Oct. 10, 1939. H. A. TRIPLETT 2,175,495

ARC EXTINGUISHING METHOD AND DEVICE

Filed July 19, 1935 3 Sheets-Sheet 1

Fig. 1.

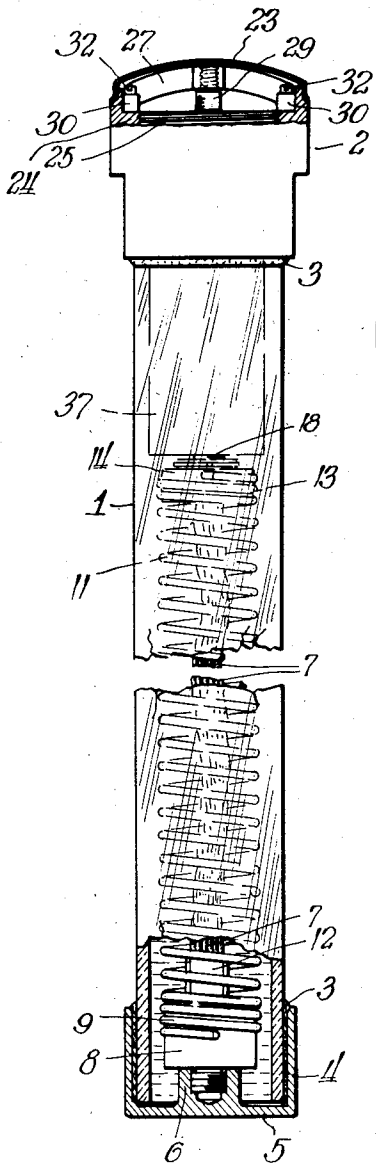


Fig. 3.

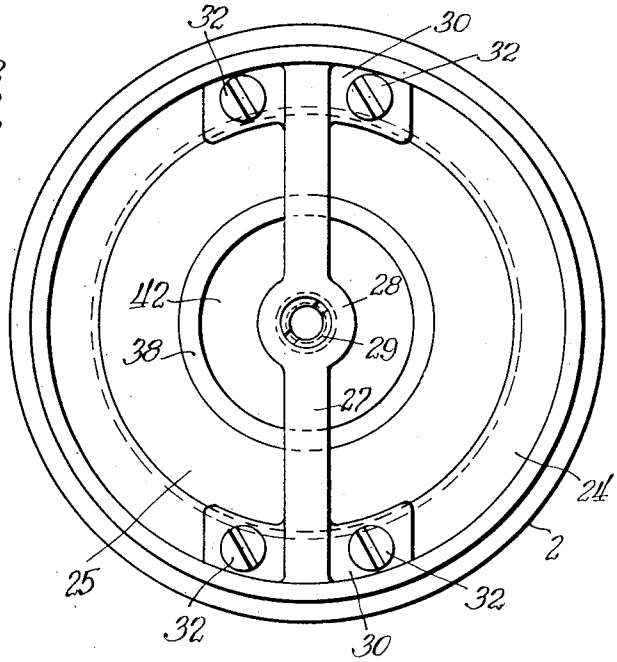
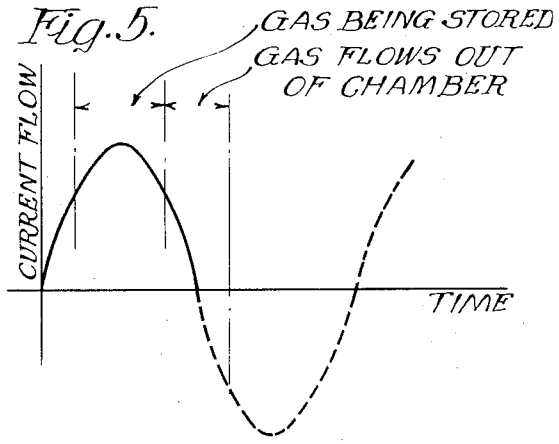


Fig. 5.



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ARC EXTINGUISHING METHOD AND DEVICE

Filed July 19, 1935 3 Sheets-Sheet 2

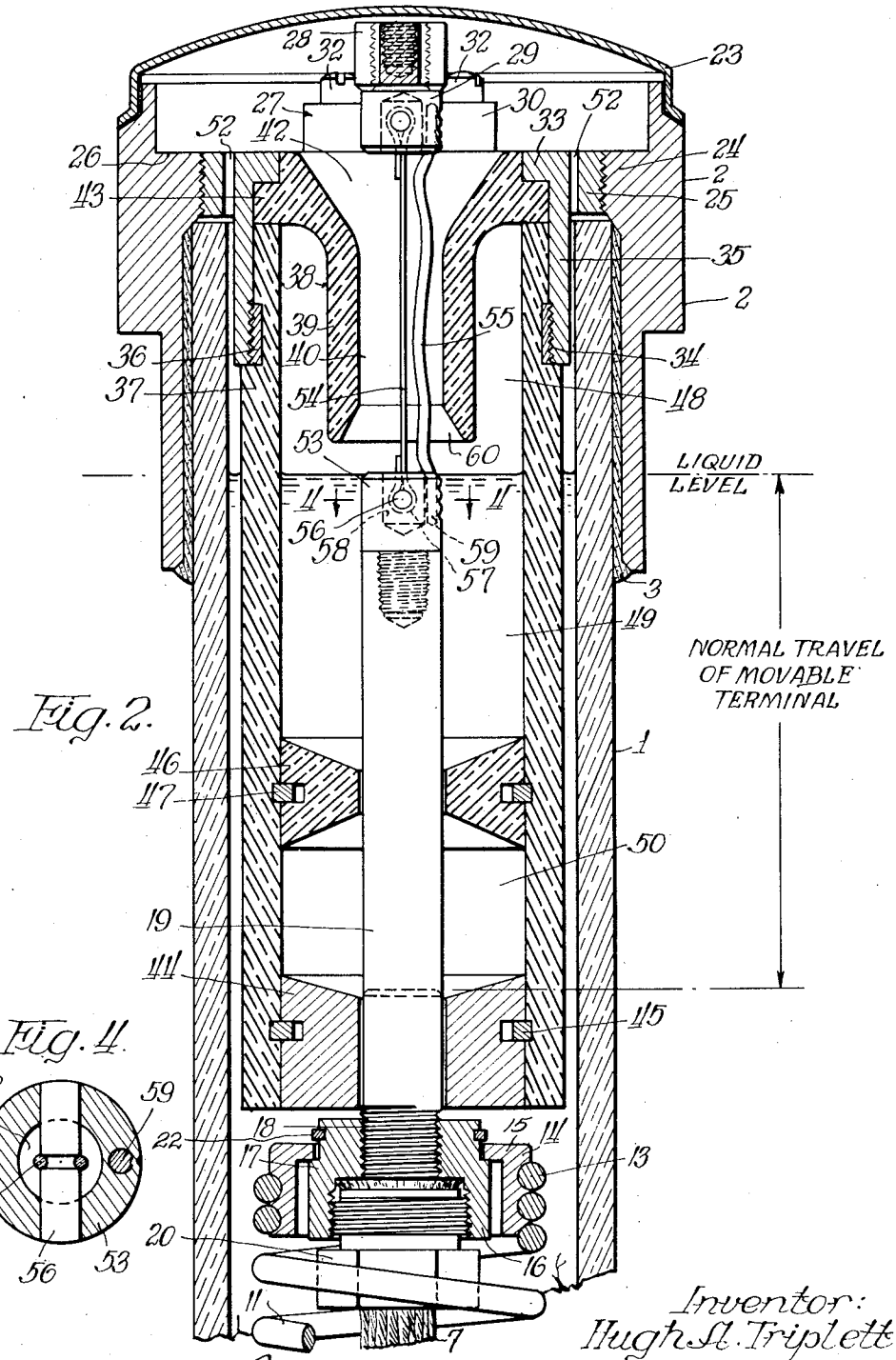


Fig. 2.

