

Dec. 8, 1942.

B. P. BAKER

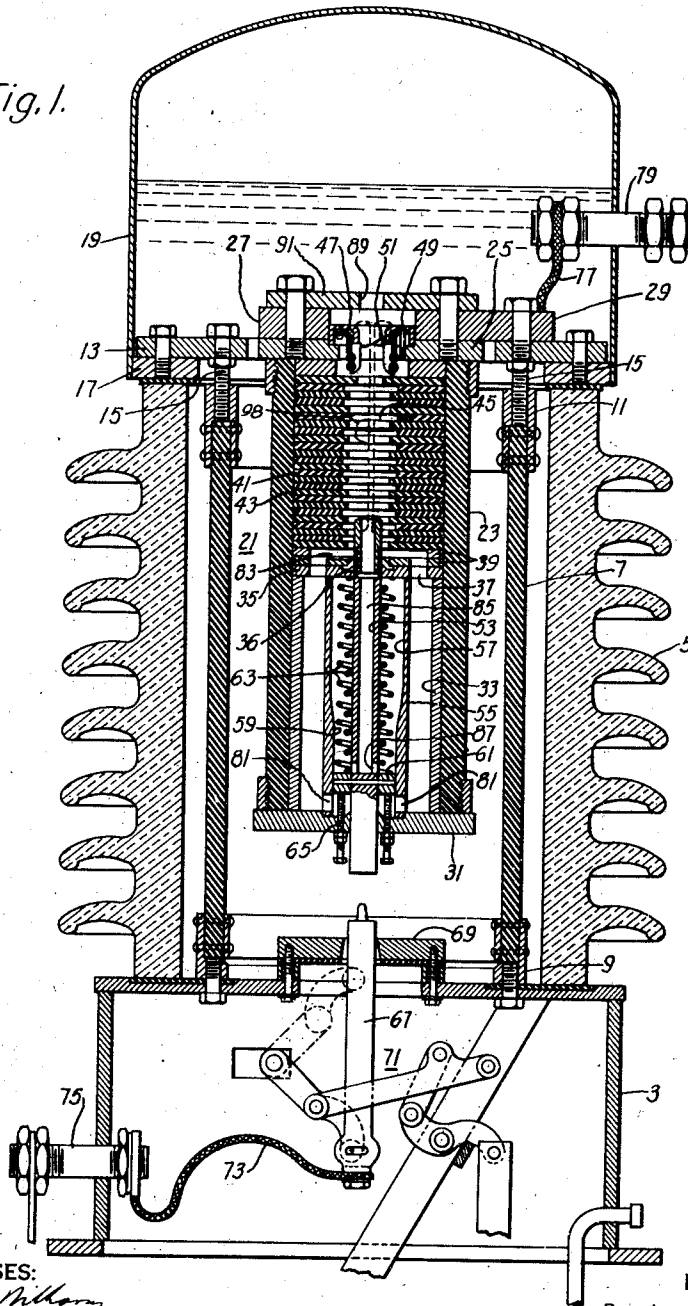
2,304,529

CIRCUIT INTERRUPTER

Filed May 15, 1940

2 Sheets-Sheet 1

Fig. 1.



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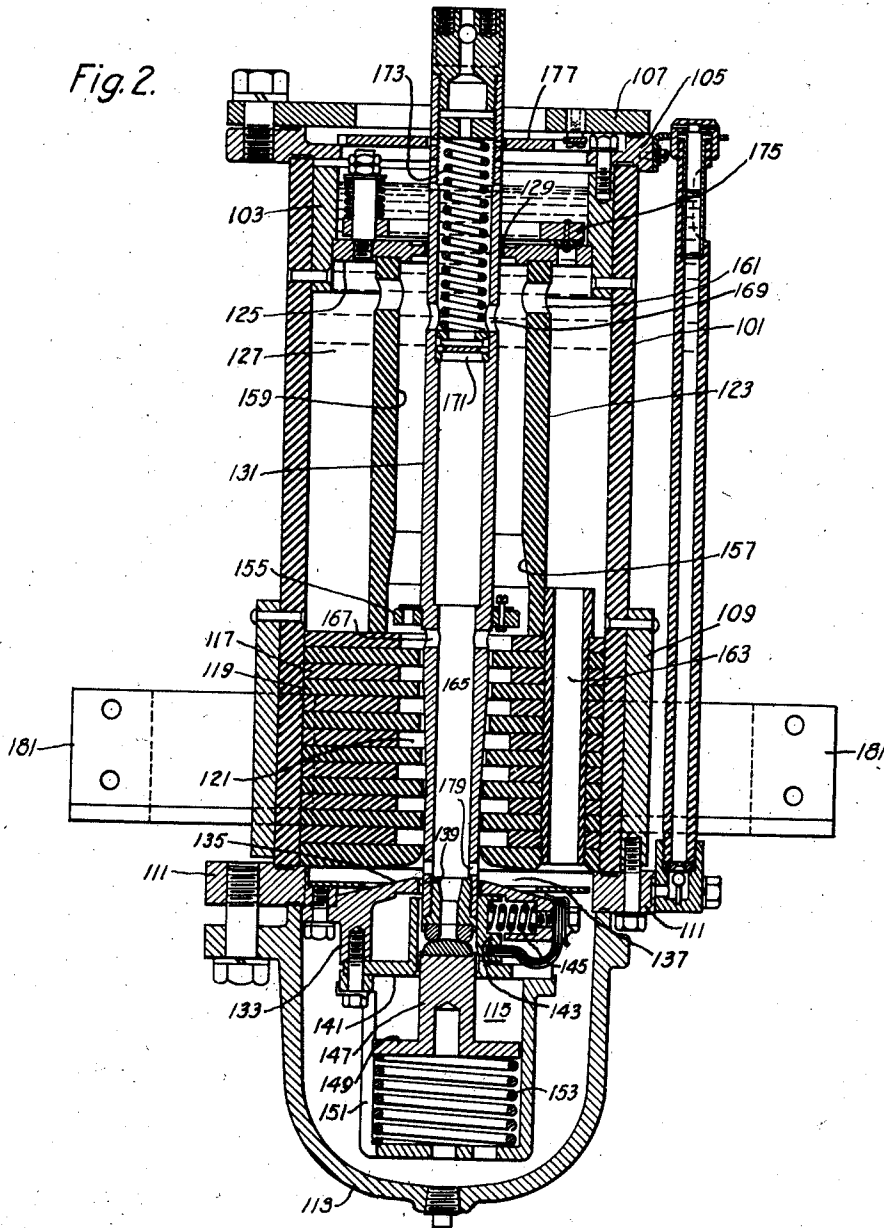
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CIRCUIT INTERRUPTER

