Aug. 31, 1937. N. J. CONRAD 2,091,431

FUSE

Original Filed July 24, 1930 5 Sheets-Sheet 1

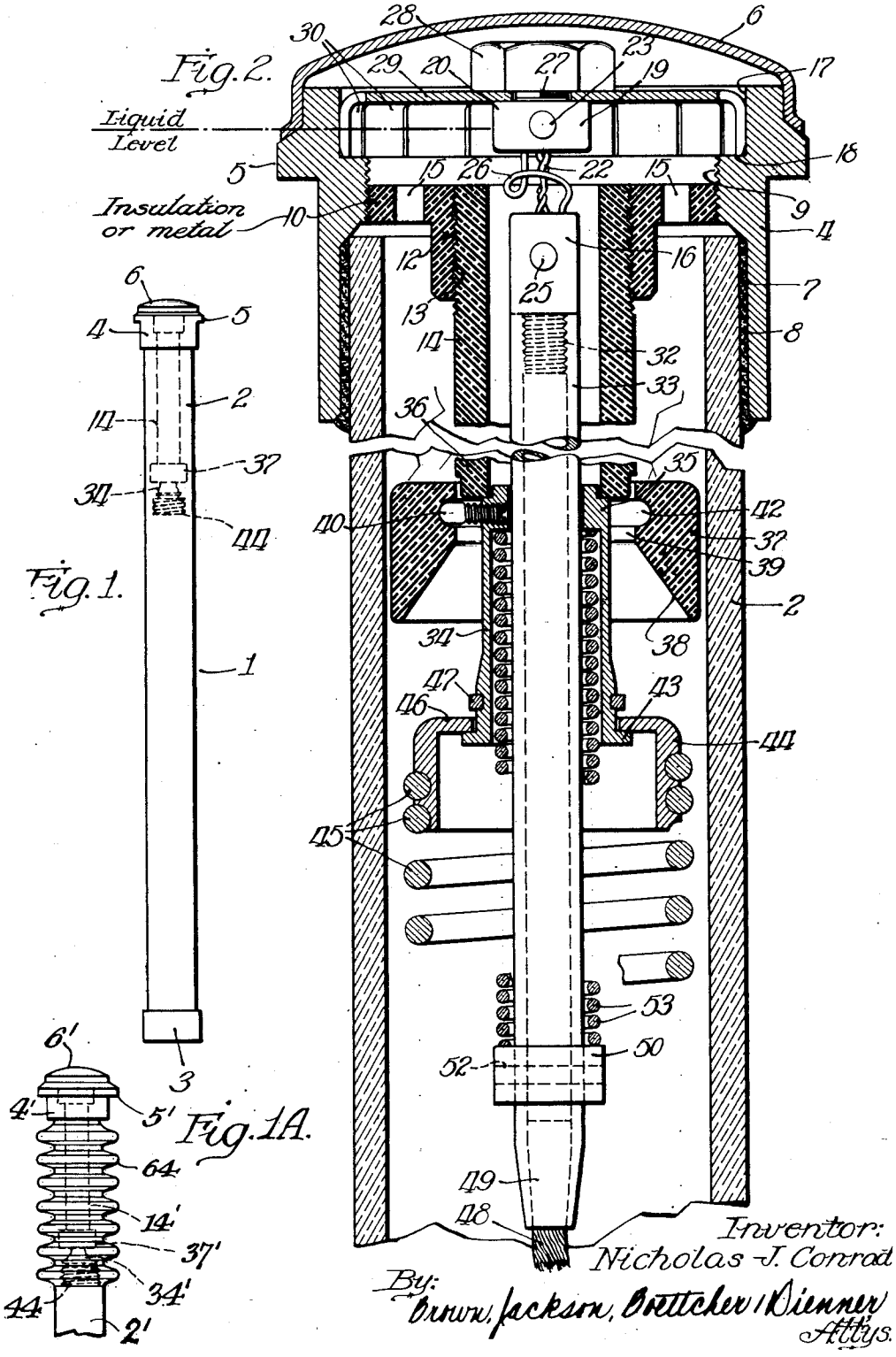


Fig. 1.

Fig. 1A.

Inventor:
Nicholas J. Conrad

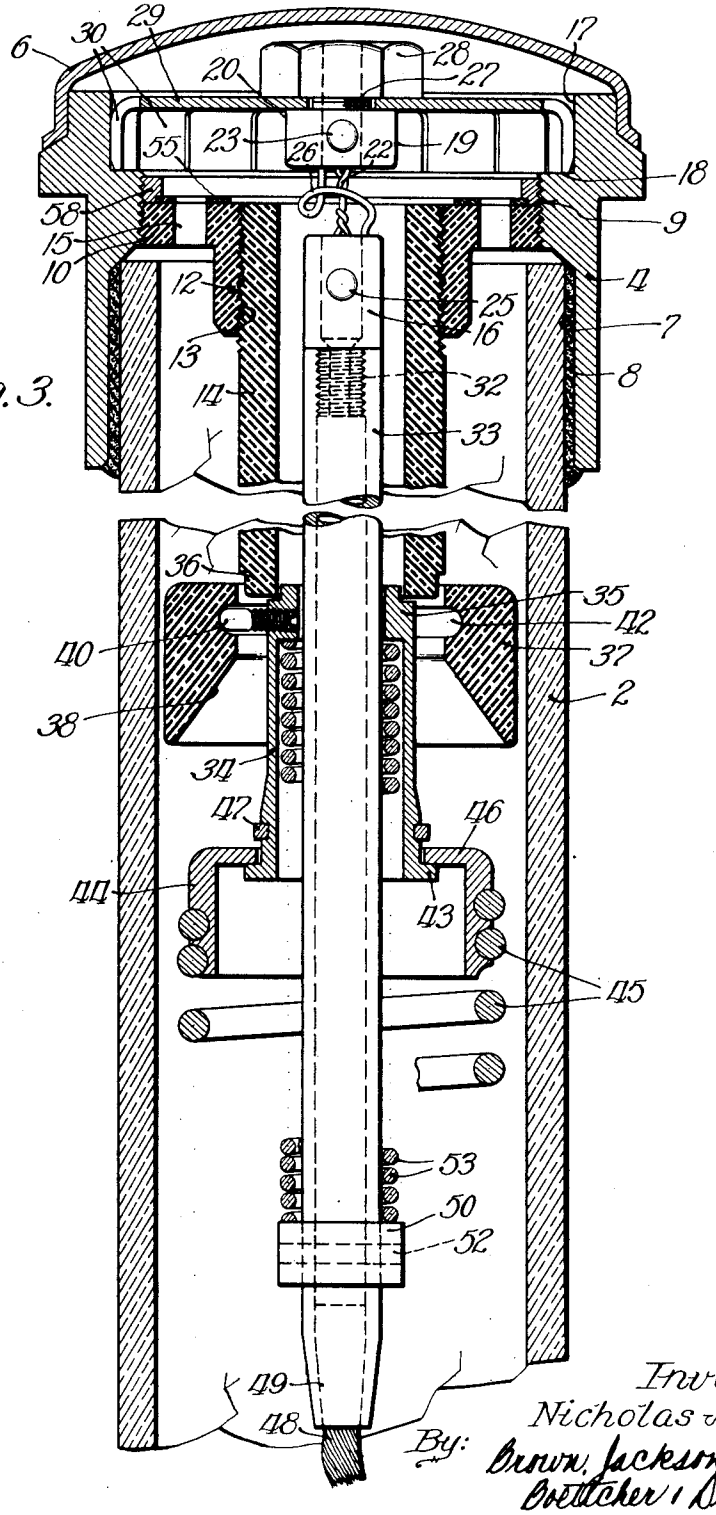
By: Brown, Jackson, Boettcher & Dienner
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Fig. 3.



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Fig. 4.

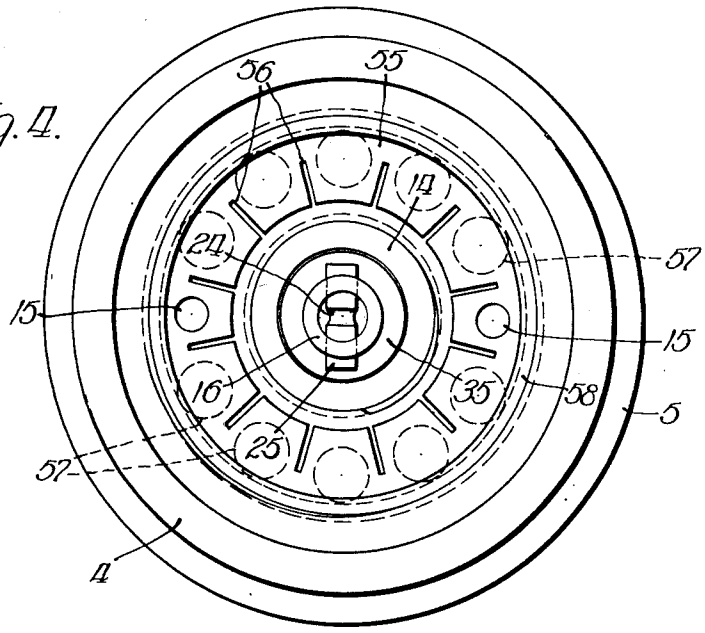
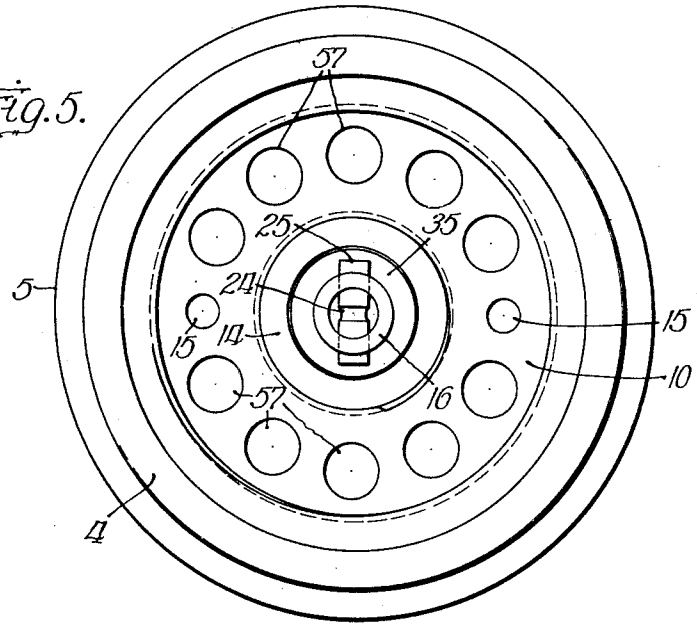


Fig. 5.



