Jan. 12, 1937. F. KESSELRING ET AL 2,067,673

CIRCUIT INTERRUPTER

Filed Nov. 13, 1934

Fig. 1.

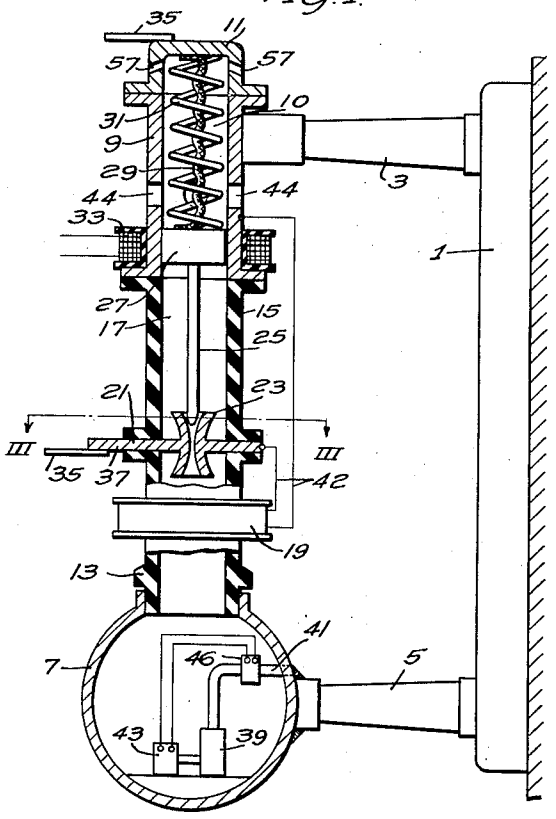


Fig. 2.

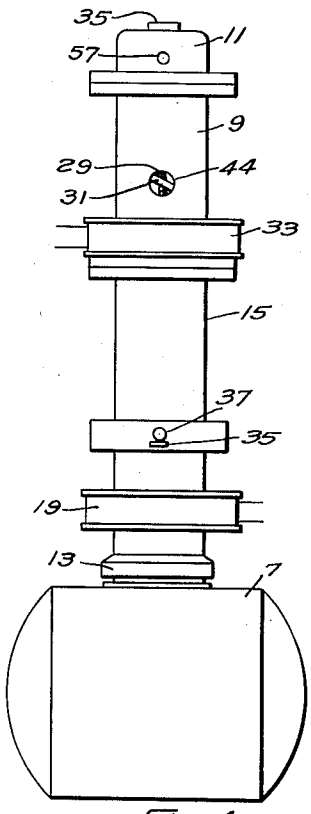


Fig. 3.

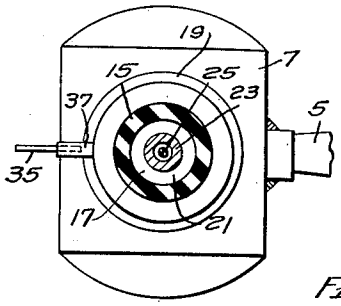


Fig. 5.

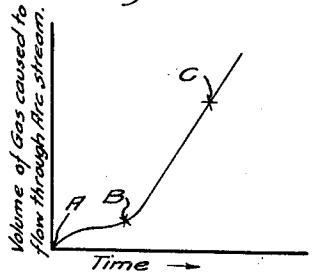


Fig. 4.

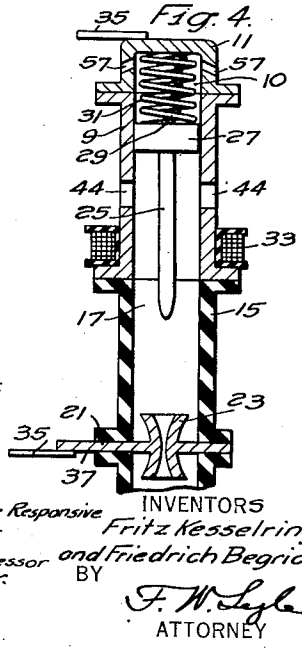
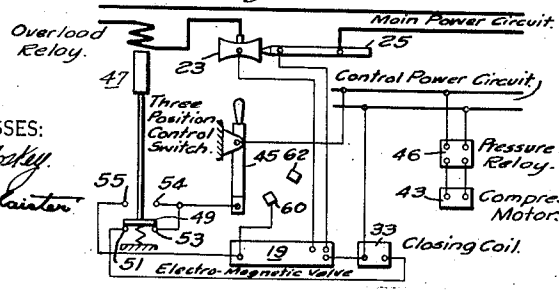


Fig. 6.



