June 1, 1948. J. M. WALLACE ET AL 2,442,477

CIRCUIT INTERRUPTER

Original Filed June 24, 1941

Fig. 1.

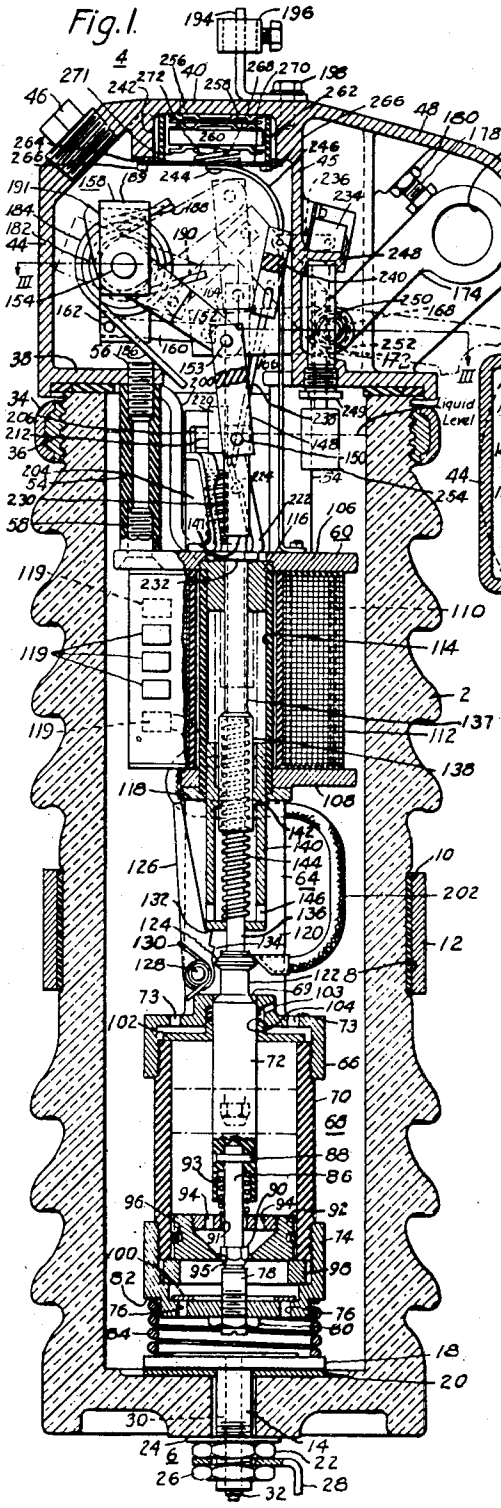

Fig. 2.

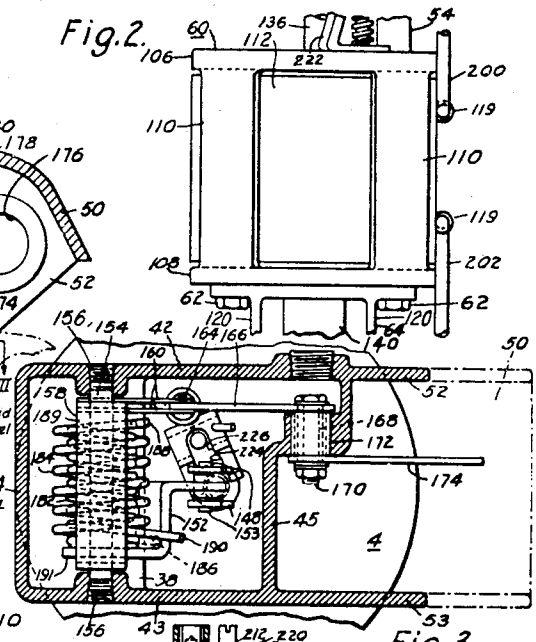

Fig. 3.

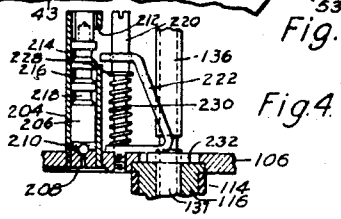

Fig. 4.

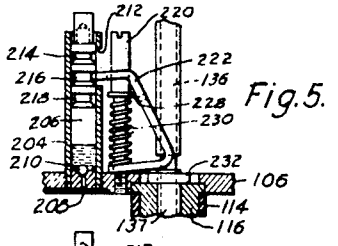

Fig. 5.

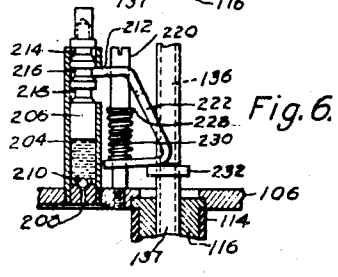

Fig. 6.

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CIRCUIT INTERRUPTER

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Original application June 24, 1941, Serial No. 399,452. Divided and this application November 10, 1944, Serial No. 562,798

12 Claims. (Cl. 200—89)

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

This invention is a division of the subject matter of our copending application on Circuit interrupters, Serial No. 399,452, filed June 24, 1941, and assigned to the same assignee of this invention.

Automatic reclosing circuit breakers of the type with which this invention is primarily concerned, generally include separable contacts which are biased closed, and are adapted to be separated in a closed arc chamber by electro-responsive means having lost motion therewith, to permit overtravel of the contacts dependent upon the pressure developed by the arc. In addition, means may be provided for automatically retaining the breaker contacts separated in response to a predetermined number of closely successive circuit interrupting operations, after which the contacts must be manually reclosed.

One object of this invention is to provide, in a circuit breaker of the type described which employs a liquid arc extinguishing medium and a means utilizing said liquid for controlling the rate of contact movement, novel means controlling the supply of fresh liquid to the arcing zone to replenish liquid in the arcing zone between successive circuit interrupting operations.

Another object of this invention is to provide, in a circuit breaker having separable contacts adapted to strike an arc in a closed, liquid-filled, arc extinguishing chamber, novel means for replenishing the liquid between successive circuit interrupting operations.

