Dec. 19, 1944. B. P. BAKER 2,365,509

CIRCUIT INTERRUPTING DEVICE

Filed Nov. 26, 1941 3 Sheets-Sheet 1

Fig. 1.

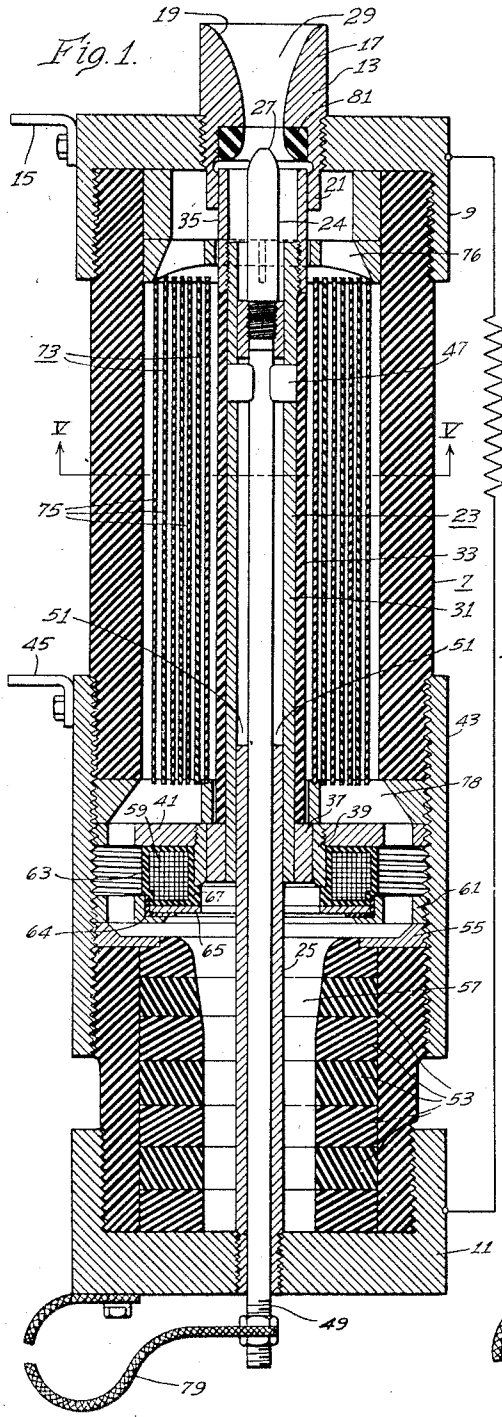
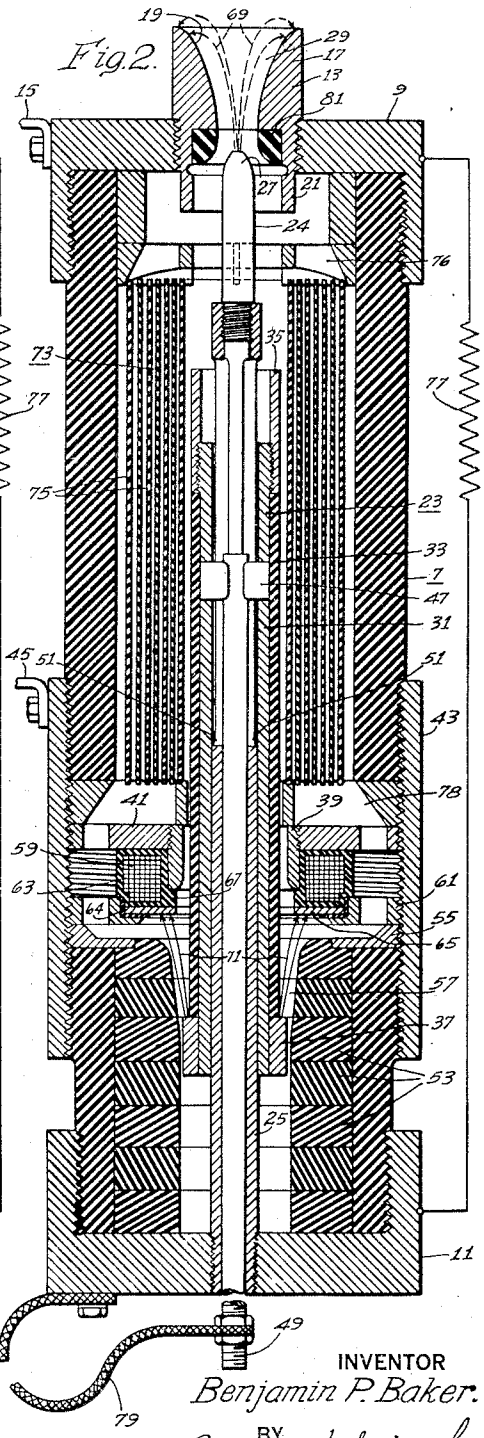


Fig. 2.



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Filed Nov. 26, 1941 3 Sheets-Sheet 2

Fig. 3.