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CIRCUIT INTERRUPTER

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7 Claims. (Cl. 200—148)

Our invention relates to circuit breakers of the type wherein a flowing stream or jet of suitable arc extinguishing fluid is used for extinguishing the arc which is established incident to the opening of the controlled circuit. One common form of such breakers comprises a reservoir, wherein a quantity of arc extinguishing gas is contained under pressure, an arc chamber, and means for causing a predetermined volume of the gas contained in the reservoir to flow through the arc chamber during each circuit opening operation.

The primary object of the present invention is to improve the operation of devices of this type through the provision of means for most effectively utilizing the flowing stream of arc extinguishing fluid and for preventing the utilization of a larger quantity of this fluid than is necessary during the operation of the breaker.

Heretofore, it has been customary to connect the passage or chamber wherein the arc is established directly with the source of the arc extinguishing fluid, and immediately upon the occurrence of an overload condition, the arc extinguishing fluid was caused to flow through the arc passage at a substantially constant rate. In order to assure satisfactory operation of these devices over the wide range of arc currents which are encountered in ordinary service, it was necessary that the rate of flow of this stream of arc extinguishing fluid be sufficiently high to assure the extinction of the largest magnitude arc which might be drawn within the arc passage during the operation of the interrupter. On low currents, this arrangement proved itself wasteful of the arc extinguishing fluid, due primarily to the fact that satisfactory extinction of low current arcs could be effected with a much smaller quantity of fluid and with a much lower rate of flow.

Not only did the prior art devices utilize an excessively large amount of arc extinguishing fluid during the extinction of low and moderate current arcs, but in addition, they did not efficiently utilize the fluid flowing therethrough even when extinguishing large current magnitude arcs. The extinction of short arcs, regardless of their current magnitude, may be effected through the use of a low velocity stream of arc extinguishing fluid with practically the same degree of efficiency as is attained through the use of a high velocity stream of arc extinguishing fluid. As the arc lengthens, however, the high velocity stream becomes more efficient. Thus a device which utilizes a constant velocity stream of arc extinguishing fluid utilizes that stream efficiently only during the final stages of the circuit opening operation, i. e. when a relatively long arc has been drawn within the arc chamber.

In overcoming these disadvantages, the present invention provides means for so controlling the flow of the arc extinguishing fluid that the amount used is restricted to not more than is necessary during the extinction of low magnitude current arcs and the maximum rate of flow is utilized only during the extinction of large current magnitude arcs; and even then the maximum rate of flow is caused to take place only when the arc drawing contact members have separated a sufficient distance to assure an efficient utilization of the arc extinguishing properties of the high velocity stream. By this arrangement the volume of arc extinguishing fluid utilized during the normal operation of the breaker is substantially reduced, and a further object of our invention, namely the minimizing of the physical dimensions of the arc extinguishing fluid reservoirs which are utilized with circuit interrupters of the type under consideration is accomplished.

An ancillary object of our invention is to provide a circuit interrupter of the type discussed above, which shall be simpler in design, more reliable and efficient in operation, and less expensive to manufacture than the previously known devices of this type, the improved operation to be brought about through a novel arrangement of the several parts of the interrupter.

These and other objects of our invention will be made more apparent by reference to the following drawing and description of a circuit interrupter embodying the features of the invention. Referring to the drawing:

Figure 1 is a side elevational view, partially in section, of a high capacity circuit breaker constructed in accordance with our invention;

Fig. 2 is an elevational view of the circuit interrupter shown in Fig. 1;

Fig. 3 is a fragmentary sectional view on the line III—III of Fig. 1;

Fig. 4 is a fragmentary view of the arc passage and contact structure of the interrupter shown in Fig. 1, the contacts are shown in a partially open position;

Fig. 5 is a curve showing the variation in the amount and the rate of flow of the arc extinguishing medium with respect to time, during the operation of a circuit interrupter constructed according to our invention; and,

Fig. 6 is a schematic view of one form of control circuit for the interrupter shown in Figs. 1 through 4.

As shown particularly in Figs. 1, 2, and 3, the preferred form of our invention includes a base 1, upon which are mounted a pair of supporting insulators 3 and 5. The lower insulator 5 is adapted to support a pressure tank 7 which serves as a reservoir for containing the arc extinguishing fluid utilized for extinguishing the arc established incident to each circuit opening operation of the breaker. The upper insulator 3 supports a metallic housing 9 which defines the walls of an expansion chamber 10 into which the arc extinguishing fluid flows during the operation of the breaker.

