March 1, 1949. F. J. FRY 2,463,029

CIRCUIT INTERRUPTER

Filed Oct. 30, 1946 4 Sheets-Sheet 1

Fig. 1.

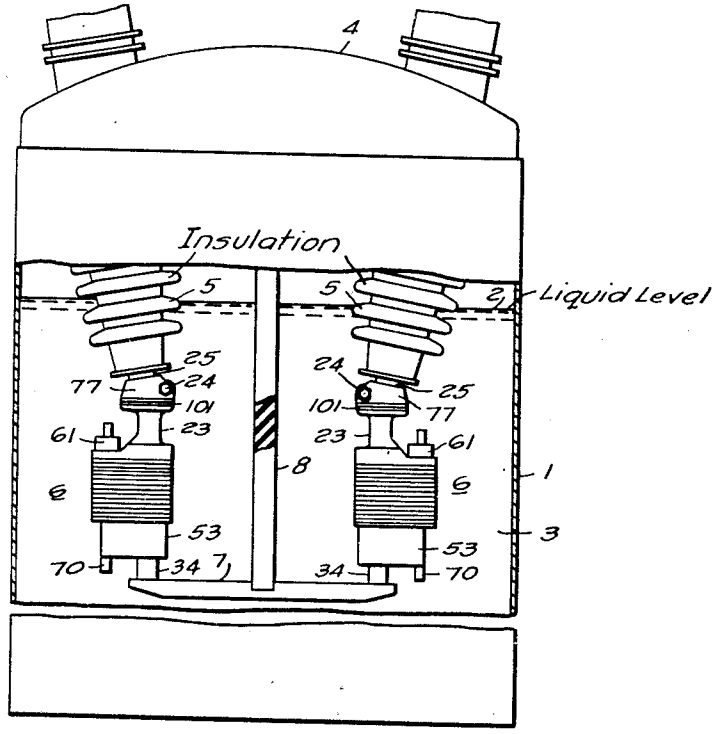


Fig. 4.

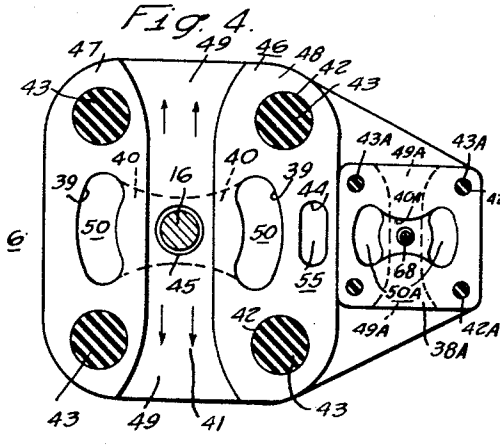
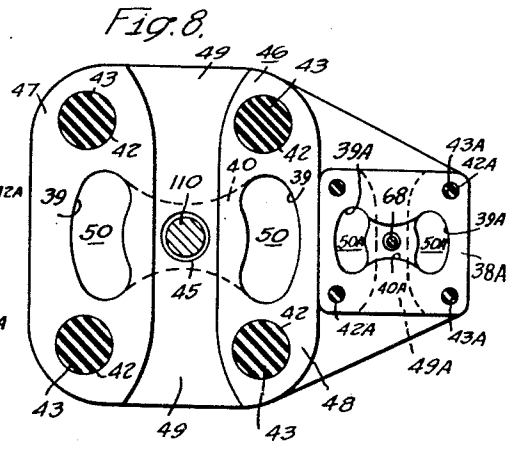


Fig. 8.



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CIRCUIT INTERRUPTER

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4 Sheets-Sheet 2

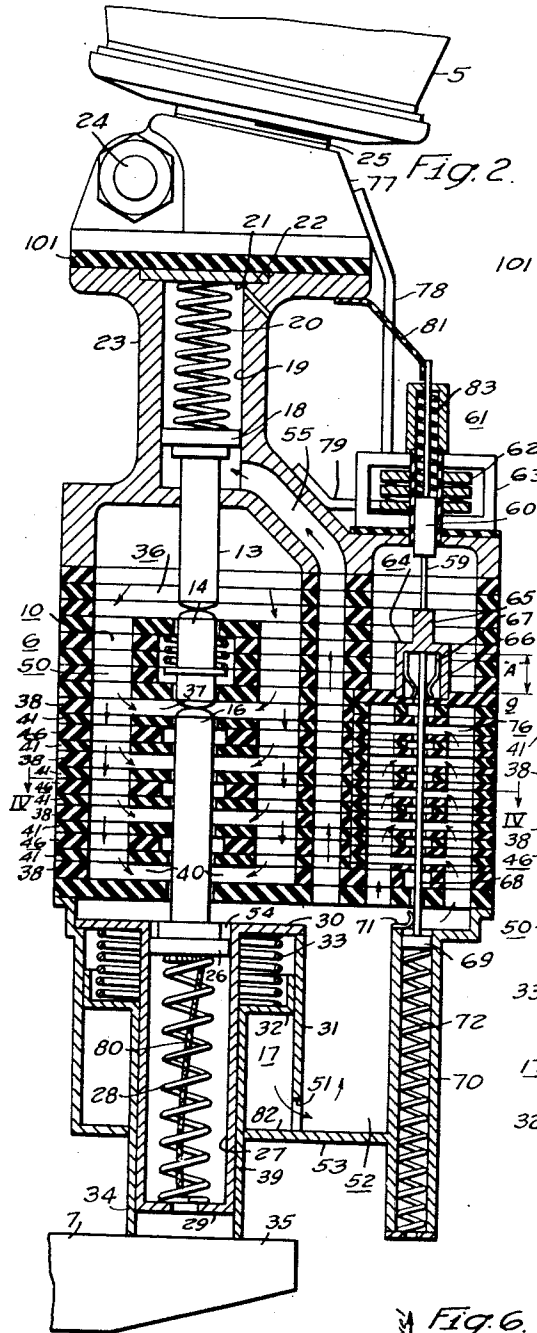


Fig. 2.

Closed Position

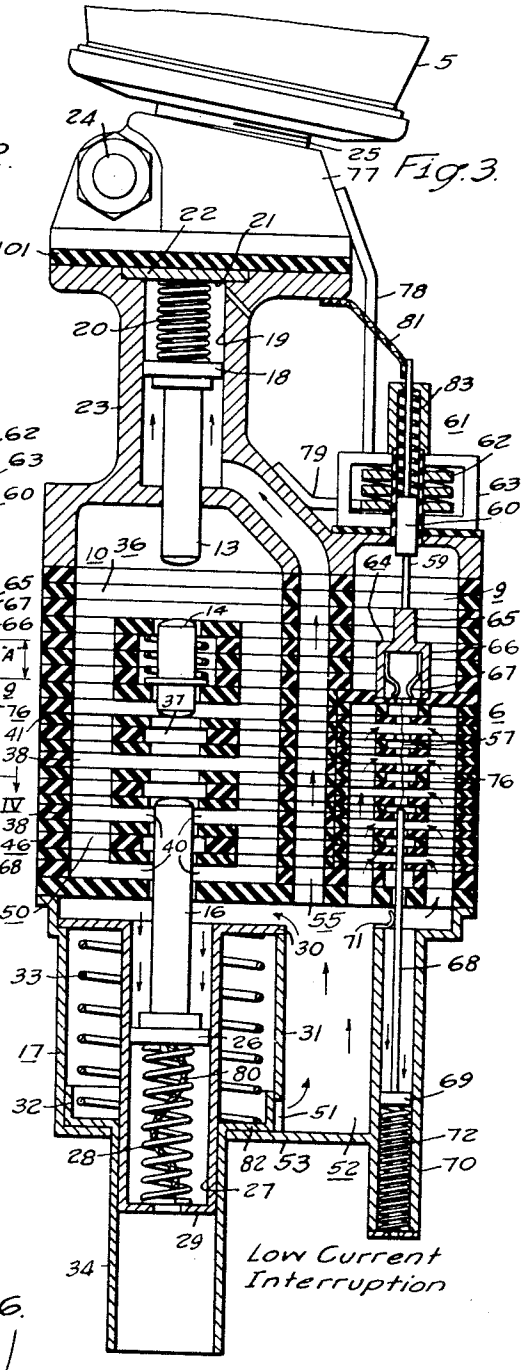


Fig. 3.

