Feb. 27, 1934. F. KESSELRING 1,948,761

EXPANSION SWITCH

Filed June 16, 1930 2 Sheets-Sheet 1

Fig. 1.

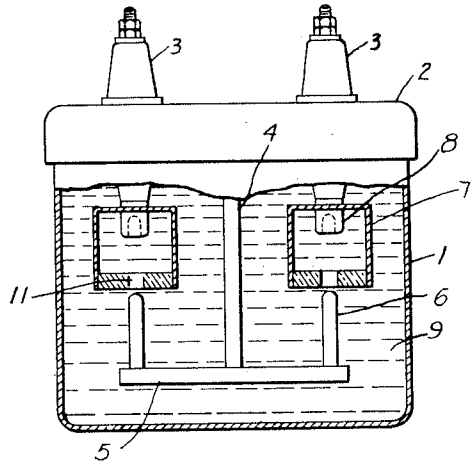


Fig. 2.

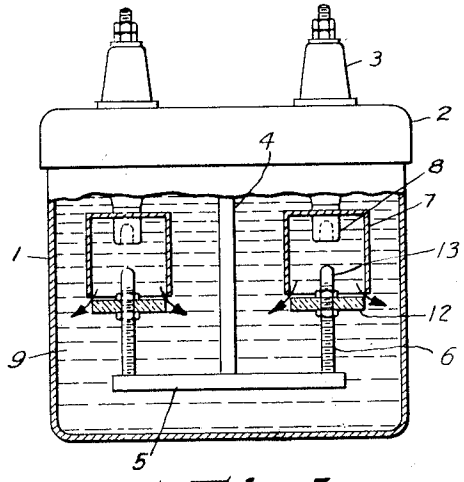
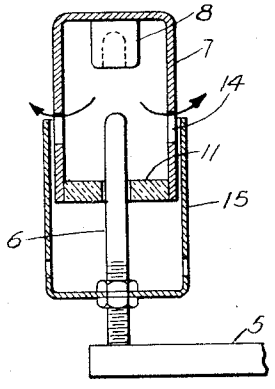


Fig. 3.



INVENTOR
Fritz Kesselring
BY
ATTORNEY

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Fig. 4.

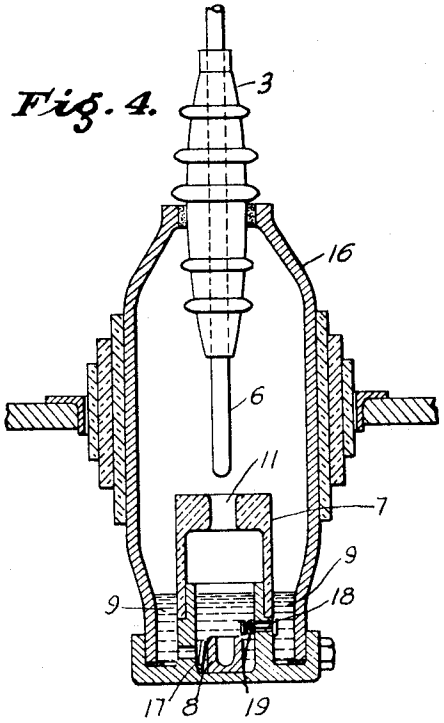


Fig. 6.