The housing 9 is substantially cylindrical in form and is closed at its upper end by a cap member 11, which is affixed thereto by any suitable means. An insulating conduit 13 is supported upon the pressure tank 7 and serves to conduct the arc extinguishing fluid contained therein to the arc passage 17, the walls of which are defined by a second insulating conduit 15 having the same internal dimensions as the lower insulating conduit 13 and the cylindrical housing 9.

An electro-magnetic valve 19, positioned intermediate the ends of the lower insulating conduit 13, is provided for controlling the flow of arc extinguishing fluid therethrough, and a plate member 21 of conducting material, which serves to support a hollow contact member 23, is positioned between the lower insulating conduit 13 and the member 15 which defines the walls of the arc passage 17. All of the connections between the pressure chamber 7, the insulating conduit 13 leading therefrom, the member 15 which defines the arc passage 17, and the upper cylindrical member 9 which serves as the expansion chamber, are gas-tight, in order to prevent leakage of the arc extinguishing fluid during the operation of the apparatus.

A rod-shaped contact member 25 is provided for cooperating with the previously mentioned hollow contact member 23 in order to permit the opening and the closing of the electrical circuit through the breaker. This rod contact member 25 is supported upon a piston 27 which is adapted to move within the upper cylindrical member 9 and is electrically connected to the cap 11, which closes the upper end of that member, by means of a flexible shunt 29. A tension spring 31, one end of which is affixed to the cap member 11 and the other end of which is affixed to the piston 27, biases the movable contact toward the open circuit position.

The piston 27, or some portion thereof, is made of magnetic material, and a coil member 33, disposed about the upper cylindrical member 9, is provided for attracting this piston, in order to move the contacts to the closed circuit position. It is, of course, necessary that the member 9 which defines the walls of the cylindrical chamber 10 wherein the piston 27 moves shall be formed of non-magnetic material. Suitable terminals 35 are affixed to the cap member 11, and to an outwardly projecting member 37 formed integral with the plate 21 for connecting the breaker into an electrical circuit.

In the particular breaker disclosed in the drawing, compressed air is utilized as the arc extinguishing fluid. This substance is used primarily because of its low cost, its universal availability, and its good arc extinguishing properties. It is, of course, within the province of our invention that other gases, or even liquids or vapors, might be used with an equal, or possibly better, degree of efficiency. The invention is primarily considered with the manner in which the arc extinguishing fluid is caused to flow through the arc passage during the operation of the device, and the particular fluid which is used is not an important part of the invention.

A compressor 39, which is disposed within the pressure tank 7, and is connected to the outer atmosphere, by a suitable conduit 41, is provided for restoring the arc extinguishing fluid to the pressure tank 7, following each operation of the breaker. The compressor 39 is preferably operated by a motor 43, which is controlled by a pressure-responsive relay 45 positioned in the conduit 41 intermediate its ends.

The electro-magnetic valve 19, which is disposed in the conduit 13 leading from the pressure tank 7 to the arc passage 17, is normally closed, in order to prevent any flow of the arc extinguishing fluid from the pressure tank 7 except during the circuit opening operation of the breaker. This valve 19 may be actuated through the operation of the overload relay which brings about the opening of the interrupter or by any other similar means. It is preferably provided with a potential means (not shown) normally electrically connected across the arc by suitable leads 42 for causing the valve to close immediately the arc is extinguished within the interrupter.

The cylindrical member 9 is provided with a plurality of vent openings or ports 44 which are so positioned that they are not uncovered by the upwardly moving piston 27 until the final stages of the circuit opening operation. Through this arrangement the rate of flow of the arc extingushing fluid is caused to vary in two successive steps during the progress of the circuit opening operation.

A suitable control circuit is shown in Fig. 6. This circuit includes a three-position switch 45, an overload relay 47, and suitable conducting means for completing the electrical circuit to the various parts. The control circuit is so arranged that the breaker may be opened or closed through the actuation of the three-position switch, provided that an overload capable of actuating the relay 47 does not exist in the power circuit. If such an overload occurs when the interrupter is in the closed circuit position, it will, of course, automatically open.

The circuit interrupter is shown in the closed circuit position in Figs. 1 and 6. Upon the occurrence of an overload, capable of effecting the actuation of the overload relay 47, the armature 49 of that relay is moved upwardly so as to open the circuit between the contact points 51 and 53 and close the circuit between the other two contact points 54 and 55. This effects a deenergization of the closing coil 33 and a simultaneous energization of the electro-magnetic valve 19. Immediately upon the deenergization of the holding coil 33, the spring 31 begins to move the piston member 27 and with it the movable contact rod 25 toward the open circuit position, thereby effecting the separation of the cooperating contact members 23 and 25, and the establishing of an arc within the arc passage 17. The opening movement is aided by the pressure of the arc extinguishing fluid since the actuation of the electro-magnetic valve 19, which occurs simultaneously with the initiation of the contact separating movement, causes a quantity of the arc extinguishing fluid to move through the hollow contact member 23 into the arc passage 17, and to exert a force against the piston 27 tending to move that member in the expansion chamber 10.

