

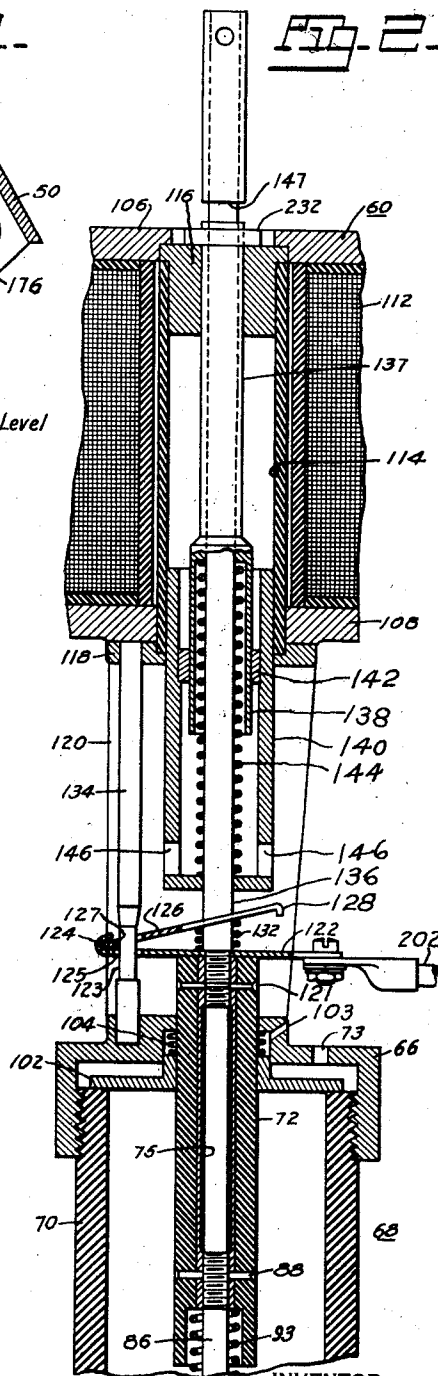
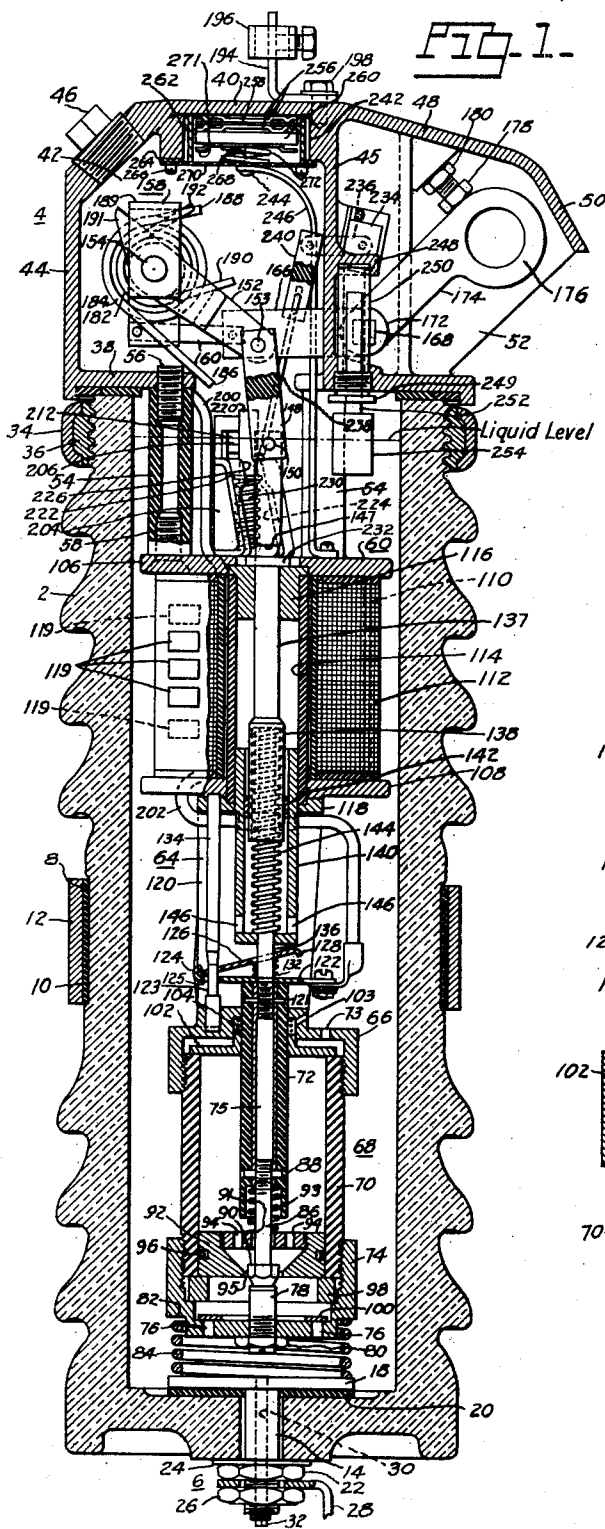
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CIRCUIT INTERRUPTER