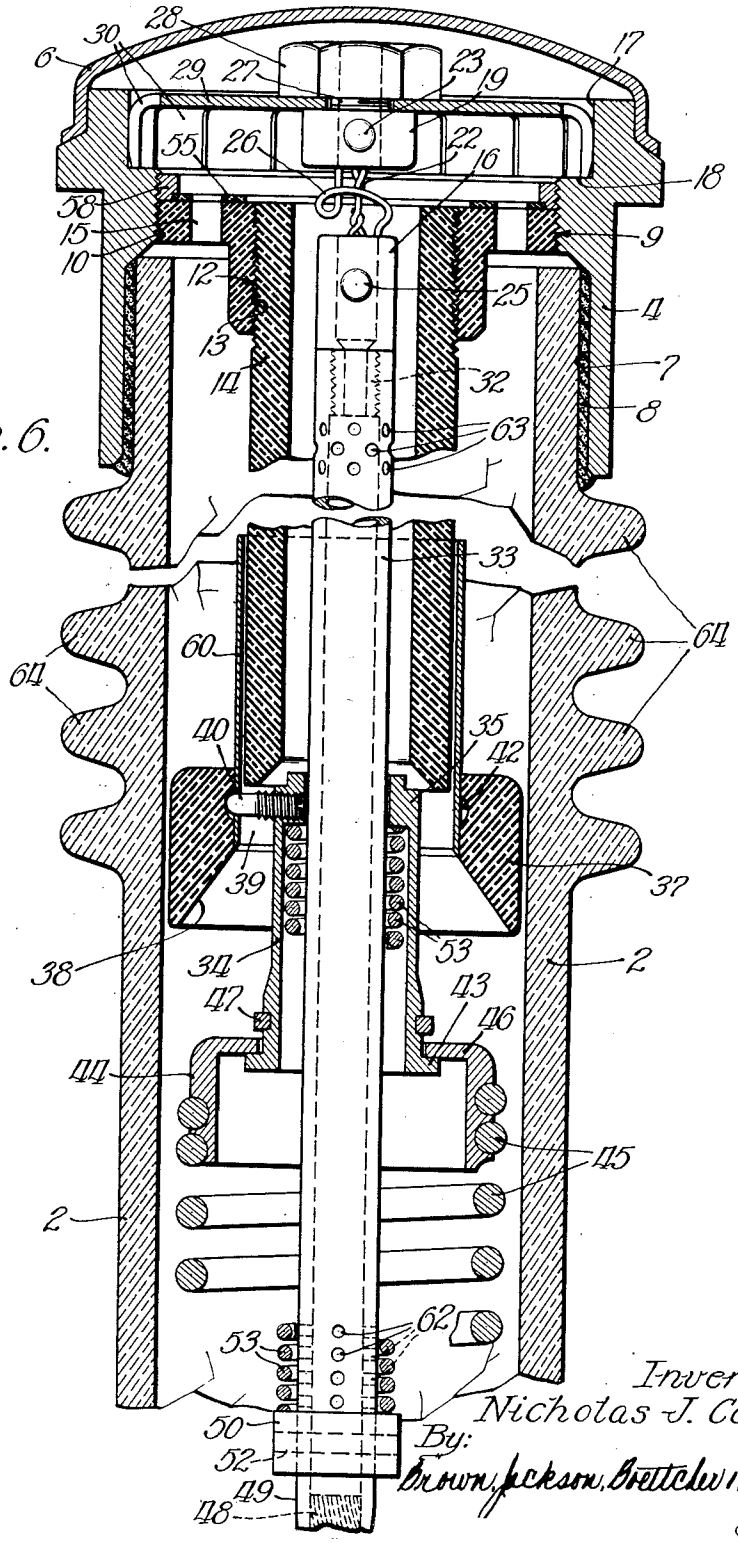
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Fig. 6.



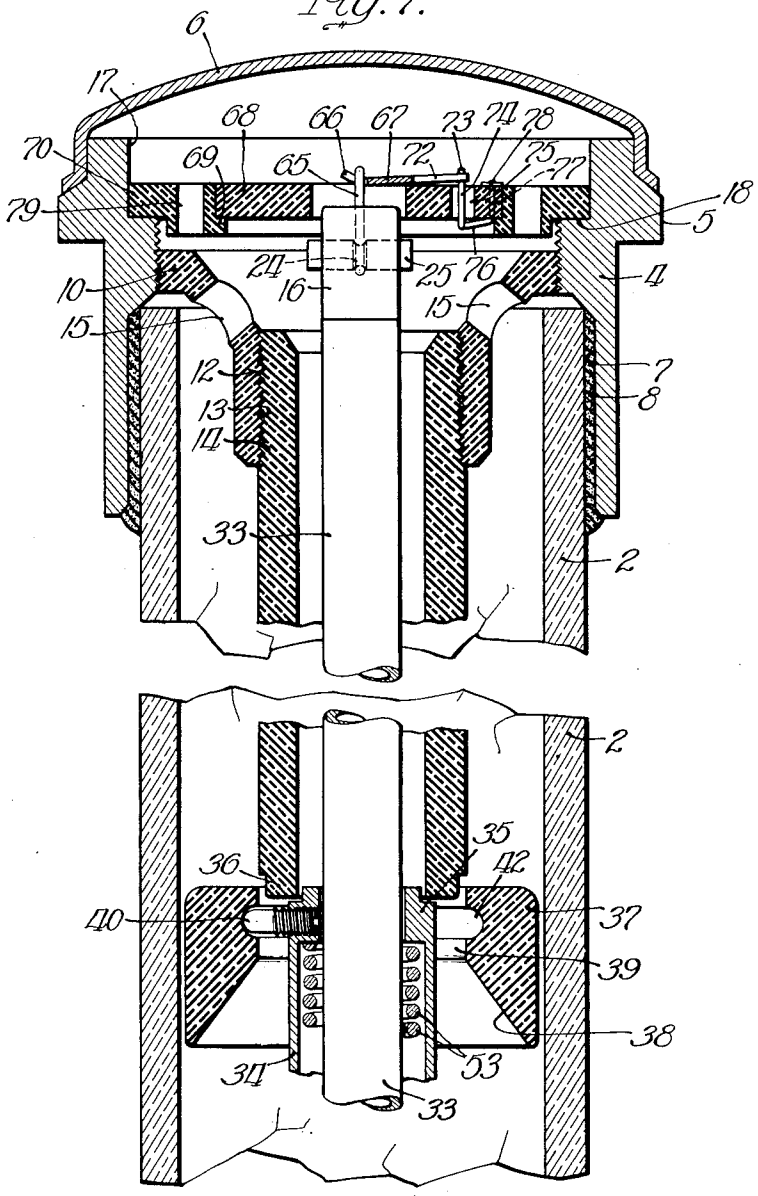
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Original Filed July 24, 1930 5 Sheets-Sheet 5

Fig. 7.



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Patented Aug. 31, 1937 2,091,431

UNITED STATES PATENT OFFICE

2,091,431

FUSE

Nicholas J. Conrad, Winnetka, Ill., assignor to Schweitzer & Conrad, Inc., Chicago, Ill., a corporation of Delaware

Application July 24, 1930, Serial No. 470,417
Renewed March 1, 1937

84 Claims. (Cl. 200—120)

My invention relates to a method of and means for interrupting current flow.

While the specific embodiment which I shall herein describe is a fuse adapted for the interruption of current flow of relatively high tension, it is to be understood that the invention is not to be limited to the specific embodiment herein shown, nor to the particular use herein described, but may be employed for other uses, such as circuit breakers, etc.

For the interruption of excessive current flow under high tension, two types of apparatus, which I shall briefly discuss, are now in common use, namely, the oil circuit breaker and the liquid quenched fuse of my assignee's construction.

The oil circuit breaker comprises, generally, a chamber closed except for a relief vent, within which is contained a body of oil. A pair of contacts submerged in the oil are arranged to be separated by spring or other means when the switch is to be operated. Electromagnetic trip mechanism, set to operate upon a predetermined current flow sets the breaker into operation. The body of oil is generally contained in a metal tank which is provided, but which is of such generous dimensions as to be spaced from the contacts so as to interpose a considerable body of oil between them and the grounded tank.

In a fuse of this type or a single pole circuit breaker of like characteristics, a grounded or metallic container is out of the question. Also, for practical reasons, a large volume of oil or arc extinguishing liquid is also not permissible. As heretofore constructed, the fuse has consisted of a sleeve of insulating material, generally glass, with metallic terminals, caps or ferrules on its end, closing it off.

Normally the two ferrules are connected by the fusible link and the conductors connected thereto. The body of arc extinguishing liquid contained in the cylindrical container formed by the sleeve and ferrules is relatively small and is of relatively small radial dimensions. As the volume of liquid is small it must be used as efficiently as possible to insure invariable operation under all conditions. The range of overloads which a fuse may be called upon to interrupt varies all the way from slightly above rated capacity of current flow to many times rated capacity. Where the overload is small, the operation of interrupting the arc may be relatively quiet and may occur entirely within the closed fuse casing. Upon overloads of a higher order very violent operation may occur with opening of the fuse casing to atmosphere, or a region of lower pressure, in order to secure a high rate of discharge of gases, vapors, and the like to promote violent agitation of the arc, and the arc extinguishing medium, by high rate of flow of gases and the turbulent action upon the arc of the same in escaping from the explosion or arc extinguishing chamber.

Inasmuch as the radial dimension is small the electrostatic stress produced between the ferrule and the conducting terminal may be very great. It has been found in practice that on higher voltages this stress may become so great as to puncture the glass sleeve and thereby destroy the upper end of the container. This peculiar action of puncturing the glass sleeve is apt to occur on light overloads where the arc produced by melting of the fuse is quickly extinguished, in fact, so rapidly extinguished that the terminal does not have time to be separated from the upper ferrule by adequate distance, with the result that the recovery voltage, that is, the inductive effects set up by interrupting current flow, may be great enough to puncture the arc extinguishing liquid and glass sleeve. The violence of the blowing of the fuse also tends to produce a high stress upon the upper end of the tube, both with regard to pressure or shock and heat.

The breakage of the upper end of the container under such circumstances might in prior constructions, cause the liquid director to become caught upon the broken edge and hung up, thereby interfering with the arc extinguishing function.

According to the present invention I provide an inner tube of insulation extending from within the metallic terminal to perform the three functions, first of increasing the dielectric strength between the movable fuse terminal and the adjacent ferrule, and second of diminishing the mechanical shock and heat of the arc upon the main container and, third, to assist in the quenching of the arc as will be explained later.

Since this inner tube is of relatively small diameter its strength against internal pressure is high; also, the liquid between the outer sleeve and the inner tube is not initially displaced by the arc, with the result that it retains substantially its full dielectric strength during the initial stages of operation, even on violent blowing of the fuse.

This tube performs the function of providing an explosion chamber as disclosed in my copending application, Serial No. 470,416, filed July

24, 1930, and in addition performs other functions, chief of which is the interposition of a positive insulating barrier between the moving arcing terminal and the lower end of the upper ferrule and also it serves as a constricted outlet for the discharge of the arc extinguishing medium in contact with the arc. It is therefore termed in the present specification and claims as an arcing chamber or an arc extinguishing chamber.

The fuse conforms to the requirements of the voltage in preserving a suitable spacing between its terminals. This, in the case of high voltage fuses, may require a fuse casing of considerable length. Since the aforesaid sleeve must extend down in the casing a considerable distance to interpose the necessary insulation while the movable terminal is descending, the part of the said movable terminal which projects up in said tube tends to take up considerable of the space which could otherwise be devoted to the retracting spring.

I have overcome this difficulty, according to the present invention, by making the said movable terminal telescopic and employing an auxiliary retracting spring to telescope the members of the movable terminal.

This compound construction of the movable terminal permits of a differential operation of the two parts. The outer, or main retracting spring carries the outer sleeve part of the telescopic terminal and carries also the liquid director. The inner telescopic portion of the movable terminal has a retracting spring which is mechanically supported against the end of the main retracting spring, and this auxiliary retracting spring is the one which retracts the inner telescopic portion of the terminal member from the arcing chamber.

