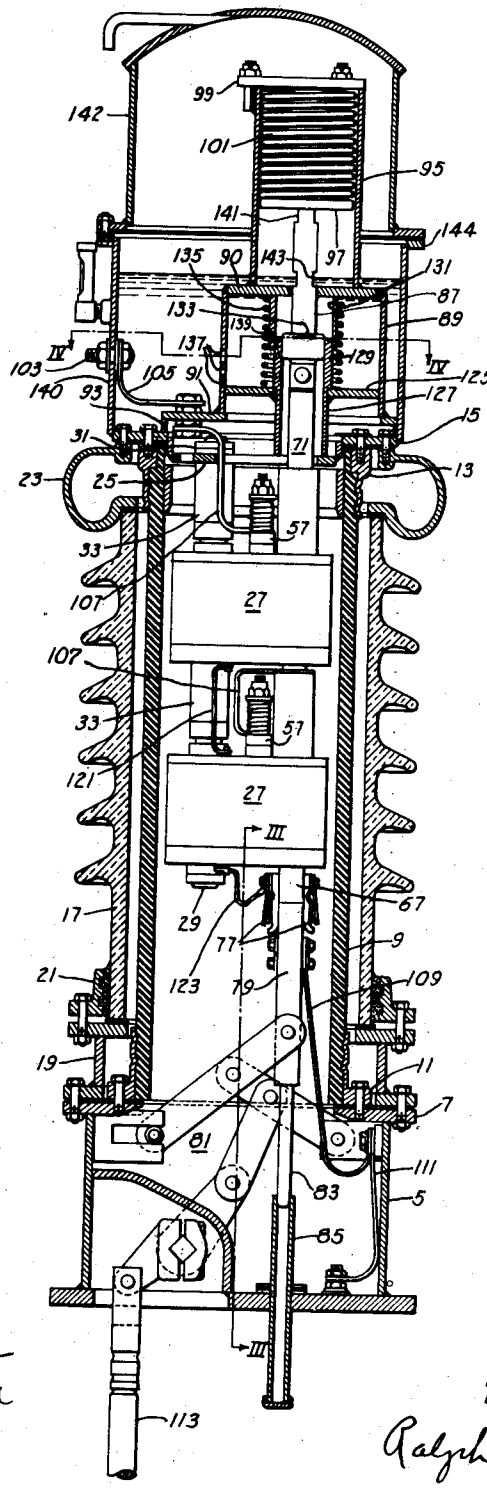
April 9, 1940. W. M. LEEDS ET AL 2,196,419

CIRCUIT BREAKERS

Filed May 28, 1937 2 Sheets-Sheet 1

Fig. 1.



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Filed May 28, 1937 2 Sheets-Sheet 2

Fig. 4.

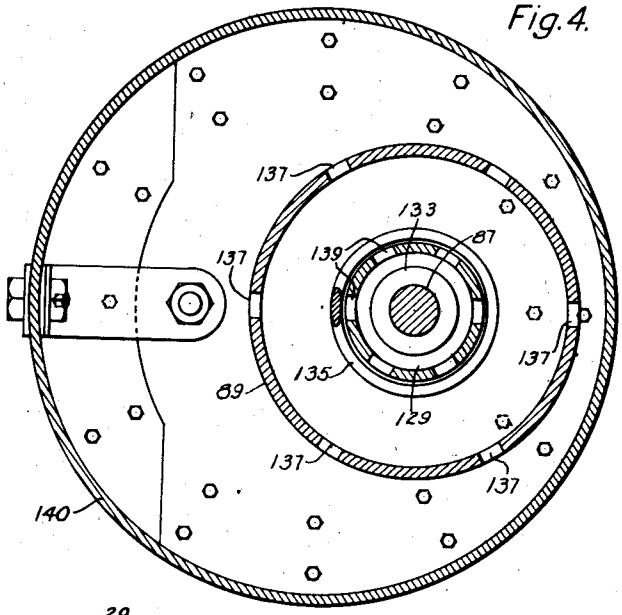


Fig. 3.

