Aug. 31, 1937. H. A. TRIPLETT 2,091,423

CIRCUIT INTERRUPTER

Filed Oct. 28, 1932 2 Sheets-Sheet 1

Fig. 1.

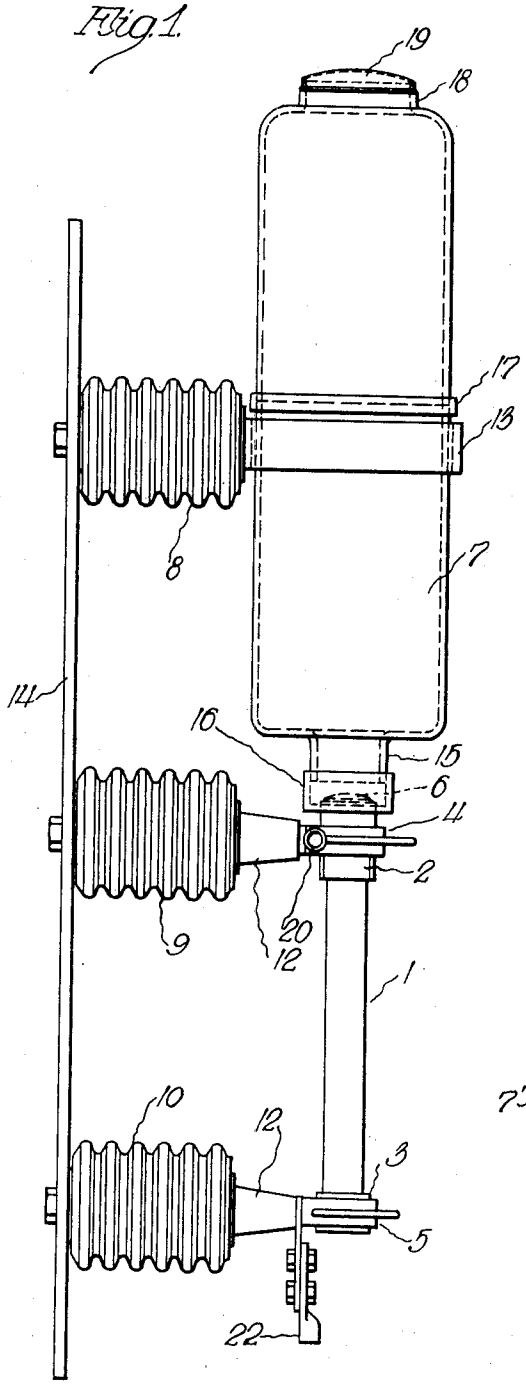
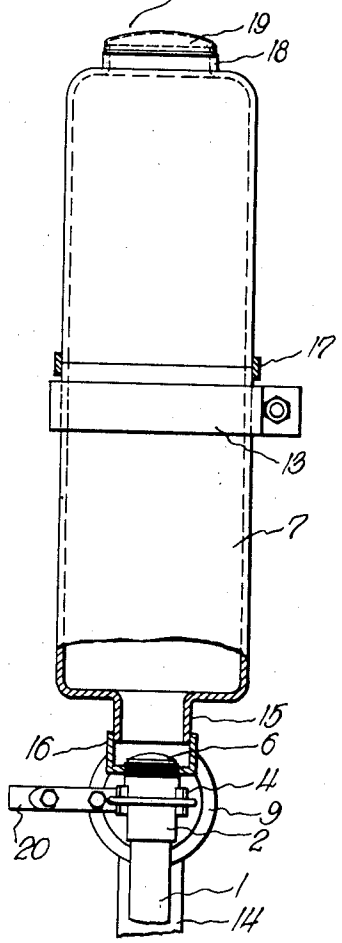



Fig. 3.



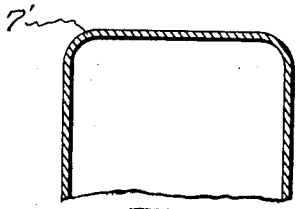




Fig. 2.

Inventor:
Hugh A. Triplett
By Brown Jackson Boettcher Dienner
Attys.

Aug. 31, 1937. H. A. TRIPLETT 2,091,423

CIRCUIT INTERRUPTER

Filed Oct. 28, 1932 2 Sheets-Sheet 2

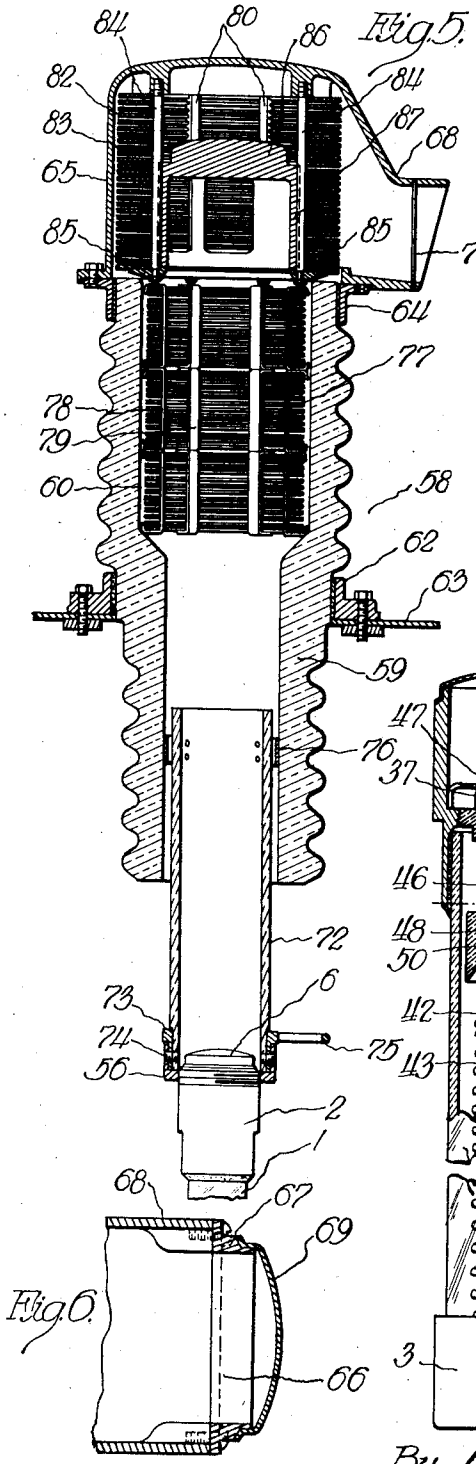



Fig. 5.

Fig. 6.

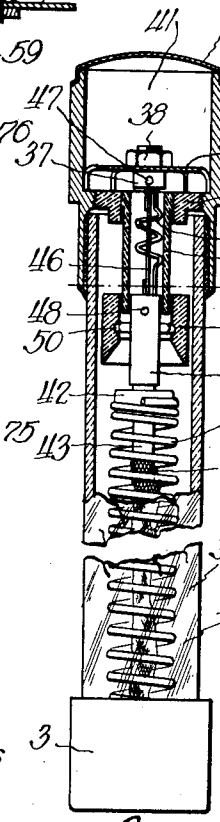



Fig. 7.

