

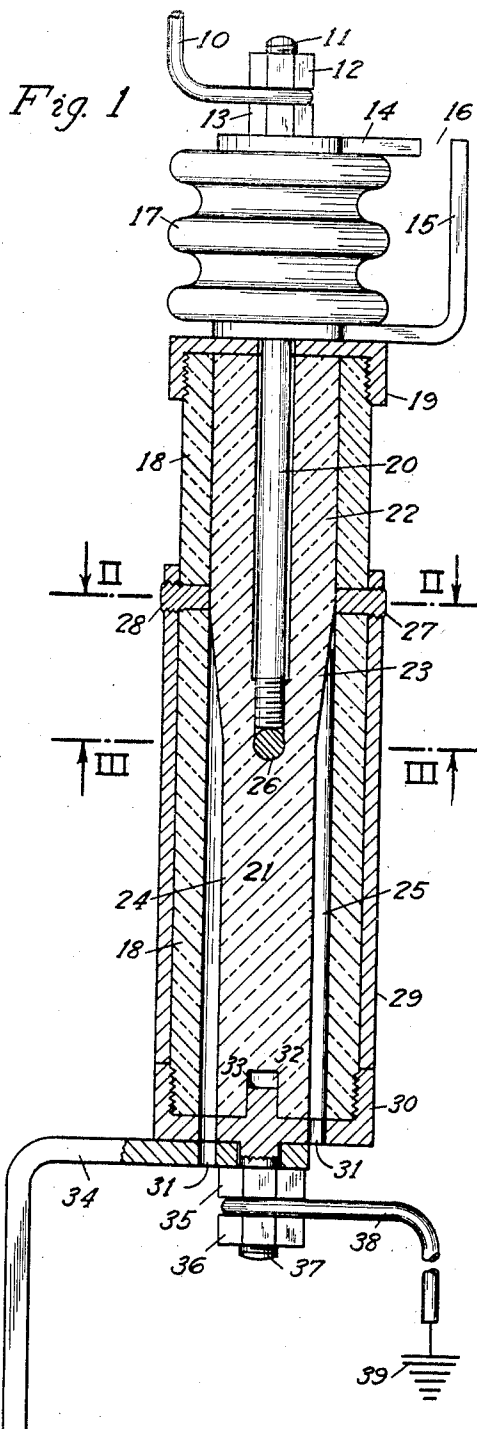
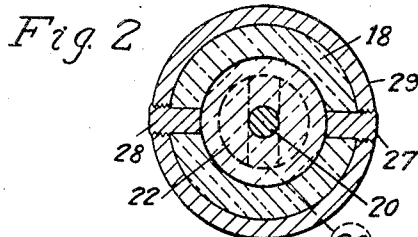
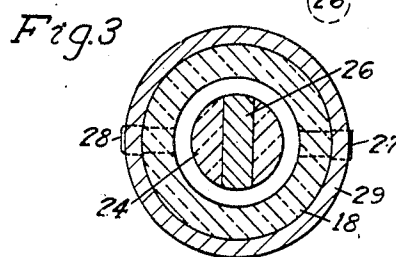
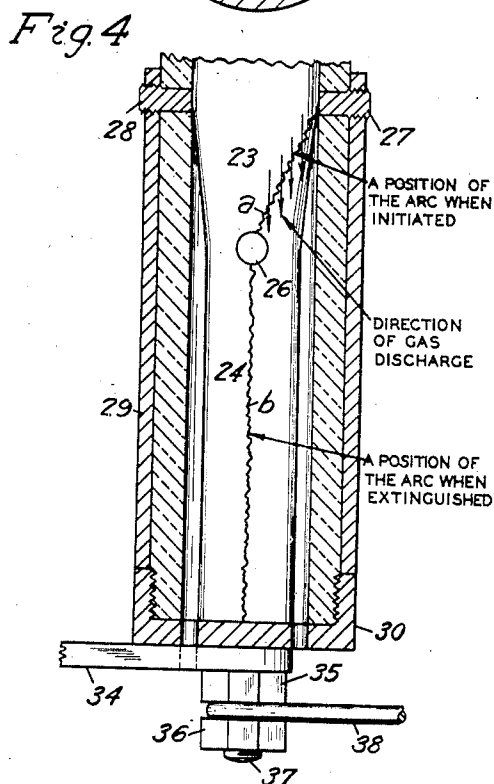
Dec. 7, 1943.