Inasmuch as the two springs are mechanically connected in series with each other it would appear that the two telescopic parts would move in proportion to the interposed spring length, but it is to be observed that the outer spring has the liquid director, which is of a relatively large area, and the inner spring has only the rod-like fuse terminal member, and the result, therefore, is that the rod-like fuse terminal is rapidly retracted from the arcing chamber and thereupon the slower motion of the liquid director occurs, forcing liquid from under the liquid director out past the movable fuse terminal member and through the explosion chamber in contact with the arc.

Numerous modifications in detail are permissible within this general mode of operation of first drawing the arc in a restricted passageway and then discharging the arc extinguishing medium into the arcing chamber or passageway while further separating the terminals.

In the copending application above referred to, the gaseous products resulting from the interacting of the arc and the arc extinguishing materials is discharged into an expansion chamber, and if the overload is relatively light, this is sufficient to extinguish the arc, whereas if the overload is of great severity, the casing of the fuse is opened by blowing off the vent or safety cap, and the discharge of the gaseous products to atmosphere occurs, providing the necessary flow and turbulence, which breaks up and tends to de-activate the arc.

Where the arc is so great as to cause pressures greater than it is safe to carry in the casing, the structure of that application progressively opens up and provides additional avenues of escape by blowing out the upper terminal, the explosion or arcing chamber and the barrier ring progressively. In the present construction, the provision of the elongated tube does not lend itself so well to progressively blowing out of the parts of the fuse, and hence I have organized the mechanism to act in two stages, namely, first, to confine the arc to the elongated tube which forms the explosion or arcing chamber, and then extend it into the enlarged bore of the glass tube below the explosion or arcing chamber. This permits escape of gases around said tube through additional openings through which the gaseous products may be discharged, any arc gases in such additional space or passageway being subject to the action of the arc extinguishing medium which is projected thereinto. Both chambers communicate with atmosphere at their upper ends after the cap has been removed.

Numerous other improvements to which I have not heretofore specifically called attention will be apparent from the following detailed specification and claims.

Now in order to acquaint those skilled in the art with the manner of constructing and operating a device embodying my invention I shall describe, in conjunction with the accompanying drawings, a specific embodiment of the invention.

In the drawings:

Figure 1 is a side elevational view of a fuse embodying my invention;

Figure 1*a* is a fragmentary view similar to Figure 1 and showing a modified form of fuse casing;

Figure 2 is a vertical longitudinal section through the fuse of Figure 1;

Figure 3 is a similar vertical longitudinal section of a modification;

Figure 4 is a top plan view of a fuse with the cap and the contact spider removed;

Figure 5 is a similar view with the release plate removed;

Figure 6 is a longitudinal vertical section of a modification similar to Figure 3, and

Figure 7 is a longitudinal vertical section of a further modification.

Throughout the following specification like reference numerals are employed to identify like parts.

In Figure 1 I have shown the fuse 1 as comprising a glass sleeve 2, having upon the lower end a cap member 3 which is formed in the shape of a cylindrical cup with the sides slabbed off to provide flat surfaces for the engagement of suitable mounting and contact terminals. The upper end of the sleeve has a ferrule 4, which is similarly slabbed off below the shoulder 5. The ferrule 4 is closed off by a releasable cap member 6 which, as will be seen from the section of Figure 2, embraces the upper end of the ferrule. The cap 6 is suitably cemented in place, or otherwise secured in a manner which permits it readily to be removed upon excessive internal pressure occurring within the fuse casing. Preferably the cap is secured by suitable cementitious materials to maintain a suitable yieldable joint which is fluid-tight until the same is removed.

The ferrule 4 has an internal socket at 7 for receiving the upper end of the glass sleeve 2, and a suitable cementitious material such as a relatively soft alloy seals the space between the ferrule and the upper end of the glass sleeve to provide a fluid-tight joint. The sleeve casing

is required to be tight at all times since the casing must retain, without leaking, an arc extinguishing medium which may be carbon tetrachloride or other halogen derivatives of hydrocarbons.

The ferrule 4 has an internally threaded bore 9 into which is threaded a ring 10 which I term herein the barrier ring. This ring has a central flanged opening provided with threads as indicated at 12 for receiving the upper threaded end 13 of the inner sleeve 14. The barrier ring 10 may be made of metal or of molded or other insulation if desired, but the tube 14 is preferably a rolled fiber tubing impregnated with a suitable insulation such as a synthetic resin or condensation product.

The barrier ring 10 is provided with a series of release ports 15 which may be left open or which may be partially or wholly closed off with provision for suitable opening under pressure. The sleeve 14 defines an explosion chamber and it will be seen from the dotted line illustration on Figure 1 that this sleeve extends downwardly into the upper end of the glass sleeve 2 for a considerable distance, sufficient that when the movable terminal 16 is withdrawn from the same, sufficient space will have been interposed between the said terminal 16 and the lower end of the upper ferrule 4 as to prevent voltage between the lower end of the ferrule 4 and the movable terminal 16 from puncturing the contained arc extinguishing medium and the glass sleeve 2. This provision of the tube 14 overcomes the defect of previous forms of fuses of this general type in which, particularly on lighter overloads, melting of the fuse resulted in an arc which is quickly extinguished, in fact, before the upper terminal such as 16 is sufficiently removed from the region of the ferrule 4 to interpose the necessary insulation, with the result that the recovery voltage from interruption or from inductive or potential effects tends to cause a disruptive discharge to occur between the terminal 16 and the sleeve 4, puncturing the glass tube 2 and tending to destroy the same.

The upper part of the ferrule 4 is provided with a counterbore 17 which terminates in a shoulder 18. The upper fuse terminal 19, which is substantially identical with the terminal disclosed in my copending application Serial Number 470,416 has a longitudinal bore through the head portion 20 and in this longitudinal bore the upper end of the strain wire 22 is received. A transverse pin 23 intersects the longitudinal bore, this pin having a peripheral groove at its center portion, as indicated at 24 in Figure 4. The movable terminal 16 has a similar transverse pin 25, the pins 23 and 25 being identical. It is to be noted that the head 20 is of a greater diameter than the terminal member 16, with the result that the pin 25 projects from the sides of the lower terminal 16 the ends of the pin 25 projecting from the terminal 16 preventing the terminal and its connected tube 33 from being drawn down through the carrier or sleeve member 34, as such operation might interfere with the descent of the carrier and the liquid director 37. Also the pin 25 presents a convenient hold for raising the terminal 16 and tube or rod 33.

The strain wire 22 has loops formed at each end which embrace the grooves 24 in the pins 23 and 25, thereby forming a mechanical connection providing suitable articulation of limited universal movement. The strain wire 22 is of a high mechanical strength, being made preferably of a chromium nickel iron alloy such as may be obtained in the market under the name of "Nichrome" or Chromel.

The terminals 19 and 16 are further connected by a fuse wire 26 which is preferably a wire of high conductivity, for example, silver, which is mechanically connected to the head 20 and the terminal 16 as by means of a longitudinal slot along each terminal into which the end of the fuse wire is laid and then the edges of the slots battered over the sides of the fuse wire to make an electrical connection which is independent of heating and the like.

The terminal member 19 has a stem 27 of reduced diameter which is preferably of cylindrical shape, with a thread for receiving the nut 28, but which has the sides thereof slabbed off to provide suitable holding faces. A supporting spider 29, formed of a flat plate with a cylindrical flange has a central hole of the same configuration as the cross-section of the stud 27, so that the stud and the plate are relatively non-rotatable. The flange of the plate 29, which is cylindrical in form, is slotted to provide a series of spring fingers 30, which are of a suitable diameter to permit their being forced into the counterbore 17 to make good electrical contact, but being at the same time releasable by pressure upon the plate as may occur upon blowing of the fuse.

The plate is preferably apertured, or punched out about the central part to form a spider having arms between the central portion and the flange portion.

This spider is the same as that disclosed in my copending application, Serial Number 470,416. The lower ends of the spring fingers 30 rest endwise against the shoulder 18 and serve definitely to position the spider and the terminal 19.

The lower terminal 16 is provided with a threaded stem 32 which is threaded into the upper open end of the rod 33. This rod is preferably a copper or brass tube, to the upper end of which the terminal 16 is fastened. The lower end of the stem or rod 33 extends through and telescopes with a sleeve member 34, the upper end of which has an inwardly extending flange 35.

The upper end of the sleeve 34 is notched to center the sleeve within the lower end of the insulating sleeve 14, said lower end 36 being trimmed down to pass loosely inside the upper end of the liquid director 37. These members are thus centered relative to each other.

The liquid director 37 has a flared inlet 38 and a central opening providing an annular passageway 39 between the bore of the liquid director and the sleeve member 34. The liquid director is supported upon the sleeve member 34 by a series of pins 40 threaded in holes in the flange 35 and having outer rounded ends engaging in the shallow rounded groove 42.

The lower end of the sleeve 34 has an annular shoulder 43 in the shape of an outwardly extending flange. The upper spring anchor 44 which is in the shape of a cylindrical ring, with a helical groove formed in the outer surface thereof for receiving the coils of the spring 45, has an inwardly extending flange 46 overhanging the flange 43 so as to couple the sleeve and the spring anchor together. A retaining ring 47, which is a split ring, seats in a groove in the sleeve 34 to prevent uncoupling of the sleeve 34 and the spring anchor 44.

The lower end of the tubular rod 33 forms a connecting socket for the upper end of the flexible conductor 48 which conductor is connected

electrically to the lower ferrule 3 in shunt of the main spring 45. The lower end of the tube is swaged upon the upper end of the flexible conductor 48 as shown at 49. A collar 50 is mounted upon the lower end of the tube 33 and is held in place by a cross pin 52. Between the flange 35 of the sleeve 34 and the collar 50 I interpose the compression spring 53. The upper end of this compression spring 53 is disposed within the sleeve 34 and the entire length of the spring is guided upon the tubular rod 33.

As is more clearly shown in Figure 2 of the drawings the upper end of the sleeve 34 abuts the lower end of the insulating sleeve 14 and the convolutions of the compression spring 53 are spaced apart. This arrangement, in which the spring 53 reacts between the rod 33 supporting the terminal 16 and the lower end of the sleeve 14, places the latter in compression and the strain wire 22 in tension. The tension spring 45, reacting between the sleeve 34 and the lower end of the glass sleeve 2 forming the fuse tube, does not in this case apply any tension to the strain wire 22. This results from the fact that the tension spring 45 must exert a force on the sleeve 34 that is greater than the force exerted thereon by the compression spring 53 in order to apply additional tension to the strain wire 22. Consequently the same tension will always be applied to the strain wire 22 when the terminal 16 is drawn up to the same position each time that the device is refused.

If desired, the flexible conductor 48 might be led up to the terminal 16 for making electrical connection and the tubular rod 33 might then be made of insulation. The main retracting spring 45 is anchored to the lower ferrule cap 3 and this spring is placed under tension.

As shown in Figure 1*a* the glass sleeve 2' may be provided with corrugations at the upper end so that as the terminal which is drawn down is drawn below the explosion chamber in the tube 14' the leakage distance over the outer surface of the glass will be sufficiently increased to prevent puncturing or injury to the sleeve by the voltage. This provision of corrugations is for the purpose of preventing a concentration of electrostatic stress which might result in puncturing the tube under the conditions that could occur if the glass sleeve had a film of moisture thereupon. Such film of moisture as by rain or the like might conduct the voltage of the terminal to a point opposite the lower end of the inner tube 14, so that when the terminal 16 descends below the tube 14, even though the arc be extinguished, the electrostatic stress might be so great as to puncture the glass sleeve at this point, and destroy the same. The speed of retraction of the small diameter light weight rod 33 is assisted by the pressure in the explosion chamber.

