Oct. 16, 1951 S. I. LINDELL 2,571,735

FUSE CONSTRUCTION

Filed Jan. 2, 1947 3 Sheets-Sheet 1

Fig. 1A.

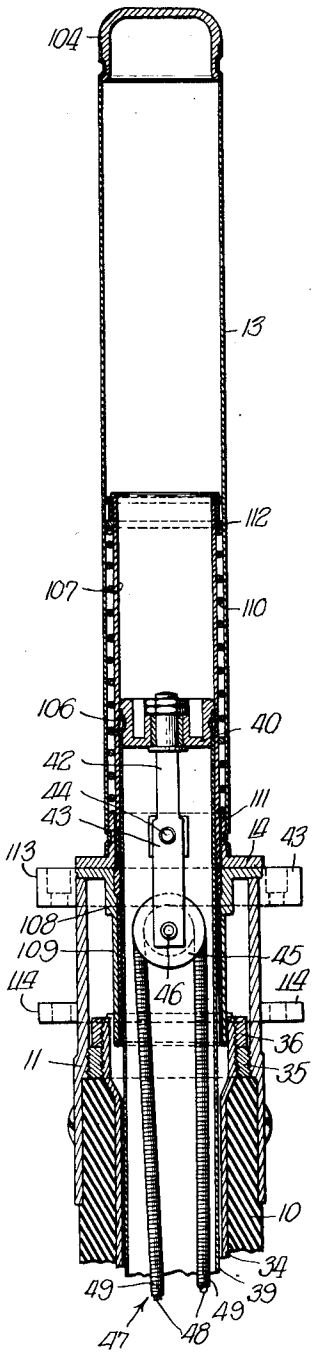


Fig. 1B.

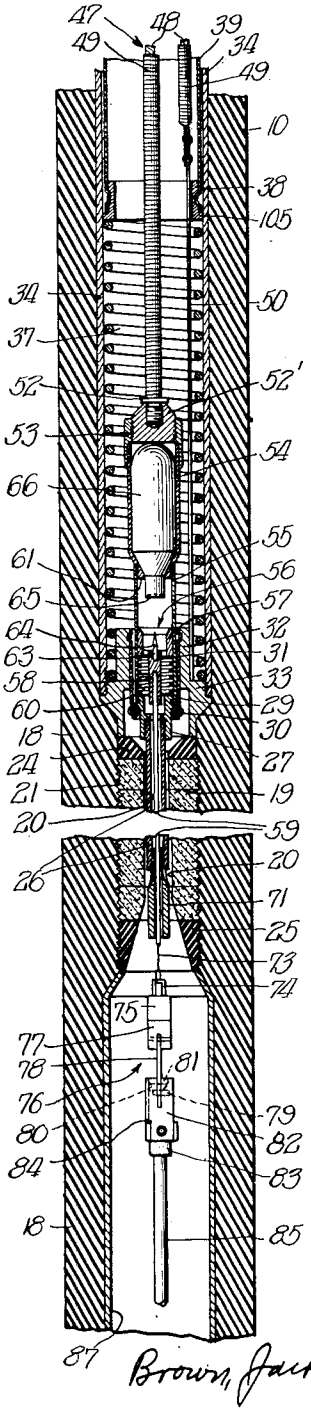
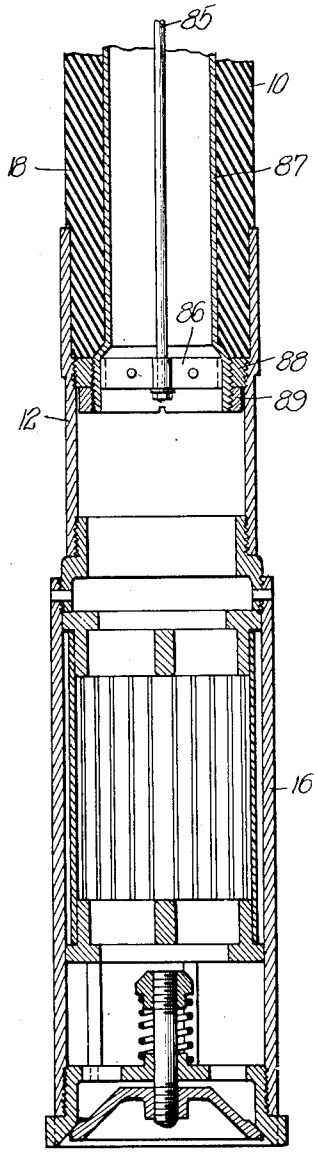


Fig. 1C.



INVENTOR.
Sigurd I. Lindell
BY
Brown, Jackson, Boettcher & Dienner
Attys.