R. R. PITTMAN

2,336,420

VOLTAGE LIMITING AND ARC EXTINGUISHING DEVICE

Filed Aug. 30, 1941



INVENTOR

Ralph R. Pittman

UNITED STATES PATENT OFFICE

2,336,420

VOLTAGE LIMITING AND ARC
EXTINGUISHING DEVICE

Ralph R. Pittman, Pine Bluff, Ark.

Application August 30, 1941, Serial No. 409,009

7 Claims. (Cl. 175—30)

This invention relates generally to lightning protective devices of a character adapted for use with energized electrical circuits, for the purpose of limiting the rise in voltage of a connected conductor to a predetermined amount by discharging the abnormal or superimposed voltage to ground and preventing the passage of energy to ground upon restoration of normal electrical conditions.

The present invention is an improvement on the structure described in Patent No. 2,177,744, dated July 4, 1939, and granted to the inventor herein.

An object of the present invention is the provision of a device in which initial sparkover occurs over a predetermined path, together with means responsive to the occurrence of an arc following sparkover for quickly moving the arc away from the initial path to a remote and relatively longer path.

More specifically, it is an object of the present invention to provide an improved construction in which initial sparkover is established within a tapered annular space bounded by insulating material and between electrodes positioned at the respective ends of the space, the arrangement being such that the heat and gaseous products attending an arc within the space quickly drive the arc from the space to a longer and less restricted path remote from the space.

Such an organization makes possible a relatively close spacing of the electrodes forming the terminals of the initial sparkover path, thus providing a high degree of protection to connected apparatus by quickly discharging the excessive superimposed voltages, while at the same time providing a structure in which the erosion of the bounding insulating material between which initial sparkover occurs is a minimum, for the reason that the arc is suddenly driven, by the heat and gas attending it, from the initial path.

To illustrate the problem solved by the present invention, the quantity of electricity to be discharged by a lightning protective device which passes a current wave of 65,000 amperes decreasing to half value in 50 microseconds is less than 4 coulombs, while the quantity involved in passing only 1,000 amperes rms of alternating current for a duration of $\frac{1}{2}$ cycle at 60 cycles per second frequency is over 8 coulombs. Since devices of this character may not extinguish the arc until the first current zero, and may be connected to systems having many thousands of amperes of 60 cycle energy available, it is desirable that a structure be provided in which the 60 cycle arc is extinguished over a path such that substantial

erosion does not affect the repeated operation of the device, at the same time preventing erosion of the insulating material bounding the initial or critical breakdown path, so that it may be as short as possible. Such a structure is an object of the present invention.

With these and other objects in view which will appear from the description, my invention resides in the novel form, combination and construction of the parts of the device, and the scope of the invention will be indicated by the appended claims.

In the drawing: Fig. 1 is a side elevational view of the device, shown partly in section; Fig. 2 is a section along the line II—II of Fig. 1; Fig. 3 is a section along the line III—III of Fig. 1; and Fig. 4 is a fragmentary view of a portion of the device, shown partly in section, for the purpose of illustrating initial and final positions of an imaginary arc.

Referring in more detail to the drawing, a hollow tubular insulator 18 is closed at its upper end by means of the upper conducting terminal 19, the latter being secured to the tubular insulator 18 by means of cooperating threads on the respective members. Similarly, the lower conducting terminal 30 is secured to the lower end of the tubular insulator 18, the terminal 30 being provided with a plurality of vent openings 31 in communication with the interior of the hollow insulator 18.