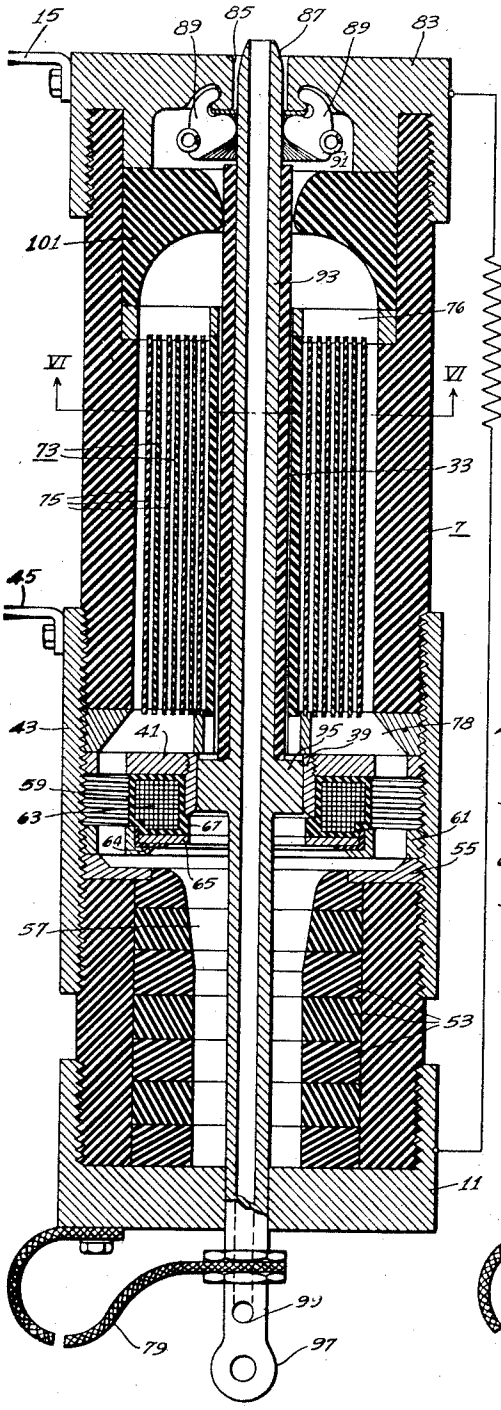
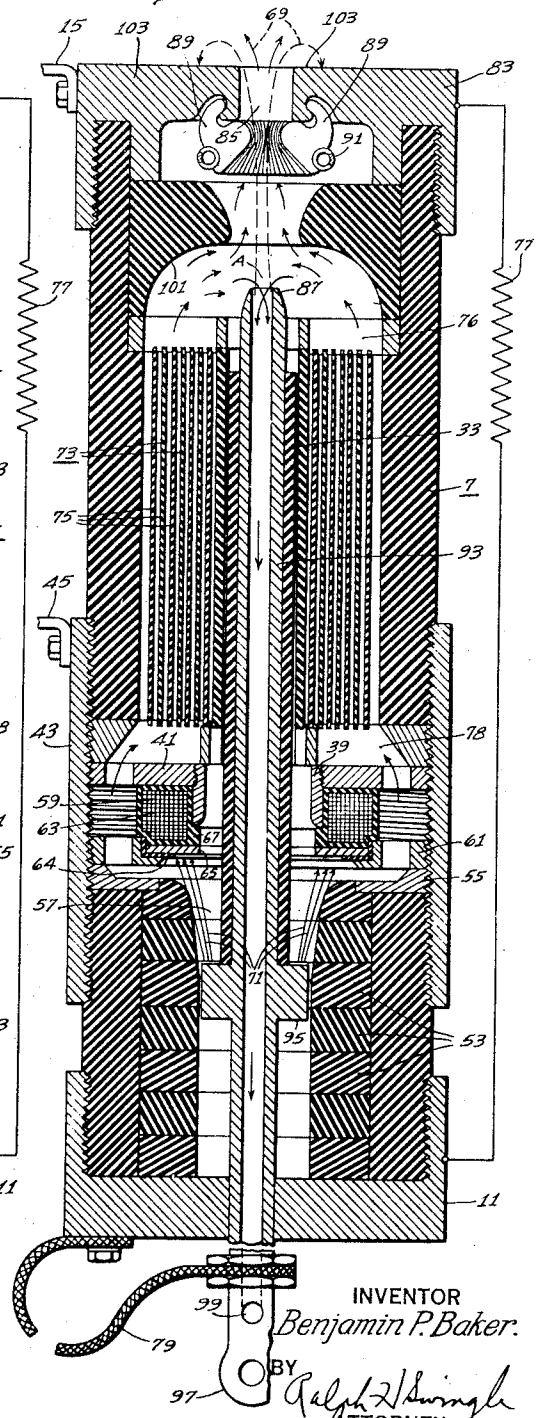


Fig. 4.



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Filed Nov. 26, 1941 3 Sheets-Sheet 3

Fig. 5.

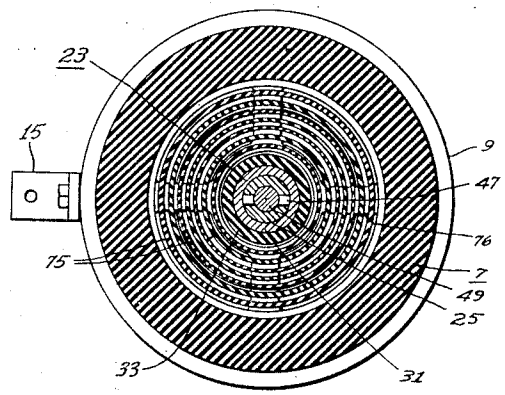
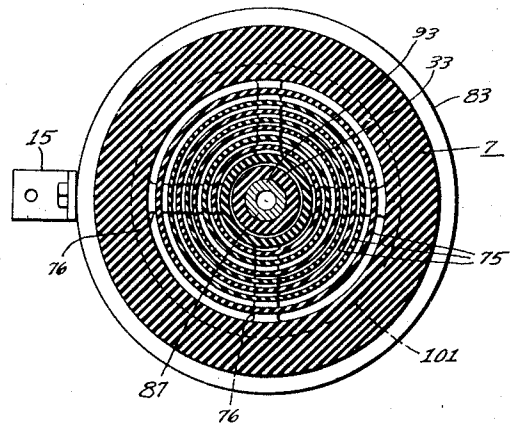


Fig. 6.