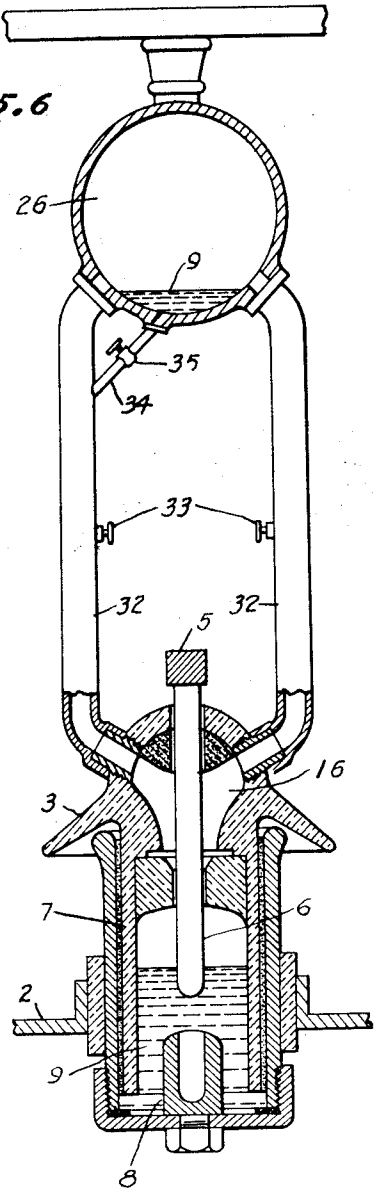
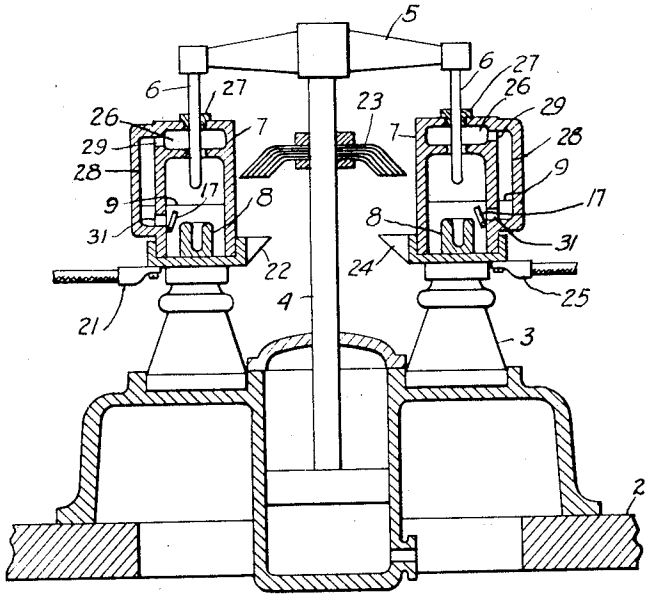


Fig. 5.



INVENTOR
Fritz Kesselring

BY
Wesley G. Carr
ATTORNEY

Patented Feb. 27, 1934 1,948,761

UNITED STATES PATENT OFFICE

1,948,761

EXPANSION SWITCH

Fritz Kesselring, Berlin-Hermsdorf, Germany, assignor to Westinghouse Electric & Manufacturing Company, a corporation of Pennsylvania

Application June 16, 1930, Serial No. 461,325
In Germany June 19, 1929

12 Claims. (Cl. 200—150)

My invention relates to circuit interrupters and particularly to interrupters for high voltage circuits.

One object of my invention is to provide a circuit interrupter with a chamber wherein a liquid is vaporized in the presence of an arc, initially confined until a predetermined pressure has been effected, and subsequently rapidly expanded in the region of the arc path to prevent arc reinitiation.

Another object of my invention is to provide a circuit interrupter of the above mentioned type with a vapor-confining and a vapor-expanding chamber wherein the vapor expansion occurs at the time the arc is extinguished.

A further object of my invention is to provide a circuit-interrupting structure of the above mentioned type with a condenser chamber that shall convert the expanded vapor into its original liquid form and return it to the region wherein the arc was initially established.

A still further object of my invention is to employ a liquid in a circuit interrupting structure of the above described type that shall be vaporized without effecting a decomposition thereof, in order that the liquid may be changed from one state to another without having its physical or chemical structure permanently affected.

Heretofore liquids have been employed surrounding the contact members of circuit interrupters in order to quench the arc by its physical presence between the separated terminals. The liquid was chosen for its dielectric properties and for its resistance to change in state to thereby minimize the evolution of gases and the resulting pressure. While oil was universally accepted as the proper liquid to meet the requirements of an arc quenching fluid, an objectionable feature inherent in oils is the liberation of free carbon in the presence of an arc which materially reduced the dielectric strength of the oil. This reduction in dielectric strength, and the accompanying hazards from fire, which result from the liberation of combustible gases, rendered the employment of oil as an arc quenching medium quite unsatisfactory for certain applications.