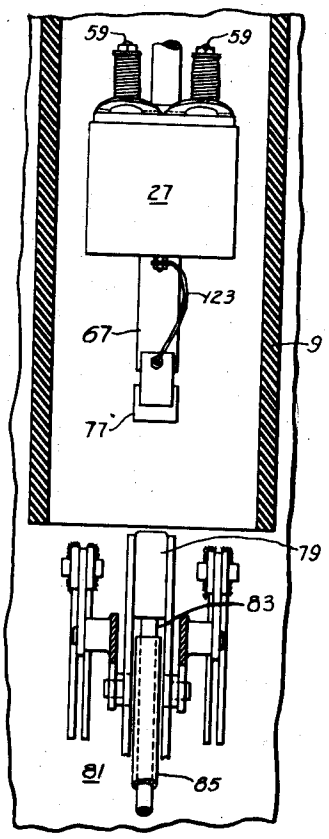
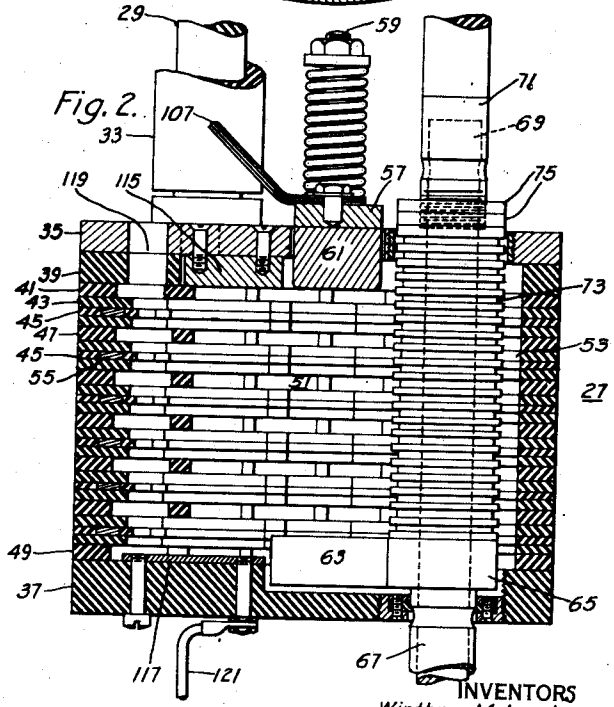


Fig. 2.



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UNITED STATES PATENT OFFICE

2,196,419

CIRCUIT BREAKERS

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Application May 28, 1937, Serial No. 145,272

19 Claims. (Cl. 200—150)

This invention relates to circuit interrupters of the liquid immersed type and more particularly to improvements in operating mechanisms for securing the rapid separation of the interrupter contacts and a more positive circulation of arc extinguishing liquid within the arc extinguishing chambers.

In order to meet present-day demands for high speed circuit breaker operation, designers have almost universally adopted spring means for accelerating the moving parts of the breaker mechanism and the movable contact structure. In the usual arrangement, the force of the accelerating spring is weakest at the end of the contact opening stroke which may permit the moving contact structure to rebound at the end of the opening stroke and interfere with the arc extinguishing function of the breaker.

In recent years, various schemes have also been devised, particularly in breakers of the liquid immersed type, for positively circulating arc extinguishing liquid within an arc rupturing chamber during the circuit interrupting operation. The means usually employed constitute a piston associated with the arc chamber and which is adapted to be actuated simultaneously with the moving contact structure. We have discovered that under certain conditions of operation the pressure within the arc chamber arising from the action of the arc upon the liquid, is sufficient to materially slow down the liquid moving means, and in some instances stopping it entirely prior to the end of its stroke, thereby rendering the liquid circulating means ineffective. It is, of course, conceivable that the deleterious effect of the pressure within the arc chamber may be overcome by increasing the tension of the accelerating spring or springs.

This method of overcoming the difficulty merely introduces a further difficulty which, from a commercial point of view, is perhaps more objectionable than the former, since for every increase in the accelerating force by means of springs, a corresponding increase in force is required to recharge the springs during the closing operation of the breaker. We have discovered that the pressure created by the arc within the breaker casing may be utilized to assist the spring charged operating mechanism to accelerate both contact separation and oil circulation. By utilizing the pressure generated by the arc in this manner, the tension of the accelerating spring may be materially decreased, thereby also reducing the force required for closing the breaker. It, therefore, follows that high speed opening and closing may be effected with a minimum expenditure of power.

More directly stated, the objects of our invention are as follows: to improve the opening and closing performance of circuit interrupters of the liquid immersed type; to provide improvements in the operating means of circuit interrupters of the liquid immersed type for securing a more rapid contact separation and a more positive circulation of arc extinguishing liquid within the arc chamber; to provide an improved mechanism for circuit interrupters of the liquid immersed type which utilizes the pressure generated by the arc to assist the mechanism in moving the contacts to open circuit position and circulating oil in the arc chamber against the pressure created by the arc; to provide an improved operating mechanism for liquid immersed breakers embodying means for utilizing the pressure generated by the arc to assist in the opening movement of the breaker, which mechanism permits the actuation of the breaker contacts to open and closed positions under conditions of no load independently of the means utilizing the internal pressure of the breaker; to provide means utilizing the pressure generated by an arc to assist in the opening operation of a liquid immersed type breaker, which means are operative without substantial time lag irrespective of the position of the breaker contacts between predetermined limits; and to provide a simplified structural arrangement whereby the above-named objects may be effected in liquid immersed breakers employing a plurality of arc extinguishing devices connected in series.

Other objects and advantages relate to details of the structure and will appear more fully in the following description taken in connection with the accompanying drawings, in which:

Figure 1 is a longitudinal sectional view showing a circuit interrupter embodying the improvements of our invention;

Fig. 2 is a longitudinal sectional view through one of the arc extinguishing units employed in the circuit interrupter of our invention;

Fig. 3 is a fragmentary sectional view taken along the line III—III of Fig. 1, showing details of the contact structure when the interrupter is in the open circuit position; and

Fig. 4 is a cross-sectional view taken along the line IV—IV of Fig. 1, showing the means for assisting the operating mechanism to actuate the interrupter to the open circuit position.

