Feb. 15, 1938. A. O. AUSTIN 2,108,465

SURGE ARRESTER

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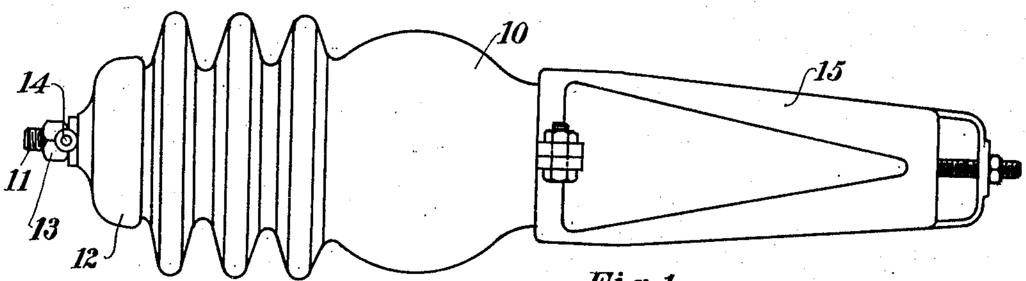

Fig.1

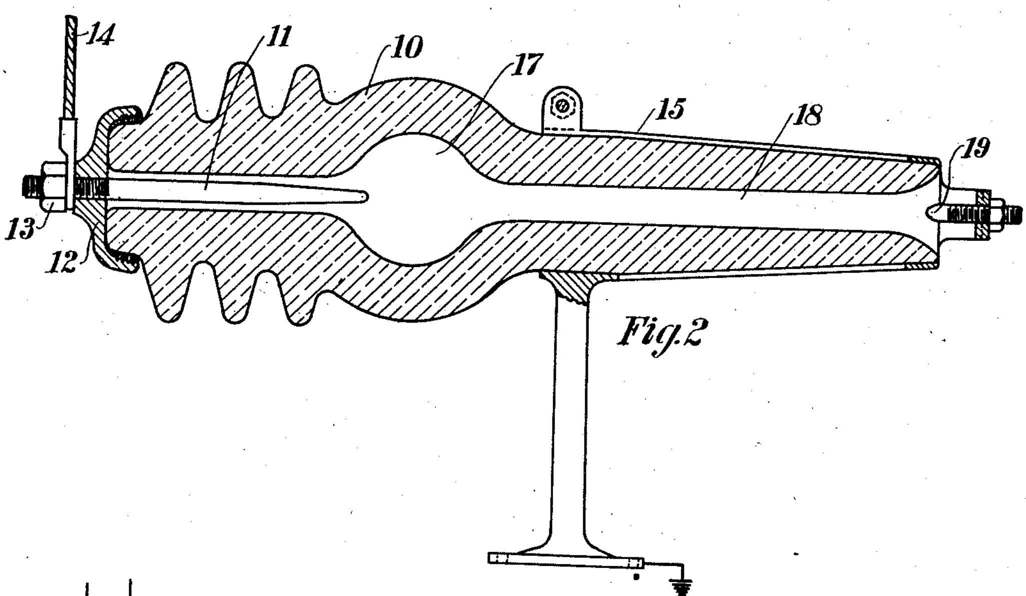

Fig.2

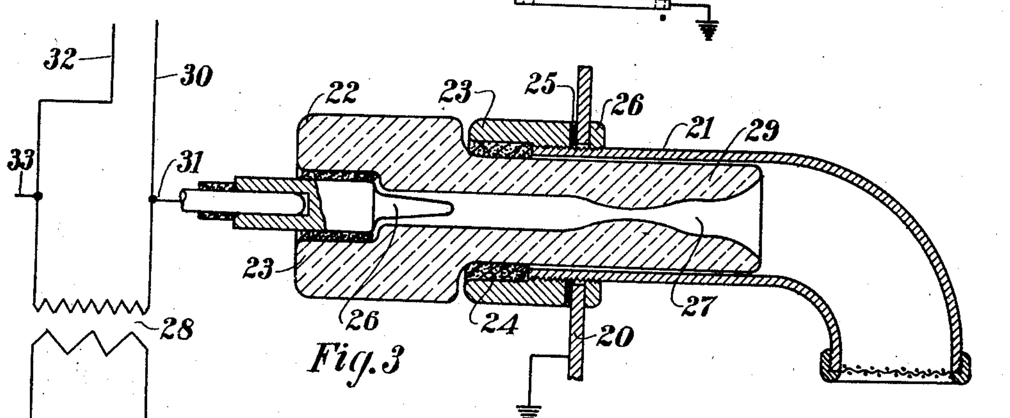

Fig.3

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