Oct. 16, 1951 S. I. LINDELL 2,571,735

FUSE CONSTRUCTION

Filed Jan. 2, 1947 3 Sheets-Sheet 2

Fig. 2

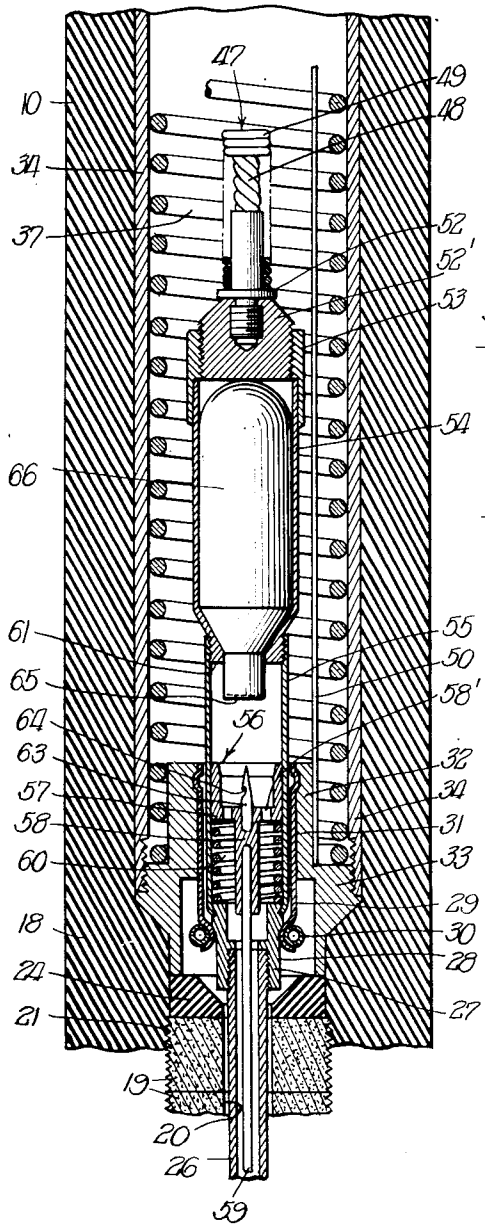


Fig. 3

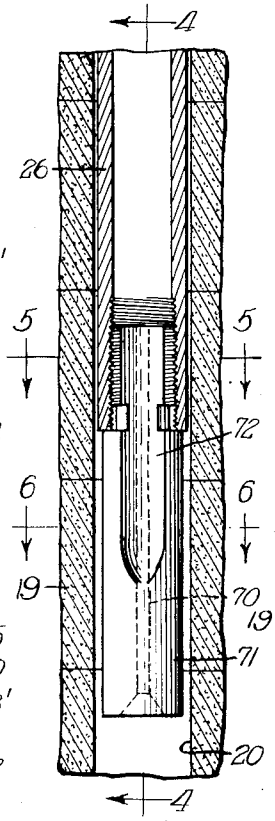


Fig. 4

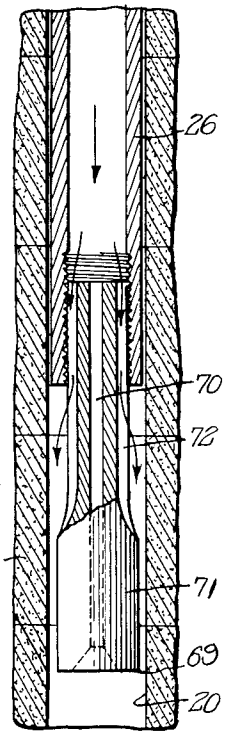


Fig. 5

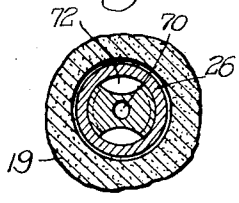
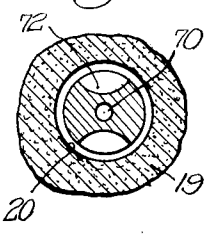


Fig. 6



INVENTOR.
Sigurd I. Lindell,
BY
Brown, Jackson, Boettcher & Dienner
Attys

Oct. 16, 1951 S. I. LINDELL 2,571,735

FUSE CONSTRUCTION

Filed Jan. 2, 1947 3 Sheets-Sheet 3

Fig. 7

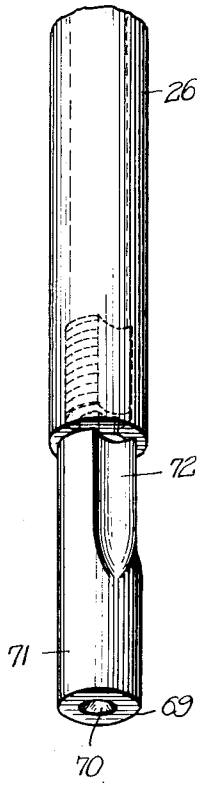
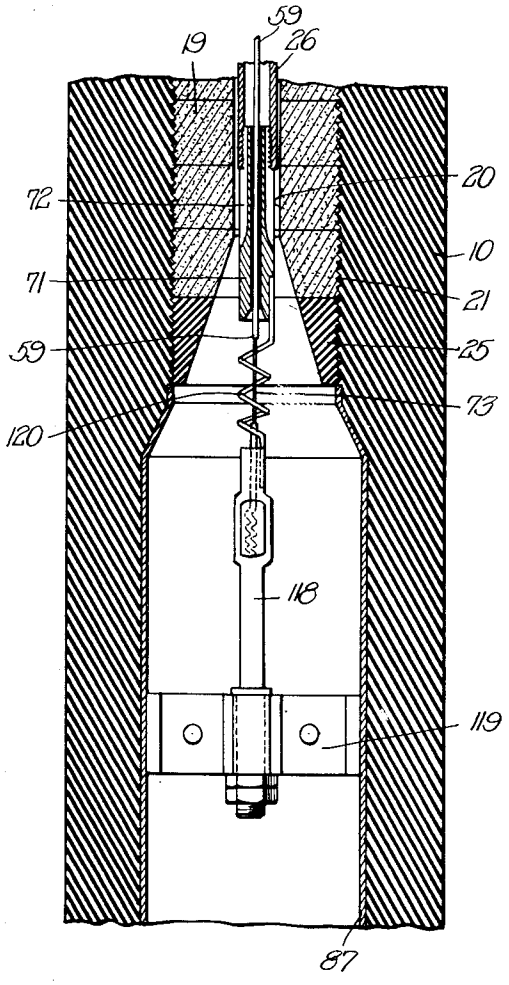


Fig. 8.



