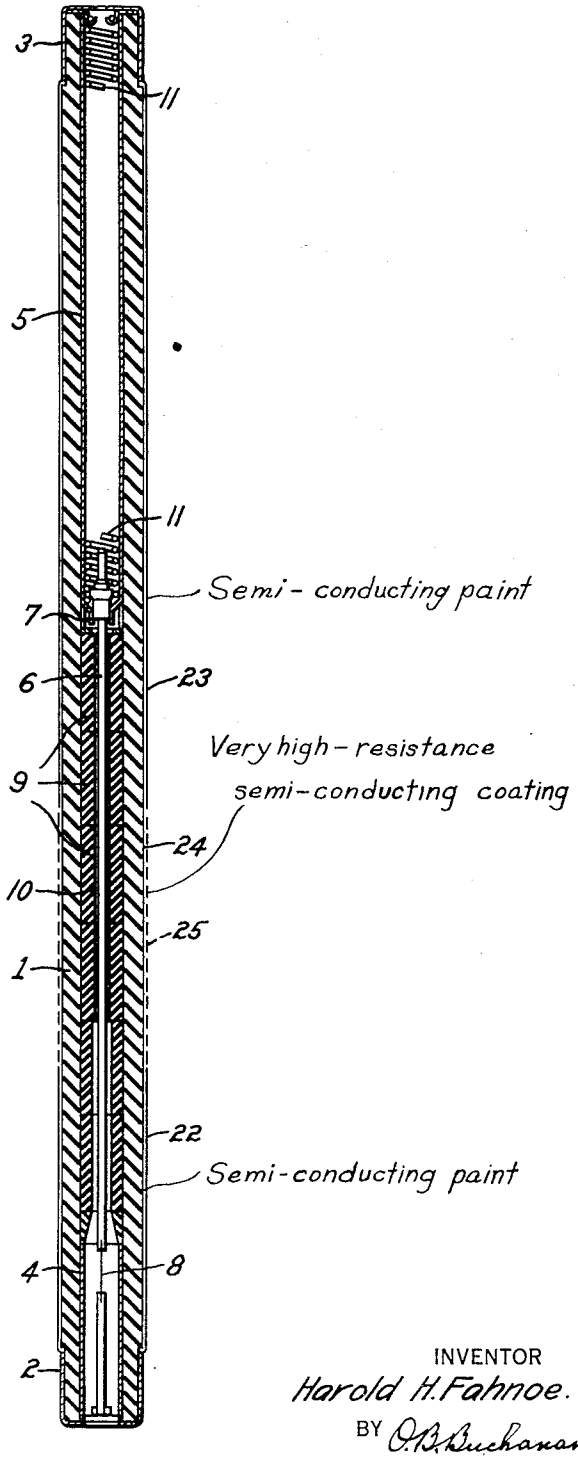
April 22, 1952 H. H. FAHNOE 2,593,426

HIGH-VOLTAGE POWER-FUSE AND THE LIKE

Filed Nov. 12, 1948



WITNESSES:

Wm. B. Sellers.

Wm. C. Groome

INVENTOR

Harold H. Fahnoe.

BY O. B. Buchanan

ATTORNEY

Patented Apr. 22, 1952

2,593,426

UNITED STATES PATENT OFFICE

2,593,426

HIGH-VOLTAGE POWER FUSE AND THE LIKE

Harold H. Fahnoe, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application November 12, 1948, Serial No. 59,712

21 Claims. (Cl. 200—120)

1

My invention is particularly related to an improvement in the type of high-voltage dropout fuse which is described and claimed in an application of H. L. Rawlins and myself, Serial No. 520,178, filed January 29, 1944, now Patent No. 2,567,236 dated Sept. 11, 1951, which in turn is an improvement over the circuit-interrupter of the Rawlins and Mikos Patent 2,403,121, granted July 2, 1946. While my invention is primarily designed and adapted for this fuse type of circuit-interrupter, it will be understood that my invention is not altogether limited to this particular type of circuit-interrupter, as certain features of my invention will be found to be of more general application.

