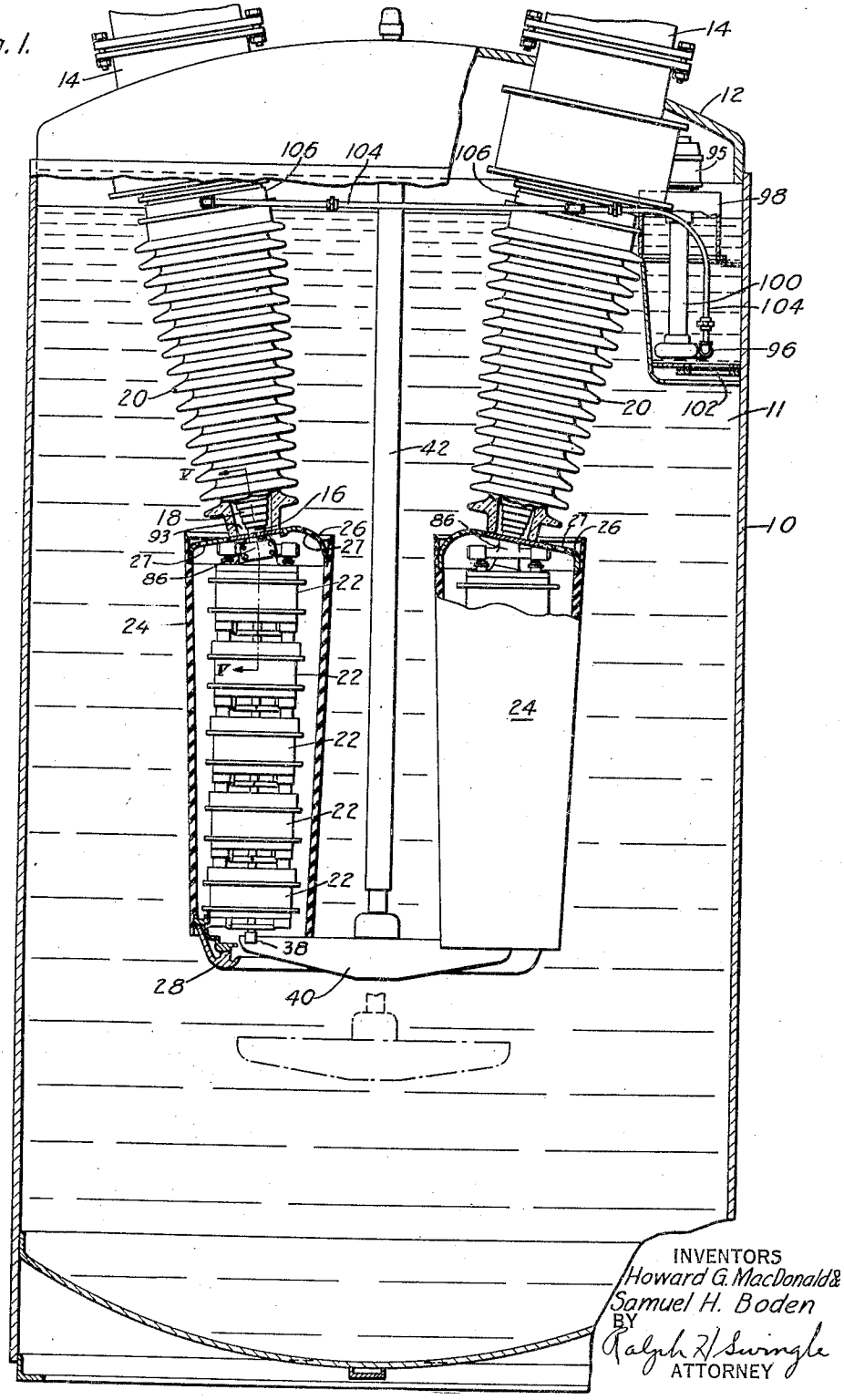
Oct. 25, 1938. H. G. MacDONALD ET AL 2,134,569

CIRCUIT BREAKER

Filed June 3, 1936 3 Sheets-Sheet 1

Fig. 1.



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Fig. 2.

