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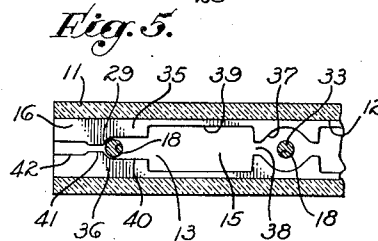
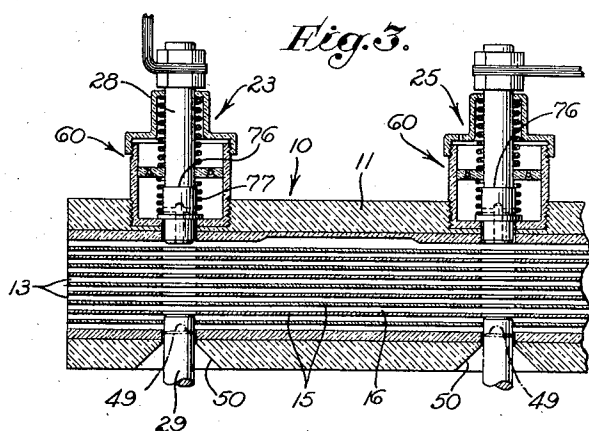
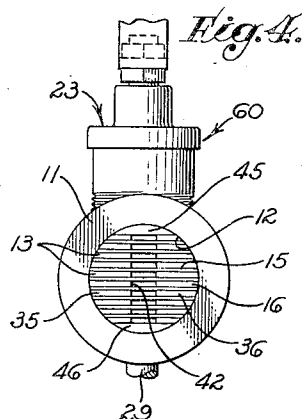
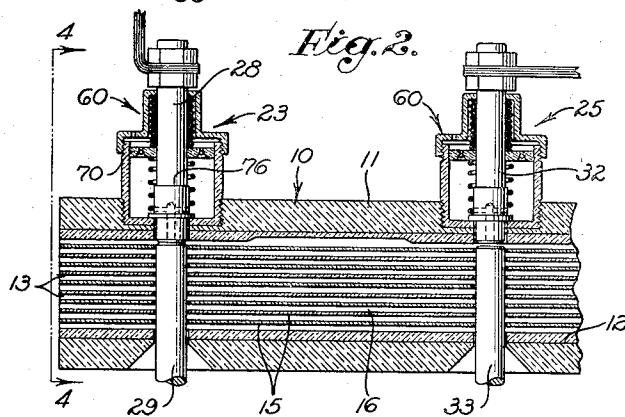
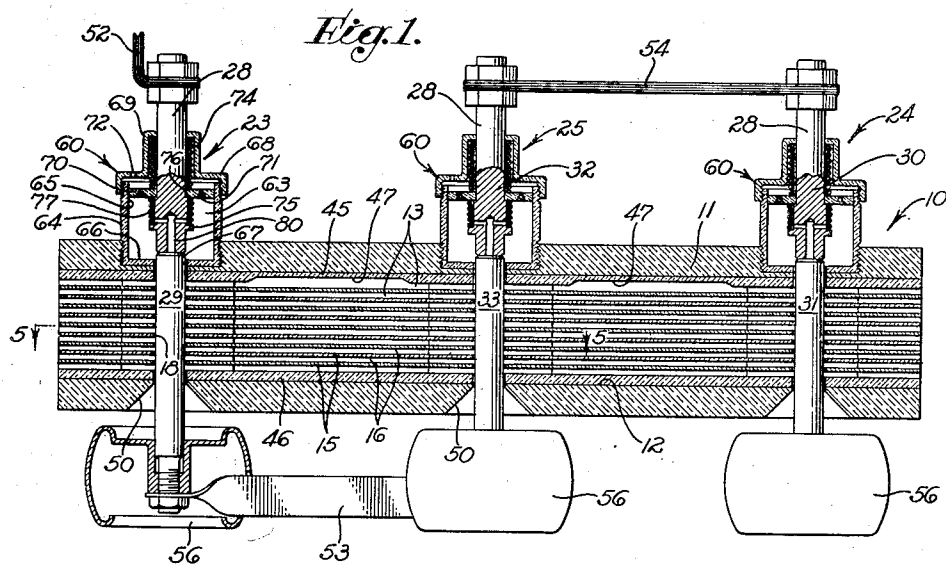
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2,292,547