Another object of this invention is to provide, in an automatic reclosing circuit breaker, novel means for delaying closing movement of the breaker contacts.

More specifically, it is an object of this invention to provide, in an automatic reclosing circuit breaker, novel means for maintaining the contacts separated following a circuit interrupting operation, in combination with time delay means for finally releasing said contacts to close the circuit.

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

Figure 1 is a substantially central vertical section through a circuit breaker embodying this invention with certain parts thereof shown in elevation;

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Fig. 2 is a partial elevational view of the operating mechanism shown in Fig. 1;

Fig. 3 is a transverse sectional view of the breaker shown in Fig. 1 taken substantially on the line III—III thereof with certain parts omitted.

Fig. 4 is a fragmentary sectional view of the lockout integrating mechanism employed in the breaker shown in Fig. 1;

Fig. 5 is a view like Fig. 4 but showing the parts of the mechanism in a different position from that shown in Fig. 4; and

Fig. 6 is also a partial sectional view illustrating the mechanism of Figs. 4 and 5 in a still different position of the parts thereof.

The circuit breaker constituting this invention is shown by way of example as being mounted in a tubular insulating casing 2 which may be of any desired insulating material, preferably porcelain or the like. The casing 2 is provided with a closed bottom and an open top, with the top being closed by a cover assembly 4, and the bottom of the casing having associated therewith a terminal assembly 6. Intermediate the ends of the casing 2 there is provided a cylindrical surface 8, and a supporting bracket 12 is adapted to be clamped around this cylindrical surface with resilient material 10 interposed between the clamp 12 and the outer casing wall to prevent damage thereto.

The terminal assembly 6 at the bottom of the casing includes a terminal bolt 14 of conducting material adapted to extend through a substantially central aperture in the bottom casing wall, and the bolt is provided with an enlarged head 18 interiorly of the casing, with packing material 20 interposed between the head 18 and the bottom wall of the casing. A nut 22 and washer 24 cooperate with bolt 14 to retain the same in position, and a conductor 28 may be secured to the bolt, for example, as by a second nut 26. Bolt 14 is preferably provided with a substantially central bore 30 for the purpose of draining casing 2, the lower end thereof being adapted to be closed by a screw-threaded closure plug 32.

The upper end of casing 2 is ribbed, and a supporting flanged ring 34 is adapted to be secured to this ribbed portion of the casing, for example, as by cast metal, or the like, 36. Supporting ring 34 is adapted to have cover assembly 4 secured thereto in any desired manner, not shown.

The casing and terminal structure 6 described above are substantially identical with those more particularly described and claimed in the copending application of J. M. Wallace and H. L.

Rawlins, Serial No. 374,686, filed January 16, 1941, and in their Patent No. 2,318,421, issued May 4, 1943, both of which are assigned to the same assignee as this application.

Cover assembly 4 comprises an integral casting having a flange 38 formed integrally with the lower end thereof and adapted to seat on the upper end wall of casing 2 and extend over the interior of the casing. Flange 38 is also provided with integral outwardly extending ears (not shown) adapted to be bolted to ears formed on supporting ring 34. The cover assembly casting is provided with a hollow portion including the top wall 40, side walls 42, 43 and end walls 44 and 45, with the bottom of the hollow portion being open and located over the open top of casing 2. At one upper corner of the hollow portion of cover assembly 4, an inclined wall is provided with a threaded aperture for cooperation with a threaded filler plug 46, by means of which casing 2 may be filled with an arc extinguishing fluid. Top wall 40 of the hollow portion of the cover assembly is extended beyond the hollow portion and slightly inclined downwardly as at 48 to form the top wall of a sleet hood portion having side walls 52 and 53. The top wall 48 of the hood portion terminates in an angularly downwardly extending lip 50, for a purpose to be hereinafter described.

As appears from Figs. 1 and 3 of the drawing, flange 38 of the cover assembly 4 has portions which extend over the open top of casing 2, and these portions are adapted to insulatingly support the circuit breaker contacts and operating mechanism, for example, as by the tubular insulating spacer sleeves 54. The spacer sleeves 54 have the opposite ends thereof threaded for cooperation with screws 56 and 58, to secure the spacers to flange 38 and the upper leg 108 of a U-shaped supporting frame 60, respectively. The other leg 108 of U-shaped frame 60 is secured to one end of a generally rectangular frame 64, and the other end of this frame is preferably formed integral with the top cap 66 of an interrupter chamber 68.

The interrupter chamber 68 includes an insulating tube 70 of fiber or the like, having one end threaded into top cap 66, and having the other end threadedly received in a bottom terminal cap 74. Top cap 66 is provided with a substantially central aperture 69 for closely slidably receiving a contact piston rod 72, and the cap is also provided with spaced outlet apertures 73 adapted to be controlled by a sliding valve plate 102, normally biased by a coil compression spring 104 into engagement with the adjacent end of insulating tube 70. The lower end cap 74 of the interrupter chamber is provided with inlet passages 76, and with a substantially centrally located threaded aperture for receiving the threaded end of an adjustable fixed contact 78 which is secured in position, for example, as by a lock nut 80. The outer end of end cap 74 is reduced in size to form a shoulder 82 on which is seated one end of a coil compression spring 84, with the other end of this spring bearing against the head 18 of terminal bolt 14. Spring 84 should be of some good resilient conducting material, such, for example, as a copper alloy or the like.