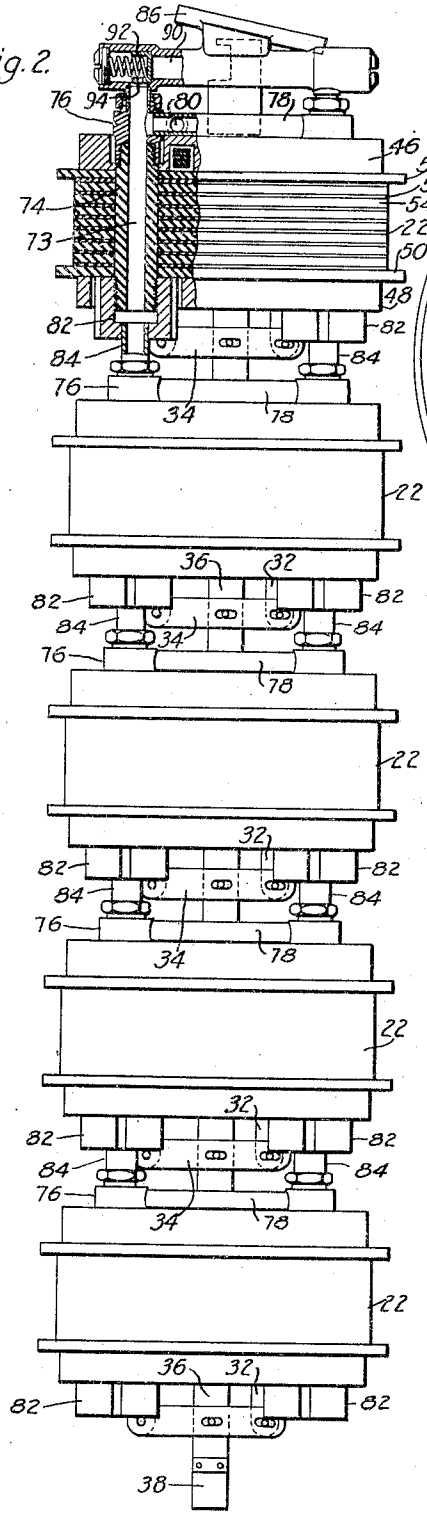


Fig. 3.

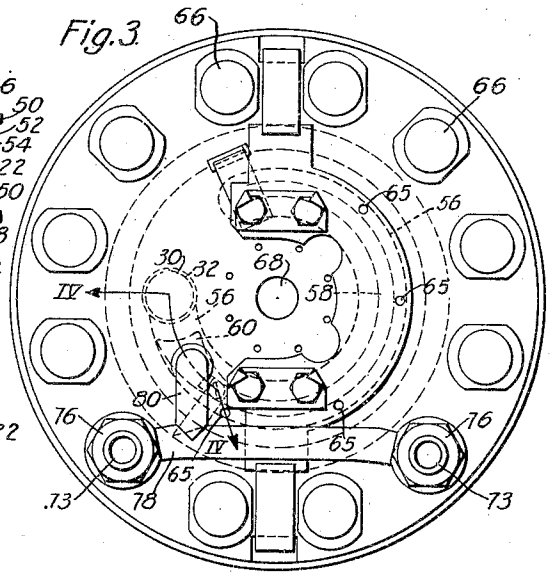
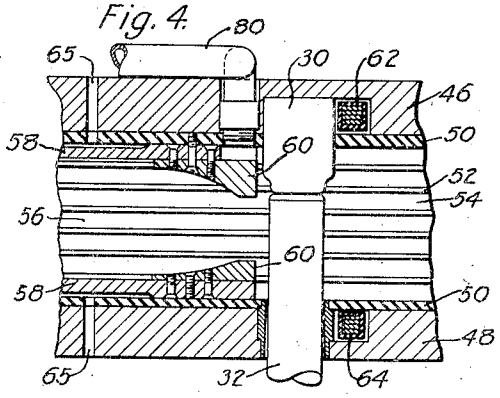


Fig. 4.



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Fig. 6.