Fig. 4.

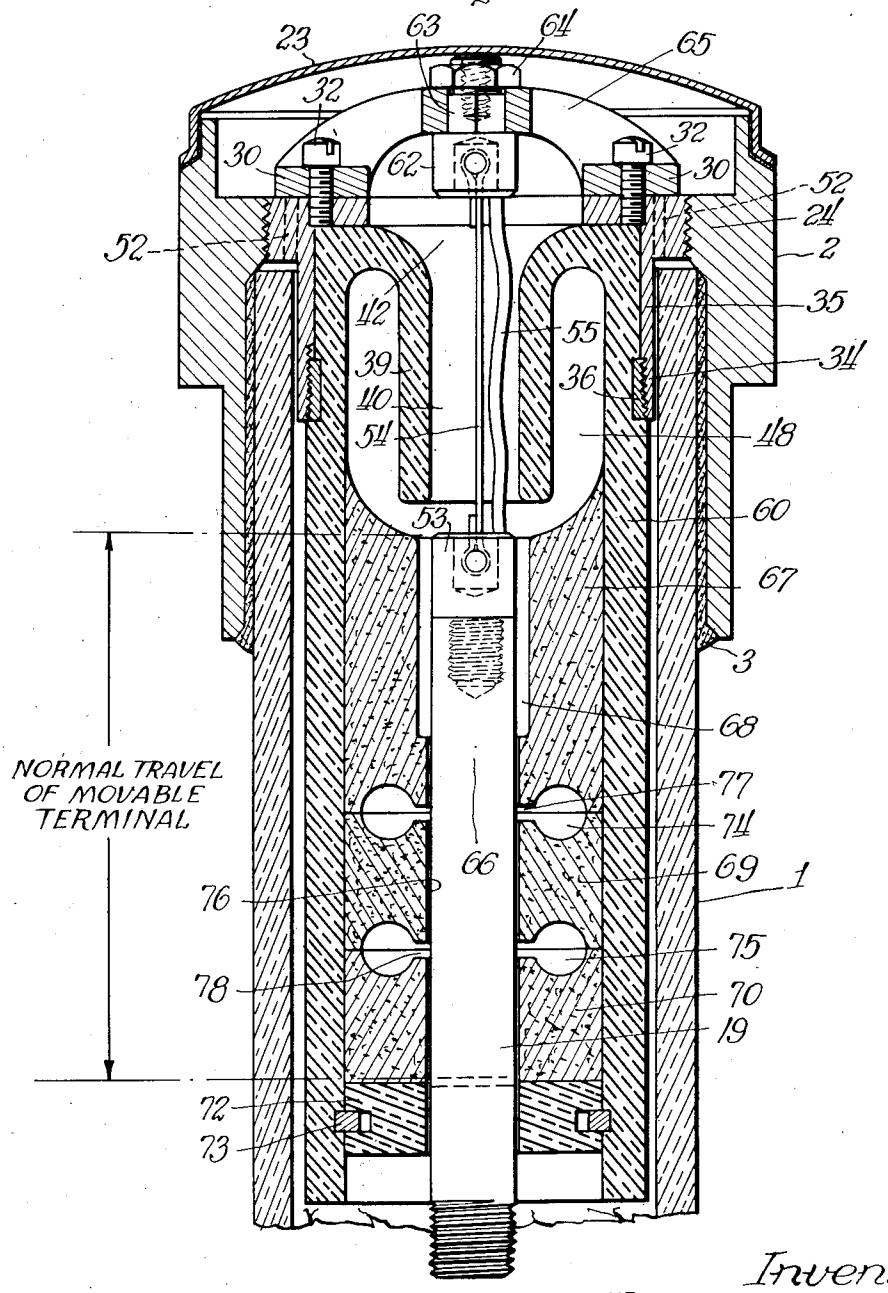
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Oct. 10, 1939. H. A. TRIPLETT 2,175,495

ARC EXTINGUISHING METHOD AND DEVICE

Filed July 19, 1935 3 Sheets-Sheet 3

Fig. 6.



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Patented Oct. 10, 1939 2,175,495

UNITED STATES PATENT OFFICE

2,175,495

ARC EXTINGUISHING METHOD AND DEVICE

Hugh A. Triplett, Wilmette, Ill., assignor to Schweitzer & Conrad, Inc., Chicago, Ill., a corporation of Delaware

Application July 19, 1935, Serial No. 32,187

43 Claims. (Cl. 200—120)

My invention provides an improvement in arc extinguishing methods and devices. It is particularly useful in high tension fuses, and provides a specific improvement in fuses. However, the invention is also useful in circuit breakers. I do not, therefore, wish to limit the broader aspects of the invention to the manner in which the arc is initiated.

The preferred embodiment in which I have elected to illustrate the invention is a high tension liquid type fuse, but as to the broader aspects this is by way of explanation, and not of limitation. My invention also provides an improved high tension fuse, one form of which is here shown.

The extinguishing of arcs of heavy current flow in high tension alternating current circuits has heretofore been attacked largely from the standpoint of creating a violent flow of deionizing gas or vapor without regard to cyclic variations. In my copending application, Serial No. 670,884, filed May 13, 1933, now Patent #2,091,424, granted August 31, 1937, I have pointed out that during the cyclic maximum current flow it is difficult, if not practically impossible, to create sufficient deionizing effect to extinguish the arc. I further pointed out that if the flow of deionizing gas or vapor through the arc space, i. e., the path to which the arc is confined by insulating barriers or the like, is maintained at a high value during the time that the current passes through zero, the arc may be more effectively and efficiently extinguished. In said application I provided a choking ring for the outlet of deionizing gases, securing thereby, in some degree, a gas reservoir effect from the space in the arcing chamber.

According to the present invention, I have developed an efficient method and structure for creating a highly effective deionizing action between half-cycles of current flow, whereby the arc, upon passing through the period of zero current, fails to be reestablished. The gist of this feature is found in constraining the arc to a definite path of adequate length; the free evolution of a gaseous deionizing medium by the arc; a storing of the medium substantially out of the ionizing influence of the arc all during the heavy instantaneous values of current flow,—that is, during the cyclical peak values,—and then between the cyclical peak values discharging the deionizing medium through the arc space or constrained path, thereby sufficiently deionizing a sufficient length of the arc path to insure termination of flow of current.