In the application of W. M. Leeds and Ennio Ortensi, Serial No. 145,273, filed concurrently herewith, now Patent No. 2,138,382 issued No-

vember 29, 1938, and assigned to the assignee of this application, a circuit interrupter of the liquid immersed type is shown and described, in which arc extinction is accomplished by means of a plurality of arc extinguishing units connected in series and arranged for tandem operation. Each of the arc extinguishing units in the above-named application comprises an arc chamber of narrow slot-like cross-section having an enlarged portion in which a pair of separable contacts are operative to establish an arc, and a restricted portion into which the arc is adapted to be moved just prior to current zero or at such time when the arc section has attained dimensions which permit easy entrance of the arc into the restricted portion. A piston member, which also carries the movable contact, is provided in each arc extinguishing unit for simultaneously establishing an arc and circulating arc extinguishing liquid into engagement with the arc.

Our invention is particularly adapted for use in connection with circuit interrupters of the type shown and described in the aforesaid application, to which reference may be made in describing the mode in which the instant invention may be carried out.

Referring to Fig. 1 of the drawings, the reference numeral 5 designates a cylindrical casing having an upper annular support plate 7, upon which is supported a cylindrical strain member 9 of insulating material, such as fibre or the like. The lower end of the cylindrical strain member 9 is provided with a metallic flange 11 which serves as a convenient means for bolting the member 9 to the support plate 7. The upper end of the cylindrical strain member 9 is provided with a metallic flange 13 to which may be bolted an annular support plate 15. Surrounding the cylindrical strain member 9 is a cylindrical member 17 of insulating and weatherproof qualities, such as porcelain or the like. The weatherproof casing 17 may be supported upon an annular subcasing 19 secured to the support plate 7. A metallic flange member 21 secured to the lower edge of the weatherproof casing 17 may be utilized in bolting the casing 17 to the support 19 as shown.

Interposed between the tops of the support plate 15 and the weatherproof casing 17 is a resilient expansion member 23, preferably of metal, and having a C-shaped cross-section. The expansion member 23 compensates for any inequality of expansion between the strain member 9 and the weatherproof casing 17, thereby maintaining the latter in compression. It will, of course, be understood that gaskets may be inserted as shown between the joints of the various members above described for the purpose of preventing the leakage of liquid with which the interrupter casing is filled.

The upper annular support plate 15 is provided with a hanger plate 25 from which is suspended a plurality of, in this instance two, arc extinguishing units 27. The arc extinguishing units 27 are similar to those shown and described in the aforenamed application and are adapted to be assembled upon four tie rods 29, only one of which is snown. The upper ends of the rods 29 have a threaded portion passing through the hanger plate 25 for the reception of nuts 31. In order to maintain the individual arc extinguishing units 27 in proper spaced relation with respect to each other and to the hanger plate 25, adjustable spacing sleeves 33 are provided surrounding the hanger rods 29.

Each of the arc extinguishing units, as more clearly shown in Fig. 2, comprises a plurality of plates of insulating material disposed between an upper end plate 35, preferably of metal, and a lower end plate 37, preferably of insulating material. The intermediate plates designated as at 39, 41, 43, 45, 47 and 49 each have a slot-like aperture therethrough to provide a relatively narrow arc chamber generally designated at 51. These latter plates are preferably of insulating material, such as fibre, and are also provided with a circular aperture joining one side of the slot-like apertures to provide a cylindrical passage 53, the purpose of which will appear more fully hereinafter. The plates 45 are provided with U-shaped inserts of magnetic material 55 disposed with their parallel elements on opposite of the slot-like passage 51 so as to provide means for moving an arc laterally within the passage.

The upper end plate 35 carries a movable contact member 57, which is resiliently mounted upon the guide and tensioning bolts 59. The contact carrying member 57 has a stationary contact 61 secured thereto, which contact is adapted to extend through the end plate 35 into the arc passage 51. The stationary contact 61 is adapted to be engaged by a moving contact 63, which is carried by the contact support member 65. The support member 65 is provided with the tubular metallic coupling member 67 secured to the lower end thereof. The tubular coupling member 67 is provided with an upstanding rod 69 of insulating material having a metallic coupling 71 secured to the upper free end thereof. The rod 69 is adapted to support a piston 73 which is maintained in assembled position upon the rod 69 by means of nuts 75 screw threaded onto the metallic portion 71.

The metallic coupling member 67 of the upper unit 27 is adapted to be joined to the metallic coupling member 71 of the next lower unit 27, thereby connecting the two units electrically in series and at the same time coupling the contact carrying members 65 and the pistons 73 in tandem for simultaneous actuation.

The coupling member 67 of the lower unit 27 is provided with yieldingly mounted contact fingers 7 adapted to engage a contact actuating member 79, which contact member is adapted to be actuated vertically in straight line motion by an actuating linkage generally designated at 81. The lower end of contact actuating member 77 is provided with a guide member 83 which is adapted to be slidably received by a guide tube 85 extending through and secured to the base of the casing 5.