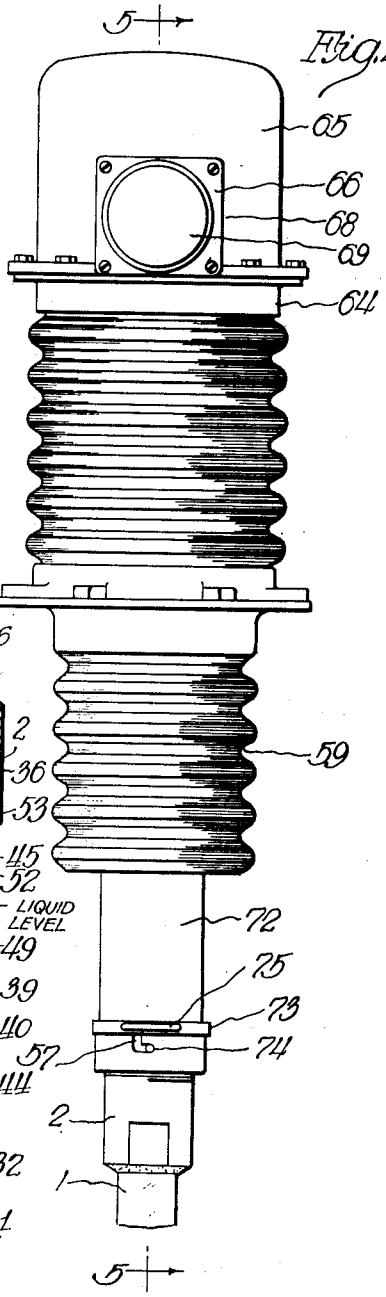



Fig. 4.

Inventor:
Hugh A. Triplett
By Mawhinney Bottcher & Brennan
Att'ys.

Patented Aug. 31, 1937 2,091,423

# UNITED STATES PATENT OFFICE

2,091,423

## CIRCUIT INTERRUPTER

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

Application October 28, 1932, Serial No. 639,939

33 Claims. (Cl. 200—117)

My invention relates to circuit interrupters, and more particularly to a method of and means for interrupting current flow. While I shall describe as the preferred embodiment a fusible circuit interrupter, this is by way of illustration, and not as a limitation.

Fuses for automatic circuit protection in high tension circuits have gone into extensive use. A large flow of current at high voltage may represent enormous energy, and the interruption of the same by a fuse involves the subjection of the apparatus to an arc which may be of great severity.

The formation of the arc involves rapid changes in temperature and pressure of the medium surrounding the fuse. When an arc is formed by the melting and vaporizing of the fusible link there is a sudden and violent rise in temperature and fluid pressure in the fuse casing or in the medium surrounding the fuse. If the arc is subjected to the action of a deionizing agent or medium, as in the well known liquid quenched type of fuse, or other fuses employing a solid or fluid medium, additional gaseous products result therefrom. If the gaseous products are so greatly confined as to create a pressure which is dangerous to the fuse casing or housing, failure of the fuse to put out the arc may result. On the contrary, if the metallic vapors and the gaseous medium are vented or discharged to atmosphere, a considerable disturbance may be created. This includes the noise and flash, which are generally undesirable if they occur in a confined space. The sudden release of gases and vapors indoors, or in a confined space such as in vaults, passageways, subways and the like is objectionable. Also, the release of ionized gases in places where the clearance to ground, or other conducting parts is limited, is to be avoided because of the danger of causing faults to ground or other phases.

The chief object of the present invention is to provide a method of and means for interrupting excessive current flow by a circuit breaker of high interrupting capacity, with minimum disturbance. This applies to various forms of circuit breakers and applies particularly to fusible circuit interrupters, where interruption of the circuit is accompanied by the evolution of gases and vapors of arc extinguishing medium acting by blast effect to extinguish the arc.

I am aware that heretofore it has been customary to enclose completely low tension fuses as in a powder filling or the like. The energy released by blowing of such fuses is relatively small, and the operation of such fuses does not involve the evolution of large volumes of gases nor the development of high pressures, nor entail arcs of any great magnitude, nor the expulsion of metallic parts.

In the preferred embodiment of my invention the fuse link proper is provided with automatic means, such as a spring, for separating the arcing terminals and lengthening the arc, and with means for causing the arc to be broken up and the gaseous products thereof to be deionized or deactivated by the use of a suitable gas, vapor, liquid or solid arc extinguishing material provided for that purpose. The arc extinguishing material in each case evolves a gaseous medium which is driven into the space occupied by the arc, to deactivate or deionize the same. The gaseous medium subjected to the heat of the arc is expanded, and its pressure tends to rise if it is confined within an enclosed space.

The successful operation of a high tension fuse depends upon the rapid restoration and/or building up of the dielectric strength of the medium between the terminals following the vaporizing of the fuse link, or fusible element.

It appears to be desirable to increase the pressure of the gaseous medium within which the arc is sustained. My experiments show that the arc finds greater difficulty in maintaining itself under greater fluid pressures than where the fluid pressure is reduced. However, there is a mechanical requirement involved, namely, that the pressure must not rise to a point where the mechanical integrity of the container is endangered. Neither must the heat of the arc be permitted to damage the container, nor should the container be subjected to shock in such a manner as to injure the same. In brief, while high pressure is desired, too much pressure must be avoided for mechanical reasons.

As heretofore constructed, the liquid quenched fuse of my assignee which is now on the market, and one form of which I shall describe herein, has been provided with a releasable vent cap, to limit the pressures which are developed within the fuse housing. Upon relatively low overloads, i. e., when the current does not exceed a certain value, the vent is not opened and the fuse operates quietly to interrupt current flow within the first half cycle. If the overload exceeds such a value the vent cap blows off and then there is a range of overloads that usually takes several half cycles to clear the circuit. Upon the vent opening, a very high velocity of gaseous discharge occurs, and this may be utilized to assist in breaking up and deionizing the arc gases or vapors.

Such high velocity expulsion of ionized gases or vapors is not without some drawback from the standpoint of noise and gas evolution, but more particularly the danger of causing a flashover to ground, or other phase. Hence, special precautions are necessary, when conducting structures are in close proximity, as may be the case indoors, to vent fuses of this character or, in fact, any high tension fuse, or any form of circuit breaker, to prevent phase to ground or phase to phase failure.

It is known that a gas under pressure is more difficult to ionize and permit current flow to pass therethrough. It is also known that as the temperature of the gas is decreased it is less conductive in character, that is, is more difficult to be broken down. The ideal situation would be to subject the arc to gas of low temperature at high pressure and remove the gas as soon as it became heated, or ionized. The discharged ionized gas should be deionized, otherwise the entire fuse and its mountings might become enveloped in a cloud of ionized gases which would be likely to cause a flashover externally.

In the preferred embodiment of the invention the fuse, or other circuit breaker, upon operation evolves a metallic vapor between the terminals. This vapor is highly conductive. The arc extinguishing material which is provided in liquid or solid form is subjected to the heat of the arc and forms, or evolves, a gaseous medium of much lower conductive or arc sustaining character than the metallic vapors. The fuse or other circuit breaker is provided with a suitable housing, or chamber, within which the arc is drawn and within which the gaseous medium is evolved, or into which the medium is driven to sweep out the metallic vapor and substitute an atmosphere of less conductive character.

One of the objects of the present invention is to provide, in conjunction with the orderly evacuation of said metallic vapors and the gaseous medium supplanting the same, a means for reducing such metallic vapors and the gaseous medium to a condition of relative inactivity, with maximum economy of either or both time and space. I may chill and condense the vapors and gases by passing them into or through a foraminated or reticulated or otherwise subdivided mass of cooling material, preferably metal. Or I may discharge these vapors and gases into a chamber which, by expansion and heat absorption by the walls, cools and/or condenses these gases and vapors and confines them to a closed space. Or, optionally within the present invention, I may employ both methods, i. e., pass the gases and vapors into a chamber which contains a subdivided mass of cooling material such as metal having a large superficial area. The gases, after expansion and/or extraction of heat thereof by the metallic or other screen, may be allowed to escape to atmosphere, or they may be retained within such chamber.