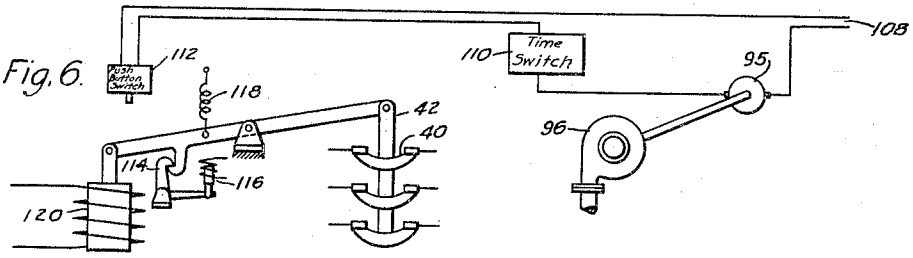
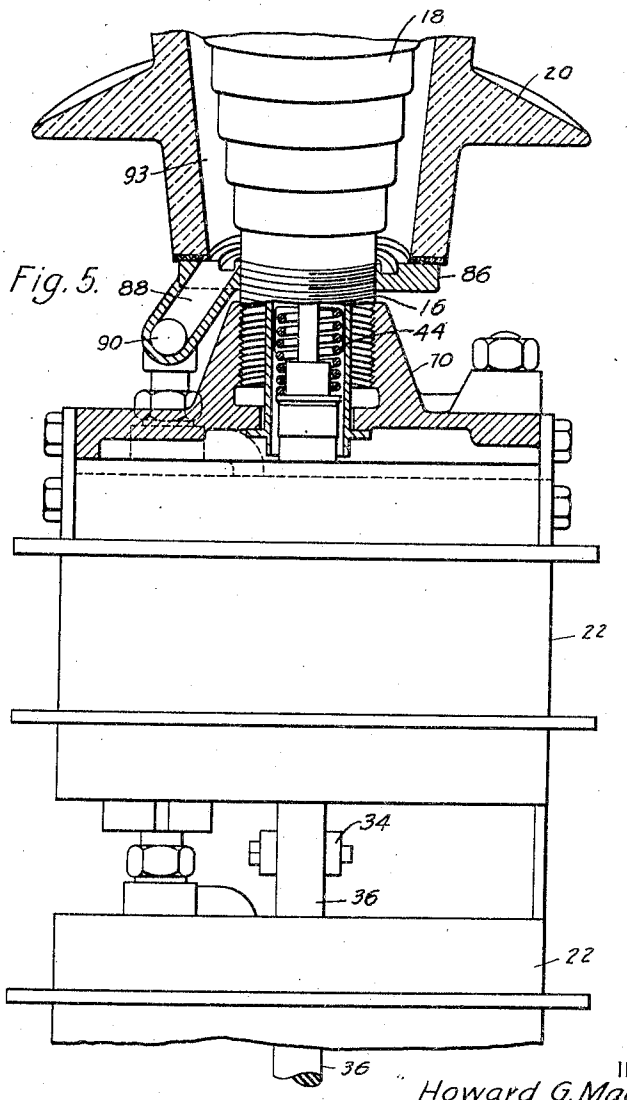


Fig. 5.



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UNITED STATES PATENT OFFICE

2,134,569

CIRCUIT BREAKER

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Application June 3, 1936, Serial No. 83,222

10 Claims. (Cl. 200—150)

This invention relates to circuit breakers and particularly to circuit breakers of the high-voltage type using an arc-extinguishing liquid in an arc extinguishing grid.

In high-voltage circuit breakers, the current which is normally conducted is usually relatively low, and since the circuit breaker must be capable of interrupting its normal load current, the arc-extinguishing device must be designed to successfully interrupt currents at least as low as its normal load current. Where arc-extinguishing devices are used which rely upon forces generated by the arc current itself, it is desirable to make the vent passages from the arc-extinguishing devices of relatively small cross-section so as to confine the arc gases and make the most effective use of the relatively small amounts of gas generated during the interruption of low currents. By making the vent openings small, difficulty may be experienced in obtaining sufficient flow of the arc-extinguishing liquid in the arc chamber to flush out the oil which has been acted upon by the arc and is of low dielectric strength due to the presence of particles of carbon or other products resulting from the arc.

In order to overcome these difficulties, it is an object of this invention to provide a pump for circulating the arc-extinguishing liquid through the arc-extinguishing structure and flush out the products formed by the arc.