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2 Sheets-Sheet 2

Fig. 2.



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2,304,529

CIRCUIT INTERRUPTER

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Application May 15, 1940, Serial No. 335,218

22 Claims. (Cl. 200—150)

This invention relates to improvements in circuit interrupters, and more particularly to circuit interrupters of the type wherein arc extinction is at least in part effected by subjecting the arc to a flow of arc extinguishing fluid.

The control of power by the use of circuit breakers in modern high-voltage high-power systems involves complete circuit opening operations within at least .133 second which corresponds to the time duration of eight cycles at a frequency of sixty cycles per second. In some instances complete circuit interruption must be accomplished in from 2.5 to 3 cycles. In order to obtain this high speed operation, attempts have been made to hasten deionization of the arc stream by applying a strong deionizing action as soon as the arc drawing contacts part. Any attempt, however, to hasten arc extinction before a normal current zero frequently results in high arc voltage, sudden peaks of arc energy, voltage surges and excessive mechanical shock to the circuit interrupting mechanism.

In Patent No. 2,253,009, granted to me August 19, 1941, and assigned to the assignee of this application, I have shown and described a circuit interrupting structure which obviates the undesirable effects of too rapid deionizing action in that it provides a flow of arc extinguishing fluid with respect to the arc such that when the instantaneous value of current is high there is a minimum of interference with the arc stream or tendency to break its continuity. In accordance with the aforesaid patent, I have found that arc extinction can be obtained at the first current zero following establishment of the arc by drawing the arc in an elongated relatively narrow arc chamber and subjecting it to a flow of arc extinguishing fluid principally longitudinally of the arc stream and exercising pressure control such that the generated arc gases are permitted to escape freely during the high values of instantaneous current so as to subject the arc stream to but little deionizing action and then, just preceding a current zero, pressure in the arc chamber is permitted to rise rapidly so as to subject the rapidly decaying arc stream to a strong deionizing action.

My present invention has for its object the provision of a circuit interrupter which operates upon the same general principles enumerated above, but contemplates structure for obtaining the desired results in a more facile and advantageous manner.

A more specific object of my invention resides in the provision of a circuit interrupter having

a contact structure arranged to establish an arc centrally of an elongated arc chamber in conjunction with means for maintaining the arc surrounded by a flow of arc extinguishing fluid so as to protect the walls of the arc chamber from the erosive effect of the arc.

Another object of the invention resides in the provision of a contact structure in an arc chamber of a circuit interrupter so arranged that a flow of arc extinguishing fluid through the arc chamber causes the arc terminals to be moved off of their respective contact surfaces to assist in arc extinction.

It is also an object of my invention to improve the interrupting performance of a circuit interrupter of a type in which the arc is subjected to a longitudinal flow of arc extinguishing fluid by delaying the streaming action of the fluid upon the arc until an arc of predetermined length has been established.

A further object of the invention resides in the provision of a circuit interrupter of the fluid flow type in which the flow of fluid for extinguishing the arc is so conducted that substantially all deleterious solids formed by the action of the arc upon the arc extinguishing fluid are swept out of the arcing chamber during each circuit interrupting operation, thereby keeping the walls defining the arc chamber free from foreign deposits which would normally cause voltage breakdown.

Still another object of the invention resides in the provision of a circuit interrupter of the fluid flow type wherein improved performance is obtained by associating the fluid moving means with the movable contact mechanism and arranging the fluid moving means in such manner that the arc pressure within the arcing chamber assists in actuating the fluid moving means and the movable contact structure during a circuit opening operation.

Other objects and advantages will appear more fully in the following description when read in connection with the accompanying drawings, in which:

Figure 1 is a sectional view showing a circuit interrupter embodying my invention; and

Fig. 2 is a sectional view showing a modified form of circuit interrupter illustrative of my invention.

Referring to the drawings, the reference numeral 3 designates a casing upon which is mounted a tubular insulator 5, preferably of vitreous weatherproof material. Disposed within the tubular insulator 5 is a tubular support and

strain member 7 of insulating material, the ends of which are provided with metal sections 9 and 11. The lower metal section 9 is preferably secured to the casing 3 by bolts as shown whereas the upper metal section 11 serves as a means for securing an annular metallic plate 13 as by means of bolts 15. The annular plate 13 in this instance is bolted to an annular plate 17 which rests upon the upper end of the insulator 5. The annular plate 17 in turn supports an upper cap or closure member 19. Suspended from the annular plate 13 and extending into the tubular member 7 is a circuit interrupting unit generally indicated at 21.

