

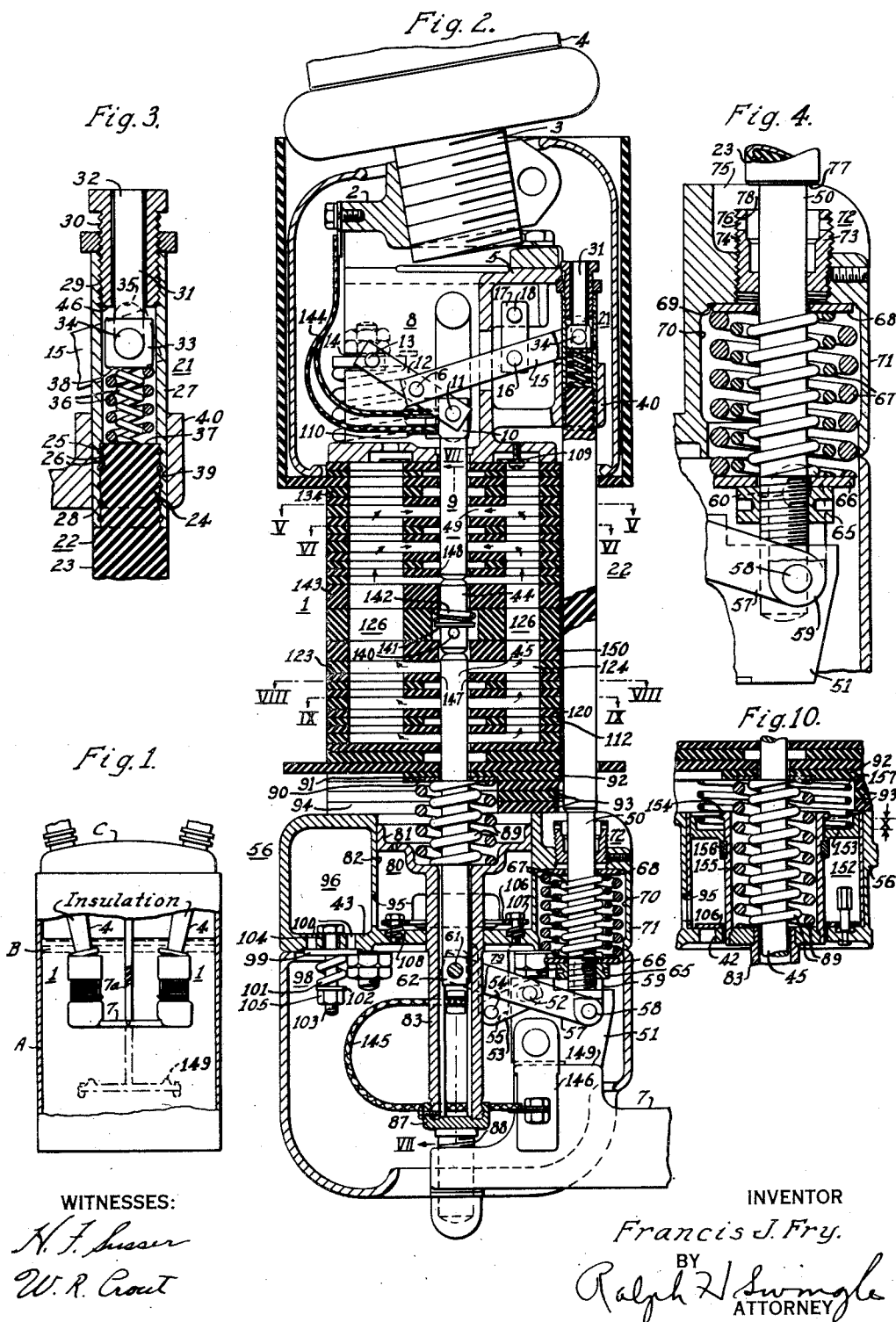
Nov. 21, 1950

F. J. FRY
CIRCUIT INTERRUPTER

2,530,952

Filed April 16, 1947

2 Sheets-Sheet 1



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2 Sheets-Sheet 2

Fig. 5.

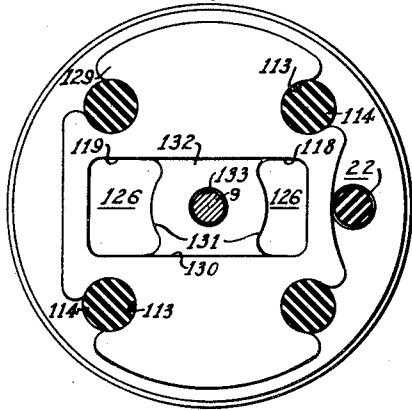


Fig. 6.