In practicing my invention, I procure rapid arc-extinguishment and prevent arc reinitiation by employing a suitable structure containing a liquid that freely vaporizes in the presence of an arc without decomposing. The vaporized gases extinguish the arc and render the arc path non-conducting, after which operation they are returned to their original state without, in any way, having undergone a permanent physical or chemical transformation.

My invention will best be understood by referring to the following specification taken in conjunction with the accompanying drawings wherein:

Figure 1 is a view, partly in section and partly in elevation, of a circuit interrupter embodying my invention.

Fig. 2 is a view similar to Fig. 1 showing a modified embodiment of my invention.

Fig. 3 is a sectional view in elevation showing a further modified form of a gas enclosing chamber embodying my invention.

Fig. 4 is a sectional view, in elevation, of another modified form of my invention.

Fig. 5 is a sectional view, in elevation, of a complete circuit interrupter embodying another form of my invention, and,

Fig. 6 is a view, partly in section, and partly in elevation, of a circuit interrupting and condensing structure embodying my invention.

My invention comprises in general a chamber 1 having a cover 2 thereon that supports the insulated conducting members or bushings 3. A lift rod 4 is suspended by suitable operating means (not shown) between the bushings 3 and is provided with a conducting bridging bar 5 that carries conducting contact rods 6 on its outer ends. A pot or chamber 7 is supported on each of the inner ends of the bushings 3 and enclose the stationary contact members 8 that are provided on the ends of the bushings.

Within the chamber 1 and surrounding the pots 7, there is provided a quantity of an arc extinguishing liquid 9 which may be semi-conducting and which is readily vaporized in the presence of an arc, without any substantial decomposition. Among such liquids that effectively accomplish arc extinguishment may be mentioned water and bromene. The vapors from such liquids are non-inflammable and the liquids are not decomposed when vaporized.

Referring to Fig. 1, it will be observed that the pots 7 are inverted and entirely enclosed except for a single small opening 11 through which the conducting rods 6 pass when moved to open-circuit or to close-circuit position. The conducting rods 6 fit snugly within the opening 11 and prevent the passage of the vapor therefrom during the initial movement of contact separation, causing the vapor to build up a considerable pressure within the pots 7. After the contact rod 6 passes out of the openings 11, the vapor passes through the opening and rapidly expands across the arc

path. The opening is made small to prevent instantaneous expansion and the expansion endures over a period of one-half cycle of alternating current or more for a reason fully explained hereinafter.

A similar circuit interrupter is disclosed in Fig. 2 wherein the bottom portion of the pots 7, containing the orifice 11, is removed and a piston 12, that snugly fits within the pot 7, is mounted on each of the contact rods 6 by bolts 13. In this arrangement, the gas is liberated ahead of the arc, permitting a rapid expansion of the gas in the vicinity of the arc without disturbing the arc path by the turbulent passage of the gas.

Fig. 3 discloses a pot 7 having side ports 14 for the escape of the confined gases, which ports are closed by the wall of a chamber 15 that is in slidable engagement with the pot 7 and is mounted on and moved with the contact rod 6. The expansion of the vapor and the extinguishment of the arc is effected in this structure in a manner similar to that effected by the structures disclosed in Figs. 1 and 2.

When an arc is established between the contact rod 6 and the stationary contact member 8, the liquid, surrounding the arc, is vaporized, and, due to the complete confinement of the vapors, which are constantly being evolved by the action of the arc upon the enclosed liquid, a considerable pressure is developed within the pot 7. Also during this time, the vapor is turbulently passing through the arc, causing the arc stream to be cooled and deionized and the arc core to shrink, thereby increasing the current density of the arc and raising the arc voltage. As the current decreases in magnitude and approaches the zero point in the course of its alternating cycle, the arc core decreases in cross-sectional area a proportional amount because of the deionizing effect produced by the turbulent vapor and at current zero the arc will become entirely extinguished.