The circuit interrupting unit 21 comprises a cylindrical member 23 of insulating material having a flanged member 25, preferably of metal, threaded or otherwise secured to the upper end thereof to which is secured a support plate 27 having a plurality of arms 29, only one of which is shown, adapted to be bolted to the annular plate 13. A metallic flanged closure 31 is screw-threaded to the lower end of the insulating member 23 and supports a lining member 33 extending upwardly substantially one-half the length of the insulating member 23. Resting upon the upper end of the tubular lining member 33 is a metallic disk 35 having a central aperture 36 therein and a plurality of apertures 37 disposed about the central aperture. The plate 35 carries a pair of spacing washers 39 of insulating material. Disposed above the washers 39 are a plurality of washers 41 and 43 of insulating material having different internal diameters. The stack of washers 41 and 43 define an elongated arc passage 45 having a corrugated wall structure.

Disposed within a recess 47 in the upper closure member 25 is a stationary contact assembly 49 of the tulip type including a plurality of contact fingers 51. A contact rod 53 extends through the lower closure member 31 and the aperture 36 in the plate 35, and is operative within the arc passage 45 and coacts with the contact fingers 51 of the stationary contact assembly 49. Surrounding the contact rod 53 and disposed between the lower closure 31 and the plate 35 is a cylindrical member 55 having an inside diameter at its upper portion as shown at 57, that is somewhat larger than the inside diameter of its lower portion as shown at 59.

A piston 61 secured to the contact rod 53, has a diameter substantially equal to that of the cylinder 55 at the lower end thereof and is operative in the cylinder. A plurality of springs 63 surrounding the contact rod 53, the respective ends of which bear against the plate 35 and the piston 61, bias the contact rod 53 to the open circuit position. The full open circuit position of the contact rod 53 is determined by suitable stop means such as the screws 65 mounted in the closure member 31 against which the piston 61 is adapted to come to rest. In the closed circuit position of the interrupter the contact rod 53 is in engagement with the contact fingers 51. In this position the piston 61, which is secured to the rod 53, takes a position adjacent to the plate 35 in the enlarged portion 57 of the cylinder 55.

Movement of the contact rod 53 in this instance is accomplished by an auxiliary contact rod 67 movable longitudinally through a support 69 and adapted to releasably engage the lower end of the rod 53. The auxiliary contact rod 67 in this instance is actuated by a suitable operating linkage generally indicated at 71, which may be of any well known type, preferably of a form to impart substantially straight-line mo-

tion to the contact member 67. It should be noted that the contact member 67 constitutes part of the electrical circuit through the interrupter and is connected by a flexible conductor 73 to a terminal 75 extending from the lower casing 3.

In the closed circuit position the auxiliary contact member 67 makes contacting engagement with the contact rod 53 which, in turn, engages the contact fingers 51 so as to complete the electrical circuit from the terminal 75, through conductor 73, auxiliary contact 67, contact rod 53, contact fingers 51, closure member 25, support plate 27, which connects by means of a conductor 77 to a second line terminal 79 extending from the upper casing 19. When the interrupter is in the full open circuit position, the auxiliary contact 67 is separated from the contact rod 53 as shown to provide an isolating gap in the circuit in addition to that formed between the contact rod 53 and the contact fingers 51.

The cylindrical member 55 has a plurality of openings 81 adjacent its lower end to provide a passage from within the cylindrical member 55 through the annular space between the cylinder 55 and the lining member 33 through the openings 37 in the plate 35 and hence to the arc passage 45. It will be noted that the plates 39 space the stack of plates 41, 43 from the lower plate 35 so as to provide a radial flow passage 63 towards the contact rod 53 at the lower end of the arc passage 45. The contact rod 53 is also preferably of tubular form, at least from its upper end to the piston 61, so as to provide a flow passage 85 therein. The passage 85 communicates with the space within the cylinder 55 by means of openings 87.

The circuit interrupter, in accordance with the foregoing description, is effective to interrupt high power circuits when using arc extinguishing fluids generally, either gaseous or liquid, as a means to assist arc extinction. When the arc extinguishing fluid used is a liquid such as oil or water, the housing is preferably filled with liquid to the level shown. Under these conditions the circuit interrupting unit 21 is completely submerged so as to fill the arc passage 45 and the various flow passages and chambers connected therewith.

The operation of the interrupter during a circuit interruption is as follows: If an overload condition exists in the circuit in which the interrupter is connected, suitable trip means (not shown) will cause the operating mechanism 71 to release the auxiliary contact 67 to permit it to move downwardly which at the same time releases the movable contact rod 53, thereby enabling the contact rod 53 and the auxiliary contact 67 to move in unison under the influence of the operating springs 63. As the contact rod 53 and the contact fingers 51 separate, an arc will be drawn in the passage 45. During the initial portion of the opening movement of the contact rod 53, the piston 61 carried thereby is operating in the enlarged portion 57 of the cylinder 55 which provides considerable clearance around the periphery of the piston 61 so that substantially no liquid is moved by the piston through the openings 81 and upwardly through the flow passage 83 in communication with the lower end of the arc passage 45. Liquid movement by the piston 61 therefore does not take place until the piston reaches the portion 59 of lesser diameter in the cylinder 55. In the meantime the upper end of contact rod 53 has sep-

arated from the contact fingers 51 a distance to draw an arc of appreciable length.

The length of arc preferred depends mainly upon the voltage rating of the interrupter, but in general corresponds to the minimum extinction distance for the particular voltage rating. In other words, the flow of liquid with respect to the arc is delayed until the arc has assumed a length which will be responsive to deionizing means, and arc extinction becomes possible.