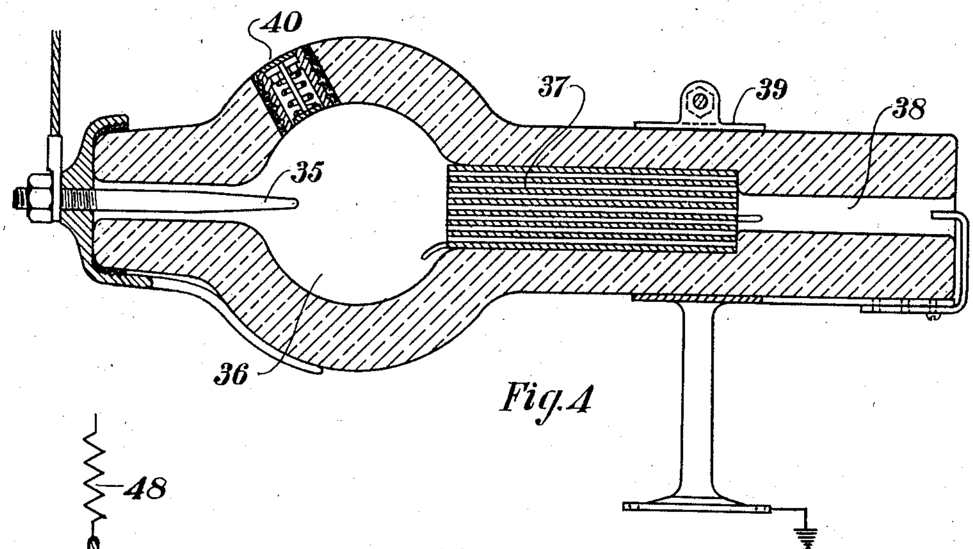

Fig. 4

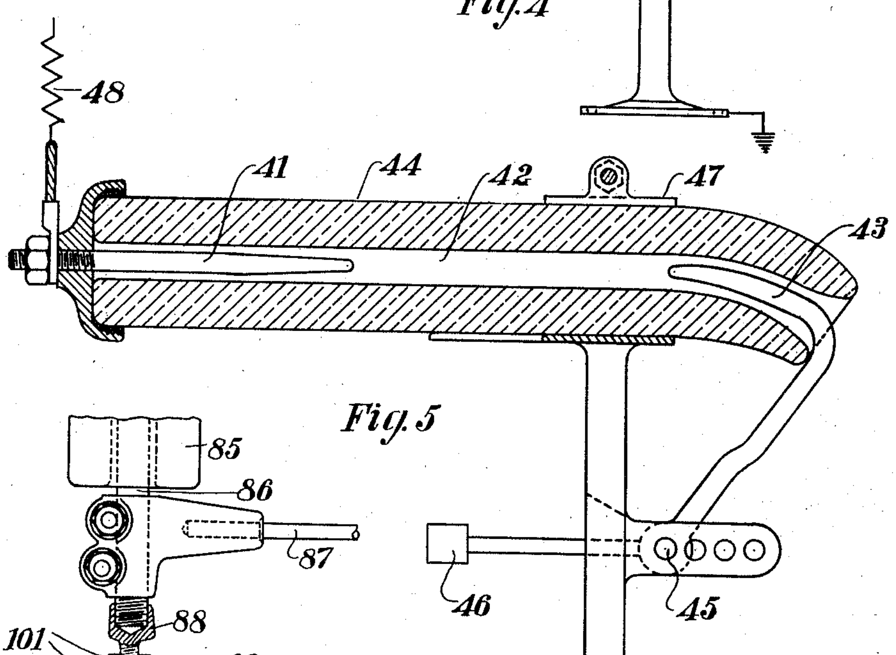

Fig. 5

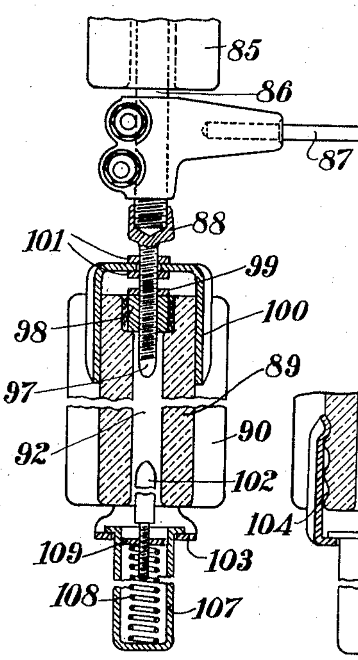

Fig. 14

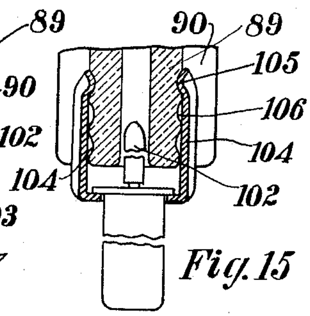

Fig. 15

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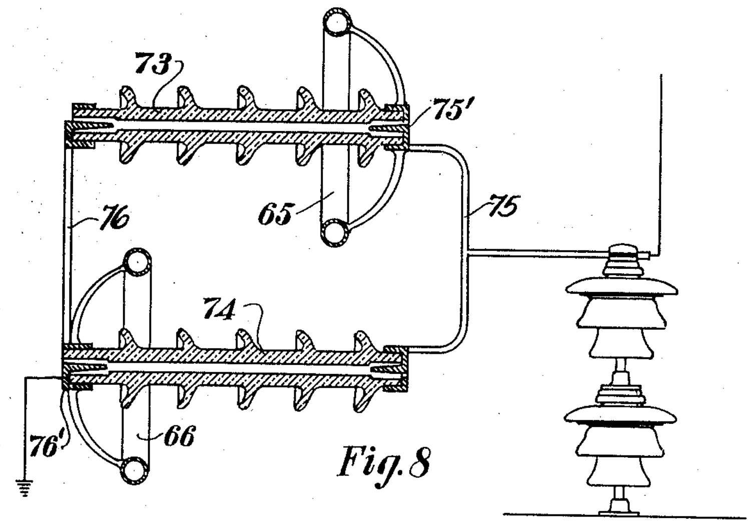