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CIRCUIT INTERRUPTER

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Application June 24, 1941, Serial No. 399,453

17 Claims. (Cl. 200—97)

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

The copending application of J. M. Wallace et al., Serial No. 399,452, filed June 24, 1941, and assigned to the same assignee of this application, discloses and claims a circuit breaker of this type, and the instant invention is primarily concerned with certain modifications and improvements in the structures of this copending application, but may be used otherwise. Circuit breakers of this type, in general, are provided with separable contacts in a closed arc chamber, with electro-responsive means for separating the contacts but having a lost motion connection therewith to permit overtravel of the contacts dependent on the pressures developed by the arc. In addition, means are provided for automatically maintaining the breaker contacts separated in response to a predetermined number of successive circuit interrupting operations, and requiring a manual operation to reset the breaker contacts.

One object of this invention is to provide novel operating mechanism for a breaker of the type described.

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

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

A further object of this invention is to provide a circuit breaker of the type described which is compact and relatively simple in structure, yet safe and efficient in operation.

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; and

Fig. 2 is a partial enlarged sectional view of the operating mechanism shown in Fig. 1.

The specific circuit breaker herein illustrated as constituting one embodiment of this invention is substantially identical with that shown in the aforementioned copending application, with the exception of the contact latch means. This breaker is shown 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 structures described above are substantially identical with those more particularly described and claimed in the copending applications of H. L. Rawlins and J. M. Wallace, Serial Nos. 346,300 and 374,686, filed July 19, 1940, and March 16, 1941, respectively, and assigned to the same assignee as this application. Application Serial No. 346,300 was issued May 4, 1943, as Patent No. 2,318,421.

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. The 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 (only one of which is shown), 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 having spaced side walls 52, only one of which is shown. The

top wall 48 of the hood portion terminates in an angularly downwardly extending lip 50, for a purpose to be hereinafter described.

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 co-operation with screws 56 and 58, to secure the spacers to flange 38 and the upper leg 106 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 for closely slidably receiving a tubular contact piston rod 72 of insulating material such as fiber or the like, and the cap is also provided with spaced outlet apertures 73 (only one shown) adapted to be controlled by a sliding valve plate 102, normally biased by 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.

Contact piston rod 72 is provided with a metallic inner tube 75 secured thereto and threaded at its ends for receiving in one end thereof the upper end of contact rod 86, secured therein, 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 identical with that described and claimed in the above-mentioned copending application of J. M. Wallace et al., Serial No. 399,452.

The operation of the interrupter chamber herein disclosed and illustrated, is substantially 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 to 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 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 automatically 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 in-flow 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 liquid 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 support-

ing 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 core for coil 112, as well as a support therefor. 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 (only one of which is shown) integral with top plate 118 at one end thereof, and with top cap 66 for the interrupter chamber at the other end thereof.

A contact operating rod 136 is threadedly secured in the upper end of contact piston rod tube 75 and maintained against removal by a rivet 121. Rod 136 extends through a sleeve 137, 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 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 flange 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.

