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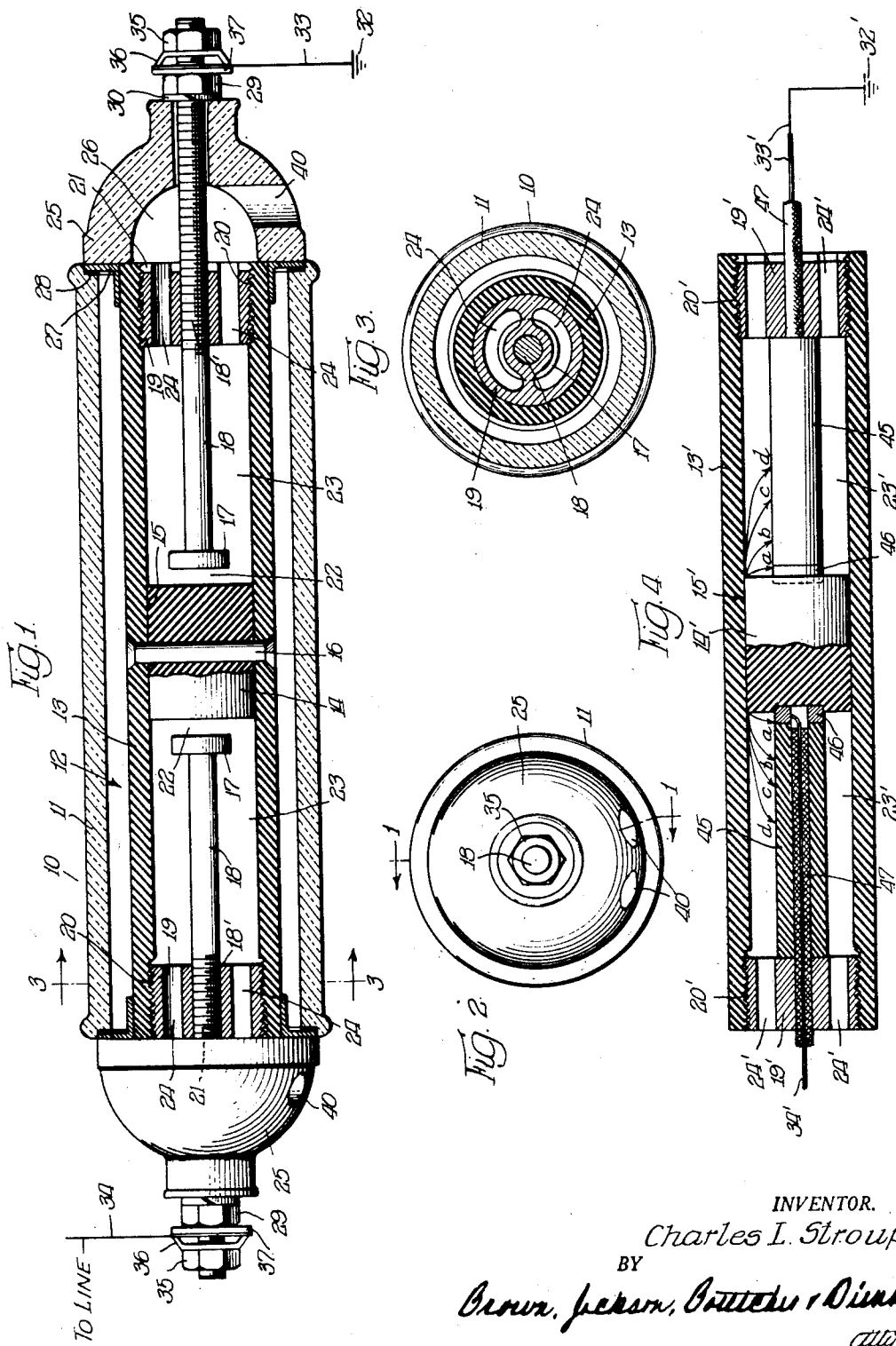
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2,454,849

