Sept. 11, 1951 H. L. RAWLINS ET AL 2,567,236

CIRCUIT INTERRUPTER

Filed Jan. 29, 1944

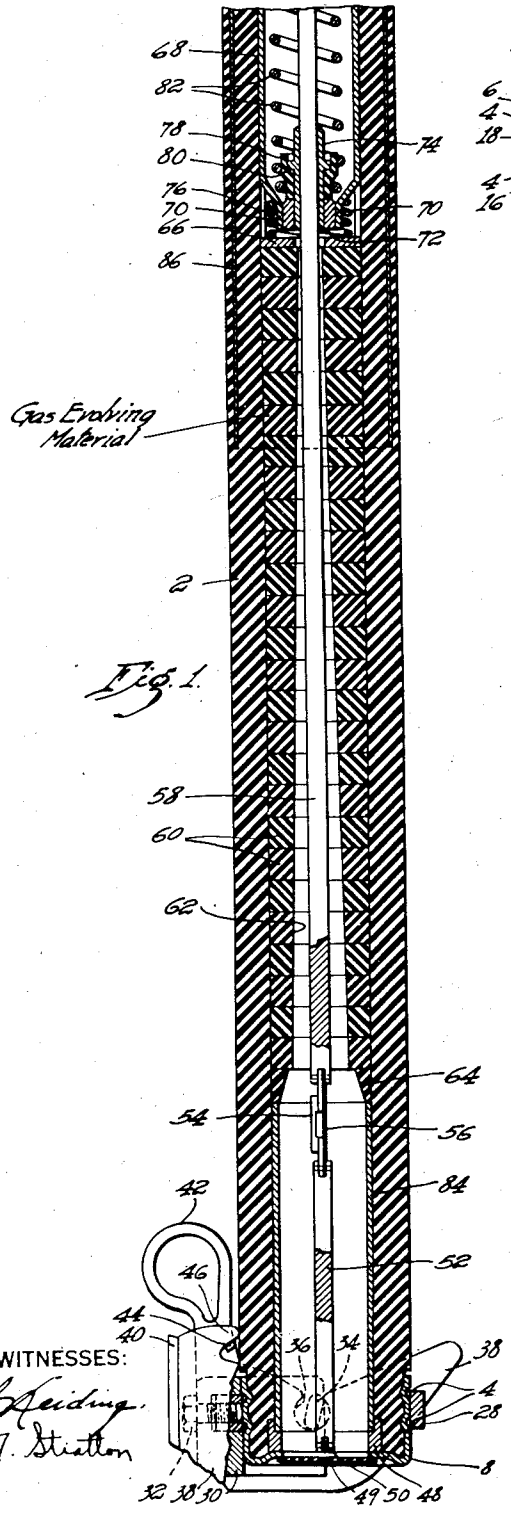


Fig. 1.

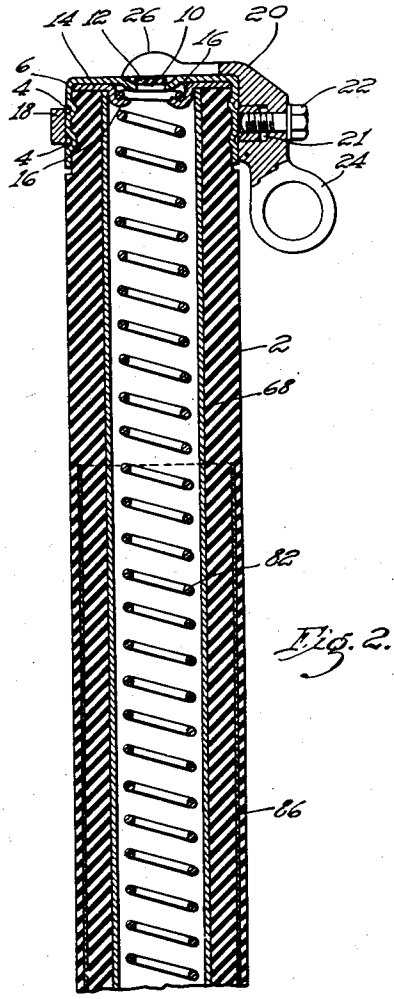


Fig. 2.

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Patented Sept. 11, 1951

2,567,236

UNITED STATES PATENT OFFICE

2,567,236

CIRCUIT INTERRUPTER

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Application January 29, 1944, Serial No. 520,178

15 Claims. (Cl. 200—120)

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This invention relates to electric circuit interrupters, in general, and more particularly, to high-voltage interrupters such as high-coltage fuses.