The metallic coupling 71 of the arc extinguishing unit 27 is provided with a coaxially aligned operating rod 87, which rod extends upwardly through a cylindrical casing 89. The casing 89 is supported and secured to a plate 91 having a flange 93 which in turn rests upon the upper annular plate 15. The upper end of the operating rod 87 terminates in a spring chamber 95 and is provided with a guide member 97. Interposed between the guide member 97 and the removable top plate 99 of the spring chamber 95 is an accelerating spring 101.

The moving contact assemblage, in accordance with the foregoing description, comprises the guide member 97, operating rod 87, metallic coupling member 71 of the upper unit 27, the insulating rod 69 carrying the contact support 65 and the movable contact 63, the metallic coupling member 67, which is joined to the metallic cou-

pling member 71 of the lower unit 27, which unit also has an insulating rod 69, contact carrying member 65 of the lower unit and its movable contact 63, the lower metallic coupling member 67 carrying contact fingers 77 in turn engaging the movable contact actuating member 79. This assemblage also carries the pistons 73 disposed about the insulating rods 69. Thus actuation of the operating linkage 81 will operate the movable contact assembly as a unitary structure to open and closed positions. During movement of the assemblage upwardly to the closed circuit position, the linkage 81 is required to overcome the bias of the accelerating spring 101.

When in the closed circuit position, as shown in Fig. 1, the electrical circuit through the interrupter proceeds from the line terminal 103 through the flexible connection 105, connection 107 to the contact carrying member 57 of the upper unit 27, contact 61, movable contact 63, contact carrying member 65, coupling member 67, coupling member 71 of the lower unit 27, from whence the circuit proceeds through the lower unit 27 in like manner as the upper unit and emerges at the contact fingers 77 and proceeds to the contact actuating member 79. The contact actuating member 79 is provided with a flexible conductor 109, which is joined with a conductor 111 connected to the base of the casing 5 which may serve as the other line terminal of the interrupter.

Upon operating the interrupter to the open circuit position, the actuating mechanism of the interrupter (not shown) through the medium of an actuating rod 113 operates the linkage 81 which in turn lowers the contact actuating member 79, thereby permitting the accelerating spring 101 to move the operating rod 87 and the entire movable contact assemblage of both arc extinguishing units 27 to the open circuit position. The arc established between the stationary contact 61 and the movable contact 63 of each unit will be moved laterally in the arc passage 51 onto the arc horns 115 and 117 disposed in the upper and lower ends of the arc passage.

The products of decomposition of the arc are permitted to escape from the passage 51 through a vent opening 119 provided in the plates 35 and 39 of each arc extinguishing unit 27 which join the rearward end of the slots in the respective plates forming the passage 51. Thus the pressure developed in each of the arc extinguishing units 27 resulting from the formation of the arc therein is communicated to the liquid contained within the enclosure defined by the cylindrical strain member 9.

When the arc has been moved onto the upper and lower arc horns 115 and 117, respectively, th- electrical circuit through the two arc extinguishing units proceeds from the upper contact carrying member 57 of the upper unit 27 to the metallic end plate 35, the upper arc horn 115 through the arc to the lower arc horn 117, connection 121 to the upper plate 35 of the lower unit 27, through which it proceeds in a similar manner as for the upper unit 27, and emerges at a connection 123 which is in turn connected to the contact fingers 77.

During the opening movement of the movable contact 63, the action of piston 73 in the cylindrical passage 53 circulates arc extinguishing liquid contained within the passage into engagement with the arc, thereby forcing the products of decomposition of the arc from the arc passage substantially as rapidly as they are formed. The arc passage 51, as more specifically disclosed in the afore-named application, has a configuration such that movement of the arc laterally toward the rearward portion of the passage 51 does not take place until the arc has a predetermined cross-sectional area. In other words, the arc is permitted to play in an enlarged portion of the passage in the region of the contacts 61 and 63 until its cross-sectional area has been reduced sufficiently to permit entrance into the restricted portion just prior to the current zero, whereupon it may readily be moved by the magnetic action of the U-shaped plates 55 into the constricted portion rearwardly of the passage 55. While in this constricted portion, the arc is subjected to a turbulent cross blast of the products of decomposition of the arc and also to the flow of oil resulting from the action of the piston 73. The turbulent intermixing of un-ionized gas and oil particles with the arc while being thus confined subjects the arc stream to a rapid deionizing action, so that when the arc current passes through its zero value in the current wave, the conductivity of the arc path has been decreased to such an extent that the arc will not restrike when the voltage builds up in the opposite direction. In operating the movable contact assemblage to the fully open position, the moving contacts 63 are brought to rest against the lower end plates 37 of each arc extinguishing unit 27. The contact actuating member 79, however, is free to continue its downward movement for a predetermined distance, causing the contact fingers 79 to be disengaged therefrom to thereby introduce an additional gap in the circuit, as shown in Fig. 3.