The lower end of contact piston rod 72 is provided with a socket for receiving the upper end of contact rod 86, secured in the socket, for example, as by a rivet 88. The lower end of contact rod 86 is enlarged to form a contact head 90. A liquid directing piston 92 is provided with a central aperture 91 so that the piston may be slidably mounted on contact rod 86 for movement between contact head 90 and the lower end of contact piston rod 72. The lower end of contact piston rod 72 is counterbored to receive a coil compression spring 93 which normally operates to bias liquid directing piston 92 towards contact head 90. As shown, piston 92 is provided centrally with a hollow portion to which access is obtained by means of a plurality of top apertures 94, and a single lower aperture 95 concentric with contact head 90 so as to form an annular liquid passage therewith. Liquid director piston 92 may have a peripheral slot for the reception of a piston ring 96 to prevent leakage of liquid between the piston and inner wall of tube 70. A stop ring 98 is secured in position between the lower end of insulating tube 70 and lower end cap 74 and, as shown, projects inwardly so as to form a stop for liquid director piston 92, so that when the contacts are closed, the piston is maintained in a position intermediate the limits of its movement on contact rod 86. The inlet apertures 76 in cap 74 are adapted to be controlled by a check valve plate 100 freely mounted between the end wall of end cap 74 and stop ring 98. The interrupter chamber 68 described above is substantially identical with that described and claimed in the above-mentioned copending application of J. M. Wallace and H. L. Rawlins, Serial No. 374,686, except that in the interrupter chamber herein described, valve plate 102 is spring biased in one direction, rather than being frictionally associated with contact piston rod 72 as in the said copending application.

The operation of the interrupter chamber herein disclosed and illustrated is subtantially the same as that in the above-identified copending application and comprises, briefly, utilization of fluid pressures generated by an arc drawn, to obtain contact separation. This is accomplished by the instant structure, because it will be observed that as soon as contact piston rod 72 is moved upwardly and contact head 90 moves out of engagement with fixed contact 78 to strike an arc, the action of such an arc on the arc extinguishing liquid within the chamber, such, for example, as oil or the like, will decompose the same to generate a gas which will build up a pressure within chamber 68. As soon as this pressure builds up, it will obviously force check valve plate 100 and valve plate 102 outwardly relative to insulating tube 70 to close both the inlet and outlet apertures 76 and 73, respectively. Outward movement of valve plate 102 readily occurs because the upper side of this plate is vented by aperture 103. Accordingly, such pressures within the chamber will act on contact piston rod 72 in a piston-like manner to force the same to move outwardly of the chamber, and thereby increase the contact separation. In the upward movement of contact rod 86, liquid director piston 92 remains stationary until contact head 90 engages the upper wall of the director to thereby draw the arc out to an optimum length before moving the director to cause a flow of liquid through apertures 94 and 95 and into the arc to extinguish the same. Contact piston rod 72 and contact rod 86 will be moved outwardly by the pressure developed within arc chamber 68 until the combined action of attenuation of the arc and flow of liquid therethrough cause extinction. As soon as the arc is extinguished, the contact piston rod 72 is adapted to be moved downwardly towards fixed contact 78

in a manner to be hereinafter further described, and since pressure is no longer being generated within the chamber, spring 104 will be free to move valve plate 102 downwardly to open outlet passages 73 and permit exhaust of gases and used liquid out of the upper end of the arc chamber. This up-flow of gas and used liquid from the chamber will be taken care of by an inflow of fresh liquid through inlet apertures 76, which will cause check valve plate 100 to be unseated due to the pressure at the bottom of the casing because of the head of liquid therein, and especially because of the difference in pressure due to the difference in the head of liquid between inlet apertures 76 and outlet apertures 73. Consequently, it can be seen that the fluid pressure developed by the arc is utilized in this interrupter to obtain contact separation, and that during a closing operation of the breaker contacts, the used arc extinguishing fluid within the chamber is replaced by fresh fluid from casing 2.

As previously stated, the substantially U-shaped supporting frame member 60 is secured to the upper end of rectangular supporting frame 64, and the frame member 60 is for the purpose of supporting a solenoid coil 112. The upper and lower legs 106 and 108 of supporting member 60 are connected by spaced integral legs 110 positioned at one side thereof, so that the solenoid coil 112 may be assembled with support 60 by merely slipping the entire coil between legs 106 and 108 through the open side of support 60. The legs 106 and 108 of the U-shaped frame 60 are provided with aligned apertures adapted to coincide with the central bore provided in solenoid coil 112, and a securing sleeve 114, of insulating material, is adapted to be inserted through the aperture in leg 108 of the U-shaped support 60 into engagement with a shouldered plug 116 seated against a shoulder provided about the aperture through leg 106 of U-shaped supporting frame 60. Securing sleeve 114 is maintained against movement downwardly from the supporting frame 60, as viewed in Fig. 1, by the connection of rectangular frame 64 thereto, inasmuch as the end plate 118 of this frame is provided with a shouldered aperture, with the adjacent end of securing sleeve 114 seated on the shoulder of this aperture to prevent movement thereof with respect to U-shaped frame 60. Frame 60 is of magnetic material to form a stationary frame for coil 112 as well as a support therefor. Rectangular frame 64 is secured to the lower leg 108 of U-shaped frame 60, for example, as by screws 62, or the like. It will be noted that solenoid coil 112 is provided with a plurality of taps 119 which are connected to different sections of the coil, and located away from the connecting legs 110 of the U-shaped support 60, at the open side thereof so as to be readily accessible for the purpose of changing the coil connections when desired. Rectangular supporting frame 64 is provided with the side plates 120 integral with top plate 118 at one end thereof, and with top cap 66 for the interrupter chamber at the other end thereof.

The upper end of contact piston rod 72 is peripherally grooved as at 122 to form a notch and a latch projection 124 at the upper end thereof, for cooperation with a latch lever 126. The latch lever is adapted to be pivotally mounted on top end cap 66 of the interrupter chamber, for example, as by a pivot pin 128, and a coil spring 130 is wound about pivot pin 128 with the ends thereof engaging end cap 66 and latch lever 126, respectively, for biasing the latch lever in a clockwise direction about its pivot, as viewed in Fig. 1. The latch lever is provided with a plurality of latch lugs 132 and 134 for cooperation with the latch projection 124 on the upper end of contact piston rod 72, and with the core of solenoid coil 112. A contact operating rod 136 is rigidly secured to contact piston rod 72 and extends from the upper end thereof through a sleeve 137 extending through the central opening of solenoid coil 112 and securing sleeve 114. The lower end of sleeve 137 is enlarged as shown at 138 to receive the upper end of a coil compression spring 144, with the lower end thereof bearing against the bottom wall of a tubular solenoid core member 140. The tubular solenoid core 140, which is of magnetic material, has the bottom wall thereof apertured to be slidably mounted on contact operating rod 136, and has adjacent the upper end thereof a peripheral inwardly extending rib 142 of a size to closely engage the outer surface of enlarged portion 138 of sleeve 137. Adjacent the lower end of solenoid core 140 are radially directed vent apertures 146, for a purpose to be hereinafter described.