Although the invention is hereinafter particularly disclosed as embodied in a high-voltage power fuse of the type disclosed in the copending application of H. L. Rawlins and J. J. Mikos, Serial No. 428,710, filed January 29, 1942, now Patent No. 2,403,121 issued July 2, 1946, to the same assignee of this invention, wherein this invention has certain particular novel features of cooperation, it will be apparent to persons skilled in the art, that the invention may also be used with other types of high-voltage fuses, or with high-voltage circuit interrupters other than fuses.

In order to interrupt all overload and short circuit currents, any interrupting means employing arc lengthening means in the process of interruption must be efficient enough so that on many overloads interruption occurs after the arc has been lengthened but a very short distance. On high voltages, for example, voltages of 46 kilovolts and above, a very high-voltage stress will therefore be imposed upon interruption, across the relatively short distance between the arc terminals at this time. Since some arc extinguishing means must be employed to efficiently extinguish the arc, such as supplying un-ionized gas to the arc path by evolution, due to the heat of the arc, from the material forming the arc passage, as in the above-mentioned Rawlins et al. patent, the dielectric strength of the space within the arc passage will be very high upon interruption because of the presence of this un-ionized gas under pressure and in a very turbulent condition. Consequently, in interrupters of the type disclosed in the above-mentioned Rawlins et al. patent, where the arc is elongated by movement of a relatively small arcing rod through a tube of insulating material, the voltage stress at the time of interruption is predominantly across the air outside the tube, between the end of the arcing rod and the adjacent exterior fittings of the tube terminals of opposite polarity. At the high voltages mentioned, this high-voltage stress concentration may create ionization of the air outside the tube which will initiate a flashover for the full length of the interrupter.

While exterior flashovers of this type can be prevented by increasing the length of the interrupter, as a practical matter space considerations in the mounting of fuses limit their maximum length, and, in any event, this would not prevent ionization of the outside air in the area

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of high-voltage stress concentration at interruption, as mentioned above, in the outside space between the end of the arcing rod and adjacent tube terminal fittings.

The main object of this invention, therefore, is to provide a novel high-voltage power circuit interrupter, which is of reasonable length and yet will not flash over during interruption.

The copending application of H. H. Fahnoe on "Circuit Interrupters," Serial No. 654,571, filed March 15, 1946, which is a continuation of his abandoned application Serial No. 432,576, filed February 27, 1942, both assigned to the same assignee as this invention, disclose one means for controlling external flashover in an interrupter of this type, by transferring the area subjected to high-voltage stress during interruption so that it is located mainly through solid insulation, by embedding in the insulation forming the arc passage a tubular conductor conductively connected with the stationary arc terminal, which tubular conductor extends in the direction of movement of the arcing rod a substantial distance beyond all exterior fittings mounted on the stationary terminal.

It has been found that improved results are obtained by shifting the area subjected to high-voltage stress at interruption to the arc chamber, and, accordingly, another object of this invention is to provide a novel high-voltage fuse construction wherein the space subjected to high-voltage stress at interruption is entirely confined to the chamber where interruption occurs.

It has also been found that external flashovers may be prevented on interrupters of the type described by the use of shielding means for the moving contact rod, and, therefore, another object of this invention is to provide in an interrupter, novel means for reducing the voltage stress concentration of the relatively small moving arcing rod.

Another object of this invention is to provide an interrupter of the type described with novel means for preventing flashover after interruption, comprising means for confining the region subjected to high-voltage stress to the arc chamber in cooperation with means for reducing the stress concentration on the relatively small movable arcing rod.

Another object of this invention is to provide a high-voltage power fuse with novel means for preventing flashover following a circuit interrupting operation.

Another object of this invention is to provide a high-voltage power fuse of the type described,

with novel means for confining the high-voltage stress existing at the time of interruption to the arcing space.

Another object of this invention is to provide in a high-voltage power fuse of the type wherein the arc formed during circuit interruption is elongated by movement of a relatively small arcing rod, novel means for reducing the concentration of high-voltage stress on said rod at least following actual interruption of the circuit.

Still another object of this invention is to provide in an interrupter of the type described, a novel arrangement of withdrawing spring and arcing rod to prevent damage to the spring during interruption.

These and other objects of this invention will become more apparent upon consideration of the following description of a preferred embodiment thereof, when taken in connection with the attached drawing, in which:

Figure 1 is a partial longitudinal sectional view of a fuse embodying the invention, and

Fig. 2 is a view similar to Fig. 1 but showing the remaining portion of the fuse.