Low Current Interruption

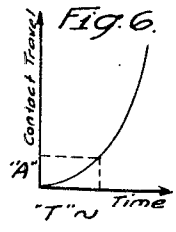


Fig. 6.

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CIRCUIT INTERRUPTER

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Fig. 5.

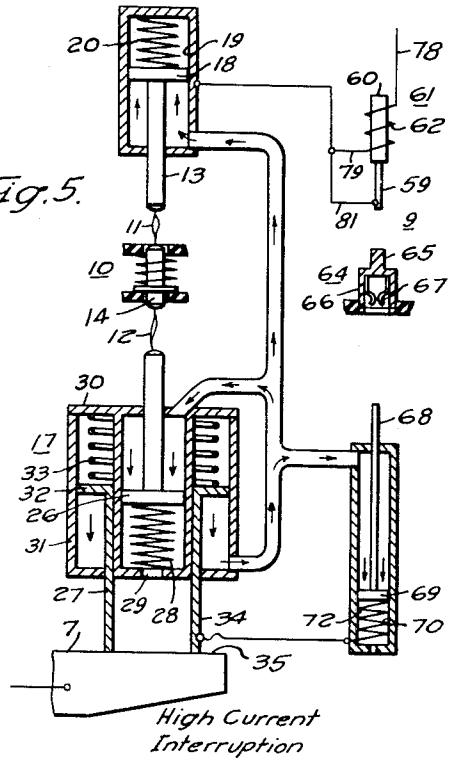


Fig. 9.

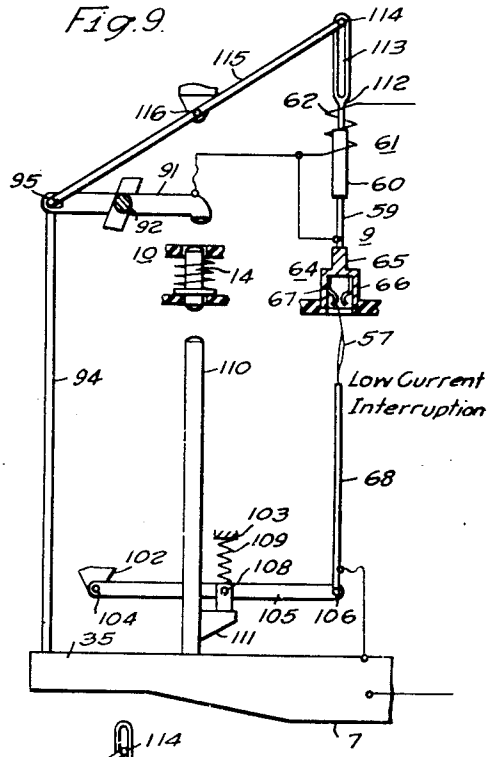
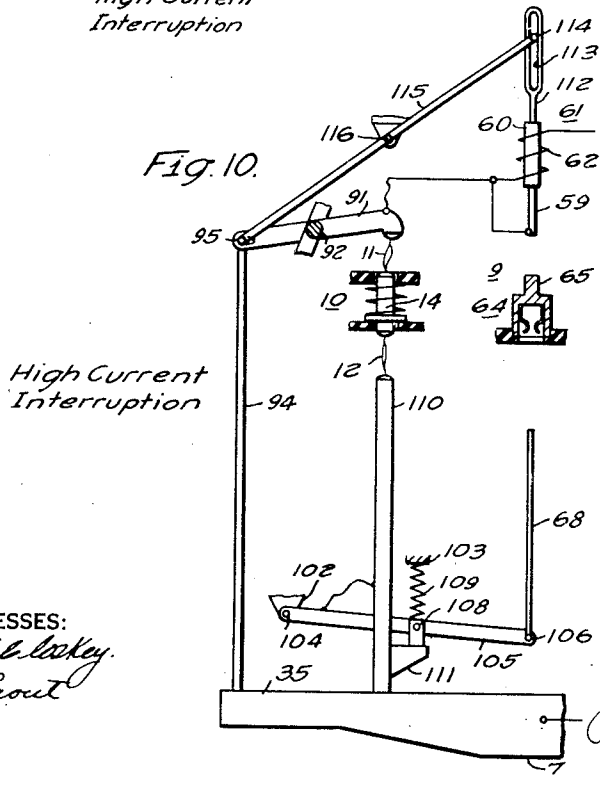


Fig. 10.



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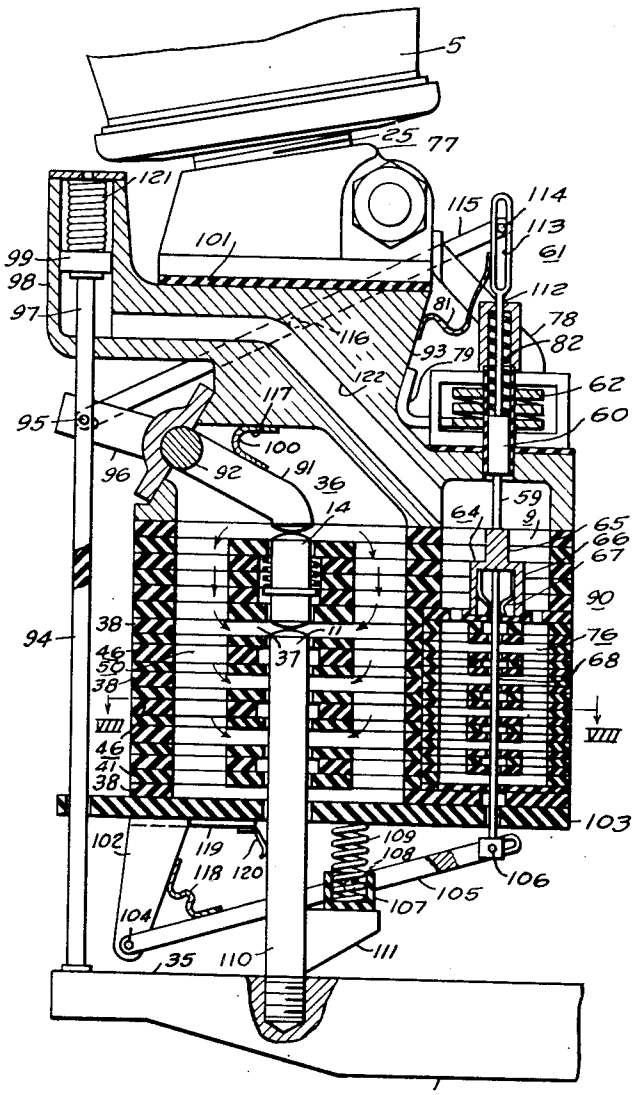
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CIRCUIT INTERRUPTER

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Fig. 7.