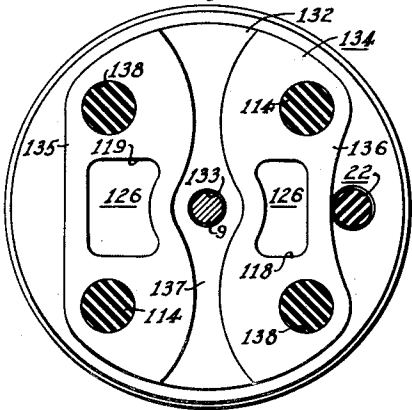
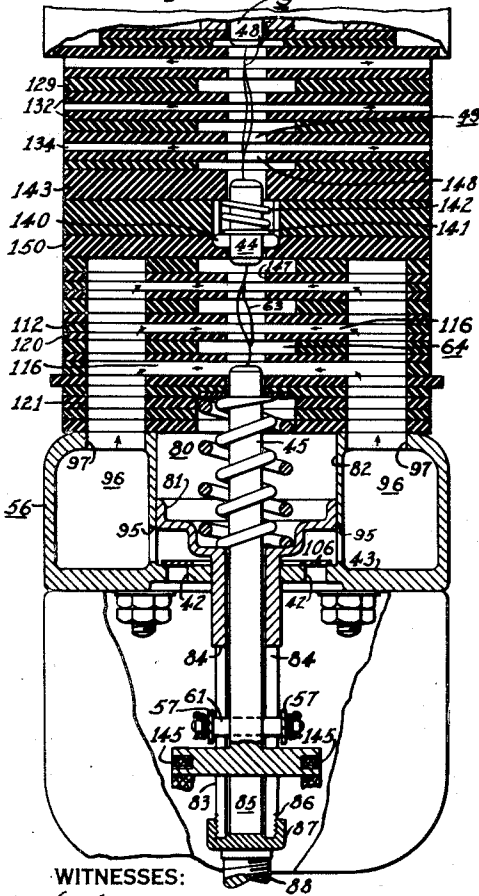


Fig. 7.



WITNESSES:

N. F. Sussler.
W. R. Croust

Fig. 8.

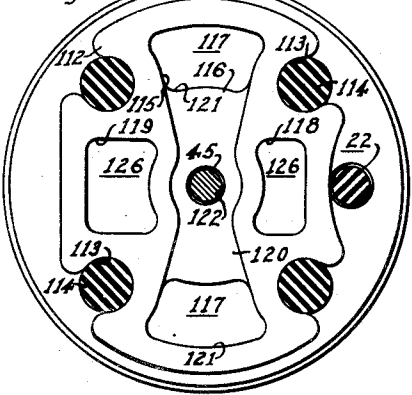
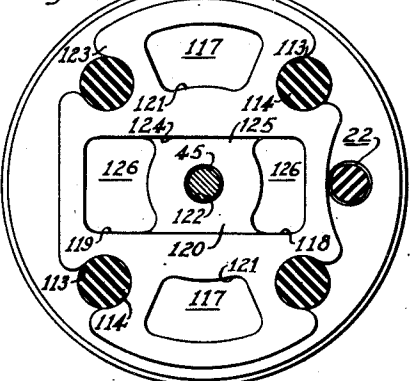


Fig. 9.



INVENTOR

Francis J. Fry.

BY
Ralph H. Swingle
ATTORNEY

UNITED STATES PATENT OFFICE

2,530,952

CIRCUIT INTERRUPTER

Francis J. Fry, Champaign, Ill., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application April 16, 1947, Serial No. 741,865

3 Claims. (Cl. 200—150)

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This invention relates to circuit interrupters in general, and more particularly to arc-extinguishing structures for relatively high-voltage liquid-break circuit interrupters.

In United States patent application filed December 15, 1943, Serial No. 514,366, subsequently abandoned, and continued in patent application filed February 5, 1948, Serial No. 6,436 by Winthrop M. Leeds, Robert E. Friedrich and Francis J. Fry and assigned to the assignee of the instant application, there was disclosed and claimed a method for interrupting relatively low currents, particularly in the charging current range, which involved delayed fluid motion toward one or more of the established arcs. In other words, fluid or oil flow toward the arcs was deliberately delayed for a predetermined time which fell within a disclosed time range. The disclosed limits of this range were a time no earlier than $\frac{1}{2}$ cycle before the contact separation gap is of sufficient length to withstand double peak normal voltage when said gap is filled with clean fluid, and a time no later than the time the contact separation gap is no longer than two times the length of the first-mentioned contact separation gap.

In the aforesaid patent application the predetermined delay of the fluid flow toward the one or more established arcs was provided by employing a pumping piston which was connected by a lost-motion connection to the operating mechanism for the movable contact structure.

It is an object of my invention to provide delayed fluid flow toward the one or more established arcs by an improved means, however following the broad principles set forth in the aforesaid patent application.

Also in United States patent application filed August 31, 1944, Serial No. 552,132, now U. S. Patent 2,445,442, issued July 20, 1948, to Winthrop M. Leeds and Robert E. Friedrich and assigned to the assignee of the instant application, there is disclosed and claimed an improved interrupting structure disposed adjacent to the pressure-generating arc, assuming the form of a multi-orifice interrupting construction in which fluid flow is directed toward the pressure-generating arc at a plurality of axially disposed levels and forced to flow longitudinally adjacent to the pressure-generating arc through a plurality of orifices to then exhaust out away from the pressure-generating arc through laterally provided vent passages.

A further feature of my invention is to improve the interrupting construction adjacent to the pressure-generating arc following the pattern of

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teachings set forth in the aforesaid Patent 2,445,442.

Still a further object of my invention is to provide an improved arc-extinguishing unit of the liquid break type in which the piston means is disposed adjacent the lower end of the unit and in which the normal order of the pressure-generating and interrupting arcs is inverted so that the length of passage interconnecting the piston means and the pressure-generating arc is short.

Another object is to provide an improved arc-extinguishing unit of the liquid break type in which piston means are disposed adjacent the lower end of the unit with the pressure-generating arc immediately adjacent thereto. Preferably the piston means is inoperative during high current interruption and is operative during low circuit interruption to force liquid sequentially through the pressure-generating break and then onto the interrupting break which is disposed at the other end of the unit.