Referring to the drawing, wherein the invention is disclosed as being embodied in a high-voltage power fuse of the general type disclosed in the above-mentioned copending applications and patent, it will be observed that the fuse is enclosed in a fuse tube 2 of insulating material, such as fiber or a synthetic resin. End terminal caps 6 and 8 are provided for the opposite ends of fuse tube 2, and these caps may be secured on the tube in any desired manner, such, for example, as by having circular indentations 4 rolled therein to form and engage in depressions in the tube proper. The upper terminal cap 6 is provided with a substantially centrally located aperture 10 which is normally closed by a disk 12 of insulating material and this disk may be adhesively secured in position. The terminal cap 6 also serves to secure between it and the end of fuse tube 2 an anchor disk 14 having integral supporting arms 16, for a purpose to be described. The terminal cap 6 may have a terminal fixture secured thereto for cooperation with a line contact, which fixture comprises a clamping ring 18 of a size to freely fit over the terminal cap, and this ring is secured to the cap by a clamping member 20 adapted to fit part way about the terminal cap, and having a groove 21 for receiving the clamping ring 18. Clamping member 20 is provided with an aperture for receiving a screw 22, which is adapted to be threaded into an aperture provided in clamping ring 18 to move the clamping ring and member in opposite directions when the screw is tightened to thereby tightly clamp the ring and member to terminal cap 6. Clamping member 20 is preferably provided with an integral hook eye 24 to facilitate manual manipulation of the fuse, and may also be provided with integral latch projections 26 (only one of which is shown) at opposite sides of the fuse tube for cooperation with a line contact latch for maintaining the fuse in engagement with the line contact.

The other terminal cap 8 may also be provided with a terminal fixture secured thereto in substantially the same manner as the terminal fixture mounted on terminal cap 6. Thus, a clamping ring 28 may be slipped over terminal cap 8, and secured thereto by a clamping member 30 of arcuate form, and having an arcuate slot for receiving a portion of the clamping ring.

The clamping ring 28 and member 30 are secured on terminal cap 8 by a screw 32 in the same manner as clamping ring 18 and member 20 are secured to the upper terminal cap 6. Clamping member 30 is preferably provided with integral flat sided trunnions 34 at opposite sides thereof (only one of which is shown) adapted to be received in keyhole slots 36 provided in spaced supporting plates 38 positioned at opposite sides of terminal cap 8. The fuse is thus pivotally mounted with respect to supporting plates 38, and the keyhole slot 36 cooperates with trunnions 34 so that the trunnions are prevented from escaping from the slots except when the fuse is substantially in a vertical position. Supporting plates 38 are preferably integrally joined at one end to a base plate 40 which may be secured in any desired manner to a supporting insulator. Clamping member 30 preferably is provided with an integral hook eye 42 which will be accessible when the fuse is in a vertical depending position with respect to supporting plates 38, for lifting the fuse out from between the supporting plates. Clamping member 30 is also provided adjacent hook eyes 42 with oppositely extending stop lugs 44, which are adapted to engage beneath a locking projection 46 integral with each supporting plate 38 to prevent escape of trunnions 34 from keyhole slots 36 in the vertically upright position of the fuse. Obviously, when the fuse is pivotally moved to any other position, lugs 44 move from beneath locking projections 46.

Terminal cap 8 is adapted to secure a supporting ring 48 in engagement with an internal shoulder on fuse tube 2. A cross bar 50 extends diametrically across supporting ring 48 and may be integral therewith. Terminal cap 8 is provided with a relatively large aperture adapted to be normally covered by a closure disk 49 of insulating material, which may be adhesively secured to the terminal cap. A stationary terminal rod 52, of conducting material, such, for example, as copper or the like, is slotted at one end for securement to cross bar 50 in any desired manner, such, for example, as by a rivet or the like. The other end of terminal rod 52 is also slotted so that a fusible element 54 and strain element 56 may be secured thereto. An arcing rod 58 preferably has one end thereof slotted for receiving the other ends of fusible element 54 and strain element 56, so as to be normally held in the position shown in Fig. 1, where the arcing rod 58 extends through a bore 62 provided in a plurality of superposed blocks 60 of an insulating material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, such, for example, as boric acid, or the like. Preferably the bore 62 is made to taper from a relatively large diameter adjacent the fusible element 54 to a relatively small diameter of substantially the same size as arcing rod 58 at the other end thereof. The blocks 60 are supported at one end by a spacer block 64 having a tapered aperture therein leading to the adjacent end of bore 62. The other end of the stack of blocks 60 is held in position by a washer 66 maintained in spaced relation with respect to terminal cap 6 by a tube 68 of conducting material, such, for example, as copper or the like.

Arcing rod 58 is normally electrically connected with terminal cap 6 by contact fingers 70 formed by inwardly bent portions of the lower end of conductor tube 68, to engage a contact ring 72 secured on a supporting sleeve 74, which,

in turn, is secured on arcing rod 58. Contact ring 72, supporting sleeve 74, and arcing rod 58 may be secured together in any desired manner, such, for example, as by friction, welding, or the like. A small coil compression spring 76 reacts between washer 66 and the inwardly bent portions of contact fingers 70 to bias the contact fingers into engagement with contact ring 72 on the arcing rod.