APPARATUS FOR INTERRUPTING ELECTRIC CIRCUITS

Filed Sept. 13, 1939

2 Sheets-Sheet 1



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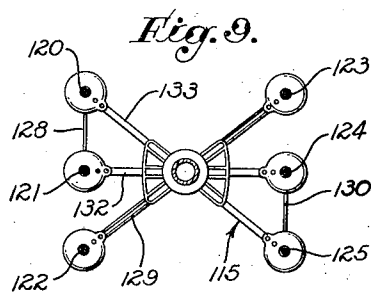
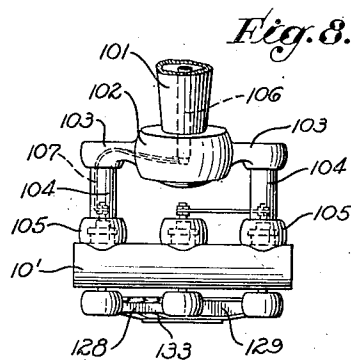
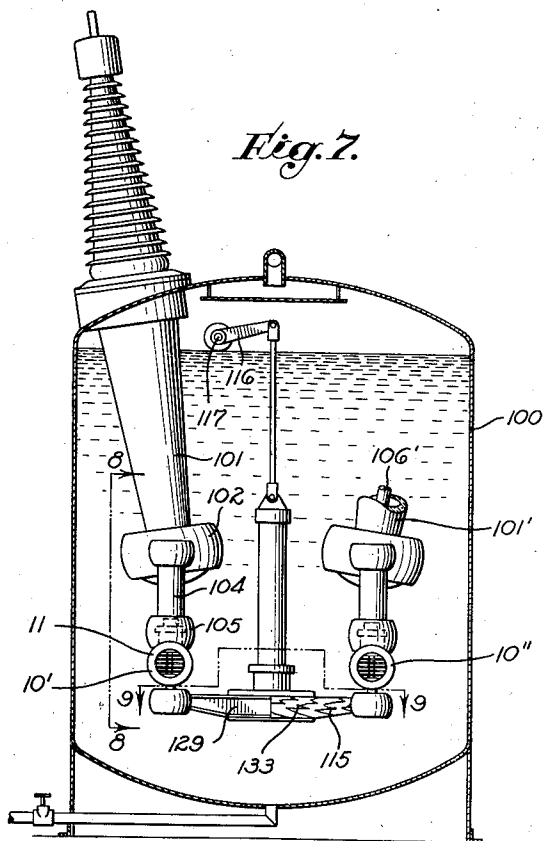
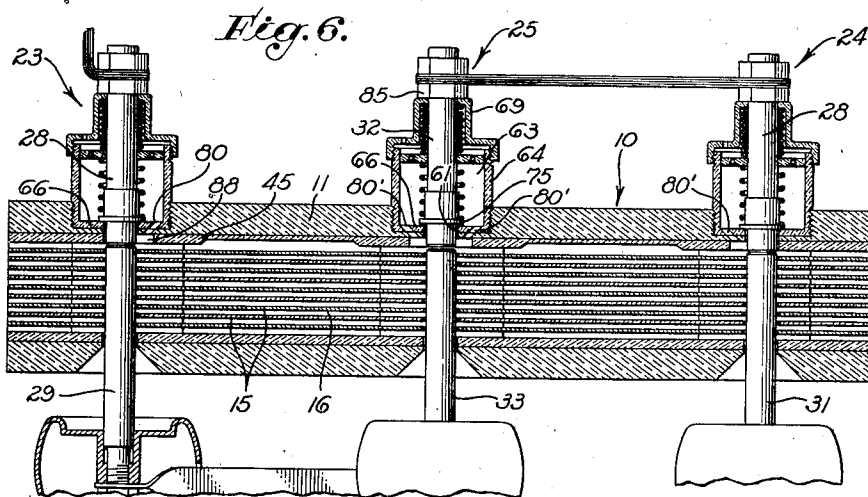
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APPARATUS FOR INTERRUPTING ELECTRIC CIRCUITS

Filed Sept. 13, 1939

2 Sheets-Sheet 2



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2,292,547

APPARATUS FOR INTERRUPTING ELECTRIC CIRCUITS

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15 Claims. (Cl. 200—150)

My invention relates to circuit interrupters and, more particularly, to electric circuit breakers of the type which interrupts a high-voltage circuit by the formation and quenching of an arc in a dielectric fluid.

It has previously been proposed to force a blast of oil or other dielectric fluid through the space between two rapidly separating contact members connected in an electric circuit to quench an arc therebetween. One of the simplest and most effective ways of creating such an arc-quenching blast is by generation of pressure through use of another arc, usually connected in series with the arc to be quenched. For example, the pressure surge may be established by an explosive arc between a generating set of contacts, this pressure surge being used to force a stream of dielectric fluid transversely across a set of interrupting contacts.

With certain devices of this general character, two objections have sometimes been apparent. In the first place, difficulty has sometimes been encountered in maintaining the flow of arc-extinguishing fluid for a sufficient time to interrupt the circuit. In the second place, certain low-current arcs, for example, those formed when interrupting light loads or merely the charging current of a transmission line, sometimes fail to give an explosive surge of such violence as to quench quickly the arc between the interrupting set of contacts. In the latter connection, some circuit breakers of this type encounter difficulty in interrupting currents of less than 100–200 amperes even though they operate very satisfactorily at higher currents.

It is an object of the present invention to provide a simple current interrupter effective to interrupt currents of various magnitudes.