The problem of interrupting arcs in which fairly light overload current is flowing has also presented a difficult problem. Obviously, in a power circuit of a given voltage, it is easier to extinguish an arc of light current flow than one of heavy current flow, but in a structure which must be effective whether the current flow is light or heavy, a serious problem is presented. If the device is designed to effectively handle light current flow, i. e., to evolve sufficient gaseous medium from light current flow to deionize the arc space, excessive evolution of gases tends to occur on heavy current flow arcs. Such excessive evolution of gases tends to develop destructive pressures and to produce violent explosive effect and external disturbance.

The present structure provides a solution of the problem of providing, in a single structure such as a fuse or circuit breaker, a means for opening the circuit by extinguishing the arc under any value of current which may be encountered.

For extinguishing arcs of relatively light current flow, I have provided a mechanism comprising a plurality of chambers through which the arc is drawn in succession. In each of these chambers the arc is given an opportunity to evolve a gaseous deionizing medium, and these chambers discharge in series with each other towards a common outlet, at which outlet the arc is preferably confined to a definite predetermined path. The wall between adjacent chambers has an aperture constricting the communication between chambers. Where a liquid is employed, these chambers are superposed so that the head of liquid on the lowermost chamber is increased by the liquid in the upper chamber, and the gravity transfer of liquid from an upper chamber to a lower chamber tends to bring the same into such contact with the arc as will evolve sufficient gaseous medium to prevent restriking of the arc after it passes through a cyclical current zero.

In fuses of the high tension type, and particularly those which are liquid-filled, it is desirable to employ a transparent housing, such as is provided by a glass sleeve, for the purpose of permitting inspection of the fuse at all times. While the fusible element itself is not visible, the position of the parts readily indicates whether or not the fusible part is intact. Thereby the condition of the fuse about to be put into service, or which has been in service, may be readily determined without the necessity for a test.

The disadvantage of a glass housing lies mainly in the fact that it does not possess sufficient me-

chanical strength to withstand the pressures developed during short circuit, particularly in the larger diameters. The external surface of the glass is ideal for weather-resisting purposes, and a glass housing is generally desirable.

One of the objects of the present invention is to increase the interrupting capacity of a high tension fuse without sacrificing prompt circuit interruption during overloads, or without sacrificing the dielectric strength after operation, and without sacrificing the visibility feature.

According to the present invention, I dissociate the regions in which high pressures are generated by the arc from the main space in the housing. This dissociated or segregated space is permitted to discharge to atmosphere or to substantially free space, such as would be provided by a condenser substantially independently of the main space in the housing.

In other words, the generation of pressure is confined to the chamber or space which is specifically designed to withstand the same, and this high pressure chamber or space is arranged to discharge in such a manner as not to increase to a dangerous degree the pressure in the housing.

According to the preferred construction, the arc is confined as much as possible to a definite path, and between definitely located terminals. Particularly at the upper end of the fuse herein shown, the upper or stationary terminal is solidly anchored, so as to confine the arc within the structure and to prevent it from extending beyond the terminal. This terminal is also cooled by the blast of gases and the arc is held where it is subjected to the maximum deionizing effect by the blast. The arc is also retained inside the device, where it will not spill over to outside structures or connections.

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 connection with the accompanying drawings, a specific embodiment of the same.

In the drawings:

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

Figure 2 is an enlarged vertical longitudinal section through the upper part of the fuse shown in Figure 1;

Figure 3 is a top plan view of the fuse with the cover removed;

Figure 4 is a cross sectional view taken on the line 4—4 of Figure 2;

Figure 5 is a diagram illustrating the relation of gas flow to current flow;

Figure 6 is a diagrammatic longitudinal section of a modified form of fuse embodying certain features of my invention.

The fuse shown in Figure 1 has a housing made up mainly of the glass sleeve 1 and enclosures for the same. These enclosures comprise a ferrule 2 cemented as by an alloy seal 3 to the upper end of the sleeve, and a similar ferrule 4 likewise cemented as by an alloy seal 3 to the lower end of the glass sleeve. The lower ferrule 4 is in reality a cup or cap, that is, it has the end wall 5 integral with the cylindrical portion. On the inside of the wall 5 there is a threaded boss 6 for receiving a threaded stud on the lower end of the spring and flexible lead assembly. This spring and flexible lead assembly comprises a stranded flexible copper lead 7 secured at the lower end to a spring anchor fitting 8 comprising a main body portion of cylindrical form, with the outer periphery provided with a helical groove into which are threaded the lower convolutions 9 of the tension spring 11. A central hollow stud or cup 12 integral with the body 8 receives the lower end of the flexible lead 7 and is collapsed or deformed upon the end of the lead 7 to provide a permanent mechanical and electrical connection between the member 8 and the lower end of the lead 7. The upper end of the spring 11 has its convolutions 13 threaded into a helical groove formed on a flanged cylindrical ring 14 of which the flange 15 extends radially inwardly. This flange 15 overhangs a shoulder 17 on a fitting 16. The fitting 16 has at its upper end a threaded bore 18 for receiving the threaded lower end of a terminal rod or plunger 19. The lower end of the fitting 16 is counterbored and threaded to receive the hollow plug 20. The upper end of the flexible lead 7 extends through the bore of the hollow plug 20, and is clamped into electrical and mechanical connection with the fitting 16, and thereby with the plunger rod 19. A spreading cone may be inserted at the end of the flexible lead 7. This cone may be formed on the lower end of the plunger rod 19. A locking ring 22 is let into a groove above the flange 15 to hold the ring 14 and the fitting 16 together.

The upper ferrule 2 is shown as closed by the removable vent cap 23, which vent cap is cemented to the upper end of the ferrule in accordance with known practice, to provide a fluid-tight joint, subject to release upon the occurrence of predetermined pressure within the fuse housing. The vent cap 23 may be replaced by a recombining chamber or condenser, as disclosed in my application, Serial No. 670,884, filed May 13, 1933, or it may be embraced by the condenser, as disclosed in my other copending applications, where it is desired to dispose the fuse indoors or in confined spaces. Alternatively, the condenser may be connected to the ferrule 2, and the vent cap 23 close off communication between the condenser and the inside of the fuse housing. The ferrule 2 has an inwardly extending flange 24 which overhangs the upper end of the glass sleeve 1. The flange 24 is threaded to receive a ringlike fitting 25. Above the flange 24, the ferrule 2 is counterbored to provide a shoulder 26 upon which rests the terminal bridge 27 shown in plan in Figure 3. This bridge comprises a cross bar having a boss 28 at the center into which is threaded a removable arcing tip 29. The ends of the cross bar have pads or feet 30, 30 resting upon the shoulder 26 and rigidly secured thereto as by means of the machine screws 32, 32. The ringlike fitting 25 has an inwardly extending flange 33 at its upper end, and a cylindrical extension terminating in the internal threads 34 at its lower end. The cylindrical portion 35 is spaced radially inwardly from the internal cylindrical surface of the glass sleeve 1 to provide a passageway and to provide mechanical clearance. The internally threaded portion 34 holds, through the medium of a metal ring 36 inlet into a groove thereof, a cylindrical sleeve 37, which may be made of fiber or fiber impregnated with a synthetic resin of the phenol condensation type, or the like, or which may consist of inner layers of fiber paper and outer impregnated layers of the aforesaid synthetic resin and fiber paper. This sleeve 37 forms the main wall of an arcing chamber, which in turn is subdivided into subchambers. The upper end of the sleeve 37 is covered by a flanged outlet piece or neck member 38, which comprises a cylindrical downwardly extending portion 39 having a constricted outlet