A spring anchoring sleeve 78 of insulating material, such, for example, as fiber or the like, is adapted to be mounted on supporting sleeve 74 above contact ring 72, and to be held in position by an annular projection 80 on sleeve 74. This is for the purpose of anchoring one end of a coil tension spring 82 by having the end coils of the spring tightly engaging the portion of anchor sleeve 78 below projection 80. The other end of spring 82 has the end coil thereof seated on supporting arms 15, previously described.

The structure thus far described is substantially the same as that disclosed in the copending applications of H. L. Rawlins et al. and H. H. Fahnoe mentioned above, and differs only in the method of anchoring tension spring 82 to arcing rod 58, and by the provision of stationary terminal rod 52 which has the effect of shifting the fusible elements from a point adjacent the lower end of the tube as in the previous disclosures to a point spaced a considerable distance from that end of the tube. This also results in the shifting of arc bore 62 a corresponding distance from the adjacent end of fuse tube 2.

In operation, the fuse described above functions similarly to those of the above-mentioned copending applications in that upon the occurrence of an overload sufficient to melt fusible element 54, strain element 56 also melts substantially instantaneously, so that coil tension spring 82 is then free to move arcing rod 58 through bore 62. This has the effect of elongating the arc and drawing it out into intimate relation with gas evolving material 60, to cause the evolution therefrom of un-ionized gas which builds up a certain amount of pressure within bore 62, and is in a turbulent state in the bore due to the lateral flow thereof into the bore, and longitudinal flow out of the bore. Longitudinal flow of gas through the bore is permitted by displacement of closure disk 49, as soon as pressure is built up within the bore sufficient to overcome the holding power of the means holding the closure disk in place. This combination of arc elongation and flow of un-ionized gas through the arc results in a very efficient arc extinguisher, so that on many overloads the arc will be extinguished in but a very short travel of arcing rod 58. On other overloads, the arc may be drawn out for a considerable portion of the length of bore 62 wherein it is progressively restricted by the tapered form of the bore. After the arc is extinguished, movement of the arcing rod 58 continues, with the upper end thereof being projected through opening 10 in terminal cap 6 to displace closure disk 12, until supporting sleeve 74 on the arcing rod engages the terminal cap to halt further movement. This projection of the end of arcing rod 58 through aperture 10 in terminal cap 6, provides a readily visible indication of the operation of the fuse, and may be utilized, as in the Rawlins et al. application previously mentioned, to actuate a release mechanism, if desired. It will be observed that normally the current path through the fuse extends from terminal cap 6 by way of tube 68, contact

fingers 70, contact ring 72, to arcing rod 58, fusible element 54, stationary terminal rod 52, and to the other terminal cap 8. Tension spring 82 normally carries no current, because of anchor sleeve 78 of insulating material. This prevents arcing to the lower turns of coil spring 82 during a circuit interrupting operation, which was found to occur under some conditions in previous designs. The current is carried from arcing rod 58 to tubular conductor 68 during interruption, that is, after disengagement of contact ring 72 from contact finger 70, by an arc from the contact fingers 70 to arcing rod 58. One difference from the previous designs, therefore, is the insulation of withdrawing spring 82 from the circuit through the fuse.

Another difference in the operation of this fuse from prior designs is due to the provision of stationary terminal rod 52. Where fuses are used at very high voltages, for example, from 46 kv. and above, difficulty may be encountered because the voltage stress becomes very highly concentrated at the closest points of opposite polarity, because these points are of such small area. This high stress concentration creates ionization of the surrounding air when one of the points of high stress concentration is located on the outside of the fuse, and this may cause an external flashover and consequent failure of the device. Thus, prior devices which did not employ a stationary terminal rod 52, but instead had fusible element 54 and the adjacent end of bore 62 located at the adjacent open end of the fuse tube, obtained points of high-voltage stress concentration during and after circuit interruption at the upper ends of supporting plates 38, and at the upper end of hook eye 42 outside of fuse tube 2. The lower end of arcing rod 58, of course, provided a highly concentrated point of voltage stress of opposite polarity. Moreover, in such prior devices during interruption, the highly concentrated point of voltage stress at the arcing tip of rod 58 had to move past the highly concentrated points of voltage stress on members 38 and 42. The relative movement of these points of high-voltage stress concentration past each other often caused an arc through the side wall of tube 2 through the ionized outside air, which would touch off a flashover over the entire length of fuse tube 2. Moreover, immediately after the arc was extinguished on such prior devices, the high recovery voltage would be concentrated at the same points, and it was found that this also under certain conditions would cause an arc between the points of high-stress concentration which touches off a flashover between the fuse terminals. The reason for this appears to be that, because of the high efficiency of the interrupter which causes bore 62 to be filled with un-ionized gas at elevated pressure, in a turbulent condition, the dielectric strength of available paths within the fuse tube 2 is very high, so that the voltage stress during and after interruption is predominantly from the end of arcing rod 58, through the side of the fuse tube and across the air outside the fuse adjacent to the external fittings which, as previously stated, may be in at least partially ionized condition. The provision of stationary terminal rod 52 places a point of the same polarity as terminal cap 8 and all parts secured thereto within the fuse tube, above the outermost points on supporting plate 38 and hook eye 42. The free end of stationary terminal rod 52 thus becomes the point of high-voltage stress concentration associated