INVENTOR.
Sigurd I. Lindell,
BY
Brown, Jackson, Boettcher & Dienner
attys.

Patented Oct. 16, 1951

2,571,735

UNITED STATES PATENT OFFICE

2,571,735

FUSE CONSTRUCTION

Sigurd I. Lindell, Chicago, Ill., assignor to S & C Electric Company, a corporation of Delaware

Application January 2, 1947, Serial No. 719,849

12 Claims. (Cl. 200—120)

1

This invention relates, generally, to circuit interrupting devices and it has particular relation to fuses for use with alternating-current electric-power systems operating at high voltages, of the order of 115 kv., where the transient recovery voltage may be substantially greater than the normal-frequency recovery-voltage, and where both large and small fault-currents may be encountered.

Fuses are extensively used in the primary connections to high voltage transformers, and must be capable of clearing any fault current within the wide range of values obtainable in such service. For example, a short circuit at the primary terminals will draw the full short-circuit current that the generators and transmission equipment can deliver to that point, which on a typical 115 kv. circuit may be as high as 6000 amperes. A fault in the secondary circuit must draw its power through the impedance of the transformer and so will produce a much lower primary current but of low power factor. An extreme case is presented by a potential transformer. Such a transformer supplying only meters and relays may draw a primary current of a few milliamperes under normal operation, and only a few amperes even when the secondary (output) terminals are short-circuited. In other installations, faults may be encountered that give rise to primary currents between these extreme values. A fuse must be capable of promptly and surely interrupting any value of current from the lowest that will sever its fusible element to the maximum that the system can deliver on a short circuit.

In a fuse of the present type, wherein an arcing terminal is withdrawn through a bore of arc-extinguishing material for extending the arc, the arc-passageway must be large enough to handle the largest possible fault currents without producing destructive pressures, but a small current, which the fuse must also be capable of interrupting, produces an arc of small cross section which tends to be blown away from the walls of the passageway and so does not excite the production of sufficient arc-extinguishing gas—such as water vapor—from those walls for the effective extinction of the arc.

In a fuse of this type it is desirable that the arcing terminal substantially fill the bore so as to minimize escape of exhaust gas past the retreating terminal, and also to give the terminal as high a current-carrying capacity as possible. The permissible closeness of this fit must be determined by actual tests of the fuse and I have found that under certain severe operating conditions molten metal flows to the side of the arcing terminal and solidifies and thus reduces the clearance between the moving terminal and the bore. I have discovered that contributing causes of this difficulty are a tendency of the arc to find its root at the peripheral edge of the arcing terminal, and an unavoidable flow of some exhaust gas into the small clearance space between the bore and moving terminal.

2

In accordance with the present invention a sealed reservoir is provided which contains a fluid, such as carbon dioxide, that, when released into the arc space, quickly fills it and provides a blast action which tends to sweep out the products of the arc and to scavenge the inner surface of the arc passageway to remove therefrom material likely to form a conducting path thereover. The fluid is released from the reservoir immediately upon the rupture of the fusible, current-responsive element, and before the terminal in the arc passageway begins to move therethrough to extend the arc, so that even low-current arcs are subjected to a scavenging, arc-extinguishing blast from their very beginning. The fluid is conducted through the moving terminal for direct and efficient injection at that part of the bore that contains the arc. Furthermore a blast of arc-extinguishing fluid is made to flow out of the space between the retreating terminal and the wall of the bore, and over the tip portion of that terminal to oppose the tendency of the arc root to move toward the edge of the end-face of the terminal, and to oppose the flow of exhaust gases and molten metal into the clearance space.

Preferably, the carbon dioxide gas is stored under high pressure in a reservoir attached to the movable terminal itself. The release of this gas and the retraction of the movable arcing terminal are effected by spring mechanism all controlled by a single, fusible, current-responsive, restraining wire. The movable terminal may have a hollow bore through which this restraining wire may be threaded to reach the control mechanism, and through which the gas may be conducted to the arcing tip for discharge into the arc space.

In accordance with the present invention provision is made for initiating the functioning of the fuse in response to low currents such as those produced in the primary circuit of a potential transformer on the occurrence of a secondary fault. This, in combination with the provision of the reservoir containing the arc extinguishing fluid which is released into the arc passageway, provides a construction which will quickly and reliably interrupt the flow of fault current before

any damage can be done to the transformer and without harm to adjacent equipment, as might be the case if the arc, once drawn by the fuse, were not promptly extinguished. Provision is made for carrying the current carrying capacity of the fuse up to high values by employing, in addition to the strain wire, a fusible element having relatively large current-carrying capacity.