In the embodiments herein illustrated an expansion chamber of either closed or of vented type is provided for receiving the vapors and gases. This may be a metallic chamber, suitably insulated, or it may be a chamber made up in whole or in part of insulating material. The additional heat extracting effect of a mass of subdivided metal of large area is optionally provided, as by disposing the same within the chamber, or a passageway leading to or from the same. The design of the chamber must, of course, conform to the characteristics of the fuse to which it is applied.

The volume of the expansion chamber should be sufficient to allow the expansion of the gaseous medium generated by action of the fuse at its maximum interrupting capacity so as to secure the desired freedom from flashover. This chamber should be of sufficient capacity to prevent the pressure therein again rising to the danger point, otherwise its mechanical integrity would be endangered. The rise in pressure may be prevented by a cooling or condensing effect upon the gaseous medium, so that a small cubical capacity of chamber, with condensing means, may serve the same purpose as a larger chamber without condensing means. It is desirable to permit the pressure to rise in the chamber for arc extinguishing purposes, but not to rise to too great a value for mechanical purposes.

In one form of my invention I employ a type of fuse which provides a multiple effect of pressure increase and release. That is to say, the arc is initially formed in a relatively small bore chamber or passageway, and the pressure is permitted to rise therein by the action of the arc upon a medium which liberates gas, or vapor, or both. This rise in pressure, together with lengthening of the arc, has a highly effective deionizing action, and if the arc is not too severe will tend to extinguish the same. The size of the arc may be considered as a direct function of the current flow.

The preferred form of fuses which are employed in connection with my invention automatically lengthen the arc upon fusion of the fusible link, primarily to increase the distance between the terminals, so as to prevent restriking of the arc if it is once extinguished, and secondarily to bring more of the arc extinguishing medium under the influence of the arc. The greater the length of the arc for a given current flow, the easier it is to deionize and put out.

After the formation of the arc has occurred and extension of the length begun, the pressure in the confined space rises rapidly and it may be permitted immediately to cause a flow of the gaseous medium through the passageway into the larger communicating space, such flow tending to break up the arc. The flow of the gaseous medium from the smaller space to the larger space results in an increase in pressure in the larger space, which increase in pressure would shortly prevent further flow. Then I suddenly release the pressure in the said larger chamber into another closed chamber which may be of considerably more volume than either of the other chambers, for if the arc has persisted throughout the first stage of pressure and velocity to raise the pressure in the second chamber, then a greater arc extinguishing effect is required and the expansion into the third progressively larger chamber affords opportunity for this action. For relatively light overloads in which the current flow does not reach a great value the extinguishing action may be secured with a pressure rise which does not exceed the value for which the cap is secured. In that case the current flow is stopped within a half cycle. If the rate of current increase is such as to raise the pressure within the upper chamber of the fuse beyond the predetermined value the cap is driven off. Heretofore, with the fuse venting to atmosphere, it has taken several half cycles to clear the arc through a portion of the range of overloads. It is for such overloads that my invention is peculiarly valu-

able, for I have found that it is now possible to receive the cap and the metallic vapors resulting from a heavy current flow, together with the following gaseous medium, into the cooling chamber and raise the pressure in the said chamber and in the communicating arcing chamber and interrupt very great current flow within a half cycle, a result which, so far as I have been able to ascertain, has not heretofore been possible in fuses of this type. Fuses of the type herein illustrated, i. e., of the liquid quenched type, have generally been mounted in a substantially vertical position so as to retain the liquid by gravity. Sometimes water, as from rain, or other foreign matter or impurities have entered the open end and reduced the dielectric value of the liquid. By the use of my invention this possibility is substantially eliminated. By employing my invention in connection with any form of upwardly opening fuse the same or a similar advantage may be gained.

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 and the manner of using the same in the practice of my invention.

In the drawings:

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

Figure 2 is a fragmentary sectional view of the top of an expansion and condensing chamber in which no outlet is provided;

Figure 3 is a side elevational view, partly in section, of the device shown in Figure 1;

Figure 4 is a side elevational view of a modified form of expansion and condensing chamber embodying my invention;

Figure 5 is a vertical sectional view, taken on the line 5—5 of Figure 4;

Figure 6 is a fragmentary sectional view of the form of outlet illustrated in Figure 4; and

Figure 7 is a vertical longitudinal section of a form of fuse suitable for use in each embodiment of my invention.

Referring now to the embodiment shown in Figures 1 to 3 and 7, I provide a fuse 1 of the well known liquid quenched type, or any other type suitable for use in interrupting current flow in high tension circuits. The fuse has external terminals 2 and 3 which are mounted in spring clips 4, 5, these clips being of the type disclosed and claimed in Conrad Patent No. 1,665,046 of April 10, 1928. The upper terminal or ferrule 2 is provided with a sealing cap 6, shown in dotted lines in Figure 1, sealing the housing or container within which the operating parts of the fuse 1 are enclosed. A chamber 7, formed of welded steel parts, is supported upon an insulator 8 axially in line with the fuse 1. The insulators 9 and 10 upon which the fuse 1 is mounted have extending blocks 12—12 for raising the fuse 1 into line with the chamber 7. An encircling band 13 is clamped to the chamber 7 and is in turn supported upon the insulator 8. The insulators 8, 9 and 10 are in turn supported upon a grounded metal structure such as a plate or channel 14. At its lower end the chamber 7 has a neck 15 adapted to receive the upper end of the ferrule 2 so that the discharge from the fuse in case the cap 6 is blown off will be into the closed chamber 7. A ferrule 2 is threaded at its upper end and a coupling, or union 16 is adapted to be threaded down upon the upper end of the ferrule 2 to make a tight joint between the chamber 7 and the housing of the fuse 1.

The expansion chamber is preferably constructed of two cup shaped members welded together at the center as by means of a joining and reinforcing ring 17. The upper half of the expansion chamber has a nozzle or neck 18 which is sealed by a pressure release cover adapted to be blown off of the neck 18 in case the pressure within the chamber rises to an excessive value. The cover 19 is pressed or sprung upon the neck 18 to give a predetermined strength which requires a fairly definite pressure to blow off the same. The cap may be sealed by a suitable cementitious material, or otherwise so constructed as to give way at a substantially definite pressure. The fuse 1 is connected in circuit by means of the terminals 20 and 22, which are connected to the fuse mounting clips 4 and 5, respectively.

The construction of the fuse may be of the form shown in the patent to Conrad, No. 1,743,322 of January 14, 1930, or in Patent No. 1,834,578 of December 1, 1931, or preferably it may be of the type shown in Conrad application, Serial No. 470,416, filed July 24, 1930, one form of which I have illustrated in Figure 7.