As explained in the copending application Serial Number 470,416 the fuse wire 26, which is preferably of silver, or like metal, is disposed in a coil about the stress sustaining member 22 and the length of the wire 26 controls the time-power characteristic.

In the fuse shown in Figures 1 and 2 the liquid level is adapted to be carried above the body of the fuse 26, but this may be varied as taught in the said copending application. The terminal 19 may be lengthened for disposing the fuse lower in the explosion chamber provided by the tube 14. The barrier ring 10 may be made of metal, but is preferably formed of insulation.

The operation of the device is as follows:

The compression spring 53 and the main tension spring 45 are held in stressed condition by the means of the stress sustaining member 22, which I term the strain wire. The strain wire is articulated to the pins 23—25 and the coiling of the fuse wire gives it sufficient flexibility that there is no danger of breaking off the fuse wire, either by the manipulation required to assemble the fuse, or by vibration of the parts in use.

Upon blowing of the fuse and fusing of the strain wire 22 the movable terminal member 16 and its connected rod 33 are released, so that it is then subjected to the action of the retracting springs 45 and 53. Since the liquid director 37 is directly connected to the main spring 45 and considerable resistance is thereby afforded to its movement through the liquid, the tendency for the device is to permit the spring 53 to retract rapidly the movable terminal 16 down through the tube 14 and to a position where the projecting ends of the pin 25 engage the upper end of the sleeve 34 which continues in its downward motion. Due to the relatively small diameter of the rod or tube 33, it is projected down into the liquid by the spring 53, with the result that it displaces liquid below it. Since the area of the liquid director 37 is so much greater than that of the rod or tube 33, the descent of this rod or tube 33 with its terminal 16 is accomplished rapidly before any substantial movement of the liquid director occurs. The result is that liquid is forced from below the director 37 into the tube 14 as the terminal 16 is withdrawn. The liquid between the sleeve 14 and the glass sleeve 2 is not disturbed by the gaseous products of the arc during this initial movement and hence affords a high degree of insulation between the descending terminal 16 and the ferrule 4.

During the withdrawal of the inner telescopic member comprising the rod 33 and the terminal 16, the arc is drawn and increased in length within the tube 14. The pressure may blow off the cap 6 and expel the spider 29. The arc, if it persists, is drawn downwardly by the descending terminal 16 through the rapid expansion of the spring 53. The liquid which is displaced from the lower part of the casing by this descent tends to pass up above the end of the terminal 16 into the arc. At the same time, liquid passes through the annular passageway 39 of the liquid director 37 which begins to move downwardly. The terminal 16 is finally drawn down until the pin 25 rests against the end of the sleeve 34 and then its motion due to the spring 53 is stopped. Thereupon it takes up the proper motion of the sleeve 34 and the liquid director 37, under the influence of the spring 45. Liquid below the director 37 is forced through the annular passageway 39 and into the tube 14, also there being then a free passageway on the outside of the tube 14 out through the openings 15 to relieve pressure as the terminal 16 is drawn down with the director 37. If the arc is so severe as not to be extinguished by the time that the terminal 16 reaches the lower end of the tube 14, the pressure of the ionized gases causes them to expand within the enlarged space provided by tube 2 and be driven into the space between the glass sleeve 2 and the tube 14. If these gases approach the metal of the barrier 10, if the same is of metal, or the sleeve 4, there is a tendency to form an arc in said annular space and this space is subject to the two effects, namely, pressure and turbulence by the discharge of liquid from below the director across

and into the arc, both within the passageway formed by tube 14 and the annular passageway outside the tube 14. Both of these passageways communicate at their upper ends with the space above the barrier ring 10, and since the cap 6 may be definitely assumed to have been removed by pressure, these two passageways communicate with atmosphere and a violent discharge of gases, vapors and liquid occurs from the upper end of the fuse casing. The continued downward motion of the director and terminal causes liquid to pass through the annular passageway 39 and to wash around the tip of the terminal 16 into contact with the arc, chilling and finally extinguishing the same. It is to be observed that the length of the tube 14, to the extent necessary to prevent puncturing of the glass sleeve under the high voltage stresses, has created a choking effect upon the outward flow of gases and vapors, since the friction to flow through a tube of substantial length is much greater, particularly on great differences of pressure, than a mere orifice of the same size. Also the effectiveness of the long passageway formed by the tube 14 upon breaking up and deactivating the arc is increased over what would be the case of a very short passageway in which the arc is formed, since the voltage gradient is thereby decreased. The liquid director 37, in cooperation with the outer sleeve 2 and the lower cap 3, defines a spring chamber. This chamber is filled with liquid. As the spring 45 pulls the liquid director 37 down, the chamber is reduced in volume or is contracted, and the liquid is thereby expelled. The action is thus like a syringe.

The modification shown in Figure 3 is substantially the same as that shown in Figure 2, the distinction in this case being the provision of a relief plate 55, which comprises a flat ring having slots such as 56 cut into the same to provide segments overlying the relief passageways 57—57. A pair of smaller relief openings 15 are provided through the barrier ring 10 and the plate 55 has openings registering with the passageways 15.

The outer margin of the relief plate 55 is held by a threaded ring 58 which clamps the plate against the barrier ring 10. The structure and mode of operation of the modification shown in Figure 3 is substantially identical with that of the modification of Figure 2, the relief of pressure within the main casing outside of the inner tube 14 being controlled by the resilient segments of the relief plate 55. Internal pressure tends to raise these segments and, if necessary, disrupt or break them to provide the necessary relief for the internal pressure. The pressure to which I refer is that occasioned by descent of the terminal 16 below the lower end of the tube 14 where the ionized gases within glass sleeve 2 tend to escape into the larger passageway between the glass sleeve 2 and tube 14.

It is always advisable to hold as much pressure within the fuse casing as may be retained without danger of breakage, since the pressure of the liquid against the arc assists in chilling and quenching the same.

In Figure 6 I have shown a modification which is substantially identical with the form shown in Figure 3, except as to the construction of the stem or rod 33 and the addition of the sleeve 60 which is secured at its lower end within the liquid director 37, and which telescopes with the tube 14. The sleeve 60 is held in place in the liquid director by the threaded pins 40, which are mounted in the flange 35 and project through holes in said sleeve 60 into the groove in the liquid director 37.

The hollow rod or stem 33 upon which the fuse terminal 16 is mounted is provided at its lower end with a series of openings 62 communicating with the hollow interior, and at the upper end likewise is provided with openings 63, so that as the rod 33 is displaced downwardly liquid below the director 37 may pass through the openings 62, the hollow interior of the rod 33 and out through the axial bore of the tip or terminal 16 and also out through the openings 63. Thus liquid is transferred more easily from below the director 37 to a point above the same within the tube 14, permitting the same to be discharged adjacent the fuse or arcing terminal 16. At the same time the liquid director 37, in moving downwardly, displaces liquid from below the same into the interior of the tube 14. Since a fairly close fit is provided between the liquid director and the glass sleeve 2 on the outside and likewise a fairly close fit between the sleeve 60 and the tube 14, most of the liquid which is displaced while the tubes 60 and 14 are telescoped will be forced through the tube 14. This provides a powerful arc quenching effect. In this construction, it is attempted to confine the discharge of liquid for a longer time to the interior of the tube 14 before permitting the gases of the arc to escape into the annular space between glass sleeve 2 and tube 14.

In this modification I have illustrated also the corrugations 64 formed upon the outside of the sleeve 2 to a point at or below the end of the tube 14, so as to increase the creepage distance along the outside of the glass sleeve. The flanges or corrugations 64 may be formed on the glass sleeve 2 of any of the forms herein disclosed.

In the modification of Figure 7 I have shown a fuse employing the leverage system disclosed in my prior application Serial No. 164,155 of January 28, 1927, which application has resulted in Patent No. 1,779,929, issued October 28, 1930.

This type of fuse is adapted for carrying very small current values, such as may be required for potential transformer service. In this case the rod 33 is supported by a wire link 65 which loops around the groove 24 in the pin 25 and extends up through the bore of the terminal 16 and hooks over the short arm 66 of the lever 67. The lever 67 has laterally extending arms, the edges of which adjacent the arm 66 provide a fulcrum resting against the insulating washer 68 which is preferably made of a synthetic resin, this washer 68 resting on the flange 69 of the supporting ring 70. The ring 70 may be made of metal or insulation, as preferred. The lever 67 has a rearwardly extending arm 72 over the end of which is hooked the bent end 73 of the secondary lever 74. The secondary lever 74 passes through an opening 75 in the insulating washer 68 and has an arm 76 extending along the under side of the said washer. This arm 76 in turn is connected to a short fusible element 77 of very small current carrying capacity, the upper end of the fuse element 77 being connected to a terminal 78 which, in turn, is electrically connected to the ferrule 4, either through the ring 70, if the same is made of metal, or by a conductor leading to the ferrule 4 where the supporting ring 70 is made of insulating material.

The ring 70 rests upon the shoulder 18, being disposed in the counterbore 17, and it has a series of openings 79 therethrough for venting internal pressure. Since the upper end of the rod 33 bearing the cross pin 25 extends above the tube 14, the upper inner periphery of the tube 14 is flared out to guide the pin 25 downwardly and to prevent it from catching upon the upper end of the tube 14.

The bent lever 74—76 is pivoted about the lower edge of the opening 75. When the current flow through the element 77 exceeds the rating of the fuse sufficiently to fuse the said element 77 the rear arm 76 is tilted downwardly to release the hook end 73 from the lever arm 72. The arm 72 thereupon is swung upwardly and the loop 65 slides over the short arm 66 which is tilted downwardly, thereby releasing the loop 65 and the terminal 16, which thereupon is plunged downwardly by the spring 53 and the main spring 45 which is omitted for the sake of clearness, which spring 45 acts upon the sleeve 34 to pull the sleeve and the liquid director 37 downwardly in the liquid. The operation of extinguishing the arc is substantially as heretofore described.

The liquid director 37 may have a sleeve extending telescopically on the outside of tube 14 if desired.

The barrier ring 10 in this case is flared downwardly to provide more room for assembling the parts, although this form is optional. This also forms an explosion chamber and facilitates the flow of fluids from the tube and the annular space surrounding the lever into the region of the fixed terminal.

The internal pressure which is created may, after blowing off the cap 6, discharge the washer 68 and also, permissibly, the ring 70.

Instead of using a compound lever a single lever may be employed; that is to say, the fuse such as 77, if of sufficient mechanical strength, may be connected to the rear end of the lever 72 to hold the terminal 16 in raised position. For such service as potential transformers only very small current flow is required, and therefore the fuse 77 becomes very fragile. The levers and connecting link 65 readily carry the current required. Obviously, this form of support for the movable terminal may be employed with a fusible wire in shunt of the same where more current is to be carried.