bore 40, and a flared outer end 42, immediately adjacent the stationary terminal member 29. The flange 43 of the member 38 is gripped between the overhanging flange 33 of the member 25, and the upper end of the tubular housing member 37. The member 38 is thus rigidly held over the sleeve member 37 to close the upper end of the same, and to provide a tubular outlet bore 40, the upper end of which bore flares out at 42 around the stationary terminal 29. The lower end of the insulating sleeve 37 is plugged by a ring 44 held in place by a locking ring 45 disposed partly in a groove in the plug member 44, and partly in a groove in the sleeve member 37. This plug member 44, which is preferably made of metal or optionally of insulation, has a central opening therethrough which provides mechanical clearance for the terminal plunger 19. The fit must be free enough to insure that the plunger 19 will not bind in the opening, but otherwise it is desirable to have a close fit. This is done to prevent excessive leakage of fluid downwardly and out of the lower end of the chamber, with consequent danger of exposing the glass sleeve to too great internal pressure.

An intermediate ring member 46 locked by a spring locking ring 47 like the ring 45 divides the space within the sleeve member 37 into sub-chambers.

Arc extinguishing liquid, which may be any one of known or preferred type, fills the main fuse housing and the arcing chamber to substantially the level indicated in Figure 2, by the line marked "Liquid Level". This line is approximately at the same level as the upper end of the plunger 19, and preferably slightly below the cylindrical neck 39 of the chamber 38. The annular space between the member 38 and interior periphery of the sleeve 37 constitutes a gas chamber 48 for trapping gas under pressure out of the influence of the arc, which may be drawn between the plunger 19 and the stationary terminal 29. Thus the lower part of the sub-chamber 49 is filled with the arc extinguishing liquid; so also is the sub-chamber 50.

The upper end of the plunger 19 is fitted with a removable arcing tip 53, which is a duplicate of the arcing tip 29. In the specific form herein shown, the arcing tips 29 and 53 are connected by two electrically conductive members, namely, the strain wire 54 and the fuse wire 55. The strain wire 54 has loops formed at its ends, the free ends being bent back to form the loops, and then the ends are welded to the main body and pins, such as 56, are passed transversely through the arcing tips 29 and 53, and through the loops or eyes 57 formed on the ends of the strain wire 54. These pins 56 preferably have grooves at the center to insure centering of the strain wire 54 in the bores or recesses 58 formed as by drilling in the outer ends of the tips 29 and 53. Centering of the strain wire insures against cocking or binding of the plunger rod 19.

The fuse wire 55 is preferably a silver wire having its ends inserted into holes drilled endwise into the wall of the corresponding tips 29 and 53, the side walls of these holes being collapsed as by means of a prick punch or the like, so as to grip solidly the ends of the silver fuse wire in the recesses or holes formed in said tips 29 and 53.

The employment of a silver fuse wire is desirable for normal current carrying operation. However, the blowing operation of the silver gives rise to high pressures and other difficulties. The separate pressure chamber herein disclosed is highly desirable for limiting the adverse effects of the silver upon blowing. Also, the contamination of the liquid dielectric on the main part of the housing is limited by confining such contamination to the chamber.

The lower end of the bore 40 is flared out, as shown at 60 in Figure 2, to facilitate the flow of gas, and particularly the gas from the gas space 48 into and through the bore 40. The flare 42 at the upper end provides both a clearance about the terminal 29 and also facilitates quick and easy flow of metal vapors and gases out of the bore 40.

The operation of the fuse thus far described is as follows: Assume that the fuse is connected in circuit, and that it is subjected to a flow of current substantially greater than its normal rating, as would be the case of an overload. Thereupon, the fusible wire 55 melts. The strain wire 54, being made of a high resistance, high tensile strength metal such as a nickel-chromium alloy, saves the fuse wire 55 from mechanical stresses. As soon as the fuse wire 55 melts, all of the current is thereupon forced through the strain wire 54 and it, in turn, melts, releasing the plunger 19, which thereupon is free to descend under the tension of the spring 11.

While I have described the fuse wire 55 as of silver, which is the preferred metal, I do not intend to be limited to that specific metal or to any specific alloy. Likewise, the strain wire 54 has been described as of a specific construction or composition, and obviously the specific metal or alloy which I have described is not essential. It is desirable that the arrangement be such that the mechanical stress of the spring 11 be not imposed upon the fuse wire, and that the strain wire should not rupture before the melting of the fuse wire.

The cylindrical portion 39 of the member 38 is preferably made of layers of paper stock impregnated with a synthetic resin such as "Bakelite", wrapped and baked, or like material, or a combination of materials. It may also, for example, be made of a phenol condensation compound, or of porcelain, or lava, if desired. These materials preferably do not, of themselves, evolve any gas by contact with the arc. However, the part 38 may be made of fiber, or other material which when acted upon by the arc evolves an arc extinguishing gas.

If the walls of the bore 40 be made of a material which evolves gas from the heat of the arc, this will occur generally only in the case of a heavy arc, such as may be caused by a short circuit condition in the circuit of the fuse. On light overloads, such as above mentioned, the arc would normally not attack the walls of the bore 40 sufficiently to extinguish the arc, even if said walls be made of fiber or of a material which would yield gas.

As formation of the arc is simultaneous with release of the plunger 19, the downward movement of the plunger 19 below the level of the liquid in the chamber 49 brings more of the liquid within the influence of the arc to evolve a gaseous medium which raises the pressure in the gas chamber 48 and in the liquid chamber 49, causing an upward and outward flow through the bore 40, displacing metal vapors into the chamber surrounding the stationary terminal 29 under the cap 23. If the current flow in the arc is relatively low, the arc may not evolve sufficient gas to create a high pressure, and the extinguish-

ing may be secured without removal of the vent cap 23. In fact, the evolution of gas may be so moderate that a violent flow through the chamber 40 is not secured. In that event the lower sub-chamber is particularly effective upon the arc.

The vent cap 23 is normally intended to be removed at fairly low pressures, so as to secure the scouring effect of the flow of gas through the passageway 40. This passageway, desirably, should be relatively small, in order to secure the desired scouring and deionizing effect at relatively low current values, such as 500 amperes or less, but it must not be made so small that when a short circuit involving twenty thousand amperes occurs, it would be too greatly constrictive or restrictive. The size of the bore is therefore a compromise, and the arrangement of the arc extinguishing means below the bore 40 is designed to operate selectively upon different sizes of arcs, that is, arcs of different effective current flow. The design is intended to be such that as soon as the pressure rises to a value where the integrity of the glass sleeve 1 would be endangered, the vent cap 23 should be removed. Removal of the cap tends to initiate more violent flow through the bore 40. By the use of the substantially fluid-tight arcing chamber, the pressure therein may rise to value very materially in excess of the pressures at which vent cap 23 is removed. If the low current arc is not extinguished by the time the tip 53 reaches the ring 46, the arc is thereupon extended into the sub-chamber 50. Here the evolution of gas under a slightly higher liquid pressure, and under the restricting effect of the bore of the ring 46, creates a deionizing and extinguishing effect of greater efficiency.