The threaded lower end of contact operating rod 136 is reduced in section as shown in Fig. 2 to form a shoulder for clamping a latch supporting plate 122 between the shoulder of rod 136 and the upper end of contact piston rod 72. On end of latch supporting plate 122 is bent over as at 124 for pivotally supporting one end of latch plate 126. The other end of latch plate 126 is also turned over as at 128, to limit pivotal movement of the latch plate towards supporting plate 122. A coil compression spring 132 is positioned between the latch plate and its supporting plate, to normally bias latch plate 126 upwardly and in a counterclockwise direction about its pivoted end. A guide rod 134 is secured at its opposite ends in the lower leg 108 of U-shaped supporting frame 60, and in an aperture in the upper end cap 66 of the interrupter chamber, respectively, and latch plate 126 and supporting plate 122, are both pro-

vided with apertures through which guide rod 134 extends. The aperture 125, in supporting plate 122, is of a size to freely receive guide rod 134. In this connection it will be noted that the lower end of the guide rod is reduced in section at 123, for a purpose to be hereinafter described. The aperture 127 in latch plate 126, is of a size such that when the latch plate is in the inclined position shown on the drawing, aperture 127 will permit the latch plate to move freely over the reduced section 123 of the guide rod. However, when the assembly is moved upwardly, so that aperture 127 moves over the enlarged upper portion of guide rod 134, upward movement over this portion of the guide rod may freely take place because any tendency of the opposite sides of aperture 127 to bind on the rod will merely result in a clockwise rotation of the latch lever against the bias of the relatively weak spring 132. Upon attempted downward movement of the latch and contact assembly, opposite sides of aperture 127 in the latch lever will bind on opposite sides of the enlarged portion of guide rod 134, because of the tendency of spring 132 to rotate the latch plate in the counterclockwise direction, and because the friction of the opposite sides of aperture 127 on the opposite sides of the guide rod 134 will also attempt to rotate the latch plate in a counterclockwise direction, to thereby effectively prevent downward movement of the parts until the latch lever is released by a force exerted on the free end thereof to rotate the same in a clockwise direction.

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 inter-

rupter 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 binding engagement of opposite sides of the aperture in latch plate 126 with opposite sides of guide rod 134. In the meantime, solenoid core 140 returns very slowly, under the biasing forces of gravity and spring 144 towards 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 latch plate 126, and thereby cause clockwise rotation of the latch plate to release the binding action on guide rod 134. This permits contact rod 136 to drop down slightly, but as soon as this movement is sufficient to allow the latch lever to be raised by spring 132, its downward movement will again be halted by binding action on guide rod 134. This will continue until the aperture 127 in the latch plate reaches the reduced section 123 of the guide rod, whereupon the latch plate is ineffective to produce any binding action on the rod, and contact head 90 will be permitted to move into engagement with fixed contact 78. It will be noted that the downwardly turned end 128 of the latch plate limits clockwise rotation of the plate to prevent crushing of the relatively light spring 132.

The particular latching means for the movable contact herein disclosed does not require any extremely close tolerances in the manufacture thereof, and but a slight force is required to release the latch. Furthermore, this latch gives an infinite number of positions at which the contacts may be locked open, and it will be readily apparent that the movable contact head 90 will be maintained at whatever distance away from fixed contact 78 it is moved in opening the circuit, and that it will not be released until solenoid core 140 has had time to move down into engagement with latch plate 126, and thereafter the contact head 90 will slowly move towards fixed contact 78 at the same rate of movement as solenoid core 140, until the aperture 127 in the latch plate reaches the reduced section 123 of guide rod 134, whereupon the contact head 90 is free to quickly move into engagement with contact head 78. In the manufacture of this latch, the only part which needs to be accurately dimensioned is aperture 127 in latch plate 126. Because the movable contact assembly is latched in the furthest position to which it is required to move to open the circuit, the possibility of breakdown of the dielectric between the contacts after interruption occurs, is eliminated.

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 (only one of which is shown), 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 casing. 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 end of this toggle link being pivotally connected to a toggle lever 166, which is, in turn, secured to a hollow square shaft 168 rotatably mounted in an angled portion of end wall 45 of the cover assembly in a

bearing sleeve 172, by a through bolt (not shown), which also acts to secure an operating handle 174 to the other 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 192 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.

It will be noted that the entire circuit breaker mechanism including the breaker contacts 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.

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. However, this action is prevented by latch plate 126, and, as stated before, contact piston rod will not move downwardly at all until the contact latch lever is engaged by solenoid core 140, and thereafter movement of piston 72 downwardly is at the same rate as core 140, until aperture 127 in the latch plate reaches the reduced section 123 of guide rod 134, whereupon spring 182 will be free to quickly move contact head 90 into engagement with fixed contact 78.