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UNITED STATES PATENT OFFICE

2,365,509

CIRCUIT INTERRUPTING DEVICE

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Application November 26, 1941, Serial No. 420,515

11 Claims. (Cl. 200—149)

The invention relates to circuit interrupting devices of the fluid blast type in which interruption of the circuit is effected by a blast of arc extinguishing fluid forced through the arc drawn during circuit interruption.

More specifically, the present invention is concerned with improvements on the fluid blast type of circuit interrupter set forth and claimed in a patent application by Herbert L. Rawlins, Serial No. 212,438, filed June 8, 1938, and issued August 4, 1942, as Patent No. 2,292,088, and assigned to the assignee of the present invention. Development work on the type of circuit interrupter described in the aforesaid patent application has disclosed desirable improvements which will be the subject of the present invention.

An object of the present invention is to prevent the re-ignition of the arc extinguished during circuit interruption when a circuit interrupter of the above type is used to interrupt large currents at high voltages.

Another object of the present invention is to provide a circuit interrupter of the above type wherein the flow of arc extinguishing fluid is for a portion of its length substantially perpendicular to the arc stream, thus creating and maintaining lateral pressure on the arc to force the cross-section of the arc to zero as the current approaches its zero value.

A more specific object of the invention is to provide a circuit interrupter of the above type in which the arc restriking distance between the electrodes constantly increases as the opening movement of the circuit interrupter progresses.

Another object of the present invention is to provide a circuit interrupter of the above type which has a very short arcing time even when used to interrupt large currents at high voltages.

Other objects and advantages will become apparent from a reading of the following detailed description considered in conjunction with the drawings, in which:

Figure 1 is a sectional view of a circuit interrupter shown in the closed circuit position and containing an embodiment of the present invention;

Fig. 2 is a sectional view similar to Fig. 1, but showing the device during the initial portion of the circuit opening operation;

Fig. 3 is a sectional view of a circuit interrupter similar in basic construction to the circuit interrupter shown in Figs. 1 and 2, yet incorporating a preferred embodiment of the present invention, and shown in the closed circuit position;

Fig. 4 is a sectional view of the circuit interrupter shown in Fig. 3, but shown during the initial portion of the circuit opening operation;

Fig. 5 is a transverse sectional view of the circuit interrupter shown in Fig. 1 taken substantially along the line V—V of Fig. 1 and looking in the direction of the arrows; and

Fig. 6 is a transverse sectional view of the circuit interrupter shown in Fig. 3 taken substantially along the line VI—VI of Fig. 3 and looking in the direction of the arrows.

Referring to Figs. 1, 2 and 5, there is illustrated a circuit interrupter constructed in accordance with the invention of Herbert L. Rawlins in the above-mentioned patent application, yet containing an improvement which is an embodiment of the present invention. The three Figures 1, 2 and 5 show a circuit breaker comprising a two-part casing of insulating material, indicated generally by the reference numeral 7, and on the ends of which are threaded a pair of metal caps 9 and 11. The cap 9 forms one terminal of the interrupting device and has a central opening in which is threaded an annular electrode 13. The cap 9 is also provided with a terminal lug 15 for connecting the cap 9 and electrode 13 to an external electrical circuit.

The electrode 13 forms a nozzle which communicates with the interior of the casing and through which the arc extinguishing gases generated within the casing are expelled, as will be hereinafter described. The electrode 13 has an arcing tip portion 17 which extends outside of the cap 9, the throat of which is flared outwardly, as indicated at 19. The electrode 13 is also provided with an annular contact portion 21 which extends inside of the casing 7 and is adapted to be engaged by a movable contact carried by a movable switch member indicated generally at 23.

A hollow tube 25 of conducting material extends centrally within the casing 7, and has one end threaded in a central opening provided in the cap 11. A fixed electrode 24 is threaded in the opposite or upper end of the fixed conducting tube 25, and this electrode has a rounded nose 27 which projects partially into the throat 29 of the nozzle or electrode 13.

The movable switch member 23 comprises a tubular sleeve 31 of conducting material, around the outer surface of which is mounted a sleeve 33 of an insulating material, such as horn fibre, which evolves an arc extinguishing gas when subjected to the heat of an arc. The upper end of the conducting sleeve 31 has a ring-shaped

movable contact 35 threaded thereon which is movable by the switch member 23 into and out of engagement with the contact portion 21 of the electrode 13 to close and open the circuit through the interrupting device. The lower end of the conducting sleeve 31 carries a second movable ring-shaped contact 37 which is engageable with a stationary annular contact 39 carried by the casing 7. The stationary contact 39 is carried by a spider member 41 which is threaded in an outer terminal sleeve 43 which forms the opposite terminal of the interrupting device. The terminal sleeve 43 connects the upper and lower sections of the insulating casing 7 together by threadedly engaging the opposed ends of the two sections. A terminal lug 45 is bolted to the terminal sleeve 43, which, together with the terminal lug 15, serves to connect the interrupting device in series in the external electrical circuit.