Another object of the invention is to deliver a dielectric fluid to an arc using both physically-acting and electrically-acting means to force the arc-quenching fluid into the arc. For example, by the present invention I can combine the desirable generation of pressure surges by an electric arc with generation of pressure by use of a pump or other energy-storing means.

Another object of the invention is to provide a novel method and apparatus for circuit interruption which maintains a flow of dielectric fluid into a gap between a pair of separating contact members until the arc is effectively quenched, even though the arc might be sustained for several cycles.

An arc formed between such separating contact members is surprisingly small in cross-sectional area, being about 1 sq. mm. per 1000 amperes, even though the corona-like glow surrounding same is of considerably larger area. On the other hand, it is necessary for various reasons to use contact members having a cross-sectional area very considerably larger, for example, 1 square inch or more. Considerable difficulty is encountered in insuring a sufficient arc-quenching flow when the gap between such contact members is relatively small in length, for example, $\frac{1}{8}$ inch to $\frac{1}{4}$ inch.

It is an object of this invention to provide an effective arc-quenching flow of dielectric fluid between a pair of separating contact members even when they are separated only slightly. It is a further object of the invention to start to lave the contact members with a dielectric fluid before they separate to form the arc. Another object is to provide a pump means in which energy can be stored by the closing movement of the switch, whereby this energy can be released to produce a flow of dielectric fluid when the circuit breaker is tripped.

Still further objects of the invention lie in the structural details, the position and the point of discharge of the pump means, and in the other features of the invention which will be evident to those skilled in the art from the following description of selected embodiments of the invention.

Referring to the drawings, Fig. 1 is a vertical cross-sectional view of an arc-quenching unit illustrating one embodiment of the invention, the contact members being in closed-switch position.

Fig. 2 is a fragmentary cross-sectional view similar to Fig. 1, showing the contact members in a position assumed during the circuit-interrupting movement.

Fig. 3 is a sectional view similar to Fig. 2, showing the contact members in a later-assumed position during the current-interruption cycle.

Fig. 4 is an end view of the arc-quenching unit, taken as indicated by the line 4—4 of Fig. 2.

Fig. 5 is a sectional view taken as indicated by the line 5—5 of Fig. 1.

Fig. 6 is a vertical cross-sectional view similar to Fig. 1 except showing the contact members in a position assumed during the circuit-interrupting movement, illustrating an alternative embodiment of the invention.

Fig. 7 is a vertical cross-sectional view of a complete circuit breaker embodying the invention.

Fig. 8 is an end view of some of the mecha-

Fig. 9 is a vertical cross-sectional view of a complete circuit breaker embodying the invention.

Fig. 10 is a vertical cross-sectional view of a complete circuit breaker embodying the invention.

Fig. 11 is a vertical cross-sectional view of a complete circuit breaker embodying the invention.

nism of Fig. 7, taken on the line 8—8 of Fig. 7. Fig. 9 is a cross-sectional view taken along the line 9—9 of Fig. 7.

Referring particularly to Fig. 1, I have shown an arc-quenching unit, indicated generally by the numeral 10, as including an open-ended and relatively thick tube 11 preferably formed of insulating material, such as fiber, Bakelite, or various ceramic materials. This tube 11 can be of any suitable shape but is shown as being circular in cross section. Generally speaking, it comprises a main passage 12 (see Fig. 4), which is preferably baffled in such manner as to form numerous longitudinal passages 13 (Fig. 1), the entire arc-quenching unit being preferably submerged in a dielectric fluid, which, for example, may be a high resistance oil.

To form the longitudinal passages 13 I prefer to utilize a plurality of baffles 15 held in spaced relationship by spacers 16, these baffles and spacers being preferably of such length as to extend throughout the length of the tube 11, the baffles being of such width as to traverse the main passage 12, as best shown in Fig. 4. Each baffle 15 is substantially imperforate except for openings 18 (Fig. 5) adapted to receive and being only slightly larger than the contact members to be hereinafter described. These openings 18 of the various baffles are in alignment with each other to form operating zones through which the contact members may move.

In the embodiment shown in Fig. 1, three sets of contact members are disclosed, the end sets being indicated by the numerals 23 and 24 and being hereinafter termed interrupting sets of contact members, and the intermediate set being indicated by the numeral 25 and comprising a generating set of contact members. The set 23 comprises essentially first and second contact members 28 and 29 to be hereinafter described in greater detail, while the set 24 comprises first and second contact members 30 and 31. Similarly, the set 25 comprises first and second contact members 32 and 33. The contact members 29, 31, and 33 are adapted to be moved in the operating zones defined by the openings 18.