In tube-type circuit-interrupting devices which are adapted to operate in a power-line circuit at a voltage which is high enough to make corona a problem, serious difficulty has been experienced by reason of the accumulation of thick incrustations of greenish nitrate salts on the copper conductor-rod which is disposed inside of the tube, as a result of the corona which is produced at the outside surface of this rod by reason of the high operating-voltage of the line in which the device is located. This incrustation forms during the period of time when the device is carrying the line-current, that is, before it undertakes to perform its circuit-interrupting action in response to an overcurrent in the line.

This difficulty has been experienced more particularly in the type of high-voltage power-fuse which has already been referred to, in which it is necessary for the conductor-rod in question to be withdrawn longitudinally through the bore of a boric-acid lining in the tube, during the circuit-interrupting operation of the tube, that is, after the fuse-element therein has melted. It is necessary for the bore of this boric-acid lining to be as small as practicable, in order that the arc which results from the current-interruption will come into contact with the side-walls of said bore, as the rod is being withdrawn out of the bore during the circuit-interrupting operation, so that the surfaces of said bore will evolve arc-extinguishing gases. In order that the rod shall have sufficient mechanical strength and current-carrying ability, the outer diameter of the rod cannot be made much smaller than the bore of the boric-acid lining, so that, when the rod is subjected to the influences of corona, it does not take very much outer incrustation on the rod to prevent it from being withdrawn through the bore of the boric-acid liner during the circuit-interrupting operation.

2

The foregoing difficulty has been experienced in all of the standard high-voltage power-fuses of the type described, in all of the high-voltage ratings, namely 69, 92, 115, and 138 kilovolts. The diameter of the movable conductor-rod within these standard tubes has been ¼ inch, and at this diameter there has been very considerable corona at the exposed surface of the rod, between the two internal, tubular shields or electrodes which have been previously used, and which will be subsequently described. Consideration of the curve showing the relation between the incipient corona-starting voltage and the diameter of the conductor in question, shows that it is not at all practicable to make the diameter of the movable conductor-rod, inside of the tube, large enough to prevent corona, at the high-voltage tube-ratings in question.

It is the object of my present invention to prevent corona on the inner movable conductor-rod of the tube, by a special kind or arrangement of shielding-means, placed on the outer surface of the insulating tube which houses the conducting parts which normally carry current, within the device, from one terminal thereof to the other. In designing this external shielding-device, it is necessary to make the design such that, even though the fuse should fail to drop out (or to automatically disconnect itself from the line) after a circuit-interrupting operation, the shielding-means will not draw an undesirably large amount of leakage-current, with the full line-voltage impressed across the terminals of the device. The shielding-means should also be designed so that it will not impose abnormally large voltage-gradients or strains, during the circuit-interrupting operation, on the insulation-material of which the tube-walls are composed; and also so that sufficiently excessive voltage-gradients shall not be imposed upon the air surrounding the tube, during this circuit-interrupting operation, to cause corona, and hence an external arc-formation, on the outside of the tube.

An exemplary form of embodiment of my invention is shown in the accompanying drawing, the single figure of which is a somewhat simplified and schematic vertical longitudinal sectional view, not to scale, showing an exemplary tube-type fuse-assembly embodying my invention.

In the drawing, I have shown the bare essentials of the tube-structure proper, including a long insulating tube 1, having two conducting terminal members 2 and 3, which are adapted to be connected to a high-voltage power-line

(not shown), so that the line-current normally passes through the tube, from terminal to terminal. Extending inside of the tube, for a short distance up from the bottom terminal 2, is a first stationary tubular electrode 4. At the top of the tube, a somewhat longer stationary tubular electrode 5 extends down from the top terminal 3, inside of the tube, for a somewhat longer distance than the bottom tubular electrode 4.