The movable switch member 23 comprising the two movable contacts 35 and 37 which are electrically connected by the tubular conducting sleeve 31, is mounted for sliding movement on the fixed conducting tube 25, and is connected by a key 47 of conducting material with an operating rod 49 also of conducting material. The operating rod 49 is mounted for sliding movement within the fixed conducting tube 25 and the tube 25 is provided with a pair of elongated slots 51 for accommodating the key 47 and for permitting movement of the switch member by the operating rod 49.

The stationary contacts 21 and 39 and the cooperating movable contacts 35 and 37 form two pairs of separable contacts which are connected in series in the circuit through the device by means of the conducting sleeve 31. The two movable contacts 35 and 37 are simultaneously movable to open and to closed circuit position by the axial movement of the switch member 23 and operating rod 49.

In the closed circuit position of the switch shown in Fig. 1, the movable contacts 35 and 37 engage their cooperating stationary contacts 21 and 39, respectively, and the circuit through the device extends from the upper terminal cap 9 through the stationary contact portion 21, movable contact 35, conducting sleeve 31, movable contact 37, stationary contact 39, and the spider 41 to the opposite terminal sleeve 43.

To open the circuit interrupter the operating rod 49 is moved downwardly by any suitable operating mechanism to cause the switch member 23 carrying the movable contacts 35 and 37 to move to the open circuit position out of engagement and away from the cooperating stationary contacts 21 and 39. Thus in the open circuit posiiton two gaps in series are introduced in the circuit through the device.

In order to extinguish the arcs drawn between the pairs of separable contacts, there is provided in the lower section of the casing 7 a stack of annular plates 53 composed of an insulating material, such as horn fibre, which evolves an arc extinguishing gas when subjected to the heat or contact of an arc. The plates 53 are held in position in the lower section of the casing 7 by means of a ring 55 which clamps the plates together against the cap 11 to form a solid gas-generating structure. The plates 53 are shaped to provide a tapered annular slot 57 in which the arc drawn between the movable contact 37 and the stationary contact 39 plays, one wall of the slot being formed by the inner surfaces of the plates 53 and the opposite wall being formed by the fibre insulating sleeve 33 of the switch member 23 when the switch member 23 is moved downwardly.

The purpose of the tapered shape of the slot 57 is to adapt the device for interrupting currents of varying magnitude over a considerable range. By providing a tapered annular slot, arcs of varying current magnitude are caused to intimately engage the walls of the annular slot. Current arcs of large magnitude will engage the enlarged upper end of the annular slot and current arcs of small magnitude will engage the walls of the lower or narrow portion of the slot.

In order to ensure a more complete and uniform engagement of the arc with the walls of the annular tapered slot 57 there is provided an electromagnet 59 which is carried by the spider 41 and an additional spider 61. The electromagnet 59 has a winding 63 which is adapted to be connected in series in the circuit of the two arcs by means of an electrode 65 arranged in the path of the arc drawn between the movable contact 37 and the stationary contact 39 and insulated from the stationary contact by a sleeve 67. The electrode 65 is also insulated from the spider 61 by an insulating ring 64. One terminal of the winding 63 is connected to the fixed electrode 65 and the opposite terminal thereof is electrically connected to the spider 41 and through the same to the terminal sleeve 43. As soon as the movable contact 37 passes the electrode 65 in its downward opening movement, the arc drawn between the movable contact 37 and the stationary contact 39 is transferred from the stationary contact 39 to the fixed electrode 65 so that at this point the coil 63 of the magnet 59 is connected in series circuit with the arc and is traversed by the current flowing through the interrupting device. The electromagnet 59 when energized serves to rotate the arc drawn between the movable contact 37 and the fixed electrode 65 around the annular tapered slot 57 so that it is caused to intimately engage a large portion of the surface of the walls of the slot.

The annular slot 57 forms a pressure chamber which communicates with the nozzle formed by the electrode 13 through openings in the spiders 41 and 61 around the electromagnet 59.

The pressure developed by the arc in the annular slot 57 causes the gases evolved by the action of the arc on the walls of the slot 57 to be blasted through the openings in the spiders 41 and 61 around the electromanet 59 and out through the nozzle 13 to extinguish the arc drawn in the nozzle.

As soon as the movable contacts 35 and 37 have separated a predetermined distance from their cooperating stationary contacts 21 and 39, respectively, during a circuit opening operation of the device, the arc extinguishing gases generated under pressure in the annular slot 57 are blasted up through the casing and through the arc drawn between the contacts 21 and 35 and out through the nozzle 13. This initial blast of gas blows the arc drawn between the contacts 21 and 35 upwardly in the throat of the nozzle 13 so that its terminal which was on the movable contact 35 is transferred to the fixed electrode 24. The other terminal of the arc which was on the contact 21 is driven up through the throat of the electrode 13 to the arcing tip portion 19, so that the arc is looped up somewhat in the manner so indicated at 69 in Fig. 2, having one of its terminals on the arcing tip portion 19 and its other terminal on the nose 27 of the fixed electrode 24.

At this point the current flows through the interrupting device as follows: from the terminal cap 9 through the arcing tip portion 19 of the electrode 13, through the arc 69, fixed electrode 24, through the fixed conducting tube 25 and the conducting sleeve 31, movable contact 37, through another arc 71 to the fixed electrode 65 through the winding 63 of the electromagnet 59 and spider 41 to the opposite terminal sleeve 43 of the device. The position of the parts at this stage of the opening operation are illustrated in Fig. 2.