The longitudinal passages 13 are traversed by the contact members 29, 31, and 33, and these longitudinal passages are preferably formed by the spacers 16 in the manner best shown in Fig. 5. As there shown, each spacer comprises complementary elements 35 and 36 separated from each other to define one of the longitudinal passages 13 which is bounded by the walls of the elements 35 and 36 and the surfaces of the adjacent baffles 15. The elements 35 and 36 are arcuately enlarged in the zone of the contact member 33 to form a chamber 37 extending around this contact member. A more restricted zone 38 communicates between the chamber 37 and an enlarged chamber 39, while a similar restricted zone 40 extends from the enlarged chamber 39 to the vicinity of the contact member 29. A throat 41 and an exit portion 42 complete the passage 13, the portion 42 being in open communication with the surrounding dielectric fluid. The complementary elements 35 and 36 are similarly formed in the zone between the contact members 31 and 33 so as to be symmetrical about the latter. Correspondingly, each longitudinal passage 13 in effect traverses the operating zone occupied by each of the contact members 29, 31, and 33. It will be understood that a similar longitudinal passage 13 is formed between each of the baffles 15 even though the distance across

some portions of the longitudinal passages 13 will be less toward the upper and lower portions of the arc-quenching unit due to the cylindrical configuration of the tube 11.

Also, it should be noted that above and below the baffles 15 and spacers 16 are disposed upper and lower filler elements 45 and 46. I have found it preferable to cut away a portion of the upper filler element 45 to form an enlarged chamber 47 on each side of the generating set of contacts 25. This enlargement is particularly useful in the uppermost longitudinal passage and serves as a storage for dielectric fluid. It will be understood that this uppermost longitudinal passage, as well as the corresponding lowermost longitudinal passage, is defined by suitable spacers 16.

By means to be hereinafter described in detail, the contact members 29, 31, and 33 are adapted to be substantially simultaneously withdrawn from the operating zones defined by the openings 18. When the circuit breaker is closed, these contact members are in the position shown in Fig. 1, and in moving toward open-switch position they assume the intermediate positions indicated in Figs. 2 and 3. The maximum retraction of these contact members is indicated by the dotted lines 49 of Fig. 3, in which position they are substantially clear of the longitudinal passages 13. In the event that complete withdrawal is desired, tapered portions 50 of the tube 11 will guide these contact members into the proper zones during the first portion of the switch-closing movement.

It is usually desirable to connect the three sets of contact members in series with the circuit to be interrupted. In Fig. 1 the first contact member 28 may be connected to the circuit to be interrupted through a conductor 52, in which event the current will flow downward through the set of contact members 23 and be conducted to the set 25 through a conductor 53, moving upward through the set 25 and through a conductor 54 to the set 24, and returning to the circuit to be interrupted. Suitable electrostatic shields 56 may be disposed at the lower end of each of the contact members 29, 31, and 33, and likewise at the upper ends of the contact members 28, 30, and 32 if desired, for equalization of stress and prevention of arcing or corona discharge from sharp edges.

In the preferred embodiment of the invention, both contact members of each set are movable. By way of example, it is desired that the contact member 28 should follow the contact member 29 until the engaging surfaces reach the first longitudinal passage 13, after which further movement of the contact member 28 is resisted so that further retraction of the contact member 29 will form a gap between these members and establish an arc. It is desired to interrupt this arc by flowing transversely into the gap at high velocity a stream of dielectric fluid. The present invention contemplates the use of both electrically and mechanically-induced pressure surges to set up such a blast of dielectric fluid. The electrically-induced pressure surge is developed by the generating set of contact members 25, and when an arc forms therebetween, a violent pressure surge is developed which forces outward along the upper longitudinal passage streams of dielectric fluid moving respectively toward the contact members 29 and 31 and into the gaps thereadjacent. However, this electrically-induced pressure surge is usually of short du-

ration. By way of explanation, the arc forming between the generating set of contact members will vaporize a portion of the dielectric fluid and form a high pressure gas bubble which, upon expanding, forces dielectric fluid ahead toward the interrupting sets of contact members. However, as soon as this gas bubble is formed, the arc has a tendency to persist through the gas and not to be contacted by fresh dielectric fluid. It is one feature of the present invention that additional dielectric fluid can be fed to a position adjacent this gap to be vaporized by the heat of the arc and thus prolong and intensify the flow of dielectric fluid to the interrupting sets of contact members. Likewise, it is a feature of the invention that the arcs between the contact members of the interrupting sets can be fed with additional dielectric fluid to cool and quench these arcs.

To feed additional dielectric fluid to such arcs, I prefer to use a pump means associated with one or more of the sets of contact members 23, 24, and 25. As shown in Fig. 1, a pump means, indicated generally by the numeral 60, is associated with each of these sets. It will be sufficient to describe particularly the pump means associated with the set 23, it being understood that the remaining pump means are of similar construction.

Essentially, the pump means 60 comprises stationary and movable elements cooperating in defining a pressure zone 63. The construction illustrated includes a housing 64 defining a cylinder 65 bounded at its lower end by a wall 66 which provides an opening 67 only slightly larger in diameter than the contact member 29 so as to restrict flow of dielectric fluid from the high pressure zone along the contact member 29 and toward the passages 13. Closing the upper end of the cylinder 65 and forming a part of the housing 64 is a detachable cover 68 providing a dome 69 through which the contact member 28 may move.