In the operation of the mechanism thus far described, it will be apparent that upon the occurrence of predetermined circuit conditions, solenoid coil 112 will become sufficiently energized to attract core 140 and cause it to move upwardly on operating rod 136 and compress spring 144 between the core and sleeve 137. Furthermore, because of the close fit between core 140, securing sleeve 114 and enlarged portion 138 of sleeve 137, and since these parts are all immersed in the arc extinguishing fluid, it will be obvious that upward movement of core 140 will be relatively slow because of the necessity of displacing the fluid within securing sleeve 114 through the relatively small clearance between the core and sleeve. However, after sufficient movement of the core upwardly so that rib 142 clears the upper end of enlarged sleeve portion 138, there will then be a relatively large annular passage through core 140 and outlet apertures 146 for liquid entrapped in securing sleeve 114, so that further movement of core 140 upwardly will take place at a relatively rapid rate. During this rapid movement of the core, the bottom wall thereof will engage the lower end of enlarged sleeve portion 138 to cause movement of the sleeve upwardly with the core, and engagement of the upper end of the sleeve with shoulder 147 formed on contact operating rod 136, will thus quickly separate contact head 90 from fixed contact 78. This movement of contact head 90 by solenoid core 140 away from fixed contact 78 need be but a small amount, because as soon as the contacts are separated sufficiently to draw an arc, the pressure generated by such an arc operates to increase the contact separation sufficiently to extinguish the arc. Obviously because of the sliding connection of solenoid core 140 with respect to contact operating rod 136, the contact operating rod and contact head 90 are permitted to have a considerable overtravel independent of solenoid core 140 in response to pressures built up within the interrupter chamber 68. As soon as the arc is extinguished and the pressure drops within interrupter chamber 68, contact operating rod 136 is permitted to move downwardly to reclose the contacts. However, its downward motion is halted by engagement of latch projection 124 at the top of contact piston rod 72 with upper latch lug 132. In the meantime, solenoid core 140

returns very slowly under the biasing forces of gravity and spring 144, to the position shown in Fig. 1, because of the dashpot action thereof in securing sleeve 114, so that considerable time must elapse until the solenoid core 140 moves down into engagement with the upper end of latch lever 126, and thereby causes counterclockwise rotation of the latch lever to disengage its upper lug 132 from contact piston rod projection 124. This permits the projection 124 to drop down slightly with contact operating rod 136, and into engagement with the lower lug 134 on latch lever 126, where it is held until further downward movement of solenoid core 140 causes further counterclockwise movement of the latch lever until projection 124 is released from lug 134, whereupon the contact head 90 is permitted to move into engagement with fixed contact 78. Incidentally, it will be noted that upper lug 132 of latch lever 126 serves as the support for preventing undue downward movement of solenoid core 140.

The reason why a plurality of lugs 132, 134 are provided on the latch lever to successively halt downward movement of contact head 90 towards fixed contact 78 is that it is necessary to maintain the contacts separated, during the time delay period before reclosure, a sufficient distance apart so that the dielectric therebetween will be capable of safely withstanding circuit voltage. Because of contamination and deterioration of the dielectric on the interruption of high current arcs, this distance is quite large. On the other hand, it is desired to make the time delay between a circuit interrupting operation and a reclosure of the circuit as long as possible with the available time delay means including the dashpot comprising solenoid core 140 and securing sleeve 114. Lug 132 on the latch lever, therefore, is positioned to engage the moving contact to hold it separated from fixed contact 78 a distance corresponding to the safe gap therebetween according to the dielectric being used. If lug 134 were not also provided on the latch lever, then the time delay between a circuit interrupting operation and a reclosure of the breaker contacts would be too short, and accordingly, to lengthen this period, the second lug 134 is provided for momentarily delaying reclosure of the breaker contacts after release of the moving contact from lug 132, to thereby obtain a longer time delay in reclosing without undue danger of flashover, inasmuch as the period of time which lug 134 operates to maintain the breaker contacts separated is so short that ionization of the path between the breaker contacts does not have time to be completed prior to reclosure of the contacts. Also on interruption of low currents, the pressure may be insufficient to move contact projection 124 as high as latch lug 132 and since the dielectric will not be unduly impaired by low current interruptions, engagement with latch lug 134 will provide a safe gap between the contacts while using full time delay on reclosure.

The upper end of contact operating rod 136 is pivotally secured as by pivot pin 150 to one end of a pair of insulating links 148, with the other ends of the links being connected to an angled crank lever 152, for example, as by the pivot pin 153. Crank lever 152 is pivotally mounted at its other end on a shaft 154 extending across the hollow portion of the top cover casting, and its outer ends are mounted in apertures provided in the side walls 42 and 43 of the cover hollow portion, with the outer ends of these apertures being closed by screw plugs 156 to prevent relative endwise movement of shaft 154. Angled crank lever 152 is rotatably mounted on shaft 154, and a generally U-shaped yoke 158 has the leg portions thereof also rotatably mounted on shaft 154, with one leg of yoke 158 pivotally connected to one end of toggle link 160, and the other ends of this toggle link being pivotally connected to a toggle lever 166, which is, in turn, secured on the squared end of a shaft 168 rotatably mounted in an angled portion of end wall 45 of the cover assembly in a bearing sleeve 172, by a bolt 170, which also acts to secure an operating handle 174 to the other squared end of shaft 168. Operating handle 174 is provided at the outer end thereof with a hook eye aperture 176 for the reception of a hook stick or other operating member. Actuating handle 174 is limited in its movement in a counterclockwise direction by a stop screw 178 which may be secured in an adjusted position, for example, as by a lock nut 180.