Also extending down, from the top of the tube, or more accurately, from a point near the bottom of the top stationary tubular electrode 5, is a lengthwise-movable rod-like electrode 6, extending inside of the insulating tube 1, beyond the inner (or lower) end of the upper stationary tubular electrode 5. Suitable means are provided for causing this lengthwise-movable rod-like electrode or conductor-rod 6 to be normally in electrical connection to the upper terminal 3 of the device, by "normally" meaning the current-conducting condition of the device, before there has been a circuit-interrupting operation. The usual means for providing this normal electrical connection is a plurality of spring-pressed contact-fingers 7 which are carried by the bottom end of the top stationary tubular electrode 5, and which press against the side-walls of the rod 6, although I am not limited to this particular means for providing the normal current-conducting connection between the upper terminal 3 of the device and the rod 6.

Spaced inside of the first (or lower) stationary tubular electrode 4 is the fusible element proper, as diagrammatically indicated at 8, for serving the dual purpose of, in effect, normally mechanically holding, and electrically connecting the inner (or bottom) end of the movable rod-like electrode 6 to the bottom terminal 2 of the device.

Inside of the insulating tube 1, and disposed between the top of the bottom tubular stationary electrode 4 and the bottom of the top tubular stationary electrode 5, there is provided an insulating gas-evolving portion 9, having a bore 10 which movably receives the lengthwise-movable rod-like electrode 6. This gas-evolving portion 9 is for the purpose of evolving arc-extinguishing gases when the rod-like electrode 6 is withdrawn lengthwise through said bore during a current-interrupting operation, as will be subsequently described. The material of the gas-evolving portion 9 is such that the walls of its bore 10 will evolve arc-extinguishing gases when subjected to the play of an arc on said surface. There are a number of known gas-evolving insulating materials for this purpose, of which the best material, for fuses of the type in question, is boric acid, as is well known.

At the upper end of the tube, inside of the upper stationary tubular electrode 5, there is disposed a rod-withdrawing spring 11, which is anchored at its top to the top terminal 3, and which is anchored at its bottom to the longitudinally movable rodlike electrode 6. This spring 11 is in tension, so that, when the fuse 8 melts, the spring will draw the rod 6 up through the bore 10 of the boric-acid gas-evolving portion 9, drawing an arc up through said bore, so that the arc plays against the walls of the bore, and thus causes a gas-evolution which extinguishes the arc.

During this arcing-operation, the lower end of the arc quickly transfers itself from the fused end of the fuse-proper 8, and plays from the upper end of the lower tubular stationary electrode 4. The upper end of the arc terminates at the lower end of the rod 6, until this rod passes up above the bottom of the upper stationary tubular member 5, at which time, if the arc has not yet been extinguished, the top end of the arc plays on the bottom of the upper tubular electrode 5, and there remains until the gas-evolution is sufficient to extinguish the arc. When the line-current is extremely excessive, the gas-evolution resulting from the hot, thick arc is sufficient to extinguish the arc at an early stage in the withdrawing-stroke or movement of the tube 6; but when the line-current has a less excessive value, the arc is drawn out longer, and may even reach its maximum length, before it is extinguished as a result of the less rapid gas-evolution.

In accordance with my present invention, I provide external shielding-means for preventing corona-formation on the movable rod 6, and in particular, on the portion of the movable rod which is exposed to external electrostatic fields, that is, the portion of the rod 6 which starts a short distance below the bottom of the top tubular electrode 5 and ends a short distance above the top of the bottom tubular electrode 4. It will be understood that these two stationary tubular electrodes 4 and 5 exercise a fringing shielding-effect upon the movable rod 6, for a short distance beyond the respective ends of said tubular electrodes, but it has been necessary to make the internal arcing-distance much too great to make it possible for this shielding effect of the two internal stationary tubular electrodes 4 and 5 to protect more than a relatively small part of the total arcing-distance between the top end of the bottom tubular electrode 4 and the lower end of the top tubular electrode 5.