ELECTRIC CIRCUIT INTERRUPTER

Filed Feb. 24, 1944

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

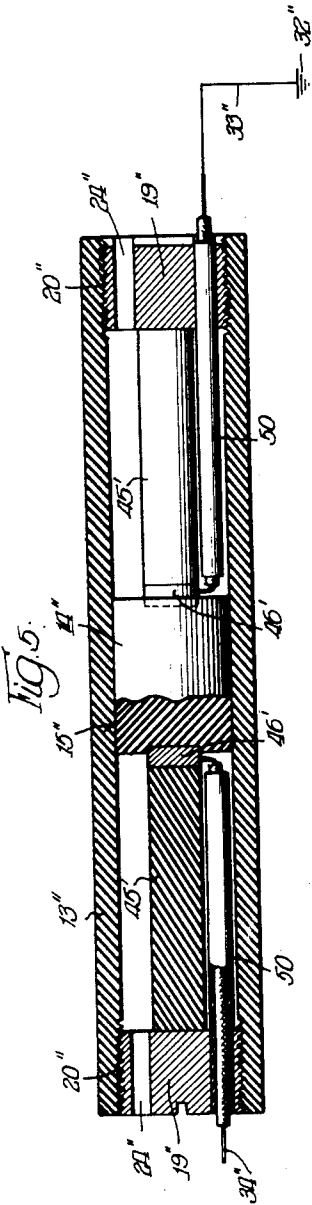
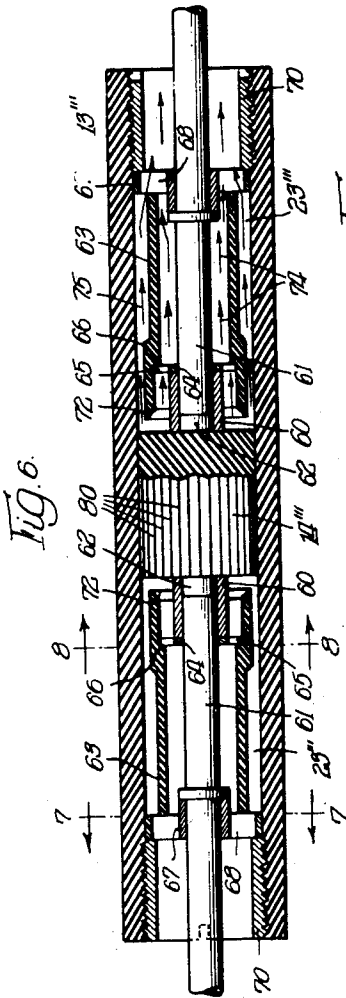
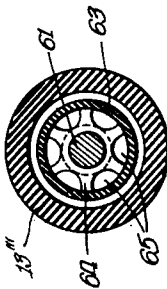
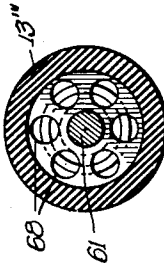


Fig. 5

Fig. 6



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## UNITED STATES PATENT OFFICE

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## ELECTRIC CIRCUIT INTERRUPTER

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Application February 24, 1944, Serial No. 523,620

7 Claims. (Cl. 175—30)

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This invention relates, in general, to electric circuit interrupters and has particular relation to circuit interrupters wherein current flow in the form of an arc is cut off by a gas or arc extinguishing medium generated by the heat of the arc.

While the particular devices which I shall describe hereinafter in connection with the drawings are lightning arresters that may be characterized as improvements over the lightning arrester which I disclosed and claim in my prior U. S. Patent No. 2,291,175, issued July 28, 1942, it is to be understood that the present invention may be embodied in expulsion tubes, circuit breakers, and a wide variety of apparatus.