The flow of liquid established by the piston 61 enters the arc passage 45 at the lower end through the radial passage 83 and flows upwardly in surrounding relation with respect to the contact rod 53 and also surrounds the arc drawn within the passage 45 so as to maintain it substantially centered with respect to the passage, thereby keeping the arc from eroding the walls of the passage as defined by the washers 41 and 43. The products of decomposition of the arc such as gas and some solids formed by the action of the arc on the arc extinguishing fluid have their principal movement upwardly in the arc passage, that is, in a direction with the flow of arc extinguishing fluid set up by the piston 61. This flow streams past the contact fingers 51 and carries the upper arc terminal up through the contact fingers 51 onto the stationary contact housing 49. The discharge of arc extinguishing fluid and the products of arcing from the arc passage 45 is controlled by a vent opening 89 provided through a cover plate 91 secured to the member 27. The vent opening 89 is preferably disposed in axial alignment with the contact fingers 51 and the arc passage 45 which further assists in maintaining the arc centered with respect to the arc passage 45 in that it always directs the flow centrally of the passage.

The arc passage 45 and the vent opening 89 are so dimensioned in conjunction with the fluid moving piston 61 that sufficient pressure is established within the passage 45 to also cause a flow of arc extinguishing fluid and some of the products of arcing into the passage 85 of the contact rod 53. Flow through the passage 85 carries the lower arc terminal from the tip of the contact rod 53 to the inside of the rod. There is thus a tendency set up by the flow of fluid to sweep both the upper and lower arc terminals of the arc off of their contact surfaces, which greatly assists in bringing about arc extinction. The position taken by the arc with respect to the arc passage 45, the contact fingers 51 and the contact rod 53, under the influence of the foregoing fluid flow conditions, is illustrated at 98 in Fig. 1 of the drawings. This action, however, as well as the main flow of arc extinguishing fluid longitudinally of the arc does not take place until after the arc has been drawn to a length suitable for extinction.

During the initial stages of arcing the pressure is relatively low in the passage 45 and the initial movement of arc extinguishing fluid longitudinally of the arc rapidly removes the products of arcing upwardly through the vent opening 89. However, as arcing continues and as the arc length increases, the pressure within the arc passage 45 increases by virtue of the more rapid formation of the products of arcing which are vented at a given rate through the vent opening 89. The flow of arc extinguishing fluid and the pressure exerted upon the arc stream thus becomes more effective as the instantaneous current in the arc approaches zero. As the arc cur-

rent approaches the current zero and the rate of ionization decreases, the deionizing effect of the arc stream is increased so that at the first current zero after a predetermined contact separation is obtained, the arc stream is deionized to such an extent that the arc will not restrike when the voltage builds up in the opposite direction following the current zero.

The delay of the piston 61 in moving arc extinguishing fluid, in addition to causing more advantageous circumstances for bringing about arc extinction, also has the advantage of permitting the attainment of a higher contact speed with a given energy stored in the accelerating springs 63. This is so because at the outset of the opening movement of the contact rod 53 the piston 61 will move freely within the upper portion 57 of the cylinder 55. Appreciable resistance is not encountered until the piston 61 reaches the constricted portion 59 of the cylinder 55, at which time the arc has assumed a length advantageous to extinction and at which time a relatively slow lengthening is more desirable. The high acceleration of the contact rod 53 during the initial portion of its opening stroke is also desirable in that it materially decreases the overall operating time of the interrupter and it makes available a high kinetic energy for moving fluid at high velocity longitudinally of the arc when the piston 61 finally encounters the constricted portion 59. The operating force moving the contact rod 53 and the piston 61 to the open circuit position is augmented by the pressure in the arc chamber 45 acting through the passage 85 and the openings 87 on the upper side of the piston 61.

It will be noted that the flow of fluid through the arc passage 45 as established by the piston 61 continues until the contact rod 53 reaches its full open circuit position. This arrangement possesses several advantages. Since arc extinction normally takes place before the contact rod 53 reaches its full open circuit position, the flow of arc extinguishing fluid will continue for a considerable period following arc extinction. This continued flow causes the deleterious solids formed by action of the arc upon the arc extinguishing fluid to be swept upwardly out of the arc passage 45, thereby preventing the deposit of these solids upon the walls formed by the plates of the washers 41 and 43, thus maintaining the walls of the passage 45 clean and free from voltage breakdown. Furthermore, in the event that water is used as the arc extinguishing fluid, the piston 61 maintains a high velocity flow between the tip of the contact rod 53 and the contact fingers 51, thereby reducing the heating effect of the residual current following arc extinction to a point below that which would cause vaporization of the water which is now recognized as being the cause for voltage breakdown following arc extinction in breakers of this type. It should be noted that this flow of fluid between the contacts 53 and 51 continues until the piston 61 reaches the stop 65, after which the auxiliary contact 67 parts from the contact 53 to provide an isolating break of sufficient length to prevent further likelihood of voltage breakdown.

In the case where water is used as an arc extinguishing liquid, it is, of course, desirable to provide the isolating break in air rather than a liquid and it would be more advantageous to utilize an arc extinguishing structure arranged as shown in Fig. 2.