It will be noted that the formation of the arc in the passage 51 of each unit 27 may produce considerable pressure, which would ordinarily react on the lower exposed face of the support member 65 of the piston 73, thereby tending to retard the opening movement of the contacts 63. In order to overcome the retardation of the moving contacts 63 during the opening operation and also to increase the speed of separation of the contacts even though a relatively low tension accelerating spring 101 is used, we have provided an accelerating device that utilizes the pressure communicated from each unit 27 to the enclosure defined by the cylindrical strain member 9.

The upper end of the strain member 9 is substantially enclosed by the support plate 91 and the cylidrical chamber 89. Within the cylindrical chamber 89 is provided a movable piston or baffle member 125 which in turn is carried by a tubular member 127 extending therethrough in coaxial alignment therewith. The tubular member 127 has an enlarged annular cross-sectional or piston portion 129 extending above the baffle 125, and is adapted for sliding movement in an inner cylindrical casing 131. The upper ends of the coaxially disposed cylindrical casings 89 and 131 are respectively enclosed by the plate 90 supporting the spring housing 95. The operating rod 87 is provided with a piston 133 rigidly secured thereto and slidably operative in the bore of the tubular piston 129. The baffle member 125 and its cooperating tubular piston member 129 are biased downwardly by a spring 135 encircling the inner casing 131, so that the lower end of the tubular member 127 normally rests upon the hanger plate 25.

The side walls of the cylindrical casing 89 are provided with a series of graded vent open-

ings or apertures as indicated at 137. These vent openings are positioned adjacent and immediately above the baffle member 125 when the baffle is in its normal position, as shown in Fig. 1, and have successively increasing areas in the upward direction. The inner cylindrical casing 131 is also provided with a series of apertures of vent openings, in this instance preferably in the form of segmental circumferential slots, and shown at 139. The vent openings 139 are positioned just above the upper edge of the tubular piston 129 when the piston is in its normal position as shown.

A cylindrical casing 140 is preferably sealed at its lower end to the annular support plate 15 and extends upwardly beyond the cylindrical chambers 89 and 131 so that these chambers may be completely submerged in arc extinguishing liquid. A hood 142 bolted to a flange 144 of the casing 140 encloses the upper end of the circuit interrupter housing.

From the foregoing description, it follows that as the operating rod 87 is moved downwardly during the circuit opening operation carrying with it piston 133, liquid will be drawn in through the apertures 139 to maintain the inner casing 131 filled with liquid. As soon as the pressure resulting from the arcs within the interrupting units 27 builds up within the tubular strain member 9, this pressure will react upon the baffle member 125, which is free to move vertically within the outer cylindrical casing 89, to thereby actuate the tubular piston 129 upwardly, which seals the apertures 139 and subjects the liquid within the inner cylindrical casing 131 to pressure, which pressure reacts downwardly upon the piston 133 to assist the operating rod 87 to move the contacts 63 to the open position and to force the piston 73 against the pressure set up within the arc passages 51. Movement of the baffle member 125 upwardly also uncovers the vent openings 137 through the side walls of the cylindrical chamber 89 to thereby relieve the pressure within the casing 9.

As soon as the pressure subsides within the casing 9 following the interruption of the circuit, biasing spring 135 assisted by gravity again returns the baffle member 125 and its associated tubular piston 129 to the normal position. In this position, the ports or vents 139 are again uncovered, and operating rod 87 with its piston 133 are free to be moved vertically in order to return the interrupter to the closed circuit position. It will thus be seen that the movable contacts with their associated pistons 73 are free to be moved to the open and closed circuit position independently of the baffle member 125.

It should also be noted that the particular arrangement described permits the baffle member 125 to become effective in assisting the opening movement of the interrupter contacts at any point in the opening stroke without appreciable time delay following the creation of pressure within the casing 9. In other words, the force resulting from the pressure within the arc passages 51 of the units 27, communicated to the liquid in the casing 9 and acting upon the baffle 125 is transmitted through hydraulic force-multiplying means to the operating rod 87. This hydraulic force-transmitting connection may be termed a hydraulic ratchet in that it permits the effective operation of the baffle member 125 without time delay in the transmission of force to the operating member 87.

The ratchet action will be apparent upon noting that when the baffle 125 is in the lowermost position, as shown in Fig. 1, the ports 139 are opened, thus permitting the actuating member 87 and the attached piston 135 to move downwardly and to draw liquid through the ports 139 to maintain the casing 131 filled with liquid. As long as the pressure within the casing 9 is insufficient to raise the baffle 125, the ports 139 will remain open and the hydraulic connection between the baffle and the operating rod 87 will remain ineffective. In the event of a time delay in the building up of pressure within the casing 9, the operating rod 87 may move an appreciable distance before the baffle 125 is raised sufficiently to close the ports 139. For example, the operating rod 87 may have moved half away to the open circuit position prior to movement of the baffle 125 and the closing of the ports 139. As soon as the ports 139 are closed, a further movement of the baffle 125 in the upper direction immediately subjects the liquid within the casing 131 to pressure from the action of piston 129 carried by the baffle 125, since the casing 131 is always maintained filled with liquid. This resultant pressure within the casing 131 then reacts upon the piston 135 to assist in moving the contacts 63 to their open circuit position during the remaining portion of the opening stroke. It is, therefore, apparent that the baffle 125 may become operatively coupled to the operating rod 87 at any time during the opening operation of the interrupter. Since this hydraulic coupling between the baffle 125 and the operating rod 87 resembles a mechanical ratchet in action, it may properly be called a hydraulic ratchet.