One of the main objects of the present invention is to extend the operation of the device to higher interrupting capacities and to increase the life of the device at lower interrupting capacities.

Another object of the invention is to provide a substantially complete insulating enclosure for the device.

Another object of the invention is to provide for removing operating voltage from the insulating plug of the device without external horn gaps or other external gaps which are objectionable at lower voltages because in such cases the lines are usually worked with the current on, which is dangerous.

One of the novel principles involved is to confine the arc in a pressure-confining path along a part of its length and allow the arc and the gas or arc extinguishing medium evolved by the heat of the arc to enter directly and abruptly into one or more expansion chambers for sudden and substantial release of the pressure generated in the pressure-confining path. The space within the one or more expansion chambers is preferably in open communication with the pressure-confining path from the inner surface of the housing to the electrode and its extending conductor, and the one or more expansion chambers are preferably substantially unrestricted and preferably have substantially unrestricted communication with atmosphere.

I also provide for exposure of the electrode and its extending conductor to the arc throughout substantially the extent of the expansion chamber.

I further contemplate, within the scope of the present invention, the provision of means for splitting the arc and dividing the stream or blast of gas approximately as the arc and gas pass

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from the pressure-confining path into the expansion chamber.

It is also an object of the present invention to provide a device which may be relatively short and of simple and inexpensive construction.

In order to acquaint those skilled in the art with the manner of constructing and operating several embodiments of the invention, I shall describe in connection with the accompanying drawings certain preferred embodiments of the invention.

In the drawings:

Figure 1 is a longitudinal sectional view of a lightning arrester embodying the present invention, taken on the line 1—1 of Figure 2 and with the end cap at one end in elevation;

Figure 2 is a view in end elevation of the device shown in Figure 1;

Figure 3 is a detail sectional view taken along the line 3—3 of Figure 1;

Figure 4 is a longitudinal sectional view of a modified form of device embodying the invention;

Figure 5 is a longitudinal section through another modification;

Figure 6 is a longitudinal section through a further modification;

Figure 7 is a detail section taken along the line 7—7 of Figure 6; and

Figure 8 is a detail section taken along the line 8—8 of Figure 6.

Referring first to Figures 1, 2, and 3 of the drawings, the reference character 10 designates, generally, a lightning arrester construction comprising an outer weather-proof housing 11 and the lightning arrester assembly 12 which is preferably of unitary construction and can be assembled as such for insertion in the housing 11. The outer housing 11 may be made of frangible insulating material such as glass or porcelain or other suitable insulating material.

The lightning arrester assembly 12 comprises a tubular housing 13 having internally and intermediate the ends thereof a generally cylindrical imperforate plug 14. The housing 13 and plug 14 are formed of fiber or other similar material so as to be capable of evolving an arc extinguishing medium, such as water vapor, due to the heat of an arc. The plug 14 preferably has a contact or relatively close fit with the inner surface of the insulating housing 13 so that the juxtaposed surfaces, as indicated at 15, are close together. It is along these surfaces that the arc is formed on operation of the device. Because of the extremely limited space at 15, relatively great pressures are generated along this pressure-confining path for

the arc. The plug 14 is preferably anchored against displacement within the tubular housing 13, for example, by a transverse pin 16.

At the opposite ends of the plug 14 are electrodes 17 which have conductors in the form of rods or stems 18 which extend out from the opposite ends of the housing. Each electrode and its conductor is in the form of a bolt, with the headed inner ends of the bolts constituting the electrodes 17. The outer ends of the conductor or electrode stems 18 are threaded as illustrated at 18'. These threaded portions of the stems are screwed through end plugs 19 which support the electrodes and their stems in position along the axis of the housing, and in turn are screwed, at 20, into the opposite ends of the housing or tube 13. Transverse grooves or kerfs 21 are provided in the outer ends of the plugs 19 for screwing these plugs into place and removing same from the ends of the housing.