Fig. 8

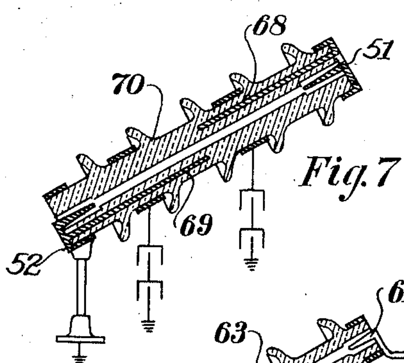

Fig. 7

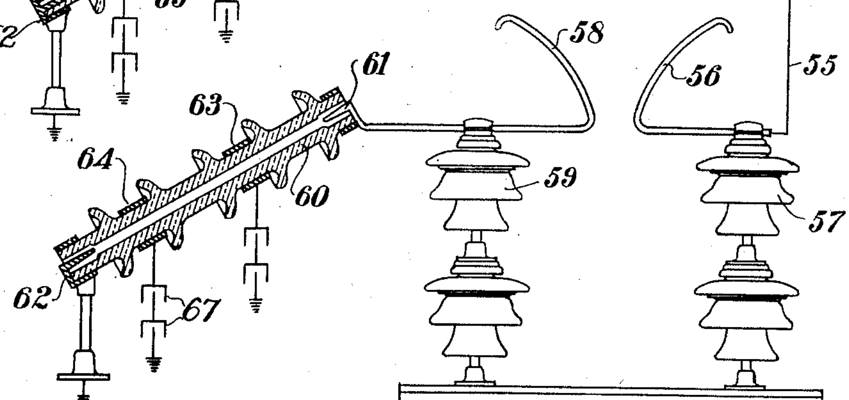

Fig. 6

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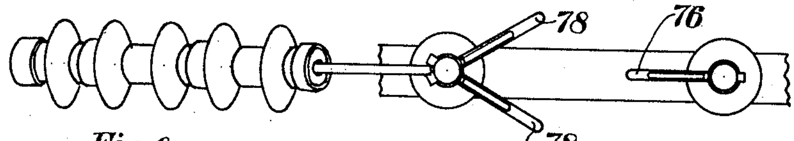