In an alternating current, the actual instantaneous current flow through the arc varies cyclically. Thus, during the part of the cycle when the current flow passes through zero, the evolution of gas would not occur. In the present structure I have provided the chamber 48 in which gas for deionizing the arc gases may be stored during the peak values of current within the half cycle, and upon diminution of the current cyclically this trapped gas under pressure escapes through the outlet opening 40, and provides a very effective deionizing and extinguishing effect between periods of current flow, with the result that the voltage is unable to restrike the arc and interruption of flow in the circuit is effected.

In the case of short circuit currents, the action is very much more violent, and the extinguishment is usually more rapidly accomplished because of the great evolution of gases by the arc. The liquid in the chamber 49 stands substantially at the level of the tip 53, and is immediately acted upon by the arc to evolve vapor and gas, some of which flows through the bore 40. During periods of maximum generation, a considerable quantity of the gaseous medium is driven and compressed into the annular chamber 48, substantially out of the influence of the arc, so that it will be free of ionization, and then upon diminution of current towards the zero value, the gas stored in the chamber 48 flows out through the passageway 40 and through the arc space, and prevents reignition.

On short circuit values, the arc is usually extinguished before the tip 53 approaches the ring 46, and it is intended that only on overloads, that is, low current arcs, will the arc, in some instances, hang on until the tip 53 reaches the lower chamber. The tip 53 may be stopped at the dotted line indicated in Figure 2, that is, just as it is withdrawn within the ring 44. This tip and its plunger 19 may be withdrawn completely below the arcing chamber and out of ring 44, so as to secure a greater break distance or disconnecting effect by interposition of the liquid dielectric in the main housing.

It will be observed that since the plunger 19 forms a substantially tight fit with the ring 44, the downward thrust of the plunger 19 displaces liquid in the main body of the housing. This liquid rises in the annular space between the tubular arcing chamber sleeve 37 and the glass sleeve 1. A series of vents 52 may be formed through the member 25 to facilitate the free movement of the liquid upwardly and to allow a relatively slow equalization of pressures between the chamber above the member 25 and the main part of the housing below the member 25.

In Figure 5 I have indicated diagrammatically the action of gas flow with respect to chamber 48. As the current flow attains a given value, which may be lower or higher than the particular point I have indicated diagrammatically, gas will be forced into the chamber and compressed by pressure created by the arc. Obviously, gas flows out through outlet 40 during this action, but such flow is not effective to extinguish the arc. Then, as the current flow and the resultant evolution of gas decreases, the pressure of the gas being evolved drops below that of the gas stored in the chamber. Then the chamber 48 begins to discharge gas through the outlet 40 where the arc is confined. As the current flow drops to zero, evolution of gas tends to cease, and as the pressure of gas evolution drops, the gas stored under pressure issues and flows through the outlet 40, substituting a deionized medium for the gases which were in said passageway. This deionized medium resists breakdown by the succeeding cyclical rise in voltage, with the result that the circuit is definitely interrupted. The terminal 53 on rod 19 may be withdrawn from the chamber 50 through ring 44 into the uncontaminated liquid dielectric in the main part of the fuse housing, thereby producing an effective disconnection.

While I have shown liquid arc extinguishing medium in the sub-chambers 49 and 50, it is to be understood that this is by way of illustration of the invention rather than limitation. Liquid has the property of tending to close in upon the arc by gravity and pressure, but it has also the defect that it is too easily displaced, as by gas pressure, and I have therefore provided a structure, such as the ring 46, which compels the liquid to flow into the gas space and to be limited against too easy displacement for the more certain evolution of the required volumes of arc extinguishing gas.

Where a solid material is employed, it is under the difficulty that it cannot close in upon the arc. Neither can it readily expand under the requirements of pressure or flow out of the way. However, it is possible to secure some of the advantages of my invention by the use of solid materials or solids and liquids where the liquid enters in less degree, or in slightly different manner into the desired action.

In Figure 6, I have shown a modification in which solid arc extinguishing material of different operating characteristics is employed for evolving a deionizing medium.

In this construction, the main housing, including the glass sleeve 1, ferrule 2, and ferrule 4 (not shown) is substantially the same as shown in the embodiment of Figure 1. The metal fitting 35 is threaded to the flange 24 of the ferrule 2, and the lower end of this fitting 35 is threaded into a ring 36 let into the tubular insulating sleeve 60. This holds the sleeve 60 fixedly in the housing. The tubular insulating member 60 may be made of fiber stock paper impregnated with a synthetic resin, such as "Bakelite" and may be made up in parts as illustrated in connection with Figure 2 to provide the main tubular sleeve and the neck member 39, which, in this case, is shown as integral with the main body of the sleeve 60. The neck member 39 has a flared outlet 42 to facilitate outward flow of the gas through the bore 40 around the upper removable terminal 62, which may be constructed like the terminal 29 of Figure 3, or as herein shown, may consist of a squared shank 63, the outer end of which is cylindrical and provided with screw threads to carry the clamping nut 64. The shank of the arcing tip 62 may be bored and internally screw threaded to facilitate handling. The bridge member 65 which supports the upper terminal 62 is in this case mounted upon the upper end of the fitting 35, being fastened thereto by machine screws extending through foot portions 30, as in the construction in Figure 2. Optionally, in either embodiment, this bridge may be mounted on the ferrule 2 or upon fitting 35. The movable arcing tip 53 is mounted upon the rodlike plunger 66, which may be a round plunger as in Fig. 2, where the parts are to be assembled from the top, or which may be square in cross section to keep it from turning in the ring 72 for the method of assembling discussed below. The fuse 55 and strain wire 54 connect the tips 53 and 62, as explained in connection with Figure 2. Within the upper end of the sleeve 60 and outside the neck member 39, there is provided the gas storage chamber 48 for receiving gas evolved from suitable arc extinguishing material, such as 67, provided immediately below the neck member 39. This arc extinguishing material 67 may be boric acid, or it may be fibrous vegetable matter suitably compacted. The arc extinguishing material 67 has a bore 68 which is substantially larger than the rodlike plunger 66, for the purpose of providing a larger opening for the flow of gases evolved under short circuit arcs. This bore may be approximately the size of the bore 40, but preferably is slightly larger. Below the arc extinguishing material 67, are two other blocks 69 and 70 of arc extinguishing material assembled in the sleeve 60 and held in place by a closure ring 72 pinned and locked to the sleeve 60 by a spring ring 73. Pockets 74 and 75, of annular shape, communicate with the bore 76 which extends through the blocks of arc extinguishing material 69 and 70, through annular slots 77 and 78. The pockets 74 and 75 are annular, and form gas storage spaces. These pockets may be arranged in any desired manner to secure an effect comparable to that of chamber 48, namely, of storing gas under pressure during the peak of the current wave and playing it out or discharging it into the arc space when the current passes through zero value in the cyclical variation of current flow.