A further object of the invention is to provide a control system for a fluid circulating pump for a circuit breaker which causes the liquid to begin to flow only after the arc has been extinguished and which stops the flow of liquid after a predetermined time.

Another object of the invention is to provide an arc-extinguishing structure suspended from an insulating bushing extending through a metal tank with means for introducing the liquid to the arc-extinguishing structure by having it flow through a passage within the supporting insulator bushing, whereby the insulator bushing itself forms an insulating conduit between the fluid circulating means, at ground potential, and the arc extinguishing device at line potential.

An additional object of the invention is to provide a fluid circulating system for a liquid immersed circuit breaker in which a check valve is provided to prevent any flow of fluid from the arc-extinguishing device back to the pump due to pressure set up in the arc-extinguishing device when the arc is drawn.

It is also an object of the invention to mount an electrically driven pump within the tank of a circuit breaker with the electric motor positioned above the level of the liquid in the tank and with the inlet of the pump immersed in the liquid.

A further object of the invention is to provide a stack of circuit interrupting units, each having a pair of contacts for opening the circuit and a tubular insulated passage extending through the stock of circuit interrupting units for supplying liquid under pressure to each of the circuit interrupting units.

These and other objects of the invention will be made apparent through the following description of the specific embodiment of the invention illustrated in the drawings, in which:

Figure 1 is a view partly in section and partly in elevation of a circuit breaker embodying the invention;

Fig. 2 is an enlarged view of one of the stacks of arc-extinguishing units, with part of one arc-extinguishing unit in section in order to show the passages through which the fluid is caused to flow;

Fig. 3 is a plan view of one of the arc-extinguishing units;

Fig. 4 is a developed view of part of one of the arc-extinguishing units with part of the structure shown in section taken generally on the line IV—IV of Fig. 3;

Fig. 5 is a view partly in section on the line V—V of Fig. 1 showing the passages connecting the insulator bushing and the first interrupting unit fastened thereto; and

Fig. 6 is a schematic view showing the connections of the motor-driven pump and its control circuit.

The circuit breaker shown in Fig. 1 has a metal tank 10, including a top 12, through which extend lead-in bushings 14. The tank 10 contains a body 11 of oil or other arc-extinguishing liquid. The lead-in bushings 14 are of the condenser bushing type, including a conducting member 16, on which is wound a plurality of layers of insulating material 18, which may have embedded therein sheets of conducting material for controlling the potential distribution along the bushing. The lower end of the condenser bushing 18 within the metal tank is enclosed within a porcelain arc shield 20. A stack of arc-extinguishing units 22 is suspended from the lower ends of the conducting rods 16 of each of the bushings 14. Each stack of arc-extinguishing units 22 is enclosed within a tubular member of insulating material 24 supported on

a metal end bell 26 at the upper end of each stack, and having a metal end bell 28 at the lower end of each stack. Holes 27 in the upper end bell 26 and the opening for the bridging bar in the lower end bell 28 permit circulation of fluid into the tubular member 24.

As shown in Fig. 4, each of the arc-extinguishing units has a fixed contact member 30 and a moving contact rod 32 which is movable through an opening at the bottom of each arc-extinguishing unit. All of the sets of contacts are electrically connected in series so as to interrupt the circuit at a plurality of points. The moving contacts 32 are actuated through a suitable linkage mechanism 34, each of which is connected to an operating rod 36 of insulating material, which extends through an opening in the center of each circuit interrupting unit, so as to simultaneously open and close all of the plurality of contacts.

The operating rod 36 is provided at its lower end with a disconnecting contact member 38 which is electrically connected in series with the plurality of sets of contacts 30 and 32. The two stacks of circuit interrupting units are electrically connected at their lower ends through a conducting bridging bar 40 which makes contact with each of the contacts 38. The bridging bar 40 is moved by a lift rod 42 of insulating material which may be operated by any suitable mechanism. The operating rods 36 are actuated through the engagement of the bridging bar with the contacts 38 at the end of each operating rod. The operating rod 36 of each stack of arc-extinguishing units is biased to move downwardly to open position by a coil spring 44 at the top of the rod, as shown in Fig. 5. The operating rod 36 and the moving contacts 32 carried thereby are held in closed position against the spring 44 due to the bridging bar engaging the lower end of the operating rod and being held in closed position through the lift rod 42.

