Oct. 31, 1950

J. M. WALLACE

2,528,197

CIRCUIT INTERRUPTER

Filed June 29, 1944

2 Sheets-Sheet 1

Fig. 1.

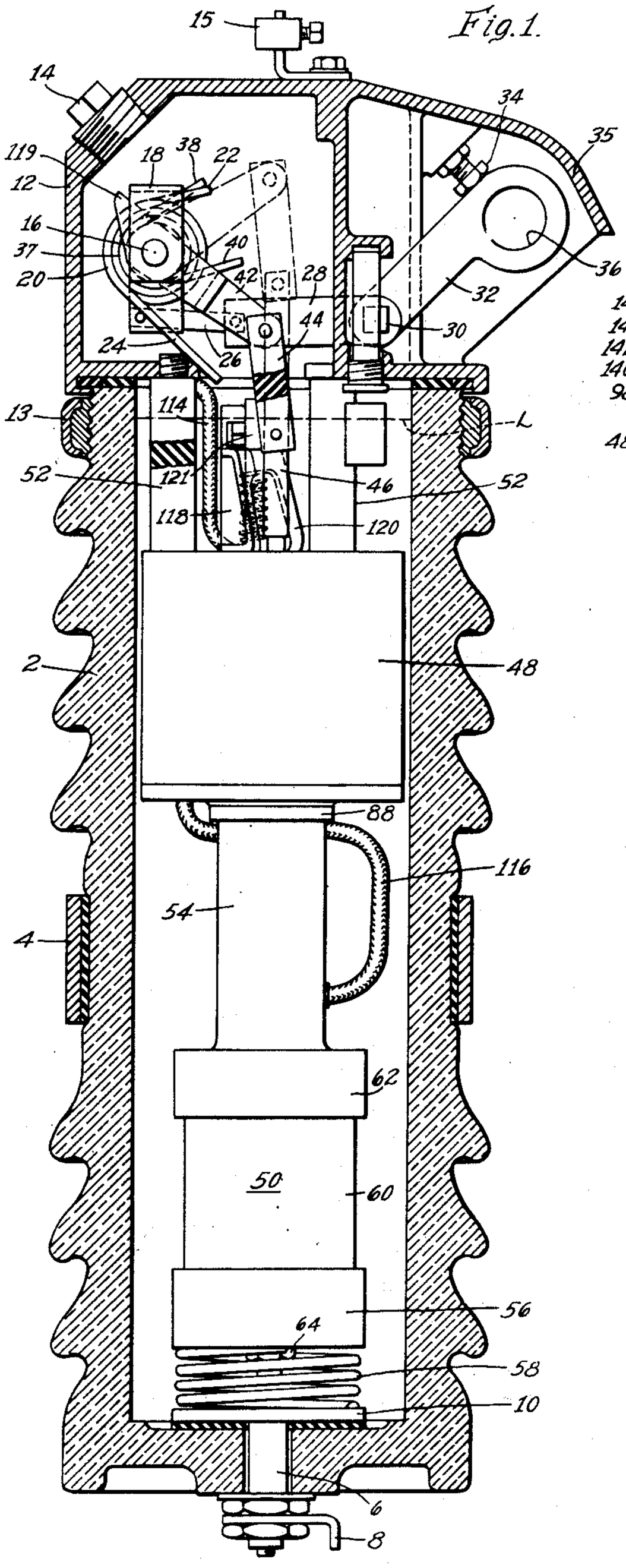
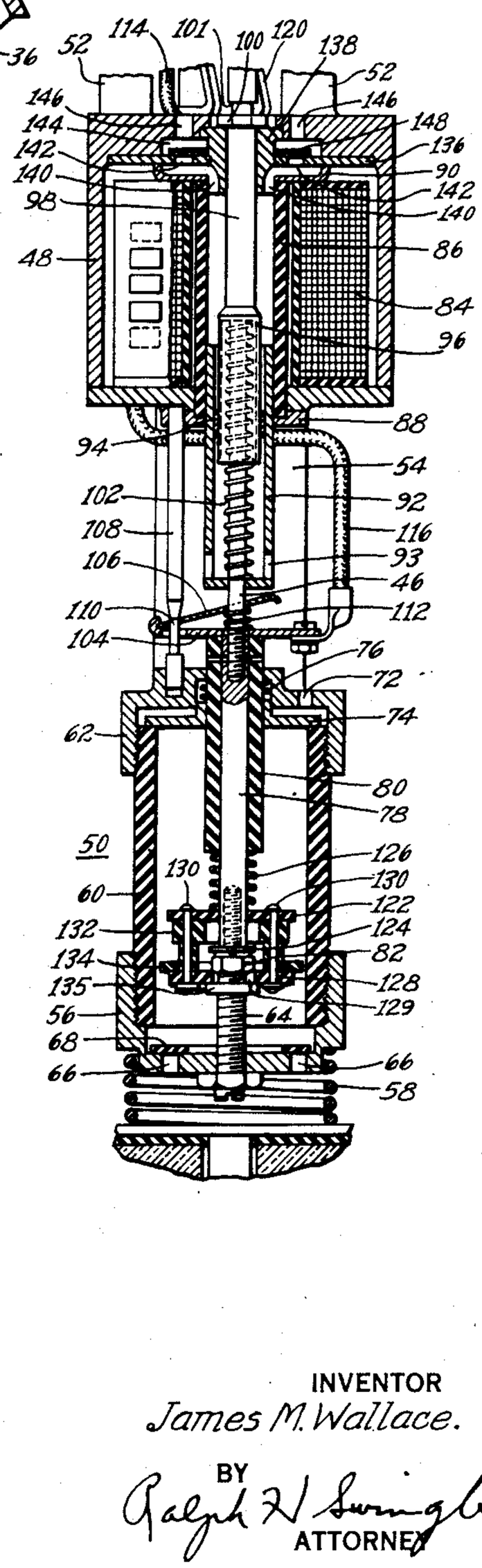


Fig. 2.