The movable element of the pump means may comprise a piston 70 which is actuated by the first contact member 23. During upward movement of this piston the volume of the pressure zone 63 is increased and dielectric fluid will flow thereinto through an intake means which may comprise one or more check valves 71 cooperating with corresponding ports in the piston as shown (or in the housing 64) and being spring-actuated in a manner not disclosed but well known in the art, so as to close these ports upon downward movement of the piston. In the form shown the dielectric fluid moving through this intake means is supplied from the zone above the piston which in turn communicates with the surrounding dielectric fluid through one or more vents 72.

In the pump means shown, the piston 70 provides an opening which slidably receives the first contact member 23. A spring means is provided for controlling the movement or position of the piston with respect to this contact member. It is preferred to use a spring for biasing this piston 70 in a direction tending to reduce the volume of the pressure zone 63. A spring 74 serves in this capacity and extends upward in the dome 69, the lower end of this spring contacting the piston 70 so that upward movement of this piston compresses the spring.

In this embodiment of the invention, downward movement of the first contact member is limited by a shoulder or ledge 75 which engages

the wall 66 in sealing relation with the opening 67.

Upward movement of the piston 70 is effected through use of any suitable interengaging means acting between the contact member 23 and this piston. By way of example, this interengaging means may comprise a shoulder 76 formed on the first contact member between upper and lower sections thereof of different diameter. When the shoulder 76 moves upward to engage the lower end of the piston 70, the contact member 23 and the piston 70 will move upward as a unit, and the upward movement of the piston will compress the spring 74.

An auxiliary compression spring 77 may be disposed between the ledge 75 and piston 70. In some instances, the shoulder 76 can be eliminated and reliance placed entirely upon compression or compaction of the auxiliary spring 77 in moving the piston 70 upward, in which event the piston will move under the action of one or the other of the springs and will, in effect, float therebetween. Usually, however, it is preferred to use both the shoulder 76 and the auxiliary spring 77 and to design the auxiliary spring so that the necessary compressive force is less than that required to compress the spring 74. The auxiliary spring 77 may serve to maintain the contact members 28 and 29 in pressural engagement during their joint downward movement, for it forces the first contact member 28 downward against the second contact member even though the piston 70 is retained in upper position by entrapment of dielectric fluid in the pressure zone 63. In the preferred design, the shoulder 76 is of such length that the auxiliary spring 77 is never completely compacted.

With the pump means just described, it is possible to store energy which can be quickly released when the circuit breaker is tripped. This energy is stored, or, in other words, the pump means is "cocked" by movement of the second contact member 29. For example, when this second contact member is in open-switch position and it is desired to close the circuit breaker, movement of this contact member from the position shown in Fig. 3 to the position shown in Fig. 2 will bring it into pressural engagement with the first contact member 28. Further upward movement of the second contact member 29 will move the first contact member 28 upwardly therewith. Assuming that the piston 70 is in a lower position, this upward movement will be transmitted to the piston by the interengaging means to fill the pressure zone 63 with dielectric fluid. It will be apparent, however, that this interengaging means does not prevent rapid downward movement of the first contact member 28 upon tripping of the circuit breaker even though the piston 70 is held upward by dielectric fluid filling the pressure zone 63.

As soon as the circuit breaker is tripped, the contact members move downward in pressural engagement until the ledge 75 engages the lower wall 66 of the housing 64, at which time the contact members 28 and 29 are in the position shown in Fig. 2. Continued movement of the contact member 29 forms the gap. It is preferred to form the ledge 75 in such manner as to close and effectively seal the small annular space between the contact member 29 and the opening 67. Correspondingly, when the contact members and the piston are in the intermediate position shown in Fig. 2, the dielectric fluid in the pressure zone 63 will be in effect entrapped therein

except for escape through the means to be presently described. On the other hand, before sealing engagement between the ledge 75 and the wall 66 takes place, the circuit breaker may be so designed as to produce a small flow of dielectric fluid from the pressure zone 63 through the opening 67 to lave the contact members prior to the time they separate.

The pressure in the pressure zone 63, when the elements are in the position shown in Fig. 2, is used to deliver a stream of dielectric fluid to a point adjacent the gap and, in the embodiment shown, into the first longitudinal passage 13. This is accomplished by a passage communicating with the pressure zone 63 and discharging dielectric fluid adjacent the gap. In the embodiment of Fig. 1 this passage is indicated by the numeral 80 and is formed by intersecting longitudinal and transverse bores in the contact member 28. In this embodiment, it will be clear that the engaging surfaces of the first and second contact members 28 and 29 form an effective seal preventing flow of dielectric fluid through the passage 80 until such time as the second contact member 29 separates from the first contact member 28. This system is of particular advantage in that the flow of dielectric fluid is delivered centrally into the gap and, in escaping therefrom, must come into contact with the arc therein. This cools the arc and insures rapid quenching thereof.