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 and, consequently, raise crank lever 152, by engagement of the cross bar 189 of the yoke with a projection 191 on the lever, and 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 mounted on the upper leg 106 of U-shaped support 60, and provided with an inlet aperture in the bottom wall thereof controlled by a check valve 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 ratchet-like portion on the piston accessible through a side opening 212 in 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 is adapted to be seated, with a coil compression spring 230 engaging between the washer and the lower leg of U-shaped pawl 222 to normally maintain the pawl out of engagement with respect to piston 206.

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, so that the upper end thereof moves toward piston 206 and engages the ratchet portion thereof, so that continued upward movement will move the entire piston upwardly and thereby 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 its lowermost position 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. 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 the next lower notch in the ratchet portion of piston 206, inasmuch as the piston will not have had time to sink to its original

position, it will be moved upwardly a further predetermined amount. 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 to which it was raised, the contacts will again be opened, and this time pawl 222 will be pivoted into engagement with the next lower notch in the ratchet portion of 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 a position, 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 a lower notch of the ratchet formed 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 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 consequential 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 delay 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 sleeves 114 and 138 adjacent the end of its stroke. Following a circuit interrupting operation, the breaker contacts are automatically reclosed with a time delay also due to the dashpot action of core 140 and sleeve 114, and the contacts are maintained separated at the distance apart to which they have been separated in the circuit interrupting operation, and this separation is maintained for a predetermined time, that is, until solenoid core 140 engages latch plate 126. Thereafter the breaker contacts are slowly moved towards each other at

a speed determined by the dashpot action of core 140 and sleeves 114 and 138, for a predetermined distance, and thereafter the contacts are closed with a quick action to prevent arcing. Also, in response to a predetermined number of closely successive circuit interrupting operations, 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.

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 series gap 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 blocks 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 will prevent the solenoid coil from opening the breaker contacts in response to surges inasmuch as the coil will cooperate 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 ex-

terior 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 quick opening of the breaker contacts and while maintaining the breaker contacts separated in a novel manner.

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.

I claim as my invention:

1. In a circuit interrupter, movable contact means movable into and out of engagement with respect to cooperating contact means, means having a part limitedly movable relative to said movable contact means and responsive to predetermined electrical conditions to move said part in one direction to one limit of its relative movement for actuating said movable contact means away from said cooperating contact means, said part biased for movement in the opposite direction, time delay means for delaying movement of said part toward said one limit, latch means effective to latch said movable contact means at any position at which it is separated from said cooperating means except positions closely adjacent its closed circuit position, and said part adapted to release said latch means after predetermined movement thereof toward its other limit.

2. In a circuit interrupter, movable contact means movable into and out of engagement with respect to cooperating contact means, means having a part limitedly movable relative to said movable contact means and responsive to predetermined electrical conditions to move said part in one direction to one limit of its relative movement for actuating said movable contact means away from said cooperating contact means, said part biased for movement in the opposite direction, time delay means for delaying movement of said part toward said one limit, latch means effective to latch said movable contact means at any position at which it is separated from said cooperating means except positions closely adjacent its closed circuit position, and means for releasing said latch means a predetermined time after a circuit interrupting operation.

3. In a circuit interrupter, movable contact means movable into and out of engagement with respect to cooperating contact means, means having a part limitedly movable relative to said movable contact means and responsive to predetermined electrical conditions to move said part in one direction to one limit of its relative movement for actuating said movable contact means away from said cooperating contact means, said part biased for movement in the opposite direction, time delay means for delaying

movement of said part toward said one limit, latch means effective to latch said movable contact means at any position at which it is separated from said cooperating means except positions closely adjacent its closed circuit position, and means controlled by said time delay means for releasing said latch means a predetermined time after a circuit interrupting operation.

4. In a circuit interrupter including separable contacts, means responsive to predetermined conditions of said circuit for separating said contacts, latch means operative to latch said contacts separated any distance apart except a relatively short distance adjacent their closed circuit position, means biasing said contacts closed, and time delay means effective to release said latch means a predetermined time following a circuit interrupting operation.