The fuse comprises a glass sleeve 32 having metallic terminals at the ends thereof, the lower terminal 3 being in the form of a closed cap cemented on the glass sleeve, and the upper terminal 2 being in the form of a ferrule or sleeve, likewise cemented on the upper end of the glass sleeve 32. The upper ferrule 2 is closed releasably by a cap 6 which, in case of excessive pressure and upon heavy blowing of the fuse, is adapted to be removed by the development of a predetermined internal pressure. The sleeve or ferrule 2 is counterbored to provide a shoulder for mounting the upper terminal plate 36, which has slotted spring fingers pressing radially against the walls of the counterbore and axially against the shoulder formed by the counterbore. A terminal stud 37 has a threaded shank extending through the plate 36 and it is held in place by the nut 38 threaded on said shank. A cooperating movable terminal 39 is mounted upon the upper end of the tension spring 40 through the medium of a spring head 42, to which the spring 40 is anchored. This spring head 42 has a threaded coupling with the terminal 39 and also has a socket 43 to which the flexible cable 44 is firmly anchored, electrically and mechanically. The cable 44 shunts the spring 40. A silver fuse wire 45 formed in the shape of a helix with the ends straightened out axially is connected between the movable terminal 39 and the stationary terminal 38. A high tensile strength wire, preferably of nickel-chromium-alloy, indicated at 46, has loops formed at each end and these loops are engaged by pins 47 and 48 in the terminals 37 and 39, respectively. The ends of the fusible link 45 are mechanically anchored in slots in the terminals 37 and 39 to give a good mechanical and electrical anchorage, the edges of the slots being riveted or battered over to grip the fuse wire along a considerable length. A liquid director 49 is supported on radially extending arms 50 upon the terminal 39. An arcing chamber is provided about the fusible element by means of the sleeve 52, the upper end of which is pressed into, or otherwise anchored in the barrier plate 53, which barrier plate is threaded into the bore of the ferrule 2 to form a transverse wall. The upper end of the liquid director 49 embraces loosely, but fairly closely, the

upper end of the explosion chamber sleeve 52. The glass sleeve is filled with arc extinguishing liquid to a point preferably just above the liquid director 49, as indicated by the broken line. This level may be varied. The barrier plate 53 and sleeve 52 forming the arcing chamber are preferably formed of insulating material such as a phenolic condensation product or fiber impregnated with the same. The barrier plate may, if desired, be made of metal. The high tensile strength wire 46 is of high resistance, and carries very little of the current in normal operation.

In operation, upon the occurrence of overload the fuse element 45 first melts, throwing the electrical load upon the high tensile strength wire 46, termed the strain wire. Thereupon the strain wire melts and permits the coil spring 40 to retract the terminal 39. The fusing of the silver wire 45 and the strain wire 46 develops metallic vapor which is highly conductive. This vapor should be driven out from between the terminals and deposited elsewhere. If the metallic vapors can be kept from uniting with the oxygen of the air, or otherwise evolving further heat by chemical action, the blowing of the fuse may occur with greatly reduced noise and flash. In the present construction the metallic vapors expand chiefly in an upward direction because of the liquid below, and discharge into the chamber 41 in the upper end of ferrule 2. Here they tend to be chilled and condensed. Immediately upon the vaporization of the metal of the fusible link an arc is formed, and tends to maintain current flow through the metal vapor. At the same time, the fusing of the fusible link releases the spring 40 and its contracts, throwing liquid arc extinguishing material into the arcing chamber formed by the sleeve 52. This material is immediately vaporized, and, to some extent, decomposed, evolving a gaseous medium which sweeps out of the arcing chamber the metallic vapors and continues to sweep them out as fast as they tend to be formed. The vapors and gases are driven into the chamber 41, and here are condensed and chilled to the capacity of the chamber and its heat absorbing capacity. If the arc is interrupted before the pressure rises to too high a value the operation of interrupting current flow occurs without blowing off the cap 6. If the operation is severe, as in a short circuit on a system of large capacity, the pressure in the fuse housing may rise to a value high enough to blow off the cap 6. The terminal plate 36 and terminal 37 may then also be expelled, and as the terminal 39 and liquid director 49 descend, vapors and gases of high pressure and very high velocity are expelled through the arcing chamber, sweeping out metallic vapors and tending to deionize or deactivate the gases carrying the arc, to put out the same. The discharge of the metallic vapors and the propelling of gaseous medium into the chamber 7 not only removes such vapors and the gaseous medium from the arc, but gives them room to expand, and be cooled and condensed. The walls of the chamber have considerable thermal capacity, and the construction of the chamber 7 may, in well known manner, be modified to enhance the ability to extract heat from the contents and dissipate the same.

The operation of the device shown in Figures 1, 3 and 7 is, therefore, as follows:

Upon the occurrence of overload sufficient to melt the fusible element 45, the strain wire 46 becomes overheated and the tension of the spring 40 begins the separation of the terminals, an arc meanwhile forming in the place of the fuse and strain wire. If the overload is not severe, the immediate action of the arc extinguishing medium in driving the metallic vapors endwise from between the terminals and substituting a less conductive medium, may be sufficient to put out the arc and stop current flow. A limiting factor in this operation is, of course, the severity of the arc, with the consequent amount of metal vapor formed, and the flow of gases and vapors from the arcing chamber formed by the sleeve 52 into the chamber 41, under the releasable cap 6. If the pressure rises to a value at which the cap is designed to release, the cap is blown off of the ferrule 2 into the expansion chamber 7. The result is a quick release of the contents of the chamber 41 into the much larger chamber 7. At the same time the terminal plate 36 and terminal 37 are discharged from the fuse housing into the expansion chamber 7. Meanwhile, a violent flow of gaseous medium through the arcing chamber formed by the sleeve 52 is set up, and this continues either until the arc is extinguished or, assuming the arc to be of such violence as to persist through the continuing separation and the injection of arc extinguishing material into the chamber formed by the sleeve 52, the pressure in the expansion chamber 7 rises until a predetermined value therein is attained. If the permissible pressure in the expansion chamber 7 is reached, a removable cover, or cap 19 blows off, and a quick release of the pressure in the chamber 7 and communicating parts occurs, again establishing a violent flow of gaseous medium through the space occupied by the arc. If the arc is so severe as to generate excessive pressure below the arcing chamber formed by the sleeve 52, the tube forming the chamber 52 is expelled, thereby providing a larger opening for the flow of gases and vapors. From the above it can be seen that this organization produces successive stages of pressure and flow which are highly effective in extinguishing the arc. The cap 19 on chamber 7 may be protected from direct impingement by the cap 6, by interposing a suitable guard. This guard may be part of a heat absorbing screen, or grating, contained within the chamber 7, as will be described in connection with Figures 4 and 5.

For a 7500 volt fuse, which is illustrated in Figures 1 and 2, the glass sleeve 32 may be of 2¾" diameter, and 8" between the centers of the mounting clips 4 and 5, the current through the fuse, upon the occurrence of short circuit, being dependent upon the short circuit capacity of the connected source. The fuse is known on the market as a size No. 4 S & C fuse.

The expansion chamber 7, while shown as of metal, may be made of insulating material or it may be made partly of each. Also, instead of having a releasable cap or cover 19 it may have integral walls or a tight cover, as shown at 7' in Fig. 2. In the construction shown, the expansion chamber has a capacity of 260 cubic inches for the aforesaid size of fuse. This, of course, may be varied.

It will be observed that the danger of ionized gases flashing over between the conducting parts, such as the blocks 12—12 or the fuse clips 4—5, upon violent blowing of the fuse, is completely obviated, since the rapid expansion permitted by blowing of the fuse cap or cover 6, and opening of the fuse housing into the expansion chamber, causes a quick, sudden expansion and cooling and

condensation of the gases and vapors discharged from the fuse.

The expansion chamber may be provided with additional arc extinguishing material for replacing or for supplementing the arc extinguishing medium within the fuse. Preferably the expansion chamber is filled, normally, only with air at atmospheric pressures. It is not essential that the expansion chamber 7 be absolutely tight, but the joints should not be such as to permit any appreciable amount of gas to escape therethrough.

The expansion chamber may contain means for providing a heat absorbing medium having a large condensing surface, so as to chill the vapors and gases and condense out such vapors as can be condensed, these vapors being produced by the heat of the arc acting upon various parts, chiefly the liquid arc extinguishing medium.