Still a further object is to provide an improved interrupting contact construction in which a pair of movable contacts move in opposite directions away from a relatively stationary intermediate contact through a plurality of orifices in which the pair of contacts serve as valve members to prevent fluid flow through the orifices for a predetermined time.

Another feature of my invention is to provide an improved construction according to the preceding paragraph in which the two movable contacts clear the two orifices associated therewith simultaneously. Preferably I employ a multi-orifice interrupting construction adjacent each movable contact so that the orifices for both contacts are progressively simultaneously opened in the same order.

Another object is to provide an improved liquid break arc-extinguishing unit in which piston means are disposed adjacent one end of the unit, pressure-generating contact means disposed intermediate the ends of the unit and interrupting contact means disposed adjacent the other end. Preferably a multi-orifice interrupting construction is employed adjacent each break and the contact members serve as valve members to delay for a predetermined time liquid flow through the multi-orifice interrupting constructions, the time falling within a preferred time range.

Further objects and advantages will readily become apparent upon a reading of the following specification taken in conjunction with the drawings; in which,

Fig. 1 is a side elevational view, partly in sec-

tion, of a circuit interrupter embodying my invention and shown in the closed circuit position;

Fig. 2 is an enlarged vertical sectional view through one of the two improved arc-extinguishing units of Fig. 1, the unit being shown in the closed circuit position;

Fig. 3 is an enlarged fragmentary vertical sectional view through the lost-motion connection interconnecting the upper movable interrupting contact with the operating rod;

Fig. 4 is a fragmentary enlarged vertical sectional view through the extreme lower end of the operating rod;

Fig. 5 is a sectional view taken along the line V—V of Fig. 2;

Fig. 6 is a sectional view taken along the line VI—VI of Fig. 2;

Fig. 7 is a fragmentary vertical sectional view of my improved arc-extinguishing unit taken at 90° to the view of Fig. 2 along the line VII—VII of Fig. 2, the contact structure being shown in the almost fully open circuit position;

Fig. 8 is a sectional view taken along the line VIII—VIII of Fig. 2;

Fig. 9 is a sectional view taken along the line IX—IX of Fig. 2; and

Fig. 10 is a fragmentary vertical sectional view of a modified type of time delay mechanism for actuating the piston means.

Referring to the drawings, and more particularly to Fig. 1 thereof, it will be observed that I have shown a pair of serially related arc-extinguishing units generally designated by the reference numeral 1, depending within a tank A filled with a suitable arc-extinguishing liquid B, preferably circuit breaker oil.

As shown in Fig. 2, the two extinguishing units 1 are threadedly secured by a pair of contact foot castings 2 to the lower ends of the terminal studs 3, the latter extending interiorly through a pair of terminal bushings 4. As is usual, the terminal bushings 4 are clamped by suitable flange means to the cover C of the oil tank A.

Electrically interconnecting the two serially related arc-extinguishing units 1 is a conducting bridging or actuating member 7 which is actuated vertically in a reciprocal manner by an insulating lift rod 7a. The lift rod 7a is actuated by suitable mechanism responsive to manual operation or to the existence of excessive current conditions in the protected circuit.

There is preferably provided a straight line linkage, generally designated by the reference numeral 8, to provide reciprocating vertical linear motion of the upper movable interrupting contact 9. Preferably the movable contact 9 is rod-shaped in configuration, but this is not necessarily so, inasmuch as the movable contact 9 may be square-shaped or oval-shaped or have other configuration. The upper end of the movable interrupting contact 9 has a head portion 10 preferably of square shape through which extends a pivot pin 11. The opposed outer ends of the pivot pin 11 extend through the right-hand ends of a pair of link members 12. The left-hand ends of the links 12 have a pin roller 13 interconnecting them, which is guided by a pair of horizontally extending slots 14 provided in a casting member 5.

Pivotaly connected at 6 intermediate the ends of the links or levers 12 are a pair of actuating levers 15. The two levers 15 have a pivot pin 16 extending thereacross which passes through the lower ends of two guide links 17, the upper ends of which are pivotaly connected by pivot pins

18 to the casting member 5. I provide a lost-motion connection 21 interconnecting the right-hand ends of the two actuating levers 15 with a vertically extending operating rod 22. Fig. 3 shows the construction more clearly.

Referring to Fig. 3, it will be noted that the operating rod 22 has a central insulating body portion 23 which is reduced at its upper end at 24. The reduced portion 24 of the insulating operating rod 22 is externally threaded and steel wire 25 wrapped therearound in helical fashion within the thread grooves 26. A metallic sleeve 27 is interiorly threaded at 28 adjacent its lower end to be threaded upon the steel wire 25 so as to rigidly maintain the sleeve 27 with the operating rod 22.

The upper end of the sleeve 27 is interiorly threaded as at 29 and threadedly receives a guide plug 30. An actuating member 31 having an upper rod portion 32 and a lower square head portion 33 is provided, being disposed interiorly within the sleeve 27 before the guide plug 30 is threaded into the upper end of the sleeve 27. A pin 34 passes by a press fit through the head portion 33 and extends through a pair of slots 35 provided diametrically in the opposite side walls of the sleeve 27. The opposed outer extremities of the pin 34 pass through the right-hand ends of the actuating levers 15. A battery of relatively light compression springs 36 are provided interiorly within the sleeve 27, having their lower ends abutting or seating against the upper end 37 of the body portion 23 of the operating rod 22. The upper ends of the compression springs 36 seat against the lower side 38 of the head portion 33 of the actuating member 31.