The gases generated in the annular slot 57 are at a very high temperature and for this reason are not well suited for interrupting an arc efficiently, although they are capable of interrupting lower voltages. In order to cool and deionize the gases there is interposed between the pressure chamber or annular slot 57 and the nozzle 13 a cooling means indicated generally at 73. The cooling means 73 comprises a plurality of concentrically disposed tubes 75 composed of insulating material such as horn fibre which evolves an arc extinguishing material when heated. The tubes 75 are mounted within the casing 7 by means of a pair of spiders 76 and 78. The tubes 75 provide a large cooling surface area along which the hot gases generated in the annular slot 57 are passed prior to their being blasted out through the nozzle 13. The heat of vaporization of the hot gases, in passing over the cooling surface of the cooling means is absorbed by the tubes 75 so that the gases are cooled and deionized to increase their dielectric or arc extinguishing strength before being blasted through the nozzle 13. The heat of the hot gases absorbed by the tubes 75 liberates an additional quantity of gas from the material of the tubes which is at a low enough temperature to materially assist in extinguishing the arc drawn in the throat of the nozzle.

The ability of a gas blast type circuit interrupter to interrupt a circuit is largely dependent upon the rate of rise of the recovery voltage. The higher the rate of rise of the recovery voltage the more difficult the circuit is to interrupt. In order to reduce the rate of rise of recovery voltage and thus increase the circuit interrupting ability of the device, there may be provided a resistance 77 which is connected at one end to the terminal cap 9 and at its other end to the metal cap 11, so as to be shunted across the arc 69 in the throat of the nozzle of electrode 13. The resistance 77 is connected to the electrode 13 by the conducting material of the terminal cap 9 and to the fixed electrode 24 through the cap 11, a flexible conductor 79, operating rod 49 and the fixed conducting tube 25. The resistance very greatly increases the effectiveness of the gas blast through the nozzle in extinguishing the arc between the annular electrode 13 and the fixed electrode 24. The residual current which flows through the resistance 77 in series with the arc 71 following extinction of the arc 69 in the nozzle is readily interrupted in the annular slot 57.

During circuit interruption the amount of gas generated by the arc in the annular slot 57 is proportional to the magnitude of the current flowing through the interrupter. In the case of heavy magnitude currents a large quantity of gas is generated so that the circuit will be interrupted when the separable contacts have been separated only a small part of their total distance of separation. In the case of lower currents a greater distance of separation of the contacts is required before a sufficient quantity of gas is generated to extinguish the arc, it being necessary for the arc to play in the restricted lower portion of the slot 57 to generate sufficient gas in the case of low magnitude currents. It will be understood, however, a smaller quantity of gas is required to extinguish low current arcs; therefore, the device automatically operates to generate the required amount of gas in accordance with the magnitude of the current to be interrupted.

The cooling means 73 may take other forms than the specific structure shown and described. Any suitable form of cooling means may be used which has a multiplicity of passages or interstices to form a large cooling surface area for cooling the gases.

While the plates of the gas generating structure have been described as being composed of horn fibre, it is to be understood that any suitable material which evolves an arc extinguishing gas or vapor when acted on by an arc may be used in place thereof.

The operating means for moving the operating rod 49 may be similar to any of the various types of operating mechanism which are well known in the art. For example, the operating rod may be biased to open circuit position by a suitable spring and releasably held in closed circuit position by a current responsive trip device such as a fusible element or a current responsive latch means. Provision may also be made for manually or electrically operating the rod 49 if desired.

The operation of the device is briefly as follows: To interrupt the circuit the operating rod 49 is moved downwardly to cause the movable contacts 35 and 37 carried by the switch member 23 to separate from the cooperating stationary contacts 21 and 39 and draw a plurality of arcs in series, one between the contacts 21 and 35 and another between the contacts 37 and 39. As soon as the contact 37 passes beyond the fixed electrode 65 the arc drawn between the contact 37 and the contact 39 leaves the contact 39 and transfers to the fixed electrode 65, causing energization of the electromagnet 59. The magnetic field produced by the electromagnet 59 causes the arc to be rotated in the annular chamber 57 where it engages and heats the walls of the chamber 57 to generate a quantity of arc extinguishing gas. The pressure produced by the arc causes the gas to be blasted up through the tubes 75 of the cooling means 73 and through the arc drawn between the movable contact 35 and the stationary contact 21 and out through the nozzle opening. The initial blast of gas through the arc drawn between the contacts 21 and 35 moves the arc up into the throat 29 of the electrode 13 with one of its terminals on the arcing tip portion 19 of the electrode 13 and its other terminal on the fixed electrode 24 as illustrated in Fig. 2. The blast of cooled arc extinguishing gas through the arc in the nozzle quickly extinguishes the same in a well known manner. The arc drawn between the movable contact 37 and the electrode 65 which is connected in series with the resistance 77 following extinction of the arc 69 in the nozzle is quickly extinguished in the annular slot 57 in a well known manner. To reclose the circuit interrupter the operating rod 49 is moved upwardly to cause the movable contacts 35 and 37 carried by the switch member 23 to move into engagement with their cooperating stationary contacts 21 and 39.