In Figures 4, 5 and 6 I have shown a modified form of expansion chamber in which special means is provided for chilling and condensing the gaseous medium expelled from the fuse. In this case the upper ferrule 2 of the fuse 1 is provided with a fitting 56 threaded upon the upper end thereof. This fitting has an upwardly extending flange in which there is formed a bayonet slot 57. The expansion and condensing chamber 58 in this case comprises a tubular insulating member 59, the upper end of which is provided with a counterbore or enlarged bore, as shown at 60. A metal mounting flange in the form of a ring 62 is cemented upon the sleeve 59 at approximately the center part of the same and this mounting flange 62 is adapted to be clamped to a sheet metal plate 63 having a hole therethrough for the sleeve 59, the expansion chamber 58 in this case being supported upon the sheet metal plate 63 which forms the top of a grounded steel cabinet within which the fuse 1 is mounted or insulators such as 9, 10 of Figure 1 through fuse clips 4, 5 shown in Figure 1.

At its upper end the insulating sleeve 59, which is preferably made of porcelain or the like, has a second flanged ring 64 cemented or leaded thereto and a metal dome or cap 65 is clamped to the flanged ring 64 by cap screws or the like. The dome 65 is provided with a lateral nozzle providing a port which, in the form shown in Figures 4 and 6, is closed by a plate 66 having a flanged neck 67. A releasable cap or cover member 69 is cemented or soldered or pressed onto the flange 67 of the plate 66, which is fastened to the nozzle 68 as by machine screws. The laterally extending nozzle or outlet 68 may be left open to atmosphere if desired. In that case a series of rods or wires 70 are placed in holes which are drilled through the side walls to form bars for excluding birds or the like from the inside of the chamber. Within the lower end of the sleeve 59 there is provided a horn fiber or "Bakelite" tube 72 which telescopes with the said lower end of the sleeve 59. Upon the lower end of the tube 72 a metal ring or ferrule 73 is mounted, and pins 74 extend diametrically from the ring 73 to cooperate with the bayonet slots 57, two of which are provided in the flanged ring 56 on the upper end of the fuse terminal 2. An operating eye 75 is formed on the ring 73 so that by means of the usual hook stick the ring 73 may be manipulated to release the pins 74 from the bayonet slots 57 and the sleeve 72 pushed upwardly in the insulating sleeve 59. A spring 76 is mounted between the upper end of the tube 72 and the sleeve 59, to provide frictional engagement between these parts so that the tube 72, after it is raised, will stay in position while the fuse is being removed or replaced. The annular space between the sleeve 72 and the tubular porcelain body 59 is preferably closed by packing of a suitable character. The space need not be closed fluid tight. When the fuse has been removed or replaced the operator pulls the sleeve 72 down, registers the pins with the bayonet slots, and locks the same together.

Within the upper end of the insulating sleeve 59 in the counterbore 60 I provide a condenser 77. This condenser may take various forms and should be a foraminated, reticulated, or laminated mass of metal with a large surface for cooling the gases and vapors and condensing the latter. In the form here shown I have wound a copper bar edgewise into helical form, with the turns closely spaced. The turns are supported by longitudinal extending bars which are bent outwardly and around the adjacent end turns, as is clearly shown in Figure 5. Instead of a spiral, rings or annular plates may be provided. These are preferably spaced by offsets or by interposing spacing members. The condenser is shown in three similar sections, but obviously, this may be varied. The desired structure is a mass of metal presenting a very extensive area to the gases and vapors so as to extract the heat of the same quickly and effectively, for deionizing the same.

Within the dome 65 a similar mass of metal, in the form of annular plates spaced apart by the spacing bars 80 is provided. This provides a similar condenser 82. The plates 83 (or coils, whichever is utilized) are held by means of the bolts 84—84 on the annular clamping plate 85 within the dome 65. The dome itself is made of metal and assists in cooling the gases and vapors driven into the same. A sliding buffer member 86, provided with a solid wall 87 opposite the opening or nozzle 68, is arranged to be guided on the rods 84—84. This buffer acts as a baffle for preventing the direct flow of gases and vapors through the bore of the condenser 77, through the condenser 82 and out the nozzle 68. Ports are provided in the buffer member 86 at the back, or away from the nozzle 68, so as to compel the gases and vapors to flow in a circuitous path. The buffer is slidable vertically, and it serves to take the impact of the cap 6 and the gases following the same upon a violent blowing of the fuse 1.

The buffer 86 is a cup shaped member mounted on the rods 84—84 which lie within the rings 83 of the condenser 82. The operation of this form of device is substantially as indicated in connection with Figures 1, 3 and 7. The fuse 1 is preferably of the same type and form of fuse as heretofore described, that is, it may be of the type and form shown in the aforesaid patents or patent application, and more particularly shown in Figure 7 hereof. I do not wish to confine the invention to the specific form of fuse, however, since obviously fuses of various characters having the capability of interrupting high tension current flow may be employed in this connection.

A fuse suitable for this service should preferably have spring means for lengthening the arc and means for providing an arc extinguishing medium, either in the form of liquid, solid, or gas, in such position as to be effective in deionizing the arc.

The operation is substantially as heretofore described. The fuse acts first to form an arc, separate the terminals and bring the arc extinguishing material into effective engagement with the

arc, with resultant increase in pressure, velocity of flow of gases, and, depending upon the severity of the arc, building up a high pressure inside the fuse casing, release of the same by blowing of the cap 6, a violent flow of the gaseous medium from the fuse housing into the expansion chamber and condenser, with the resultant expansion, chilling, condensation of gases and vapors within the expansion chamber and condenser.

The fit between the tube 72 and sleeve 59 may be made gas tight, or substantially gas tight, if desired, and the outlet nozzle or opening 68 may be covered by a solid plate or by a plate with a releasable cover. It is desired to muffle the noise as well as to trap the gases and vapors which are blown out of the fuse and particularly it is desirable to prevent the establishment of current flow to ground, or a different phase conductor, by the ionized gases and vapors which are driven out of the fuse on a severe blow where the vent cap 6 is removed.

In the present instance the main body of the expansion and condensing chamber is made up of insulation such as porcelain, and therefore independent insulation is not required, as was the case in Figure 1, where the chamber is constructed of metal throughout. The cooling and condensing fins such as 78 and 83 may be provided inside of the metallic expansion and condensing chamber 7 of Figure 1. The cooling and condensing of the gases and vapors tends, of course, to keep down the pressure which would otherwise occur within such expansion chamber, with the result that a greater effective flow of the gaseous medium from the body of the fuse 1 can occur.

In the case of an arc sufficiently heavy to persist to the point of blowing off the cap 6 in the device of Figures 4 and 5, this cap is thrown upwardly against the buffer 86 and a violent flow of gas and vapor into the expansion and condensing chamber results, these gases and vapors striking the fins or rings, which are of copper, or other metal. The gases are cooled and the vapors are condensed, with the result that the pressure in the chamber does not increase as rapidly as it would otherwise, hence the flow of gaseous medium from the fuse 1 may continue, both for a longer time and with greater velocity. At the same time, no ionized gases are emitted from the device to endanger the electric circuits. The transfer of heat from the hot gases to the cooling means depends upon several factors such as the difference in temperature, the rate of sweep of the gases over the cooling surfaces, and the intimacy of contact, i. e., the pressure of the gases upon the solid surfaces. The relatively cool surfaces of the condensing chamber and contents, and the release of the pressure from under the fuse cap, gives an immediate chilling action to the metallic vapors which is highly beneficial in promptly precipitating them and preventing possible reentry into the arcing chamber. The pressure trapped below the arcing chamber is also valuable for this effect. Reentry of conductive gases into the arc space after the arc has ceased is to be prevented, otherwise the rate of voltage rise on the next half cycle may be more rapid than the recovery of dielectric strength and the arc might again be established.