Where liquid is to be employed in the main housing the manner of assembly may be the same as in Figure 2. Where the housing need not be liquid tight, the anchor for the lower end of the spring may be extended through an opening in wall 5.

It will be seen that by the above arrangement, a complete refill unit, including both the stationary and movable terminal, and the pressure retaining chamber with its sub-chambers, is provided. The threaded end of the plunger 19 may be threaded into the fitting 17, shown in Figure 2. In this event, for field refill (no liquid being employed), the lower fitting 8 (see Figure 1) may be formed with a square shank extending through the lower end of the lower ferrule 4 and fastened by a nut, just as the renewable tip 62 is shown as mounted in the bridge member 65 (Figure 6). To do this a rod may be inserted through the central opening in the end wall 5, threaded into the threaded socket in the shank of the fitting 8, and pulled outwardly to tension the main spring 11 and then be fastened by a suitable nut on the outside.

The operation of the fuse shown in Figure 6 is similar to that described in connection with Figures 1 to 5, in that upon the occurrence of a current flow in excess of the carrying capacity of the fuse, the fuse 55 and its strain wire 54 become melted. Assume that the excess of current flow is due to overload. The downward travel of the plunger 19 extends the arc into the bore 68, but in view of the relatively small size of the arc, the evolution of gas may not be sufficiently rapid to deionize the arc path to the point of stopping the arc. However, as the terminal is drawn down into the small bore 76, both due to the increased surface exposed and due to the closer approach of the walls of the arc extinguishing material, sufficient gas will be evolved and will tend to be stored under pressure in the pockets 74, 75 during the peak of the cyclical current flow, and discharged or paid out as the current flow approaches zero. The result is that at a cyclical current zero, the arc space will be sufficiently deionized and its dielectric strength sufficiently restored to prevent breakdown by the rise of current after a current zero, with resultant termination of current flow.

In case the excess current flow is that due to a short circuit, the evolution of gas in the upper tube 60 will be sufficiently rapid and violent to produce a violent outward flow of gas through the bore 40 to create a strong deionizing effect. The generation of gas also results in driving gas under pressure into the chamber 48, with resultant outward flow from the chamber 48 through the bore 40 when the cyclical current flow decreases towards zero, with the result that the arc is unable to restrike and current flow ceases.

The construction shown in Figure 6 may be employed in conjunction with a charge of arc extinguishing dielectric liquid. If desired, the liquid may fill substantially the housing and sleeve 60 to approximately the top of the arcing tip 53, in which event the combined action of liquid and solid arc extinguishing material is employed, or the liquid may reach only to approximately the lower end of the arc extinguishing material 70, and it serves only as a dielectric medium to increase the disconnecting ability of the device after the arc is extinguished, and the said rod 19 withdrawn from the sleeve 60 and into said dielectric liquid.

As explained in connection with Figures 1 and 2, the bore of the neck member 39 may, if desired, be formed of arc extinguishing material, for example, fiber. In that event, the arc on heavy current flow, such as is caused by short circuit, may evolve gas from the bore of the member 39, part of the same being discharged out the flared throat 42, and a part stored in the chamber 48.

during the peak of the cyclical current flow. From the chamber **48**, the gas may then be discharged out through the bore **40**, as above explained. Optionally, the arrangement of gas storage chambers in which the gas is received, deionized and again discharged, may be widely varied within the scope of my invention.

Where solid arc extinguishing material is employed, the rodlike terminal **19** is preferably stopped before it leaves the end of the ring **72**.

Where solid arc extinguishing material evolving a condensable gas or vapor is employed, a closed condenser chamber may effectively be employed to receive the discharge through the bore **40** to confine the blowing of the fuse to a completely closed chamber. If the fuse housing contains no liquid, the cap **23** may be omitted and the gases discharged directly into the condensing chamber, or into atmosphere. The open end may be covered or loosely plugged.

The means for extinguishing an arc as above described are particularly advantageous for extinguishing an arc initiated by a fusible link. However, the same means and mode of operation are equally applicable to the extinguishment of an arc otherwise initiated, as, for example, by separation of switch contacts, as will be at once apparent to those skilled in the art.

I do not intend to be limited to the specific features shown and described, except as they are recited as essentials in the following claims. I intend to claim the invention as broadly as is permitted within the scope of the prior art.

I claim:

1. A high tension current interrupter adapted to interrupt current of values extending from overload to short circuit value, comprising a pair of chambers disposed end to end in communication with each other, an unobstructed venting outlet opening into a space containing a readily compressible fluid from that end of one chamber which is remote from the other chamber, means for producing and drawing an arc first in said one chamber and tending to extend it into the other chamber, and arc extinguishing means in each of said chambers.

2. The combination of claim 1 wherein the arc producing and drawing means comprises a terminal member mounted for motion endwise from the one chamber to the other chamber.

3. The combination of claim 1 wherein the arc producing and drawing means comprises a relatively fixed terminal and a movable terminal, and spring means for retracting the movable terminal from the relatively fixed terminal and moving it out of the one chamber into the other chamber to extend the length of the arc.

4. In combination, an arc extinguishing chamber comprising two communicating sub-chambers, the first sub-chamber having an unobstructed venting outlet for gases produced by the arc, said outlet opening into a space containing a readily compressible fluid, the second sub-chamber communicating with said outlet through the first sub-chamber, arc extinguishing material in each of said chambers for evolving a gaseous arc extinguishing medium under the influence of the arc, and means for forming an arc in the first sub-chamber and tending to extend it into the second sub-chamber.

5. The combination of claim 4 wherein said means comprises a fuse, a movable fuse terminal and a spring for moving said fuse terminal from the first sub-chamber into the second sub-chamber.

6. In combination in a fuse device, an arc extinguishing chamber having an unobstructed venting outlet, a fuse, a movable fuse terminal adapted to be retracted endwise through said chamber away from the outlet, said outlet being defined by a tubular inwardly extending neck defining between itself and the inner walls of the chamber a fluid pressure reservoir, and arc extinguishing material disposed in the annular space surrounding the movable terminal.

7. The combination with claim 6 of a stationary fuse terminal disposed at said outlet, and a fusible link connected between said terminals.

8. In a fuse, a housing comprising a glass sleeve bearing ferrules at its ends, an elongated arc extinguishing chamber fixed in said housing, said chamber having an outlet for the discharge of gases externally of said sleeve, said chamber being divided into sub-chambers, a terminal adjacent said outlet and connected with the adjacent ferrule, a movable arc drawing member extending endwise through one sub-chamber into the other, a fuse link connecting said terminal and said arc drawing member, and a spring outside the chamber for drawing the member towards the end of the chamber remote from the outlet and tending to extend the arc through the sub-chambers in succession, each of the sub-chambers containing an arc extinguishing medium.

9. The combination of claim 8 wherein the terminal is fixed in alignment with the outlet, the outlet comprises a short tube which surrounds the fuse, and wherein the housing is filled up to the level of the fuse with arc extinguishing liquid.