Fig. 9

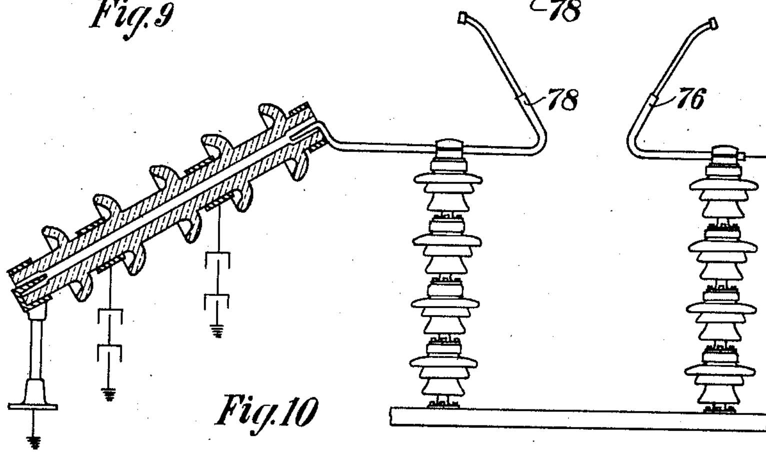

Fig. 10

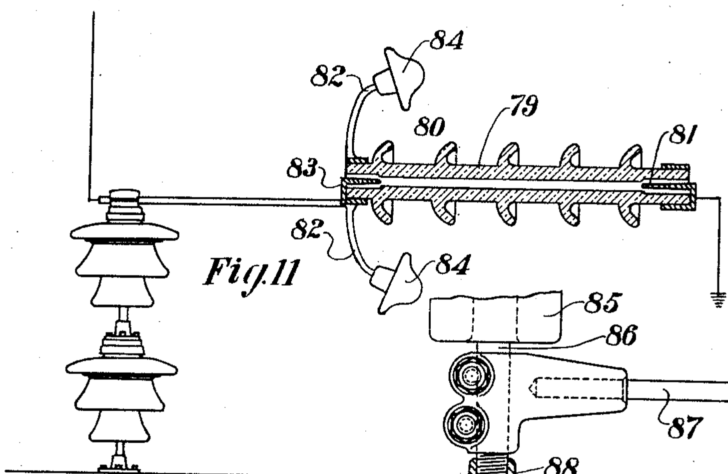

Fig. 11

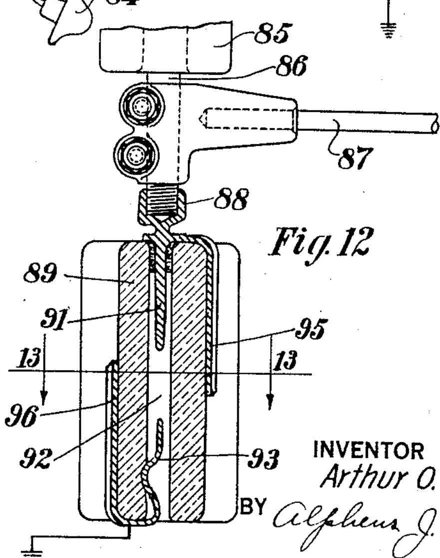

Fig. 12

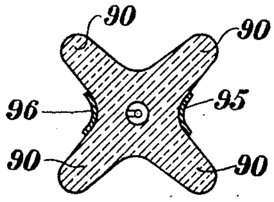

Fig. 13

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UNITED STATES PATENT OFFICE

2,108,465

SURGE ARRESTER

Arthur O. Austin, near Barberton, Ohio, assignor, by mesne assignments, to The Ohio Brass Company, Mansfield, Ohio, a corporation of New Jersey

Application May 12, 1932, Serial No. 610,849

20 Claims. (Cl. 175—30)

This invention relates to abnormal voltage or surge arresters for protecting electrical apparatus, and has for one of its objects the provision of a device of the class named which shall be entirely automatic, quick in operation and which shall require no maintenance expense.

A further object is to provide a device which can be readily adapted to a large range of conditions.

A further object is to provide means for controlling the electrostatic field about the terminals of a discharge gap so as to control the conditions of discharge and to adapt the device for either positive or negative discharges.

A further object is to provide a surge arrester which shall be of improved construction and operation.

Other objects and advantages will appear from the following description.

The invention is exemplified by the combination and arrangement of parts shown in the accompanying drawings and described in the following specification, and it is more particularly pointed out in the appended claims.

In the drawings:

Fig. 1 is a top plan view of a surge arrester showing one embodiment of the present invention.

Fig. 2 is a vertical sectional view of the device shown in Fig. 1.

Fig. 3 is a vertical sectional view of the device applied to a transformer housing.

Figs. 4 and 5 are vertical sectional views of modified forms of the invention.

Fig. 6 is an elevation with parts in section showing a further modification of the invention.

Fig. 7 is a vertical sectional view of a discharge tube showing another form of the invention.

Fig. 8 is a view similar to Fig. 6 showing a different form of the invention.

Fig. 9 is a top plan view of another modification.

Fig. 10 is an elevation with parts in section of the device shown in Fig. 9.

Fig. 11 is an elevation with parts in section showing another form of the invention.

Fig. 12 is a sectional view of another modification.

Fig. 13 is a section on line 13—13 of Fig. 12.

Fig. 14 is a vertical sectional view of a modified form of the invention.

Fig. 15 is a fragmentary section at right angles to Fig. 14.

This application is in part a continuation of application Serial Number 493,316, filed November 4, 1930.

In a limiting gap two things are desirable; one is to limit the voltage so that apparatus to which the gap is connected will not be damaged by over-potential, and the other is to clear or prevent a power arc from following a discharge caused by over-voltage. The time lag between the rise in voltage and the operation of the protective device is important as the protecting gap must relieve the over-voltage before the connected apparatus is damaged. It is also desirable to be able to control the relief voltage for impacts or over-potentials of different polarity. The cost of the device is also important. To secure these desirable features, the use of a control, as provided by the present invention, to start discharge across the limiting gap is quite important. In small size devices, the form of apparatus may appear quite different from that of large sizes and still embody the same general principles.

In the form of the invention shown in Figs. 1 and 2, a tubular dielectric member 10 is provided with a discharge electrode 11. In the drawings it is shown screwed through a cap 12 and locked in place by a nut or other suitable device 13. A lead 14 is attached to the apparatus or line which is to be protected from over-voltage so that the protecting gap provides a shunt path to ground about the devices to be protected. Over the end of the tube 10 opposite the electrode 11, either wholly or partially surrounding the tube, is a member 15 which is connected to ground or to a resistance as desired. In operation, the over-potential energizing the tip 16 of the electrode 11 tends to cause a discharge from the tip into the space 17. The size of this space will depend upon the electrical constants of the system. The grounded member 15 sets up a control or teaser field which tends to concentrate electrostatic stress upon the point of the electrode 11, particularly where the insulating member 10 has a high flux carrying capacity; and under the high frequency of an abnormal impulse or surge, a discharge is started from the tip 16. The discharge, due to charging currents, tends to discharge into the opening 17 and as there is increasing capacity toward the open end of the tubular member 10 because of the shape of the capacitance member 15, the streamer progresses toward the open end, finally making contact with the ground shield or another electrode 19 placed in the mouth or in front of the mouth of the opening 18. The heating of the gas in the chamber 17 causes an explosion which tends to blow out the arc. Where the opening 18 is small, a high velocity is developed so that upon expansion of the gas, considerable heat is absorbed. Heat is taken up by the walls of the tube and this, together with the cooling effect due to expansion of the gas, tends to quench the arc. The sleeve 15 may be made in several portions or, if desired, it may be formed of tapered strips, as shown, to provide increasing capacity toward the mouth of the opening 18 so that the tendency of the arc will be to progress readily toward the outer end of the tube due to the high frequency of the arc. At normal frequency, the effect of the increasing capacity will be rather small.