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Oct. 31, 1950 J. M. WALLACE 2,528,197

CIRCUIT INTERRUPTER

Filed June 29, 1944 2 Sheets-Sheet 2

Fig. 3.

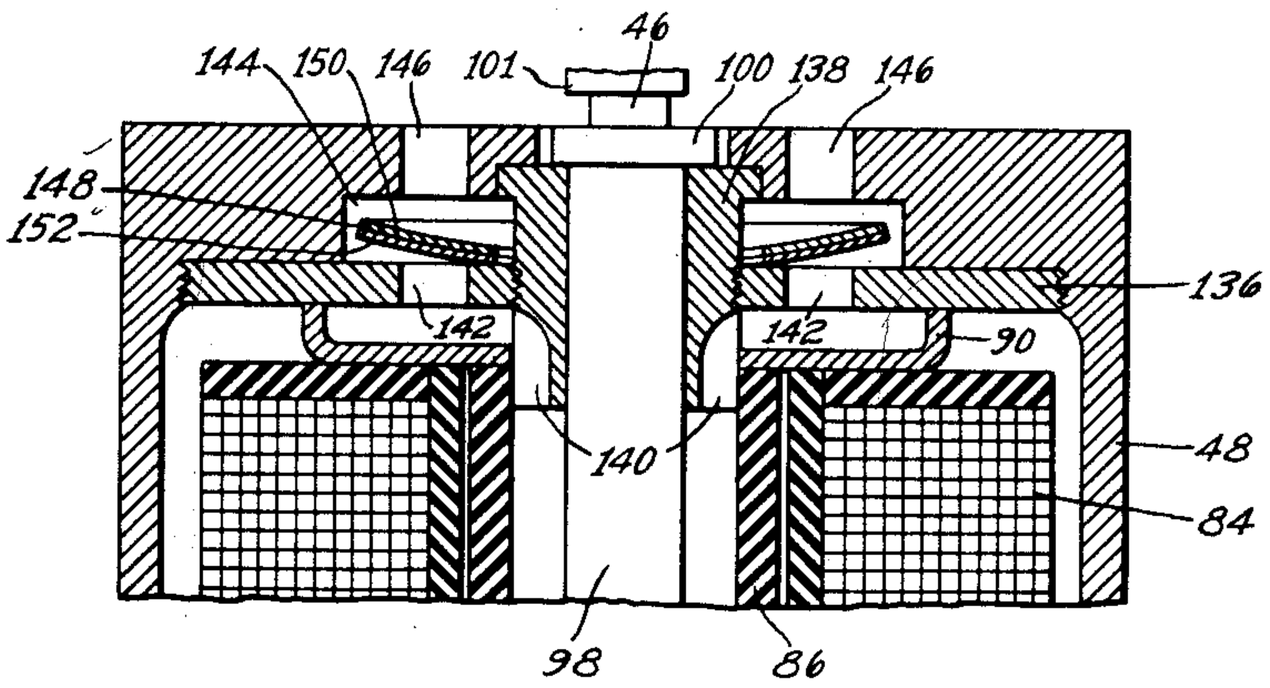
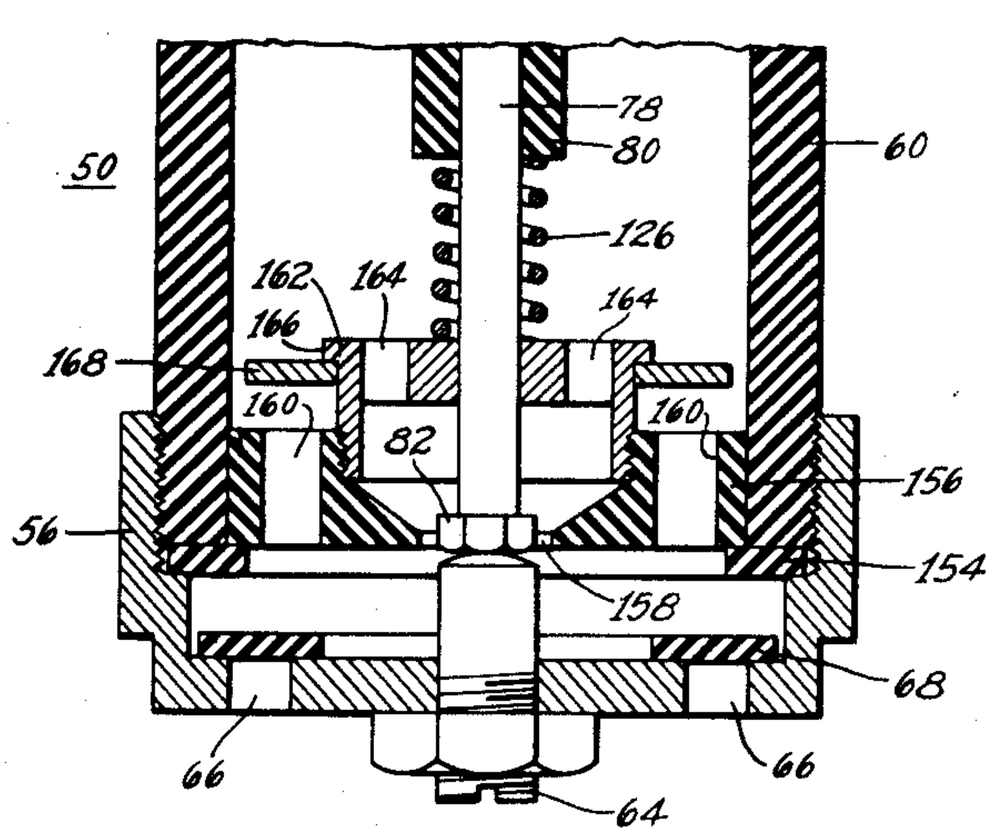


Fig. 4.