Accordingly, these are among the objects of this invention: To provide a low-current, high-voltage fuse which shall be simple, efficient and accurate in operation; to release an arc extinguishing fluid from a container or reservoir to flow into the arc passageway of the fuse immediately upon the melting of the fusible element and before lengthening the arc; to cause the arc-extinguishing fluid to flow through a tubular terminal, which is movable through the arc passageway and which constitutes one of the terminals between which the arc incident to circuit interruption is drawn; to control the location of the arc root on the face of the moving terminal for preventing mobile material in the arc space from interfering with the movement of the terminal through the arc chamber; to envelop an arcing tip in a stream of gas flowing away from it; to restrain the operating mechanism of the fuse by a strain wire that extends through a tubular terminal; to provide a spring operated mechanism restrained by a fusible, current-responsive element for releasing arc-extinguishing gas immediately upon the rupture of that fusible element; to provide improved means for releasing a store of arc-extinguishing gas early in the operation of the fuse; and to provide an improved high-voltage fuse construction.

Other objects of this invention will in part be obvious and in part appear hereinafter.

This invention is disclosed in the embodiments thereof shown in the accompanying drawings and it comprises the features of construction, combination of elements, and arrangement of parts which will be exemplified in the constructions hereinafter set forth, and the scope of the application of which will be indicated in the appended claims.

For a more complete understanding of the nature and scope of this invention reference can be had to the following detailed description taken in connection with the accompanying drawings, in which:

Figures 1A, 1B and 1C, taken together, show a longitudinal, sectional view through a fuse construction in which the present invention is embodied, the fuse being shown in the unblown condition, Figure 1B being broken near the mid-section in order to show the details of construction at the scale chosen within the limits of the space available;

Figure 2 is a detailed sectional view, at a larger scale, of the fuse construction as shown in the preceding figures at the section adjacent the reservoir;

Figure 3 is a detailed view, at a larger scale, of the movable arcing tip in mid-operation;

Figures 4, 5 and 6 are sectional views taken along the lines 4—4, 5—5 and 6—6 of Figure 3;

Figure 7 is a perspective view of the arcing tip shown in Figures 3 to 6; and

Figure 8 is a sectional view showing the present invention adapted for higher current ratings through the use of a high conductivity fusible element, such as silver.

Referring now particularly to Figures 1A, 1B and 1C of the drawings, it will be observed that the reference character 10 designates an insulating tube which forms the housing of the fuse or circuit interrupter to be described in detail hereinafter. At its opposite ends the insulating tube 10 is provided with external or line terminals 11 and 12 which are arranged to have contact engagement with suitable terminal clips of a fuse-mounting (not shown) as is more fully set forth in my copending application Serial No. 663,833, filed April 22, 1946, now Patent No. 2,484,839, issued October 18, 1949.

As disclosed more fully in my copending application Serial No. 663,834 filed April 22, 1946, the fuse herein disclosed is arranged to be mounted so that, when the fuse blows, it will automatically move or swing in its fuse mounting, under the influence of gravity and the biasing force of the contact clips, to a position in which an air gap is provided between the upper line terminal 11 and the associated terminal clip which is connected to the circuit. In order to provide such operation the fuse has a latch tube 13 which is secured at its lower end to a latch release flange 14 that, together with the tube 13, is arranged to be moved upwardly in a manner to be described hereinafter for the purpose of unlatching the locking mechanism on the fuse mounting and permitting the fuse to fall or drop out to the open-circuit position.

At the central portion of the tube 10 its internal diameter is smaller as indicated at 18 for the purpose of providing a section which has greater resistance to bursting pressure, because high pressures may be generated within the tube 10 in the portion thereof in which the arc is drawn and extinguished. This configuration also aids in more uniformly distributing the dielectric flux in the air outside of the tube 10 about the ends of the terminals embedded in the tube.

With a view to providing an arcing passageway from whose surface an arc-extinguishing medium can be evolved, cakes 19 of solid boric acid, or arc-extinguishing material are positioned along the bore of the small-diameter section 18. These cakes 19 are annular in form and when placed one above the other provide a continuous bore 20 in which the arc may be drawn and extinguished. At each end of the column of cakes 19 of solid arc extinguishing material there is provided a reenforcing ring of suitable insulating material, such as fiber. One of these is indicated at 24 at the upper end in Figure 1B and the other is indicated at 25 at the lower end. The reenforcing ring 25 is flared outwardly to facilitate the outward flow of the products of the arc, as will be readily understood.

Movably mounted within the bore 20 in the cakes 19 of solid arc extinguishing material is a hollow, rodlike, or tubular terminal 26, which is movable through the bore 20 by mechanism that will be described in detail hereinafter. At its upper end the terminal 26 has a contact tip 27 threaded onto it. As is shown more clearly in Figure 2, the contact tip 27 has a cylindrical contact portion 28 making contact with the inturned ends of contact fingers 29 that are biased inwardly by a garter spring 30. The contact fingers 29 are formed by longitudinally slotting a tubular shell 31. The base section of the shell 31 may be rolled into a flange 32 which extends upwardly from a contact fitting 33, the lower end of which is shaped to conform to the adjacent surface of the fuse tube 10 and bears against the reenforcing ring 24 and serves to hold it in place.

The contact fingers 29 by their engagement with the contact tip 27 serve to provide a low-resistance, high-current-carrying, separable connection between the fitting 33 and the contact tip 27.