Suitable vent openings 57 in the cap 11 prevent any gas which may be entrapped in the expansion chamber 10 from impeding the free movement of the piston 27.

The amount of arc extinguishing fluid which flows through the hollow contact member 23 into the arc passage 17 during the period of time required for the piston 27 to move from the position shown in Fig. 1 to the position shown in Fig. 4 is, of course, a function of the volume of the arc passage 17, the dimensions of the hollow contact 23, the volume of the expansion chamber 10 made available by the upward movement of the piston 27, and the pressure maintained within the tank 7. Preferably, these several quantities are so correlated that rapid and efficient extinction of all except the largest current magnitude arcs is effected before the ports 44 are uncovered by the upwardly moving piston. If this has been done the amount of arc extinguishing fluid which is used during each circuit opening operation may be substantially minimized, as compared with the previously known devices, without any decrease in the operating efficiency of the breaker.

The amount of arc extinguishing fluid which may be caused to flow through the arc passage 17 prior to the time that the ports 44 formed in the side walls of the expansion chamber 10 are uncovered by the upwardly moving piston 27 is obviously limited to a definite value. Further, since the volume of the arc passage 17 and the volume of the expansion chamber 10 which is opened by the upward movement of the piston, is also a fixed quantity, the rate of flow of the arc extinguishing fluid decreases from a predetermined maximum value to a less value during this stage of the circuit opening operation. This decrease resulting from the increase in back pressure is caused by the flow of gas into the closed arc passage 17 and expansion chamber 10. For all ordinary values of arc current, this initial quantity of arc extinguishing fluid is sufficient to effect the extinction of the arc and immediately the arc is extinguished, the potential unit of the electro-magnetic valve 19 which is connected across the terminals of the interrupter effects the closing of that valve, thereby preventing further flow of the arc extinguishing fluid.

If, however, this initial flow of arc extinguishing fluid is incapable of effecting the extinction of the arc before the ports 44 are uncovered by the upwardly moving piston 27, the uncovering of those ports immediately causes a very substantial reduction in the back pressure opposing the flow of the arc extinguishing fluid through the arc passage 17, and thereby brings about a very substantial increase in the rate of flow of the arc extinguishing fluid through the arc passage. When the ports 44 are completely opened, the back pressure existing in the arc passage 17 is not substantially greater than atmospheric and the arc extinguishing fluid thus flows through the hollow contact 23 into the arc passage 17 with the maximum possible velocity, and brings about the extinction of the arc within a short interval of time. Immediately upon the extinction of the arc, the potential element of the electro-magnetic valve 19 effects the closing of the conduit 13 leading to the pressure chamber and thereby cuts off the flow of the arc extinguishing fluid.

By making the hollow contact 23 the only inlet into the arc passage 17, an intimate intermixing of the arc extinguishing fluid with the arc stream is assured at all times during the operation of the interrupter. The total area of the ports 44 which are opened in the expansion chamber 10 during the circuit opening operation of the breaker must be determined for each installation wherein the invention is embodied. Similarly, the interval of time which elapses before the arc extinguishing fluid is caused to flow at its maximum possible rate must be determined in accordance with the requirements of the circuit on which the breaker is used.

The curve in Fig. 5 illustrates the variation in the rate of flow of the arc extinguishing gas during the operation of the interrupter. The portion of the curve between A and B illustrates how the rate of flow falls off slightly while the piston is moving upwardly in the expansion chamber, and the increase in the slope of the curve between the points B and C illustrates the increase in the rate of flow which accompanies the opening of the ports 44 within the expansion chamber. No attempt has been made in this curve to attach any quantitative values to the conditions portrayed. It merely serves to illustrate, in a general manner, the variation in the rate of flow of the arc extinguishing fluid during the circuit opening operation.

To open the circuit manually, the three position switch 45 is moved from the position shown in Fig. 6 to a position where the contact arm engages the second contact point 60. This effects a deenergization of the closing coil 33 and a simultaneous energization of the electro-magnetic valve 19. The opening operation then proceeds in exactly the same manner as described above. If it is desired to leave the breaker in the open circuit position for an extended period of time, the switch 45 is moved to the third contact point 62, at which time the operating element of electro-magnetic valve 19 and the closing coil 33 are entirely deenergized. The pressure-responsive relay 46 and the compressor motor 43 are ordinarily connected in the circuit at all times, in order to assure that adequate supply of arc extinguishing fluid shall be available for the operation of the breaker.