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UNITED STATES PATENT OFFICE

2,528,197

CIRCUIT INTERRUPTER

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Application June 29, 1944, Serial No. 542,681

10 Claims. (Cl. 200—89)

1

This invention relates generally to electric circuit interrupters, and more particularly to certain improvements in automatic reclosing circuit breakers.

This invention is particularly disclosed herein as embodied in an automatic reclosing circuit breaker of the type shown in J. M. Wallace Patent No. 2,333,604, issued November 2, 1943 to the same assignee of this invention. In circuit breakers of this type which have a closed, liquid-filled arc chamber in which the arc is extinguished, provision must be made for flushing gases generated by the arc from the arc chamber after each circuit interruption. This flushing operation requires an appreciable time under normal conditions, especially where the liquid must flow through arc extinguishing structure during the flushing operation, and when the arc extinguishing fluid is cold, and consequently has high viscosity, the flushing time correspondingly increases. Moreover, where the arc extinguishing structure moves with the movable breaker contact, the arc extinguishing fluid may exert appreciable delaying action which is undesirable, especially during reclosing of the breaker contacts.

One object of this invention, therefore, is to provide novel arc extinguishing means in a circuit breaker of the type described, so arranged that there is substantially no opposition to closing movement of the breaker contacts.

A more specific object of this invention is to provide in a circuit breaker of the type described, liquid directing means which is movable with the movable breaker contact in opening the circuit to force a blast of liquid to pass through the arc to aid in extinguishing the arc, so constructed and arranged that the liquid directing means does not appreciably restrict the flow of liquid during closing movement of the movable contact of the breaker.

When fluid time delay means is used to control the rate of opening or closing of breaker contacts, the resistance offered by such time delay obviously varies considerably with temperature and consequent variations in viscosity of the fluid employed by the time delay means. This causes widely variable time delay between circuit opening and reclosing in automatic reclosing circuit breakers of the type described, whereas it is highly desirable that this time period be substantially a fixed increment, so as to correlate with the time required for flushing the arc chamber; and also that it be not too great a time interval, in order to obtain better continuity of service,

2

and to enable proper coordination with other circuit interrupters.

Accordingly, another object of this invention is to provide novel fluid time delay means for controlling movement of the contacts in a reclosing circuit breaker of the type described, wherein the delaying action of the time delay means is substantially constant at all temperatures.

Another object of this invention is to provide in a reclosing circuit breaker of the type described using an arc extinguishing liquid, and having flushing of the arc space after each circuit opening operation and liquid time delay means for controlling movement of the breaker contacts, novel means preventing undue delay in operation of the breaker contacts or in the flushing operation, especially at low temperatures.

These and other objects of this invention will become more apparent upon consideration of the following detailed description of preferred embodiments thereof, when taken in connection with the attached drawings, in which:

Figure 1 is a longitudinal sectional view of a circuit breaker embodying this invention, with most of the parts within the breaker casing being shown in elevation,

Fig. 2 is a longitudinal sectional view of a part of the breaker mechanism shown in Fig. 1,

Fig. 3 is an enlarged longitudinal sectional view of a part of the mechanism shown in Fig. 2, with the valve of the time delay dashpot in a different position, and

Fig. 4 is a longitudinal sectional view of a portion of a circuit breaker such as that shown in Figs. 1 and 2, but illustrating one of the parts thereof in modified form.

This invention is illustrated on the drawings as embodied in a circuit breaker like that disclosed in the aforesaid Wallace patent which is of the type responsive to overloads for automatically interrupting the circuit a predetermined time following the occurrence of an overload, and is automatically operative to reclose the circuit in response to a circuit interrupting operation. Circuit breakers of this type are also generally provided with lockout means operative to maintain the breaker contacts in open circuit position in response to a predetermined number of closely successive circuit openings and reclosures, as on a continuing overload. In the event of the occurrence of overloads which clear themselves or are isolated before the circuit breaker goes through its predetermined number

of closely succeeding circuit interrupting operations and locks out, the lockout mechanism is arranged to reset so that it will go through the same predetermined number of circuit openings and reclosings when an overload occurs at a later time.

This type of automatic reclosing circuit breaker comprises, in general, a tubular casing 2 of insulating material, such, for example, as porcelain or the like, which may be supported at a mid-portion thereof, for example by a supporting bracket 4. The casing 2 illustrated, is provided with a closed lower end having an aperture for receiving a terminal bolt 6, having an enlarged head 10 positioned interiorly of the casing, and adapted to have a line conductor 8 secured thereto exteriorly of the casing.