It is also to be noted that the hydraulic coupling between baffle 125 and the operating rod 87 becomes effective substantially as soon as the baffle is actuated by the pressure within the casing 9, and this is so irrespective of the position of the operating rod 87 between predetermined limits which are fully set forth hereinafter. In other words, there is no lost motion between the baffle 125 and the operating rod 87 once the ports 139 are closed. This absence of lost motion, therefore, permits the baffle 125 to become effective in assisting the opening movement of the contact 63 without appreciable time delay following the creation of pressure within the casing 9.

It will be observed that the lower or effective area of the baffle member 125 is large as compared to the upper or effective area of the tubular piston 129. The effective area of the baffle 125 is also large as compared to the effective areas of the piston 135 and the pistons 73 within the arc passages 51. The difference in these areas makes it possible to utilize the relatively low pressure within the casing 9 to counteract the reactive forces upon the pistons 73 due to a relatively higher pressure within the arc passage 51 of each arc extinguishing unit 27. By properly selecting the areas of the several pistons, it is possible to substantially completely compensate the reactive forces operating upon the piston 73 due to the pressure within the arc passages 51, so that the accelerating spring 101 need only supply a force sufficient to overcome the inertia and friction of the moving parts and the frictional resistance of the liquid flow. It is also possible to proportion the respective areas of the pistons so as to over-compensate the reactive pressure and thereby further assist in accelerating the moving contact assembly to the open circuit position.

When overcompensation is obtained of the reactive pressure acting upon the pistons 73, it is apparent that the hydraulic system including the arc extinguishing liquid, baffle 125, pistons 129 and 135 and their associated casings constitute a hydraulic force multiplying means since a force is obtained tending to move the pistons 73 to the open circuit position that is greater than the force tending to oppose the opening movement.

From the foregoing, it follows that the areas of the pistons may also be proportioned so as to only partially compensate the effect of the reactive force opposing opening movement of the pistons 73. However, in practice overcompensation is more desirable where a high contact acceleration is to be secured since the ultimate result is obtained with a correspondingly smaller accelerating spring 101.

With the above arrangement there may be conditions under which the pressure within the casing 9 is insufficient to cause upward movement of the baffle member 125 until the operating rod 87 and the contacts 63 have reached their full open position. The delayed upward movement of the baffle 125 under these circumstances immediately seals the ports 139 prior to uncovering of the ports 137. Therefore, unless further provision is made to relieve the pressure within the inner cylindrical casing 131, further upward movement of the baffle 125 is prevented which may result in building up pressure within the casing 9 to a dangerously high value. In order to relieve the pressure within the cylindrical casing 131 at the end of the opening stroke, we have provided vents or notches 141 in the operating rod 87 adjacent the guide member 97. These notches permit the relief of pressure from within the casing 131 to the spring chamber 95. Thus a relief of pressure in the inner chamber 131 permits the baffle 125 to be raised and relieve the pressure within the casing 9 through the ports 137.

It may also occur that during the closing operation of the interrupter during conditions of load that an arc may be established between the contacts prior to the complete closing of these contacts which may build up sufficient pressure within the casing 9 to raise the baffle 125, thereby sealing off the openings 139 and stall the piston 133 and its operating rod 87, thereby preventing the completion of the closing stroke. Thus an arc may be maintained for a period of time sufficient to cause a pressure within the casing 9 high enough to injure the interrupter casing. In order to avoid this injurious effect, we have provided a second series of openings or notches on the operating rod 87 located as indicated at 143. The notches 143 are so positioned with respect to the upper wall at 99 of the inner casing 131 that the pressure within the latter casing is relieved just before the contacts 61 and 63 make engagement with each other. The notches 143 are, however, so arranged that upon final movement of the contacts 63 to the fully closed position, the enclosure within the casing 131 is again sealed, thereby preventing further movement of the baffle in the upward direction which might put it in the uppermost position of its path of travel and render it useless in the event that it were called upon to operate in an immediate interrupting operation following the closing of the breaker contacts.

From the foregoing description, it follows that the interrupter contacts may be moved to the open position irrespective of the pressure conditions within the casing 9. Movement of the contact structure to the closed circuit position is prevented as long as sufficient pressure exists in the casing 9 to maintain the baffle 125 raised and the ports 139 closed. However, since the pressure within the casing 9 is quickly dissipated through the vent openings 137, the baffle 125 is lowered promptly by the joint action of gravity and the spring 135 to its normal position so as to again uncover the ports 139 thereby permitting free movement of the operating rod 87 to the closed circuit position.

Although we have shown and described a specific circuit interrupter structure, utilizing a particular arrangement responsive to the pressure within the circuit interrupter casing for assisting the operating mechanism during the opening operation of the interrupter, it is to be understood that the same is for the purpose of illustration and that changes and modifications may be made by those skilled in the art without departing from the spirit and scope of the appended claims.