The sleeve 27 is vertically guided in an aperture 39 provided in a lug 40 integrally formed with the casting 5 and jutting sidewardly or laterally therefrom. From the aforesaid construction it will be apparent that upon downward opening motion of the operating rod 22 there will initially be a slight motion of the actuating levers 15 or movable interrupting contact 9 downwards as permitted by the simultaneous downward motion of the intermediate contact 44 and the pressure-generating contact 45. During this motion the pin 34 slides upwardly within the slots 35 of the sleeve 27. Thus the compression springs 36 provide the contact pressure between the movable interrupting contact 9, the intermediate contact 44 and the lower movable pressure-generating contact 45.

When the head portion 33 strikes the lower end 46 of the guide plug 30, the lost motion will have been dissipated, and thereafter further downward opening motion of the operating rod 22 will cause clockwise rotation of the actuating levers 15 about the pivot pin 16 as a floating center. This opening clockwise motion of the actuating levers 15 will cause corresponding counterclockwise rotation of the levers 12 about the pin roller 13 as a laterally movable center, the roller 13 moving slightly toward the left within the slots 14. This will cause upward opening motion of the upper movable interrupting contact 9 away from the relatively stationary intermediate contact 44 to thereby establish an interrupting arc 48 within a multi-orifice interrupting structure, generally designated by the reference numeral 49 as shown in Fig. 7.

Referring to Fig. 4, it will be observed that the lower end of the body portion 23 of the operating rod 22 is secured to a metallic rod member 50. The connection may be similar to that here-

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inbefore described in relation to the securing of the body portion 23 to the metallic sleeve 27. The lower end of the rod 50 is externally threaded to be threadedly received by an operating member 51. The operating member 51 has a pivot pin 52 extending therethrough. The pin 52 extends through the right-hand ends of a pair of guide links 53, the left-hand ends of which are pivotally mounted by means of a pin 54 to a downwardly extending bracket portion 55 integrally formed with the lower casting member 56.

The pin 52 also has its ends passing through intermediate portions of a pair of actuating levers 57, the right-hand ends of which are pivotally connected by a pair of pins 58 to the lower ends of a pair of guide links 59. The fixed upper ends of the guide links 59 are pivotally secured at 60 to a pair of downwardly extending lug portions of the casting 56, not shown.

The left-hand ends of the actuating levers 57 are connected by means of a pin 61 to a square-shaped lower head portion 62 of the lower movable rod-shaped pressure-generating contact 45. Thus upon downward opening motion of the operating rod 22 and of rod member 50 secured thereto as permitted by downward opening motion of the bridging member 7, the operating member 51 rigidly secured to the operating rod 22 will also move downwardly to thereby cause counterclockwise rotation of the actuating levers 57 about the movable centers 53. Thus the counterclockwise rotation of the actuating levers 57 will cause downward opening motion of the rod-shaped lower movable pressure-generating contact 45 away from the relatively stationary intermediate contact 44 to establish a pressure-generating arc 63 within a multi-orifice pressure-generating chamber, generally designated by the reference numeral 64 as shown in Fig. 7.

It will be observed that I have secured a collar 65 by means of a threaded connection to the lower end of the metallic rod 50. Immediately above the collar 65 is a washer 66 loosely mounted upon the rod 50 and serving as a lower seat for a battery of relatively heavy accelerating compression springs 67, the upper ends of which seat against a washer 68 also freely slidable about the rod 50. The washer 68 abuts against the upper end 69 of a recess 70 formed within a lug portion 71 integrally formed with the casting member 56. Thus the accelerating compression springs 67 force the downward opening motion of the operating rod 22 as permitted by the lowering of the bridging member 7.

Preferably I provide a dashpot, generally designated by the reference numeral 72, and including a cup-shaped member 73 threadedly secured at 74 within an aperture 75 provided in the lug portion 71. The cup member 73 has laterally extending apertures 76 out of which oil may be forced by the piston action exerted when the extreme lower end 77 of the body portion 23 of operating rod 22 enters the dashpot piston chamber 78. Thus the downward opening motion of the operating rod 22 is arrested in a cushioned manner by operation of the dashpot 72.

Thus it will be apparent that I have provided a straight line linkage mechanism, generally designated by the reference numeral 79, interconnecting the motion of the operating rod 22 with the movable pressure-generating contact 45.

Associated with the lower end of the movable pressure-generating contact 45 is a piston means, generally designated by the reference numeral

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80, and including a piston 81 movable within a piston chamber 82, in this instance formed as an integral portion of the casting 56.

The piston 81 has a downwardly extending sleeve portion 83 surrounding the lower end of the rod-shaped movable pressure-generating contact 45 and having longitudinally extending slots 84 diametrically provided therein, as more clearly shown in Fig. 7. Thus the pin 61 has its ends slidably within the slots 84 so that motion of the pressure-generating contact 45 may be independent of motion of the piston member 81. Preferably the lower end 85 of the sleeve portion 83 is threaded as at 86 to threadedly receive a cap 87. A plug 88 threadedly secured to the extremity of the bridging member 7 abuts against the cap 87 near the end of the closing stroke and during the initial portion of the opening stroke. The plug 88 therefore cooperates with the cap 87 to cause upward charging motion of the piston 81 against the biasing action exerted by a battery of piston accelerating springs 89. The lower ends of the piston springs 89 seat against the piston 81 itself. The upper ends of the piston springs 89 seat against a metallic washer 90 embedded in a recess 91 provided in an insulating plate 92.