When the lift rod 42 is lowered to open the circuit, the bridging bar 40 remains in engagement with the contacts 38 due to the downward bias of the operating rods 36 by the springs 44 until the moving contacts 32 have moved to their fully open position. The circuit is thus interrupted simultaneously by the drawing of a plurality of arcs in series, each of the arcs being within one of the arc-extinguishing units 22. After the moving contacts 32 have reached the end of their travel and are in fully open position, the lift rod 40 continues to move downwardly and thereby disengages the disconnecting contacts 38 and inserts in the circuit two long breaks in the clean oil at the bottom of the tank. Each of the moving contacts 32 may move only an inch or two, whereas the bridging bar 40 may continue to move for a foot or more after the arc drawing contacts 32 have reached their fully open position.

Each of the arc-extinguishing units 22, shown particularly in Figs. 2, 3, and 4, comprises a top end plate 46 of iron, or other magnetic material, and a lower end plate 48 also of iron. Next to each of the iron plates is an insulating plate 50 of fibre of a larger size than the other plates in the stack to provide a barrier between the iron end plates. Between the insulating end plates 50 are provided a plurality of alternate plates 52 and 54 of fibre or other insulating material.

The fibre plates 52 and 54 of the arc-extinguishing structure are circular in shape, and have an arcuate slot 56, as shown in Fig. 3, extending not quite all the way around the plates. The slots 56 in the plates are aligned forming an arcuate groove in which the arc is drawn longitudinally by the moving contact 32. At both the top and bottom of the groove there is provided an arc horn 58, which is arcuate in shape, and provided near one end with an arc terminal member 60 to which the arc transfers from the arc drawing contacts 30 and 32.

There is embedded in a slot in each of the iron end plates 46 and 48 a circular coil 62 and 64 for generating a radial magnetic field across the arcuate slot 56. When the arc has been drawn between the contacts 30 and 32 and has transferred to the arc terminal members 60, it is caused to move laterally in the groove along the arc horns 58 due to the magnetic reaction between the current flow in the arc and the radial magnetic field.

Oil is retained along the arcuate slot 56 by the recesses formed by the thin fibre plates 52 having a slightly narrower slot than the thick fibre plates 54. The products formed by the arc are vented through openings 65 through the top and bottom plates 46 and 48 and the fibre plates 50. As shown in Figs. 3 and 4, the vent openings 65 are positioned along the arc horns 58.

As shown in Fig. 3, the plates of each circuit interrupter unit are held together by nuts 66 on insulating studs which extend through openings arranged in a circle around the outer periphery of the plates. Each of the circuit interrupter units 22 is provided with a hole 68, shown in Fig. 3, through the center of the unit. The common operating rod 36 of insulating material extends through the aligned holes 68.

The stack of circuit interrupting units 22 is supported, as shown in Fig. 5, at their top from the lead-in conductor 16 by means of a metal casting 70, which is threaded on the lower end of lead-in conductor 16.

In order to provide for a flow of fluid through each of the arc-extinguishing units 22, which will flush out the slot in which the arc is drawn and remove the oil which has been subjected to the arc and replace it with oil of high dielectric strength, the arc-extinguishing units 22 are connected together with means providing a pair of tubular passages 73 extending the whole length of the stack of units. These passages are formed by insulating tubes 74 extending through two of the openings around the periphery of the plates. A coupling 76 is screwed onto the upper end of each of the tubes 74, and is provided with a radial passage in which is fastened a cross-tube 78 connecting the two passages 73 at the top of each unit. Each cross-tube 78 has a branch 80 in the form of an elbow which projects as shown in Fig. 4 through the upper iron plate 46 and the fibre plate 50 to provide a passage through which the fluid flows into the slot 56. A coupling 82 is threaded to the lower end of each of the insulating tubes 74 and is provided with a nipple 84 which connects to the coupling 76 on the top of the insulating tube 74 of the unit below. It is thus seen that the insulating tube 74 through each arc-extinguishing unit is connected to the insulating tube 74 extending through the other units of the stack and provides a continuous passage through which oil may be forced into each arc-extinguishing unit.