The electrodes 17 are preferably spaced at 22 from the opposite ends of the plug 14 for removing operating voltage from the plug 14. In the operation of an arrester an isolating gap usually is used to remove 60 cycle operating voltage from the plug 14 with the idea that destruction of the fiber, due to leakage current, is prevented. However, with the electrodes 17 spaced from the ends of the plug 14, as shown at 23, the leakage paths over fiber will be along the inner surface of the housing 13 from one of the metallic end plugs 19 to the other end plug 19. This leakage path may be sufficiently great that no external gap will be necessary. Adjustment of the gap 22 may be obtained by screwing the electrodes inwardly or outwardly through the plugs 19.

In the structure as thus far described it will be apparent that the housing 13 forms a pair of substantially unrestricted expansion chambers 23, one at each end of the plug 14. These expansion chambers 23 have substantially unrestricted communication with atmosphere through a plurality of extensive and generally arcuate vent openings 24 in the end plugs 19. The pressure-confining path 15, along which the arc is adapted to form between the electrodes 17, opens at its opposite ends directly and abruptly into the relatively large expansion chambers 23 for relatively great and sudden release of the pressure generated in the pressure-confining path 15. Moreover, the electrodes 17 and their stems or conductors 18 are exposed throughout substantially the entire lengths of the expansion chambers 23 to the inner surface of the housing 13 and to the arc formed along the pressure-confining path 15.

The insulating housing 13 is shown as to the same length as the outer weather-proof housing 11. It is held therein by insulating end caps 25 which are made of frangible insulating material, such as glass or porcelain or other suitable insulating material. Each of the end caps 25 is hollow or cupped at its inner end with the space 26 in communication with the vent openings 24. At each end of the device a metallic or other suitable ring 27 of angle section has a longitudinally extending annular flange which fits around the adjacent end of the tube 13, and a lateral flange which seats, for example, against a ring 28 of suitable packing in an annular groove in the end of the housing 11. The outer threaded ends of the electrode stems 18 extend out through the tubular or hollow cylindrical outer ends of the caps 25. The end caps 25 are held in place by nuts 29 and lock washers 30, the nuts 29 clamp-

ing the inner ends of the caps 25, for example, against the lateral flange of the ring 27 at the adjacent end of the housing 11.

The conductor 18, at one end of the device, is adapted for connection to ground 32 through a conductor 33. The other conductor 18, at the other end of the device, is adapted for connection through a conductor 34 to the line, which may be a transmission line. The conductors 33 and 34 are secured to the outer ends of the conductors or electrode stems 18, for example, by nuts 35 which serve to hold clamp members 36 securely against the conductors 33 and 34 which are placed between the clamp members 33 and 34 and washers 37.

The spaces 26, in the cap members 25, are vented downwardly (the device being preferably positioned horizontally in use) through one or more openings 40 which open through the walls of the cap members. These openings 40 permit relatively free and unrestricted venting of the expansion chambers 23 to atmosphere. In Figure 2 of the drawings, two downwardly directed openings are shown in the cap member 25 but, of course, this may vary. The insulating cap members 25, one at each of the opposite ends of the device, in conjunction with the insulating housing 11, form a substantially complete insulating enclosure for the arrester unit. This reduces to a minimum exposed metallic or conducting parts.

In operation, on the occurrence of an over-voltage, such as caused by a lightning or switching surge, an arc is formed between the electrodes 17 along the juxtaposed surfaces of the housing 13 and plug 14. Because of the confinement of the arc along the path 15 due to the contact or close fit between the housing 13 and plug 14, and, further, because of the arc extinguishing medium evolved and the other features which have been disclosed, the arc is quickly extinguished. I find that the structure illustrated and described extends the operation of the interrupter to higher interrupting capacities and provides an interrupter of increased life at lower interrupting capacities. For example, the interrupter of my prior U. S. Patent No. 2,291,175, issued July 28, 1942, operates up to interrupting capacities, in general, of about 2,000 amperes, whereas the interrupter herein illustrated and described operates up to interrupting capacities, in general, of about 10,000 amperes.