The circuit breaker illustrated in Figs. 1, 2 and 5 thus far described is constructed in accordance with the invention of Herbert L. Rawlins com-

pletely described and claimed in the aforesaid patent application.

I have discovered that when the above-described circuit breaker is used under some conditions to interrupt large currents at high voltages there is a tendency, when an all-metal nozzle 13 is used, toward long arcing time as a result of the arc restriking after a current zero between the nose 27 and the lower portion of the nozzle 13 nearest the nose 27. To prevent this reestablishment of the extinguished arc after a current zero, I have provided an annular insulating insert 81. This annular insert 81 prevents the arc restriking at high voltages, and thus reduces the arcing time when the interrupter is used to break large currents at high voltages. I have found that if the annular insulating insert 81 is too long, the arc terminal, which played on the stationary contact 21 when the breaker was slightly opened, will not be blown by the initial blast of arc extinguishing gas from the pressure chamber 57 across the annular insert 81 to the arcing tip portion 19. On the other hand, I have found that if the annular insulating insert 81 is too short, the long arcing time obtained when the breaker is used to interrupt large currents at high voltages will not be effectively reduced. The relative size of the insert 81 to the size of the entire breaker, as shown in Figs. 1 and 2, has been found to be very satisfactory.

The circuit breaker illustrated in Figs. 3, 4 and 6 is similar in basic construction to the Rawlins breaker described above, but it has a number of improvements embodying the present invention. It comprises a two-part casing of insulating material, generally indicated by the reference numeral 7, and on the ends of which are threaded a pair of metal caps 83 and 11. The cap 83 forms one terminal of the device and has a central opening 85, through which is loosely inserted in the closed circuit position of the breaker a central movable electrode 87. A plurality of radially disposed conducting plates 89 biased inwardly by a ring-shaped helical tension spring 91 serve to electrically connect the cap 83 to the central movable electrode 87 in the closed circuit position of the breaker, as illustrated in Fig. 3. The central movable electrode 87 forms the upper end of a tubular movable conducting member 93 adapted for longitudinal movement axially of the casing 7 to open and close the breaker.

Integrally formed with the movable tubular conducting member 93 is the movable contact 95, which performs the same function as movable contact 37 in the circuit breaker illustrated in Figs. 1, 2 and 5. At the lower end of the movable tubular conducting member 93 is formed a ring 97 which may be engaged by any suitable form of operating mechanism. The operating mechanism for the breaker is not shown, but it may be of any suitable type. A vent 99 in the lower end of the movable tubular conducting member 93 communicates to the interior of the movable tubular conducting member 93, and thus permits the flow of gas from within the casing 7 to the air surrounding the casing 7 when the circuit breaker is being opened.

The electromagnet 59, and its method of connection into the circuit through the breaker, is identical with that of the electromagnet 59 previously described in connection with the circuit breaker illustrated in Figs. 1, 2 and 5. The construction of the gas generating and pressure chamber 57 and its function are the same as in the previously described breaker illustrated in Figs. 1, 2 and 5. The cooling means 73 is the same as the cooling means previously described. An insulating sleeve 33, analogous to the sleeve 33 in Figs. 1, 2 and 5, surrounds the upper portion of the movable tubular conducting member 93, and performs the same function as the sleeve 33 in Figs. 1, 2 and 5. The resistance 77 and its function are the same as resistance 77 previously described in connection with the circuit interrupter illustrated in Figs. 1, 2 and 5.

It will be noted that in the circuit breaker illustrated in Figs. 3, 4 and 6 there is provided an annular insulating insert 101 which changes the direction of flow of the arc extinguishing gases formed both in pressure chamber 57 and in the cooling means 73. Thus, the arc extinguishing gases do not flow substantially longitudinally of the arc stream as in the circuit interrupter illustrated in Figs. 1, 2 and 5; but instead the insulating annular insert 101 forces the arc extinguishing gases to flow substantially perpendicularly into the arc stream, as shown in Fig. 4.

When the circuit interrupter is in the closed circuit position, as shown in Fig. 3, the electrical circuit through the breaker consists of the following: terminal lug 15, upper terminal cap 83, conducting plates 89, movable tubular conducting member 93, movable contact 95, stationary contact 39, spider 41, terminal sleeve 43 to terminal lug 45. When it is desired to open the interrupter, the operating mechanism (not shown) is actuated to pull the ring 97 and hence the movable tubular conducting member 93 downward. During the initial portion of the opening operation of the breaker, two arcs are formed, one arc being formed between the conducting plates 89 and the central electrode 87, and the other arc being formed between the stationary contact 39 and the movable contact 95. When movable contact 95 moves below stationary electrode 65, the upper terminal of the second arc is transferred from contact 39 to electrode 65, bringing the electromagnet 59 into the circuit. The initial blast of arc extinguishing gas formed in chamber 57 and augmented by the formation of arc extinguishing gas in the cooling chamber 73 transfers the upper terminal of the upper arc from the conducting plates 89 to the arcing region 103 of the terminal cap 83 in a manner similar to that described in connection with the circuit breaker illustrated in Figs. 1, 2 and 5. Continued downward movement of the movable tubular conducting member 93 increases the distance between the central electrode 87 and the arcing region 103 to lengthen the arc stream, and also to initially subject the arc stream to a substantially perpendicular blast of arc extinguishing gas which thereafter changes to a parallel blast of gas. The upper arc is extinguished by this blast of gas, and the lower arc which is now in series with the shunting resistance 77 is also broken by the arc extinguishing gas formed in pressure chamber 57. There are consequently two air gaps introduced into the circuit through the breaker in the open circuit position. The full open circuit position of the breaker is not shown in the drawings.