As is shown best in Figures 1A and 1B, an electric connection between the line terminal 11 and the contact fingers 29 is provided by a conducting tube, or terminal extension, 34 of brass or conducting material. It will be noted that the lower end of the conducting tube 34 is threaded onto the contact fitting 33 and that a nut 35 is threaded onto the upper end of the tube 34 and also is threaded into the line terminal 11, thereby forming an extension thereof. A lock nut 36 serves to hold the contact nut 35 in place.

As will hereinafter appear, it is desirable that, when the fuse blows, the tubular terminal 26 be withdrawn through the bore 20 in order to extend the arc therein and permit the heat thereof to evolve arc-extinguishing water vapor from the cakes 19 so as to deionize the arc space and assist in extinguishing the arc. In order to move the tubular terminal 26, a helical compression spring 37 lies within the conductor tube 34 and at one end bears against the fitting 33 and at the other end against the underside of a spring seat 38 which is secured to the lower end of a brass compression tube 39. The compression tube 39. The compression tube 39 carries a base 40 at its upper end from which a stud 42 depends. On opposite sides of the lower end of the stud 42, straps 43 (only one of which is shown) are pivoted by a pin 44. Between the straps 43 a pulley 45 is rotatably mounted on a pin or shaft 46.

A cable assembly, shown generally at 47, extends over the pulley 45 and provides both mechanical and electric connection to the tubular terminal 26 for effecting reaction thereof and for maintaining electric circuit connection thereto while it is being moved through the bore 20 after the contact tip 27 has moved away from the contact fingers 29. The cable assembly 47 consists of a core 48 formed of a large number of strands of fine copper wire, and an outer sheath 49 formed by a closely wound coil spring of stainless steel. One end of the cable assembly 47 is connected by a strap or cable link 50 to the terminal fitting 33.

The other end of the cable assembly 47 has a threaded terminal 52 which is screwed into a connecting tube terminal 52'. This terminal carries a bushing 53 which in turn carries a flask holder 54 at the lower end of which is fastened a sleeve 55 for carrying the contact tip 27 and the tubular terminal 26. Slideable within sleeve 55 is a needle holder 56 having cylindrical guide portion 57 and a central rod portion 58 connected by a perforated web 58'. This needle holder 56 is urged upwardly in the sleeve 55 by a coil spring 60 and it carries a needle 63 for puncturing the diaphragm 65 of a flask 66 mounted in the holder 54. This flask or reservoir 66 is a steel capsule filled with carbon dioxide. Such capsules are well known and readily obtainable on the market. The needle 63 has a notch 64 at such a distance from its tip that when the top of the cylindrical guide portion 57 of the needle holder abuts against the shoulder 61 of the flask holder 54, the notch 64 lies in the hole of the diaphragm 65 and so permits the escape of the carbon dioxide. The gas so released, flows down through the tube 55, passing through the perforated web 58' and the needle holder 56, and thence down through the tubular terminal 26.

Normally the needle holder is held in its lowermost position by a strain wire 59, the upper end of which is fastened in the lower end of the cylindrical portion 58 of the needle holder 56. This strain wire extends down through the terminal 26 and forms a part of the current responsive means employed for effecting operation of the fuse as will be described in detail hereinafter. As long as strain wire 59 remains taut it holds needle holder 56 in its lowermost position within the sleeve 55 against the force of spring 60 and also holds the sleeve 55, and with its terminal 26, in the lowermost position against the force of spring 37. When strain wire 59 slackens, it releases the needle holder 56 for operation within the sleeve 55 and thereby releases also the whole mechanism for withdrawing the tubular terminal 26 upward through the bore 20 in the arc extinguishing material 19.

The force exerted by spring 60 is nearly equal to that exerted by spring 37, and the inertia of the needle holder 56 is very small compared to that of the tube 54, pulley 45, cable 47, sleeve 55, terminal 26, and other parts moved by spring 37. Consequently the needle holder 56 experiences a much higher acceleration than does the terminal 26 and so travels the inch or so required for puncturing the capsule 66 during the time that the terminal 26 moves a much smaller distance. Thus the arc extinguishing gas is released from the capsule 66 by the time the tubular terminal 26 has moved a small fraction of an inch, and impelled through the bore of the terminal 26 by the high pressure, reaches the arc space promptly thereafter. The full stroke of terminal 26 is about 24 inches in a 115 kv. fuse and is completed in about one-tenth second.

At the lower end of the tubular terminal 26, an arcing tip 71 is carried as is best shown in Figures 3 to 7 inclusive. This tip is of substantially solid metal and is fluted at 72 to conduct the arc extinguishing gas into the space between the tip 71 and the surface of the bore 20 in the boric acid cakes 19. As may be seen in the sectional views of Figures 5 and 6, the flutes 72 are large compared to the central bore 70 through which the strain wire extends so that the flutes 72 offer the freest path for the gas. While the tube 26 nearly fills the bore 20 so as to impede the upward escape of gas from the arc space, tip 71 is smaller in diameter so as to leave sufficient clearance for the free flow of the gas from the flutes 72. The gas from the tube 26 thus sweeps downward over the surface of the tip 71 as indicated by arrows in Figure 4 for controlling the arc. These gases also sweep over the surface of the bore 20 at the receding end of the tubular terminal 26 and of the arcing tip 71, thereby directly sweeping out particles of conducting matter or the like which may facilitate the restriking of the arc once it has been extinguished.