At present this improvement in interrupting capacity and increased life at lower interrupting capacities appears to be due to the feature of allowing the arc and the gas or arc extinguishing medium, which is evolved in the pressure-confining path 15, to enter directly and abruptly into the expansion chambers 23 for sudden and very substantial release of the pressure generated in the pressure-confining path 15. The arc and arc extinguishing medium enter the expansion chambers 23 at opposite ends of the plug 14 while a portion of the arc and arc extinguishing medium remain under great pressure in the pressure-confining path 15. The result appears to be that the force of the blast is increased and a very substantial cooling effect is obtained in the chambers 23, thereby extinguishing the arc more effectively and quickly. It also appears that with the expansion chamber 23 in open communication from the interior of the housing 13 to the electrodes 17 and their extending conductors 18, and with the electrodes and their extending conductors exposed throughout the extent of the expansion chamber 23 to the opposite

ends of the pressure-confining path 15 and the arc formed therein, that a sort of "horn-gap" effect may be secured. In other words, it may be that the arc is gradually elongated between the electrodes and their extending stems and extinguished by this gradual elongation, in conjunction with the arc extinguishing medium which is evolved, and the more forceful blast and very substantial pressure release and cooling effect obtained in the expansion chambers 23. It appears likely that it is more difficult to extinguish an arc which must continue, for example, between only the electrodes 17 and the inner ends of the stems 18, or strike the relatively great distance to the end plugs 19 without being free to be elongated outwardly along the electrode stems.

The foregoing theories appear to be the most likely theories in so far as I am able to state the same. I am not certain, however, that these theories are correct, and therefore I do not intend to limit myself to the theories set forth, or to any theory, and I reserve the right to change or amplify, as and when necessary, the theory and reasons for the improved results which I obtain.

In the modified form of device shown in Figure 4, the metallic electrodes 17 and their extending metallic stems 18, as shown in Figure 1, are replaced by tubular carbon or other suitable resistors 45 having abutting contact at their inner ends with ring-shaped metallic arcing contacts 46. The arcing contacts 46 may, if desired, be centered in recesses in the opposite ends of the plug 14'. Insulating sleeves 47 extend through the arcing contacts 46 and tubular resistors 45, and out through the metallic retainer or end plugs 19'.

The conductor 34', for connection to the line, extends in through one of the insulating sleeves 47 and is connected at its inner end in circuit with the metallic arcing contact 46 at one end of the plug 14'. The conductor 33', for connection to ground at 32', extends in through the other insulating sleeve 47 and is connected at its inner end to the other metallic arcing contact 46. The insulating tube 13' and pressure-confining path 15' correspond with the tube 13 and pressure-confining path 15 of the embodiment of the invention shown in Figure 1. The expansion chambers 23' correspond with the expansion chambers 23 of the preceding embodiment of the invention and the expansion chambers 23' are in open communication from the interior of the housing 13' to the metallic arcing contacts 46 and resistors 45, and the metallic arcing contacts 46 and resistors 45 are exposed throughout the extent of the expansion chambers 23' to the opposite ends of the pressure-confining path 15' and the arc formed therein.

The operation of this embodiment of the invention is substantially the same as the operation of the previous embodiment of the invention except that as the arc is elongated or moves, for example, from a to b to c to d, etc., the resistance of the resistors 45 will be added to the circuit. The current, therefore, is reduced greatly, with the result that the arc will be much easier to extinguish.