10. Means for interrupting current flow, comprising a pair of chambers, the first being especially adapted for extinguishing arcs carrying relatively heavy current flow, the second being especially adapted for extinguishing arcs carrying relatively light current flow, the first chamber having a discharge outlet for gases, said outlet opening into a space containing a readily compressible fluid, the second chamber having an opening into the first chamber, arc drawing means comprising a stationary conducting member near the outlet and a movable conducting member, said movable member comprising a rod extending through the second chamber and through the opening between said chambers and into the first chamber, said movable member being retractible from the first chamber into the second chamber to extend the arc into the second chamber if it is not extinguished in the first chamber, and arc extinguishing material surrounding the movable member in each chamber.

11. In combination, a pair of arc extinguishing chambers, means for forming an arc in one chamber only, said means including a relatively stationary terminal member and a movable terminal member, said one chamber having an unobstructed venting outlet opening into a space containing a readily compressible fluid for venting immediately the arc gases as soon as the arc is formed, and means for causing the movable terminal member to extend the arc into the second chamber, the current flow in the arc determining in which chamber the arc will be extinguished, each of said chambers having arc extinguishing material surrounding the movable terminal member.

12. In an arc extinguishing structure, a stationary arcing terminal, a movable arcing terminal for drawing an arc between itself and the stationary terminal, a tubular container having

a space in the vicinity of the stationary terminal into which the gases of the arc discharge and having a series of transverse walls defining a plurality of chambers, said walls having apertures in alignment, said movable arcing terminal extending through a plurality of said walls, the arc being extended through a plurality of said walls and being restricted to a predetermined position where it extends through said apertures, said chambers containing arc extinguishing material.

13. In a device of the class described, a tubular container having stationary transverse walls defining plurality of chambers, said transverse walls having apertures in alignment, a stationary arcing terminal adjacent said uppermost aperture, said uppermost aperture providing a space in the vicinity of the stationary terminal for receiving the discharge of the gases produced by the arc, a movable arcing terminal extending through a plurality of said apertures, means below the lowermost aperture for retracting said movable arcing terminal to extend the arc from one chamber into another, and arc extinguishing material in each of said chambers.

14. In combination with an arcing chamber having an unobstructed outlet, an arcing terminal disposed within the chamber, an arcing terminal disposed outside the chamber, said outlet comprising a tubular neck of relatively limited diameter, said outlet being made of a relatively solid material which when attacked by the arc evolves a gaseous arc extinguishing material, and a liquid arc extinguishing material disposed in the chamber and adapted when acted upon by the arc to evolve a gaseous arc extinguishing medium which is vented through said outlet.

15. The combination with claim 14 of means for separating said terminals automatically upon the occurrence of overload.

16. In a high tension fuse having a fuse housing, a closed gas trapping chamber fixedly supported in said housing, said chamber being capable of withstanding relatively high internal pressures, said chamber having an unobstructed but restricted outlet, a pair of terminals one of which lies inside the chamber and the other which lies outside the chamber, arc extinguishing material in said chamber, and a silver fuse wire connecting said terminals and being disposed partly in said outlet.

17. The combination of claim 16 wherein said one terminal is retractible within the chamber, and a spring for retracting said one terminal, said spring being disposed in said housing and outside said chamber.

18. In a high tension fuse having a fuse housing, a closed gas trapping chamber fixedly supported in said housing, said chamber being capable of withstanding relatively high internal pressures, said chamber having an obstructed but relatively restricted outlet, a pair of fuse terminals one of which is disposed in said chamber and is retractible, a fuse connecting said terminals, arc extinguishing material in said chamber subject to the action of the arc to form an extinguishing medium which is expelled through said outlet, a retracting spring for said movable terminal, and a body of dielectric medium in the housing outside said chamber.

19. In a fuse, a fuse ferrule having an internal radial shoulder, a transverse bridge piece having its ends resting upon said radial shoulder, said bridge piece having a central opening, retaining means holding said bridge piece to said radial shoulder and preventing blowing off thereof on operation of the fuse and a renewable member forming an arcing tip and fuse terminal mounted in said opening.

20. The combination with claim 19 of a gas retaining chamber with a restricted outlet disposed in line with and adjacent said renewable tip, said chamber being supported fixedly by said ferrule, a cooperating fuse terminal in said chamber, and a fuse between said terminals and disposed in said outlet.

21. In a high tension alternating current interrupting device, the combination of a pair of arcing terminals between which an arc is adapted to be formed, means for confining the arc to a definite predetermined path, means subject to the arc for evolving a gaseous arc extinguishing medium, and means to receive and store under pressure away from the influence of the arc some of said evolved gas and to discharge the same into said predetermined path as the current approaches its cyclical zero.

22. A refill unit for a high tension fuse comprising a cylindrical housing, comprising a chamber having an unobstructed but restricted outlet and having a gas storage chamber, arc extinguishing material in said chamber, a stationary terminal mounted on said housing at said outlet, a movable terminal disposed in said chamber and surrounded by said arc extinguishing material, and a fusible link connected between said terminals and extending through said outlet.

23. A refill unit for a high tension fuse comprising a cylindrical housing comprising a chamber having a restricted outlet at one end, a metallic coupling at said end of the housing, a bridge member mounted on said coupling and extending over said outlet, a stationary tip mounted on said bridge in line with said outlet, a movable terminal in said chamber, arc extinguishing material in said housing, and a fusible link connecting said tip and said movable terminal.

24. In a high tension fuse, an extinguishing chamber comprising a tubular housing having an outlet at one end, a stationary terminal associated with said outlet, arc extinguishing material in said chamber, a movable terminal surrounded by said arc extinguishing material, and a dividing wall of insulation dividing said arc extinguishing material into separate portions, said movable terminal extending through said wall.

25. In a current interrupter a first terminal and a second terminal between which an arc is adapted to be formed, the second terminal being carried by a longitudinally movable rod, and arc extinguishing means comprising a first chamber provided with a space for venting the gases produced by the arc beyond said first terminal, a second chamber disposed in endwise alinement and communicating with said first chamber, said arc being initially formed in said first chamber, said movable rod tending to draw the arc from the first chamber into the second chamber, each chamber being provided with arc extinguishing material which when acted upon by the heat of the arc evolves a gaseous arc extinguishing medium that is driven into said space.

26. The combination of claim 25 wherein a fusible element normally connects said terminals and a spring tends to separate said terminals.

27. In a circuit interrupter, a pair of terminals between which an arc is adapted to be formed, a stationary tubular body of insulation having a bore with a flared free outlet forming an expansion nozzle, one of said terminals being fixedly mounted at said outlet in line with the bore

whereby it is in position to be engaged by gaseous fluid flowing out of said expansion nozzle and cooled thereby, the other of said terminals being disposed in line with said bore and being retractible in a direction away from the fixedly mounted terminal.

28. In a circuit interrupter, a pair of terminals between which an arc is adapted to be formed, a stationary tubular body of insulation having a bore with a flared free outlet forming an expansion nozzle, one of said terminals being fixedly mounted at said outlet in line with the bore whereby it is in position to be engaged by gaseous fluid flowing out of said expansion nozzle and cooled thereby, the other of said terminals being disposed in line with said bore and being retractible in a direction away from the fixedly mounted terminal, and a chamber surrounding said tubular body and said movable terminal and having its sole outlet through said bore, said chamber containing arc extinguishing material.