At the top of the stack, a casting 86 is pro-

vided, as shown particularly in Figs. 2 and 5, in the form of a plate which is threaded on the lower end of the lead-in conductor 16 and forms a liquid-tight joint between the lower end of the porcelain arc shield 20 and the lead-in conductor 16. The casting 86 has a passage 88 extending downwardly from one side thereof to connect with a cross-tube 90 which feeds the oil into the top of each of the two passages 73. At each end of the cross-tube 90 there is provided a check valve 92 which prevents a reverse flow of liquid from the arc-extinguishing units up into the cross-tube 90. The valve 92 has an opening 94 which permits a flow of fluid from the passage 73 into the space behind the valve so that the presence of high pressure in the arc-extinguishing units will hold the valve closed.

There is a hollow passage 93 between each condenser bushing 18 and its porcelain arc shield 20. As shown in Fig. 1, an electrically driven pump, including an electric motor 95 and a centrifugal pump 96, is mounted at the upper end of the tank 10. The motor 95 is supported on a housing 98 mounted on the side wall of the tank 10. The motor 95 is mounted above the level of the liquid 11 and has a tube 100 extending down into the liquid 11, for supporting the centrifugal pump 96 and enclosing its drive shaft. The bottom of the housing 98 is provided with a screen 102 through which liquid may be drawn by the centrifugal pump 96. The outlet of the pump is connected through piping 104 to conduct the oil to openings in the metal collars 106, by which the insulator bushings 14 are supported on the top of the tank 10. The openings in the collars 106 through which the oil flows feed the oil into the space 93 between the condenser bushing 18 and the porcelain arc shield 20.

There is thus provided a complete circuit for the oil which may be drawn from the main body of fluid 11 in the tank 10 through the screen 102 and into the inlet of centrifugal pump 96, by which the oil is pumped through the pipe 104 into the hollow passage 93 of each insulator bushing. The oil flows down the inside of the insulator bushing and through the passage 88 leading from the end of each bushing and into the cross-tube 90, which divides the stream of fluid so that it flows down the two insulating passages 73 extending through the stack of arc-extinguishing units. The oil is fed from the passages 73 through the cross-tubes 78 and conduits 80 into each arc-extinguishing unit. The arc products are forced by the incoming flow of oil out through the vent opening 65 into the main body of the liquid 11 where particles of carbon or other solid matter may settle to the bottom of the tank.

Since the electrically driven pump 95 is mounted on the wall of the tank 10 at ground potential, its conduit leading to the arc-extinguishing units 22 at line potential must provide for electrically insulating the pump from the arc-extinguishing units. This insulation is provided by the insulator bushings 14 through which the oil is caused to flow. The insulator bushings, therefore, function not only to support and insulate the arc-extinguishing structures from the tank, but also act as an insulating conduit for conducting the oil from the pump to the arc-extinguishing units.

As shown in Fig. 6, the electric motor 95 for driving the pump 96 is energized from any suitable low voltage circuit 108 through a time switch 110. The time switch 110 is set in operation by means of a push button switch 112 which is actuated when the lift rod 42 of the bridging bar 40 reaches approximately its fully open position. The movement of the lift rod 42 is controlled through a latch 114 which may be tripped by a tripping solenoid 116. When the latch 114 is tripped, the lift rod and bridging bar are moved to open position by a spring 118. The circuit breaker is closed by means of a closing solenoid 120.

The operation of the circuit breaker of this invention is as follows: When the circuit breaker is in closed-circuit position, the lift rod and bridging bar are in the position as shown in Figs. 1 and 6. To open the circuit, the trip coil 116 is energized which releases the latch 114 and permits the spring 118 to move the lift rod 42 downwardly. As the lift rod 42 moves downwardly, the spring 44 biases the insulating operating rod 36 to move downwardly following the bridging bar 40 without breaking the electrical connection between the contact 38 and the bridging bar. This causes the circuit to be interrupted simultaneously between the contacts 30 and 32 in each of the arc-extinguishing structures. As illustrated on the drawings, there are five arc-extinguishing structures in each stack so that there are a total of ten breaks in series. This makes possible a very rapid opening of the circuit since a movement downwardly of the bridging bar 40 for only one inch will cause a ten inch gap in the circuit. The plurality of arcs which have been drawn are each rotated rapidly in the arcuate slots 56 by means of the radial magnetic field, and are extinguished very rapidly, probably within one cycle of the alternating current, and before the bridging bar 40 has broken connection with the disconnecting contact 38 on the end of each of the operating rods 36. The lift rod 42 continues to move downwardly after the arc is extinguished and finally separates from the disconnecting contact 38 at the end of each stack and inserts a large gap in clean oil which has not had its dielectric strength reduced due to having been acted upon by the arc.