The embodiment of the invention shown in Figure 5 is the same as the embodiment shown in Figure 4 except that the lead 34'' to the line and the lead 33'' to ground are led or extend in through fiber or other insulating tubes 50 on the outside of the resistance units rather than through the centers of the resistors. The insulating tubes 50 extend out through the retainer

or end plugs 19''. It is understood that in either case these leads must be insulated from the resistance or covered with an insulated housing in order that the impulse voltage may be carried directly to the arcing contacts which are designated 48' in Figure 5. The other parts of Figure 5 corresponding with parts shown in Figure 4 are designated by double primed reference characters to correspond with the reference characters used in Figure 4. It is obvious that the impulse surge current itself does not go through the resistors, but when the arc is blown laterally out of the tube or toward the ends of the tube it must follow the resistance rather than the leads to the line and to ground.

In the embodiment of the invention shown in Figures 6, 7, and 8, the arching contact sleeves 60 have contact fit over the inner ends of their extending stems or conductors 61. The arcing contacts 60 also fit over short studs 62 on opposite ends of the insulating plug 14'''. This form of device has intermediate insulating sleeves 63 surrounding the arcing contacts 60 and their extending stems 61 and disposed between the arcing contacts and their extending stems and the inner surface of the insulating tube 13'''. Discs 64, having vent openings 65 therethrough, seat against the outer ends of the arcing contact sleeves 60 and against shoulders 66 in the insulating sleeves 63. The outer ends of the insulating sleeves 63 seat against spider members 67 having integral tubular center portions through which the electrode stems 61 extend. The spider members 67 are also preferably provided with vent openings 68 providing free and unrestricted venting of the expansion chambers 23''' to atmosphere.

The parts are clamped and retained in the position shown in Figure 6 by the retainer or end plugs 70 which are screwed into the outer ends of the insulating tube 13'''. The inner ends of the inner insulating sleeves 63 are preferably tapered to relatively sharp edges 72 at the outer peripheries of their inner ends.

In this embodiment of the invention the expansion chambers 23'' are again in substantially open communication from the inner surface of the housing 13''' to the arcing contacts 60 and their extending stems 61, and the pressure-confining path 15''', between the juxtaposed surfaces of the housing 13''' and plug 14''', opens directly into the expansion chambers 23''' for sudden and substantial release of the pressure generated in the pressure confining path. The arcing contacts and their extending stems are also exposed, throughout the length of the expansion chambers, to the ends of the pressure confining path 15''' and the arc formed therein. In this case the intermediate sleeves 63 split the arc and the flow of arc extinguishing medium into inner paths, indicated at 74, between the interiors of the sleeves 63 and the arcing contacts, and their extending stems and outer paths 75, between the outer surfaces of the sleeves 63 and the inner surfaces of the tube 13'''.

In Figure 6 the plug 14''' is shown as having spaced circumferentially about its periphery and extending longitudinally of the plug a plurality of relatively close parallel lines 80. These lines 80 represent conducting lines or threads, such as pencil lines or streaks of graphite or other conducting material of relatively great tenuity. These conducting lines or streaks 80 form multiple conducting paths for the arc along the pressure-confining space 15'''. They may be made in scratches or grooves in the surface of

the plug, or directly on the surface of the plug or along the adjacent inner surface of the tube 13''.

The pencil lines or streaks 80 of graphite or other suitable material provide multiple paths for the arc along the pressure-confining path 15'', for the purpose of assuring distribution of the charges. This tends to prevent localized disintegration of the plug and tube. Upon the occurrence of an arc the line 80 along which it passes is blown clean, so that the next or succeeding arc will follow another line or conducting path 80. This assures distribution of successive arcs about the periphery of the plug 14''. This feature may, of course, be embodied in any of the other devices shown and described.

I do not intend to be limited to the specific embodiments of the invention herein disclosed, as the improvements which are disclosed are applicable to other forms of apparatus which I intend to cover with the appended claims.