29. In a circuit interrupter, an upper relatively stationary terminal and a lower relatively movable terminal between which an arc is adapted to be drawn, said terminals being disposed in substantially vertical alinement, a first chamber having an unobstructed top outlet for directing the products of the arc beyond the upper terminal, a second chamber having an opening at its upper end communicating with the bottom of the first chamber, said lower terminal extending through the second chamber and through said opening and being retractible from the first chamber into the second chamber, and a bath of arc extinguishing liquid filling the second chamber and at least a part of the first chamber.

30. In a circuit interrupter, an upper relatively stationary terminal and a lower relatively movable terminal between which an arc is adapted to be drawn, said terminals being disposed substantially in vertical alinement, means providing a chamber surrounding the movable terminal, said chamber having a tubular outlet at its upper end, the walls of the chamber and said tubular outlet defining an annular gas trap above the bottom of said tubular outlet, and a body of liquid in the chamber the level of which lies substantially below the bottom of said tubular outlet, and means for drawing said movable terminal down into said liquid.

31. In a fuse, a fuse ferrule, a transverse bridge piece carried by said ferrule, said bridge piece having a central opening, retaining means preventing relative movement between said bridge piece and said ferrule on blowing of the fuse, and a renewable member forming an arcing tip and fuse terminal mounted in said opening.

32. In a fuse, a housing comprising a glass sleeve bearing ferrules at its ends; a refill unit stationarily mounted at one end of said sleeve including an elongated arc extinguishing chamber opening into a gas filled space at said one end of said sleeve, a pair of terminals, and a fuse link interconnecting said terminals, one of said terminals being stationarily mounted at the end of said chamber adjacent said space and the other being movably mounted within said chamber; an arc extinguishing liquid in said sleeve, and a spring outside said chamber operatively connected to said other terminal for drawing it into said liquid and toward the other end of said housing.

33. In combination, in a circuit interrupter, a container, an arc extinguishing liquid in said container, a tubular member stationarily mounted in a vertical position in said container and extending into said liquid, a tubular arcing chamber stationarily mounted in said container concentrically with said tubular member, with the lower end spaced from the surface of said liquid, the space between said tubular member and said arcing chamber being closed at the upper end, a lower movable terminal extending into said tubular member, a cooperating upper terminal adjacent the upper end of said arcing chamber, an arc being adapted to be formed between said terminals, and means for moving said lower terminal downwardly in said liquid to extend the length of said arc.

34. In combination, in a circuit interrupter, a pair of concentric spaced apart sleeves disposed in a vertical position with the inner sleeve shorter than the outer sleeve and the space therebetween at the upper end being closed, said outer sleeve opening downwardly into a relatively incompressible fluid and said inner sleeve opening upwardly and downwardly into a readily compressible fluid, and means for drawing an arc in said inner chamber.

35. In combination, in a circuit interrupter, a container, an arc extinguishing liquid in said container, a tubular arcing chamber vertically mounted in said container with both ends thereof opening into gas filled spaces at least the lower of which is confined by walls the inner surface of which is electrically insulated from the exterior of the circuit interrupter, a pair of relatively movable terminals between which an arc is formed in said arcing chamber on operation of the interrupter, and means for moving one of said terminals into said liquid on formation of the arc to lengthen and extinguish the same.

36. In combination, in a circuit interrupter, a vertically positioned tubular arcing chamber having both ends opening into gas filled spaces, means confining the lower of said spaces having the inner surface entirely formed by insulating material, a pair of relatively movable terminals between which an arc is drawn in said chamber, and a relatively incompressible arc extinguishing material forming a part of said confining means and adapted to evolve a gas by the heat of the arc for extinguishing it.

37. In combination, in a circuit interrupter, a vertically positioned tubular arcing chamber having both ends opening into gas filled spaces at least the lower of which is confined by walls the inner surface of which is electrically insulated from the exterior of the circuit interrupter, a first terminal, means for stationarily mounting said first terminal at the upper end of said chamber and positively holding it in position on operation of the interrupter, a relatively movable terminal cooperating with said first terminal for drawing an arc therebetween, and a relatively incompressible arc extinguishing material positioned below said chamber and adapted to evolve a gas by the heat of the arc for extinguishing it.

38. A refill unit for a high tension fuse comprising, a housing having a longitudinal bore, a terminal movably mounted in said bore, a second terminal, means carried by said housing for stationarily mounting said second terminal substantially at one end of and in line with said bore, and fusible means interconnecting said terminals.

39. A circuit interrupter comprising a pair of separable terminals, and a body of insulating material having a longitudinal bore in which an arc formed on separation of said terminals is

drawn and from which a gaseous arc extinguishing medium is evolved by the heat of the arc, said bore being recessed to provide space in said body of insulating material for storing said gaseous arc extinguishing medium during current maximum in each half-cycle, said gaseous arc extinguishing medium being released into said bore during current minimum in each half-cycle.

40. A circuit interrupter comprising a pair of separable terminals, and a body of insulating material having a longitudinal bore in which an arc formed on separation of said terminals is drawn and from which a gaseous arc extinguishing medium is evolved by the heat of the arc, said body of insulating material being provided with at least one enlarged space opening through a restricted passageway into said bore for storing said gaseous arc extinguishing medium during current maximum in each half-cycle, said gaseous arc extinguishing medium being released into said bore during current minimum in each half-cycle.

41. In a circuit interrupter for alternating current, arc extinguishing means depending upon the heat of the arc drawn on opening of the interrupter for producing a gas which assists in extinguishing the arc, and means for storing under pressure the gas produced by the heat of the arc during the portions of each cycle during which maximum current flow through the arc takes place and for releasing the stored gas during the remaining portions of each cycle for deionizing the arc space.

42. In a circuit interrupter for alternating current, arc extinguishing means depending upon the heat of the arc drawn on opening of the interrupter for producing a gas which assists in extinguishing the arc, and means for storing under pressure the gas produced by the heat of the arc out of contact with the same during the portions of each cycle during which maximum current flow through the arc takes place and for releasing the stored gas during the remaining portions of each cycle for deionizing the arc space.

43. In a circuit interrupter for alternating current, arc extinguishing means depending upon the heat of the arc drawn on opening of the interrupter for producing a gas which assists in extinguishing the arc, and a chamber the inner surface of which is formed by insulating material for storing under pressure the gas produced by the heat of the arc during the portions of each cycle during which maximum current flow through the arc takes place and for releasing the stored gas during the remaining portions of each cycle for deionizing the arc space.

HUGH A. TRIPLETT.

CERTIFICATE OF CORRECTION.

Patent No. 2,175,495. October 10, 1939.

HUGH A. TRIPLETT.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows: Page 7, first column, line 13, claim 13, before the word "plurality" insert a; line 60, claim 18, for "obstructed" read unobstructed; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 21st day of November, A. D. 1939.

Henry Van Arsdale,
Acting Commissioner of Patents.

(Seal)