The upper end of casing 2 is open, and is adapted to be closed by a terminal cover structure 12 having a flange adapted to be seated on the upper end of casing 2, and cover 12 may be secured to the casing in any desired manner, such, for example, as by securing means (not shown) connecting the cover to a securing ring 13 fixed to the upper end of the casing. Cover 12 is preferably hollow and may be provided with a threaded filler plug 14, and with a wire connector 15, for connection to another circuit conductor. Within hollow cover 12 there is provided a supporting shaft 16 extending transversely thereof and mounted at its opposite ends in opposite walls of the hollow portion of the cover, for supporting a generally U-shaped spring support 18. Spring support 18 preferably has the leg portions thereof rotatably mounted on shaft 16, and a lockout spring 20 is coiled about shaft 16, and has one end 22 thereof reacting against the bight portion of spring support 18, with the other end 24 thereof reacting against a part of cover 12, to bias spring support 18 in a counterclockwise direction about shaft 16. However, spring support 18 is normally prevented from rotating counterclockwise on shaft 16 by an overcenter toggle, comprising pivotally connected toggle levers 26 and 28 which are pivoted to spring support 18 and to cover 12, respectively. Toggle lever 28 is fixed to a rotatable shaft 30 for pivotally mounting toggle lever 28 on the casing and toggle levers 26 and 28 are held at the overcenter position shown in full lines in Fig. 1, by an indicating handle 32 which is also rigidly mounted on shaft 30, and engages an adjustable stop screw 34 mounted beneath a hood 35 integral with cover 12. The outer end of handle 32 is provided with a hook eye aperture 36, so that it may be actuated by a hook stick operating member or the like.

Shaft 16 within the hollow portion of cover 12 also supports a reclosing spring 37 of smaller diameter and mounted within lockout spring 20, with one end 38 of this spring reacting against the bight portion of spring support 18, and with the other end 40 of the reclosing spring reacting against an actuating lever 42 which is pivotally mounted on shaft 16. The breaker contacts are adapted to be actuated at least to close the circuit by spring 37 and actuating lever 42, and for this purpose the lever is connected to a contact actuating rod 46, by means of a pair of connecting links 44 of insulating material, such, for example, as fiber or the like. Contact actuating rod 46 extends through casing 2, passing through a solenoid coil supporting frame 48 and into an arc chamber 50 located adjacent the closed lower end of the casing. All of the parts within casing

2 are supported from cover 12, since coil supporting frame 48 is secured to the cover by spaced supporting posts 52 of insulating material, such, for example, as fiber or the like, and arc chamber 50 is supported from coil supporting frame 48 by spaced supporting plates 54, which are secured to frame 48 and to arc chamber 50. The lower end of arc chamber 50 is provided with a terminal cap 56 threadedly mounted thereon, and a coil compression spring 58 of conducting material, is adapted to be compressed between terminal cap 56 and head 10 of terminal bolt 6, when cover 12 is assembled in operative position with the casing, to conduct curent from terminal bolt 6 to terminal cap 56.

Arc chamber 50 is preferably formed by a tube 60 of insulating material, such as fiber or the like, and has, in addition to terminal cap 56, an upper cap 62 threadedly mounted on the upper end thereof. Terminal cap 56 of the arc chamber is provided with a contact screw 64 substantially centrally thereof, and also has a plurality of inlet openings 66 adapted to be controlled by a valve ring 68 freely movable between terminal cap 56 and the adjacent end of tube 60. Upper cap 62 for the arc chamber is provided with at least one outlet opening 72 adapted to be controlled by a valve plate 74 movable between the upper end of tube 60 and cap 62, but normally held at a position uncovering opening 72, by a coil compression spring 76.

Contact actuating rod 46 is provided with an end section 78 which extends through a central aperture in arc chamber cap 62, and section 78 is provided with a sheath 80 of insulating material, such, for example, as a molded insulating material, for engagement with the aperture in cap 62. Section 78 of the contact rod is provided with a contact head 82 at its outer end for engagement with fixed contact screw 64.

Because of the particular construction of arc chamber 50, when movable contact 82 is moved away from fixed contact 64 to strike an arc, such an arc will create pressure within the arc chamber such as to cause valve disk 68 and valve plate 74 to close both the inlet and outlet openings. Preferably casing 2 is filled with an arc extinguishing liquid, such as oil, up to the level L shown in Fig. 1, so that arc chamber 50 will be submerged in such liquid and will always be filled with liquid. Accordingly, an arc formed within chamber 50 will cause deterioration of the arc extinguishing liquid, and form gases to further increase the pressure within the chamber. This pressure within the chamber acts on section 78 of the contact actuating rod, together with its sheath 80, in a piston-like manner to aid in moving contact 82 away from fixed contact 64, and may even cause overtravel of the movable contact with respect to its actuating mechanism. As soon as the arc is extinguished, pressure will drop within the arc chamber, and spring 76 will be operative to move valve plate 74 to a position uncovering outlet opening 72. This will permit the gas bubble formed within the arc chamber during arcing to escape from the upper end of the chamber, and the head of liquid outside the arc chamber will cause valve disk 68 to be displaced, thereby permitting fresh liquid to flow in through inlet openings 66. This provides an automatic flushing of arc chamber 50 after each circuit interrupting operation, during reclosure of the breaker contacts by reclosing spring 37.

In order to cause an initial separation of movable contact 82 from fixed contact 64, which is at

least sufficient to establish an arc within the arc chamber, there is provided a solenoid coil 84 mounted within the supporting frame 48. This coil is annular in form, and is provided with a dashpot sleeve 86 which extends through the center of the coil, with the sleeve preferably being of an insulating material such, for example, as a molded insulating material. Dashpot sleeve 86 is held in engagement with a cup-shaped washer member 90 reacting against the top of frame 48, by engagement of a cross frame member 88, which is integral with supporting plates 54. A tubular core 92, of any desired magnetic material such as iron or the like, is provided for coil 84, and the core is slidably mounted within dashpot sleeve 86 and has a close fit therein to act as a dashpot piston. The lower end of core 92 is preferably closed and provided with a central aperture for closely slidably receiving contact actuating rod 46, and has vent apertures 93 through the side wall thereof adjacent the closed lower end. Core 92 is provided with an internal wear ring 94 adjacent the other end thereof having a close sliding fit with an enlarged portion 96 of an actuating sleeve 98 which is slidably mounted on contact actuating rod 46. Actuating sleeve 98 is provided with a flange 100 at the upper end thereof above frame 48, for engagement with a shoulder 101 on the contact actuating rod. A coil compression spring 102 reacts between the closed end of solenoid core 92 and the enlarged portion 96 of actuating sleeve 98, to bias the core to the lower position shown in Fig. 2.