7 Closed Position

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UNITED STATES PATENT OFFICE

2,463,029

CIRCUIT INTERRUPTER

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Application October 30, 1946, Serial No. 706,735

18 Claims. (Cl. 200—150)

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This invention relates to circuit interrupters in general, and, more particularly, to improved arc-extinguishing structures therefore.

A general object of my invention is to provide an improved circuit interrupter of the type providing a pair of parallel disposed arc-extinguishing units, one of the units being particularly suitable for interrupting high current power arcs and the other unit being especially adaptable for the interruption of relatively low currents, such as low value magnetizing currents or charging currents. Preferably I employ improved current responsive means for selectively determining in which unit the circuit will be interrupted so as to have the circuit interrupted in the unit which is particularly adapted for the current being interrupted.

In United States patent application, Serial Number 465,244, filed November 11, 1942, now U. S. Patent 2,406,469, issued August 27, 1946, to Leon R. Ludwig, Winthrop M. Leeds and Benjamin P. Baker, and assigned to the assignee of the instant application, there is disclosed and claimed a circuit interrupter of the liquid break type in which multi-orifice plate structure is disposed adjacent to the interrupting arc to effectively direct the oil into the interrupting arc to effect the extinction thereof. This type of interrupter has been demonstrated to show that the arc voltage encountered is extremely low and effective deionizing conditions are brought to bear upon the interrupting arc to effectively extinguish the latter in a very short period of time. The orifices in such a structure are designed to carry sufficient liquid or oil flow in such quantities as to bring about the fast interruption of high power interrupting arcs.

However, during the interruption of low value currents, such as charging currents, the orifices normally used to interrupt power currents of larger magnitude may be too large to effectively direct oil flow against such small arcs.

It is a further object of my invention to take advantage of the remarkable interrupting ability of a multi-orifice type of interrupting structure, such as that described in the above patent application, by employing two such interrupting structures in parallel, one of which is designed to interrupt power currents and the other of which is designed to interrupt low amperage currents such as charging currents. Preferably I employ improved current responsive selective means for drawing the arc in the interrupting structure which is the more suitable for the value of current being interrupted.

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Another object is to provide an improved circuit interrupter of the foregoing type in which improved means are provided so that the circuit will always be closed in the high power interrupting structure and not closed in the low power interrupting structure, the elements of which are relatively small.

Another object is to provide an improved hydraulic operating mechanism for a liquid-type circuit interrupter embodying two such multi-orifice interrupting structures in parallel.

A further object is to provide a mechanical operating mechanism which will also achieve the selectivity desired.

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

Figure 1 is a side elevational view, partially in section, of a tank-type liquid break circuit interrupter embodying my invention and shown in the closed circuit position;

Fig. 2 is a vertical enlarged sectional view through the right hand arc-extinguishing assemblage of Figure 1, the contact structure being shown in the closed circuit position;

Fig. 3 is a view similar to Fig. 2 but showing the disposition of the contact structure during the interruption of relatively low currents;

Fig. 4 is a sectional view taken along the line IV—IV of Fig. 2, looking in the direction of the arrows;

Fig. 5 is a diagrammatic view of the circuit interrupter of Figs. 1–4 showing the disposition of the contact structure during the interruption of relatively high currents;

Fig. 6 is a curve showing the contact travel of the movable contact in the low current unit as a function of time;

Fig. 7 is a vertical sectional view through a modified type of arc-extinguishing assemblage, the mechanism being mechanical, and the contact structure being shown in the closed circuit position;

Fig. 8 is a sectional view taken along the line VIII—VIII of Fig. 7 looking in the direction of the arrows;

Fig. 9 is a diagrammatic view of the interrupter of Figs. 7 and 8 showing the disposition of the contact structure during the interruption of relatively low value currents; and

Fig. 10 is a diagrammatic view similar to Fig. 9 but showing the disposition of the contact structure during the interruption of relatively high value currents.

Referring to the drawings, and, more particularly, to Figure 1 thereof, the reference numeral 1 designates a tank filled to the level 2 with a suitable arc-extinguishing fluid 3, in this instance circuit breaker oil. Depending from the cover 4 of the tank 1 are terminal bushings 5, to the lower ends of which are threadedly secured and clamped arc-extinguishing assemblages generally designated by the reference numeral 6.

The arc-extinguishing assemblages 6 are electrically interconnected in the closed circuit position, as shown in Figure 1, by a conducting bridging member 7 reciprocally operated in a vertical direction by an insulating lift rod 8. The lift rod 8 is actuated by suitable mechanism, not shown, but which is responsive to either manual operation or to the existence of excessive currents carried by the circuit to cause reciprocal motion of the lift rod 8 to effect opening and closing of the interrupter.

Referring to Fig. 2, which more clearly shows the internal construction of the arc-extinguishing assemblage 6, it will be observed that the extinguishing assemblage 6 includes a low current arc-extinguishing unit, generally designated by the reference numeral 9 disposed in parallel with a high current arc-extinguishing unit generally designated by the reference numeral 10. Suitable contact structure is employed in the high current unit 10 to effect the establishment of a pressure-generating arc 11 and an interrupting arc 12 as more clearly shown in Fig. 5. More specifically, such contact structure includes an upper movable pressure-generating contact 13 cooperable with a relatively stationary intermediate contact 14 to establish the pressure-generating arc 11. A lower movable interrupting contact 16 cooperates with the intermediate contact 14 to establish the interrupting arc 12.

In this embodiment of my invention, I employ a hydraulic operating mechanism or means generally designated by the reference numeral 17 to effect both the opening of the contact structure and also the desired flow of oil through the low current unit 9. It will be observed that the pressure-generating contact 13 has an operating piston 18 secured to its upper end and movable within an operating cylinder 19, the piston 18 being spring-biased to the closed circuit position, as shown in Fig. 2, by a compression closing spring 20. The lower end of the spring 20 seats upon the piston 18 and the upper end of the spring 20 seats against a plate 21 embedded in a recess 22 formed in a casting member 23. The casting member 23 is secured by insulating bolts, not shown, to an insulating plate 101. The latter is secured by insulating means to a contact foot 17 threadedly secured and clamped by a bolt 24 to the terminal stud 25 which passes interiorly through the terminal bushing 5.

The lower movable interrupting contact 16 likewise has an operating piston 26 secured to its lower end which is movable within an operating cylinder 27 and biased to its upper closed circuit postion by a compression closing spring 28. The lower end of the compression spring 28 seats upon a suitably inwardly extending flange portion 29 integrally formed with the operating cylinder 27. The upper end of the cylinder 27 has a horizontally extending flange portion 30 which abuts against the upper edge of a pump cylinder designated by the reference numeral 31.

Movable within the pump cylinder 31 is a pumping piston 32, the latter being biased downwardly in the pumping direction by a pump spring 33. The pumping piston 32 has a depending cylindrical portion 34 which in the closed circuit position of the interrupter, as shown in Fig. 2, makes abutting engagement with the extremity 35 of the bridging member 7.

The pressure-generating arc 11 (Fig. 5) is established within a pressure-generating chamber generally designated by the reference numeral 36 in Fig. 2. The interrupting arc 12 (Fig. 5) is established within an interrupting chamber generally designated by the reference numeral 37 and formed by the superpositioning of a plurality of suitably configured insulating plate members. More specifically, the plate members form a multi-orifice interrupting structure adjacent to the path of movement of the interrupting arc 12.

The plate structure is formed of three different types of plates. The first type is herein called an insulating inlet plate and is designated by the reference numeral 38 in Fig. 4. It will be noted that the insulating inlet plate 38 has two cutout portions 39 formed therein which are interconnected by inlet passages 40.