It will be observed that the three insulating plates 93 immediately below the insulating plate 92 have laterally extending cut-out portions 94 removed therefrom so that the upper side of the piston 81 is exposed to substantially atmospheric pressure. Consequently, the downward opening pumping motion of the piston 81 will not draw a vacuum or produce cavitation effects above it. The piston chamber 82, integrally formed with casting 56, has in this instance three apertures 95 which lead from the piston chamber 82 to a region 96 which extends almost around the annular casting 56, as shown more clearly in Fig. 7. Thus downward pumping motion of the piston 81 will compress the operating liquid, in this instance oil, within the piston chamber 82 to cause the liquid to flow outwardly through the three apertures 95 into the region 96 and upwardly through two apertures 97 provided in the top of the casting member 56, as shown more clearly in Fig. 7.

An over-pressure valve 98 is provided associated with the casting 56, and includes a washer-shaped valve plate 99 which normally covers apertures 100 provided through the lower wall 43 of the casting 56. The valve plate 99 is biased to its closed position by a compression spring 101, the lower end of which seats against a washer 102 encircling a bolt 103, which passes through an aperture 104 also provided in the lower wall 43 of the casting 56. A nut 105 threaded on the bolt 103 holds the washer 102 in position.

Upon the attainment of excessive pressure within the region 96 within the casting member 56, the over-pressure valve 98 will function to open and relieve the pressure within the region 96.

I also provide a ring-shaped valve plate 106 supported by bolts 107 having their lower ends threaded into the bottom plate portion 43 of the casting 56, as shown in Fig. 2. The valve plate 106 is biased upwardly by a plurality of compression springs 108 which encircle the bolts 107. Apertures 42 are provided through the bottom plate portion 43 of the casting 56, the fluid flow through which is controlled by motion of the valve plate 106.

Thus upon downward opening pumping motion of the piston 81 within the piston chamber 82 the oil pressure thereby caused will close the valve plate 106 over the apertures 42, which would

otherwise permit oil to flow out through the bottom plate 43 of casting 56. Conversely, the upward charging motion of the piston 81 within piston chamber 82 will permit the compression springs 108 to cause the opening of the valve plate 106 to permit oil to be drawn into the piston chamber 82 through the apertures 42 provided in the lower plate portion 43 of the casting 56. A unidirectional oil flow into the piston chamber 82 is thereby assured.

The multi-orifice insulating plate structure 64 adjacent the pressure-generating arc 63 will now be described. Referring to Figs. 8 and 9, it will be observed that I have provided three types of insulating plates adjacent the pressure-generating arc 63. The first type is herein designated an insulating inlet plate 112, being shown more clearly in Fig. 8. The insulating plate 112 has recesses 113 provided therein which permit reception of insulating tie rods 114. Also the insulating inlet plate 112 has a cut-out portion 115 removed therefrom to provide two inlet passages 116. The inlet passages 116 permit the flow of fluid, in this instance oil, upwardly through first fluid flow passage means or two vertical flow passages 117 from the region 96 provided in the casting member 56 toward the arc 63. The inlet plate 112 also has portions 118, 119 removed therefrom the purpose for which will appear more clearly hereinafter.

Immediately above and below each insulating inlet plate 112 is an insulating orifice plate designated by the reference numeral 120, the configuration of which is more clearly shown in Figs. 8 and 9. It will be observed that each insulating orifice plate 120 has portions 121 removed therefrom which upon alignment with portions 121 of the other plates form the two vertical flow passages 117. Also, each orifice plate 120 has portions 118, 119 removed therefrom as was the case with the insulating inlet plate 112. Each orifice plate 120 also has the recesses 113 provided therein to accommodate the insulating tie rods 114. Furthermore, each orifice plate 120 has a centrally provided orifice 122 which closely surrounds the movable pressure-generating contact 45 so that the latter may control, by valve action, the flow of oil through the orifice 122, the purpose for which will appear more clearly hereinafter.

On the other side of each insulating orifice plate 120 is an insulating vent plate having a configuration more clearly shown in Fig. 9 and designated by the reference numeral 123. Each vent plate 123 has the portions 121 removed therefrom to provide the two vertical flow passages 117 leading upwardly from the region 96 in casting 56 to the pressure-generating arc 63. Also, each vent plate 123 has a cut-out portion 124 removed therefrom to thereby provide two oppositely disposed vent passages 125 which lead from the pressure-generating arc 63 to second fluid flow passage means or two vertical flow passages 126 leading from the pressure-generating arc 63 upwardly toward the interrupting arc 48.

Thus from the foregoing description it will be apparent that the multi-orifice interrupting construction 64 disposed adjacent to the pressure-generating arc 63 is such as to permit, during relatively low current interruption, the upward passage of oil upwardly from the region 96 through the apertures 97 provided in casting 56, and upwardly through the two vertical flow passages 117, radially inwardly toward the pressure-generating arc 63 through the oppositely disposed

inlet passages 116. The oil then flows longitudinally of the pressure-generating arc 63 through the orifices 122 as provided by the insulating orifice plates 120, to exhaust out of the multi-orifice interrupting construction 64 through the several pairs of oppositely provided vent passages 125 provided by the several vent plates 123.

The oil exhausting away from the pressure-generating arc 63 through the several pairs of vent passages 125 flows upwardly through the two vertical flow passages 126 into the multi-orifice interrupting construction 49 disposed adjacent to the interrupting arc 48 (Fig. 7).