The tubular insulator 18 contains the longitudinally extending element of insulating material 21, which is formed of three portions—an upper portion 22, which is preferably tightly fitted into an upper portion of the insulator 18; a lower portion 24, the outside diameter of which is less than the inside diameter of the insulator 18, thereby forming an annular space 25 between the inner surface of a lower portion of the tubular insulator 18 and the outer surface of the portion 24; and an intermediate portion 23, which joins the upper portion 22 to the lower portion 24, and which uniformly tapers from the diameter of the upper portion 22 to that of the lower portion 24. The element of insulating material 21 is circular in cross-section throughout its entire length.

A line electrode 26, of conducting material, extends diametrically through the element 21 at the juncture of the lower portion 24 with the tapered portion 23, and is electrically connected to the upper terminal 19 by the conducting member 20, the latter being fastened to the former by cooperating threads on the respective members, and extending coaxially and downwardly through the element 21 to engagement with the line electrode

26. The lower portion of the conducting member 20 may threadedly engage a portion of the element 21, if desired, to assure contact with the electrode 26.

For holding the lower portion of the element 21 in position, an integral unthreaded portion 33 of the lower conducting terminal 30 may extend upwardly for a short distance into the axially positioned upwardly extending recess 32 at the lower end of the element 21.

An externally disposed conductor, in the form of a sleeve of conducting material 29, is fitted over the lower portion of the tubular insulator 18, in physical and electrical contact with the upper surface of the lower conducting terminal 30, and extends upwardly from the contact to a point slightly above the upper end of the tapered portion 23. A pair of oppositely disposed initiating electrodes 27 and 28 extend through the sleeve 29 and the wall of the tubular insulator 18, the inner surface of each of the initiating electrodes being positioned at the inner surface of the wall of the tubular insulator 18 and at the upper end of the tapered portion 23 of the element 21. The initiating electrodes 27 and 28 may be secured in place by threaded engagement with the sleeve 29, as shown.

In accordance with common practice, a leakage-gap arrangement is provided at the upper end of the device. An insulator 17, preferably of ceramic material, is secured at its lower end in any suitable manner to the conducting member 20, and the lower leakage-gap electrode 15, which threadedly engages the conducting member 20, is positioned between the conducting terminal 19 and the lower surface of the insulator 17, and extends outwardly and upwardly in spaced relationship with the insulator 17 to a point near its upper end. A threaded stud member 11 is secured at the upper end of the insulator 17 in any suitable manner, and the upper leakage-gap electrode 14 is clamped between the top of the insulator 17 and the nut 13, the upper leakage-gap electrode 14 extending outwardly toward but spaced from the top of the lower leakage-gap electrode 15 to provide the leakage gap 16. A line conductor 10 may be conveniently connected to the device by bending it around the stud 11, the bent portion being clamped between the nuts 12 and 13.

At the lower end of the structure, the terminal member 30 is provided with a centrally positioned, downwardly extending threaded portion 37, and any suitable mounting bracket 34 attached by clamping a portion thereof between the lower surface of the terminal 30 and the nut 35, the latter being threaded on the portion 37. To complete the circuit to ground, one end of the conductor 38 is connected to the symbolically indicated ground 39, and the other end clamped between the nuts 35 and 36, the latter also being threadedly fitted on the portion 37 of the lower conducting terminal 30.

The element 21, and the tubular insulator 18, are preferably constructed from some material having high resistance to heat and ability to evolve cooling gases in the presence of an arc. One such material is hard fiber.

The weakest electrical path through the device from line conductor 10 to grounded conductor 38 includes an upwardly and laterally extending path from the line electrode 26 to either the initiating electrode 27 or 28, these paths being over the external surface of the tapered portion 23 and between its respective ends. Fig. 4 illus-

trates, at *a*, an imaginary sparkover path. Immediately following the occurrence of an arc over the sparkover or weakest electrical path, the conducting gases attending the initiation of the arc move downwardly to the vent openings 31, and the arc is transferred from its original position between the electrodes 26 and 27 (as illustrated) to a position between the line electrode 26 and the lower conducting terminal 30, the position after transfer of such an imaginary arc being indicated by the reference character *b* in Fig. 4.