In accordance with my invention, therefore, I coat the outside surface of the insulating tube 1 with a conducting or semi-conducting shielding-means, which is applied in a particular way which is suited to the exigencies or requirements of the case. The essential requirements of the external shielding-means, which surrounds the outer surface of the insulating tube 1, is that the boundary-line of the electrostatic field which surrounds the entire device shall at all points have a diameter larger than the internal diameter of the insulating tube 1, so that the critical corona-producing voltage-gradient (of about 31 kilovolts per centimeter) does not occur in any gas-filled or air-filled space inside of the insulating tube 1.

A desirable form of shielding-means consists of two painted coatings 22 and 23 of a semi-conducting paint, leaving a bare intermediate area 24 having a length which may be of the order of four-tenths of the total arcing-distance between the top of the bottom tubular electrode 4 and the bottom of the top tubular electrode 5. The axial length of this bare area 24 is not very critical. In general, it should be sufficient so that the fringing shielding-effect which extends beyond the ends of the coatings 22 and 23 will coalesce and merge, before an unshielded portion of the rod 6 is reached. Axial bare-area lengths of from one-quarter to one-half of the total arcing-distance may be quite acceptable.

A convenient method of applying the shielding-coatings 22 and 23 is to first wrap the intermediate bare area 24 of the insulating tube 1 with paper or other sheet-material (not shown) having the required width, after which the entire surface can be painted with a conducting or semi-conducting paint, after which the protective strip of paper or other sheet material is removed, leaving the bare area 24. A suitable semi-

conducting paint for this purpose is a varnish which contains finely powdered conducting carbonaceous material, such as graphite or coke-dust. While this material is preferably painted on, so as to extend all the way around the portions of the insulating tube 1 which are thus painted, it would be quite possible, so far as the shielding effect of the coating is concerned, for the coating to be applied in streaks, with bare spaces between the streaks, making a kind of grid-like construction (not shown), because it is well known that a plurality of spaced shields will have very much the same effect as a solid single shield, because of the overlapping of the fringing-areas at the edges of each shield-element.

In the broader aspects of my invention, I am not limited to any particularly critical order of conductivity or semi-conductivity of the painted coatings 22 and 23, other than taking care that the leakage-current which might flow from terminal to terminal of the device, after a current-interrupting operation, when the entire line-voltage appears across the two terminals 2 and 3, shall not be sufficient either to overheat the device or to be of objectionable current-magnitude in any other way, and this requirement is to be met, even when the external surface of the insulating tube 1 is wet and dirty, so that there will be some perceptible conductivity over the bare area 24 between the two semi-conducting coatings 22 and 23. I have found a total longitudinal resistivity of the order of 10 to 20 megohms to be satisfactory for the long upper shielding-coating 23, and perhaps one-quarter as much as that for the shorter lower shielding-coating 22, although I believe that values which are greater or lower than these amounts, by as much as a hundredfold or more, would still be quite satisfactory.

It is also feasible, although by no means necessary, or even desirable in the preferred and simplest form of my invention, to coat the previously described bare area 24 with a semi-conducting coating or shield-formation, as indicated by dotted lines 25, having a very much higher order of resistance than the resistance of either one of the two end-coatings 22 and 23.

So far as the corona-preventing effects are concerned, it would be conceivably possible to coat the entire outer surface of the insulating tube 1 with a uniform semi-conducting coating, extending from terminal to terminal; but this would not be the most advantageous coating from the standpoint of the resulting electrostatic stresses which would be imposed upon the solid insulation of the tube-walls during, and after, a circuit-interrupting operation, because the inner ends of the two internal tubular electrodes 4 and 5 would be at the potentials of the respective terminals 2 and 3, whereas the corresponding electrostatic potentials of the outer surface of the tube, radially outward from these two points, would have certain intermediate potentials, due to the fact that a uniform outer coating would act like a potentiometer which divides the total voltage uniformly along the length of the outer surface, thus imposing insulation voltage-stresses which can be easily avoided by my preferred shielding-construction, and which might conceivably do harm, if not avoided.