It can now be seen that according to the present invention the differential operation of the two parts of the movable member are secured, the additional insulation of the tube 14 is provided, and a novel method of extinguishing the arc is secured. It will be observed that the tube 14, which acts as an explosion chamber, will have the terminals withdrawn therefrom so that the arc extends through the tube. The downward motion of the rod 33 tends to displace liquid from below the same through the tube 14 in which the arc is contained, and the terminal 16 is then plunged down into the body of arc extinguishing liquid, the director 37 serving further to project liquid into the explosion chamber defined by the tube 14 and therethrough. A highly efficient action is thereby secured. If the arc is not extinguished by the primary action of withdrawing the terminal 16 through the arcing chamber formed by the tube 14, the terminal 16 continues downwardly with the liquid director, and is plunged further downward, the liquid being projected upwardly by the force of the spring. The gases from the arc then tend to escape into the annular passageway between the sleeve 2 and tube 14, and if the arc forms outside of the tube 14, it is here subject to the discharge of liquid into said space, and escape of the gases through the openings 15 in the barrier ring. In other words, if the arc cannot be extinguished by withdrawal of the terminal through the tube 14, then it continues in the enlarged space below tube 14, and it is permitted to discharge both through tube 14 and the annular space or passageway about tube 14, and both paths provide escape for the gases, vapors, and liquid to the upper end of the fuse casing, assuming the cap 6 to be either open or closed. This fuse is adapted for higher voltages, where a high degree of insulation is required while the terminal 16 is descending and moving away from the electrostatic influence of the ferrule 4. In brief, the chief problem is to get the fuse to cover a wide range of overloads, that is, be capable of interrupting without failure either a small overload or a dead short circuit or flashover of the line. Where the current flow is quickly checked by prompt de-activation of the arc to quench the same, the terminal 16 may not have moved away sufficiently to be out of striking distance between the terminal 16 and the ferrule 4 because of the very small radial dimension of the device.

I do not intend to be limited to the details shown and described, as they may be varied within the skill of those practiced in the art, without departing from my invention.

I claim:

1. In combination, a tubular fuse casing, a pair of terminals adjacent one end of the casing, a fuse connecting said terminals, a tubular explosion chamber having an opening therethrough, means for pulling one of the terminals through said explosion chamber when the fuse is melted and means for discharging arc extinguishing liquid into the explosion chamber, the opening in said explosion chamber being sufficiently large throughout its length as compared with the terminal pulled therethrough to provide for free entry of the arc extinguishing liquid into the same under action of said discharge means.

2. In combination, a tubular fuse casing having a releasable end wall, a ferrule on said casing a pair of terminals disposed substantially axially with respect to the casing adjacent said releasable end wall, a fuse connecting said terminals, a longitudinally disposed tubular explosion chamber mounted adjacent said releasable end wall, means for pulling one of the terminals through said tubular explosion chamber when the fuse is melted the explosion chamber having an opening therethrough which is sufficiently large throughout its length as compared with the terminal pulled therethrough to provide for free entry of the arc extinguishing liquid in same, said explosion chamber forming a barrier between the pulled terminal and the ferrule throughout sufficient movement of said pulled terminal to remove same from proximity to said ferrule, and means for discharging arc extinguishing liquid into the tube after the terminal is withdrawn therefrom.

3. In combination, a tubular fuse casing having a metallic terminal adjacent one end, a ferrule on said casing a pair of fuse terminals adjacent said metallic terminal, a fuse connected between said fuse terminals, a tubular explosion chamber disposed longitudinally in the casing and supported adjacent said metallic terminal, and a retracting spring for drawing one of the

fuse terminals downwardly in the tubular explosion chamber to elongate the arc formed between the terminals upon blowing of the fuse, the interior of the tubular explosion chamber being sufficiently large throughout its length as compared with the drawn terminal to provide for free entry of the arc extinguishing liquid into the same and said explosion chamber forming a barrier between said terminal and the ferrule throughout sufficient movement of said terminal to remove same from proximity to said ferrule.

4. In combination, a tubular fuse casing having a releasable end wall, a ferrule on said casing said casing having a metallic terminal adjacent one end, a relatively stationary fuse terminal releasably mounted upon said metallic terminal, a relatively movable fuse terminal, a fuse connecting said terminals, a tubular explosion chamber disposed longitudinally in the casing and being supported adjacent said metallic terminal, and means including a retracting spring for drawing the second fuse terminal downwardly in the tubular explosion chamber, the interior of the tubular explosion chamber being sufficiently large throughout its length as compared with the drawn terminal to provide for free entry of the arc extinguishing liquid into the same and said explosion chamber forming a barrier between said terminal and the ferrule throughout sufficient movement of said terminal to remove same from proximity to said ferrule.

5. In combination, a tubular fuse casing comprising a sleeve of insulation having a metallic ferrule thereupon forming a terminal, a relatively stationary fuse terminal supported within said ferrule, a relatively movable fuse terminal adjacent the first fuse terminal, a fuse connecting said fuse terminals, a stationary tubular explosion chamber disposed longitudinally in the casing and being spaced from the walls of said casing and extending to a point below the ferrule to reinforce the insulation between the movable fuse terminal and the ferrule as the movable fuse terminal is moved downwardly, and a spring for drawing the movable fuse terminal downwardly in the tubular explosion chamber, the interior of the sleeve forming the explosion chamber being sufficiently large throughout its length as compared with the drawn terminal to provide for free entry of the arc extinguishing liquid into same, said explosion chamber forming a barrier between the drawn terminal and the ferrule throughout sufficient movement of said terminal to remove same from proximity to said ferrule.

6. In combination, a tubular fuse casing comprising a sleeve of insulation having a metallic ferrule mounted on the upper end thereof, a relatively stationary fuse terminal disposed within the ferrule, a spider for supporting said relatively stationary fuse terminal in the ferrule, a relatively movable fuse terminal, a fuse connecting said fuse terminals, a tubular explosion chamber having its upper end supported within the ferrule and its lower end extending sufficiently below the ferrule to protect the sleeve against puncture by the potential impressed upon the fuse, means for withdrawing the movable fuse terminal from the explosion chamber, and means for projecting an arc extinguishing medium into the explosion chamber, the interior of the sleeve forming the explosion chamber being sufficiently large throughout its length as compared with the drawn terminal to provide for free entry of the arc extinguishing liquid into same, said explosion chamber forming a barrier between the drawn terminal and the ferrule throughout sufficient movement of said terminal to remove same from proximity to said ferrule.

7. In combination, a casing containing an arc extinguishing medium, a pair of terminal members, means for holding said terminal members in conducting relation, one of said terminal members having a rod extending therefrom, a sleeve slidably mounted on the rod, a spring disposed between the end of the rod and the sleeve to separate the terminals, and a separate spring connected to the sleeve for moving the sleeve in a direction to separate the terminals.

8. In combination, a casing containing an arc extinguishing medium, a pair of terminal members, means for holding said terminal members in conducting relation, one of said terminal members having a rod extending therefrom, a sleeve slidably mounted on the rod, a spring disposed between the end of the rod and the sleeve to separate the terminals, a separate spring connected to the sleeve for moving the sleeve in a direction to separate the terminals, and a liquid director surrounding and carried by the end of the sleeve for directing liquid upon the end of the rod when the first spring has completed its travel, said liquid director being actuated by the second spring and being guided in the casing to keep the sleeve and the rod central of the casing.

9. In combination, a casing containing an arc extinguishing medium, a pair of terminal members, means for holding said terminal members normally in conducting relation and adapted to release them upon excessive current flow, one of said terminal members having a rod connected thereto, a tubular explosion chamber surrounding said rod, a sleeve on the outside of the rod, a spring disposed between the end of the rod and the sleeve tending to separate the terminals, and a separate spring connected to the sleeve for moving the sleeve in a direction to separate the terminals.

10. In combination, a casing containing an arc extinguishing medium, a pair of terminal members, means for holding said terminal members normally in conducting relation and adapted to release them upon excessive current flow, one of said terminal members having a rod connected thereto, a tubular explosion chamber surrounding said rod, a sleeve on the outside of the rod, a spring disposed between the end of the rod and the sleeve tending to separate the terminals, and a separate spring connected to the sleeve for moving the sleeve in a direction to separate the terminals, and a liquid director surrounding and carried by the sleeve said director being guided in the casing to hold the sleeve central of the casing throughout the travel of the rod.

11. In a fuse a sleeve of insulation having a ferrule at its upper end, a releasable cap for the ferrule, a relatively stationary fuse terminal mounted on the ferrule, a relatively movable fuse terminal, a rod carrying said relative movable fuse terminal, a fuse connecting said terminals, a tube of insulation surrounding the rod, said tube being supported at its upper end by the ferrule, said tube projecting down sufficiently far below the ferrule to prevent puncture of the sleeve by the voltage upon the fuse when the relatively movable terminal is moved away from the relatively stationary terminal.

12. In a fuse a sleeve of insulation having a ferrule at its upper end, a releasable cap for the ferrule, a relatively stationary fuse terminal

mounted on the ferrule, a relatively movable fuse terminal, a rod carrying said relatively movable fuse terminal, a fuse connecting said terminals, a tube of insulation surrounding the rod, said tube being supported at its upper end by the ferrule, said tube projecting down sufficiently far below the ferrule to prevent puncture of the sleeve by the voltage upon the fuse when the relatively movable terminal is moved away from the relatively stationary terminal, and a pair of springs acting in series relation for withdrawing the relatively movable fuse terminal through the tube.

13. In a fuse, a sleeve of insulation having a ferrule at its upper end, a releasable cap for the ferrule, a relatively stationary fuse terminal mounted on the ferrule, a relatively movable fuse terminal, a rod carrying said relatively movable fuse terminal, a fuse connecting said terminals, a tube of insulation surrounding the rod, said tube being supported at its upper end by the ferrule, said tube projecting down sufficiently far below the ferrule to prevent puncture of the sleeve by the voltage upon the fuse when the relatively movable terminal is moved away from the relatively stationary terminal, a pair of springs acting in series relation for withdrawing the relatively movable fuse terminal through the tube, and a liquid director actuated by one of said springs for projecting arc extinguishing liquid into the tube said movable fuse terminal having motion independently of said liquid director.

14. In a fuse, a sleeve of insulation having a ferrule at its end, a relatively stationary terminal mounted on the ferrule, a relatively movable terminal cooperating with the stationary terminal, a rod carrying said relatively movable terminal, a tube of insulation surrounding the rod, said tube being supported at one end on said ferrule, said tube projecting beyond the ferrule to prevent puncture of the sleeve by the voltage upon the device when the relatively movable terminal is moved away from the relatively stationary terminal, and means for moving the relatively movable terminal away from the relatively stationary terminal.

15. In a fuse, a sleeve of insulation having a ferrule at its end, a relatively stationary terminal mounted on the ferrule, a relatively movable terminal cooperating with the stationary terminal, a rod carrying said relatively movable terminal, a tube of insulation surrounding the rod, said tube being supported at one end on said ferrule, said tube projecting beyond the ferrule to prevent puncture of the sleeve by the voltage upon the device when the relatively movable terminal is moved away from the relatively stationary terminal, and means for moving the relatively movable terminal away from the relatively stationary terminal, the outer surface of the sleeve being flanged at its upper portion only to increase the creepage distance over the outside surface of the same between the upper ferrule and the lower end of the tube to reduce the electrostatic stress tending to puncture the sleeve below the tube.

16. In combination, a tubular fuse casing, a pair of terminals adjacent one end of the casing, a fuse connecting said terminals, a tubular explosion chamber, spring means for pulling one of the terminals through said explosion chamber when the fuse is melted, and means for discharging arc extinguishing liquid into the explosion chamber, said explosion chamber having a space between the outside of the same and the interior of the casing.