In this figure the same general principles of

arc extinction heretofore described will apply, although slight modifications have been made in the general arrangement of the structure as a whole. In Fig. 2, the interrupter housing comprises a tubular member 101 of insulating material having an internally disposed metal collar 103 at its upper end to which is secured a flanged support 105, in turn carrying the cover plate 107. The lower end of the tubular member 101 is provided with an external metal collar 109 to which may be bolted an annular support plate 111, which carries a cup-shaped closure member 113. Disposed within the closure member 113 is a stationary contact assembly generally indicated at 115. Disposed above the stationary contact assembly 115 is a stack of washers 117 and 119 of different internal diameter so as to provide an arc passage 121 having corrugated side walls. The inside diameters of the washers 119 also progressively decrease from top to bottom of the stack of washers so that in general the cross section of the arc passage 121 becomes smaller in the direction aforesaid. A cylindrical member 123 of insulating material is disposed above the stack of washers 117 and 119 and secured at its upper end to a partition member 125 which closes the upper end of the annular space 127 between the cylinder 123 and the outer tubular member 101, and also closes in part, except for an aperture 129, the end of the cylinder 123. A contact rod 131 is mounted for sliding movement through the cover 107 and the aperture 129 in the partition 125 and extends through the arc passage 121 so as to make contacting engagement with the stationary contact assembly 115. Operation of the contact rod 131 to open and closed circuit positions may be accomplished by any suitable mechanism.

The contact assembly 115 comprises a hollow support 133 secured to the support ring 111 and has a frusto-conical face 135 adjacent but spaced from the lowermost plate 119 so as to provide a radial flow passage 137. The conical face 135 of the support 133 has a centrally disposed opening 139 through which the movable contact rod 131 extends. Disposed within the hollow support 133 are a plurality of guide members 141, only one of which is shown, which extend radially inwardly from the outer wall of the support 133 and terminate substantially in alignment with the opening 139. Disposed between the guide members 141 are a plurality of yieldingly mounted contact fingers 143, only one of which is shown, each of which is biased radially inwardly by a suitable spring 145 into contacting engagement with the contact rod 131. An arcing contact 147 of cylindrical form and substantially the same diameter as the contact rod 131 and having a plate-like base 149 is slidably mounted in a guide member 151 secured to the lower portion of the hollow support 133. A spring 153 disposed between the lower portion of the guide member 151 and the plate 149 urges the arcing contact 147 upwardly into engagement with the lower end of the moving contact rod 131. It is thus seen that as the contact rod 131 is moved upwardly, the arcing contact 147 will follow until the plate 149 engages the guide members 141, whereupon the continued movement upwardly of the contact rod 131 will cause separation of the rod from the arcing contact 147.

As the contact rod 131 is moved out of engagement with the contact fingers 143, the arcing contact 147 makes sliding engagement with these contact fingers so as to transfer the electrical

circuit from the contact fingers 143 to the arcing contact 147 and then to the arcing tip of the moving contact rod 131 which is in abutting engagement with the arcing contact 147. Thus, in the closed circuit position an electrical circuit exists in the interrupter from the contact rod 131 to the main current carrying contact fingers 143 to the support plate 111, which may serve as one of the terminals of the interrupter. The other line terminal is not shown but may be of conventional form connected in the usual manner to the moving contact rod 131. The moving contact rod 131 may also be serially connected with an isolating break contact structure as, for example, that disclosed in the application of A. J. A. Peterson et al., Serial No. 311,652, filed December 29, 1939, and assigned to the assignee of this application.

When the contact rod 131 is moved to the open circuit position, the arcing contact 147 moves upwardly to fill the opening 139 in the hollow support 133. The arcing contact 147 is of such length that when it is in the open circuit position the upper tip thereof is substantially flush with the conical face 135 and forms a continuation of the surface thereof.

The movable contact rod 131 is provided with a piston 155 operative within the cylinder 123 for moving arc extinguishing fluid during the circuit opening operation. The cylinder 123 in this instance also varies in diameter from one end thereof to the other, that is, the inner diameter at the lower end as shown at 157 is somewhat greater than its diameter at 159 at the upper end thereof. A plurality of openings 161 at the upper end of the cylinder 123 provide a flow passage from the cylinder through the annular space 127 surrounding the cylinder to a passage 163 formed by tubular members extending through the washers 117 and 119 which, in turn, communicate with the annular flow passage 137 adjacent the contact assembly 115. Thus, during a circuit interrupting operation movement of the contact rod 131 upwardly out of engagement with the stationary contact assembly 115 will cause an arc to be established between the arcing contact 147 and the lower tip of the rod 131. This arc will be drawn upwardly into the arc passage 121 and will be maintained substantially centrally of the passage by virtue of the central position of the arcing contact 147 with respect to the passage.

As explained in connection with Fig. 1, the initial movement of the movable contact to open circuit position does not initiate a flow of arc extinguishing fluid longitudinally of the arc until a predetermined arc length has been established. So, in the instant case, arc extinguishing fluid is not circulated until the piston 155 moves through the enlarged portion 157 of the cylinder 123 and engages the more restricted portion 159.

Upon reaching the constricted portion 159, fluid will be moved from within the cylinder 123 through the openings 161 through the annular space 127, the passage 163, the passage 137 at which the flow will be radial across the conical face 135 towards the arc from whence the flow is upwardly in surrounding relation with respect to the arc. The lower portion of the moving contact rod 131 or the portion which extends into the arc passage 121 is preferably tapered so as to conform to the tapered conformation of the arc passage. Thus, as the contact rod 131 is moved out of the arc passage 121, progressively greater clearance between the rod and the side walls

of the passage is obtained which permits a freer streaming of fluid between the rod and the walls of the arc passage as the opening operation proceeds. This is an advantage in that as arcing continues and the arc length increases, larger quantities of arc gas are produced which must be removed rapidly longitudinally of the arc in order to maintain fresh unionized arc extinguishing fluid in contact with the arc stream.