As shown more clearly in Figure 1B, the strain wire 59 has a reduced section 73 adjacent the lower end of the arcing tip 71. The purpose of this is to provide a portion of the strain wire 59 which will melt in preference to other parts of this wire on the occurrence of relatively heavy fault current. It will be apparent that when the section 73 melts, the resulting arc will be formed near the end of the arcing tip 71 so that full use can be made of the bore 20 for drawing the arc therein to aid in extinguishing it.

The lower end of the strain wire 59 is secured

in a tubular terminal extension 74 of a terminal 75. The extension 74 is deformed onto the end of the strain wire 59 for providing mechanical and electric connections to it.

As indicated hereinbefore, it may be desirable to employ the fuse construction of the present invention for protecting potential transformers. The normal current flow to the potential transformer is relatively small, and under certain conditions, the flow of fault current thereto may also be small but yet of sufficient amount to require that the circuit be interrupted. Thus, it is necessary to provide a current responsive element which is capable of releasing the strain wire 59 at a relatively small overload but which still has sufficient mechanical strength to withstand the force of springs 37 and 60 and restrain their movement. For this purpose a fuse link construction, indicated generally at 76, may be employed, the construction of which is set forth in detail in Lindell Patent No. 2,084,495. The fuse link assembly 76 includes a terminal 77 which may be threaded into the terminal 75. One end of a conducting link 78 is pivoted to the terminal 77 and the other end has an eye that receives a lever 79 which is the first of a set of inter-related levers comprising additional levers 80 and 81. The levers 79, 80 and 81 are fulcrumed between plates 82 (only one of which is shown) of insulating material that, in turn, are supported on a terminal 83. A fusible element 84 in the form of a relatively fine wire mechanically and electrically connects the lever 81 with the terminal 83. The size of the wire 84 determines in part the time-current characteristics of the fuse link assembly 76. Because of the mechanical advantage provided by the levers 79, 80 and 81 the full force of the spring 37 is not applied directly to the fuse wire 84. Accordingly, it can be calibrated to melt on flow of a predetermined low current with an accuracy that would be impossible if the wire 84 were required to withstand the full force of the springs 37 and 60.

The fuse link assembly 76 is particularly intended to operate when the flow of fault current is relatively low and persists over an extended period. In such case, the fuse wire 84 will finally part and release the levers 79, 80 and 81, whereupon the springs 60 and 37 act immediately, as described hereinbefore, to puncture the diaphragm 65 and release the arc extinguishing fluid from the reservoir or flask 66 into the tubular terminal 26. In this case the arc will be drawn between the receding end of the link 78 and the terminal 83. Terminal members 75 and 77 and link 78 are small enough to enter the bore 20 for extending the arc therein to be extinguished. The arc will be of relatively small current magnitude and the arc extinguishing fluid from the reservoir or flask 66 will materially assist in extinguishing it since the arc is unlikely to evolve the necessary amount of arc extinguishing medium from the cakes 19 of arc extinguishing material. The carbon dioxide blast persists after the extinction of the arc and so sweeps out all residual ionized and conducting particles from the space between the arcing terminals, and increases the rate at which the arc-space builds up its resistance to any tendency of the arc to restrike in response to the recovery voltage that appears at the fuse terminals promptly after the arc interruption.

When a relatively heavy fault current flows, as in the case of a short circuit, both the reduced section 73 of the strain wire 59, and the fuse wire 84 will melt immediately. The functioning of the springs 37 and 60 in withdrawing the tubular terminal 26 and releasing the arc extinguishing fluid from the reservoir or flask 66 will be the same as already described. The terminal 77, being thus left unsupported, simply falls harmlessly into the exhaust passage. The arc promptly establishes itself between terminal 83 and tip 71 of the retractable terminal 26.

As in the case of the low-current fault, the arc extinguishing gas issuing from the tip 71 assists in the creation of a blast down through the bore 20, although in this case the arc is large enough that it also releases large amounts of water vapor from the boric acid 19. The force of the carbon dioxide gas from the flutes 72 opposes any migration of the arc root toward the edge 69 and also any flow of metal to this edge. Thus the gas issuing from the tube 26 insures that the arc will not enlarge the tip 71 to impede the free movement of the terminal in the bore 25. This control of the arc permits smaller clearance to be employed.

As in the case of the low current fault, the carbon dioxide blast, by persisting after the extinction of the arc and sweeping out residual conducting particles, increases the rate at which the arc space builds up its resistance to restriking.

The terminal 33 is connected to the lower fuse tube terminal 12 by a rod 85. The lower end of the rod 85, as viewed in Figure 1C, is secured to a narrow bridge 86 that is carried by a metal exhaust tube 87. The metal exhaust tube 87 extends well up into the lower end of the fuse tube 10 for assisting in more uniformly distributing the electrostatic stress incident to circuit interruption, as is set forth in more complete detail in the copending application of Lindell and Baker, Serial No. 663,832, filed April 22, 1946. A nut 88 is threaded onto the lower end of the tube 87 and is also threaded into the lower fuse tube terminal 12 to provide connection thereto. A lock nut 89 holds the nut 88 in place.

The fuse is arranged to expel the gases from the arc down through the lower line terminal 12. In order to cool and condense the arc-products and limit the escape of flame from the lower end of the fuse, a condenser assembly of the type shown in Triplett Patent No. 2,379,200 may be provided within the shell 16 just below the terminal 12.