In order to hold the contacts separated to prevent too rapid a reclosure thereof following a circuit interrupting operation, contact actuating rod 46 has mounted thereon a transversely extending supporting plate 104, and a latch plate 106 is pivotally mounted at one end on this supporting plate. Latch plate 106 is provided with an aperture for receiving contact actuating rod 46 which is large enough to permit pivotal movement of the latch plate, and with another aperture adjacent its mounting on supporting plate 104, for relatively closely receiving a latch rod 108 supported between frame 48 and cap 62. Latch rod 108 is provided at the lower end thereof with a portion 110 which is reduced in section, for a purpose to be described, and latch plate 106 is normally biased upwardly by a compression spring 112.

The electrical circuit through the breaker illustrated in Figs. 1 and 2 extends from connector 15 on cover 12, by way of a conductor 114 to solenoid coil 84, then by a flexible conductor 116 to contact actuating rod 46, to fixed contact 64, conducting spring 58, then to terminal bolt 6 and line conductor 8. It is thus apparent that solenoid coil 84 is connected in series in the circuit through the breaker so that it will be responsive to currents above a predetermined value to attract core 92 upwardly into the coil while compressing spring 102. This movement of core 92 will be delayed due to the dashpot action thereof in dashpot sleeve 86, and will not cause separation of the contacts because spring 102 is considerably weaker than closing spring 37. When core 92 finally engages the lower end 93 of actuating sleeve 98, the latter will be moved upwardly into engagement with shoulder 101 on actuating rod 46, to cause separation of contact 82 from fixed contact 64. This establishes an arc in arc chamber 50, which is extinguished as previously explained, and due to the lost motion of core 92

on the contact actuating rod, pressure within the arc chamber may cause overtravel of contact 82 and contact actuating rod 46, beyond the point to which it is moved by core 92. During opening movement of contact 82, latch plate 106, which is carried up with contact actuating rod 46, slides over latch rod 108, and any tendency of latch plate 106 to bind on latch rod 108 is overcome by pivotal movement of the latch plate in a clockwise direction, while compressing spring 112. However, as soon as the arc is extinguished and reclosing spring 37 attempts to move contact 82 towards fixed contact 64, latch plate 106 will bind on latch rod 108 due to counterclockwise rotation thereof under the influence of spring 112. In order to release latch plate 106, it is necessary to depress the free end of the plate to rotate it in a clockwise direction. This is done by solenoid core 92 during its return movement under the influence of gravity and compression spring 102. However, return movement of solenoid core 92 is quite slow, because of the dashpot action of the core in sleeve 86, and consequently movable contact 82 will return substantially at the same speed as core 92, until latch plate 106 arrives at reduced portion 110 of latch rod 108 where it can no longer bind on the latch rod, and at this point contact 82 will be rapidly moved into engagement with fixed contact 64 by reclosing spring 37. It should be noted that in a circuit opening operation, movement of solenoid core 92 upwardly is delayed by its dashpot action in sleeve 86 only until ring 94 reaches the upper end of enlarged portion 96 of the actuating sleeve. Thereafter liquid trapped in the upper end of the sleeve 86 may escape through the core and its vent openings 93, so that the final movement of core 92 into engagement with actuating sleeve 98 to separate contact 82 from fixed contact 64 takes place rapidly, to obtain at least a predetermined separation of the contacts on each circuit interrupting operation at a relatively rapid rate.

As previously stated, lockout means may be provided for counting the number of closely successive circuit interrupting operations, such as a lockout piston and cylinder 118 mounted on coil supporting frame 48, which is adapted to be actuated by a lockout pawl 120. The pawl 120 is tiltably and slidably mounted on a guide rod 121, and is adapted to be actuated by flange 100 on actuating sleeve 98 each time it moves upwardly during a circuit interrupting operation, to advance the lockout piston, until after a predetermined number of closely succeeding circuit interrupting operations, the piston is finally advanced sufficiently to engage toggle lever 28 adjacent the knee of the toggle to move the toggle levers over center, and thereby permit lockout spring 20 to rotate spring support 18 counterclockwise. This causes the bight portion of spring support 18 to engage an extension 119 on actuating lever 42 to also rotate the actuating lever counterclockwise and hold the breaker contacts in open circuit position. It will be observed that counterclockwise rotation of spring support 18 removes the reaction point for end 38 of reclosing spring 37, so that this spring will be inoperative to reclose the contacts. When the toggle formed by levers 26 and 28 is moved overcenter and breaks, handle 32 rotates with lever 28 in a clockwise direction and extends below hood 35 to give a readily visible indication of the lockout condition of the breaker. The breaker will remain in a lockout position until manually reset by operation of handle 32 back to the position

shown in Fig. 1, wherein toggle levers 26 and 28 are moved back to the over-center position shown, to prevent operation of lockout spring 20.

The parts of the breaker described thus far are substantially all more particularly disclosed in the aforementioned Wallace patent. Moreover, these parts operate in the same manner set forth in the Wallace patent, so that for a more complete description of these parts and their mode of operation, reference is hereby made to the aforesaid Wallace patent.