I also prefer to use a hollow contact rod 131 having a passage 165 longitudinally thereof. A plurality of radial openings 167 just below the piston 155 also permits a free flow of fluid and arc gases through the passage 155 to the lower side of the piston 155. Thus the pressure within the arc chamber 121 reacting upon the piston 155 assists in the opening movement of the contact rod 131.

In the event that pressure within the arc chamber 121 becomes excessive, vent openings 169 disposed in the contact rod 131 provide a means for relieving the pressure. Escape of fluid from these vent openings is controlled by a valve 171 biased to the closed position by a spring 173. The spring 173 is so tensioned that the valve 171 will not open until the moving contact rod 131 has been moved toward the open circuit position a distance sufficient to bring the venting ports 169 above the partition member 125 so that any fluid venting therefrom discharges into the space above the aforesaid partition.

It will be apparent that upon further movement of the contact rod 131 in the upward direction so that the exhaust ports 169 take a position beyond the closure member 107, pressure relief may be had through the ports 169 direct to the atmosphere. A relief valve 175 is also provided in the partition 125 so as to relieve the pressure in the annular space 127 in the event this becomes excessive. The valve 175 is so arranged that it permits flow in one direction only, namely, from the annular space 127 to the space above the partition 125, thereby preventing the reverse flow of fluid in the event fluid is discharged from the ports 169 during travel of these ports through the space above the partition 125. The chamber above the partition 125 is also adapted to be vented through a relief valve 177 provided in the upper closure member 107.

The piston 155 maintains a continuous stream of arc extinguishing fluid over the conical surface 135 of the stationary contact support 133 and longitudinally of the arc passage 121 following arc extinction or until the piston 155 reaches the partition member 125. In this respect the flow action is similar to that previously described in connection with the interrupter of Fig. 1 in that the arc passage 121 is swept clear of deleterious products of arcing which, unless removed, would form a partially conducting coating on the walls of the arc passage, thereby subjecting the arc passage to electrical breakdown.

Inasmuch as the moving contact rod 131 substantially completely closes the arc passage 121 when the contact is in the closed circuit position, the flow passage 137 is thereby substantially completely closed. I have found that the provision of a plurality of relatively small openings 179 through the walls of the movable contact rod 131 substantially in alignment with the passage 137 is beneficial in that it permits slight circulation of arc extinguishing fluid by convection as a result of heating of the contacts by the current flow through the contacts when the interrupter is in the closed circuit position. This flow of fluid is

sufficient to cool the contacts while carrying heavy load currents.

Although the interrupting structure as illustrated in Fig. 2 is particularly efficient in interrupting high power electrical circuits when using water as an arc extinguishing fluid, it is to be understood that other arc extinguishing media, either gaseous or liquid, may in some cases be used to advantage. It is also to be understood that the interrupting unit, as shown in Fig. 2, may be mounted within a weatherproof housing similar to that shown in Fig. 1 when it is desired to use the interrupter for outdoor service. In the event that the interrupter is to be used for indoor service, the interrupting unit may be used without further housing structure as shown, and may be supported upon a suitable framework attached to a pair of support arms 181 extending from the outer metal collar 109. It will be apparent that the interrupting unit 21 of Fig. 1 could be arranged similarly as the interrupter shown in Fig. 2, thereby adapting it for indoor switching service.

It will also be apparent that any further specific disclosure as shown herein is for the purpose of illustration and that changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

I claim as my invention:

1. In a circuit interrupter, a vessel containing arc extinguishing fluid, means defining an elongated arc passage immersed in said fluid, separable contact means for establishing an arc in said passage, means initiated after a predetermined arc length and operative in accordance with movement of said separable contact means for moving a quantity of arc extinguishing fluid into one end of said arc passage and longitudinally of the arc, and means controlling the discharge of fluid from the other end of said arc passages for causing said fluid moving means to maintain fluid surrounding the arc at a pressure sufficient to prevent engagement of the arc with the walls defining said arc passage.
2. In a circuit interrupter, a vessel containing arc extinguishing fluid, means defining an elongated arc passage immersed in said fluid, a pair of contacts at least one of which is movable for establishing an arc in said arc passage, fluid moving means actuated after a predetermined arc length by said movable contact and arranged for moving a quantity of arc extinguishing fluid into one end of said arc passage and longitudinally of the arc during the circuit opening operation, said fluid moving means subjecting substantially the entire length of said arc to an enveloping stream of arc extinguishing fluid, and means providing a vent for controlling the discharge of fluid from the other end of said arc passage, said venting means maintaining said enveloping fluid at a pressure sufficient to prevent intimate contact of the arc with the walls defining said arc passage.
3. In a circuit interrupter, a vessel containing arc extinguishing fluid, a stationary contact member, a coacting contact member movable to establish an arc of substantial length between said contact members, means for entrapping arc extinguishing fluid along the arc path between said contact members, venting means adjacent one end of said arc path open at least during the circuit interrupting operation, and fluid moving means initiated after a predetermined arc length and operative in accordance with the position of said movable contact member for moving a quantity of arc extinguishing fluid from the other end

of said arc path longitudinally thereof toward said venting means.

4. In a circuit interrupter, a container having arc extinguishing fluid therein, means of insulating material defining an elongated arc passage, said arc passage being normally open at each end, a stationary contact adjacent one end of said arc passage, a substantially closed chamber adjacent the other end of said arc passage, an elongated contact member extending through said chamber and movable through said arc passage into and out of engagement with said stationary contact, means providing a passage from said chamber to said arc passage, and a piston in said chamber operatively connected to said movable contact member for causing an enveloping flow of fluid about said arc and longitudinally through said arc passage during an opening movement of said movable contact member.