The principle of confining the discharge of gaseous medium from the fuse, cooling, and condensing the same, may be applied to most forms of fuses of the high tension type now on the market. Even so-called air expulsion type fuses may be employed in cooperation with such expansion and condensing chamber, as above described.

The expansion and condensing chamber of my invention can advantageously be employed in connection with fuses of the blast quenched type, that is, fuses employing arc extinguishing material in liquid, solid or gaseous form for displacing and expelling the metallic vapors from between the fuse terminals by a blast of gaseous arc extinguishing medium. The invention is also applicable to all forms of fuses generally designated as expulsion fuses. With fuses of the aforesaid types equipped according to my invention it is possible to confine the effect of blowing of the fuse to a limited space, and to keep the contaminating gases and vapors from spaces occupied by tenants or operators, and also to prevent possible flashovers due to contact of the ionized gases with other conductors. The chamber may be made as a separate chamber, to be put into communication with the fuse chamber only when the fuse blows and vents, or it may be merely an enlargement or extension of the tube or sleeve of an expulsion or explosion type fuse.

Its chief electrical function is first to receive and confine the metallic vapors, and to prevent the arc from spreading. Its chief mechanical function is to confine the heat and contaminating gases, and eliminate the noise and flash resulting from heavy blowing of the fuse. By the mechanical or pneumatic effect of confining the gases and vapors the fluid pressure upon the arc is caused to rise, thereby producing the electrical effect of increasing the rate of recovery of dielectric strength in the arc space and increasing the voltage required to sustain the arc and assisting materially in extinguishing the same. Also, the metal parts expelled from the fuse are caught and retained in the chamber.

The chamber may be made of insulating material and may be molded, or may be made of porcelain or the like, or it may be constructed in any desired manner, partly of metal or insulation. Metal is generally required to give it the necessary strength, hence metal may be employed for the necessary mechanical strength and a layer of insulation, either inside or outside, or both, for electrical protection.

The invention is of importance in that it makes possible the use of high voltage fuses in confined spaces, adjacent to metallic structures or other apparatus, and particularly it makes it possible to use a high tension fuse indoors. It also makes possible a submersible unit. If sufficient cooling means be employed the size of the chamber may be reduced. The expansion chambers 7 of Figure 1, 7' of Figure 2, and 58 of Figure 4 provide a further useful function in that impurities or contaminating matter such as water, dust, soot, etc., are substantially excluded, and prevented from entering the open end of the fuse device 1 after blowing has removed the vent cap 6. This is of particular value where such impurities might enter the open end of an expulsion or blast type fuse and reduce the dielectric value which it is desired to maintain, or cause corrosion of the fuse link.

It is contemplated within the invention to expand and enlarge the upper ferrule of the standard liquid quenched fuse now on the market, instead of employing a separate chamber. Preferable, a diaphragm or wall is interposed between the fuse proper and the expansion chamber, such

wall being ruptured only upon the occurrence of excessive pressures. I have found that fuses such as that shown in detail in Figure 7 are effective to extinguish within a half cycle arcs in which the overload current flow is moderate, without blowing off of the vent cover. But for heavy arcs a small chamber such as the chamber 41 does not permit sufficient flow of the metallic vapors and the following arc extinguishing medium without exceeding the pressure for which the cap is set. The pressure retained by the cap appears to be beneficial for such moderate overloads as the flow is sufficient to scour the metallic vapors out of the arcing chamber, so that the increase in pressure upon the medium in the arc space is effective to assist in extinguishing the arc. The larger chamber 7 permits the smaller chamber 41 to exert its effect initially, and if the arc current is not excessive, the small chamber is sufficient. If, however, the arc current is excessive, the pressure is first quickly built up in the small chamber, and it opens into the large chamber.

The principles of the invention, while applicable to any form of circuit breaker in which metallic vapors and/or other vapors and/or gases are evolved, is peculiarly applicable to fuses because of the volatilizing of the metallic fuse link into a relatively large amount of metallic vapor which is highly conductive and hence undesirable, unless it is under control. The use of the expansion chamber also takes care of the problem of the uncontrolled expulsion of metallic parts or particles.

The fuse, instead of employing liquid arc extinguishing material, may employ a solid material for the evolution of the gaseous medium. The fuse of the Ringwald Patent No. 1,862,317 may be used as the fuse 1, herein illustrated in Figures 1 and 4.

In designating the chamber as "substantially closed", I intend to include such constructions wherein useful pressure is or may be built up during the existence of the arc. The closure may be complete or only partial, so long as the function of retaining pressure of the gaseous arc extinguishing medium and exerting it in useful degree upon the arc is secured.

I do not intend to be limited to the details shown and described except as they are specifically called for in the appended claims, and in which event I contemplate the employment of equivalents.

I claim:

1. In combination, a blast quenched fuse having a closed housing comprising a vent closure adapted to be removed upon the occurrence of excessive pressure, and an enlarged expansion chamber closed to the atmosphere and coupled to the housing and adapted to be put into communication with the fuse housing upon blowing of the vent closure, said fuse being adapted to discharge metallic vapor and ionized gases directly into the expansion chamber.

2. In combination, a blast quenched fuse having a closed housing comprising a vent closure adapted to be removed upon the occurrence of excessive pressure, and an enlarged substantially closed expansion chamber coupled to the housing and adapted to be put into communication with the fuse housing upon blowing of the vent closure, said expansion chamber having a releasable member to vent the chamber upon the occurrence of excessive internal pressure.

3. In combination, a fuse device comprising a tubular housing permanently closed at one end, a conductor comprising a fusible portion, said fusible portion being disposed adjacent the other end of the fuse tube, and a pressure retaining expansion chamber mounted independently of the housing and communicating in substantially fluid-tight relation with the said last named end of the housing whereby upon blowing of the fusible portion the products of the arc may be discharged in substantially a direct line from said latter end of the tubular housing into the expansion chamber without traversing the tubular fuse housing, the tubular housing being readily disengageable from said chamber for replacement as a unit.

4. In combination, a fuse device, comprising a tubular fuse housing permanently closed at one end, a fusible link in said housing adjacent the other end thereof, terminals for the link, arc extinguishing material in the housing acting upon the formation of an arc to project a blast of gaseous medium in a direction which carries it between the terminals and out of the housing, a pressure retaining expansion chamber connected to said latter end of the housing, and a dividing wall between the housing and the chamber adapted to be opened upon blowing of the link.

5. In combination, a fuse device, comprising a housing, a fusible link within the housing, an expansion chamber closed to the atmosphere and connected to the housing, a wall between said housing and said chamber, said wall being opened upon blowing of the link, and a mass of heat absorbent material in the chamber.

6. In a device of the class described the combination of a housing having a communicating pressure retaining expansion or cooling chamber, a fusible link in the housing, a vent for the expansion chamber, a movable vent cover adapted to be opened under a predetermined pressure in the expansion chamber and a mass of metal of thin section forming extensive cooling surfaces within said expansion chamber with which the gases and vapors evolved upon blowing of the link contact and in contact with which said gases and vapors flow to reach the vent when the vent cover is opened.