5. In a circuit interrupter including separable contacts, means responsive to predetermined conditions of said circuit for separating said contacts, latch means operative to latch said contacts separated a plurality of distances apart except a relatively short distance adjacent their closed circuit position, said latch means including an elongated member and a tiltable locking member having an opening for slidably receiving said elongated member, one of said members associated with said contacts and the other of said members being relatively fixed, means biasing said locking member to a tilted position with respect to said elongated member so that opposite sides of said opening will engage opposite sides of said elongated member, and said biasing means tilting said locking member in a direction such that upon opening movement of said contacts said members are freely relatively movable and upon closing movement of said contacts said members will bind to prevent relative movement thereof, means biasing said contacts closed, and time delay means effective to release said latch means a predetermined time following a circuit interrupting operation.

6. In a circuit interrupter including separable contacts, means responsive to predetermined conditions of said circuit for separating said contacts, latch means operative to latch said contacts separated a plurality of distances apart except a relatively short distance adjacent their closed circuit position, said latch means including an elongated member and a tiltable locking member having an opening for slidably receiving said elongated member, one of said members associated with said contacts and the other of said members being relatively fixed, means biasing said locking member to a tilted position with respect to said elongated member so that opposite sides of said opening will engage opposite sides of said elongated member, said biasing means tilting said locking member in a direction such that upon opening movement of said contacts said members are relatively freely movable and upon closing movement of said contacts said members will bind to prevent relative movement thereof, means biasing said contacts closed, time delay means effective to release said latch means a predetermined time following a circuit interrupting operation, and said elongated member having the portion thereof traversed by said locking member adjacent the closed position of said contacts reduced in section to prevent binding action of said members so that the contacts will be finally quickly moved into engagement.

7. In a circuit interrupter, separable contacts,

actuating means for moving said contacts into and out of engagement, fluid time delay means having a part thereof mounted on a member movable with said contacts for delaying relative separating movement of said contacts, and means operative to vent said time delay means in response to predetermined movement of said part whereby at least a part of the opening movement of said contacts is not delayed by said fluid time delay means.

8. In a circuit interrupter, a movable contact actuating rod, a contact actuable by movement of said rod into and out of engagement with a cooperating contact, fluid dashpot means having a movable member slidably mounted on said rod, spaced means limiting relative sliding movement of said member on said rod, actuating means operative to move said member in one direction, said member biased to move in the opposite direction to one limit of its relative sliding movement on said rod, and means venting said dashpot means in response to predetermined relative sliding movement of said member on said rod, whereby said contact is rapidly moved away from said cooperating contact only a predetermined time after said actuating means is energized.

9. In a circuit interrupter, a movable contact actuating rod, a contact actuable by movement of said rod into and out of engagement with a cooperating contact, fluid dashpot means having a tubular piston member slidably mounted on said rod and a relatively stationary dashpot cylinder receiving said piston member, spaced means limiting relative sliding movement of said member on said rod, actuating means operative to move said member in one direction, said member biased to move in the opposite direction to one limit of its relative sliding movement on said rod, and means venting said dashpot means in response to predetermined relative sliding movement of said member on said rod, whereby said contact is rapidly moved away from said cooperating contact only a predetermined time after said actuating means is energized.

10. In a circuit interrupter, a movable contact actuating rod, a contact actuable by movement of said rod into and out of engagement with a cooperating contact, fluid dashpot means having a tubular piston member of magnetic material slidably mounted on said rod and a relatively stationary dashpot cylinder receiving said piston member, spaced means limiting relative sliding movement of said member on said rod, solenoid actuating means having a bore in which said dashpot cylinder is mounted, said solenoid means when energized operative to move said member in one direction, said member biased to move in the opposite direction to one limit of its relative sliding movement on said rod, and means rendering said dashpot means ineffective to delay movement of said member under the influence of said actuating means in response to predetermined relative sliding movement of said member on said rod, whereby said contact is rapidly moved away from said cooperating contact only a predetermined time after said actuating means is energized.

11. In a circuit interrupter including separable contacts, means responsive to predetermined conditions of said circuit for separating said contacts, latch means operative to latch said contacts separated a distance apart at least corresponding to the safe gap between said contacts for the circuit voltage, means biasing said contacts closed, said latch means when released

effective to automatically latch said contacts apart at a plurality of successively lesser distances apart except for a short distance prior to engagement of said contacts, and time delay means for successively releasing said latch at predetermined times after a circuit interrupting operation.