A pair of concentric coil springs 182 and 184 are provided about shaft 154 within the hollow portion of the cover assembly 4, with one end 186 of the outer large diameter coil spring 184 engaging flange 38 of the cover assembly, and the other end 188 thereof engaging the connecting portion 189 of yoke 158, to thereby bias the yoke for movement about shaft 154 in a counterclockwise direction. This movement of the yoke is normally prevented by virtue of the toggle formed by links 160 and 166 being below their dead-center position when actuating handle 174 is in engagement with stop screw 178. One end 190 of the smaller diameter inner coil spring 182 is extended to engage the angled portion of crank lever 152, and the other end of this spring also engages the connecting portion 189 of yoke 158, so that when the yoke is locked by toggle levers 160 and 166 against movement in a counterclockwise direction, biasing spring 182 will operate to bias crank lever 152 downwardly or in a clockwise direction relative to shaft 154, to thereby bias contact actuating rod 136 and contact head 90 downwardly, and cause engagement of the contact head with fixed contact 78.

The circuit through the interrupter herein disclosed extends from a terminal bracket 194 secured to the top cover assembly, for example, as by a screw 198 with the bracket having a terminal socket 196 for the reception of a line conductor, through the cover casting, by way of a conductor 200 to one tap 119 of solenoid coil 112, through the coil, conductor 202 to contact piston rod 72, contact rod 86, contact head 90, fixed contact 78, end cap 74, compression spring 84, terminal bolt 14, to another line conductor 28. Thus, it can be seen that the solenoid coil 112 is connected in series in the circuit including the breaker contacts, and as shown, the whole coil is connected in series, inasmuch as the end taps of the coil are used, and, therefore, the connection is for the lowest rating of the breaker which can be obtained with the coil employed, inasmuch as the maximum flux generating capacity of the coil is employed to thereby obtain sufficient force to separate the contacts on relatively low currents. To obtain higher current ratings, it would be merely necessary to connect conductor 202 or 200 to other taps 119 of the coil to utilize smaller portions of the coil winding. It will be noted that the entire circuit breaker mechanism including the breaker con-

tacts and interrupting chamber are supported as a unit with the casing cover assembly 4, so that they may be removed with the cover from the casing when desired by merely unfastening the securing means of the cover to support 34 on the casing. Another feature of the particular supporting means for the circuit breaker mechanism illustrated is the specific support of the solenoid coil permitting ready replacement thereof by another similar coil, or by a coil having a different number of turns to thereby change the available ratings of the breaker. In order to remove coil 112, it is merely necessary to remove screws 62 holding U-shaped frame 60 and rectangular frame 64 together. This permits securing sleeve 114 to drop downwardly out of U-shaped frame 60, and then by removing one pivot pin, for example, the pivot pin 150, the entire contact operating rod and sleeve 137 can be slipped out of U-shaped frame 60 through apertures in legs 106 and 108 of the frame, whereupon coil 112 may be slipped laterally out of the open side of U-shaped frame 60. To insert a new coil, it is simply necessary to slide it in the open side of U-shaped frame 60 until the bore therethrough is aligned with the apertures in legs 106 and 108 of the frame, whereupon contact actuating rod 136 and securing sleeve 114 may be inserted through the apertures and through the bore in the coil, and rectangular frame 64 secured to the lower leg 108 of the U-shaped supporting frame to thereby firmly secure the solenoid coil in operative position. Consequently, in order to remove the coil, it is only necessary to remove two screws 62 and one pivot pin 150.

The operation of contact biasing spring 182 mounted on shaft 154 in cover assembly 4 is believed to be obvious from the foregoing. In other words, when the circuit is interrupted by energization of solenoid coil 112 sufficiently to raise core 140 and separate the contacts against the bias of spring 182, this spring will be effective as soon as the circuit is interrupted to move the contact operating rod and contact head 90 downwardly towards fixed contact 78, until projection 124 on contact piston rod 72 is engaged by latch lug 132, whereupon reclosure of the contacts will be delayed until the latch is released by solenoid core 140 in the manner previously described.

In the event an overload occurs on the circuit which is not self-clearing but continues after a predetermined number of successive interrupting operations, there is provided means for tripping the toggle which normally prevents rotation of yoke 158, so that spring 184 becomes effective to rotate the yoke in a counterclockwise direction to the dotted line position shown in Fig. 1, and, consequently, raise crank lever 152, by engagement of the cross bar 189 of the yoke with a projection 191 on the lever, together with contact actuating rod 136 and contact head 90 to a position wherein the contact head is maintained out of engagement with fixed contact 78, because coil spring 182 will be ineffective to reclose the contacts. The means for tripping the toggle includes a cylindrical tube 204 threadedly mounted in the upper leg 106 of U-shaped support 60, and provided with an inlet aperture 208 in the bottom wall thereof controlled by a ball-check valve 210 to permit flow of liquid into tube 204, but preventing outflow of liquid. A piston member 206 is slidably mounted within cylindrical tube 204, and the upper end thereof is provided with a plurality of spaced peripheral grooves 214, 216, and 218, respectively, to form a ratchet-like portion on the piston accessible through a side opening 212 in a cylindrical sleeve 204. A pawl guide rod 220 is also secured to leg 106 of U-shaped support 60 between cylindrical sleeve 204 and contact operating rod 136, for guiding a substantially U-shaped pawl member 222, having the connecting portion thereof slotted, as shown at 224 to receive the contact operating rod, and with the ends of the slot extending into the legs of the U-shaped pawl but reduced in width, as shown at 226, to more closely fit guide rod 220. Contact actuating rod 136 is adapted to extend through the slot 224 so that the bottom portion of the pawl seats on flange 232 formed on the upper end of sleeve 137 slidable on the contact actuating rod. Guide rod 220 is formed with an intermediate shoulder on which a washer 228 is adapted to be seated, with a coil compression spring 230 engaging between washer 228 and the lower leg of U-shaped pawl 222 to normally maintain the pawl in the position shown in Fig. 4.