The transfer of the arc from the initial to the final position is extremely rapid, particularly at the higher values of current, the time decreasing as the current in the arc increases. The higher current arcs remain in the initial path for the shorter times, this mechanism resulting in minimum erosion of the material bounding the critical sparkover path, and causing the erosion attending arc extinguishment to occur along the less critical and longer path provided. Once the arc is moved to the final path, restrike over the initial path is prevented by the downward current of gases, which immediately eject any portion of an arc playing within the device from the tapered arc space shielding the initiating electrodes.

The foregoing description of the invention is intended as illustrative rather than limiting.

I claim as my invention:

1. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator having vent means at the lower end thereof, an element of insulating material extending within said tubular insulator, said element of insulating material being formed with an upper portion which extends into and closes the upper end of said insulator, a lower portion having diameter less than the internal diameter of said insulator extending through a lower portion thereof to provide an annular space between the inner surface of said insulator and the outer surface of said lower portion of said element, and a tapered intermediate portion extending longitudinally within said insulator and joining the upper and lower portions of said element, and structural means for causing sparkover to occur between the respective ends and over the outer surface of said tapered portion, said structural means including normally insulated conducting electrodes so related that the weakest electrical path through the device is therebetween, said electrodes being mounted at the respective ends of said tapered portion.

2. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator having vent means at the lower end thereof, an element of insulating material extending within said tubular insulator, said element of insulating material being formed with an upper portion which extends into and closes the upper end of said insulator, a lower portion having a diameter less than the internal diameter of said insulator extending through a lower portion thereof to provide an annular space between the inner surface of said insulator and the outer surface of said lower portion of said element, and a tapered intermediate portion extending longitudinally within said insulator and joining the upper and lower portions of said element, and structural means for causing sparkover to occur over the outer surface of said tapered portion, said structural means including a first conducting electrode positioned at the surface

of the larger and upper end of said tapered portion, and a second conducting electrode positioned at the surface of the smaller and lower end of said tapered portion, and a conducting member engaging said second electrode and extending upwardly therefrom within said element to the upper end of said tubular insulator in spaced and insulated relationship with said first electrode.

3. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator, upper and lower conducting terminals secured to said insulator at its respective ends, a longitudinally extending element of insulating material associated with said insulator, said element being formed with an upper portion having an outside diameter substantially equal to the internal diameter of said tubular insulator, a lower portion having a diameter less than that of the upper portion, and a tapered intermediate portion between the upper and lower portions, means supporting said element within said tubular insulator, vent means at the lower end of said insulator, and structural means for causing breakdown to occur within the hollow of the insulator and over an initial path between the respective ends of said tapered portion and over the outer surface thereof, said structural means including normally insulated conducting electrodes, one electrode being positioned at a point on the outer surface of the larger and upper end of said tapered portion, the other electrode being positioned at a point on the outer surface of the smaller and lower end of said tapered portion, and a conducting member electrically connecting said other electrode to the upper terminal, said conducting member extending coaxially and upwardly within said element from said other electrode to said upper terminal in spaced and insulated relationship with said one electrode, and a conductor mounted externally on said insulator and electrically connecting said one electrode to the lower terminal.

4. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator, upper and lower conducting terminals secured to said insulator at its respective ends, a longitudinally extending element of insulating material associated with said insulator, said element being formed with an upper portion having an outside diameter substantially equal to the internal diameter of said tubular insulator, a lower portion having a diameter less than that of the upper portion, and a tapered intermediate portion between the upper and lower portions, means supporting said element within said tubular insulator, vent means at the lower end of said insulator, and structural means for causing breakdown to occur within the hollow of the insulator and over an initial path between the respective ends of said tapered portion and over the surface thereof, said structural means including normally insulated conducting electrodes, one electrode being positioned at a point on the outer surface of the larger and upper end of said tapered portion, the other electrode being positioned at a point on the outer surface of the smaller and lower end of said tapered portion and at a point below said one electrode and laterally spaced therefrom, and a conducting member electrically connecting said other electrode to the upper terminal, said conducting member extending coaxially and upwardly within said element from said

other electrode to said upper terminal in spaced and insulated relationship with said one electrode, and a conductor mounted externally on said insulator and electrically connecting said one electrode to the lower terminal.

5. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator, upper and lower conducting terminals secured to said insulator at its respective ends, a longitudinally extending element of insulating material associated with said insulator, said element being formed with an upper portion having an outside diameter substantially equal to the internal diameter of said tubular insulator, a lower portion having a diameter less than that of the upper portion and extending coaxially therewith, and a uniformly tapered intermediate portion extending coaxially between the upper and lower portions, means supporting said element within said tubular insulator in coaxial relationship therewith, vent means at the lower end of said insulator, and structural means for causing breakdown to occur within the hollow of the insulator and over an initial path between the respective ends of said tapered portion and over the surface thereof, said structural means including at least two normally insulated conducting electrodes, means supporting one electrode at a point on the outer surface of the larger and upper end of said tapered portion, means supporting the other electrode at a point on the outer surface of the smaller and lower end of said tapered portion and a point below said one electrode and laterally spaced therefrom, and a conducting member electrically connecting said other electrode to the upper terminal, said conducting member extending coaxially and upwardly within said element from said other electrode to said upper terminal in spaced and insulated relationship with said one electrode, and conducting means electrically connecting said one electrode to the lower terminal, said means being normally insulated from said other electrode.

6. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator, upper and lower conducting terminals secured to said insulator at its respective ends, a longitudinally extending element of insulating material associated with said insulator, said element being formed with an upper portion having an outside diameter substantially equal to the internal diameter of said tubular insulator and a lower portion having a diameter less than that of the upper portion, means supporting said element within said tubular insulator, said element extending longitudinally therein, vent means at the lower end of said insulator, and structural means for causing breakdown to occur over an initial path between the inner surface of said hollow insulator and the outer surface of said lower portion, said structural means including at least two normally insulated conducting electrodes, means supporting one electrode at a point on the inner surface of the tubular insulator at the lower end of said upper portion, means supporting the other electrode at a point on the outer surface of said lower portion and at a point below said one electrode, and a conducting member electrically connecting said other electrode to the upper terminal, said conducting member extending upwardly within said element from said other electrode to said upper terminal in spaced and insulated relationship with said one electrode, and conducting means electrically connecting said one elec-

trode to the lower terminal, said means being normally insulated from said other electrode.

7. A voltage limiting and arc extinguishing device comprising a hollow tubular insulator, upper and lower conducting terminals secured to said insulator at its respective ends, a longitudinally extending element of insulating material associated with said insulator, said element being formed with an upper portion having an outside diameter substantially equal to the internal diameter of said tubular insulator and a lower portion having a diameter less than that of the upper portion and extending coaxially therewith, means supporting said element within said tubular insulator in coaxial relationship therewith, vent means at the lower end of said insulator, and structural means for causing breakdown to occur over an initial path between the inner surface of said tubular insulator and the outer sur-

face of said lower portion, said structural means including at least two normally insulated conducting electrodes, means supporting one electrode at a point on the inner surface of the tubular insulator at the lower end of said upper portion, means supporting the other electrode at a point on the outer surface of said lower portion and at a point below said one electrode and laterally spaced therefrom, and a conducting member electrically connecting said other electrode to the upper terminal, said conducting member extending coaxially and upwardly within said element from said other electrode to said upper terminal in spaced and insulated relationship with respect to said one electrode, and a conductor mounted externally on said insulator and electrically connecting said one electrode to the lower terminal.

RALPH R. PITTMAN.