17. In combination, a tubular fuse casing, a pair of terminals adjacent one end of the casing, a fuse connecting said terminals, a stationary tubular arcing chamber of restricted bore relative to the size of the casing, means for pulling one of said terminals through said bore upon melting of the fuse, there being means for projecting arc extinguishing fluid into the arc in said bore to deactivate the same, the fluid brought into contact with the arc in said bore being violently discharged out of one end of the bore to create a high degree of turbulence tending to extinguish the arc.

18. In combination, a tubular sleeve of insulation, a metallic ferrule on the end of the sleeve, a pair of fuse terminals, one connected to the ferrule, the other being movable, and both lying within the sleeve, a fuse connecting the terminals, and a stationary solid sleeve of insulation of relatively small bore forming an arcing chamber and disposed between the movable terminal and the ferrule on the end of the sleeve said solid sleeve of insulation and said tubular sleeve of insulation being interposed in series between the movable terminal and the ferrule.

19. In combination, a tubular sleeve of insulation, a metallic ferrule on the end of the sleeve, a pair of fuse terminals, one connected to the ferrule, the other being movable, and both lying within the sleeve, a fuse connecting the terminals, and a stationary sleeve of insulation forming an arcing chamber and disposed between the movable terminal and the ferrule on the end of the sleeve, an annular support between the upper end of the arcing chamber and the ferrule and spring means for retracting the movable terminal through the arcing chamber, there being an arc extinguishing medium within the tubular sleeve, adapted to act upon the arc within the arcing chamber.

20. In combination, a tubular sleeve of insulation, a metallic ferrule on the end of the sleeve, a pair of fuse terminals, one connected to the ferrule and the other being movable, and both being disposed adjacent the end of the sleeve of insulation, a second sleeve of insulation comprising a solid tubular member of relatively restricted bore through which the movable terminal is adapted to move, said second sleeve of insulation extending a substantial distance beyond the metallic ferrule within the first sleeve to serve as a barrier between the terminal and the ferrule for preventing puncturing of the first sleeve of insulation, said first sleeve of insulation having means disposed along only that part of its length wherein the second sleeve is disposed to prevent concentration of the electrostatic stresses between the movable terminal and the outer surface of the first sleeve of insulation.

21. In combination, a fusible link, a metallic chamber enclosing the same, said chamber having a releasable wall to permit venting of pressure in said chamber to atmosphere, a pair of passageways within each of which an arc may be formed upon blowing of the fusible means and separation of the terminals, both passageways communicating at their adjacent ends with said metallic chamber, spring means for separating said terminals, and an arc extinguishing material for both of said passageways and adapted to act in each of the passageways, the products therefrom being vented through said common communicating chamber.

22. In combination, fusible current carrying means, a fixed terminal, a primary arcing chamber, a secondary arcing chamber, a movable terminal having parts providing relatively differential motion with respect to said fusible means, spring means for providing the differential motion between the parts of the movable terminal upon blowing of the fusible means, the resultant arc being adapted to form first in the primary arcing chamber and thereafter in the secondary arcing chamber, there being an arc extinguishing medium for acting upon the arc in either or both of the said chambers to extinguish the same.

23. In a device of the class described, a primary arcing chamber and a secondary arcing chamber, said chambers being of different diameters adapted to extinguish arcs of different magnitude, terminal means for the chambers including stationary terminal means and movable terminal means, spring means for the movable terminal means and a common body of arc extinguishing medium adapted to act upon the arc in either chamber for extinguishing the arc between the terminal means.

24. In a device of the class described, the combination of a primary arcing chamber and a secondary arcing chamber of different effective bores, adapted to extinguish arcs of different magnitude, said chambers comprising passageways disposed in parallel, stationary terminal means and movable terminal means, fusible means between said terminal means, spring means for providing differential motion of said movable terminal means with respect to the fusible means, and a common body of arc extinguishing medium for acting upon an arc established in either arcing chamber.

25. In combination, a tubular fuse casing having a metallic external terminal at each end, one of said terminals providing an opening and the other being closed, a pair of passageways communicating with the open end of said one terminal and extending longitudinally of the fuse casing, a movable internal terminal and a stationary internal terminal connected to said open external terminal, fusible means connecting said terminals, spring means for separating the terminals upon blowing of the fuse means, the resultant arc being increased in length by said spring means and being adapted to establish itself first in one of said passageways and, upon failure to be extinguished therein, to be formed in the other passageway, and an arc extinguishing medium for acting upon the arc in either of said passageways.

26. In combination, an outer sleeve of insulation having external terminals embracing the ends of the sleeve, one of said terminals forming a ferrule and the other forming a cap, stationary internal terminal means and movable internal terminal means connected conductively to the ferrule and cap respectively, fusible means connecting said terminal means, spring means for moving the movable terminal means toward the cap, and a longitudinally extending body of solid insulating material disposed between said fusible means and the sleeve of insulation and defining two elongated passageways within which the arc formed upon blowing of the fusible means is adapted to be drawn successively, there being a mass of arc extinguishing material within the sleeve adapted to release a vapor under the action of the arc to extinguish the arc in either of said passageways and an annular connecting member between the upper end of said body of insulating material and the ferrule.

27. In a fuse, the combination of a tubular fuse casing having external terminals, a tubular arc extinguishing chamber supported within one end of the casing, a pair of fuse terminals supporting a fusible link between them adjacent one end of the chamber, one of said fuse terminals comprising a rod adapted to be drawn through the chamber when the link blows, spring means for drawing said rod, the other end of the chamber being substantially closed off during the drawing of said rod, and arc extinguishing material disposed within said chamber and substantially filling the annular space between the walls of said chamber and said rod, and an annular support between the outside of the arc extinguishing chamber and the fuse casing.

28. In a fuse, the combination of a tubular fuse casing having external terminals, a tubular arc extinguishing chamber supported within one end of the casing, a pair of fuse terminals supporting a fusible link between them adjacent one end of the chamber, one of said fuse terminals comprising a rod adapted to be drawn through the chamber when the link blows, spring means for drawing said rod, the other end of the chamber being substantially closed off during the drawing of said rod, arc extinguishing material disposed within said chamber and substantially filling the annular space between the walls of said chamber and said rod, an annular support between the outside of the arc extinguishing chamber and the fuse casing, and means for injecting more arc extinguishing material into the chamber when the rod has been withdrawn from the chamber.

29. In a fuse, the combination of a tubular fuse casing having external terminals, a tubular arc extinguishing chamber supported within one end of the casing, a pair of fuse terminals supporting a fusible link between them adjacent one end of the chamber, one of said fuse terminals comprising a rod adapted to be drawn through the chamber when the link blows, spring means for drawing said rod, the other end of the chamber being substantially closed off during the drawing of said rod, an annular support between the outside of the arc extinguishing chamber and the fuse casing, arc extinguishing material disposed within said chamber and substantially filling the annular space between the walls of said chamber and said rod, and means for removing the rod and its terminal from proximity to the chamber and interposing additional dielectric between the terminals when the arc is extinguished.

30. In a fuse, the combination of a housing comprising a tubular arcing chamber, a separate spring chamber, a movable fuse terminal rod extending from the spring chamber into the arcing chamber, a fuse holding the terminal rod, means operable upon blowing of the fuse to pull the rod out of the arcing chamber and into the spring chamber, and means for thereafter contracting the spring chamber.

31. In a fuse, the combination of a housing comprising a tubular arcing chamber, a separate spring chamber, a movable fuse terminal rod extending from the spring chamber into the arcing chamber, a fuse holding the terminal rod, means operable upon blowing of the fuse to pull the rod out of the arcing chamber and into the spring chamber, means for thereafter contracting the spring chamber, and a dielectric which is expelled from the spring chamber when the same is contracted, to prevent restriking of the arc.

32. In a fuse, a sleeve of insulation, external

terminals upon the ends thereof, a relatively movable fuse terminal and a relatively stationary fuse terminal within the casing, a fuse connecting the fuse terminals, means for shifting the relatively movable terminal within the sleeve upon blowing of the fuse, said sleeve of insulation having means along its one end only for controlling the distribution of the potential drop between the external terminals to minimize the electrostatic stress tending to puncture the walls of the tube upon interruption of the flow of current.

33. In a fuse, a sleeve of insulation, external terminals on the ends of the sleeve, a fuse within the sleeve adjacent one end thereof, a movable terminal for said fuse, the sleeve having substantially greater potential drop along that part adjacent the location of the fuse than that part remote from the location of the fuse to minimize the tendency of the electrostatic stress to puncture the sleeve.

34. In a fuse, a housing comprising an outer sleeve of insulation having external terminals fastened upon the ends of the same, a tubular arcing chamber within one end of the housing, a fuse adjacent said one end of the housing connected to the adjacent ferrule, a spring actuated movable terminal held in said arcing chamber by said fuse, said outer sleeve having means along that part of its length only which is adjacent said arcing chamber for increasing the external surface resistance to creepage.

35. In a fuse device, a main fuse housing comprising a main tubular insulating sleeve, an annular metal external terminal fixed upon the one end of the sleeve and extending beyond the same, an inner sleeve forming a stationary arcing chamber lying within the main sleeve, a metal annulus embracing one end of the inner sleeve, said annulus being supported in the annular external terminal, a fuse within the fuse housing adjacent the said one end of the inner sleeve, a movable fuse terminal member connected to said fuse and lying within the bore of the inner sleeve, an external metal terminal member on the opposite end of the main sleeve and being connected to said movable terminal, and spring means disposed within the main sleeve outside said inner sleeve for moving said movable terminal away from said first named external terminal toward said second named external terminal to increase the length of the arc when the fuse blows, said inner chamber extending toward the second named external terminal a substantial distance beyond the adjacent end of the first named external terminal.

36. In a fuse device, the combination of a sleeve of insulation having a first and a second end and having two external terminals, the first of said terminals on the first end forming a closure during the operation of the fuse device, the second terminal on the second end comprising a tubular ferrule through which may be expelled the products of blowing of the fuse, an annular supporting member disposed in said second terminal above the second end of the sleeve, a tube of insulation having its first end disposed a substantial distance within the first sleeve of insulation beyond the extent of said second ferrule and having its second end secured in and supported by said annular supporting member, said tube providing an arcing chamber, a movable fuse terminal lying within said tube and extending to substantially the second end of the same, said terminal being adapted to be drawn toward the first end of the tube for drawing out in said arcing chamber the length of the arc formed on blowing of the fusible link, a fusible link disposed at the second end of the arcing chamber and connecting said second external terminal with said movable fuse terminal, and spring means for moving said movable terminal to elongate the arc in said arcing chamber.

37. In a fuse device, the combination of a sleeve of insulation having a first and a second end and having two external terminals, the first of said terminals on the first end forming a closure during the operation of the fuse device, the second terminal on the second end comprising a tubular ferrule through which may be expelled the products of blowing of the fuse, an annular supporting member disposed in said second terminal above the second end of the sleeve, a tube of insulation having its first end disposed a substantial distance within the first sleeve of insulation beyond the extent of said second ferrule and having its second end secured in and supported by said annular supporting member, said tube providing an arcing chamber, a movable fuse terminal lying within said tube and extending to substantially the second end of the same, said terminal being adapted to be drawn toward the first end of the tube for drawing out in said arcing chamber the length of the arc formed on blowing of the fusible link, a fusible link disposed at the second end of the arcing chamber and connecting said second external terminal with said movable fuse terminal, spring means for moving said movable terminal to elongate the arc in said arcing chamber, and means for removing the movable fuse terminal from proximity to said arcing chamber.