Because of the decrease in pressure toward the mouth of the opening 18, the wall of the insulating member 10 may be tapered in thickness toward the ground or open end of the tube. This, in addition to the increase in the surface of the member 15, increases the electrostatic capacity toward the end of the tube.

In protecting transformers, the limiting gap is mounted in a flange or casing of the transformer, the open end discharging into the air, as shown in Fig. 3, in which 20 designates the wall of the transformer housing which is perforated to receive the end of a metal pipe 21. A tube of porcelain or other dielectric material 22 extends into the pipe 21 from within the transformer housing and is secured to the inner end of the pipe by a collar 23 threaded on to the end of the pipe and cemented to the tube 22 by cement 24. The outer end of the pipe 21 may be provided with a screen, as shown, to exclude insects. A gasket 25 may be inserted between the collar 23 and the wall 20 and a nut 26 threaded on the pipe 21 is screwed against the outer face of the transformer housing to hold the pipe and insulating tube in position and form a tight closure for the opening in the transformer housing. A discharge electrode 26 extends into the central opening 27 in the tube 22 and may be secured in the end of the tube by cement 23. The transformer windings are shown diagrammatically at 28 and the electrode 26 is connected to one of the incoming high potential leads 30 by a suitable jumper 31. It will be understood that the other high potential lead 32 is connected to a similar surge protector by means of a jumper 33. Whenever an abnormal surge, such as a lightning charge, is impressed on the line 30, electrostatic stress will be concentrated on the point of the discharge electrode 26 because of the proximity of this point to the grounded member 23 and the transformer wall 24 so that a discharge will be started in the passage 27. This will continue through the passage and strike the grounded pipe 21 at the outer end, thus relieving the winding 28 of the abnormal voltage. The explosion in the tube 27 caused by the discharge through the tube will blow out the arc and prevent a power arc from following the discharge. In practice, the device has been found to be very quick and reliable in operation and to provide protection for transformers and other apparatus which is entirely automatic, and requires no maintenance expense.

In Fig. 4 the discharge starts from the point 35 into a chamber 36. Heat expands the gas in the chamber which is caused to flow through heat absorbing material 37. This may be metal or insulating material, providing a large number of small passages extending in the direction of the discharge. The member 37 may be of laminated material as shown in the drawings. The gas advancing through the member 37 is partially cooled and tends to blow out through the outer portion of the opening 38 and quench the continuation of the arc from this point, the teaser field induced by the grounded member 39 tending to cause the further discharge of the high frequency arc along the opening 38. The cooling of the gas tends to reduce its volume. A portion of the air in the chamber 36 will be forced out and create a very considerable blast, particularly under the very high rate of heat generation produced by lightning or other transients. With the invention it is possible to start a discharge at a comparatively low rise in voltage. The more severe the over-voltage the quicker will be the action.

The size of the openings 18 and 38 must necessarily be regulated to meet the particular requirements for which any device is designed. If the passages are too small, too high pressures will be developed, and if too large, the arc may not clear. In order to mitigate this condition and increase the range of a device having a given size of opening, the chamber 36 may be provided with a safety valve 40 which will relieve stress after a given pressure is reached. Any desired number of valves 40 may be provided. Where the device is placed inside of a transformer case, the valves 40 should be vented to the outside.

In the form of the invention shown in Fig. 5, a discharge electrode 41 discharges into the chamber or opening 42. Another electrode on the ground terminal 43 is provided with a pivotal mounting 45 and counterpoise 46 which will permit it to move outward and increase the length of the discharge gap and then return after the pressure or discharge is relieved. By curving the discharge chamber 42 downward at its mouth, water will be kept out and a type of construction provided which is readily manufactured.

The types shown in Figs. 1, 2, 3, 4 and 5 will discharge readily on a positive wave or impulse. For a negative wave or impulse, it is advisable to reverse the connections in regard to the electrostatic field. With this reversal in Fig. 1, the shield 15 would be insulated from ground, the enclosed discharge gap electrode 11 being attached to ground or supported by the cap 12 or electrode member 13. Where the gap has two electrodes in the chamber, the effect of polarity may be materially changed by sliding the shields forward or back for the two ends. The tube 44 is supported by a grounded support 47 which forms a control for the field. The device may be provided with movable teaser controls which will change the characteristics of the field so that the relative negative and positive discharge voltage can be controlled. In Figs. 4 and 5 this may be effected by shifting the position of the grounded support on the dielectric tube. By changing the field, it is also possible to affect the relief voltage very materially. Placing a resistance 48 in series with the gap tends to limit the amount of discharge.

In the arrangement of the invention shown in Fig. 6, the discharge device is used as a voltage limiting and arc clearing device or lightning arrester. The lead 55 for attachment to the bus or high voltage conductor terminates in an arcing horn 56, or other suitable discharge gap. The gap member 56 is supported by an insulator stack 57 which may be made to rotate so as to change the width of the limiting gap or to permit servicing or adjustment of the apparatus. Another complementary electrode 58 of the discharge gap is placed opposite the member 56. This is supported by a suitable insulator stack 59 which may be movable or rotatable in order to facilitate adjustment or provide sufficient clearance so that the apparatus may be worked upon without removing voltage from the line side of the device. In operation, an over-voltage of sufficient magnitude will cause a discharge between the gap electrodes 56 and 58. The capacity of the bus members to ground will tend to throw stress across the air gap electrodes 56 and 58. If the capacitance between the two portions 56 and 58 is sufficient, it may be possible to start a discharge in the tubular member 60. If a long discharge path in the tubular member 60 is provided so that there will be a tendency for the arc to clear after the discharge, it is evident that the device might not provide sufficient protection as a very high voltage would be required to cause a discharge.