It will be noted in connection with the interrupter illustrated in Figs. 3, 4 and 6 that the central electrode 87 moves away from the upper terminal cap 83 during the opening operation of the interrupter, thus lengthening the arc stream and also increasing the arc restriking distance. It will also be observed that, during the initial opening operation when the central

electrode 87 has just separated from the conducting plates 89, the position of the central electrode 87 in the annular insulating insert 101 is such as to cause the arc extinguishing gas formed in chamber 57 and cooling chamber 73 to flow upward substantially longitudinally of the arc stream to force a transfer of the upper arc terminal from the conducting plates 89 to the arcing region 103 of terminal cap 83. When, however, the central electrode 87 has moved down past the annular insulating insert 101, the flow of gas below the insert 101 is substantially perpendicular to the arc stream, as shown in Fig. 4, and thus maintains the pressure on the last little thread of arc just preceding a current zero. Since the gas flow is substantially perpendicular to the arc stream, and since the gas flows out of the casing 7 through the opening 85 in terminal cap 83 and through the tubular member 93, both of which are substantially parallel to the arc stream, all the kinetic energy of the gas is given up near point A, thereby increasing the lateral pressure on the arc at this point and forcing the cross-section of the arc at this point to zero as the current approaches its zero value. Point A, therefore, represents the region of most rapid gain in dielectric, and from this point fresh gas continuously sweeps the residual ionization back in the direction of the arc terminals 103 and 87, and hence out of the interrupter. Any thermal ionic emission from the arcing region 103 or the electrode 87 is thus immediately carried out of the interrupter. Also, most of the arc energy and, therefore, most of the heat and metallic vapor are carried directly out of the breaker by the opening 85 and through the tubular member 93, and not into the arc stream. Point A, which is the point where the dielectric should build up most rapidly, is near to the central electrode 87, and hence thermal ionic emission from the hot central electrode 87 should not be permitted to enter the region near point A to prolong the arcing. The opening through the tubular movable conducting member 93 permits the fresh gas to sweep the thermal ionic emission and the heat from the central electrode 87 away from region A and out of the breaker casing 7.

While the invention has been disclosed in accordance with the provisions of the patent statutes, it is to be understood that various changes in the structural details thereof may be made without departing from the spirit of the invention. It is desired, therefore, that the appended claims be given the broadest reasonable interpretation permissible in view of the prior art.

I claim as my invention:

1. In a circuit interrupter, a pair of fixed electrodes one being annularly shaped and the other projecting into the throat of said annularly-shaped electrode and spaced therefrom, an annular insulating member positioned within said annular electrode at a place which is at a shorter distance to the other electrode than is any part of said annular electrode, means for establishing an arc between said fixed electrodes, means for lengthening the arc and extinguishing it, said annular insulating member increasing the restriking distance between the electrodes after the lengthened arc has been extinguished.

2. In a circuit interrupter, a casing having an annular electrode therein and having a pressure chamber communicating therewith, a fixed electrode in said casing projecting near said annular electrode and spaced therefrom, an annular insulating member positioned within the throat of said annular electrode, means for generating arc extinguishing fluid under pressure in said pressure chamber, said arc extinguishing fluid lengthening the arc drawn between said electrodes during the circuit opening operation of the interrupter and finally extinguishing said lengthened arc, said annular insulating member helping to prevent the restriking between the two electrodes of the arc after the lengthened arc has been extinguished.

3. In a circuit interrupter, a casing having an annular electrode forming a nozzle and having a pressure chamber communicating with said nozzle, a fixed electrode in said casing projecting into the throat of said annular electrode and spaced therefrom, an annular insulating insert positioned within the throat of said annular electrode so as to be nearest the fixed electrode, means providing fluid under pressure within said chamber, means for establishing an arc between said electrodes during the opening operation of said interrupter, means for lengthening said drawn arc by causing one terminal thereof to jump across said insert and for extinguishing the same, said annular insulating insert increasing the restriking distance between said two electrodes after the lengthened arc has been extinguished.

4. In a circuit interrupter, a casing having an annular electrode forming a nozzle and having a pressure chamber communicating with said nozzle, a fixed electrode positioned within said casing projecting into the throat of said annular electrode and spaced therefrom, means for providing fluid pressure in said chamber, an annular insulating member positioned in said annular electrode between it and said fixed electrode, movable contact means for bridging said electrodes, said movable contact means causing an arc to form with one terminal of the arc on the annular electrode and the other terminal of the arc on said fixed electrode during the opening operation of said interrupter, the fluid pressure in said chamber causing the fluid to be blasted through the arc and the nozzle to lengthen said arc by causing one terminal thereof to jump across said insulating member and to extinguish said lengthened arc, said annular insulating member helping to prevent a restriking of the extinguished lengthened arc between said two electrodes.

5. In a circuit interrupting device, a casing having an annular electrode forming a nozzle and a pressure chamber communicating with said nozzle, a movable electrode projecting into the throat of said annular electrode and making contact therewith in the closed circuit position of the interrupting device, means for drawing a plurality of arcs in series one between the annular and movable electrodes and another in said chamber, means in said pressure chamber acted on by the arc therein for developing a fluid under pressure, said fluid being blasted through the arc in said nozzle to extinguish the same, and means for directing the fluid blast initially substantially longitudinally of the arc stream between said movable and said annular electrodes and for directing the fluid blast substantially perpendicularly to the arc during the final portion of the opening operation of the interrupter.