5. In a circuit interrupter, a vessel having arc extinguishing fluid therein, an elongated arcing chamber having a fluid entrance at one end and a vent opening at the other, a tubular stationary contact adjacent the vented end of said arcing chamber, a cooperating contact movable through said arcing chamber to establish an arc therein, a second chamber adjacent said arcing chamber, a passage connecting said chambers, and a piston operative in said second chamber and actuated by said movable contact to move arc extinguishing fluid longitudinally of the arc in said arcing chamber to expel the products of arcing through said tubular contact and said vent opening, said piston maintaining a longitudinal flow of fluid about said arc of velocity sufficient to move one terminal end of the arc to the discharge side of said tubular contact, the side walls of said second chamber being so arranged with respect to said piston that the latter is inoperative to move arc extinguishing fluid until a predetermined contact separation has taken place within said arcing chamber.

6. In a circuit interrupter, a vessel having arc extinguishing fluid therein, an elongated arcing chamber having a fluid entrance at one end and a vent opening at the other, a stationary contact adjacent the vented end of said arcing chamber, a cooperating contact movable through said arcing chamber to establish an arc therein, a cylinder communicating with said arcing chamber, and a piston operative within said cylinder and movable by and in accordance with said movable contact to establish a flow of arc extinguishing fluid longitudinally of the arc in said arcing chamber, said cylinder providing a variable clearance with respect to said piston so as to render the piston inoperative to establish said flow of arc extinguishing fluid until a predetermined contact separation has been obtained in said arcing chamber.

7. In a circuit interrupter, a vessel having arc extinguishing fluid therein, means defining an elongated arc passage, a stationary contact at one end of said arc passage, a closure for the stationary contact end of said arc passage, said closure having a vent opening therethrough in axial alignment with said arc passage, a coacting movable contact movable in said arc passage to establish an arc therein, and a piston actuated by said movable contact to establish a flow of arc extinguishing fluid longitudinally of the arc, said vent opening cooperating with said piston to maintain a streaming envelope of fluid about the arc at a pressure sufficient to sweep off their respective contact surfaces.

8. In a circuit interrupter, a vessel having arc extinguishing fluid therein, means at least partially of insulating material defining an elongated arc passage of generally circular cross-section, a stationary contact of tubular form at one end of said arc passage, a coacting contact member movable to establish an arc in said arc passage, a piston actuated by said moving contact to establish a flow of arc extinguishing fluid longitudinally of the arc, and a closure for the stationary contact end of said arc passage having a vent opening therethrough in axial alignment with said stationary contact and said arc passage, said vent opening being so positioned with respect to said stationary contact that it assists the streaming arc extinguishing fluid in maintaining the arc centrally positioned within said arc passage.

9. In a circuit interrupter, a vessel containing arc extinguishing fluid, means defining an elongated arc passage within said vessel, a stationary contact at one end of said arc passage, a coacting contact member movable to open and closed circuit positions, a piston chamber having a fluid connection with said arc passage, said movable contact member extending through said piston chamber and having a piston operatively secured thereto, and operating means for actuating said movable contact member and piston to the open circuit position to establish an arc in said arc passage and subject it to a longitudinal flow of arc extinguishing fluid, said movable contact member having a passage therethrough connecting said arc passage with the back side of said piston to cause the arc pressure within said arc passage to assist said piston in moving fluid through said fluid connections to said arc passage.

10. In a circuit interrupter, a vessel containing arc extinguishing fluid, means defining an elongated arc passage within said vessel, a stationary contact at one end of said arc passage, a coacting contact member movable to open and closed circuit positions, a piston chamber having a fluid connection with said arc passage, said movable contact member extending through said piston chamber and having a piston operatively secured thereto, and operating means for actuating said movable contact member and piston to the open circuit position to establish an arc in said arc passage and subject it to a longitudinal flow of arc extinguishing fluid, said movable contact member having a passage therethrough connecting said arc passage with the back side of said piston to cause the arc pressure within said arc passage to assist said piston in moving fluid through said fluid connections to said arc passage, and means operative in response to pressure within the passage in said movable contact member for establishing a vent opening from said passage to the exterior of said vessel.

11. In a circuit interrupter, means defining an elongated arc passage, stationary contact means including a hollow support, said hollow support having a frusto-conical face provided with a central opening in alignment with said arc passage, said conical face being spaced from the end of said arc passage, a movable contact rod operative in said arc passage and having one end thereof extending into said opening when in the closed circuit position, stationary contact members in said hollow support biased toward said contact rod, an arcing contact having an arcing tip coacting with said contact rod and biased for

movement with said contact rod during the opening movement thereof, said arcing contact filling said opening and terminating with its arcing tip substantially flush with said conical face upon movement of said contact rod to the open circuit position, and means for moving a quantity of arc extinguishing fluid radially across said conical face toward said arcing tip and then longitudinally of said arc passage to completely surround an arc drawn between said arcing tip and contact rod with streaming arc extinguishing fluid.

12. In a circuit interrupter, means defining an elongated arc passage, a stationary contact at one end of said passage, means for venting said arc passage at the other end thereof, a coacting movable contact operative through said arc passage, and means for actuating said movable contact to the open circuit position to establish an arc in said passage, said arc passage increasing in cross-section in a direction away from said stationary contact to provide a venting space about said moving contact for the products of arcing that increases in cross-section as the arc increases in length.

13. In a circuit interrupter, means defining an elongated arc passage, a stationary contact at one end of said passage, means for venting said arc passage at the other end thereof, a coacting movable contact operative through said arc passage, and means for actuating said movable contact to the open circuit position to establish an arc in said passage, said arc passage increasing in cross-section in a direction away from said stationary contact to provide a venting space about said moving contact for the products of arcing that increases in cross-section as the arc increases in length, said movable contact substantially filling said arc passage when in the closed circuit position and having a passage therethrough to provide an additional vent for the products of arcing from said arc passage.