7. In combination, a fuse housing having a tubular arcing passageway of relatively small bore, a fusible link in said passageway, fusion of said link resulting in an arc in said passageway, arc extinguishing material in said housing adapted to be acted upon by the arc to evolve a gaseous arc extinguishing medium, said medium being driven at high velocity through said bore to displace the ionized gaseous products of the arc endwise of the bore and out of the fuse housing, a chamber closed to the atmosphere and of relatively large diameter and volume, as compared with the diameter and volume of said passageway, for receiving the said gaseous products of the arc, and a pressure releasable seal between said passageway and said chamber.

8. In combination, a tubular fuse housing closed at one end and open at the other, a fusible link in the housing adjacent said open end, annular insulating means fixed in the housing adjacent said open end, providing an annular constriction for the arc formed on blowing of the fuse, arc extinguishing material beyond said constriction, a movable terminal connected to the adjacent end of the fuse, a spring for drawing said terminal away from the open end to lengthen the arc, said arc acting upon said arc extinguishing material to evolve a gaseous arc extinguishing medium

which is adapted to flow at high velocity through said annular constriction in contact with the arc and out of the fuse housing, an expansion chamber communicating with the open end of said housing, said expansion chamber being substantially fluid tight to retain the gaseous medium under pressure, and a releasable vent closure closing said open end of the housing and closing the housing off from the expansion chamber, said vent closure being blown off by pressure in the housing to permit free discharge of the gaseous medium into the expansion chamber.

9. In combination, a grounded metal housing, a blast type fuse releasably mounted therein in insulated relation thereto, said fuse having one end permanently closed, a pressure retaining expansion chamber mounted on the housing and adapted to receive the blast of the fuse on blowing, and a releasable coupling between the fuse and the chamber, said coupling permitting replacement of the fuse independently of the chamber, said chamber serving to insulate electrically the blast of the fuse from the housing.

10. In combination, a grounded metal housing, a blast type fuse releasably mounted therein in insulated relation thereto, said fuse having one end permanently closed, a pressure retaining expansion chamber mounted on the housing and adapted to receive the blast of the fuse on blowing, a releasable coupling between the fuse and the chamber, said coupling permitting replacement of the fuse independently of the chamber, said chamber serving to insulate electrically the blast of the fuse from the housing, and a pressure releasable vent for said chamber external of said housing.

11. In combination, an expulsion fuse having a tubular housing permanently closed at one end, a silver fuse link in the housing adjacent the other end and being adapted to be vaporized upon overload therethrough, terminals for the link, a substantially closed pressure retaining housing freely communicating with the said other end of the fuse housing for receiving the said metal vapors and the accompanying blast of gases, said pressure retaining housing having means comprising a mass of metal of thin section providing extensive cooling surfaces out of the region of the arc and beyond the region of the terminals upon which the silver vapor is condensed and deposited and by which the gases are cooled.

12. In combination, an expulsion fuse having one end permanently closed and adapted upon blowing to discharge metal vapor and gas from the other end, an expansion and cooling chamber connected to said other end of the fuse for receiving said vapor and gas and having a solid wall directly in the path of said vapor and gas, and means adapted to be impinged by the gas and metal parts discharged from the fuse and serving to protect said wall of said chamber from damage.

13. In combination, a blast type fuse having one end permanently closed, and adapted upon blowing to discharge a blast of metal vapor and gas from the other end, an expansion and cooling chamber connected to said other end of the fuse for receiving said vapor and gas, said chamber having an outlet, and movable means adapted to be impinged by said blast, the discharge of gases through said outlet being controlled by said movable means.

14. In a high tension circuit interrupter, the combination of a housing containing a body of dielectric liquid, a pair of terminals between which an arc is adapted to be formed near the surface of the liquid, one of said terminals being adapted to be moved downwardly in the liquid, means for moving said member, a tubular arcing passage surrounding the arc to limit the amount of liquid acted upon by the arc and to direct the gaseous products of the arc endwise of the arc and out of the housing, a closure for the housing capable of being opened by internal pressure, and a pressure retaining expansion chamber above the closure and adapted to communicate with said arcing passageway to receive the products of the arc discharged from said arcing passageway the capacity of the expansion chamber being such as to permit a flow of the gaseous products through the arcing passage effective in extinguishing an arc.

15. In a high tension circuit interrupter, the combination of a housing containing a body of dielectric liquid, a pair of terminals between which an arc is adapted to be formed near the surface of the liquid, one of said terminals being adapted to be moved downwardly in the liquid, means for moving said member, a tubular arcing passage surrounding the arc to limit the amount of liquid acted upon by the arc and to direct the gaseous products of the arc endwise of the arc and out of the housing, a closure for the housing capable of being opened by internal pressure, a pressure retaining expansion chamber above the liquid and adapted to communicate with said arcing passageway to receive the products of the arc discharged from said arcing passageway, the capacity of the expansion chamber being such as to permit a flow of the gaseous products through the arcing passage effective in extinguishing an arc, and releasable coupling means between the liquid containing housing and the expansion chamber, whereby the housing and its contained terminal may be removed and replaced.

16. In a high tension circuit interrupter, the combination of a housing containing a body of dielectric liquid, a pair of terminals between which an arc is adapted to be formed near the surface of the liquid, one of said terminals being adapted to be moved downwardly in the liquid, means for moving said member, a tubular arcing passage surrounding the arc to limit the amount of liquid acted upon by the arc and to direct the gaseous products of the arc endwise of the arc and out of the housing, a closure for the housing capable of being opened by internal pressure, a pressure retaining expansion chamber above the liquid and adapted to communicate with said arcing passageway to receive the products of the arc discharged from said arcing passageway, the capacity of the expansion chamber being such as to permit a flow of the gaseous products through the arcing passage effective in extinguishing an arc, and a metallic grounded enclosure enclosing the circuit interrupter and supporting the chamber in insulated relation to prevent the ionized gases of the arc from coming into contact with a grounded metallic conductor.

17. In a high tension circuit interrupter, the combination of a tubular housing, a pair of terminals between which an arc is adapted to be formed adjacent one end of the housing, one of said terminals comprising a member adapted to be moved away from the other terminal to increase the length of the arc, a tubular arcing passageway for surrounding the arc and provided with an arc extinguishing material adapted to form a gaseous medium discharged freely from one end of the passageway adjacent the end of the housing, and a pressure retaining expansion

chamber adapted to communicate with said arcing passageway to receive the gaseous products of the arc discharged from said arcing passageway, said expansion chamber and said tubular housing being independently supported in substantially fluid-tight connection.

18. In a high tension circuit interrupter, the combination of a tubular housing, a pair of terminals between which an arc is adapted to be formed adjacent one end of the housing, one of said terminals comprising a member adapted to be moved away from the other terminal to increase the length of the arc, a tubular arcing passageway for surrounding the arc and provided with an arc extinguishing material adapted to form a gaseous medium discharged freely from one end of the passageway adjacent the end of the housing, a pressure retaining expansion chamber adapted to communicate with said arcing passageway to receive the gaseous products of the arc discharged from said arcing passageway, said expansion chamber and said tubular housing being supported in substantially fluid-tight connection, external terminals on said tubular housing, a grounded enclosure for the housing, insulated circuit terminal means for cooperating with the housing terminals, said enclosure supporting said expansion chamber in insulated relation to prevent the ionized gases of the products of the arc from coming into contact with a grounded metallic conductor, and releasable coupling means between the tubular housing and expansion chamber.