As pointed out hereinabove, the expansion of the vapor takes place over a period of time at least equal to one-half of an alternating cycle, and the resulting change in state of the fluid within the expansion chamber is thus caused to persist during the time the current passes through at least one zero value of the arc current. The rapid expansion of the vapors effects a considerable reduction of temperature which causes them to condense. This condensation takes place upon the electrons present in the arc path, which act as nuclei about which the excess moisture condenses, and which, heretofore, maintained the arc path in a conductive condition because of the ionization effected by the collision of the highly mobile electrons. The loading of the electrons and ions with the condensed vapor particles increases their mass (as much as thirty thousand times for some fluids) and renders them relatively immobile and incapable of producing ions by collision. Thus the arc path is rendered non-conductive, and the reinitiation of the arc is prevented.

To reduce the dimensions of circuit interrupting structures embodying my invention, I eliminate the enclosing chamber and the large body of liquid illustrated in Figs. 1 and 2 by employing the pot 7 about each of the contact members that are surrounded by air. In Fig. 4, the pot 7 is enclosed by a chamber 16 in which the gas liberated from the opening 11, after the passage of the rod 6 therefrom, is expanded. After the expansion takes place and the arc is extinguished, the vapor in the chamber 16 and also that in the chamber 7 is condensed and collected at the bottom of the chambers.

A check valve 17 is provided in the lower portion of the wall of the pot 7 (Fig. 4). This valve permits the passage of the liquid 9 from the chamber 16 into the pot 7 but prevents the passage of the liquid therefrom, and thereby assures that sufficient liquid is always present in the pot 7 to effectively obtain arc extinguishment and to prevent arc reinitiation.

A second valve 18 is mounted on the wall of the chamber 7 which is provided with a spring 19 that effectively retains the valve 18 in its closed or sealed position. The tension of the spring 19 is such that the valve 18 will open before the pressure in the pot 7 accumulates sufficient force to rupture the pot. In this construction, none of the liquid 9 or its vapor escapes from the chamber 16 and, as the liquid is not decomposed by the arc, it may be repeatedly changed from one state to another without reducing its volume or impairing its arc extinguishing qualities.

In Fig. 5, I disclose a complete circuit interrupter wherein the current normally flows through the terminal 21, the main stationary contact member 22, a flexible bridging member 23, a stationary contact member 24, and a terminal member 25. Paralleling the bridging member 23, a secondary or arcing circuit is provided that includes the bridging bar 5, the conducting rods 6 and the stationary contact members 8. The contact member 8 is enclosed within the chamber 7 and is immersed in the liquid 9 therein. The contact member 6 extends into the chamber 7 and engages the contact member 8. Upon the separation of the contact members 6 and 8, an arc is established and is extinguished in the manner heretofore described.

The conducting rod 6 extends through a chamber 26 into which the vapor expands since it communicates with the chamber 7 after the conducting rod 6 has passed from the opening 11. Suitable packing 27 is provided on the top of the chamber 26 to prevent the vapor from escaping through the opening for the conducting rod 6.

Condensers 28 are provided adjacent to the chambers and directly communicate therewith through the conduits 29 and 31. Check valves 17 are provided adjacent to the conduit 31 in the wall of the chambers 7 to permit the ingress of the liquid 9 thereto and to prevent its escape therefrom.

In this construction, when the circuit interrupter is in closed position, all of the current passes through the main current carrying brush 23 and practically no current flows in the secondary circuit, that is to say, through the contact rods 6 and the bridging bar 5. When the circuit interrupter is moved to open position the brush 23 is first separated from the contacts 22 and 24, while the contact rods 6 and the bridging bar 5 remain in series relation with the terminal members 21 and 25. Further movement of the circuit interrupting structure to the open position effects the separation of the conducting rods 6 from the contacts 8 whereupon two serially connected arcs are established. The arcs are extinguished by the turbulent passage of the vapor therethrough and prevented from reigniting by the expansion of the vapor as described hereinabove. The expanded vapors are condensed within the chambers 28 and are returned

as liquid to the chambers 7 through the conduits 31 and the valves 17.