The multi-orifice interrupting construction 49 disposed adjacent to the interrupting arc 48 will now be described. The multi-orifice interrupting construction 49 includes three different types of plates. The first type is herein designated an insulating inlet plate 129 and is shown more clearly in Fig. 5. The insulating inlet plate 129 has recesses 113 formed therein to accommodate the insulating tie rods 114. The inlet plate 129 has a cut-out portion 130 provided therein to thereby furnish two oppositely disposed inlet passages 131 which lead from the two vertical flow passages 125 toward the interrupting arc 48.

Immediately above and below each insulating inlet plate 129 is an insulating orifice plate 132 having a configuration more clearly shown in Fig. 5. The orifice insulating plate 132 has the portions 118, 119 removed therefrom which upon alignment with such portions 118, 119 in the other plates provide the vertical flow passage 126. Each orifice plate 132 has an orifice 133 provided centrally therein which closely surrounds the upper movable interrupting contact 9. The construction is such that the contact 9 controls, by valve action, the flow of oil through the orifice 133 provided in each insulating orifice plate 132.

On the other side of each insulating orifice plate 132 is a composite vent plate, generally designated by the reference numeral 134, and including two insulating halves 135, 135 laterally spaced apart so as to provide two opposed vent passages 137, as more clearly shown in Fig. 6. The insulating half 136 has the portion 119 removed therefrom and also has apertures 138 provided therein to accommodate the insulating tie rods 114. The insulating half 135 of the composite vent plate 134 has the portion 119 removed therefrom and also has apertures 138 provided therein to accommodate the insulating tie rods 114.

Thus, upon the upward flow of oil upwardly through the vertical flow passages 126 as indicated by the arrows in Fig. 2, the oil passes radially inwardly toward the interrupting arc 48 through the opposed inlet passages 131 to strike the interrupting arc 48 and pass longitudinally thereof in intimate engagement therewith through the orifices 133 as provided by the insulating orifice plates 132. The oil then passes radially away from the interrupting arc 48 out of the unit 1 through the oppositely disposed vent passages 137 provided by the vent plates 134.

It will be observed that the relatively stationary intermediate contact 44 has a pin 140 passing therethrough, above which seats a washer 141. A compression spring 142 is disposed above the washer 141 and has its upper end seating against an insulating plate 143. Thus the compression spring 142 biases the intermediate contact 44 downwardly into following engagement with the lower movable pressure-generating contact 45 during the initial portion of the circuit opening operation. The result is the establishment of the

interrupting arc 48 slightly ahead of the establishment of the pressure-generating arc 63.

Such a construction of the intermediate contact 44 is set forth and claimed in United States patent application, Serial No. 704,884, filed October 22, 1946, now U. S. Patent 2,434,422, issued January 13, 1948 to Douglas J. Marsden, entitled "Circuit Interrupter" and assigned to the assignee of the instant application.

In the closed circuit position of the interrupter, as shown in Figs. 1 and 2, the electrical circuit therethrough includes terminal stud 3, contact foot 2, flexible conductors 144 to the head portion 10 of the movable interrupting contact 9. The circuit then extends through the contact 9, through intermediate contact 44 and through lower movable pressure-generating contact 45. The electrical circuit then extends through the head portion 62 at the lower end of contact 45 and through a pair of flexible conductors 145 to the relatively stationary disconnect contacts 146, which make contacting engagement with the sides of the conducting bridging member 7. The circuit then passes through the other serially related arc-extinguishing unit 1 to the other terminal stud 3 of the interrupter.

During the opening operation, suitable mechanism, not shown, but which is responsive to either manual operation or to the existence of excessive current conditions in the protected circuit, caused downward opening motion of the lift rod 7a connected intermediate the ends of the bridging member 7. The downward motion of the lift rod 7a causes corresponding downward opening motion of the conducting bridging member 7.

During the interruption of relatively high amperage currents, the pressure generated within the pressure-generating chamber 64 will be relatively high. This pressure will act outwardly through the inlet passages 116 provided by the inlet plates 112 and downwardly through the vertical flow passages 117 to act through the region 96 and through the apertures 95 to thereby act upwardly upon the lower surface of the piston member 81. Since the upper surface of the piston member 81 is exposed to substantially atmospheric pressure, and the lower surface thereof is exposed to the high pressure within the pressure-generating chamber 64, the piston 81 is stalled during the interruption of high currents by the interrupter and will not move downwardly. However, the fact that the piston 81 may be stalled has no effect upon the opening downward motion of the contact 45, since the mechanism 79 associated therewith is independent of the motion of the piston 81 by virtue of the presence of the slots 84 provided in the sleeve portion 83 of piston member 81.

Thus, even though the piston 81 may be stalled due to the high pressure caused by the interruption of high amperage currents, nevertheless the contact structure will move independently therefrom as caused by the biasing action exerted by the battery of heavy compression accelerating springs 67.

The downward motion of the operating rod 22 as caused by the compression springs 67 causes upward opening motion of the interrupting contact 9 through the linkage 8 and downward motion of the contact 45 as caused by the linkage 79. Eventually the dashpot 72 arrests the downward opening motion of the operating rod 22 to thereby terminate the separating motion of the movable contact structure.

As mentioned previously, the intermediate contact construction follows the teachings of the Marsden patent so that the opening of the pressure-generating contacts 44, 45 occurs subsequently to the opening of the interrupting contacts 9, 44. The movable pressure-generating contact 45 does not move past, and thus open by valve action, the first orifice 147 (Fig. 2) associated therewith until the upper movable interrupting contact 9 opens, by valve action, at the same time the first orifice 148 associated therewith. Thus, the interrupting influence is delayed for a predetermined time which falls within the time range set forth above in connection with patent application Serial No. 514,366.