The pump means 60 adjacent the sets of contacts 24 and 25 act in a similar manner. In addition, however, the pump means associated with the set 25 cooperates novelly with the interrupting sets 23 and 24 in that it delivers a stream of dielectric fluid to the arc between this generating set of contact members, and continues this delivery to force dielectric fluid outward through the passages in accumulating sequence, thus insuring that the gaps between the interrupting sets of contact members 23 and 24 will be filled with transverse jets of dielectric fluid regardless of the length of these gaps. In addition, it will be apparent that the contact member 33 of the generating set 25 acts as a valve to open the different passages 13 successively and in so doing draws the arc into the vicinity of the dielectric fluid retained in the several chambers 37, thus further increasing the dielectric fluid available for vaporization and generation of pressure acting to force dielectric fluid along the several passages 13 toward the interrupting sets 23 and 24.

It will be apparent that the flow of dielectric fluid from the pressure zone 63 will continue for a time determined by numerous factors including the strength of the spring 74 and the throttling action of the passage 80. It is preferred to continue this flow into the several gaps until the contact members 29, 31, and 33 have assumed their maximum-retracted position which, in the embodiment shown, is represented by the dotted lines 49 of Fig. 3. The invention thus insures an adequate delivery of dielectric fluid to the gaps even though, as is sometimes the case in interrupting currents of relatively low magnitude, the arc continues for several cycles if an alternating current circuit is being interrupted.

It is preferred to open the generating set of contact members 25 slightly ahead of the time that the interrupting sets 23 and 24 open. This condition is shown in Fig. 2 and insures an electrically-induced flow of dielectric fluid across the interrupting sets 23 and 24 at the instant of separation. On the other hand, it is sometimes

difficult to force a stream of dielectric fluid through a gap as small as $\frac{1}{8}$ inch between the contact members 28 and 29, particularly if the diameter of these contacts is considerably larger. The pump means 60 associated with these contact members will, however, forcibly move dielectric fluid into the gap even at this small spacing of the contact members, and as soon as the gap lengthens, the transverse flow induced by the generating set is available for cooling and sweeping the arc from the gap between the interrupting set.

An alternative embodiment of the invention is shown in Fig. 6, which resembles, in structural details, the form shown in Fig. 1 except that a different form of passage 80 is shown and a different means is used for stopping the motion of the first contact member 32 of the generating set 25. In this embodiment the contact member 32 follows the contact member 33 until a nut 85 threaded to the former engages the dome 69. This engagement takes place just prior to the time that the ledge 75 engages the lower wall 66 of the housing 64 so that in this embodiment a small portion of the dielectric fluid entrapped in the pressure zone 63 may continue to flow downward immediately around the contact member 28 or 29 through the opening 67. A similar construction can be used in the form of the invention shown in Figs. 1 to 5.

The passage 80' shown in Fig. 6 is external of the first contact member 28, for example. Referring particularly to the interrupting set of contact members 23, the passage 80' is formed through the wall 66 and the material of the tube 11, being preferably inclined so as to be directed into a space 88 formed by the member 45. The position and inclination of this passage 80' are such that it discharges adjacent the gap between the contact members 28 and 29, and, further, it is preferred that the direction of discharge be toward the corresponding outer end of the tube 11, as best shown in Fig. 6. Likewise, the passage 80' of the other interrupting set 24 is inclined to discharge toward the other end of the tube 11. The pump means associated with the generating set of contact members 25 preferably affords a plurality of passages 80' inclined to intersect at or near the axis of movement of the contact member 33. On the other hand, only one such passage can be used in some instances, or an internal passage such as shown in Fig. 1 can be employed in this connection. Likewise, it will be understood that both internal and external passages on any or all of the sets 23, 24, or 25 can be employed without departing from the spirit of this invention.

The invention is not limited to the use of a plurality of sets of contact members even though it has been thus disclosed. Advantageous results accrue from the use of a pump means on a single set of contact members. On the other hand, in interrupting high voltage circuits, it is often desirable to use a plurality of sets, and in some instances to employ a plurality of arc-quenching units of the type shown in Fig. 1. Fig. 7 illustrates two such arc-quenching units enclosed in a tank 100 and indicated respectively by the numerals 10' and 10''. A high voltage bushing 101 extends downward in the tank and supports the arc-quenching unit 10'. This support may comprise a member 102 having arms 103 extending outward to support tubes 104 formed of insulating material. These tubes are connected to

shields 105 similar to those indicated by the numeral 56 in Fig. 1 but being suitably secured to the tube 11. The bushing 101 carries a conducting rod 106, best shown in Fig. 3, which in turn is connected by a conductor 107, similar to the conductor 52 of Fig. 1, to one of the contact members, for example, the contact member 28.

The other arc-quenching unit 10'' is similarly supported from a bushing 101' which, being diagonally disclosed with reference to the bushing 101, is only partially shown in Fig. 7. The conductor 106' in this instance is electrically connected to that one of the contact members which is diagonally opposite the contact member to which the conductor 106 is connected.

The six contact members are moved simultaneously by a cross-arm construction 115 to which they are connected, this cross-arm being moved up and down by any suitable means, such as a crank 116 pivoted to the tank at 117 and connected to any suitable tripping and resetting mechanism disposed outside the tank.