This difficulty may be offset by distributing the stress electrostatically so that even though the long discharge path is used, discharge may be started between the terminal members 61 and 62. This may be accomplished by setting up an external electrostatic field, as by capacitance members 63 and 64 adjacent the outside of the tube 60, so that a high potential will cause an overstress on the discharge members or electrodes 61 and 62. This potential will tend to progress from point to point along the discharge path within the tube until the arc is completed. In general the discharge voltage from a point to a plate or ground is greatly reduced where the point is positive. If, then, the terminal 61 is positive, it will be seen that the flashover voltage will be much lower than if it were negative under ordinary field conditions. It is possible, however, to shield the field so that the device will arc at approximately the same voltage regardless of polarity. An insulated control or grading device, like those shown at 65 and 66 in Fig. 8, will approximate this condition. In general, however, it is advisable to start flashover voltage at a low potential compared to the length of the member 60.

It is evident that where a field is controlled by a conductor 64 attached to a condenser that the stress on the terminal 61 can be increased so that discharge will start where terminal 61 is positive. The discharge starting from 61 will tend to travel towards the plate 64. The current in the discharge lowers the resistance so that the potential between 61 and the inside of the tube opposite to 64 will be greatly reduced. Owing to the presence of the field set up by the condenser 67 and the capacitance to ground, the arc may then be prolonged until the discharge completes the path between 61 and 62. The result may be secured by several different means.

One other arrangement is shown in Fig. 7 in which two insulated control rods 68 and 69 are placed one at each side of the discharge opening in the tubular dielectric member 70. These control rods may be made integral with the terminal members 51 and 52. While it is possible that under certain conditions the control members could be bare, the close proximity between the control members and the discharge path within the tube will generally require that they be insulated.

One method of providing for different polarities of the discharge is to use two discharge tubes, one of which will discharge with the positive transient on the transmission line, and the other with the negative transient on the transmission line. In this way it is possible to set up the necessary field strength so that a discharge can be obtained over a comparatively long path which will tend to increase the ability of the device to clear on the discharge. An arrangement of this kind is shown in Fig. 8 in which two discharge tubes 73 and 74 are connected in parallel, the tube 73 having the terminal 75′ connected to the line through the electrode 75 and provided with a flux ring 65 to facilitate discharge. The tube 74 has its grounded terminal 76′ provided with a flux ring 66. When the abnormal charge on the line is positive, the ring 66 will help to induce a discharge through the tube 74 and when the charge on the line is negative, the ring 65 will help to induce discharge through the tube 73. If desired the gap in series with the discharge tubes, as shown in Fig. 6, may be omitted, as shown in Fig. 8. In general, however, the use of this gap will permit much smaller apparatus for the discharge end and under normal operating voltage the parts will not be under stress where the gap is used. It is evident that the discharge tube in its various forms may be used for the protection of insulator strings, bus structures, circuit breakers, transformers, transmission lines or other equipment.

The form of the invention shown in Figs. 9 and 10 is similar to that shown in Fig. 6 except that the arcing gap is provided with a single terminal 76 connected to the line 77 and has two horns or electrodes 78 on the ground side of the gap for controlling the direction of discharge across the gap.

In Fig. 11 a discharge tube 79 is provided with inwardly extending electrodes 80 and 81 and with flux control members 82 secured to the terminal 83 and extending toward the terminal 81 for controlling the electrostatic field and inducing discharge from the electrode 80. The ends of the control members 82 are covered by dielectric members 84 to reduce the possibility of discharge on the outside of the tube 79. By this means the discharge is induced within the tube 79 where it is extinguished by the action of the tube to prevent a power arc from following the discharge induced by abnormal voltages.

In the form of the invention shown in Figs. 12 and 13, at 85 there is a lead-in bushing for a high potential conductor 86 to which a lead 87 is connected for carrying current to apparatus to be supplied thereby. The protective device is connected with the conductor 86 and may be supported or attached directly to the lower end of the conductor by a threaded coupling shown at 88. The protective device comprises an insulator 89 of porcelain or other suitable material having radially extending ribs or fins 90. A discharge terminal 91 is connected with the coupling 88 and extends into an opening 92 through the center of the dielectric member 89. The grounded terminal 93 is located at the end of the opening 92 opposite the terminal 91. The terminal 91 has a control member 95 connected therewith and extending in one of the grooves between the ribs 90. The terminal 93 has a control member 96 connected to it and disposed in the groove opposite the control member 95. The control member 96 extends to a point adjacent the terminal 91 and the control member 95 extends to a point adjacent the terminal 93. The ribs on the dielectric member prevent leakage and discharge between the control members 95 and 96 which have opposite polarity. Whenever an abnormal surge is impressed on the conductor 86, the control members 95 and 96 will induce concentration of electrostatic flux on the extremities of the discharge members 91 and 93. If the charge on the conductor 86 is positive, discharge will start from the conductor 91 but if the charge is negative on the conductor 86, discharge will start from the terminal 93 which will be positive. It will be seen that the arrangement provides for discharge at the same potential irrespective of polarity of the charge on the conductor 86.