with terminal cap 8, and since this is located substantially at the end of bore 62, this results in locating the high-voltage stress concentration substantially entirely through bore 62 where the dielectric strength is greatest. It has also been found to be desirable to reduce the concentration of voltage stress, by providing a tube 84 of conducting material, which may also act to maintain spacer block 64 in spaced relation with respect to terminal cap 8, by engagement of tube 84 with the spacer block 64 and with a shoulder provided on supporting ring 48. Tube 84, being concentric with terminal rod 52, functions to distribute the high-voltage stress annularly, instead of being entirely concentrated on the relatively small area provided by the end of stationary terminal rod 52, and also enables the use of a flexible conductor in place of stationary terminal rod 52, if desired. Tube 84 has the further advantage, since it extends to a point above rod 52 which is closer to the lower end of bore 62, that the arc drawn by rod 58 when the fuse blows will transfer from terminal rod 52 to the tube 84, which places this end of the arc directly at the lower end of bore 62.

While the provision of stationary terminal rod 52 and conducting tube 84 forms a very satisfactory method to prevent external flashovers on very high voltages, it may be desirable where extremely severe voltage recovery rate conditions are encountered, to provide a means such as the tubular conductor 86 for reducing the voltage stress concentration on the arcing tip of rod 58. Tubular conductor 86 constitutes, in effect, an electrostatic shield, and is preferably embedded in the material of fuse tube 2. Where the fuse tube is made of a laminated plastic material, tubular conductor 86 may comprise a conducting foil, or conducting layer of plastic material, incorporated between the laminations of the tube. Tube 86 will assume substantially the same potential as arcing rod 58 by capacity effect, or it may have the same potential by actual conduction if the tube 86 is extended to terminal cap 6, so that the stress concentration which would otherwise have been concentrated on the small area of the arcing tip of rod 58 is distributed annularly by tubular conductor 86, so that the concentration is materially reduced, thereby reducing the ability to ionize adjacent atmospheric air.

The structure described above makes provision in a circuit interrupter of the type where the arc is elongated in extinguishing it, for means to prevent external flashover by reducing the concentration of high voltage at points of opposite polarity, and confining the high-voltage stress to an area of extremely high dielectric strength.

Although means are disclosed for accomplishing the foregoing result at points of opposite polarity, it is obvious that for certain applications it will be sufficient merely to employ applicants' novel stress concentration reducing means for but a single terminal of the device. This invention also makes provision for isolating the arc lengthening spring from the electric circuit through the interrupter, to thereby prevent damage to this spring and insure that the arc will be drawn out to the proper length so that it can be extinguished.

Having described a preferred embodiment of the invention in accordance with the patent statutes, it is desired that the invention be not limited to this particular embodiment inasmuch as it will be obvious, particularly to persons

skilled in the art, that many modifications and changes may be made in this particular structure without departing from the broad spirit and scope of this invention, as defined in the following claims.

We claim as our invention:

1. In a high-voltage power circuit interrupter, tubular means of insulating material having a tubular arc passage therein, terminal means at least adjacent one end of said tubular means, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress may be concentrated, means providing a dielectric strength in said passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, said terminal means having conducting means which is located outside said tubular means extending inwardly along the outer surface of said tubular means and is electrically connected with said terminal means at least when said interrupter is mounted in operative position, said conducting means being unsymmetrical in form so as to provide a portion of high-voltage stress concentration outside said tubular means, and a relatively thin-walled annular stationary arc terminal in said tubular means, said stationary arc terminal being exposed to the interior of said arc passage and having an external dimension substantially the same as the internal dimension of said tubular means and an internal dimension substantially larger than said arc passage, said stationary arc terminal further being electrically connected with said terminal means and extending away from said one end of said tubular means a substantial distance which is far enough beyond said portion of high voltage stress concentration outside of said tubular means so that said arc will be substantially entirely located in said arc passage.