One difficulty with dashpot time delay means, especially those designed to operate in a viscous liquid, such as oil, is the variation in time encountered with temperature variations due to the change in viscosity of the oil with such temperature changes. It is of particular importance in automatic reclosing circuit breakers that the time of operation, including both opening and reclosing of the contacts, be a predetermined value which does not substantially vary, due to the necessity of coordinating such circuit breakers with other circuit interrupting apparatus, such as fuses and other circuit breakers having definite time characteristics. In order to improve the time characteristic of the dashpot time delay means described above, the upper end of dashpot sleeve 86 is provided with vents which are opened gradually in response to a decrease in temperature and consequent increase in viscosity of the arc extinguishing fluid. For this purpose, a closure disk 136 is threaded into the upper end of coil supporting frame 48, and has threadedly mounted in a central aperture a plug 138 adapted to be held in engagement with a shoulder provided in the upper end of frame 48. Plug 138 is provided with a plurality of channels 140 communicating the upper end of sleeve 86 with the space within cup washer 90. Closure disk 136 extends across the open side of cup washer 90 and is provided with vent apertures 142, communicating the space within cup washer 90 with a space 144, provided within the upper end of frame 48. The space 144, in turn, opens to the interior of casing 2 by means of vent apertures 146, preferably aligned with the vent apertures 142. Both sets of vent apertures 142 and 146 are adapted to be controlled by a bimetal valve disk 148, mounted in space 144. Bimetal valve disk 148 is provided with a central aperture for freely receiving plug 138, so that the valve disk is freely movable to cover and uncover vent apertures 142 and 146. Bimetal valve disk 148 is constructed in a well-known manner of laminations 150 and 152 intimately secured together as by welding or the like. Lamination 150 of the disk is of a material having a relatively high coefficient of thermal expansion, such as brass, and the other lamination 152 is of a material having a relatively lower thermal coefficient of expansion, so that at normal temperatures the disk 148 will be substantially flat, as shown in Fig. 2, and will assume the upwardly concave shape shown in Fig. 3 upon lowering of the temperature. Valve disk 148 is positioned below the level of arc extinguishing fluid within casing 2, so that it is responsive to the temperature of such liquid to more or less cover vent apertures 142 and 146.

During operation of the circuit breaker, if it be assumed that the arc extinguishing liquid is at a normal temperature so that valve disk 148 is in flat condition, as soon as solenoid core 92 moves upwardly, it will cause a flow of fluid through vent apertures 142 and move valve disk 148 upwardly to cover vent apertures 146, and the rate of movement of core 92 will be governed by the rate of escape of fluid trapped in the upper end of dashpot sleeve 86 through the relatively small clearances between the core, and sleeve 86, and enlarged sleeve portion 96. Now, if the temperature of liquid within casing 2 drops so that its viscosity increases, valve disk 148 will assume a curved shape similar to that of Fig. 3, so that when core 92 moves upwardly, there will be an additional path opened for fluid to escape, through vent openings 142 and through the central opening in valve disk 148 and out vent openings 146, even though the valve disk be moved up by the flow of fluid outwardly into engagement with the upper wall of space 144. Similarly, upon return movement of core 92, valve disk 148 will be drawn down to cover vent openings 142 if the valve disk is in a flat condition, but if it is curved as in Fig. 3, an additional path for the flow of fluid into the upper end of dashpot sleeve 86 will be provided through vent openings 146, and around the outside edge of the valve disk and through vent openings 142 and channels 140 into the dashpot sleeve, to thereby compensate, both during circuit opening and circuit closing, for any increase in viscosity of the arc extinguishing liquid, by increasing the openings for inflow and outflow of liquid with respect to dashpot sleeve 86.

The specific features of the temperature compensating dashpot valve are claimed in the copending application of J. M. Wallace on Dashpot Controlled Circuit Interrupter, Serial No. 152,883, filed March 30, 1950 as a continuation-in-part of this application, and assigned to the same assignee as this application.

In order to effectively utilize the arc extinguishing liquid within arc chamber 50 to extinguish the arc formed upon circuit interruption in as short a travel of the moving contact as possible, a liquid pumping and liquid directing structure is mounted on contact actuating rod extension 78, between contact head 82 and the lower end of insulating sheath 80. This structure preferably comprises a plate 122 apertured at its center for receiving rod extension 78, for sliding movement on the rod extension between a stop washer 124 positioned above contact head 82 and the lower end of insulating sheath 80. A coil compression spring 126 reacts between the end of sheath 80 and plate 122 to bias the plate towards contact head 82. A piston plate 128 having a relatively large central orifice 129 is secured to plate 122, for example as by rivets 130, with the plates maintained in spaced relation by shouldered spacing sleeves 132 on each rivet. Plates 122 and 128 are of appreciably less diameter than the interior of arc chamber tube 60, and a valve ring 134, which more closely fits the interior diameter of arc chamber tube 60, is slidably mounted on the reduced portions of spacing sleeves 132, for movement between piston plate 128 and the shoulders on the spacer sleeves. In the operation of the circuit breaker, it will be observed that at the closed circuit position, piston plate 128 of the liquid pumping and directing structure is held, by engagement with a flange 135 on fixed contact 64, at an intermediate position on contact actuating rod extension 78, with compression spring 126 in compressed condition. Accordingly, during initial separation of contact 82 from fixed contact 64, the liquid pumping and directing structure is held stationary by spring 126 until plate 122 is engaged by washer 124. There-