14. In a circuit interrupter, means defining an elongated arc passage, a stationary contact at one end of said passage, means for venting said arc passage at the other end thereof, a coacting movable contact operative through said arc passage, said movable contact being tapered in a direction toward said stationary contact and means for actuating said movable contact to the open circuit position to establish an arc in said passage, said tapered portion of said movable contact providing a venting space between the walls of said arc passage and said movable contact which increases in cross-section in accordance with movement of the movable contact away from said stationary contact.

15. In a circuit interrupter, a vessel containing arc extinguishing fluid, means defining an elongated arc passage within said vessel, a tubular stationary contact at one end of said arc passage, a coacting tubular contact member movable to open and closed circuit positions, a piston chamber having a fluid connection with the other end of said arc passage, said movable contact member extending through said piston chamber and having a piston operatively secured thereto, and operating means for actuating said movable contact member and said piston to the open circuit position to establish an arc in said arc passage and subject it to a longitudinal flow of arc extinguishing fluid, said piston subjecting said fluid to a pressure sufficient to cause the terminal ends of the arc to be moved respectively towards the discharge ends of said tubular sta-

tionary contact and said tubular moving contact member.

16. In a circuit interrupter, a vessel containing arc-extinguishing fluid, means defining an elongated arc passage within said vessel, a tubular stationary contact at one end of said arc passage, a coacting tubular contact member movable to open and closed circuit positions, a piston chamber having a fluid connection with said arc passage, said movable contact member extending through said piston chamber and having a piston operatively secured thereto, and operating means for actuating said movable tubular contact member and said piston to the open circuit position to establish an arc in said arc passage and subject it to a longitudinal flow of arc-extinguishing fluid, the passage through said movable tubular contact member connecting said arc passage with the back side of said piston to cause the arc pressure within said arc passage to assist said piston in moving fluid through said fluid connection to said arc passage, said piston subjecting said fluid to a pressure sufficient to cause the terminal ends of the arc to be moved respectively towards the discharge ends of said tubular stationary contact and said tubular moving contact member.

17. In a circuit interrupter, means defining an elongated corrugated arc passage, a tubular stationary contact adjacent one end of said arc passage, a coacting movable contact member, means for actuating said movable contact member to the open circuit position to establish an arc within said arc passage, and piston means for moving arc-extinguishing fluid within said arc passage longitudinally of said arc and toward said tubular stationary contact, at least part of said arc-extinguishing fluid discharging through said tubular stationary contact during a circuit opening operation of said circuit interrupter.

18. In a circuit interrupter, means defining an elongated corrugated arc passage, a tubular stationary contact adjacent one end of said arc passage, a coacting movable tubular contact member, means for actuating said movable tubular contact member to the open circuit position to establish an arc within said arc passage, and means for moving arc-extinguishing fluid within said arc passage longitudinally of said arc, at least part of said arc-extinguishing fluid discharging through both said tubular stationary contact member and said movable tubular contact member.

19. In a circuit interrupter, means defining an elongated arc passage, a stationary contact disposed adjacent one end of said arc passage, a coacting movable contact member movable within said arc passage, operating means for actuating said movable contact member to the open circuit position to establish an arc within said arc passage, means for moving arc-extinguishing fluid within said arc passage longitudinally of said arc to effect the extinguishment thereof, an arcing contact disposed adjacent the stationary contact end of said arc passage, said arcing contact supported for limited movement axially of said arc passage during the initial portion of the circuit opening operation, at least one of said contacts having a passage therethrough, and at least part of the discharge of said arc-extinguishing fluid from said arc passage taking place through said passage during a circuit opening operation.

20. In a circuit interrupter, an arcing chamber, a stationary contact, a movable contact

member, an arcing contact member cooperating with said stationary contact and mounted for limited movement in the direction of movement of said movable contact member, said arcing contact member and said stationary contact engaging said movable contact member in the closed circuit position of said interrupter, said arcing contact member moving relative to said stationary contact and following the initial movement of said movable contact member to draw an arc between said movable contact member and said arcing contact member during a circuit opening operation, means for extinguishing said drawn arc by the use of an arc-extinguishing fluid, said arc-extinguishing fluid discharging from said arcing chamber largely through a passage provided in at least one of said contact members.

21. In a circuit interrupter, an arcing chamber, a stationary contact, a coacting movable contact, an arcing contact cooperable with said stationary contact and adapted for limited motion in the direction of movement of said movable contact, said movable contact engaging both said stationary and said arcing contacts during a closed circuit position of said interrupter, said movable contact separating from said stationary

contact before separating from said arcing contact to draw an arc between said movable and arcing contacts during a circuit opening operation of said interrupter, means for extinguishing said drawn arc by the utilization of arc-extinguishing fluid, said arc-extinguishing fluid at least in part discharging from said arcing chamber through a passage provided in said movable contact.

22. In a circuit interrupter, a container having arc extinguishing fluid therein, stationary means of insulating material defining an elongated arc passage, said arc passage being normally open at each end, a stationary contact adjacent one end of said arc passage, a substantially closed chamber adjacent the other end of said arc passage, an elongated contact member extending through said chamber and movable through said arc passage into and out of engagement with said stationary contact, means providing a passage from said chamber to said arc passage, and a piston in said chamber operatively connected to said movable contact member for causing a flow of fluid longitudinally through said arc passage during an opening movement of said movable contact member.

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