2. In a high-voltage power circuit interrupter, tubular means of insulating material having a tubular arc passage therein, terminal means at least adjacent one end of said tubular means, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress of one polarity may be concentrated, means providing a dielectric strength in said passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, said terminal means located adjacent said one end of said tubular means having conducting means which is located outside said tubular means extending inwardly along the outer surface of said tubular means and is electrically connected therewith at least when said interrupter is mounted in operative position, said conducting means being unsymmetrical in form so as to provide a portion of high-voltage stress concentration outside said tubular means, and means for confining said high-voltage stress to said passage to prevent external discharge and flashover during and after movement of said movable arc terminal means, said stress confining means comprising conducting means electrically connected

with said terminal means and fixedly secured with respect to said tubular means and extending inwardly to a point close to the adjacent end of said passage to form a stationary point of high-voltage stress concentration of opposite polarity which is located in said tubular means a distance from said one end thereof which is at least substantially beyond said outside portion of high-voltage stress concentration, and said stress confining conducting means being exposed to the interior of said arc passage to form a stationary arc terminal.

3. In a high-voltage power fuse, a fuse tube of insulating material open at its lower end during operation of the fuse for the expulsion of gases formed during a circuit interrupting operation, terminals mounted on said tube adjacent the upper and lower ends thereof, a restricted arc passage formed in said tube and being open at its lower end, said arc passage having inner wall portions of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, an arcing terminal electrically connected with the upper tube terminal and mounted for movement through said arc passage, said lower tube terminal having conducting means located outside of said tube and electrically connected therewith at least when said fuse is mounted in operative position, said conducting means providing a portion of high-voltage stress concentration outside said tube, a stationary arcing terminal electrically connected with the lower tube terminal and extending into said tube a distance substantially beyond said outside portion of high-voltage stress concentration and into proximity with the adjacent end of said arc passage, fusible means connecting the adjacent ends of said stationary and movable arcing terminals, and means biasing said movable arcing terminal for upward movement through said passage away from the open end of the tube so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means and the voltage stress during and after interruption will be confined by said arcing terminals within said tube and arc passage, and said stationary arcing terminal being of relatively small cross section area so as not to substantially impede the aforesaid expulsion of gases from the open end of said tube.

4. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on said tube adjacent the upper and lower ends thereof, a restricted arc passage formed in said tube and being open at its lower end, said arc passage having inner wall portions of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said arc passage, said lower tube terminal having conducting means which is located outside of said tube and is electrically connected therewith at least when said fuse is mounted in operative position, said conducting means providing a portion of high-voltage stress concentration outside said tube, a tubular stationary arcing terminal electrically connected with the lower tube teminal, said tubular stationary arcing terminal having a relatively large bore and extending into said tube a distance at least beyond said outside portion of high-voltage stress concentration and into proximity with the adjacent end of said arc passage and being exposed thereto, fusible means connecting said stationary and movable arcing terminals, and means biasing said movable arcing terminal for upward movement through said arc passage so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means and the voltage stress during and after interruption will be confined by said arc terminals within said tube and arc passage.

5. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on said tube adjacent the upper and lower ends thereof, a restricted arc passage formed in said tube and being open at its lower end, said arc passage having inner wall portions of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said passage, said lower tube terminal having conducting means which is located outside of said tube and is electrically connected therewith at least when said fuse is mounted in operative position, said conducting means providing a portion of high-voltage stress concentration outside said tube, a tubular stationary arcing terminal having a relatively large bore electrically connected with the lower tube terminal, said tubular stationary arcing terminal extending into said tube a distance at least beyond said outside portion of high-voltage stress concentration and into proximity with the adjacent end of said arc passage and being exposed thereto, fusible means connecting said stationary and movable arcing terminals with at least the major portion of said fusible means being located within said tubular arcing terminal, and means biasing said movable arcing terminal for upward movement through said passage so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means, and the voltage stress during and after interruption will be confined by said arc terminals within said tube and arc passage.

6. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on said tube adjacent the upper and lower ends thereof, a restricted arc passage formed in said tube and being open at its lower end, said arc passage having inner wall portions of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said passage, said lower tube terminal having conducting means which is located outside of said fuse and is electrically connected therewith at least when said fuse is mounted in operative position, said conducting means providing a portion of high-voltage stress concentration outside said tube, a tubular stationary arcing terminal having a relatively large bore electrically connected with the lower tube terminal, said tubular stationary arcing terminal extending into said tube a distance at least beyond said outside portion of high-voltage stress concentration and into proximity with the adjacent end of said arc passage, fusible means connecting said stationary and movable arcing terminals and located closely adjacent the inner end of said tubular stationary arcing terminal so that the latter acts as a corona shield for said fusible means, and means biasing said movable arcing terminal for upward movement through said arc passage so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means, and the voltage stress during and after interruption will be confined by said arc terminals within said tube and arc passage.