Figs. 14 and 15 show a device similar to that of Figs. 12 and 13 except that provision is made for adjusting the discharge terminals and the control members, both with respect to each other and with respect to the dielectric member. The upper discharge terminal 97 is threaded into a collar 98 cemented in the upper end of the dielectric 89 to permit adjustment of this member relative to the opening 92. A lock nut 99 is provided for holding the discharge terminal in its adjusted positions. The control member 100 is adjustably supported on the discharge terminal 97 by adjustable nuts 101. The lower terminal 102 is supported by a yoke 103 which connects the control members 104. These control members are adjustably supported on the dielectric 89 by any suitable means such as projections 105 arranged to enter depressions 106 in the control member. The yoke 103 supports a socket 107 containing a spring 108 on which the control member 102 is adjustably supported by a nut 109 threaded on the downwardly extending stem on the lower end of the member 102. This arrangement not only permits adjustment of the terminal 102 and the controls 104 but also permits the control 102 to be forced outwardly by the expanding gases produced by a discharge so as to increase the length of the arc, helping to break the arc. The discharge member 102, after the explosion, is automatically returned to its position by the spring 108.

I claim:

1. A surge arrester comprising a tube of dielectric material, an electrode at one end of said tube and extending into the opening in said tube, said opening being enlarged adjacent the end of said electrode to provide an explosion chamber, and a capacitance member disposed outside of said tube and between the ends thereof and of opposite polarity from said electrode for inducing discharge from said electrode into said explosion chamber, said chamber having an opening to atmosphere to permit exit of a blast from said chamber for extinguishing an arc formed by discharge in said tube.

2. A surge arrester comprising a tube of dielectric material, an electrode at one end of said tube and extending into the opening therein, and means for inducing discharge from said electrode through said tube comprising a capacitance member of opposite polarity from said electrode disposed about the end of said tube opposite said electrode, the wall of said tube being tapered from a point adjacent said electrode toward the opposite end thereof to provide increased capacitance from said point toward said end.

3. A surge arrester comprising a tube of dielectric material, an electrode at one end of said tube and extending into the interior thereof, and a capacitance member of opposite polarity from said electrode and disposed outside of said tube and extending from a point between the ends of said tube toward the end thereof opposite said electrode, said capacitance member having increasing area from said point toward said end and the wall of said tube having decreasing thickness from said point toward said end to provide increasing capacity from said point toward said end to induce progress of an arc from said electrode toward the opposite end of said tube.

4. Means for controlling an electrical discharge comprising a tubular dielectric member open to atmosphere at one end thereof, discharge terminals disposed at opposite ends of said member, the terminal at said open end having a capacitance member connected therewith and extending beyond the terminal with which it is connected toward the other terminal to facilitate discharge through said member, the opening in said tubular member having an enlarged portion forming an explosion chamber and being of sufficient length that the explosion in said chamber caused by a discharge between said terminals will extinguish the arc caused by such discharge at the operating conditions for which said controlling means is designed.

5. A surge arrester comprising a tube of dielectric material, an electrode at one end of said tube and means for inducing discharge from said electrode through said tube comprising a second electrode adjacent the other end of said tube, and a capacitance member disposed outside of said tube and conductively connected with said second electrode and extending from said electrode to a point between the ends of said tube, said capacitance member having gradually increasing area from said point toward the electrode with which it is conductively connected.

6. A surge arrester comprising a tube of dielectric material, an electrode at one end of said tube and means for inducing discharge from said electrode through said tube, said means comprising a second electrode adjacent the other end of said tube and a capacitance member disposed outside of said tube and conductively connected with said second electrode for controlling the electrostatic field within said tube, said capacitance member and tube being so constructed that the electrostatic capacity of said member gradually increases from a point adjacent said first named electrode toward said second named electrode.

7. A combined discharge gap and arc clearing device comprising a dielectric member having a passage therethrough, spaced discharge terminals for directing a discharge through said passage, and means for controlling the electrostatic field between said terminals to initiate discharge through said passage, said means comprising a capacitance member of conducting material electrically connected with one of said terminals and disposed adjacent said passage but separated therefrom by said dielectric member and having one extremity thereof located in a plane normal to the axis of said tube between the adjacent extremities of said discharge terminals, said passage having an opening to atmosphere to permit exit of a blast for extinguishing the arc formed by a discharge between said terminals and being of sufficient length that the blast caused by said discharge will extinguish the arc thus formed at the operating conditions for which said device is designed.

8. A combined discharge gap and arc clearing device comprising a dielectric member formed of material having a higher flux carrying capacity than air and having a restricted passage therein, spaced discharge terminals for directing a discharge through said passage and means for controlling the electrostatic field between said terminals to initiate discharge through said pas-

sage, said means comprising a capacitance member of conducting material electrically connected with one of said terminals and disposed adjacent said passage but separated therefrom by said dielectric member and having one extremity thereof located in a plane normal to the axis of said tube between the adjacent extremities of said discharge terminals, said passage having an opening to atmosphere to permit exit of a blast for extinguishing the arc formed by a discharge through said passage.