I claim:

1. In a device of the class described, in combination, a tubular housing of insulating material, a plug of insulating material fitting closely within said tubular housing and forming a peripheral pressure-confining arc path between the juxtaposed peripheral surfaces of said housing and said plug, at least one of said juxtaposed surfaces being capable of evolving an arc extinguishing medium when subjected to the heat of an arc, said tubular housing providing a relatively large space into which the arc extinguishing medium and the arc can expand from between said surfaces and having a discharge opening at the end away from said plug, and electrodes at opposite ends of said plug between which an arc may be struck along said peripheral pressure-confining arc path, at least one of said electrodes extending in an axial direction from the end of said plug and through said spaces, said extending electrode being bared and its outer surface openly exposed throughout a substantial portion of its length to the adjacent peripheral end of said pressure-confining arc path whereby a fixed and axially extending conducting path is provided along which one end of an arc striking along said pressure-confining arc path anywhere about the periphery thereof is adapted, while remaining in contact with the outer surfaces of said electrode, to be forced axially of the extending electrode between its outer surface and the inner surface of said housing by the expansion of said arc extinguishing medium in said space due to the heat of the arc, said extending electrode being bared and its outer surface openly exposed to the peripheral end of said pressure-confining arc path for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

2. In a device of the class described, in combination, a tubular housing of insulating material, a plug of insulating material fitting closely within said tubular housing and forming a peripheral pressure-confining arc path between the juxtaposed peripheral surfaces of said housing and said plug, at least one of said juxtaposed surfaces being capable of evolving an arc extinguishing medium when subjected to the heat of an arc, said plug being spaced axially from at least one end of said housing to provide an elongated expansion chamber of relatively great volume beyond the adjacent end of the plug, with

the outer end of said chamber in open communication with atmosphere and with the adjacent peripheral end of the pressure confining arc path opening abruptly into said expansion chamber for relatively great and sudden release of the pressure generated in said pressure-confining arc path, and electrodes at opposite ends of said plug between which an arc may be struck along said peripheral pressure-confining arc path, at least one of said electrodes extending in an axial direction from the end of said plug and through a substantial part of the length of the end of said housing from which said plug is spaced, said extending electrode being bared and its outer surface openly exposed throughout a substantial portion of its length to the adjacent peripheral end of said pressure-confining arc path whereby a fixed and axially extending conducting path is provided along which one end of an arc striking along said pressure-confining arc path anywhere about the periphery thereof is adapted, while remaining in contact with the outer surface of said electrode, to be forced axially of the extending electrode between its outer surface and the inner surface of said housing by the expansion of said arc extinguishing medium in said expansion chamber due to the heat of the arc, said extending electrode being bared and its outer surface openly exposed to the peripheral end of said pressure-confining arc path for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

3. In a device of the class described, in combination, a tubular housing of insulating material, a plug of insulating material fitting closely within said tubular housing and forming a peripheral pressure-confining arc path between the juxtaposed peripheral surfaces of said housing and said plug, at least one of said juxtaposed surfaces being capable of evolving an arc extinguishing medium when subjected to the heat of an arc, said tubular housing providing a relatively large space into which the arc extinguishing medium and the arc can expand from between said surfaces and having a discharge opening at the end away from said plug, and electrodes at opposite ends of said plug and abutting said plug between which an arc may be struck along said peripheral pressure-confining arc path, at least one of said electrodes extending in an axial direction from the end of said plug and through said space, said extending electrode being bared and its outer surface openly exposed throughout a substantial portion of its length to the adjacent peripheral end of said pressure-confining arc path whereby a fixed and axially extending conducting path is provided along which one end of an arc striking along said pressure-confining arc path anywhere about the periphery thereof is adapted, while remaining in contact with the outer surface of said electrode, to be forced axially of the extending electrode between its outer surface and the inner surface of said housing by the expansion of said arc extinguishing medium in said space due to the heat of the arc, said extending electrode being bared and its outer surface openly exposed to the peripheral end of said pressure-confining arc path for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