7. In a high-voltage power tube, a fuse tube of insulating material open at one end for the expulsion of gases formed during a circuit interrupting operation, terminals mounted on said tube adjacent the upper and lower ends thereof, a restricted arc passage formed in said tube and being open at its lower end, said arc passage having inner wall portions of a material which is capable of evolving an arc extinguishing gas when in proximity to an electric arc, an arcing terminal electrically connected with the upper tube terminal and mounted for movement through said arc passage, said lower tube terminal having conducting means located on the outside surface of said tube and electrically connected therewith at least when said fuse is mounted in operative position, said conducting means providing a portion of high-voltage stress concentration outside said tube, a stationary arcing terminal electrically connected with the lower tube terminal and extending into said tube a distance substantially beyond said outside portion of high-voltage stress concentration and into proximity with the adjacent end of said arc passage, said stationary arcing terminal comprising at least at its inner end a central portion and an annular portion receiving said central portion in spaced relation, fusible means connecting said movable arcing terminal to the central portion of said stationary arcing terminal, and means biasing said movable arcing terminal for upward movement through said passage away from the open end of the tube so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means and the voltage stress during and after interruption will be confined by said arc terminals within said tube and arc passage.

8. In a high-voltage power circuit interrupter, tubular means of insulating material having a tubular arc passage therein, terminal means at least adjacent one end of said tubular means, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress of one polarity may be concentrated, means providing a dielectric strength in said arc passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, means for confining said high-voltage stress to said arc passage to prevent external discharge and flashover during and after movement of said movable arc terminal means, said stress confining means comprising conducting means electrically connected with said terminal means and fixedly secured with respect to said tubular means and extending inwardly to and terminating at a point which is adjacent and exposed to the end of said arc passage closest to said one end of said tubular means to form a stationary arcing terminal point of high-voltage stress concentration of opposite polarity which is located in said tubular means a distance from said one end thereof which is at least beyond any conductive part associated with said terminal means at the outside of said tubular means, and tubular means of conducting material within the outer confines of said tubular means of insulating material and position to receive in spaced relation at least one of said points of high-voltage stress and being electrically associated therewith in a manner to reduce the concentration of voltage stress thereon.

9. In a high-voltage power circuit interrupter, tubular means of insulating material having a tubular arc passage therein, terminal means at least adjacent one end of said tubular means, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress of one polarity may be concentrated, means providing a dielectric strength in said arc passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, and means for confining said high-voltage stress to said arc passage to prevent external discharge and flashover during and after movement of said movable arc terminal means, said stress confining means comprising conducting means electrically connected with said terminal means and fixedly secured with respect to tubular means and extending inwardly to and terminating at a point which is adjacent the end of said arc passage closest to said one end of said tubular means to form a stationary point of high-voltage stress concentration of opposite polarity which is located in said tubular means a distance from said one end of said tubular means which is at least beyond any conductive part associated with said terminal means at the outside of said tubular means, and tubular means of conducting material within the outer confines of said tubular means of insulating material and positioned to receive in spaced relation both of said points of high-voltage stress and being electrically connected therewith in a manner to reduce the concentration of voltage stress thereon.

10. In a high-voltage power circuit interrupter, tubular means of insulating material having a tubular arc passage therein, terminal means at least adjacent one end of said tubular means, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress of one polarity may be concentrated, means providing a dielectric strength in said arc passage during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, means for confining said high-voltage stress to said arc passage to prevent external discharge and flashover during and after movement of said movable arc terminal means, said stress confining means comprising conducting means electrically connected with said terminal means and fixedly mounted relative to said tubular means and extending toward the end of said arc passage closest to said one end of said tubular means a distance from said one end of said tubular means which is at least beyond any conductive part associated with said terminal means at the outside of said tubular means, and tubular means of conducting material also electrically connected with said terminal means and fixedly mounted relative to said tubular means of insulating material and located in said tubular means of insulating material in spaced surrounding relation with and extending inwardly beyond the first-mentioned conducting means to form an annular stationary point of

voltage stress concentration of opposite polarity during and after a circuit interrupting operation.

11. In a high-voltage power circuit interrupter, tubular means of insulating material forming a tubular arc passage, terminal means at least at one end of said arc passage, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal means during and after a circuit interrupting operation constituting a point where high-voltage stress may be concentrated, means providing a dielectric strength in said arc passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, and means for relieving the concentration of voltage stress on said movable arc terminal means to prevent discharge therefrom through the side wall of said passage to the portions of said terminal means outside the passage, said stress relieving means comprising a tube of conducting material spaced from said one end of the arc passage and in insulated relation with said terminal means, and said tube being supported so as to telescopically receive at least a portion of said arc passage through which said movable arc terminal means operates.