In Fig. 6, I have disclosed a circuit interrupting structure wherein the chamber 16 has oppositely disposed conduits 32 that are connected to opposite sides of the chamber in order to equalize the forces effected during the expansion of the vapors. The conduits 32 are in communication with the condenser 26 and are provided with regulating means 33 that effect a prolonged expansion of the vapor. When the regulating means 33 are properly adjusted, the expansion will endure for at least a half cycle and continue at the time the arc is extinguished. The liquid 9 trapped within the condensing chamber 26 may be returned to the chamber 7 by the conduit 34 and valve 35.

It will thus be seen that I have provided an improved circuit interrupter which utilizes an arc quenching liquid that is vaporized in the presence of an arc. The vapor effects arc-extinguishment by its turbulent motion, while confined, and prevents arc-reinitiation by its rapid expansion after arc-extinguishment which deionizes the arc path. The vapor and the liquid are entirely enclosed and are changed from the liquid state to the vapor state without decomposition and without reducing the dielectric quality of the liquid. The expansion of the liquid is so arranged that a current zero and arc-extinguishment occurs during the time of expansion.

While I have described several modifications of my invention, it will be apparent to those skilled in the art, that many changes, omissions, additions, and substitutions may be made therein without departing from the spirit and scope of my invention as set forth in the accompanying claims.

I claim as my invention:—

1. In an alternating current circuit interrupter, means defining a chamber that is substantially closed when said interrupter is in the closed circuit position, means for drawing an arc in said chamber, said chamber containing a quantity of a liquid, a portion of which is adapted to be gasified by the arc, said gasified portion being at least partially condensable when cooled, and means operable during each circuit interrupting operation to cool the entrapped gaseous fluid adjacent the arc thereby effecting a change of state from the superheated to the saturated vapor condition, said means and said chamber being so proportioned that said cooling and the resulting change of state in the fluid surrounding the arc is made to persist for a sufficient period of time to include at least one zero point in the arc current.

2. In an alternating current circuit interrupter, means defining an expansion chamber that is substantially closed when said interrupter is in the closed circuit position, means for drawing an arc in said chamber, said chamber containing a quantity of liquid, a portion of which is adapted to be gasified by the arc to produce a gas substantially all of which is inorganic in nature, said gasified portion being at least partially condensable when cooled, and means operable during each circuit interrupting operation for effecting a substantially adiabatic expansion of said gasified portion in order to cool the entrapped gaseous fluid adjacent the arc, said cooling causing said gas to change from the superheated to the saturated vapor condition, said chamber and said expansion means being so proportioned that said cooling and the resulting change of state in the fluid surrounding the arc is made to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

3. In an alternating current circuit interrupter, means defining a chamber that is substantially closed when said interrupter is in the closed circuit position, means for drawing an arc in said chamber, said chamber containing a quantity of liquid, a portion of which is adapted to be gasified by the arc, said gasified portion being at least partially condensable when cooled, and means operable during each circuit interrupting operation to vent said chamber and to thereby cool the entrapped gaseous fluid adjacent the arc to effect a change of state in said fluid from the superheated to the saturated vapor condition, said venting means and said chamber being so proportioned that said cooling and the change of state produced thereby is caused to persist for a sufficient period of time to include at least one zero point in the arc current.

4. In an alternating current circuit interrupter, means defining a chamber that is substantially closed when said interrupter is in the closed circuit position, means including a stationary contact member and a movable contact member for drawing an arc in said chamber, said chamber containing a quantity of a liquid, a portion of which is adapted to be gasified by the arc to produce a gas that is readily condensable when cooled, and means operable in response to the movement of said movable contact member to vent said chamber and to thereby cool the entrapped gaseous fluid within said chamber so as to cause the fluid surrounding the arc stream to change from the superheated to the saturated vapor condition, said venting means and said chamber being so proportioned that the venting operation and the resulting cooling is prolonged for a sufficient period of time to insure that the arc stream shall be surrounded with saturated vapor during at least one zero point in the arc current.