On opposite sides of the inlet plate 38 are disposed a pair of insulating orifice plates designated by the reference numeral 41 and shown more clearly in Fig. 4. The orifice plates 41 have the cutout portions 39 formed therein and, in addition to the plates 38, have apertures 42 provided therein through which extend insulating tie rods 43 which serve to hold the plate structure fixedly in position. Furthermore the plates 38, 41 have cutout portions 44 provided therein, the purpose for which will appear more clearly hereinafter.

The insulating orifice plate 41 has an orifice 45 formed therein through which the movable interrupting contact 16 passes to draw the interrupting arc 12 therethrough.

The third type of insulating plate used in the interrupting chamber 37 is a composite vent plate generally designated by the reference numeral 46. The composite vent plate 46 consists of two insulating halves 47, 48 laterally spaced apart to form opposite vent passages 49 leading out of the assemblage 6 away from the interrupting chamber 37. The insulating half 47 has apertures 42 provided therein for the reception of the tie rods 43. The insulating half 47 also has the cutout portion 39 provided therein.

The insulating half 48 has the cutout portion 39 formed therein and also has the apertures 42 provided therein through which extend the insulating tie rods 43. Also the plate 48 has the cutout portion 44 provided therein.

The cutout portions 39 provided in the several insulating plates align to form vertical flow passages generally designated by the reference numeral 50 and interconnecting the pressure-generating chamber 36 with the interrupting chamber 37.

From the above description, it will be apparent that upon opposite movement of the contacts 13, 16 away from the relatively stationary intermediate contact 14 there will be formed the pressure-generating arc 11 within the pressure-generating chamber 36 and the interrupting arc 12 within the interrupting chamber 37, as more clearly shown in Fig. 5.

Fluid, in this instance oil, under pressure from the pressure-generating arc 11 will flow downwardly through the two vertical flow passages 50 into the interrupting chamber 37 through the

plurality of inlet passages 40, to strike the interrupting arc 12 radially thereof.

The oil will then be compelled to flow longitudinally of the interrupting arc 12 through the orifices 45 provided by the several insulating orifice plates 41, to vent out of the high current unit 10 through the oppositely disposed vent passages 49 as provided by the several vent plates 46. Interruption of the interrupting arc 12 soon follows by such effective deionizing conditions and the circuit passing through the contacts 13, 14, 16 is thereby interrupted.

The interrupting plate structure is set forth and claimed in United States patent application, Serial Number 465,244, filed November 11, 1942, now U. S. Patent 2,406,469, issued August 27, 1946, and assigned to the assignee of the instant application.

It will be noted that upon the opening downward motion of the extremity 35 of the member 7, the pump spring 33 will be permitted to force the pumping piston 32 downwardly to thereby cause a flow of fluid, in this instance oil, to pass out of the pump cylinder 31, as shown by the arrows in Fig. 2, through one or more apertures 51 provided in the pump cylinder 31 to flow upwardly through a passage 52 provided by a casting member 53, integrally formed with cylinder 31, to flow through a passage 54 to the top side of the operating piston 26 and also upwardly through a conduit 55 (as provided by the alignment of the several cutout portions 44 provided in the plate structure) to act upon the lower surface of the operating piston 18.

Thus the operating liquid will serve during the opening operation to force by hydraulic action upward movement of the piston 18 and contact 13 against the biasing action exerted by the closing spring 20, and downward opening motion of the piston 26 and contact 16 against the upward biasing action exerted by the closing spring 28. The result is a simultaneous movement of the contacts 13, 16 away from the intermediate stationary contact 14 to practically simultaneously establish the pressure-generating arc 11 and the interrupting arc 12 within the high current arc extinguishing unit 10 of the assemblage 6.

Immediately adjacent to the high current interrupting unit 10 is the low current interrupting unit 9, which will now be described. This unit 9 consists of a first movable selective current responsive contact 59 having secured thereto at its upper end an armature 60 which is actuated by a current responsive mechanism generally designated by the reference numeral 61, and including a series coil 62 disposed in a suitable magnetic structure 63. Upon the passage of current of predetermined magnitude through the series coil 62, the electromagnetic force will cause upward opening movement of the armature 60 and first movable selective contact 59 away from an intermediate contact structure generally designated by the reference numeral 64.

The intermediate contact structure 64 includes an upstanding stationary contact 65, which in the closed circuit position of the interrupter, as shown in Fig. 2, makes abutting contacting engagement with the selective contact 59. The lower portion of the intermediate contact structure 64 includes a cup-shaped portion 66, within which are disposed a plurality of contact segments 67 biased inwardly by the resiliency thereof and into contacting engagement with a lower second movable contact 68 of the unit 9. The second movable contact 68 has secured

thereto at its lower end an operating piston 69 movable within an operating cylinder 70, in this instance formed as an integral portion of the casting member 53. Preferably a slider contact 71 is provided furnishing electrical contact between the contact 68 and the casting 53. A closing compression spring 72 is provided which biases the piston 69 and contact 68 upwardly toward their closed circuit position.

It will be observed that in the low current interrupting unit 9 there is provided a contact overlap designated by the length of arrow A. Thus the movable contact 68 must move downwardly a predetermined distance equal to the length of the contact overlap distance A before it is permitted to separate from the contact segments 67 to draw an arc in the low current unit 9. The purpose of the contact overlap distance A will be more fully apparent hereinafter.

The interrupting portion 76 of the low current unit 9 is formed by the superpositioning of a plurality of insulating plates which form the same type of multi-orifice interrupting structure adjacent the arc drawn between the contacts 67, 68 as was provided in the interrupting chamber 37 of the high current unit 10 of the assemblage 6. The plate members are considerably smaller than those used in the interrupting chamber 37 to more effectively direct the oil flow adjacent the smaller size arc, but their general configuration is the same. Consequently since the plate members are merely smaller and have the same type of interrupting structure as was described formerly, they have been used with the same reference numeral but with the suffix A. Since the interrupting plate structure for the interrupting chamber 37 was previously specifically described, it is not believed to be necessary to repeat the aforesaid description for the interrupting portion 76 of the low current unit 9.

In the closed circuit position of the interrupter as shown in Figs. 1 and 2, the electrical circuit therethrough includes terminal stud 25, contact foot 77, conducting strap 78, series coil 62, conducting strap 79, casting member 23. The electrical circuit then has two parallel paths through the two electrical parallel disposed units 9, 10 to the lower depending portion 34.

More specifically, the path through the high current unit 10 includes the piston 18, contact 13, contact 14, contact 16, piston 26, flexible shunt 80 to the operating cylinder 27 and hence to the depending portion 34.

Also the current can pass through the parallel disposed low current unit 9, as by means of the casting 23, flexible conductor 81, movable selective contact 59, stationary contact 65, cup-shaped portion 66, contact segments 67, lower movable contact 68, slider contact 71 to the casting member 53. The circuit extends from the casting member 53 through the conducting depending portion 34 to the bridging member 7, and through the other arc-extinguishing assemblage 6 of the interrupter (Fig. 1). The electrical circuit then extends in parallel paths through the left hand assemblage 6 in an identical manner to its passage through the right hand assemblage 6, to the left hand terminal stud 25 of the interrupter.

During the opening operation, suitable mechanism not disclosed, but which is responsive to either manual operation or to the existence of excessive current conditions existing in the electrical circuit controlled by the interrupter, causes downward opening motion of the lift rod 8. The downward motion of the lift rod 8 causes cor-

responding downward opening motion of the bridging member 7.