It will be understood, of course, that the entire outer surface of the shielded tubular device, after the shielding-coatings 22 and 24 have been applied, can be covered with a protective or water-proofing insulating covering which I have not attempted to indicate on the diagrammatic drawing, as this feature is quite altogether well known in the art.

In the normal use of my shielded high-voltage power-fuse, no material voltage-difference appears across the terminals 2 and 3 of the tube as a result of the flow of the line-current through the conductive inner parts of the tube, including the fuse-element proper, 8, the rod 6, the contact-fingers 7, and the upper internal conducting-tube 5. However, during such normal use of the device, all of these conducting parts are at the line-potential, which is high enough to produce corona, with its subsequent nitrate-incrustations, if the part of the rod 6 which extends between the inner ends of the two inner tubular electrodes 4 and 5 is not entirely or effectively shielded, so that the electrostatic effect of the entire shielded assembly, even at a point midway within the bare area 24, shall be the same as the electrostatic effect of a conductor having an outer diameter which falls within the solid insulating-walls of the tube 1. In other words, it is necessary for the two shields 22 and 23 to come near enough together so that the shape of the electrostatic field is determined by the shields and not by the presence of the conducting rod 6 inside of the tube.

Thus, in my externally shielded tube, there is no corona on the movable rod 6, and hence this rod does not swell to such an oversize-diameter that it cannot slide freely through the bore 10 of the boric-acid gas-evolving member 9. It must be remembered that it is necessary for only a relatively small clearance to be provided between the rod 6 and the bore 10, because at least a portion of this bore has to be as small as possible, in order to best perform its gas-evolving function, when played upon by an electric arc.

So far as the normal or non-interrupted operation of my fuse-assembly is concerned, it is immaterial how much lengthwise-resistance is possessed by the shielding-means or coating or coatings, because the two terminals 2 and 3 of the assembly are both at the same electrical voltage. This statement is true, so long as the conductivity of the shielding-coating is sufficient to substantially control the electrostatic field-potentials, that is, so long as the lengthwise-resistance of the shielding-coatings 22 and 23 is not too extremely high. Since these shielding-coatings 22 and 23 are at the line-potential, there is a certain infinitesimal capacity-current flowing from these shielded surfaces to the nearest grounded conductor, or to the nearest conductor of opposite potential, and these infinitesimal currents must be able to flow lengthwise through the resistance of the coatings 22 and 23 without producing a voltage-drop which is a very appreciable part of the total line-voltage. In other words, the electrostatic potential, or the voltage-level, of the free ends of the shielding-coatings 22 and 23, that is, the ends next to the bare area 24, ought to be controlled by the conductivity of the shielding-coatings 22 and 23, rather than being controlled by the tiny infinitesimal capacity-currents which would cause incipient corona, if they were allowed to play upon the surface of the rod 6. Coatings having a longitudinal resistance of the general order of a megohm or megohms will have a degree of conductivity which is very much more than adequate to control the electrostatic field-distribution so as to prevent corona.

As soon as a fuse-operation or current-inter-

rupting operation is obtained, however, as by reason of an overcurrent condition, the fuse 8 melts, and the spring 11 begins to move the rod 6 rapidly away from the fuse-end 2 of the tube, thus drawing out an arc, so that practically the entire line-voltage is consumed in the arc. As previously explained, the bottom terminus of this arc quickly fixes itself upon the top edge or rim of the bottom tubular electrode 4, which is at the potential of the bottom terminal 2 of the device, while the top end of the arc plays on the bottom end of the rod 6, which has substantially the same electrical potential as the top terminal 3 of the device. As the rod 6 moves upwardly, the arc is drawn out longer and longer, until it plays on the bottom edge or rim of the upper tubular electrode 5, which is at substantially the potential of the upper electrode 3, if the arc is not extinguished before it reaches this ultimate arc-length.