5. In an alternating current circuit interrupter, a pair of separable contact members, an expansion chamber surrounding the junction of said contact members, a liquid in said chamber which gasifies when exposed to an electric arc to produce a readily condensable gas, and an opening in said chamber through which one of said contact members moves to establish an arc and to vent said chamber, said chamber, said opening, and the speed of movement of said contact member being so proportioned that the venting of said chamber causes the entrapped gasified fluid therein to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

6. In an alternating current circuit interrupter, a stationary and a moving contact for opening and closing the circuit, a chamber for surrounding the junction of said contacts, a quantity of liquid within said chamber which gasifies when exposed to the arc formed incident to the interruption of the controlled circuit to produce a readily condensable gas, and means for venting said chamber into a second chamber wherein said gas is condensed, said first chamber and said venting means being so proportioned that the venting of said first chamber causes the entrapped gasified fluid therein to change from the super-

heated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

7. In combination in an alternating current circuit interrupter, separable contact members, an enclosing chamber therefor, a substance within said chamber which liberates a condensable gas when brought in proximity to an electric arc, means for confining the gas formed incident to the drawing of an arc in said chamber by said separable contact members during a predetermined portion of the contact separating movement, and for thereafter effecting a rapid expansion of the gas entrapped within said chamber, and means externally associated with said chamber for condensing said entrapped gas subsequent to the operation of said expansion means, said chamber and said expansion means being so proportioned that the entrapped gas is caused to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

8. In an alternating current circuit interrupter, a pair of separable contact members, an expansion chamber surrounding the junction of said contact members, a liquid in said chamber which gasifies when exposed to an electric arc to produce a readily condensable gas, an opening in said expansion chamber through which one of the contact members is movable, said opening in the expansion chamber being above the level of the liquid therein, a condensation chamber leading from said expansion chamber, means for venting said chamber, and means for returning the condensed liquid from said condensation chamber to said expansion chamber, said chamber and said venting means being so proportioned that the venting of said chamber and the resulting expansion of the gas entrapped therein causes said entrapped gas to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

9. In an alternating current circuit interrupter, a pair of separable contact members, an outer chamber enclosing the junction of said contact members, said outer chamber including a base having side walls secured thereto and having an opening in the top thereof, an inner chamber, the base of which is formed by the base of said outer chamber, the side walls of said inner chamber being secured to said base, an opening in the top of said inner chamber aligned with the opening in the top of said outer chamber, one of said contact members being movable through both of said openings, said inner chamber containing a quantity of a liquid, a portion of which is adapted to be gasified by the arc to produce a gas that is readily condensable when cooled, and means operable in response to the movement of said movable contact member for venting said inner chamber into said outer chamber and to thereby cool the entrapped gaseous fluid within said inner chamber so as to cause the fluid surrounding the arc stream to change from the superheated to the saturated vapor condition, said venting means and said chamber being so proportioned that the venting operation and the resulting cooling is prolonged for a sufficient period of time to insure that the arc stream shall be surrounded with saturated vapor during at least one zero point in the arc current.

10. The method of extinguishing an alternating current arc which includes the steps of drawing an arc, gasifying a quantity of a substance which liberates a condensable gas by the heat of the arc, confining the gas and the arc to effect a superheating of the gas, and then cooling the superheated gas in such a manner that a sufficient removal of heat is secured to cause the gas confined adjacent the arc to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

11. The method of extinguishing an alternating current arc which includes the steps of drawing an arc, gasifying a quantity of a substance which liberates a condensable gas by the heat of the arc, confining the gas and the arc to effect a superheating of the gas, and then substantially adiabatically expanding a portion of the superheated gas in such a manner that the rate of heat removal shall cause the gas confined adjacent the arc to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

12. In combination in an alternating current circuit interrupter, means for establishing an arc, a quantity of arc quenching liquid from which condensable gas is liberated in the presence of an arc, means including a chamber wherein said liquid is contained and wherein said arc is established for confining said gas, for a period of time, in proximity to the arc being extinguished in order to superheat said gas and to increase its pressure, and venting means for causing said superheated gas to expand adiabatically, said confining means and said venting means being so proportioned that the venting operation causes the confined gas to change from the superheated to the saturated vapor condition and to persist in the saturated vapor condition for a period of time at least equal to one alternation of the arc current.

FRITZ KESSELRING.