We claim as our invention:

1. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts within said liquid, means for operating said contacts to open and closed positions, and means responsive to the pressure within said casing to assist said operating means to separate said contacts, and a fluid force-transmitting means between said pressure responsive means and said operating means for transmitting a force to said operating means with substantially no time lag irrespective of the position of said operating means within predetermined limits.

2. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts within said liquid, means for operating said contacts to open and closed positions, a piston in said casing movable in response to pressure within the casing to assist said operating means to separate said contacts, and a hydraulic force-transmitting device between said piston and said operating means for transmitting a force to said operating means without substantial time lag for all positions of said operating means between predetermined limits.

3. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts submerged in said liquid at least one of which is movable to open and closed positions, an operating member for actuating said movable contact to establish an arc, a baffle member within said casing movable in response to pressure within the casing produced by said arc, a cylindrical enclosure within said casing having a fluid connection therewith for maintaining said cylindrical enclosure filled with liquid, a piston movable within said cylindrical enclosure mechanically coupled to said baffle member and adapted to be actuated thereby for subjecting the liquid within the cylindrical enclosure to pressure, and pressure responsive means mechanically coupled to said operating member movable in response to pressure created within said cylindrical enclosure to assist in moving said movable contact to the open circuit position.

4. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts submerged in said liquid at least one of which is movable to open and closed positions, an operating member for actuating said movable contact to establish an arc, a baffle member within said

casing movable in response to pressure within the casing produced by said arc, a cylindrical enclosure within said casing having a fluid connection therewith for maintaining said cylindrical enclosure filled with liquid, a piston movable within said cylindrical enclosure mechanically coupled to said baffle member and adapted to be actuated thereby for subjecting the liquid within the cylindrical enclosure to pressure, pressure responsive means operable in response to pressure created within said cylindrical enclosure to assist in moving said movable contact to the open circuit position, and means responsive to predetermined movement of said baffle member for controlling the pressure within said casing.

5. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts submerged in said liquid at least one of which is movable to open and closed positions, an operating member for actuating said movable contact to establish an arc, a baffle member within said casing movable in response to pressure within the casing produced by said arc, a cylindrical enclosure within said casing having a fluid connection therewith for maintaining said cylindrical enclosure filled with liquid, a piston movable within said cylindrical enclosure mechanically coupled to said baffle member and adapted to be actuated thereby for subjecting the liquid within the cylindrical enclosure to pressure, and a second piston within said cylindrical enclosure movable with said operating member, said second piston being responsive to pressure created within said cylindrical enclosure in response to movement of said baffle member to assist in moving said movable contact to the open circuit position.

6. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts submerged in said liquid at least one of which is movable to open and closed positions, an operating member for actuating said movable contact to establish an arc, a baffle member within said casing movable in response to pressure within the casing produced by said arc, a cylindrical enclosure within said casing having a fluid connection therewith for maintaining said cylindrical enclosure filled with liquid, a piston movable within said cylindrical enclosure mechanically coupled to said baffle member and adapted to be actuated thereby for subjecting the liquid within the cylindrical enclosure to pressure, a second piston within said cylindrical enclosure movable with said operating member, said second piston being responsive to pressure created within said cylindrical enclosure in response to movement of said baffle member to assist in moving said movable contact to the open circuit position, and means operative in accordance with predetermined movement of said operating member to relieve the pressure within said cylindrical enclosure to enable said operating member to be moved independently of said baffle member.

7. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts submerged in said liquid at least one of which is movable to open and closed positions, an operating member for actuating said movable contact to establish an arc, a baffle member within said casing movable in response to pressure within the casing produced by said arc, a cylindrical enclosure within said casing having a fluid connection therewith for maintaining said cylindrical enclosure filled with liquid, a piston movable within said cylindrical enclosure mechanically coupled to said baffle member and adapted to be actuated thereby for subjecting the liquid within the cylindrical enclosure to pressure, a second piston within said cylindrical enclosure movable with said operating member, said second piston being responsive to pressure created within said cylindrical enclosure in response to movement of said baffle member to assist in moving said movable contact to the open circuit position, the flow of liquid through said fluid connection being controlled in accordance with predetermined movement of said first piston for making said second piston operative to assist said operating member in moving said movable contact to the open circuit position irrespective of the position of said operating member within predetermined limits.

8. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts for establishing an arc within said liquid, movable means for positively moving a quantity of said liquid into engagement with said arc, operating means for actuating said movable means, pressure responsive means movable in response to the pressure within said casing, and a fluid coupling between said pressure responsive means and said operating means for transmitting a force to said operating means to assist in moving said quantity of liquid.

9. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts for establishing an arc within said liquid, movable means for positively moving a quantity of said liquid into engagement with said arc, operating means for actuating said movable means, and means responsive to the pressure within said casing for transmitting a force to said operating means with substantially no time lag irrespective of the position of said operating means between predetermined limits, said movable means being operative independently of said pressure responsive means.

10. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts for establishing an arc within said liquid, a piston in said casing for positively moving a quantity of liquid into engagement with said arc, operating means for said piston, a second piston in said casing movable in response to pressure within the casing, and a hydraulic coupling device between said second piston and said operating means for transmitting a force to said operating means to assist in moving said first piston against the pressure within said casing.

11. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts for establishing an arc within said liquid, a piston in said casing for positively moving a quantity of liquid into engagement with said arc, operating means for said piston, a second piston in said casing movable in response to pressure within the casing, and a coupling device between said second piston and said operating means for transmitting a force to said operating means without substantial time lag for all positions of said operating means between predetermined limits.

12. In a circuit interrupter, a casing containing arc extinguishing liquid, means defining an arc chamber submerged in said liquid, said chamber having a fluid connection with said casing, separable contacts for establishing an arc within said arc chamber, a piston for circulating liquid within said chamber, operating means for actuating said piston, a second piston within said

casing movable in response to pressure within the casing, a hydraulic connection between said second piston and said operating means for transmitting a force to said operating means to assist in moving said first piston against the pressure within said arc chamber, said hydraulic connection enabling said first piston to be actuated independently of said second piston.

13. In a circuit interrupter, a casing containing arc extinguishing liquid, a pair of contacts within said liquid at least one of which is movable to break the circuit to thereby establish an arc and create pressure within the casing, a piston within said casing for moving a quantity of liquid into engagement with said arc, common operating means for said movable contact and said piston, means responsive to the pressure within said casing for transmitting force to said operating means to accelerate the opening movement of said movable contact and to assist said piston in moving liquid against the pressure within said casing, and a fluid actuated coupling between said pressure responsive means and said operating means.

14. In a circuit interrupter, a casing containing arc extinguishing liquid, a plurality of arc extinguishing devices submerged in said liquid, each of said devices including an arc chamber having a fluid connection with said casing, a pair of contacts within each of said chambers at least one of which is movable to open and closed positions, a common operating member for simultaneously actuating said movable contacts to establish an arc within each arc chamber and to thereby create pressure within said casing, a piston for each arc extinguishing device adapted to be actuated simultaneously with said movable contact by said operating member to circulate liquid within each of said arc chambers, a baffle member movable within said casing in response to the pressure created by said arcs, and a force-multiplying connection between said baffle member and said operating member for transmitting a force to said operating member during the opening movement of said movable contacts, said force-multiplying connection enabling said movable contacts to be moved to the closed circuit position irrespective of the pressure conditions in said casing.

15. In a circuit interrupter, a casing containing arc extinguishing liquid, a plurality of arc extinguishing devices submerged in said liquid, each of said devices including an arm chamber having a fluid connection with said casing, a pair of contacts within each of said chambers at least one of which is movable to open and closed positions, a common operating member for simultaneously actuating said movable contacts to establish an arc within each arc chamber and to thereby create pressure within said casing, spring means biasing said operating member to the open circuit position, a piston for each arc extinguishing device adapted to be actuated simultaneously with said movable contacts by said operating member to circulate liquid into engagement with the arc in each of said arc chambers, a baffle member movable within said casing in response to the pressure created by said arcs, and a hydraulic coupling device for transmitting a force from said baffle member to said operating member with substantially no time lag irrespective of the position of said operating member within predetermined limits to assist said spring biasing means in moving said operating member to the open circuit position.

16. In a circuit interrupter, a casing containing arc extinguishing liquid, a plurality of arc extinguishing devices submerged in said liquid, each of said devices including an arc chamber having a fluid connection with said casing, a pair of contacts within each of said chambers at least one of which is movable to open and closed positions, a common operating member for simultaneously actuating said movable contacts to establish an arc within each arc chamber and to thereby create pressure within said casing, a piston for each arc extinguishing device adapted to be actuated simultaneously with said movable contact by said operating member to circulate liquid within each of said arc chambers, and means responsive to pressure within said casing created by said arcs for transmitting a force to said operating member that is greater than the forces exerted upon said pistons by the respective pressures within said arm chambers to assist movement of said operating member to the open circuit position.

17. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts within said liquid, means for operating said contacts to open and closed position, movable means operative in response to pressure within said casing, and a fluid actuated coupling means between said movable means and said operative means, normally inoperative to permit movement of said operating means independently of said movable means, and automatically made operative in response to pressure within said casing to cause said movable means to be coupled with said operating means to assist the latter in moving the contacts to open circuit position.

18. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts within said liquid, means for operating said contacts to open and closed position, a piston movable in response to pressure within said casing, a fluid actuated coupling between said piston and said operating means for transmitting a force to said operating means in a direction to assist in opening said contacts, said coupling being operative only in response to predetermined pressure conditions within said casing.

19. In a circuit interrupter, a casing containing arc extinguishing liquid, separable contacts within said liquid, means for operating said contacts to open and closed position, movable means operative in response to pressure within said casing, means biasing said movable means to an inoperative position and releasable coupling means between said movable means and said operating means for transmitting a force from said movable means to said operating means, said coupling means being inoperative when said movable means is in said inoperative position, and rendered operative in response to movement of said movable means.

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