In the operation of the circuit breaker, it will be observed that each time solenoid core 140 is drawn upwardly to open the circuit and engage the lower end of enlarged portion 138 of sleeve 137 to move the same upwardly, that it will cause a tilting of pawl 222 against the bias of spring 230, into engagement with notch 214 of piston 206 so that continued upward movement will move the entire piston upwardly and thereby unseat ball-check valve 210 and cause a predetermined amount of liquid to be drawn in the lower end of sleeve 204. As soon as the circuit is interrupted, and the contact actuating rod and associated parts are moved downwardly by biasing spring 182 in the manner previously described, compression spring 230 on guide rod 220 is operative to withdraw the upper leg of pawl 222 from the notch 214 in piston 206, so that the piston remains at the position to which it has been moved, while the contacts are reclosed. Now if the fault on the circuit has been removed, piston 206 will gradually sink to the position shown in Fig. 4 by displacement of the liquid below the piston through the relatively small clearance between the piston and cylindrical sleeve 204, so that eventually it will attain its original position shown in Figs. 1 and 4. However, in the event the fault in the circuit has not cleared upon the first reclosure of the breaker contacts, they will again be opened by solenoid 112, and this time pawl 222 will engage notch 216 in piston 206, as shown in Fig. 5, inasmuch as the piston will not have had time to sink to its original position and the piston will be moved upwardly to the position shown in Fig. 6 of the drawing. As soon as the arc is extinguished, the contacts will again be reclosed by biasing spring 182, and if the fault has cleared, piston 206 will again slowly sink to its original position as before. However, if the fault has not cleared before piston 206 has an opportunity to sink much below the position shown in Fig. 6, the contacts will again be opened, and this time pawl 222 will be pivoted into engagement with the lower notch 218 in piston 206 and cause the same to be moved upwardly a further amount and into engagement with the knee of the toggle formed by levers 160 and 166 to move the knee of the toggle overcenter, thereby releasing spring 184 and permitting the same to rotate yoke 158 and move the toggle levers and contact operating rod to the dotted-line position

shown in Fig. 1 of the drawing, wherein the breaker contacts are maintained by spring 184 in an open circuit position.

It will be observed that ordinarily actuating lever 174 is maintained entirely within the hood formed integral with top cover assembly 4, but upon tripping of the toggle constituted by levers 160 and 166, the actuating lever 174 will be moved in a clockwise direction about its pivot axis 170 to project below the hood, and thereby give a readily visible indication of the fact that the breaker contacts are now maintained in an open circuit position. When piston 206 has tripped the toggle, it will be observed that since contact operating rod 136 is maintained in an upper position, pawl 222 will be maintained in engagement with notch 218 on piston 206 to maintain the piston in its uppermost position. Accordingly, when it is desired to manually reclose the breaker contacts by movement of operating lever 174 in a counterclockwise direction to reset the toggle levers to the position shown in full lines in Fig. 1, it will be observed in the first place, that in the event it is thus attempted to close the circuit while an overload is present, that the breaker is trip-free in that it is free to open against the bias of contact biasing spring 182 irrespective of the position of actuating lever 174. In the second place, it will be noted that since piston 206 has had but a little time to move downwardly from its outermost position with respect to cylindrical sleeve 204, that in the event the breaker is reclosed manually upon an overload in the circuit, that on the consequent circuit interruption and movement of the contact operating rod and associated parts upwardly, pawl 222 will be caused to engage the lower notch 218 of piston 206 to thereby move the toggle overcenter and again permit spring 184 to maintain the contacts in an open position.

Thus, it can be seen that the circuit breaker herein disclosed is capable of automatically opening the circuit with an inverse time current characteristic due to the dashpot action of core 140 in securing sleeve 114, and yet the contacts are separated with a relatively fast action due to the venting of the dashpot formed by core 140 and sleeve 144 adjacent the end of its stroke. This feature is the invention of J. M. Wallace and is more particularly disclosed and claimed in his copending application Serial No. 399,453, filed June 24, 1941, now Patent No. 2,333,604, issued November 2, 1943, to the same assignee of this invention. Following a circuit interrupting operation, the breaker contacts are automatically reclosed with a time also due to the dashpot action of core 140 and sleeve 114, while maintaining substantially to adjacent the end of the timed period a safe gap between the breaker contacts. Also, in response to a predetermined number of closely successive circuit interrupting operations, novel means are provided for maintaining the breaker contacts in an open position, which includes a biasing means normally held inactive by a toggle which is moved overcenter by a piston actuated a predetermined amount upon each interrupting operation. The arc chamber herein disclosed is provided with an outlet valve which is positive in operation, and the electroresponsive solenoid contact opening means is supported in a manner to render the same readily replaceable, and is provided with a plurality of taps so that the rating of the breaker may be readily changed. The specific arrangement of the contact closing spring and the spring for maintaining the contacts separated is especially important with respect to space considerations and efficiency of operation.

An operation counter 234 is adapted to be mounted on the end wall 45 of the hollow portion of cover assembly 4 and to be located beneath the hood portion thereof so as to be readily visible from the exterior of the breaker while protected from the elements by the hood. This operation counter may be of any well known type provided with an actuating crank lever 236, mounted on an operating shaft extending through the angled portion of wall 45 like shaft 168, and with crank 236 pivotally connected to an operating link 238, which, in turn, is connected to pawl 222, so as to actuate the counter on each circuit interrupting operation of the breaker. The connecting link 238 is provided with an insulating portion 240 to insulate the counter from pawl 222.