It will be recalled that the fuse construction disclosed herein can be employed as part of a drop-out fuse construction as shown in my copending application Serial No. 663,834. It is for this purpose that the latch tube 13 (Figure 1A) is provided. When the fuse blows and the compression tube 39 is driven upward by the spring 37, it carries with it the base 40 until the latter engages a cap 104 that is secured to the upper end of the latch tube 13. Thereupon, the latch tube 13 is moved upwardly to lift therewith the flange 14 which releases the latch in the fuse mounting (not shown) to permit the fuse to drop out. The latch tube 13 moves upward until a flange 105 shown in Figure 1B, on the spring seat 38 engages a shoulder 106, Figure 1A, on the inside of a stop tube 107 that is secured to a fitting 108 which forms a part of the fuse mounting contact mechanism that is described in more detail in my copending application Serial No. 663,833. The stop tube 107 is held in place in the fitting 108, in part, by a sleeve 109 over which the lower end of the tube 107 is rolled and which bears against the underside of the fitting 108.

The latch tube 13 is held in the position shown in Figure 1A of the drawings by a coil compression spring 110 which is located between the tubes 13 and 107 and at its lower end bears against the upper end of a tubular extension 111 from the flange 14 and at its upper end against the underside of a collar 112 which is secured to the upper end of the stop tube 107. The fitting 103 has integrally formed ears 113 and 114 on opposite sides between which links are pivoted to provide for contact engagement between the line terminal 11 and the cooperating fuse clip.

As illustrated in Figure 8, it may be desirable to omit the low-current fuse-link assembly 76, shown in Figure 1B, and connect the strain wire 59 having the reduced section 73 therein to provide a preferred blowing section, directly to a connector 118 that may be supported by a narrow bridge 119 secured mechanically and electrically to the exhaust tube 87.

Where a still higher current rating is required, a fusible element 120, in the form of a coil of silver wire also can be used. As shown in Figure 8, the coiled fusible element 120 serves to interconnect the arcing terminal 71 and the connector 118, the same being deformed onto the ends of the fusible element 120.

Since certain further changes can be made in the foregoing constructions and different embodiments can be made without departing from the spirit and scope thereof, it is intended that all matter shown in the accompanying drawings and described hereinbefore shall be interpreted as illustrative and not in a limiting sense.

What is claimed as new is:

1. In combination in a circuit interrupting apparatus having a body of arc extinguishing material in which there is a longitudinally extending bore, a pair of terminals between which an arc may be drawn one of which is tubular and retractable through said bore for enlarging the arc space between them, a chamber fixed to the end of said tubular terminal away from the arcing end, a capsule containing an arc extinguishing material fixed in said chamber, a cutter reciprocable in said chamber, spring means within said chamber for actuating the cutter to puncture the capsule, separate spring means for retracting said tubular terminal, and fusible tension means extending through said tubular terminal and holding both said cutter and said terminal for restraining their operation by said spring means.

2. In combination in a circuit interrupting apparatus, a body of arc confining insulating material having a bore, a pair of arcing terminals one of which is movable through said bore away from the other terminal, means forming an arcing tip on the movable terminal, said tip being sufficiently smaller in cross sectional area than said movable terminal and said bore as to permit free flow of gas therepast, a portion of said movable terminal having a close fit in said bore for impeding the flow of gas therepast through said bore, a reservoir for holding material which when released is in the form of an arc extinguishing fluid, means for retracting said movable terminal through said bore away from the other terminal for enlarging the arcing space between them, releasable means holding said movable terminal against retraction, said movable terminal having duct means for conducting said arc extinguishing fluid from said reservoir into said bore at a position between said arcing tip and said portion which has a close fit with the bore, and

discharge means operable during the initial movement of said one terminal for releasing said material from the reservoir, whereby it flows into said bore, envelops said arcing tip and enters said arc space.

3. In combination in a circuit interrupting apparatus, a body of arc confining insulating material having a bore, a pair of terminals, one of which is hollow and movable through said bore away from the other terminal, releasable means holding said hollow terminal against movement, and arcing tip on said movable terminal which is sufficiently small than said movable terminal and said bore to permit free flow of gas between said arcing tip and the wall of said bore, a reservoir of arc extinguishing material at the end of said tubular terminal away from the other terminal and movable with said tubular terminal, and discharge means operable from the beginning of the retraction of said movable terminal for releasing the arc extinguishing material from said reservoir and conducting it through said tubular terminal, said tubular terminal and tip having a duct for conducting said arc extinguishing fluid from said tubular terminal into that part of said bore immediately surrounding said arcing tip.

4. In circuit interrupting apparatus having a body of arc extinguishing material in which there is a longitudinally extending bore, and a pair of relatively movable terminal members between which an arc may be drawn, one of said terminals being tubular and biased for movement through said bore, in combination, a reservoir movable with said one terminal for holding material which when released is in the form of an arc extinguishing fluid, discharge means cooperable with said reservoir for releasing said fluid therefrom to flow through said tubular terminal to assist in extinguishing said arc, a spring biasing said discharge means toward releasing position, and current responsive means restraining said tubular member from movement through said bore and said discharge means from movement by said spring until a predetermined current flow takes place whereupon said discharge means is operated to release said fluid to flow through said tubular terminal at about the same time that it starts to move through said bore.