6. In a circuit interrupter, a casing having an annular electrode forming a nozzle and a pressure chamber communicating with said nozzle, said nozzle having a contacting portion and an

arcing portion, a movable electrode engageable with said contacting portion in the closed circuit position, means for drawing a plurality of arcs one between said annular and said movable electrodes and another in said pressure chamber, means in said pressure chamber acted on by said arc formed in the pressure chamber for causing a blast of fluid through said arc in the nozzle to extinguish the same, means for directing said blast during the initial part of the opening operation of the interrupter substantially longitudinally of said arc in the nozzle to lengthen the same by moving one terminal thereof from said contacting portion to said arcing portion, and means for directing said blast during the latter part of the opening operation of the interrupter substantially perpendicular to said arc in the nozzle to effect the extinguishment thereof.

7. In a circuit interrupter, a casing having an annular electrode forming a nozzle, a second nozzle formed of insulating material within said casing and spaced from said annular electrode and having the opening thereof of larger cross-section than the opening in said annular electrode, a pressure chamber communicating with both said nozzles, a movable electrode which passes through said insulating nozzle to engage said annular electrode in the closed circuit position, means for drawing a plurality of arcs one between said annular and said movable electrodes and another in said pressure chamber, means in said pressure chamber acted on by said arc formed in the pressure chamber for causing a blast of fluid through said arc in the nozzle to extinguish the same, said insulating nozzle and said movable electrode cooperating so that the extinguishing blast of fluid first lengthens the arc and then strikes the arc substantially perpendicularly thereof.

8. In a circuit interrupter, a casing having an annular electrode forming a nozzle, a second nozzle formed of insulating material within said casing and spaced from said annular electrode, a pressure chamber communicating with both said nozzles, a movable tubular electrode which passes through said insulating nozzle to engage said annular electrode in the closed circuit position, means for drawing a plurality of arcs one between said annular and said movable electrodes and another in said pressure chamber, means in said pressure chamber acted on by the arc drawn within said chamber for causing a blast of fluid through said arc in the nozzle to extinguish the same, said insulating nozzle directing the fluid blast substantially perpendicularly to the arc stream in the nozzle during the final portion of the opening operation of the interrupter, said tubular movable electrode discharging out of said casing fluid which has been acted upon by the arc drawn in the nozzle.

9. In a circuit interrupter, a casing having an annular electrode forming a nozzle, a second nozzle formed of insulating material disposed within said casing and spaced from said annular electrode, a fixed contact disposed between said two nozzles, a movable electrode which passes through said insulating nozzle to engage said fixed contact in the closed circuit position, a pressure chamber, means for drawing a plurality of arcs one between said fixed contact and said movable electrode and another in said pressure chamber, means in said pressure chamber acted on by said arc drawn in said chamber for causing a blast of fluid through said two nozzles which first transfers the arc between said fixed contact and said movable electrode to said annular electrode and said movable electrode during the initial portion of the circuit opening operation and then effects an extinguishment of the transferred arc between said movable electrode and said annular electrode during the final portion of the circuit opening operation, said insulating nozzle directing the final extinguishing blast substantially perpendicularly to the arc stream.

10. In a circuit interrupter, a casing having an annular electrode forming a nozzle, a second nozzle formed of insulating material disposed within said casing and spaced from said annular electrode, a fixed contact disposed between said two nozzles, a movable tubular electrode which passes through said insulating nozzle to engage said fixed contact in the closed circuit position, a pressure chamber, means for drawing a plurality of arcs one between said fixed contact and said movable electrode and another in said pressure chamber, means in said pressure chamber acted on by said arc drawn in said chamber for causing a blast of fluid through said two nozzles which first transfers the arc between said fixed contact and said movable electrode to said annular electrode and said movable electrode during the initial portion of the circuit opening operation and then effects the extinguishment of the transferred arc during the final portion of the circuit opening operation, said insulating nozzle having such a configuration that it directs the blast initially substantially longitudinally of the arc stream to effect the transfer thereof and then later directs the blast substantially perpendicularly of the transferred arc said tubular movable electrode discharging out of said casing fluid which has been subjected to the arc.

11. In a circuit interrupter, a casing having an annular electrode forming a nozzle, a second nozzle formed of insulating material disposed within said casing and spaced from said annular electrode, a fixed contact disposed between said two nozzles, a movable tubular electrode which passes through said insulating nozzle to engage said fixed contact in the closed circuit position, a pressure chamber, means for drawing a plurality of arcs one between said fixed contact and said movable electrode and another in said pressure chamber, means in said pressure chamber acted on by said arc drawn therein for causing a blast of fluid through said two nozzles which first transfers the arc between said fixed contact and said movable electrode to said annular electrode and said movable electrode during the initial portion of the circuit opening operation of the interrupter and then effects the extinguishment of the transferred arc during the final portion of the circuit opening operation, said insulating nozzle having such a configuration that it directs the blast initially substantially longitudinally of the arc stream to effect the transfer thereof and then later directs the blast substantially perpendicularly of the transferred arc, said tubular movable electrode discharging out of said casing fluid which has been subjected to the arc, a resistance shunting said annular and said movable electrodes and in series with the arc in said chamber for aiding in the complete extinction of said arc in said nozzle, and means for extinguishing said arc in said chamber for interrupting said resistance circuit.

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