4. In a device of the class described, in combination, a tubular housing of insulating mate-

rial, a plug of insulating material fitting closely within said tubular housing and forming a peripheral pressure-confining arc path between the juxtaposed peripheral surfaces of said housing and said plug, at least one of said juxtaposed surfaces being capable of evolving an arc extinguishing medium when subjected to the heat of an arc, said tubular housing providing a relatively large space into which the arc extinguishing medium and the arc can expand from between said surfaces and having a discharge opening at the end away from said plug, and electrodes at opposite ends of said plug between which an arc may be struck along said peripheral pressure-confining arc path, said electrodes including an electrode spaced from the end of the plug for removing operating voltage from the plug, at least one of said electrodes extending in an axial direction from the end of said plug and through said space, said extending electrode being bared and its outer surface openly exposed throughout a substantial portion of its length to the adjacent peripheral end of said pressure-confining arc path whereby a fixed and axially extending conducting path is provided along which one end of an arc striking along said pressure-confining arc path anywhere about the periphery thereof is adapted, while remaining in contact with the outer surface of said electrode, to be forced axially of the extending electrode between its outer surface and the inner surface of said housing by the expansion of said arc extinguishing medium in said space due to the heat of the arc, said extending electrode being bared and its outer surface openly exposed to the peripheral end of said pressure-confining arc path for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

5. In a device of the class described, in combination, a tubular housing of insulating material, an imperforate plug of insulating material fitting closely within said tubular housing and spaced from opposite ends thereof to provide expansion chambers within said tubular housing at the opposite ends of said plug, wherein relatively great gas expansion can take place in unobstructed space at least one of the juxtaposed surfaces of said housing and said plug being capable of evolving an arc extinguishing gas when subjected to the heat of an arc, electrodes at the opposite ends of said plug between which an arc may be struck along a pressure confining path between the juxtaposed surfaces of said housing and plug, said electrodes extending through the respective expansion chambers in an axial direction from the ends of the plug and out of the ends of said tubular housing and bared and their outer surfaces exposed to the peripheral ends of said pressure-confining path throughout substantially the entire lengths of said expansion chambers whereby the terminals of the arc are blown along said electrodes by the expansion of gas in said chambers and the arc is extended and extinguished.

6. In a circuit interrupter, in combination a tubular housing of insulating material, a plug of insulating material within said housing and closely fitting the same, at least one of the juxtaposed surfaces of said housing and said plug be-

ing capable of evolving an arc extinguishing medium when subjected to the heat of an arc, there being a relatively large expansion space within said housing at at least one end of said plug into which said medium can expand, and electrodes at opposite ends of said plug between which an arc may be struck over said juxtaposed surfaces, at least one of said electrodes extending in an axial direction from said plug and its outer surface being bared for a substantial portion of its length whereby a fixed conducting path is provided between the inner surface of said housing and the outer surface of said one electrode along which one end of the arc remains in contact while the arc is being extended axially of said housing in said expansion space by the blast resulting from the arc extinguishing medium evolved due to the heat of the arc, the outer surface of said one electrode being bared for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

7. In a circuit interrupter, in combination a tubular housing of insulating material, a plug of insulating material within said housing and closely fitting the same, at least one of the juxtaposed surfaces of said housing and said plug being capable of evolving an arc extinguishing medium when subjected to the heat of an arc, there being a relatively large expansion space within said housing at at least one end of said plug into which said medium can expand, and electrodes at opposite ends of and abutting said plug between which an arc may be struck over said juxtaposed surfaces, at least one of said electrodes extending in an axial direction from said plug and its outer surface being bared for a substantial portion of its length whereby a fixed conducting path is provided between the inner surface of said housing and the outer surface of said one electrode along which one end of the arc remains in contact while the arc is being extended axially of said housing in said expansion space by the blast resulting from the arc extinguishing medium evolved due to the heat of the arc, the outer surface of said one electrode being bared for a length to permit extension of the arc and accompanying increase in the resistance of the arc path sufficient to render any arc to which the interrupter is likely to be subjected non-self-sustaining.

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