During the interruption of high amperage currents, the oil flow toward the interrupting arc 48 is governed entirely by the pressure produced at the pressure-generating arc 63, the piston 81 being stalled at this time by virtue of the high pressure within the pressure-generating chamber 64. Oil flow passes upwardly from the pressure-generating arc 63 through the vent passages 125, through the vertical flow passages 126 to effect extinction of the interrupting arc 48 by the oil flow through the multi-orifice interrupting structure 49, in the manner previously mentioned. After arc interruption and the consequent subsidence of the arcing pressure, the piston 81 will then be effective to force a flushing flow of fresh oil out of the piston chamber 82 and upwardly into the multi-orifice interrupting construction 64. After passing through the interrupting structure 64 the oil flows upwardly into the multi-orifice construction 49 to raise the dielectric strength in both the pressure-generating chamber and the interrupting chamber 64, 49 respectively. Continued downward movement of the bridging member 7 inserts two isolating gaps in the circuit, as indicated by the dotted lines of Fig. 1.

During the closing operation, the bridging member 7 moves upwardly in response to upward motion of the lift rod 7a so that the plug 88 strikes the cap 87 to charge the piston 81 against the opposition provided by the pump springs 89, while at the same time the upstanding portion 149 of the bridging member 7 strikes the operating member 51 to cause closing of the contact structure and compression of the accelerating springs 67. The contact pressure between the several contacts is provided by the lost-motion connection 21 and the springs 36 disposed at the upper end of the operating rod 22.

During the interruption of low currents, such as charging currents or the like, the piston 81 will at this time be effective to cause oil flow out of the piston chamber 82 and upwardly through the vertical flow passages 117 toward the pressure-generating arc 63 through the inlet passages 116. After striking the pressure-generating arc 63 the oil flows out of the pressure-generating chamber 64 through the vent passages 125 and upwardly through the vertical flow passages 126 toward the interrupting arc 48. After contacting the interrupting arc 48 the oil flows out of the unit 1 through the vent passages 137 provided by the several composite vent plates 134.

It will be noted from Fig. 7 that the insulating plate 150 terminates the upper ends of the vertical flow passages 117 so that the piston action is effective to first force oil only toward the pressure-generating arc 63. Thereafter it may flow through the exhaust passages 125 and upwardly through the vertical flow passages 126

toward the interrupting arc 48. Thus the piston action is effective to force oil flow progressively through the interrupting structures 64, 49 disposed in series, associated respectively with the pressure-generating and interrupting arcs 63, 48.

As mentioned previously, the piston action is only effective during low current interruption, when the pressure generated at the pressure-generating arc 63 is not adequate enough to send the requisite flow of oil upwardly toward the interrupting arc 48 to effect the extinction thereof.

The speed of the contacts 9, 45 and the plate spacings are such that during the interruption of all currents, both low and high, the interrupting influence is delayed for a predetermined time by virtue of the fact that the valve action of the contacts 9, 45 through the first orifices 148, 147 associated respectively therewith is such as to prevent oil flow until both contacts simultaneously clear both orifices. Thus the contacts 9, 45 serve as slide valves in controlling the flow of oil through the first orifices 148, 147. Until the contacts 9, 45 have cleared the orifices 148, 147 respectively, there is no interrupting influence brought to bear upon the arcs.

When the contacts 9, 45 eventually do clear the orifices 148, 147 then a flow of oil adjacent the arcs through the said orifices is possible.

The predetermined time before the interrupting influence is brought to bear upon the arcs 48, 63 by a simultaneous clearing of the orifices 147, 148 falls within the above time range as set forth in the aforesaid patent application, Serial No. 514,366, particularly suitable for the interruption of charging currents. Thus, in this particular embodiment of my invention, instead of providing a delayed action piston as was utilized in patent application Serial No. 514,366, I provide a delayed action as determined by the contact speed and the plate spacings before the first orifices 147, 148 are simultaneously uncovered by the two contacts 45, 9. Thereafter, succeeding orifices are simultaneously uncovered at the same rate in the pressure and interrupting chambers 64, 49.

It will be observed that by disposing the pressure-generating arc 63 at the lower end of the unit 1 and the interrupting arc 48 at the upper end of the unit 1, in an inverted order than was heretofore employed, the length of the oil passage from the piston 81 to the pressure-generating arc 63 is considerably less than with previous constructions.

Thus I have provided an improved circuit interrupter in which the upper contact 9 passes the first orifice 148 at the same time the lower contact 45 passes the first orifice 147 associated with it. No interrupting influence is available from the piston 81 until the orifices are cleared, due to the slide valve action of the contacts. When the first orifice 147 of the lower contact 45 is cleared, there is available simultaneously one orifice in the bottom section and one orifice in the top section; and succeeding orifices in both sections are introduced at the same time. On low currents then, each region is equally effective as an interrupter, whereas on high currents most of the de-ionization takes place in the interrupting gap, which is the top gap in my improved interrupter.

The intermediate contact 44 is designed with spring bias in the down direction as caused by the compression spring 142. This intermediate contact 44 will come down, as shown in Fig. 7,

even though the lower section of the unit 1 is the pressure section since the pressure drop from the bottom end of the contact 44 to the top end thereof is only due to losses around the intermediate contact enclosure.

The check valve 106 is normally biased open to allow some cooling convection currents of oil to pass upwardly through the unit 1 while the breaker is in the closed circuit position carrying load current. The check valve 109 controlling apertures 110 in the top casting member 5 assists in this convection action.