5. In circuit interrupting apparatus having a body of arc extinguishing material in which there is a longitudinally extending bore, and a pair of relatively movable terminal members between which an arc may be drawn, one of said terminals being tubular and biased for movement through said bore, in combination, a reservoir movable with said one terminal for holding material which when released is in the form of an arc extinguishing fluid, discharge means cooperable with said reservoir for releasing said fluid therefrom to flow through said tubular terminal to assist in extinguishing said arc, a spring biasing said discharge means toward releasing position, and a tension element arranged to be released on flow of predetermined current through said terminal members restraining said tubular member from movement through said bore and said discharge means from movement by said spring until said predetermined current flow takes place whereupon said discharge means is operated to release said fluid to flow through said tubular terminal at about the same time that it starts to move through said bore.

6. In combinaion in a circuit interrupting apparatus having a body of arc extinguishing ma-

terial in which there is a longitudinally extending bore, a pair of terminals between which an arc may be drawn one of which is tubular and retractable through said bore for enlarging the arc space between them, a reservoir for holding a material which when released is in the form of an arc extinguishing fluid, said reservoir being movable with said tubular terminal and connected thereto for directing said material through said terminal into said arc space, an opener movable relative to said tubular terminal and reservoir for releasing said material therefrom and operatively connected to said tubular terminal to prevent retraction thereof, and a severable tension element connected to said opener for holding it at the limit of its motion relative to said reservoir in the non-opening position, and for thereby holding said tubular terminal against retraction.

7. In combination in a circuit interrupting apparatus, a body of arc extinguishing material having an arc passage therein, means for drawing an arc in said passage including a stationary terminal and a tubular terminal retractable therefrom through said passageway, a pair of members comprising a reservoir for holding a material which when released is in the form of an arc extinguishing fluid and an opener for said reservoir having limited movement relative to said reservoir, one of said members being movable with said tubular terminal and the other being movable relative thereto and operatively connected thereto to prevent retraction thereof, and a fusible tension element connected from the other member, and extending through said tubular terminal to the stationary terminal for holding said other member at a non-opening position in its motion relative to said one member and for thereby holding said tubular terminal against retraction.

8. In combination in a circuit interrupting apparatus having a body of arc extinguishing material in which there is a longitudinally extending bore, a pair of terminals between which an arc may be drawn one of which is tubular and retractable through said bore for enlarging the arc space between them, a chamber carried by said tubular terminal at the end away from the arcing end, a capsule containing an arc extinguishing material in said chamber, a cutter reciprocable in said chamber for opening the capsule and operatively connected to said chamber thereby to prevent retraction of said tubular terminal, a severable tension element connected to said cutter at one end for holding it way from said capsule, said tension element extending through said tubular terminal and connected at its other end to the other terminal, said tension element on being severed allowing said cutter to open said capsule and thereby its contents to flow through said tubular terminal into said bore while the former is retracted through the latter.

9. The combination of the immediately preceding claim wherein said capsule lies at the end of said chamber remote from the arcing tip of said tubular terminal and said tension element holds said cutter in its extreme position toward said tubular terminal.

10. In combination in a circuit interrupting apparatus having a body of arc extinguishing material in which there is a longitudinally extending bore, a pair of terminals between which an arc may be drawn one of which is tubular and retractable through said bore for enlarging the arc space between them, a reservoir for holding material which when released is in the form of an arc extinguishing fluid, said reservoir being located at and fixed to the end of said tubular terminal away from the arcing end and arranged to discharge said fluid therethrough, an opener for said reservoir having limited movement relative thereto and operatively connected to said tubular terminal to prevent retraction thereof, spring means for operating said opener to release the material from said reservoir, separate spring means for retracting said tubular terminal, and a single severable tension element interconnecting said opener and the other of said pair of terminals and restraining both of said spring means.

11. In combination in a circuit interrupter having a body of arc extinguishing material in which there is a longitudinally extending bore, a pair of arcing terminals, one of which is tubular and movable through said bore, driving means acting on said tubular terminal for separating it from the other terminal and forming an arc space therebetween, a fusible tension element extending through said tubular terminal and providing a connection between the other terminal and said driving means for restraining said driving means, means constituting a source of fluid arc extinguishing medium in communication with the opening through said tubular terminal at a point remote from its arcing end at least during a portion of its movement through said bore, and means for releasing said fluid arc extinguishing medium to flow through said opening following rupture of said fusible tension element.

12. In circuit interrupting apparatus, in combination, a body of arc extinguishing material having a bore, a pair of relatively movable terminal members between which an arc may be formed, one of said terminal members being located adjacent one end of said bore and the other being tubular in character and movable through said bore, a reservoir movable with said tubular terminal for holding material which when released is in the form of an arc extinguishing fluid, mechanism for moving said tubular terminal member, puncturing means carried by and movable relative to said tubular terminal for releasing said fluid, and means for operating said puncturing means to release said fluid to flow through said tubular terminal member into said bore and the arc space during the initial movement of said mechanism for assisting in extinguishing the arc before and while the same is withdrawn into said bore and for blowing out of said bore products of the arc deposited on the surface thereof and likely to facilitate restriking.

SIGURD I. LINDELL.

REFERENCES CITED

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

UNITED STATES PATENTS

Number	Name	Date
2,319,276	Triplett	May 18, 1943
2,319,277	Triplett	May 18, 1943
2,328,825	McMahon	Sept. 7, 1943
2,343,422	Rawlins	Mar. 7, 1944
2,353,528	Triplett	July 11, 1944
2,491,956	Curry	Dec. 20, 1949