9. A surge arrester comprising a tube of dielectric material, a pair of electrodes, one at each end of the tube, and means for producing a concentration of electrostatic stress on one of said electrodes to induce discharge through said tube, said means comprising a capacitance member of conducting material electrically connected with the other of said electrodes and disposed adjacent to but outside of the bore of said tube and between the ends of said tube but spaced away from the extremity of said first named electrode in the direction of the axis of said tube, said tube being open to atmosphere adjacent to said second named electrode.

10. A discharge protection device comprising a dielectric member having a passage therethrough, spaced discharge terminals for directing a discharge through said passage and a flux control electrically connected with one of said terminals and disposed adjacent said dielectric member and outside of said passage, and having one extremity thereof located in a plane normal to the axis of said tube between adjacent extremities of said discharge terminals to facilitate discharge through said passage, said passage being open to atmosphere at one end thereof and being of sufficient length that the blast caused by said discharge will extinguish the arc thus formed at the operating conditions for which said device is designed.

11. A surge arrester comprising a tube of dielectric material, a pair of electrodes, one at each end of said tube, and means for producing a concentration of electrostatic stress on one of said electrodes to induce a discharge through said tube, said means comprising a capacitance member electrically connected with the other of said electrodes and disposed outside of said tube and having the extremity thereof nearest said first named electrode disposed in a plane normal to the axis of said tube between said electrode and the opposite end of said tube, said tube being open to atmosphere at the end thereof adjacent to said second named electrode.

12. In an insulating device, two conducting elements shaped to provide non-uniform potential gradients over the surfaces thereof, and insulating means separating said elements, said elements being arranged so that the maximum gradient point of each of said surfaces lies in a line of electrostatic force which terminates at a region of low potential gradient at the other of said surfaces.

13. In an insulating device, a first element having a projection to provide a point of maximum potential gradient, a second element shaped to provide a surface of low potential gradient, said first element being subject to positive voltages with reference to said second element, insulating means separating said elements, said elements being arranged so that said projection lies in a line of electrostatic force which terminates in said surface, and means for preventing a positive flash-over from said second element to said projection.

14. In an insulating device, a first element having a projection to provide a point of maximum potential gradient and having a surface of low potential gradient, a second element having a second projection to provide a point of maximum potential gradient and having a second surface of low potential gradient, and insulating means separating said elements, said elements being arranged so that said first-mentioned projection and said second surface lie in one discharge path, and said second projection and said first-mentioned surface lie in another discharge path.

15. In an insulating device, a first conducting member, a second conducting member, insulating means separating said members, means for producing a point of maximum potential gradient adjacent the surface of said first member, said point of maximum potential gradient lying in a line of electrostatic force which terminates in a region of low potential gradient on said second member, and means for producing a second point of maximum potential gradient adjacent said second member, said second point of maximum potential gradient lying in a line of electrostatic force which terminates in a region of low potential gradient on said first member.

16. Electrical discharge apparatus comprising spaced electrodes, one of which is grounded and the other insulated from ground and means for providing separate discharge paths between said electrodes for different polarities of charge on said insulated electrode, said means comprising a restricted projection on each electrode providing a point of maximum potential gradient thereon, said points of maximum potential gradient being sufficiently offset relative to each other so that a discharge starting from either point will strike a portion of the opposite electrode other than the point of maximum potential gradient thereon.

17. Electrical discharge apparatus comprising spaced electrodes, one of which is grounded and the other insulated from ground, and discharge terminals on said electrodes providing two discharge paths between said electrodes, said terminals being constructed and arranged relative to each other and to said electrodes so as to produce a greater concentration of electrostatic flux on the grounded terminal of one of said paths than on the insulated terminal thereof to induce discharge along said path when said insulated electrode is charged negatively and so as to produce a greater concentration of electrostatic flux on the insulated terminal of the other path than on the grounded terminal thereof, so as to induce discharge along said other path when the charge on said insulated electrode is positive.

18. A protective device comprising a dielectric member having an opening therethrough, discharge terminals at opposite ends of said opening for directing a discharge through said opening, and control members of conducting material connected, one to each of said discharge terminals and extending each toward the other but separated from one another and from the opening in said dielectric member by the material of said dielectric member.

19. A protective device comprising a dielectric member having an opening therethrough, discharge terminals for directing a discharge through said opening, control members of conducting material connected, one to each discharge terminal and extending, each toward the other,

said control members being disposed outside of said dielectric member, and projections on said dielectric member separating said control members from each other.

20. The combination with an electrical conductor, of a discharge device connected with said conductor, said discharge device comprising a pair of tubular members, each having one end thereof open to atmosphere and each having electrodes at opposite ends thereof for directing a discharge through said tubular members, one electrode of each member being connected to said conductor and the other electrode being grounded, and means for inducing discharge through said tubular members comprising a flux control device connected with the grounded electrode of one tubular and extending toward the other electrode thereof, and a flux control device connected with the ungrounded electrode of the other tubular member and extending toward the grounded electrode thereof, each of said flux control devices terminating between planes passing through adjacent extremities of their respective electrodes and normal to the line joining said extremities.

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