after, continued separating movement of contact 82 carries the liquid pumping and directing structure with it, and valve ring 134 seats on piston plate 128 to force liquid through orifice 129 in the piston plate, to thereby cause a blast of liquid generally longitudinally of the arc to aid in extinguishing it. After the arc is extinguished and contact 82 begins its reclosing movement, valve ring 134 will move upwardly so that liquid may flow around the outside edge of piston plate 128 and between spacing sleeves 132, as well as through orifice 129, so that the liquid pumping and directing structure offers substantially no resistance to reclosing movement. This is of importance in a circuit breaker of the type described because where provision is not made for a relatively free flow of liquid through the arc chamber during reclosure of the breaker contacts, considerably more time is required in flushing the arc chamber for the oil bubble formed therein to rise and escape from outlet opening 72. Where provision is not made for relative freedom of flow of liquid through the liquid pumping and directing structure, as in the aforementioned Wallace patent, tests show that a time on the order of 5 seconds is required for the interrupting chamber to be completely flushed out, and the dirty oil and gas to be replaced by fresh oil from casing 2. This obviously limits the minimum time between successive circuit interrupting operations, as it would be unwise to attempt a circuit interruption when the interrupting chamber is not completely flushed.

Where a liquid pumping and directing structure constructed in accordance with this invention is used within an arc chamber, such as the arc chamber 50, it is found that the reclosing time can be brought down from about 5 seconds to about 45 cycles, or about ¾ of one second. This obviously permits a much shorter closing time, and because of this service continuity may be greatly improved by the use of such shorter reclosing times, in that reclosure in less than a second will be practically unnoticed even in lighting circuits, and will frequently maintain a synchronous load. Other advantages of shorter reclosing times, are that the construction of time delay means, such as fluid dashpots or the like, is much simpler, and these devices are more reliable in operation than when constructed to delay operation of the contacts for longer periods of time. Moreover, better coordination is possible with shorter reclosing times, as such shorter reclosing times are in accordance with modern operating practice, both with respect to reclosing fuses and reclosing central station circuit breakers.

A slightly modified form of liquid pumping and director structure is shown in Fig. 4, wherein a stop ring 154 is secured between the lower end of arc chamber sleeve 60 and terminal cap 56, and a piston director 156 is normally adapted to be held seated on this stop ring by spring 126 when the contacts are in engagement. Piston director 156 is provided with a centrally located orifice 158 for directing liquid longitudinally into the arc path, and it is also provided with apertures 160 located adjacent the edge thereof. An inlet sleeve 162 is threadedly engaged in the opening leading to orifice 158, and this sleeve is provided with inlet apertures 164 for the flow of liquid through the director and out orifice 158. A valve disk 168 is slidably mounted on sleeve 162 between piston director 156 and a flange 166 on the inlet sleeve.

The structure shown in Fig. 4 operates in substantially the same manner as the structure illustrated in Fig. 2 and described above. Briefly, when the contacts separate, piston director 156 remains in engagement with stop ring 154 until sleeve 162 is engaged by contact head 82, whereupon the director moves with the contact, and valve disk 168 closes apertures 160. This requires all liquid displaced by movement of the director to pass through orifice 158 and exert a blasting action on the arc to assist in rapid extinguishing thereof. However, upon reclosing movement of contact 82, valve disk 168 is moved upwardly into engagement with shoulder 166 so that movement of the liquid director during reclosing of the contacts is substantially unimpeded, thereby permitting quicker flushing of the arc chamber and consequent faster reclosing of the breaker.

In view of the foregoing, it is apparent that this invention provides an arrangement especially adapted for use in automatic reclosing circuit breakers wherein the chamber in which arcing occurs is flushed of gases and used liquid after each circuit interrupting operation, and has a means for exerting a blast of such liquid through the arc during a circuit interrupting operation, with novel provisions within the arc chamber for speeding up the flushing action, and consequent reclosure of the contacts, all in combination with a fluid time delay means for determining opening and reclosing times of the breaker contacts, which provides a substantially constant time of operation irrespective of changes in temperature.

Having described preferred embodiments of the invention in accordance with the patent statutes, it is desired that the invention be not limited to these particular embodiments, inasmuch as it will be apparent, particularly to persons skilled in the art, that many changes and modifications may be made in these particular species of the invention without departing from the broad spirit and scope of this invention.

I claim as my invention:

1. In an automatic reclosing circuit breaker, an arc space adapted to be filled with an arc extinguishing fluid, separable contacts adapted when separated to draw an arc in said space, means for separating said contacts to interrupt the circuit in response to a predetermined electrical condition of the circuit, means restricting flow of fluid through said space during separation of said contacts to obtain a blast of fluid through the arc, means for automatically reclosing said contacts in response to a circuit interrupting operation, means also responsive to a circuit interrupting operation for providing more freedom for the flow of fluid through said arc space to permit rapid flushing of said space, fluid time delay means utilizing said arc extinguishing fluid and operated by said means for separating said contacts for controlling movement of said contacts, and temperature responsive means providing said time delay means with substantially the same resistance to movement at all temperatures.

2. In an automatic reclosing circuit breaker, an arc space adapted to be filled with an arc extinguishing fluid, separable contacts adapted when separated to draw an arc in said space, means for separating said contacts to interrupt the circuit in response to a predetermined electrical condition of the circuit, means restricting flow of fluid through said space during separation of said contacts to obtain a blast of fluid through the arc, means for automatically reclosing said contacts in response to a circuit interrupting

operation, means also responsive to a circuit interrupting operation for providing more freedom for the flow of fluid through said arc space to permit rapid flushing of said space, fluid time delay means utilizing said arc extinguishing fluid and operated by said means for separating said contacts for controlling at least a portion of the reclosing movement of said contacts, and temperature responsive means providing said time delay means with substantially the same resistance to movement at all temperatures.