12. In a circuit interrupter, movable contact means movable into and out of engagement with respect to cooperating contact means, means having a part limitedly movable relative to said movable contact means and responsive to predetermined electrical conditions to move said part in one direction to one limit of its relative movement for actuating said movable contact means away from said cooperating contact means, said part biased for movement in the opposite direction, time delay means for delaying movement of said part, latch means effective to latch said movable contact means a distance apart at least corresponding to the safe gap between said contacts for the circuit voltage, means biasing said contacts closed, said latch means when released effective to automatically latch said contacts apart at a plurality of successively lesser distances apart except for a short distance prior to engagement of said contacts, said part in its movement in said opposite direction effective to successively release said latch means at predetermined times after a circuit interrupting operation, whereby during at least the latter part of closing movement of said movable contact means it moves at an average speed substantially equal to that of said part and moves faster than said part for said short distance into engagement with said cooperating contact means.

13. In a circuit interrupter including separable contacts, means responsive to predetermined conditions of said circuit for separating said contacts, latch means operative to latch said contacts separated a plurality of distances apart except a relatively short distance adjacent their closed circuit position, said latch means including a relatively stationary elongated member and a tiltable locking member associated with said contacts and having an opening for slidably receiving said elongated member, means biasing said locking member to a tilted position with respect to said elongated member so that opposite sides of said opening will engage opposite sides of said elongated member, and said biasing means tilting said locking member in a direction such that upon opening movement of said contacts said members are freely relatively movable and upon closing movement of said contacts said members will bind to prevent relative movement thereof, means biasing said contacts closed, and time delay means having a part movable in the path of movement of said locking member during closing movement of said contacts to engage said locking member after predetermined movement thereof, whereby said locking member is released to permit closure of said contacts a predetermined time after a circuit interrupting operation and thereafter moves substantially with said part of the time delay means to a point corresponding to said relatively short distance between said contacts, and thereafter at a higher speed to correspondingly regulate the closing movement of said contacts.

14. In a circuit interrupter, separable contacts, electro-responsive means movable in one direction for separating said contacts and having lost motion relative to said contacts, means responsive to pressure generated by the arc drawn upon

separation of said contacts for further separating said contacts, means for releasably holding said contacts separated at any distance they are moved apart, and means for releasing said holding means a predetermined time after a circuit interrupting operation.

15. In a circuit interrupter, separable contacts, electro-responsive means movable in one direction for separating said contacts and having lost motion relative to said contacts, means responsive to pressure generated by the arc drawn upon separation of said contacts for further separating said contacts, means for releasably holding said contacts separated at any distance they are moved apart, means biasing said electro-responsive means for movement in the opposite direction, time delay means limiting the speed of movement of said electro-responsive means, and said electro-responsive means adapted to release said holding means after a circuit interrupting operation upon predetermined movement thereof in said opposite direction.

16. In a circuit interrupter, separable contacts, electro-responsive means movable in one direction for separating said contacts and having lost motion relative to said contacts, means responsive to pressure generated by the arc drawn upon separation of said contacts for further separating said contacts, means for releasably holding said contacts separated at any distance they are moved apart, means biasing said electro-responsive means for movement in the opposite direction, time delay means limiting the speed of movement of said electro-responsive means, means rendering said time delay means ineffective after predetermined movement of said electro-responsive means in said one direction, and said electro-responsive means adapted to release said holding means after a circuit interrupting operation upon predetermined movement thereof in said opposite direction.

17. In a circuit interrupter, movable contact means movable into and out of engagement with respect to cooperating contact means, means having a part limitedly movable relative to said movable contact means and responsive to predetermined electrical conditions to move said part in one direction to one limit of its relative movement for actuating said movable contact means away from said cooperating contact means, said part biased for movement in the opposite direction, time delay means for delaying movement of said part towards said one limit over a distance less than the full amount of relative movement of said part and movable contact means, latch means effective to latch said movable contact means a distance apart at least corresponding to the safe gap between said contacts for the circuit voltage, means biasing said contacts closed, said latch means when released effective to automatically latch said contacts apart at a plurality of successively lesser distances apart except for a short distance prior to engagement of said contacts, said part in its movement in said opposite direction effective to successively release said latch means at predetermined times after a circuit interrupting operation, whereby during at least the latter part of closing movement of said movable contact means it moves at an average speed substantially equal to that of said part and moves faster than said part for said short distance into engagement with said cooperating contact means.