Considering only the right hand assemblage 6, as shown in Fig. 2, and assuming the existence of relatively high current conditions in the circuit controlled by the interrupter, the contact mechanism for the assemblage 6 will immediately function to cause upward opening motion of the movable current responsive contact 59 as caused by operation of the current responsive mechanism 61. This is shown in Fig. 5.

The downward motion of the extremity 35 of the bridging member 7 permits the pump spring 33 to force the pumping piston 32 downwardly to force oil under pressure out of the pump cylinder 31 to flow out of the one or more apertures 51. This oil flows upwardly through the passage 52 and on the top side of the piston 26 secured to the lower movable interrupting contact 16 of the high current unit 10. The oil also flows upwardly through the conduit 55 to act upwardly against the piston 18 to cause upward motion of the movable pressure-generating contact 13 of the high current unit 10.

Furthermore, the oil acts on the top surface of the operating piston 69 to force it downwardly within the operating cylinder 70 to thereby cause separation of the contacts 67, 68 after the contact 68 has travelled the predetermined contact overlap distance A.

It will be observed that the electromagentic selective mechanism 61 will immediately function before any downward motion of the lift rod 8. This is so because the coil 62 is constantly in series circuit and is immediately responsive to any overload condition existing in the circuit in the same manner as are the overload relays which cause functioning of the mechanism which causes downward opening motion of the lift rod 8. Thus upon high current conditions existing in the circuit controlled by the interrupter, the selective mechanism device 61 will immediately (without any delay) operate to separate the movable selective control 59 from the stationary contact 65. This will cause the current path to extend through the high current unit 10 and not through the low current unit 9, the circuit through the latter being opened by the separation of the contacts 59, 65 as shown in Fig. 5.

Thereafter, the hydraulic operating mechanism 17 functions to cause opposite movement of the contacts 13, 16 in the high current unit 10 and also downward movement of the movable contact 68 in the low current unit 9. The opening of the contact structure within the high current unit 10 will cause interruption of the high amperage current therein as indicated in Fig. 5. There will be no arcing whatsoever within the low current unit 9 during high current interrupting operations.

Fig. 6 shows the contact travel of the movable contact 68 in the low current unit 9 as a function of time. It will be remembered that the contact 68 is hydraulically operated and is relatively light in construction. The contact 68 begins its opening movement from rest with a relatively low speed as indicated by the low initial slope of the curve. At time T the contact 68 has just completed the contact overlap distance A, and at this point begins its separation from the stationary contact segments 67.

During relatively high current interruption, the initial separation of the contacts 59, 65 causes the circuit to pass through the high current unit 10. Because of the gap between the contacts 59, 65 of

the low current unit 9, arcing is initiated in the high current unit 10. Because of the high speed operation of the contact 68, after its initial slow speed, as represented by the curve of Fig. 6, the sum of the two contact gaps in the low current unit 9 is greater than those of the high current unit 10. The contact 68 is relatively light in construction and moves faster than the contacts 13 or 16 of the high current unit. Since the summation of the contact gaps of the low current unit 9 is always greater than the summation of the contact gaps of the high current unit 10 during high current interruption because of the high speed of the relatively light contact 68, when interruption finally does occur in the high current unit 10, there will be no restriking in the low current unit 9 since at this time there will be a greater total gap distance in the low current unit 9 than that which exists at the time of interruption in the high current unit 10. Thus when the gap distances in the high current unit are sufficient to effect interruption, the interruption process will be completed and the circuit will be finally interrupted.

After the high current circuit has been interrupted within the high current unit 10, the pumping piston 32 will cease its downward following travel with the bridging member 7 by striking the lower plate portion 82 of the casting 53 to terminate the downward opening movement of the pumping piston 32. When this occurs the extremity 35 of the bridging member 7 will separate downwardly away from the depending cylindrical portion 34 to insert an isolating gap into the circuit.

In the fully open circuit position of the interrupter, the several closing springs 20, 28, and 72 will function to close the contact structure within the units 9, 10, leakage occurring around the several pistons 18, 26 and 69. Also a closing spring 83 associated with the electromagnetic selective mechanism 61 will cause downward closing motion of both the armature 60 and movable selective contact 59. Consequently in the fully open circuit position of the interrupter, the entire contact structure within the assemblage 6 is completely closed, as is the condition shown in the closed circuit position of the interrupter of Fig. 2. The only difference is that in the fully open circuit position of the interrupter, the bridging member 7 has moved downwardly to its fully open circuit position inserting two isolating gaps in series and permitting a complete contact closure of assemblage 6, as shown in Fig. 2.

Assuming the existence of relatively low current conditions in the circuit controlled by the interrupter, the current responsive device 61 will not function at all, and hence the contacts 59, 65 of the low current unit 9 will remain in contacting engagement. This is shown in Fig. 3.

Since there is a contact overlap distance equal to A, which must be traversed by the movable contact 68 of the low current unit 9 before there is any contact separation in the low current unit 9, the contact gaps will hence first occur in the high current unit 10. The circuit is then only completed through the low current unit 9, and arcing will first be initiated in the low current unit 9 between the contacts 67, 68 to draw an arc 57 (Fig. 3).

In other words, during the time T while the contacts 67, 68 are still in engagement, there will be separation occurring between the contacts in

the high current unit 10, to force the electrical circuit through the low current unit 9.

Deionization of the low current arc 57 will occur in the low current unit 9 by a flow of fluid, in this instance oil, pumped by the pumping piston 32 through the multi-orifice interrupting portion 76 of the low current unit 9, and circuit interruption follows.

It is to be noted that because of the failure of the current responsive device 61 to operate during low currents, and because of the predetermined contact overlap distance A, the summation of the contact gaps in the high current unit 10 will at all times during the interruption process be greater than the gap distance between the contacts 67, 68 in the low current unit 9. When interruption of the arc 57 finally does occur in the low current unit 9, the circuit will, at this time, be finally interrupted, because at this time of arc extinction the gap distances provided by the contact structure in the high current unit 10 is greater than that afforded by the contact gap at the time of interruption between the contacts 67, 68.

After the arc extinction during low current interruption, the bridging member 7 inserts two isolating gaps in the circuit, and the contact structure recloses in the manner previously described.

There may be an intermediate range of current values in which operation of the current responsive device 61 may be sluggish so it will not be definite in which interrupting unit the arcing will be initiated. Thus, the operation of the device 61 will be so rapid at high current values that interruption in the high current unit 10 is always assured. Then, also, at low values of current the device 61 will not operate at all. But both interrupting units 9, 10 are each capable of interrupting satisfactorily currents in the intermediate range in which operation of the current responsive device 61 may be sluggish.

The foregoing description referred to an assemblage 6 which was operated hydraulically and in which during the closing operation the circuit was completed exteriorly of the assemblage 6 so as not to contaminate the gaps within the units 9, 10 with any "prestriking." This term means striking of the arc during the closing operation as the nearing contacts approach one another during the closing operation with voltage on the line. Since high voltage may exist on the line, there will be flash-over between the approaching contacts during the closing operation, even before they have actually contacted one another in abutting engagement.

Referring to Figs. 7–10, it will be apparent that I have provided a mechanically actuated type of assemblage 90 as contrasted with a hydraulically actuated assemblage 6 heretofore described. The plate structure for the high current unit 10 is exactly the same as that described hereinbefore; consequently, a further description thereof is not deemed necessary. Also, the construction of the low current unit 9 is the same as previously described, and therefore a specific description thereof is unnecessary. It will be observed that I have provided in this embodiment of my invention a pivotally mounted pressure-generating contact 91, pivotally mounted at 92 to the modified casting member 93. An insulating operating rod 94 is pivotally mounted by a pin and slot connection 95 to two externally extended actuating arms 96, only one of which is shown in Fig. 7, which are preferably integrally formed

with the contact lever 91. The operating rod 94 has an upwardly extending push rod portion 97 extending within a pump cylinder 98, in this instance, integrally formed with the casting member 93. A freely moving pump piston 99 makes separable abutting engagement with the upper end of the push rod portion 97 of the operating rod 94. The lower end of the operating rod 94 makes separable abutting engagement with the extremity 35 of the bridging member 7 only near the end of the closing stroke and during the initial portion of the opening stroke.