There is preferably provided within the hollow portion of cover assembly 4, in a socket 242 provided therefor on top wall 40, a lightning arrester assembly, which may be of any well known type including electrodes 256 spaced by an insulating plate 258 to form a gap in series with a porous block 260, in the circuit between top wall 40 of the cover and terminal 244 of the assembly. A tubular insulating sleeve 262 is positioned between the assembly and the side wall of socket 242, and insulating disk 270 supports terminal 244 and is secured to the cover assembly 4 by screws 266, with a sealing gasket 264 therebetween to maintain the arrester assembly in socket 242. A shunt 268 connects terminal 244 and a contact plate 271, and this plate is maintained in contact with block 260 by a spring 272. The arrester terminal 244 is connected by conductor 246 to the top leg 106 of U-shaped frame 60 to thereby form a circuit by-passing solenoid coil 112. This obviously will prevent the solenoid coil from opening the breaker contacts in response to surges inasmuch as the coil will co-operate with the shunt circuit through the arrester assembly to by-pass such surge currents around the coil and limit the voltage across the coil insulation, and such surges will be ineffective to cause a circuit interrupting operation of the breaker. The arrester assembly herein disclosed utilizes a single series porous block and gap of the type shown in the plural series block and gap arrester shown in the patent to L. R. Ludwig, et al., No. 2,135,085, issued November 1, 1938. It will be understood that plural series porous block and gap assemblies may be used with this circuit breaker, if desired.

Also positioned beneath the hood portion of the cover assembly is a tubular sight gauge glass 250, held in position against an integral lug 248 on end wall 45 of the cover assembly, by an apertured threaded plug 249, and an indicating rod 252 is slidably mounted through the apertured plug and tubular sight glass, and is provided with a float 254 secured to the lower end thereof within casing 2 so that the level of liquid within casing 2 may be readily determined from the exterior thereof by inspection of the sight glass beneath the hood portion of the cover assembly.

Thus, there is provided in a single unit an automatic reclosing circuit breaker characterized by its ability to automatically maintain the breaker contacts in an open circuit position in response to faults which continue a predetermined period of time, and by its inverse time current tripping characteristics with predetermined time delay in reclosing of the circuit, together with means incorporated in the unit to protect

the coil insulation and prevent operation of the breaker in response to the occurrence of surges in the circuit. Moreover, the cover assembly for the breaker casing 2 is arranged with a sleet hood portion at one side thereof to conceal an operating handle which is projected into view upon lock-open operation of the breaker contacts to indicate this condition, and also houses liquid level indicating means, as well as means for indicating the number of breaker operations.

Having described a preferred embodiment of this invention in accordance with the Patent Statutes, it is desired that it be not limited to the particular embodiment herein disclosed, inasmuch as it will be obvious, particularly to persons skilled in the art, that many changes and modifications may be made in this particular embodiment without departing from the broad spirit and scope of the invention. Therefore, it is desired that the invention be interpreted as broadly as possible and that it be limited only by the prior art and by what is expressly set forth in the following claims.

We claim as our invention:

1. In a circuit breaker, separable contacts, electroresponsive means for separating said contacts, means biasing said contacts closed, means responsive to circuit interrupting operation of said breaker for releasably latching said contacts separated an amount at least sufficient to provide a safe gap between the contacts which will not break down under impressed circuit voltage, time delay means adapted to be set in operation in response to a circuit interrupting operation for releasing said latch means a predetermined time thereafter, another latch means adapted to automatically maintain said contacts separated a lesser distance than said first latching means to prevent too quick reclosure thereof upon release of said first latching means, and said time delay means also being effective to release said last-mentioned latch means a predetermined time after release of said first latching means to permit said biasing means to finally close said contacts.

2. In a circuit breaker, separable contacts, electroresponsive means for separating said contacts, means biasing said contacts closed, latch means for preventing quick reclosure of said contacts by said biasing means, said latch means including a plurality of spaced latch portions adapted to maintain said contacts different distances apart, respectively, and time delay means effective in response to a circuit interrupting operation to release said latch portions successively at predetermined times after a circuit interrupting operation, respectively, and at least the first of said latch portions released by said time delay means adapted to maintain a safe gap between said contacts.

3. In a circuit breaker, separable contacts, electroresponsive means for separating said contacts, means biasing said contacts closed, latch means for preventing quick reclosure of said contacts by said biasing means, said latch means including a latch lever having a plurality of spaced latch portions adapted to maintain said contacts different distances apart, respectively, said latch portions adapted to be successively effective to maintain said contacts separated said different distances and to be successively released upon movement of said lever in one direction, time delay means effective in response to a circuit interrupting operation to slowly move said latch lever in said one direction, whereby to control closing movement of said contacts.

4. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber at least one of which is slidably mounted through a wall of said chamber in a piston-like manner, electroresponsive means having a lost motion connection with said one contact to move said one contact outwardly of said chamber and away from the other of said contacts and to permit overtravel of said one contact under the influence of pressure generated in said chamber by the arc struck when said contacts separate, means biasing said one contact for movement in a direction to engage the other of said contacts, latch means for automatically latching said electroresponsive means upon opening movement thereof to prevent reclosing movement of said one contact, said latch means effective to latch said electroresponsive means at a plurality of positions at which said one contact is held at different distances spaced away from said other contact, respectively, at least the position of said one contact at which it is maintained the greatest ditsance from the other of said contacts providing a safe gap between said contacts, and time delay means operative in response to a circuit interrupting operation to actuate said latch means at predetermined times thereafter in a manner to successively release said one contact to permit the same to move to said different positions and finally into engagement with said other contact, successively.

5. In a circuit breaker, separable contacts, electroresponsive means for separating said contacts, means biasing said contacts closed, latch means for preventing quick reclosure of said contacts by said biasing means, said latch means effective to latch said contacts in a plurality of open positions at different distances apart, respectively, at least the open position of said contacts at which they are latched the greatest distance apart providing a safe gap between said contacts, and time delay means operative in response to a circuit interrupting operation to actuate said latch means at predetermined times thereafter in a manner to successively release said contacts to permit the same to move under the influence of said biasing means to said different positions and finally into engagement.

6. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber at least one of which is slidably mounted through a wall of said chamber in a piston-like manner, electroresponsive means having a lost motion connection with said one contact to move said one contact outwardly of said chamber and away from the other of said contacts and to permit overtravel of said one contact under the influence of pressure generated in said chamber by the arc struck when said contacts separate, said arc chamber adapted to be immersed in a body of insulating fluid, lower inlet and upper outlet openings for said chamber, check valves controlling said openings, respectively, and responsive to pressure in said chamber for closing said openings, at least said outlet valve being biased to open said outlet passage to insure opening thereof upon extinguishment of the arc in said chamber and consequent lowering of pressure to provide for flushing said chamber by flow of said liquid through said chamber after each circuit interrupting operation, means biasing said one contact for movement in a direction to engage the other of said contacts, latch means for said one contact for automatically latching said one contact upon

opening movement thereof to prevent reclosing movement, said latch means effective to latch said one contact in a plurality of open positions at different distances from said other contact, respectively, at least the position of said one contact at which it is maintained the greatest distance from the other of said contacts providing a safe gap between said contacts, and fluid time delay means also immersed in said fluid and utilizing the same so as to be operative in response to a circuit interrupting operation to actuate said latch means at predetermined times thereafter in a manner to successively release said one contact to permit the same to move to said different positions and finally into engagement with said other contact, successively, and insure flushing of said chamber after each circuit interrupting operation prior to reclosure of contacts.

7. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber, electroresponsive means having lost motion relative to said contacts and adapted to separate said contacts at least an amount sufficient to strike an arc, means responsive to pressure generated in said chamber by an arc to further separate said contacts, said lost motion permitting overtravel of said contacts under the influence of pressure generated in said chamber by the arc struck when said contacts separate, said chamber adapted to be immersed in a body of insulating fluid, lower inlet and upper outlet openings for said chamber, check valves controlling said openings, respectively, and responsive to pressure in said chamber for closing said openings, and at least the outlet valve being biased to open said outlet passage to insure opening thereof upon extinguishment of the arc in said chamber and consequent lowering of pressure, to provide for flushing said chamber by flow of said liquid through said chamber after each circuit interrupting operation and insure flushing of said chamber after each circuit interrupting operation prior to reclosure of said contacts.

8. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber, electroresponsive means having lost motion relative to said contacts and adapted to separate said contacts at least an amount sufficient to strike an arc, means responsive to pressure generated in said chamber by an arc to further separate said contacts, said lost motion permitting overtravel of said contacts under the influence of pressure generated in said chamber by the arc struck when said contacts separate, said chamber adapted to be immersed in a body of insulating fluid, lower inlet and upper outlet openings for said chamber, check valves controlling said openings respectively, and responsive to pressure in said chamber for closing said openings and at least the outlet valve being biased to open said outlet passage to insure opening thereof upon extinguishment of the arc in said chamber and consequent lowering of pressure to provide for flushing said chamber by flow of said liquid through said chamber after each circuit interrupting operation to insure flushing of said chamber after each circuit interrupting operation prior to reclosure of said contacts, and said inlet valve being freely mounted for limited movement so as to be responsive to pressures developed in said chamber to close said inlet, and responsive to the pressure due to the head of liquid outside said chamber to open said inlet.

9. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber at least one of which is slidably mounted through a wall of said chamber in a piston-like manner, electroresponsive means having a lost motion connection with said one contact to move said one contact outwardly of said chamber and away from the other of said contacts and to permit overtravel of said one contact under the influence of pressure generated in said chamber by the arc struck when said contacts separate, said arc chamber adapted to be immersed in a body of insulating fluid, lower inlet and upper outlet openings for said chamber, check valves controlling said openings, respectively, and responsive to pressure in said chamber for closing said openings, at least said outlet valve being biased to open said outlet passage to insure opening thereof upon extinguishment of the arc in said chamber and consequent lowering of pressure to provide for flushing said chamber by flow of said liquid through said chamber after each circuit interrupting operation, means biasing said one contact for movement in a direction to engage the other of said contacts, and fluid time delay means also immersed in said fluid and utilizing the same so as to be operative in response to a circuit interrupting operation to delay closing movement of said one contact a time sufficient to permit the carrying out of said flushing operation.

10. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber, electroresponsive means for separating said contacts at least sufficiently to draw an arc, means responsive to pressure generated in said chamber by the arc to further separate said contacts, said arc chamber adapted to be immersed in a body of insulating fluid, lower inlet and upper outlet openings for said chamber, check valves controlling said openings, respectively, and responsive to pressure in said chamber for closing said openings, at least said outlet valve being biased to open said outlet passage to insure opening thereof upon extinguishment of the arc in said chamber and consequent lowering of pressure to provide for flushing said chamber by flow of said liquid through said chamber after each circuit interrupting operation, means biasing said contacts for movement in a direction to engage the other of said contacts, and fluid time delay means also immersed in said fluid and utilizing the same so as to be operative in response to a circuit interrupting operation to delay closing movement of said contacts a time sufficient to permit the carrying out of said flushing operation.

11. In a circuit breaker, separable contacts, electroresponsive means for separating said contacts, means biasing said contacts closed, latch means for preventing quick reclosure of said contacts by said biasing means, said latch means effective to latch said contacts in a plurality of open positions at different distances apart, respectively, said latch means being ineffective to latch said contacts at least for a predetermined short distance apart, at least the open position of said contacts at which they are latched the greatest distance apart providing a safe gap between said contacts, and time delay means operative in response to a circuit interrupting operation to actuate said latch means at predetermined times thereafter in a manner to successively release said contacts to permit the same to move under the influence of said biasing means to said different positions and finally rapidly into engagement with said other contact, successively.

12. In a circuit interrupter, a closed arc chamber, separable contacts in said chamber, electro-

responsive means for separating said contacts at least sufficiently to draw an arc, means responsive to pressure generated in said chamber by the arc to further separate said contacts, said contacts being biased closed, latch means for preventing quick reclosure of said contacts by said biasing means, said latch means effective to latch said electroresponsive means at a plurality of positions wherein said contacts are different distances apart, respectively, at least the open position of said contacts at which they are latched the greatest distance apart providing a safe gap between said contacts, and time delay means operative in response to a circuit interrupting operation to actuate said latch means at predetermined times thereafter in a manner to successively release said contacts to permit the same to move under the influence of said biasing means to said different positions and finally into engagement with said other contact, successively.

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