During a tripping operation, a slight delay in building up pressure under the piston 81 is obtained due to the displacement of oil required to close check valve 106. This delay is normally less than provided by the valve action of the contacts 9, 45 in simultaneously pulling through the first orifices 147, 148, thereby permitting oil flow.

However, where additional delayed action is desirable beyond the first orifices 147, 148, this may be provided by a modified type of check valve 106 with sufficient area and vertical length of travel.

When the orifices 147, 148 are allowed to burn away excessively due to heavy duty service without adequate maintenance, valve action delay by contacts 9, 45 would be affected. In such a case, the modified check valve 106 could be dimensioned to give delayed action coinciding with that of the contacts 9, 45, or even more delay if desirable.

Fig. 10 illustrates a modified type of delayed action piston means 152 in which there is a lost-motion connection between the fluid moving piston 153 and the outwardly extending flange 154 at the top of the actuating cylinder 155 amounting to the vertical height "X" as shown. A collar 156 secured to the movable actuating cylinder 155 picks up and charges the piston 153 during the closing operation, against the biasing action exerted by the relatively light compression spring 157. This spring 157 ensures that the piston 153 will always rest against the collar 156 in the closed position so that the lost motion "X" will remain constant for successive opening operations. The piston spring 89 is relied upon to do the actual moving of the fluid.

Such a modified type of delayed action piston means 152 would be employed with the check valve 105, unbiased to the open position. The lost-motion mechanical connection between piston 153 and actuating cylinder 155 amounting to the distance "X" would take the place of check valve 106 of Fig. 2 biased to the open position to obtain a time delay before the piston 81 would be effective. As before, the time delay equivalent to the distance "X" could be less, coincide with, or be greater than the time delay achieved by the contact valve action of contacts 9, 45 uncovering the first orifices 147, 148.

In other words, time delay before piston action on low current interruption could be achieved entirely by the piston means 80 of Fig. 2 with a suitably dimensioned check valve 106 biased to the open position, or it could be achieved entirely by the piston means 152 of Fig. 10 exclusive of any valve control by the contacts 9, 45 pulling through the tight fitting orifices 147, 148.

From the foregoing description it will be apparent that I have provided an improved circuit interrupter in which there is a more direct path for oil flow than with the piston at the bottom end of the unit 1 and the pressure break at the top of the unit. Also, by having the contacts 75 serve as slide valve members through the orifices

to simultaneously delay, for a predetermined time, uncovering of the orifices, the interruption of charging currents is effectively increased.

Although I have shown and described specific structures, it is to be clearly understood that the same were merely for the purpose of illustration and that changes and modifications may readily be made therein 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 of the liquid break type, an arc extinguishing unit immersed in an arc extinguishing liquid, a relatively stationary intermediate contact positioned intermediate the ends of the unit, a pressure-generating multi-orifice chamber disposed adjacent one end of the intermediate contact, a rod-shaped pressure-generating contact movable through the orifices into contacting engagement with the intermediate contact, an interrupting multi-orifice chamber disposed adjacent the other end of the intermediate contact, a rod-shaped interrupting contact movable through the orifices into contacting engagement with the intermediate contact, means synchronizing the motion of both contacts so that one contact clears the first orifice of its associated chamber simultaneously with the other contact clearing the first orifice of its associated chamber, piston means operative to sequentially send liquid through the pressure-generating multi-orifice chamber and only then on to the interrupting multi-orifice chamber only when the contacts by valve action have uncovered the first orifice in each multi-orifice chamber, and a lost-motion mechanical connection for delaying for a predetermined time actuation of the piston means.

2. In a circuit interrupter of the liquid break type, an arc extinguishing unit immersed in an arc extinguishing liquid, a relatively stationary intermediate contact positioned intermediate the ends of the unit, a pressure-generating multi-orifice chamber disposed adjacent one end of the intermediate contact, a rod-shaped pressure-generating contact movable through the orifices into contacting engagement with the intermediate contact, an interrupting multi-orifice chamber disposed adjacent the other end of the intermediate contact, a rod-shaped interrupting contact movable through the orifices into contacting engagement with the intermediate contact, means synchronizing the motion of both contacts so that one contact clears the first orifice of its

associated chamber simultaneously with the other contact clearing the first orifice of its associated chamber, piston means operative to sequentially send liquid through the pressure-generating multi-orifice chamber and only then on to the interrupting multi-orifice chamber only when the contacts by valve action have uncovered the first orifice in each multi-orifice chamber, and delaying means for the piston means including a check valve biased to the open position and suitably dimensioned to allow a particular displacement of liquid before it is closed.

3. A circuit interrupter including means defining an arc extinguishing unit, means immersing the unit into a body of liquid at one end thereof, liquid flow producing means disposed adjacent the other end of the unit, means defining a pressure generating chamber disposed intermediate the ends of the unit, rod-shaped contact means for establishing a pressure generating arc within the pressure generating chamber, means defining an interrupting chamber disposed adjacent the said one end of the unit, rod-shaped contact means for establishing an interrupting arc within the interrupting chamber, the liquid flow producing means and the pressure generating chamber and the interrupting chamber being disposed in substantial alignment, first liquid flow passage means interconnecting the liquid flow producing means only with the pressure generating chamber, second liquid flow passage means interconnecting the pressure generating chamber only with the interrupting chamber, the liquid flow producing means surrounding the first-mentioned rod-shaped contact means to thereby avoid off-center stresses, and actuating means for the contact means and also for the liquid flow producing means disposed adjacent said other end of the unit.

FRANCIS J. FRY.

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