A flexible conductor 100 electrically interconnects the pivotally mounted pressure-generating contact 91 with the casting member 93. It will be noted that the casting member 93 is insulated from the contact foot 77 by an insulating plate 101, as was the case in Fig. 2, so that the electrical circuit may pass entirely through the strap 78 and series coil 62 of the electromagnetic selective mechanism 61.

A pair of brackets 102 are secured to the lower plate 103 of the assemblage 90 to pivotally support at 104 a contact arm 105 having pivotally connected thereto by a pin and slot connection 106, the movable contact 68 of the low current unit 9.

The contact arm 105 has a cup-shaped spring seat 107 pivotally secured thereto at 108 to serve as a lower seat for a compression spring 109, the upper end of which seats against the lower plate 103 of the assemblage 90.

In this modification, the interrupting contact 110 of the high current unit 10 is fixedly secured by a threaded connection to the bridging member 7 so as to move therewith. Fixedly secured to the side of the movable interrupting contact 110 is an actuating lug 111 which makes separable abutting engagement with the spring seat 107 during the closing operation to cause upward closing movement of the contact 68 of the low current unit 9.

An armature 60 of the selective mechanism 61 has an upstanding rod portion 112 having a slot 113 formed therein through which passes a pin 114 guided thereby, the pin 114 being secured to the right hand extremity of an actuating lever 115 pivotally mounted at 116 to the casting member 93. The left-hand end of the actuating lever 115 is pivotally connected at 95 to the operating rod 94.

From the foregoing description, it will be apparent that in the closed circuit position of the interrupter, as shown in Fig. 7, the electrical circuit therethrough includes terminal stud 25, contact foot 77, strap 78, series coil 62, strap 79, to the casting member 93. The circuit then extends through two parallel paths through the parallel disposed units 9, 10 to the contact 110, which is affixed to the conducting bridging member 7. More specifically, the electrical path through the high current unit 10 includes the flexible conductor 100, pressure-generating contact 91, intermediate contact 14 to the lower movable interrupting contact 110. The other parallel electrical path which extends through the low current unit 9 includes flexible conductor 81, upper rod portion 112, armature 60, movable selective contact 59, stationary contact 65 of the intermediate contact structure 64. The circuit then extends through the contact segments 67, through movable contact 68 and thence through the conducting contact arm 105.

The circuit then extends through a flexible conductor 118 to the conducting bracket 102 and

through an integrally formed plate portion 119 through a slider contact 120 to the lower movable contact 110. The electrical path then passes through the conducting bridging member 7 to the other assemblage 90, not shown, through which the circuit passes in an identical manner to the right-hand terminal stud 25 of the interrupter.

During the opening operation, assuming the existence of relatively high currents to be interrupted, the selective mechanism 61 will immediately function, as shown in Fig. 10, to cause upward motion of the movable selective contact 59 away from the stationary contact 65. This causes the electrical circuit to pass through the high current unit 10 and to be interrupted therein.

The high current carried by the circuit controlled by the interrupter will cause the actuation of suitable relay mechanism to cause actuation of the operating mechanism, not shown, which drives the insulating lift rod 8 in a downward circuit opening direction. The downward opening movement of the lift rod 8 causes corresponding downward opening movement of the conducting bridging member 7 and the lower movable interrupting contacts 110 secured fixedly thereto. The downward motion of the bridging member 7 permits the compression spring 121 to force both the pump piston 99 and the operating rod 94 downwardly. The downward motion of the pump piston 99 forces fluid, in this instance oil, under pressure downwardly within the pump cylinder 98 and through a conduit 122 to the low current unit 9 where the oil under pressure passes through the multi-orifice interrupting structure 76 adjacent the path of movement of the movable contact 68 in a manner as previously described.

The compression spring 121 also forces the operating rod 94 downwardly as permitted by downward motion of the bridging member 7. The downward opening movement of the operating rod 94 causes counterclockwise opening rotative motion of the pressure-generating contact 91 to cause the separation thereof upwardly away from the intermediate contact 14. This draws a pressure-generating arc 11, as more clearly shown in Fig. 10.

Since the lower movable interrupting contact 110 is fixedly secured to the bridging member 7, it moves therewith downwardly during the opening operation to separate downwardly away from the intermediate contact 14 to draw an interrupting arc 12, as more clearly shown in Fig. 10. Also, the downward motion of the actuating lug 111 permits the compression spring 109 to force the contact arm 105 downwardly to thereby cause downward opening movement of the movable contact 68 in the low current unit 9.

During the interruption of high amperage currents, as previously mentioned, there first occurs upward separating motion of the movable selective contact 59 to insert a gap in the low current unit 9 between contacts 59 and 65. This opens the circuit through the low current unit 9 and forces the current to flow through the high current unit 10. The downward motion of the bridging member 7 establishes practically simultaneously a pressure-generating arc 11 and an interrupting arc 12 within the high current unit 10 as shown in Fig. 10.

As was the case with the hydraulic operating assemblage 6, the summation of the contact gaps in the low current unit 9 is greater at all times during the opening operation than the summation of the contact gaps in the high current unit 10, in which arcing is initiated and extinguished. In this connection it will be noted that the lever arm distance to the movable contact 68 is over twice that for the contact 110, it being remembered that the spring seat maintains abutting relationship with the lug 111 movable with the contact 110. So the speed of opening of contact 68 is over twice that of contact 110.

Once the contact separation in the high current unit 10 is sufficient to effect interruption, at this same time the contact separation is greater in the low current unit 9 so the circuit will remain interrupted.

It will be observed that in the fully open circuit position of the interrupter that the pin 114 holds the armature 60 and movable selective contact 59 in their upper position. The reason for this is that during a closing operation it is more desirable to close the circuit through the high current unit 10 in which the contact structure is relatively heavy, than in the low current unit 9, where the contact structure is relatively light and not adapted for the carrying of currents of considerable magnitude. Thus, by having the pin 114 maintain the selective mechanism 61 in its open position in the fully open circuit position of the interrupter, during a subsequent closing operation the contacts 91, 14, 110, moving fast, will make engagement to complete the circuit in the unit 10, even before the movable selective contact 59 has lowered sufficiently to make contacting engagement with the stationary contact 65 to thus close the circuit through the low current unit 9. Thus, the arrangement is operable to always close the circuit through the high current unit 10 and not through the low current unit 9 during a closing operation.

Assuming the existence of relatively low current in the circuit to be interrupted, the current responsive device 61 will not be actuated as shown in Fig. 9. Since the movable contact 68 must traverse the predetermined contact overlap distance A before there is any contact gap distance in the low current unit 9, the contacts in the high current unit 10 will open during this time T and hence open the circuit through the high current unit 10. Thus, the circuit is closed through the low current unit 9 and open in the high current unit 10 as shown in Fig. 9.

The construction is such that the summation of the contact gaps in the high current unit 10 is at all times greater during low current interruption than the gap distance between the contacts 67, 68 in the low current unit 9. Thus, when the contacts 67, 68 have separated a sufficient extent so that extinction of the low current arc 57 in the low current unit 9 may take place, since at this same time the summation of the gap distances in the high current unit 10 is greater than the gap distance between the contacts 67, 68, the circuit when interrupted in the low current unit 9 will remain open and no arc will restrike in the high current unit 10.