12. In a high-voltage power circuit interrupter, tubular means of insulating material forming a tubular arc passage, terminal means at least at one end of said arc passage, arc terminal means movable through said arc passage in a direction away from said terminal means to elongate the arc formed during a circuit interrupting operation, said movable arc terminal during and after a circuit interrupting operation constituting a point where high-voltage stress may be concentrated, means providing a dielectric strength in said arc passage at least during a circuit interrupting operation which is greater than the dielectric strength of the medium outside of said tubular means, and means for relieving the concentration of voltage stress on said movable arc terminal means to prevent discharge therefrom through the side wall of said arc passage to the portions of said terminal means outside the arc passage, said stress relieving means comprising a tube of conducting material spaced from said one end of the arc passage and in insulated relation with said terminal means, and said tube being embedded in said insulating material so as to telescopically receive at least a portion of said arc passage through which said movable arc terminal means operates.

13. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on the upper and lower ends of said tube, a restricted arc passage formed in said tubular means and opening at its end adjacent the lower end of said tube, said arc passage having inner wall portions of a material which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said arc passage, fusible means connecting said movable arcing terminal to the lower tube terminal, means biasing said movable terminal for upward movement through said passage, the upper tube terminal having stationary contact means in said tube, a contact portion on said movable arcing terminal positioned to engage said contact means at least in the closed circuit position, whereby upon fusion of said fusible means said arcing terminal is moved upwardly through said arc passage by said biasing means to elongate the arc and the arcing tip of said movable arcing terminal constitutes a point where high-voltage stress may be concentrated, and tubular means of conducting material supported by said tube in insulated relation with said lower terminal and within the outer confines of said tube so as to be concentric with and to telescopically receive at least an upper portion of said arc passage through which said arcing tip moves during a circuit interrupting operation so that said tubular means can relieve the voltage stress at the outer surface of said fuse tube at the location corresponding to that of said arcing tip immediately following arc extinction, and when the rod has completed its movement through said arc passage, the lower end of said tubular means is located below said arcing tip so as to at least then become the lowermost point having a potential due to the potential at the upper tube terminal.

14. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on the upper and lower ends of said tube, a restricted arc passage formed in said tubular means and opening at its end adjacent the lower end of said tube, said arc passage having inner wall portions of a material which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said arc passage, fusible means connecting said movable arcing terminal to the lower tube terminal, means biasing said movable terminal for upward movement through said arc passage, means for carrying current from the upper tube terminal to said movable arcing terminal, whereby upon fusion of said fusible means said movable arcing terminal is moved upwardly through said passage by said biasing means to elongate the arc and the arcing tip of said movable arcing terminal constitutes a point where high-voltage stress may be concentrated, and tubular means of conducting material supported by said tube in insulated relation with said lower terminal and so as to be concentric with and to telescopically receive at least an upper portion of said arc passage through which said arcing tip moves during a circuit interrupting operation so that said tubular means can relieve the voltage stress at the outer surface of said fuse tube at the location corresponding to that of said arcing tip immediately following arc extinction, and when the rod has completed its movement through said arc passage, the lower end of said tubular means is located below said arcing tip so as to at least then become the lowermost point having a potential due to the potential at the upper tube terminal.

15. In a high-voltage power fuse, a fuse tube of insulating material, terminals mounted on the upper and lower ends of said tube, a restricted arc passage formed in said tubular means and opening at its end adjacent the lower end of said tube, said passage having inner wall portions of a material which is capable of evolving an arc-extinguishing gas when in proximity to an electric arc, an elongated arcing terminal mounted for movement through said arc passage, a tubular stationary arcing terminal connected with the lower tube terminal and extending into said tube a distance at least beyond all conductive parts associated with said lower tube terminal at the outside of said tube and exposed at its inner end to the lower end of said arc passage, fusible means connecting the inner ends of said stationary and movable arcing terminals, means biasing said

movable arcing terminal for movement through said arc passage so that the arc will be drawn out and extinguished in said arc passage upon fusion of said fusible means, and the voltage stress during and after interruption will be confined by said arcing terminals within said tube and arc passage, and tubular means of conducting material supported by said tube so as to be concentric with at least a portion of said arc passage through which said movable arcing terminal operates, whereby the voltage stress at both arcing terminals is distributed annularly to reduce the concentration thereof.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,466,423	Conrad	Aug. 28, 1923
1,730,716	Austin	Oct. 8, 1929
2,167,781	Schweitzer, Jr.	Aug. 1, 1939
2,188,792	Muller	Jan. 30, 1940
2,247,702	Ramsey	July 1, 1941
2,292,088	Rawlins	Aug. 4, 1942
2,315,618	Huffstutter	Aug. 6, 1943
2,342,310	Taylor	Feb. 22, 1944
2,403,121	Rawlins et al.	July 2, 1946