In Fig. 9 the six lower contact members are indicated by the numerals 120 to 125 respectively for the purpose of tracing the circuit. Current may move down through the conductor 106 of the bushing 101, flowing downward through the first set of interrupting contacts, thence from the contact member 120 through a conductor 126 (corresponding to the conductor 53 of Fig. 1), to the contact member 121, and thence upward through the generating set of contacts, thence through a conductor (not shown in Fig. 9) corresponding to the conductor 54 of Fig. 1, the current then flowing downward through the remaining interrupting set to the contact member 122. An electrically conducting arm 129 forming a part of the cross-arm structure 115 carries the current diagonally across the tank to the contact member 123, whence it flows upward, across and downward to the contact member 124, thence through conductor 130 to the contact member 125, and thence upward through the corresponding upper contact member which is connected to the conductor 106' of the bushing 101'. The remaining arms 132 and 133 of the cross-arm structure 115 are formed of wood or other insulating material so that current is not conducted thereby. This manner of conducting the current in series through a plurality of sets of contacts has been found very advantageous in circuit breaker design.

While the invention has been described with reference to two preferred embodiments and with reference to a tank-type circuit breaker, it will be clear that the invention is not limited thereby and finds applications in various types of circuit breakers.

I claim as my invention:

1. In a high-voltage circuit breaker adapted to interrupt a circuit by forming and extinguishing an arc in a zone containing a dielectric fluid, the combination of: a first contact member electrically connected to said circuit; a second contact member electrically connected to said circuit and normally engaging said first contact member to close said circuit; means for movably mounting said second contact member for movement away from said first contact member to form a gap therebetween; means for movably mounting said first contact member for limited movement while in engagement with said second contact member and before separation therefrom; pump means comprising stationary and

movable elements cooperating in defining a pressure zone containing a portion of said dielectric fluid; means for operatively connecting said movable element and said first contact member to build up a pressure in said pressure zone during said limited movement; and walls defining a passage communicating with said pressure zone and discharging at a position adjacent said gap for conducting dielectric fluid to said gap.

2. In a high-voltage circuit breaker adapted to interrupt a circuit by forming and extinguishing an arc in a zone containing a dielectric fluid, the combination of: pump means including stationary and movable elements cooperating in defining a pressure zone containing a dielectric fluid; a first contact member connected to said circuit and operatively associated with said movable element to move same when said first contact member is moved; a second contact member connected to said circuit; actuating means for moving said second contact member into engagement with said first contact member and thus into operative relation with said movable element of said pump means and for moving said second contact member entirely away from said first contact member to form a gap therebetween; and walls defining a passage communicating with said pressure zone and discharging dielectric fluid therefrom at a position adjacent said gap.

3. In a high-voltage circuit breaker adapted to interrupt a circuit by forming and extinguishing an arc in a zone containing a dielectric fluid, the combination of: pump means including stationary and movable elements cooperating in defining a pressure zone; means for biasing said movable element of said pump means in a direction tending to decrease the volume of said pressure zone; a first movable contact member connected to said circuit for retracting said movable element against the action of said biasing means to increase the volume of said pressure zone; intake means for delivering dielectric fluid to said pressure zone when the volume of said pressure zone increases; a restricted discharge means for discharging dielectric fluid from said pressure zone when the volume thereof decreases; a second contact member connected to said circuit; and means for moving said second contact member into and from engagement with said first contact member, said movement of said second contact member being sufficient to move said first contact member enough to retract said movable element of said pump means.

4. In a high-voltage circuit breaker adapted to interrupt a circuit by forming and extinguishing an arc in a zone containing a dielectric fluid, the combination of: pump means including stationary and movable elements cooperating in defining a pressure zone containing dielectric fluid; first and second movable contact members respectively connected to said circuit and engaging to complete said circuit; means for moving said first and second contact members together and in engagement with each other for a fraction of the locus of motion of said second contact member and for then retarding the motion of said first contact member whereby continued movement of said second contact member forms a gap between said contact members; walls defining a passage communicating with said pressure zone and discharging adjacent said gap; and means for maintaining a flow of dielectric fluid from said pressure zone along and from said passage substantially throughout the time that said sec-

ond contact member is moving to increase the distance across said gap.

5. In a high-voltage circuit breaker adapted to interrupt a circuit by forming and extinguishing an arc in a zone containing a dielectric fluid, the combination of: a pair of members defining a longitudinal passage containing dielectric fluid and providing aligned openings; a first contact member of a size to be extensible through one of said openings; means for movably mounting said first contact member in alignment with said one of said openings to move toward and away from this opening, said means including means for preventing any movement of said first contact member entirely through said longitudinal passage; a second contact member extensible through said openings to engage said first contact member and retractable entirely from said longitudinal passage whereby said contact members separate in said passage to form a gap; pump means including stationary and movable elements cooperating in defining a pressure zone containing dielectric fluid; and means for delivering a stream of dielectric fluid from said pressure zone to said gap when said second contact member is retracted from engagement with said first contact member, said means including walls defining a passage communicating with said pressure zone and discharging dielectric fluid therefrom into said longitudinal passage at a position adjacent said gap.