As a result of these considerations, it will be seen that, during the time when an internal arc is playing within the tubular insulator 1, and also after the time when the arc has been interrupted, it is quite desirable that the corresponding inner and outer surfaces of the insulating tube 1, at each point along the tube, should be at approximately the same electrostatic potentials, especially at each of the inner termini of the two inner stationary tubular electrodes 4 and 5, respectively. In other words, since the upper end of the lower tubular electrode 4 is at the same potential as the bottom terminal 2 of the device, the corresponding portion of the outer surface of the insulating tube 1 should also be at this same potential, and this effect is precisely the effect which is produced by the shielding-coating 22, which is conductively connected to the bottom terminal 2 and which extends up to a point which is a certain distance above the upper end of the inner tubular electrode 4, this distance being of the order of 5 inches or more.

In like manner, it is to be noted that the bottom end of the upper inner tubular electrode 5 is at the same potential as the top terminal 3 of the device, and it is also quite desirable that the outer surface of the insulating tube 1, opposite this point, should also be practically at that same potential, which is precisely the effect of the upper shielding-coating 23, which is conductively connected to the top terminal 3, and which extends down for a certain distance below the lower end of the upper tubular electrode 5, this downwardly-extending distance of the coating 23, below said upper tubular electrode 5, being also of the order of 5 inches in a 69-kilovolt tube, and being preferably considerably more than 5 inches in tubes of still higher voltage-ratings. It is necessary for the two coatings 22 and 23 to approach as closely together as safety-considerations will permit, in order that the fringing-actions which extend beyond their ends will merge with each other and unite to protect the movable rod 6 against corona during the normal operation of the device before the current-interrupting movement of the rod, as has already been explained.

If the extremely high-resistance intermediate coating is used, which is indicated by the dotted lines 25, it is obviously necessary, or at best extremely desirable, for the resistance of such an intermediate coating 25 to be so high that the current which it draws, at the line-voltage, is not sufficient to cause a very great voltage-drop in the shielding coatings 22 and 23. This is necessary or desirable so that undesirable voltage-stresses shall not be applied through the wall-thickness of the insulating tube 1 at the termini of the respective inner tubular electrodes 4 and 5.

While I have more explicitly described and explained my invention in connection with a fuse, and indeed in connection with a particular type of fuse, having the two inner tubular electrodes 4 and 5, I wish it to be understood that my invention, at least in the general principles thereof, is also generally applicable to any tube-type circuit-interrupting device having circuit-interrupting means of a type which responds to abnormal line-current conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthening arc is produced within the tube until the arc is interrupted, in the general manner which has been described for the illustrated device.

I wish it to be understood, also, that I contemplate that there is considerable latitude in the design and the resistance of the shielding-coatings 22 and 23, either with, or without an intermediate coating 25 of still higher resistivity than either one of the shielding-coatings 22 or 23, so long as the total lengthwise leakage-current resisitivity of the entire tube is not sufficiently low, on the one hand, to draw an obnoxiously high leakage-current, nor sufficiently high in resistance, on the other hand, to be unable to control the electrostatic field-distribution during the normal operation of the device, as hereinabove explained.

I desire, therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation.

2. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect

normally mechanically holding, an electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation.

3. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a lengthwise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation.

4. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation.

5. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two relatively low-voltage-drop portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

6. A tube-type circuit-interrupting device

adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the device, and being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

7. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the device, and being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, the overall lengthwise resistance of at least one of the two end-portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

8. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal

circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the device, and having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

9. A tube-type circuit-interrupting device adapted to operate in a line at a voltage high enough to make corona a problem, said device comprising an insulating tube having two conducting terminal members and having internal circuit-interrupting means within the tube for normally conducting current from end to end through the tube from terminal to terminal, said circuit-interrupting means being of a type which responds to abnormal conditions by producing a progressively lengthening circuit-interruption gap within the tube, whereby a progressively lengthened arc is produced within the tube until the arc is interrupted; said device being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said internal circuit-interrupting means at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptable low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the device, and having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an

inside arc will be produced during a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two end-portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

10. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation.

11. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two relatively low-voltage-drop portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

12. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly and being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

13. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube

for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly and being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two end portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

14. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

15. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a stationary electrode extending inside of the tube for a short distance from one terminal, a lengthwise-movable rod-like electrode extending inside of the tube in normal electrical connection to the other terminal, and a fusible element inside of the tube for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the current-conducting path within the tube is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two end-portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

16. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a lengthwise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect

normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lenghtwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means including an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation.

17. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminals members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a lengthwise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means including an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two relatievly low-voltage-drop portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

18. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a lengthwise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two relatively low-voltage-drop portions, electrically connected to the respective terminals of the device, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means including an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two relatievly low-voltage-drop portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

19. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a lengthwise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means being discontinuous over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, the overall lengthwise-resistance of at least one of the two end-portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

20. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a length-wise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and extending along the outside surface of the tube further than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation.

21. A tube-type fuse-assembly adapted to operate in a line at a voltage high enough to make corona a problem, said fuse-assembly comprising an insulating tube having two conducting terminal members, a first stationary tubular electrode extending inside of the tube for a short distance from one terminal, a second stationary tubular electrode extending inside of said tube for a longer distance from the second terminal of the assembly, a length-wise-movable rod-like electrode extending inside of the tube beyond the inner end of said second stationary tubular electrode, said lengthwise-movable rod-like electrode being normally in electrical connection to

said second terminal, a fusible element inside of the first stationary tubular electrode for in effect normally mechanically holding, and electrically connecting, the inner end of said movable electrode to said first-mentioned terminal, the inside of said tube having a gas-evolving portion disposed between the two stationary tubular electrodes and surrounding a portion of the length of said lengthwise-movable rod-like electrode and having a bore only slightly larger than said lengthwise-movable rod-like electrode for evolving arc-extinguishing gases when said rod-like electrode is withdrawn lengthwise through said bore during a circuit-interrupting operation of the fuse-assembly, and a rod-withdrawing spring inside of said second tubular electrode for withdrawing said lengthwise-movable rod-like electrode during said circuit-interrupting operation; said fuse-assembly being characterized by having outside shielding-means extending along the outside surface of said insulating tube from each terminal, in such manner that, under normal, non-interrupted conditions, the electrostatically effective outer diameter of the portion of the rod-like electrode between the two stationary tubular electrodes is large enough to prevent corona-troubles at the surface of said lengthwise-movable rod-like electrode at the operating-voltage of the device, said outside shielding-means having such a high order of terminal-to-terminal resistance as to draw an acceptably low leakage-current after a circuit-interrupting operation, said outside shielding-means having two end-portions, electrically connected to the respective terminals of the assembly, and extending along the outside surface of the tube further

than the lengthwise extent of the respective stationary tubular electrodes inside of the tube, said outside shielding-means having an intermediate shield-portion of much higher lengthwise-resistance than either of said end-portions, where a large part of the outside terminal-to-terminal voltage will appear during and after a circuit-interrupting operation, said intermediate shield-portion extending between said two end-portions and extending over an intermediate tube-surface area of limited length, located outside of a part of the place where an inside arc will be produced during a circuit-interrupting operation, the over-all lengthwise-resistance of at least one of the two end-portions of the outside shielding-means falling within the range from substantially .1 megohm to substantially 2,000 megohms.

HAROLD H. FAHNOE.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
1,730,716	Austin	Oct. 8, 1929
1,800,128	Allan	Apr. 7, 1931
1,821,761	Lemmon	Sept. 1, 1931
1,934,442	Newton	Nov. 7, 1933
2,109,850	Sandicoeur	Mar. 1, 1938
2,403,121	Rawlins et al.	July 2, 1946

FOREIGN PATENTS

Number	Country	Date
376,828	Great Britain	July 18, 1932