19. In combination, a grounded frame, a high tension circuit interrupter comprising a tubular housing having external terminals, said housing containing terminals between which an arc is adapted to be formed adjacent one end of the circuit interrupter housing, insulated line terminals mounted on the frame, said circuit interrupter being releasably mounted in said line terminals, an expansion chamber fixedly mounted on and insulated from the frame, and detachable coupling means between the expansion chamber and the said one end of the circuit interrupter whereby the products of the arc are discharged from the said one end of the circuit interrupter housing into the expansion chamber.

20. In combination, a tubular high tension fuse housing, arc extinguishing material in the housing, a conductor in the housing having a fusible link adjacent one end of the housing, said link being adjacent to but spaced from said arc extinguishing material, a movable rod-like fuse terminal for the link adapted to be moved to draw the arc into said material away from said one end when the fuse blows, a spring for automatically retracting said terminal when the link is melted, a cooling chamber for receiving the gases discharged from the said one end of the fuse housing, and a releasable tubular coupling for coupling the end of the fuse housing in which the arc is initiated with said cooling chamber the gases evolved by the arc from said arc extinguishing material flowing without change of direction from the arc into said cooling chamber.

21. For use with a replaceable circuit interrupter having an outlet, a recombining chamber comprising a closed casing having an inlet, coupling means for said inlet for releasably coupling with the outlet of said circuit interrupter, a vent opening remote from said inlet, a pressure releasable vent closure for said vent opening, and a mass of metal in plate-like form having an extensive area for contact with the gases and vapors discharged from said outlet of the circuit interrupter, said mass of metal being supported within the casing between the inlet and the vent opening, said mass of metal serving while the closure is in place as gas and vapor condensing means, and serving after the vent closure is removed as a flame suppressor to prevent the discharge of flame from said vent opening.

22. The combination of claim 7 wherein the arc extinguishing medium is a liquid filling the level of which in the fuse housing is approximately at the height of said arcing passageway and which liquid prevents the flow of gases evolved by the arc into the space occupied by the liquid.

23. In a high tension circuit interrupter, the combination of a housing containing a body of dielectric liquid, a pair of terminals between which an arc is adapted to be formed near the surface of the liquid, one of said terminals being adapted to be moved downwardly in the liquid, means for moving said member, a tubular arcing passage surrounding the arc to limit the amount of liquid acted upon by the arc and to direct the gaseous products of the arc endwise of the arc and out of the housing, a closure for the housing capable of being opened by internal pressure, and a pressure retaining expansion chamber above said closure and adapted to communicate with said arcing passageway to receive the products of the arc discharged from said arcing passageway, the capacity of the expansion chamber being such as to permit a flow of the gaseous products through the arcing passage effective in extinguishing an arc, the level of the dielectric liquid in the housing standing at substantially the height of the movable terminal whereby the products of the arc are compelled to travel through said arcing passageway toward the expansion chamber, said movable terminal being retracted into said body of liquid to interpose a disconnecting dielectric between said terminals.

24. In a high tension circuit interrupter, the combination of a tubular housing, a pair of terminals between which an arc is adapted to be formed adjacent one end of the housing, one of said terminals comprising a member adapted to be moved away from the other terminal to increase the length of the arc, a tubular arcing passageway for surrounding the arc and provided with an arc extinguishing material adapted to form a gaseous medium discharged freely from one end of the passageway adjacent the end of the housing, a pressure retaining expansion chamber adapted to communicate with said arcing passageway to receive the gaseous products of the arc discharged from said arcing passageway, and adjustable telescopic means arranged and adapted to provide a substantially fluid-tight connection between said tubular housing and said expansion chamber.

25. In a high tension circuit interrupter, the combination of a tubular housing, a pair of terminals between which an arc is adapted to be formed adjacent one end of the housing, one of said terminals comprising a member adapted to be moved away from the other terminal to increase the length of the arc, a tubular arcing passageway for surrounding the arc and provided with an arc extinguishing material adapted to form a gaseous medium discharged freely from one end of the passageway adjacent the end of the housing, a pressure retaining expansion chamber adapted to communicate with said arcing passageway to receive the gaseous products of

the arc discharged from said arcing passageway, said expansion chamber and said tubular housing being supported in substantially fluid-tight connection and said expansion chamber being disposed above said tubular housing and provided with a laterally disposed vent opening, and a pressure releasable member closing said vent opening.

26. In combination, a closed pressure retaining condensing chamber containing cooling means for efficiently and rapidly extracting heat from a gaseous medium driven thereinto, a narrow passageway adapted to discharge directly into said condensing chamber, means for producing a heavy current arc in said narrow passageway wherein the arc is confined, and a limited mass of arc extinguishing material acted upon by the arc for producing a gaseous medium which will furnish a sustained flow through the narrow passageway, and means for compelling such gaseous medium to be driven at high velocity through the narrow passageway endwise of the arc and in contact therewith and into the condensing chamber for carrying the conductive material of the arc rapidly into the condensing chamber, where said gaseous medium and products of the arc are rapidly cooled, whereby a heavy current arc may be extinguished without release of the gases produced thereby into the atmosphere.

27. In a high tension circuit interrupter, the combination of a tubular housing, a pair of terminals between which an arc is adapted to be formed adjacent one end of the housing, one of said terminals comprising a member adapted to be moved away from the other terminal to increase the length of the arc, a tubular arcing passageway for surrounding the arm and provided with an arc extinguishing material adapted to form a gaseous medium discharged freely from one end of the passageway adjacent the end of the housing, and a pressure retaining expansion chamber adapted to communicate with said arcing passageway to receive the gaseous products of the arc discharged from said arcing passageway, said expansion chamber and said tubular housing being supported in substantially fluid-tight connection and said expansion chamber being insulated from said terminals.

28. In combination, a circuit interrupter of the blast action arc extinguishing type, a metal enclosure for said interrupter adapted to be grounded, and an expansion chamber disposed in insulated relation with respect to said enclosure in such position as to receive the products of the arc resulting from the blast action.

29. In combination, a circuit interrupter of the blast action arc extinguishing type, a metal enclosure for said interrupter adapted to be grounded, and an expansion chamber closed to the atmosphere and disposed in insulated relation with respect to said enclosure in such position as to receive the products of the arc resulting from the blast action.

30. In combination, a circuit interrupter of the blast action arc extinguishing type, a metal enclosure for said interrupter adapted to be grounded, and an expansion chamber formed of insulating material and carried by said enclosure in such position as to receive the products of the arc resulting from the blast action.

31. In a circuit interrupter, two terminals between which an arc is formed, means for withdrawing one terminal from the other terminal for lengthening the arc, arc extinguishing material adapted to be acted on by the arc as the terminal is withdrawn to give off arc extinguishing fluid, a stationary restricting tubular chamber surrounding a portion of the arc and through which fluid evolved from the arc extinguishing material may flow in a direction away from the receding terminal, a condenser chamber closed to the atmosphere into which said fluid may flow, cooling means in said chamber for condensing said fluid therein, and a closure for said chamber capable of being opened by internal pressure.

32. In combination, a circuit interrupter of the blast action arc extinguishing type, a first condenser chamber into which the products of the arc resulting from the blast action may flow, a closure for said first chamber capable of being opened by internal pressure, and a second condenser chamber into which said products may flow from said first chamber on opening of said closure.

33. In combination, a circuit interrupter of the blast action arc extinguishing type, a first condenser chamber into which the products of the arc resulting from the blast action may flow, a closure for said first chamber capable of being opened by internal pressure, a second condenser chamber closed to the atmosphere into which said products may flow from said first chamber on opening of said closure, and a closure for said second chamber capable of being opened by internal pressure for venting said second chamber to the atmosphere.

HUGH A. TRIPLETT.