Deionization of the low current arc in the low current unit takes place by the oil flow down the conduit 122 and through the multi-orifice interrupting structure 76.

As before, there may be an intermediate range of current values in which operation of the current responsive device 61 may be sluggish, and it will not be certain in which interrupting unit interruption of the circuit will take place. But this is not important since either unit is capable of adequately interrupting the circuit in this intermediate circuit range.

During the closing operation, the bridging

member 7 moves upwardly to thereby cause the entrance of the interrupting contact 110 into the arc-extinguishing unit 90, while at the same time the extremity 35 engages the operating rod 94 to cause closure of the pressure-generating contact 91 against the intermediate contact 14 and also to cause charging motion of the pumping piston 99. The spring 121 is thereby compressed. Also, the actuating lug 111 movable with the interrupting contact 110 strikes the spring seat 107 to cause upward closing movement of the movable contact 68 in the low current unit 9.

It will be apparent from the foregoing description that I have provided an improved circuit interrupter in which the orifice size in each unit is such as to most effectively direct fluid flow adjacent the arc drawn into the orifice. I have employed a relatively large multi-orifice interrupting construction for interrupting relatively high currents, and I have utilized a relatively small bore multi-orifice interrupting construction to effect extinction of relatively low currents.

Furthermore, the constructions are such so that when arcing occurs in one unit the summation of the contact gaps in the other unit is always greater during the entire opening operation.

The hydraulic construction is operable in a simple manner, having relatively few moving parts and permitting contact closure in the fully open circuit position of the interrupter. The mechanically actuated interrupter is operable to always close the circuit during a closing operation through the high current interrupting unit.

Thus, I have employed an interrupting construction particlarly adapted for the use of liquid flow in which interruption is brought about in the unit particularly adapted for the magnitude of current being interrupted.

Although I have shown and described specific constructions, 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 blast type, an arc-extinguishing assemblage including electrically parallel arc-extinguishing units, one of the units being especially suitable for high current interruption, the other of the units being especially adaptable for low current interruption, contact means associated with the high current unit operable to establish a pressure-generating arc and a serially related interrupting arc, liquid flow passage means interconnecting the two arcs so that liquid under pressure from the pressure-generating arc may flow under pressure toward the interrupting arc to effect the latter's extinction, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact cooperating with a relatively stationary contact and a second movable contact also cooperable with the relatively stationary contact, means providing a contact overlap distance between the said second movable contact and the relatively stationary contact, the current responsive mechanism causing the opening motion of the movable selective contact only during high current interruption, and a hydraulic operating mechanism for actuation of the contact means of the high current unit and also of the second movable contact of the low current unit.

2. In a circuit interrupter of the liquid blast type, an arc-extinguishing assemblage including electrically parallel arc-extinguishing units, one of the units being especially suitable for high current interruption, the other of the units being especially adaptable for low current interruption, contact means associated with the high current unit operable to establish a pressure-generating arc and a serially related interrupting arc, a multi-orifice interrupting structure disposed adjacent to the interrupting arc so that liquid under pressure from the pressure-generating arc may flow through the multi-orifice interrupting structure adjacent the interrupting arc to effect the extinction of the latter, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact cooperating with a relatively stationary contact and a second movable contact also cooperable with the relatively stationary contact, means providing a contact overlap distance between the second movable contact and the relatively stationary contact, the current responsive mechanism causing the opening motion of the movable selective contact only during high current interruption, and a hydraulic operating mechanism for actuation of the contact means of the high current unit and also of the second movable contact of the low current unit.

3. In a circuit interrupter of the liquid blast type, an arc-extinguishing assemblage including electrically parallel arc-extinguishing units, one of the units being especially suitable for high current interruption, the other of the units being especially adaptable for low current interruption, contact means associated with the high current unit operable to establish a pressure-generating arc and a serially related interrupting arc, a multi-orifice interrupting structure disposed adjacent to the interrupting arc so that liquid under pressure from the pressure-generating arc may flow through the multi-orifice interrupting structure adjacent the interrupting arc to effect the extinction of the latter, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact cooperating with a relatively stationary contact and a second movable contact also cooperable with the relatively stationary contact, the current responsive mechanism causing the opening motion of the movable selective contact only during high current interruption, a hydraulic operating mechanism for actuation of the contact means of the high current unit and also of the second movable contact of the low current unit, means defining a multi-orifice interrupting structure disposed adjacent the arc established between the second movable contact and the relatively stationary contact associated with the low current unit, and means whereby the hydraulic mechanism is operable to send liquid through the multi-orifice interrupting structure in the low current unit to effect the extinction of the arc drawn therein during low current interruption.

4. In a circuit interrupter, an arc-extinguishing assemblage including two interrupting units in parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing therein an arc, contact means associated with the low current unit including a movable selective contact, a relatively stationary contact and a second movable contact, means providing a contact overlap distance between the

said second movable contact and the relatively stationary contact, and current responsive means for ensuring that the circuit will be interrupted only in the high current unit during high current interruption and in the low current unit during low current interruption, the current responsive means causing actuation of the movable selective contact only during high current interruption.

5. In a liquid break type of circuit interrupter, a high current unit connected in electrical parallel with a low current unit, contact structure associated with the high current unit including two oppositely movable contact members, a pair of operating pistons secured to the two contact members for causing opening of the same, a pair of operating cylinders within which the pair of operating pistons move, a pump cylinder, a pump piston movable within the pump cylinder, a member for charging the pump piston, biasing means for the pump piston, conduit means interconnecting the pump cylinder with the two operating cylinders so that opening motion of the pump piston will force operating liquid through the conduit means to effect opening of the pair of contact members, contact structure associated with the low current unit including a movable selective contact, a relatively stationary contact and a second movable contact, a current responsive mechanism for causing opening separating motion of the movable selective contact only during currents of predetermined large magnitude, an operating piston secured to the second movable contact, an operating cylinder within which the last-mentioned operating piston moves, conduit means interconnecting the pump cylinder with the last-mentioned operating piston to cause opening of the second movable contact of the low current unit simultaneously with the movement of the pair of contact members, and means providing a predetermined contact overlap distance between the relatively stationary contact and the second movable contact of the low current unit.

6. In a liquid break type of circuit interrupter, a high current unit connected in electrical parallel with a low current unit, contact structure associated with the high current unit including two oppositely movable contact members, a pair of operating pistons secured to the two contact members for causing opening of the same, a pair of operating cylinders within which the pair of operating pistons move, a pump cylinder, a pump piston movable within the pump cylinder, a member for charging the pump piston, biasing means for the pump piston, conduit means interconnecting the pump cylinder with the two operating cylinders so that opening motion of the pump piston will force operating liquid through the conduit means to effect opening of the pair of contact members, contact structure associated with the low current unit including a movable selective contact, a relatively stationary contact and a second movable contact, a current responsive mechanism for causing opening separating motion of the movable selective contact only during currents of predetermined large magnitude, an operating piston secured to the second movable contact, an operating cylinder within which the last-mentioned operating piston moves, conduit means interconnecting the pump cylinder with the last-mentioned operating piston to cause opening of the second movable contact of the low current unit simultaneously with the movement of the pair of contact members, means defining a multi-orifice interrupting structure of relatively large bore within the high current unit, and means defining a multi-orifice interrupting structure of relatively small bore within the low current unit through which liquid from the last-mentioned conduit means may flow.