38. In a fuse device, a main housing having a plurality of chambers comprising a fuse chamber containing a fuse, an arcing chamber having therein a rod-like movable fuse terminal connected to the fuse, and a collapsible spring chamber, said chambers being disposed end to end, means for drawing the movable fuse terminal through the arcing chamber into the spring chamber, and means for thereafter contracting the spring chamber and interposing a dielectric medium between the movable fuse terminal and the arcing chamber.

39. In a fuse device, a main housing divided into a plurality of chambers comprising a fuse chamber and a spring chamber, an arcing chamber of relatively restricted bore connecting said chambers, a fuse in the fuse chamber, a rod-like arcing terminal connected to the fuse and lying within the bore of the arcing chamber, an arc extinguishing material within said arcing chamber, a wall between said arcing chamber and said spring chamber through which said arcing terminal projects, and means in the spring chamber for drawing the arcing terminal from the arcing chamber and projecting a part of the same into the spring chamber.

40. In a fuse device, a main housing divided into a plurality of chambers comprising a fuse chamber and a spring chamber, an arcing chamber of relatively restricted bore connecting said chambers, a fuse in the fuse chamber, a rod-like arcing terminal connected to the fuse and lying within the bore of the arcing chamber, an arc extinguishing material within said arcing chamber, a wall between said arcing chamber and said spring chamber through which said arcing terminal projects, means in the spring chamber for drawing the arcing terminal from the arcing

chamber and projecting a part of the same into the spring chamber, and means for moving said wall and arcing terminal away from the arcing chamber.

41. In a fuse device, a main housing divided into a plurality of chambers comprising a fuse chamber and a spring chamber, an arcing chamber of relatively restricted bore connecting said chambers, a fuse in the fuse chamber, a rod-like arcing terminal connected to the fuse and lying within the bore of the arcing chamber, an arc extinguishing material within said arcing chamber, a wall between said arcing chamber and said spring chamber through which said arcing terminal projects, means in the spring chamber for drawing the arcing terminal from the arcing chamber and projecting a part of the same into the spring chamber, and means for moving said wall and arcing terminal away from the arcing chamber, there being a liquid dielectric in the spring chamber which is interposed between the arcing terminal and the arcing chamber by operation of said last named means.

42. In a fuse device, an outer sleeve of insulation having metal terminals, an arcing chamber inside the sleeve adjacent the upper end thereof, a fuse, a movable arcing terminal within the chamber connected to the fuse, means for retracting the arcing terminal upon blowing of the fuse, and means on the outer sleeve substantially coextensive with the length of the arcing chamber for increasing the creepage drop whereby the tendency of the electrostatic stress developed between the upper sleeve terminal and the movable arcing terminal as the gap between the arcing terminals is increased, to puncture the sleeve, is reduced.

43. In a fuse, a main fuse housing divided into a plurality of chambers comprising an arcing chamber and a spring chamber, a rod-like arcing terminal extending from the spring chamber into the arcing chamber, a fusible link for holding the rod-like terminal, spring means for retracting the arcing terminal upon blowing of the link, means for contracting the spring chamber, said chamber containing a dielectric fluid, and means for conducting the dielectric fluid from the spring chamber, as it is contracted, into the arcing chamber.

44. In a fuse, a main fuse housing divided into a plurality of chambers comprising an arcing chamber and a spring chamber, a rod-like arcing terminal extending from the spring chamber into the arcing chamber, a fusible link for holding the rod-like terminal, spring means for retracting the arcing terminal upon blowing of the link, means for contracting the spring chamber, said chamber containing a dielectric fluid, and means for conducting the dielectric fluid from the spring chamber, as it is contracted, into the arcing chamber, said latter means comprising a telescopic connection between the arcing chamber and the spring chamber.

45. In a fuse device, an outer sleeve of insulation, a ferrule at the upper end thereof, a cap at the lower end, an annular ring secured to the inside of the ferrule, an insulating tube mounted at its upper end in said ring, a fuse at the upper end of said tube having connection with the ferrule, an arcing terminal disposed in said tube and being connected to said cap, a sleeve disposed at the lower end of the tube, an annular piston fitting in the outer sleeve and being coupled to said second sleeve, said arcing terminal comprising a rod extending through said second sleeve, a spring between the lower end of the rod and the second sleeve, a spring for lowering the second sleeve and annular piston, and said annular piston and said arcing chamber being telescoped relative to each other.

46. In a high tension fuse, a relatively long small bore arcing chamber, fuse terminals supporting a fuse substantially at one end of the arcing chamber, means to move one of said terminals for extending the length of the arc in said arcing chamber until the same is extinguished, and for simultaneously causing a flow of arc extinguishing medium lengthwise of the arc in said chamber, the combined effect of extending the length of the arc in the relatively small bore and the expansion of the arc extinguishing medium creating a violent scouring of the arc by endwise flow of gases evolved from said medium, and a body of fluid of high dielectric strength outside the chamber into which said one terminal is moved to prevent restriking of the arc.

47. In a device of the class described, a closed fuse housing, a first fuse terminal, means for guiding said terminal centrally of the housing, a movable rodlike fuse terminal, a fuse link between said fuse terminals, a spring for moving said latter terminal, a body of liquid in the housing, and a liquid director for directing liquid upon the end of the latter terminal, said liquid director and rodlike terminal having lost motion connection to permit of motion of the rodlike terminal independently of the motion of the liquid director.

48. In a device of the class described, a closed fuse housing, a fuse terminal at the upper end of the housing, means for guiding said terminal centrally of the housing, a fuse chamber adjacent said fuse terminal, a rodlike terminal projecting through an opening into the fuse chamber, a liquid director below said fuse chamber having a lost motion connection with said rodlike terminal, a body of arc extinguishing liquid in said housing, and a spring for withdrawing said rodlike terminal from said fuse chamber, and means for moving the liquid director.

49. In a fuse, a pair of separable fuse terminals, a fuse between said terminals, an arc extinguishing chamber in which the arc formed on blowing of the fuse is drawn, said chamber being longitudinally extensible, and means for moving one of said fuse terminals longitudinally of the chamber to extend the length of the arc in the chamber in addition to the extension of said chamber.

50. In combination in a device of the class described, a tubular casing containing an arc extinguishing material and having external connections, a relatively stationary internal terminal adjacent one end of the housing connected to one of said external terminals, a sleeve of insulating material forming a tubular arcing chamber of relatively small bore and relatively extensive length, mounted in line with the first fuse terminal in the adjacent end of the casing, a terminal sleeve disposed adjacent the lower end of the arcing chamber, a rodlike movable terminal slidably guided in said terminal sleeve, said movable terminal being disposed in said arcing chamber, means for holding said terminals in electrical conducting relation, a compression spring between said terminal sleeve and said movable terminal for retracting said movable terminal, said movable rodlike terminal being connected to the other of the external connections and being guided by said sleeves during its motion by said spring, a guide on said terminal sleeve for guiding the terminal sleeve centrally of said tubular casing and for guiding the rod

centrally of the arcing chamber, and a tension spring attached to said terminal sleeve and anchored in the remote end of the tubular casing for retracting said terminal sleeve, said terminal rod and said guide when the holding means releases the movable terminal.

51. In combination, circuit terminals between which an arc is adapted to be formed, an arcing chamber for laterally confining said arc, said chamber being open at one end, one of said circuit terminals comprising a plunger lying within the chamber and extending out of the other end of the chamber, a substantially closed liquid containing chamber communicating with the other end of the arcing chamber, said plunger extending into the liquid containing chamber, and means for causing travel of the plunger from the arcing chamber into the liquid containing chamber to displace liquid from the latter chamber into the arcing chamber.

52. In a high tension fuse, a relatively long small bore arcing chamber, fuse terminals supporting a fuse substantially at one end of the chamber, said end being open for the discharge of metallic vapors and gases resulting from blowing of the fuse and the establishment of an arc, one of said terminals being movable through the bore of the tube when the fuse blows, to extend the length of the arc in the bore of the chamber until the arc is extinguished, and means for introducing arc extinguishing material endwise into the arc remote from the open end of the chamber, the combined effect of extending the length of the arc in the small bore of the chamber and the introduction of arc extinguishing material into the arc remote from the open end of the chamber creating a violent scouring action which sweeps the metallic vapors and ionized gases out of the arc and causes the arc to be extinguished.

53. In a device of the class described, a tubular housing having external connections, a pair of terminals in the housing in conductive relation to said connections, means for holding the terminals in current conducting relation, spring means for separating said terminals upon the release of said holding means, a tubular arcing chamber of relatively restricted bore within which the arc formed between the terminals upon their separation is adapted to be extinguished, one end of the arcing chamber being fixedly supported in the housing adjacent an end thereof, arc extinguishing material adapted to act upon the arc within said chamber, and means for stopping said movable terminal within the confines of a part of said arcing chamber.

54. In a device of the class described, an insulating sleeve, a cap for one end of the sleeve, a ferrule for the other end of the sleeve, a fuse chamber within the ferrule, an arcing chamber of relatively restricted bore and relatively extensive length communicating with the fuse chamber, a rodlike terminal lying within the bore of the arcing chamber, a fuse lying within the fuse chamber and connecting the rodlike terminal to the ferrule, means for moving the rodlike terminal along the arcing chamber when the fuse melts, and an arc extinguishing material adapted to act upon the arc in the arcing chamber as the terminal is drawn through it.

55. In a device of the class described, an insulating sleeve, a cap for one end of the sleeve, a ferrule for the other end of the sleeve, a fuse chamber within the ferrule, an arcing chamber of relatively restricted bore and relatively extensive length communicating with the fuse chamber, a rodlike terminal lying within the bore of the arcing chamber, a fuse lying within the fuse chamber and connecting the rodlike terminal to the ferrule, means for moving the rodlike terminal along the arcing chamber when the fuse melts, an arc extinguishing material adapted to act upon the arc in the arcing chamber as the terminal is drawn through it, and a dielectric containing chamber between the arcing chamber and the cap into which the terminal is adapted to be further withdrawn after the arc is extinguished.

56. In combination with a fuse tube having external terminals at opposite ends, a conductor joining said terminals, said conductor comprising a fusible section, a relatively rigid section, and a flexible conducting section, and a helical spring coaxial with said relatively rigid section, said spring and said relatively rigid section being coextensive for at least a portion of their respective lengths.

57. In combination with a fuse tube having external terminals at opposite ends, a conductor joining said terminals, said conductor comprising a fusible section, a relatively rigid section, a flexible conducting section, and a helical spring guided by said relatively rigid section, and telescopically associated with said rigid section.

58. In a fuse, a fuse link comprising a fusible section, a relatively rigid section and a relatively flexible section, an arcing tube of relatively small bore surrounding the fusible section and a portion of the relatively rigid section, and a spring telescopically associated with said relatively rigid section and connected at one end to the relatively rigid section for causing the said relatively rigid section to be projected from the end of the tube when said fusible section is ruptured.

59. In a fuse, a main tube having terminal contacts, a fusible link in said tube connecting said terminal contacts, said link comprising a fusible portion, a flexible portion and a movable terminal portion connecting the fusible portion and the flexible portion, an arcing tube in the main tube surrounding the fusible portion and the terminal portion, and a compression spring connected at one end with said terminal portion for retracting said terminal portion from said arcing tube when said fusible portion is ruptured.

60. In a fuse, a main tube having terminal contacts, a fusible link in said tube connecting said terminal contacts, said link comprising a fusible portion, a flexible portion and a movable terminal portion connecting the fusible portion and the flexible portion, an arcing tube in the main tube surrounding the fusible portion and the terminal portion, a spring connected at one end to the terminal portion for retracting said terminal portion from said arcing tube when said fusible portion is ruptured, and an anchorage for the other end of the spring disposed at the end of the arcing tube.