6. In a high-voltage circuit breaker adapted to interrupt a circuit, the combination of: a pump means including a housing providing a cylinder and a piston in said cylinder defining a pressure zone which varies in volume when said piston is moved; spring means for biasing said piston in a direction to reduce the volume of said pressure zone; intake means for delivering dielectric fluid to said pressure zone when the volume thereof increases; means for moving said piston, said means including a movable first contact member; a second contact member movable into engagement with said first contact member to move same to compress said spring and movable away from said first contact member to form a gap; and walls defining a passage communicating with said pressure zone for discharging a stream of dielectric fluid at a position adjacent said gap, said stream being impelled by said spring means.

7. A combination as defined in claim 6 including an auxiliary spring disposed operatively between said first contact member and said piston to be compressed therebetween, whereby said auxiliary spring tends to force said first contact member toward said second contact member, and including means for limiting the extent of movement of said first contact member to permit said second contact member to separate therefrom to form said gap.

8. A combination as defined in claim 6 in which said piston provides an opening and in which said first contact member slidably extends through said opening, and including interengaging means acting between said piston and said first contact member to move said piston along with said first contact member to compress said spring means, said interengaging means permitting free movement of said first contact member in an opposite direction.

9. A combination as defined in claim 6 in which said piston provides an opening and in which said first contact member slidably extends through said opening, and including interengaging means acting between said piston and said first contact

member to move said piston along with said first contact member to compress said spring means, said interengaging means permitting free movement of said first contact member in an opposite direction, and including an auxiliary spring acting between said first contact member and said piston to be compressed prior to the time said interengaging means acts to move said piston along with said first contact member.

10. In a high-voltage circuit breaker adapted to interrupt a circuit, the combination of: two contact members connected to said circuit and separable to form a gap when it is desired to interrupt said circuit; a pump means providing a pressure zone around one of said contact members and containing a dielectric fluid; and walls defining a passage extending outward at one end to communicate with said pressure zone and extending internally of said one of said contact members to openly communicate with said gap to force dielectric fluid thereinto when said gap is formed.

11. In a high-voltage circuit breaker adapted to interrupt a circuit, the combination of: two contact members connected to said circuit and separable to form a gap when it is desired to interrupt said circuit; a pump means providing a pressure zone containing a dielectric fluid; and walls defining a passage communicating at one end with said pressure zone and extending internally of one of said contact members to communicate openly with said gap to force dielectric fluid thereinto when said gap is formed, said internally-passaged contact member and said other of said contact members providing contact surfaces engaging each other in sealing relationship until said gap is formed to prevent substantially any of said dielectric fluid from escaping through said passage until said contact members separate to form said gap.

12. In a high-voltage circuit breaker adapted to interrupt a circuit, the combination of: pump means including movable and stationary elements cooperating in defining a pressure zone containing a dielectric fluid, said stationary element providing an opening; spring means for biasing said movable element in a direction to decrease the volume of said pressure zone; a first contact member movably extending through said opening into said pressure zone to actuate said movable element in a manner to compress said spring means, there being a small space between said first contact member and the walls of said opening; a second contact member movable into engagement with said first contact member to move same to compress said spring; and stop means for limiting the extent of movement of said first contact member while in engagement with said second contact member to permit said second contact member to move away from said first contact member to form a gap.

13. A combination as defined in claim 12 in which said stop means includes a shoulder on said second contact member movable into engagement with said stationary element and extending outward to seal said small space against discharge of dielectric fluid therethrough.

14. In a high-voltage circuit breaker adapted to interrupt a circuit, the combination of: two contact members connected to said circuit and separable to form a gap when it is desired to interrupt said circuit, one of said contact members providing a passage with an exit portion opening on said gap and providing an annular contacting surface around said exit portion of said pas-

sage, the other of said contact members being imperforate to provide a contacting surface extending across said exit portion of said passage and also across said annular contacting surface whereby when said contacting surfaces are in engagement said passage is effectively sealed; and means for delivering a dielectric fluid under pressure to said passage at an instant of time prior to the separation of said contacting surfaces to form said gap and continuing until said gap is formed, the engagement between said contacting surfaces substantially sealing said passage to prevent escape of dielectric fluid therefrom until said gap is formed, said means acting upon formation of said gap to permit flow of said dielectric fluid under pressure along said passage

and toward said imperforate contacting surface to spread said dielectric fluid outward to sweep across said annular contacting surface and thus across the arc terminating at some portion of this annular surface.

5 15. A combination as defined in claim 14, in which said means includes a variable-volume chamber containing a dielectric fluid, and includes means for decreasing the volume of said chamber to build up a pressure therein prior to the separation of said contacting surfaces and for continuing to decrease the volume of said chamber after said gap is formed to force a stream of said dielectric fluid through and along said passage to contact said arc.

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