7. In a liquid break type of circuit interrupter, a high current unit connected in electrical parallel with a low current unit, contact structure associated with the high current unit including two oppositely movable contact members, a pair of operating pistons secured to the two contact members for causing opening of the same, a pair of operating cylinders within which the pair of operating pistons move, a pump cylinder, a pump piston movable within the pump cylinder, a member for charging the pump piston, biasing means for the pump piston, conduit means interconnecting the pump cylinder with the two operating cylinders so that opening motion of the pump piston will force operating liquid through the conduit means to effect opening of the pair of contact members, contact structure associated with the low current unit including a movable selective contact, a relatively stationary contact and a second movable contact, means providing a contact overlap distance between the said second movable contact and the relatively stationary contact, a current responsive mechanism for causing opening separating motion of the movable selective contact only during currents of predetermined large magnitude, an operating piston secured to the second movable contact, an operating cylinder within which the last-mentioned operating piston moves, conduit means interconnecting the pump cylinder with the last-mentioned operating piston to cause opening of the second movable contact of the low current unit simultaneously with the movement of the pair of contact members, and biasing means for all the contact structure toward the closed circuit position so that in the open circuit position of the interrupter the contacts associated with the high and low current units are completely closed.

8. In a circuit interrupter of the liquid break type, a high current unit including a pivotally mounted pressure-generating contact, a relatively stationary contact, and a movable interrupting contact, a movable member to which the movable interrupting contact is secured, an operating rod operatively connected to the pressure-generating contact and actuated by the movable member during the end of the closing operation, a low current unit in parallel with the high current unit and including a movable contact, means whereby motion of the movable member will cause movement of the movable contact of the low current unit, a movable selective contact cooperable with a relatively stationary contact, means providing a contact overlap distance between said movable contact of the low current unit and the relatively stationary contact, and a current responsive means for causing actuation of the movable selective contact associated with the low current unit only during high current interruption.

9. In a circuit interrupter of the liquid break type, a high current unit including a pivotally mounted pressure-generating contact, a relatively stationary contact and a movable interrupting contact, a movable member to which the movable interrupting contact is secured, an operating rod operatively connected to the pressure-generating contact and actuated by the movable member

during the end of the closing operation, a low current unit in parallel with the high current unit and including a movable contact, a contact arm connected to the movable contact of the low current unit, means biasing the contact arm to the open circuit position, means movable with the movable member for forcing the contact arm to the closed position, a movable selective contact, and a current responsive means for causing actuation of the movable selective contact associated with the low current unit only during high current interruption.

10. In a circuit interrupter of the liquid break type, a high current unit including a pivotally mounted pressure-generating contact, a relatively stationary contact, and a movable interrupting contact, a movable member to which the movable interrupting contact is secured, an operating rod operatively connected to the pressure-generating contact and actuated by the movable member during the end of the closing operation, a low current unit in parallel with the high current unit and including a movable contact, means whereby motion of the movable member will cause movement of the movable contact of the low current unit, a movable selective contact, another relatively stationary contact, means providing a contact overlap distance between the movable contact associated with the low current unit and the said other relatively stationary contact, a current responsive means for causing actuation of the movable selective contact associated with the low current unit only during high current interruption, and liquid flow moving means operated by the operating rod to effect extinction of the arc in the low current unit.

11. In a circuit interrupter of the liquid break type, a high current unit including a pivotally mounted pressure-generating contact, a relative stationary contact, and a movable interrupting contact, a movable member to which the movable interrupting contact is secured, an operating rod operatively connected to the pressure-generating contact and actuated by the movable member during the end of the closing operation, a low current unit in parallel with the high current unit and including a movable contact and another relatively stationary contact, means whereby motion of the movable member will cause movement of the movable contact of the low current unit, a movable selective contact cooperable with said other relatively stationary contact, a current responsive means for causing actuation of the movable selective contact associated with the low current unit only during high current interruption, means causing the opening of the movable selective contact in the fully open circuit position of the interrupter, and means delaying the closing of the movable selective contact during the closing operation until complete closure of the contacts associated with the high current unit.

12. In a liquid break type of circuit interrupter, an arc-extenguishing assemblage including two interrupting units in parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing therein an arc, contact means associated with the low current unit including a movable selective contact, a relatively stationary contact and a second movable contact, means providing a contact overlap distance between the second movable contact and the relatively stationary contact of the low current unit of predetermined amount, and current responsive means for ensuring that the circuit will be interrupted only in the high current unit during high current interruption and in the low current unit during low current interruption, the current responsive means causing actuation of the movable selective contact only during high current interruption.

13. In a liquid break type of circuit interrupter, an arc-extinguishing assemblage including two interrupting units in electrical parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing arcing therein, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact actuated to the open position by operation of the current responsive mechanism during high current interruption and also including a pair of separable contacts connected in series with the aforesaid movable selective contact, and means providing a contact overlap distance between the pair of separable contacts of predetermined amount.

14. In a liquid break type of circuit interrupter, an arc-extinguishing assemblage including two interrupting units in electrical parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing therein a pressure-generating arc and a serially related interrupting arc, passage means for the liquid under pressure from the pressure-generating arc to flow toward the interrupting arc to effect the latter's extinction, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact actuated to the open position by operation of the current responsive mechanism during high current interruption and also including a pair of separable contacts connected in series with the aforesaid movable selective contact, and means providing a contact overlap distance between the pair of separable contacts of predetermined amount.

15. In a liquid break type of circuit interrupter, an arc-extinguishing assemblage including two interrupting units in electrical parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing arcing therein, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact actuated to the open position by operation of the current responsive mechanism during high current interruption and also including a pair of separable contacts connected in series with the aforesaid movable selective contact, and means for causing the summation of the arcing distance in each unit to be greater during the interruption process than that in the other unit when arcing is initiated in the other unit.

16. In a liquid break type of circuit interrupter, an arc-extinguishing assemblage including two interrupting units in parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing therein a pressure-generating arc and a serially related interrupting

arc, passage means for the liquid under pressure from the pressure-generating arc to flow toward the interrupting arc to effect the latter's extinction, a current responsive mechanism, contact structure associated with the low current unit including a movable selective contact actuated to the open position by operation of the current responsive mechanism during high current interruption and also including a pair of separable contacts connected in series with the aforesaid movable selective contact, and means for causing the summation of the arcing distance in each unit to be greater during the interruption process than that in the other unit when arcing is initiated in the other unit.

17. In a circuit interrupter, an arc-extinguishing assemblage including two interrupting units in electrical parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing arcing therein, an operating mechanism for actuating the contact means in the high current unit, a current responsive device, contact structure associated with the low current unit including a movable selective contact and contact means including a pair of separable contacts serially related to the movable selective contact, a contact overlap distance between said last-mentioned pair of separable contacts, the current responsive device causing the opening motion of the movable selective contact during the interruption of currents of predetermined high value, and the operating mechanism also causing the opening motion of the contact means associated with the low current unit.

18. In a circuit interrupter, an arc-extinguishing assemblage including two interrupting units in electrical parallel one of which is especially adapted for high current interruption and the other of which is especially suited for low current interruption, contact means in the high current unit for establishing arcing therein, an operating mechanism for actuating the contact means in the high current unit, a current responsive device, contact structure associated with the low current unit including a movable selective contact and contact means including a pair of separable contacts serially related to the movable selective contact, the current responsive device causing the opening motion of the movable selective contact during the interruption of currents of predetermined high value, the operating mechanism also causing the opening motion of the contact means associated with the low current unit, and means for causing the summation of the arcing distance in each unit to be greater during the interruption process than that in the other unit when arcing is initiated in the other unit.

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