61. In a fuse, a main tube having terminal contacts, a fuse link in said tube connecting said terminal contacts; said link comprising terminals, a fusible portion interconnecting said terminals, and a flexible lead attached to one terminal; an arcing tube surrounding said fusible portion and said one terminal, and a spring having one end anchored at one end of said arcing tube and having its other end operatively connected to said one terminal for separating said terminals on blowing of said fusible portion.

62. In a fuse, a main tube having terminal con-

tacts, a fuse link in said tube connecting said terminal contacts; said link comprising terminals, a fusible element and a strain element interconnecting said terminals; and a flexible lead attached to one terminal; an arcing tube surrounding said fusible element and said one terminal, and a spring anchored at one end of said arcing tube and operatively connected to said one terminal for separating said terminals on blowing of said fusible element.

63. In a fuse, a main tube having terminal contacts and tension means, a fuse link in said tube connecting said terminal contacts and adapted to be placed under tension by said tension means; said link comprising terminals, a fusible element interconnecting said terminals, a strain element interconnecting said terminals and relieving said fusible element of stress otherwise imposed thereon by said tension means, and a flexible lead attached to one terminal; a relatively long arcing tube surrounding said fusible element and said one terminal, and an arc extinguishing material within said arcing tube and adapted to act upon the arc established therein.

64. In a fuse, a main tube having terminal contacts, a fuse link in said tube connecting said terminal contacts; said link comprising terminals, a fusible portion interconnecting said terminals, and a flexible lead attached to one terminal; an arcing tube surrounding said fusible portion and said one terminal, a spring anchored at one end of said arcing tube for separating said terminals on blowing of said fusible portion, and a second spring cooperating with said first mentioned spring for further separating said terminals.

65. In a circuit interrupter, in combination, a housing, a tubular arcing chamber having a length several times its cross sectional dimension stationarily mounted in said housing with its longitudinal axis in a substantially vertical position and its upper end open for discharge, means for drawing an arc near said upper end of said chamber and extending it longitudinally therein, and a liquid arc extinguishing material in said housing and said arcing chamber, the liquid in said chamber being gasified by the action of the arc as it is extended therein for assisting in extinguishing the same, the level of said liquid in said housing being such as to introduce a portion of the same not affected by the arc into said chamber after the arc is extinguished.

66. The combination, with a fuse tube having at least one external terminal for connection to an electrical circuit; of conducting means within said tube for completing said circuit including a pair of terminal members, one being electrically connected to said external terminal and the other being movable, fusible means electrically interconnecting said terminal members and holding the same against relative movement, and a flexible lead electrically connected to the other of said terminal members; a coil spring acting to separate said terminal members on blowing of said fusible means and restrained thereby, and a rigid tubular member surrounding said coil spring and guiding the same.

67. In a circuit interrupter, in combination, a tubular arcing chamber having a bore relatively long as compared to its diameter and having one end flared outwardly, arc extinguishing material in said bore, and means for drawing an arc in said flared out end of said bore and extending it longitudinally within the restricted portion of the same, the products of said arc flowing out of said flared out end.

68. In a circuit interrupter, in combination, a tubular arcing chamber having a bore relatively long as compared to its diameter and having the upper end flared outwardly, means for drawing an arc in said flared out end of said bore and extending it longitudinally within the restricted portion of the same, arc extinguishing material in said bore, and means substantially closing the lower end of said bore whereby the products formed by the arc flow principally out of the upper end.

69. In a circuit interrupter, in combination, a housing, a tubular arcing chamber having a bore relatively long as compared to its diameter stationarily mounted in said housing with its longitudinal axis in a substantially vertical position, means for drawing an arc and extending it downwardly within said bore, and an arc extinguishing liquid in said housing and said bore the level of which is such that the arc is drawn in proximity to its surface and a space is provided about the upper end of said chamber, said liquid sealing the lower end of said chamber whereby the products formed by the arc flow principally out of its upper end.

70. In a circuit interrupter, in combination, a tubular arcing chamber having a relatively long bore, a pair of terminals between which an arc is drawn on operation of the interrupter, one of said terminals being stationarily mounted adjacent one end of said bore and the other being movably mounted therein, and means for retracting said movable terminal at a relatively high speed during the initial part of its travel to extinguish the arc and at a slower speed during the final part of its travel.

71. In a circuit interrupter, in combination, a tubular arcing chamber having a relatively long bore, a pair of terminals between which an arc is drawn on operation of the interrupter, one of said terminals being stationarily mounted adjacent one end of said bore and the other being movably mounted therein, guide means for said movable terminal, spring means interposed between said movable terminal and said guide means for retracting the former to extinguish the arc, and additional spring means disposed to move said guide means away from said stationary terminal.

72. In a circuit interrupter, in combination, a tubular arcing chamber having a relatively long bore, a pair of relatively infusible terminals between which an arc is drawn at one end of said bore on operation of the interrupter, and means stationarily mounting one of said terminals adjacent said one end of said bore, the other terminal including a rigid rod-like relatively infusible member movably mounted within and spaced from said bore and adapted to draw said arc longitudinally therein to extinguish the same.

73. In a circuit interrupter, in combination, a housing, a tubular arcing chamber having a relatively long bore, means stationarily mounting said arcing chamber in said housing, a pair of terminals between which an arc is drawn at one end of said bore on operation of the interrupter, means stationarily mounting one of said terminals adjacent said one end of said bore, the other terminal including a rigid rod-like relatively infusible member movably mounted within said bore, and operating means mounted within said housing and operatively connected to said other terminal for moving it longitudinally of said bore

to extend said arc therein for extinguishing the same.

74. In combination, a tubular sleeve of insulation, a metallic ferrule on one end of said sleeve; a pair of fuse terminals lying within said sleeve, one being connected to said ferrule and the other being movable; conducting means including fusible means interconnecting said terminals, a tubular arcing chamber having a bore of a length several times its cross sectional dimension, means for stationarily mounting said arcing chamber in said sleeve in such position that the arc formed on blowing of said fusible means is extended therein and formed of a material having sufficient strength to withstand the lateral stresses set up on blowing of said fusible means, and an arc extinguishing medium in said arcing chamber adapted to be gasified by the action of the arc as it is extended therein on movement of said movable terminal.

75. In combination, a housing, a pair of relatively movable terminals between which an arc is drawn in said housing, a tubular arcing chamber having a relatively long opening therethrough, means stationarily mounting said arcing chamber in said housing, means for pulling one of said terminals through said chamber to extend the arc therein, and means for discharging arc extinguishing liquid into said chamber, the opening in said chamber being sufficiently large throughout its length as compared with the terminal pulled therethrough to provide for free entry of the arc extinguishing liquid into the same under action of said discharge means.

76. In a circuit interrupter, in combination, a housing, a relatively long tubular arc extinguishing chamber supported within said housing, means stationarily mounting said arcing chamber from said housing, a pair of relatively movable terminals between which an arc is drawn at one end of said chamber, one of said terminals comprising a rod adapted to be drawn through said chamber, spring means for drawing said rod, arc extinguishing material disposed within said chamber and substantially filling the annular space between the walls of said chamber and said rod, and means for injecting more arc extinguishing material into the chamber when the rod has been withdrawn therefrom.

77. In a high voltage circuit interrupter, in combination, a tubular arcing chamber having a bore of a length several times its cross sectional dimension, a pair of relatively movable terminals between which an arc is drawn at one end of said chamber, said end being open for discharge of products resulting from the establishment of the arc, one of said terminals being movable through said chamber to extend the length of the arc therein until it is extinguished, means holding said arcing chamber stationary relative to said movable terminal, and means for introducing arc extinguishing material endwise into the arc remote from the open end of the chamber.

78. In a circuit interrupter, two terminals between which an arc is formed, means for drawing one terminal into a liquid arc extinguishing material for lengthening the arc, a stationary restricting tubular chamber having a length several times its cross-sectional dimension surrounding said one terminal and the portion of the arc adjacent thereto, and means stationarily holding said chamber relative to said one terminal while it is being withdrawn, said chamber permitting the flow of said liquid arc extinguishing material around said one terminal into the region of the end of the arc at a limited rate and providing a laterally restricted but longitudinally free flow of the gases generated by the action of the arc on said liquid arc extinguishing material in a direction away from the receding terminal into an expansion space.

79. In combination in a circuit interrupter, a container for liquid, a tubular arcing chamber disposed at the upper end of the container, means stationarily mounting said arcing chamber from said container, a lower movable terminal extending into the bore of the chamber, a cooperating upper terminal adjacent the upper end of the chamber, an arc being adapted to be formed between said terminals, the bore of said chamber having a length several times its diameter, a body of liquid in said container with the level thereof disposed adjacent the upper end of the lower terminal, and means for moving the lower terminal downwardly in the liquid to extend the length of the arc, said chamber serving as a stationary restricting discharge passageway for the products of the arc.

80. The combination, with a fuse tube having at least one external terminal for connection to an electrical circuit; of fuse link means electrically connected to said terminal and including a flexible conductor for completing said circuit; a first coil spring substantially coaxial with said fuse tube tensioning said fuse link means and acting to produce and extend a gap in said circuit on blowing of said fuse link, and a second coil spring also substantially coaxial with said fuse tube for producing a gap in said circuit in addition to that produced by said first spring means.

81. In a fuse, a main tube having terminal contacts, a fuse link in said tube connecting said terminal contacts; said link comprising terminals, a fusible portion interconnecting said terminals, and a flexible lead attached to one terminal; an arcing tube surrounding said fusible portion and said one terminal, a spring for separating said terminals within the arcing tube on blowing of said fusible portion, and a second spring cooperating with the first spring for further separating said terminals within the main tube and for introducing an additional dielectric in the circuit to prevent restriking.

82. Means for extinguishing an arc formed between two terminals comprising the combination with a pair of relatively infusible terminals between which an arc is adapted to be formed of a tube having an open discharge end, said tube surrounding and laterally confining the arc for a substantial part of its length adjacent one terminal, means holding said tube stationary relative to said terminals, and means for supplying an arc extinguishing material in nongaseous form at the extremity of the arc at said one terminal whereby said material is subjected to the heat of the arc at said one end and is converted into a gaseous medium adjacent said one terminal, said gaseous medium being directed through said tube and being discharged lengthwise through the arc in intimate contact with the arc and out the open end of the tube.

83. In combination, a tube; a pair of terminals, one being stationarily mounted with respect to said tube and the other being movably mounted therein; fusible means interconnecting said terminals, anchor means cooperating with said tube, a spring interposed between said anchor means and the other of said terminals and arranged and adapted to place said tube under

compression and said fusible means under tension, and means connected to said anchor means in such manner that stress applied thereto does not increase the tension of said fusible means unless it exceeds the tension applied thereto by said spring.

84. In combination, a rigid arcing tube of insulating material having a length several times its internal diameter; a pair of terminals, one being stationarily mounted at one end of said tube and the other being movable longitudinally therethrough; fusible means interconnecting said terminals, anchor means abutting the other end of said tube, a spring operatively interconnecting said anchor means and the other of said terminals and arranged and adapted to place said tube under compression and said fusible means under tension, and a spring operatively connected to said anchor means in such manner that stress applied thereby does not increase the tension on said fusible means unless it exceeds the tension applied thereto by said spring.

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