said passage, each said endless spiral chamber being closed throughout the entire spiral length except at said opening and confining the arc between said pair of adjacent electrode plates within said endless chamber, and annular magnetic means disposed adjacent said stack within said housing for generating a magnetic field having a major component extending transverse to said main gap and radially of said arc chambers throughout the length thereof.

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