In the foregoing, we have pointed out how the rate of flow of arc extinguishing fluid through the arc passage of a circuit interrupter may be caused to vary during the operation of the breaker, in order to prevent the use of unreasonably large quantities of arc extinguishing fluid and to make possible a more efficient operation of the device. In the preferred form of our invention, a predetermined small quantity of arc extinguishing fluid is caused to flow through the arc passage during the initial stages of the circuit opening operation, and if this flow does not effect the extinction of the arc a further quantity of fluid is then caused to flow through the passage at an increased rate of flow, this latter flow continuing until the arc is extinguished. As a further means for assuring efficient use of the arc extinguishing fluid in the structure of our invention, we have provided means for causing the maximum rate of flow of the arc extinguishing fluid to be attained only when the contact members have been separated a sufficient distance to make possible an efficient utilization of that rate of flow. This prevents waste of the arc extinguishing fluid without any sacrifice of arc extinguishing capacity.

While in the foregoing we have pointed out the details of a preferred embodiment of our in-

vention, it is to be understood that many of these details are merely illustrative, and that variations in their precise form will be both necessary and desirable in certain instances. It is our desire, therefore, that the language of the accompanying claims shall be accorded the broadest reasonable construction, and that our invention shall be limited only by what is expressly stated therein and by the prior art.

We claim as our invention:

1. In a circuit interrupter, means for defining the walls of an arc passage which is substantially completely enclosed during the operation of said interrupter except for an inlet and an outlet opening, separable contact means for establishing the arc incident to each opening operation of said interrupter within said arc passage, a quantity of arc extinguishing fluid, means whereby said arc extinguishing fluid is admitted to said arc passage through said inlet opening at a substantially uniform inlet pressure during the operation of said interrupter, and throttling means for coacting with said outlet opening during each opening operation of said interrupter to restrict the rate of flow of said fluid into said arc passage until said contacts have separated a predetermined distance.

2. In a circuit interrupter comprising separable contact members, an enclosed arc passage associated therewith, and a supply of arc-extinguishing fluid confined under pressure, the combination of means for admitting said fluid into the passage at one rate during the initial stages of contact separation and for substantially altering said rate as the distance of contact separation increases.

3. In a circuit interrupter comprising separable contact members, an enclosed arc passage associated therewith, and a supply of arc-extinguishing fluid confined under pressure, the combination of means for admitting said fluid into the passage at one rate during the inital stages of contact separation and for substantially increasing said rate as the distance of contact separation increases.

4. In a circuit interrupter comprising separable contact members, an enclosed arc passage associated therewith, and a supply of arc-extinguishing fluid confined under pressure, the combination of means for admitting the fluid into the passage at one rate during the initial stages of contact separation, and means responsive to a failure of said fluid to extinguish the arc during said initial stages for admitting further fluid at a substantially more rapid rate as the distance of contact separation increases.

5. A circuit interrupter comprising a pair of separable contact members one of which is provided with a central opening and the other of which is adapted to close said opening during engagement, an enclosed arc passage utilizing the centrally-opened contact member as one of its end walls and completely surrounding the cooperating separable member, a supply of arc-extinguishing fluid confined under pressure, means responsive to a separation of said contact members for allowing said fluid to flow into the arc passage through said contact opening, and means for increasing the rate of said flow when the distance of separation of the contacts attains a given magnitude.

6. A circuit interrupter comprising a pair of separable contact members one of which is provided with a central opening and the other of which is adapted to close said opening during engagement, an enclosed arc passage utilizing the centrally-opened contact member as one of its end walls and completely surrounding the cooperating separable member, a supply of arc-extinguishing fluid confined under pressure, means responsive to a separation of said contact members for allowing said fluid to flow into the arc passage through said contact opening, and means responsive to a failure of said fluid to extinguish the arc during the initial stages of contact separation for admitting further fluid at a substantially more rapid rate as the distance of said contact separation increases.

7. In a circuit interrupter comprising a pair of separable contact members, an enclosed arc passage associated therewith, and a supply of arc-extinguishing fluid confined under pressure, the combination of means for admitting said fluid into the passage at a comparatively slow rate during the initial stages of contact separation and further means for substantially increasing said rate as the distance of contact separation increases, said further means comprising an expansion chamber connecting with said arc passage, said chamber being closed except for a vent port in the side wall thereof, and a piston so movable therein as to uncover said port when the distance of contact separation attains a given magnitude.

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