3. In an automatic reclosing circuit breaker, an arc space adapted to be filled with an arc extinguishing fluid, separable contacts adapted when separated to draw an arc in said space, means for separating said contacts to interrupt the circuit in response to a predetermined electrical condition of the circuit, fluid pumping and directing means movable with at least one of said contacts during a circuit interrupting operation to force said fluid through a restricted path in said space to provide a blast of arc extinguishing fluid through the arc, means for automatically reclosing said contacts in response to a circuit interrupting operation, means also responsive to a circuit interrupting operation for enlarging the path for the flow of fluid through said arc space to permit rapid flushing of said space, fluid time delay means utilizing said arc extinguishing fluid and operated by said means for separating said contacts for controlling movement of said contacts, and temperature responsive means providing said time delay means with substantially the same resistance to movement at all temperatures.

4. In an automatic reclosing circuit breaker, an arc space adapted to be filled with an arc extinguishing fluid, separable contacts adapted when separated to draw an arc in said space, means for separating said contacts to interrupt the circuit in response to a predetermined electrical condition of the circuit, a fluid pumping and directing structure extending across said arc space and being movable with at least one of said contacts, said structure having an orifice through which liquid passes upon movement of said structure through said space to direct a blast of liquid through the arc upon separation of said contacts to aid in extinguishing said arc, and valve means automatically responsive to movement of said structure upon closing of said contacts to uncover additional openings through said structure and permit more freedom of flow of liquid through said space during closing of said contacts to thereby decrease the resistance offered by said structure to a contact closing operation.

5. In a circuit interrupter, a tubular arc passage, separable contacts one of which is movable substantially longitudinally through said passage to draw an arc therein, fluid pumping and directing structure mounted on said movable contact, said structure including a piston member extending transversely of said passage, said piston member having a substantially centrally located orifice through which fluid may flow to be directed substantially longitudinally through the arc drawn during a circuit opening operation, at least one other passage for the flow of fluid longitudinally of said arc passage past said structure, and check valve means for controlling said other passage and arranged to automatically close said other passage during a circuit opening operation, and to automatically open said other passage during a circuit closing operation.

6. In a circuit interrupter, a tubular arc passage, separable contacts one of which is movable substantially longitudinally through said passage to draw an arc therein, fluid pumping and directing structure mounted on said movable contact, said structure including a piston member extending transversely of said passage, said piston member having a substantially centrally located orifice through which fluid may flow to be directed substantially longitudinally through the arc drawn during a circuit opening operation, said piston member being spaced from the walls of said arc passage to provide therebetween, at least one other passage for the flow of fluid longitudinally of said arc passage past said structure, and check valve means carried by said structure for controlling said other passage and arranged to automatically close said other passage during a circuit opening operation, and to automatically open said other passage during a circuit closing operation.

7. In a circuit interrupter, a tubular arc passage, separable contacts one of which is movable substantially longitudinally through said passage to draw an arc therein, fluid pumping and directing structure mounted on said movable contact, said structure including a piston member extending transversely of said passage, said piston member having a substantially centrally located orifice through which fluid may flow to be directed substantially longitudinally through the arc drawn during a circuit opening operation, at least one other passage for the flow of fluid through said piston member, and check valve means carried by said structure for controlling said other passage and arranged to automatically close said other passage during a circuit opening operation, and to automatically open said other passage during a circuit closing operation.

8. In a circuit interrupter, a tubular arc passage, separable contacts one of which is movable substantially longitudinally through said passage to draw an arc therein, fluid pumping and directing structure mounted on said movable contact, said structure including a piston member extending transversely of said passage, said piston member having a substantially centrally located orifice through which fluid may flow to be directed substantially longitudinally through the arc drawn during a circuit opening operation, said structure having limited sliding movement with said movable contact and being biased toward the limit of its movement relative to said movable contact which is adjacent the other of said contacts, and a shoulder on said other contact positioned to engage said structure and maintain it at a position spaced from said limit of movement when said contacts are in engagement.

9. In an automatic reclosing circuit breaker, an arc space adapted to be filled with an arc extinguishing fluid, separable contacts adapted when separated to draw an arc in said space, means for separating said contacts to interrupt the circuit in response to a predetermined electrical condition of the circuit, means restricting flow of fluid through said space during separation of said contacts to obtain a blast of fluid through the arc, means for automatically reclosing said contacts in response to a circuit interrupting operation, and means also responsive to a circuit interrupting operation for actuating a part of said restricting means to provide more freedom for the flow of fluid through said arc

space to permit rapid flushing of said space during a circuit closing operation.

10. An automatic reclosing circuit breaker comprising, an arc chamber which is closed except for upper vent means and lower intake means, said chamber adapted to be submerged in a container of arc extinguishing liquid and to be itself filled with such liquid, contacts in said chamber which are separable in a substantially vertical direction, check valve means for closing said vent means and intake means in response to elevated pressure in said chamber during a circuit interrupting operation and for opening said vent and intake means in response to lesser pressures in said chamber to permit flushing of said chamber after a circuit interrupting operation, means restricting vertical flow of liquid in said chamber during a circuit interrupting operation to direct a blast of liquid through the arc, means for automatically closing said contacts in response to a circuit interrupting operation, and means also responsive to a circuit interrupting operation for actuating a

part of said restricting means to provide more freedom for the vertical flow of liquid in said chamber to facilitate flushing of said chamber during a circuit closing operation.

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