As the lift rod 42 and bridging bar 40 reach the end of their travel, the push button switch 112 is actuated which sets the time switch in operation and energizes the motor 95 from the circuit 108 to start the pump 96. The pump 96 forces a quantity of oil to flow through the pipe 104 and down the passages 93 in the insulating bushings and through the insulating passages 73 into the arcuate slot 56 in each arc-extinguishing unit. This flushes the oil which has been subjected to the arc and arc products out of the arc-extinguishing units through the vent openings 65 and fills each arc-extinguishing unit with clean oil of high dielectric strength. After the pump has operated for a sufficient time to insure that the arc-extinguishing units have been properly flushed out, the time switch deenergizes the circuit of the motor 94 and the pump is stopped. The operation of the time switch 110 is dependent upon the push button switch 112 which is in series with it, so that the pump is stopped as soon as the circuit breaker is reclosed even though the pump has not operated for its full period. Opening of the push button switch 112 causes the time switch 110 to reset itself to run for its full normal period when the push button switch 112 is again closed.

The fact that the pump is not started until after the arc is extinguished relieves the pump from having to pump against the pressure generated by the arc in each arc-extinguishing unit. This is also made certain due to the provision of the check valve **92** which will close if the pressure in the arc-extinguishing units is higher than the pressure of the pump. This makes it impossible for the pressure in the arc-extinguishing units to force liquid to flow back into the pump. The fact that the pump **96** is of the centrifugal type makes it possible for it to continue to operate without damage even though the check valve **92** may be closed, since the pump will then merely churn the oil.

It is thus seen that this invention provides a system for circulating oil by means of a pump to flush out the arc-extinguishing units of the circuit breaker in a very desirable and efficient manner. While a specific modification of the invention has been illustrated in order to show one practical method of using the invention, it is understood that the invention is not to be limited thereby except as required by the prior art and the following claims.

We claim as our invention:

1. In a circuit breaker, a plurality of sets of separable contacts connected electrically in series, operating means for simultaneously opening said plurality of sets of separable contacts, an arc extinguishing device including an arc chamber for each of said plurality of sets of separable contacts, a body of arc extinguishing liquid, a plurality of rods at least partially of insulating material extending through said arc extinguishing devices for supporting the same in spaced relation with respect to each other, at least one of said rods having a longitudinal passage therethrough, tubular means connecting said passage with each of said arc chambers, and means for causing said arc extinguishing liquid to flow through said passage and said tubular means and into each of said arc chambers after the arc is extinguished to flush out said arc chambers.

2. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc extinguishing means carried by said bushing, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc extinguishing means, conduit means providing a passage from said tubular arc shield to said arc extinguishing means, a motor driven pump mounted on said tank with the motor above the level of the body of the liquid and with the inlet of the pump in the body of the liquid, and means to discharge liquid from said pump into the tubular arc shield at a point adjacent the tank to cause the liquid to flow between said shield and bushing into the arc extinguishing means.

3. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc extinguishing means carried by said bushing, said arc extinguishing means comprising means at least partially of insulating material forming an arc chamber and separable contacts for establishing an arc within said chamber, said chamber having vent openings leading therefrom, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc extinguishing means, conduit means providing a passage from said arc shield to said arc chamber, a motor driven pump mounted on said tank with the motor above the level of the body of said liquid and with the inlet of said pump in the body of said liquid, means to discharge liquid from said pump into said tubular arc shield at a point adjacent the tank to cause said liquid to flow between said shield and bushing into the arc chamber and through said vent openings.

4. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc extinguishing means carried by said bushing, said arc extinguishing means comprising means at least partially of insulating material forming an arc chamber and separable contacts for establishing an arc within said chamber, said chamber having vent openings leading therefrom, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc extinguishing means, conduit means providing a passage from said arc shield to said arc chamber, a motor driven pump mounted on said tank with the motor above the level of the body of said liquid and with the inlet of said pump in the body of said liquid, means to discharge liquid from said pump into said tubular arc shield at a point adjacent the tank to cause said liquid to flow between said shield and bushing into the arc chamber and through said vent openings, and check valves in said conduit means for preventing the reverse flow of oil from said arc chamber into said tubular arc shield.

5. In a circuit interrupter, means of insulating material defining the walls of a narrow slot-like arc passage, a pair of arc terminal members disposed in spaced relation within said passage and between which an arc is adapted to be moved, vent openings leading from points adjacent said arc terminal members exteriorly of said arc passage, an arc extinguishing liquid within said passage, and means for forcing additional arc extinguishing liquid into said passage at a point adjacent one end of said arc terminal members following each circuit interrupting operation for flushing said passage and arc terminal members free of the products of decomposition resulting from arc extinction.

6. In a circuit interrupter, means of insulating material defining the walls of a narrow slot-like arc passage, a pair of arc horns disposed in spaced relation within said passage, separable contact members adjacent one end of said arc horns for establishing an arc therebetween, means for moving the arc laterally with its ends in contact with said horns, vent openings leading from points adjacent said arc horns exteriorly of said passage, an arc extinguishing liquid in said passage, conduit means leading through said means of insulating material into said passage at a point adjacent said separable contact members and means for forcing additional arc extinguishing liquid through said conduit means into said arc passage along said arc horns and through said vent openings following each circuit interrupting operation for flushing said passage and said horns free of the products of decomposition resulting from arc extinction.

7. In a circuit interrupter, a plurality of arc extinguishing devices, each of said devices comprising a plurality of plates of insulating material having an arcuate slot therethrough, said plates being arranged in a stack with their slots in alinement to provide a narrow arc chamber, an arc extinguishing liquid within said chambers, a plurality of tie-rods extending through said stacks for clamping the separate plates of each stack

together and for supporting said stacks in spaced relation with respect to each other, a pair of separable contacts within each arc chamber for establishing a plurality of arcs, said chambers having vent openings for the escape of the products of decomposition of said arcs, at least one of said tie-rods having a longitudinal passage therethrough, a tubular connection from said passage to each arc chamber, and means for forcing additional arc extinguishing liquid into said passage through said tubular connections into each arc chamber for flushing said arc chambers free of the products of decomposition resulting from arc extinction.

8. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc-extinguishing means carried by said bushing, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc-extinguishing means, conduit means providing a passage from said tubular arc shield to said arc-extinguishing means, a pump for causing said liquid to flow, and means to discharge liquid from said pump into the tubular arc shield at a point adjacent the tank to cause the liquid to flow between said shield and bushing into the arc-extinguishing means to flush it out, said pump being inoperative to cause said flow while the arc is being extinguished, means for starting the operation of said pump substantially immediately after the arc is extinguished, and means for thereafter stopping the pump.

9. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc-extinguishing means carried by said bushing, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc-extinguishing means, conduit means providing a passage from said tubular arc shield to said arc-extinguishing means, an electrically driven pump for placing said liquid under pressure, and means to discharge liquid from said pump into the tubular arc shield at a point adjacent the tank to cause the liquid to flow between said shield and bushing into the arc-extinguishing means, and said arc-extinguishing means being operable to extinguish the arc without the liquid therein being subjected to said pressure, means for automatically energizing the electrical circuit to start the pump upon movement of said contacts to the open position and for thereafter automatically opening the electrical circuit to stop the pump.

10. In a circuit breaker, a tank, a body of liquid therein, a lead-in bushing extending through said tank, arc-extinguishing means carried by said bushing, a tubular arc shield of insulating material disposed in spaced relation about said bushing and extending from a point adjacent said tank to said arc-extinguishing means, conduit means providing a passage from said tubular arc shield to said arc-extinguishing means, a pump for causing said liquid to flow, and means to discharge liquid from said pump into the tubular arc shield at a point adjacent the tank to cause the liquid to flow between said shield and bushing into the arc-extinguishing means, and means for preventing a reverse flow of the liquid from the arc-extinguishing means into the space between said shield and bushing.

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