Jan. 8, 1957 J. M. WALLACE 2,777,031

CIRCUIT INTERRUPTERS

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Fig. 1.

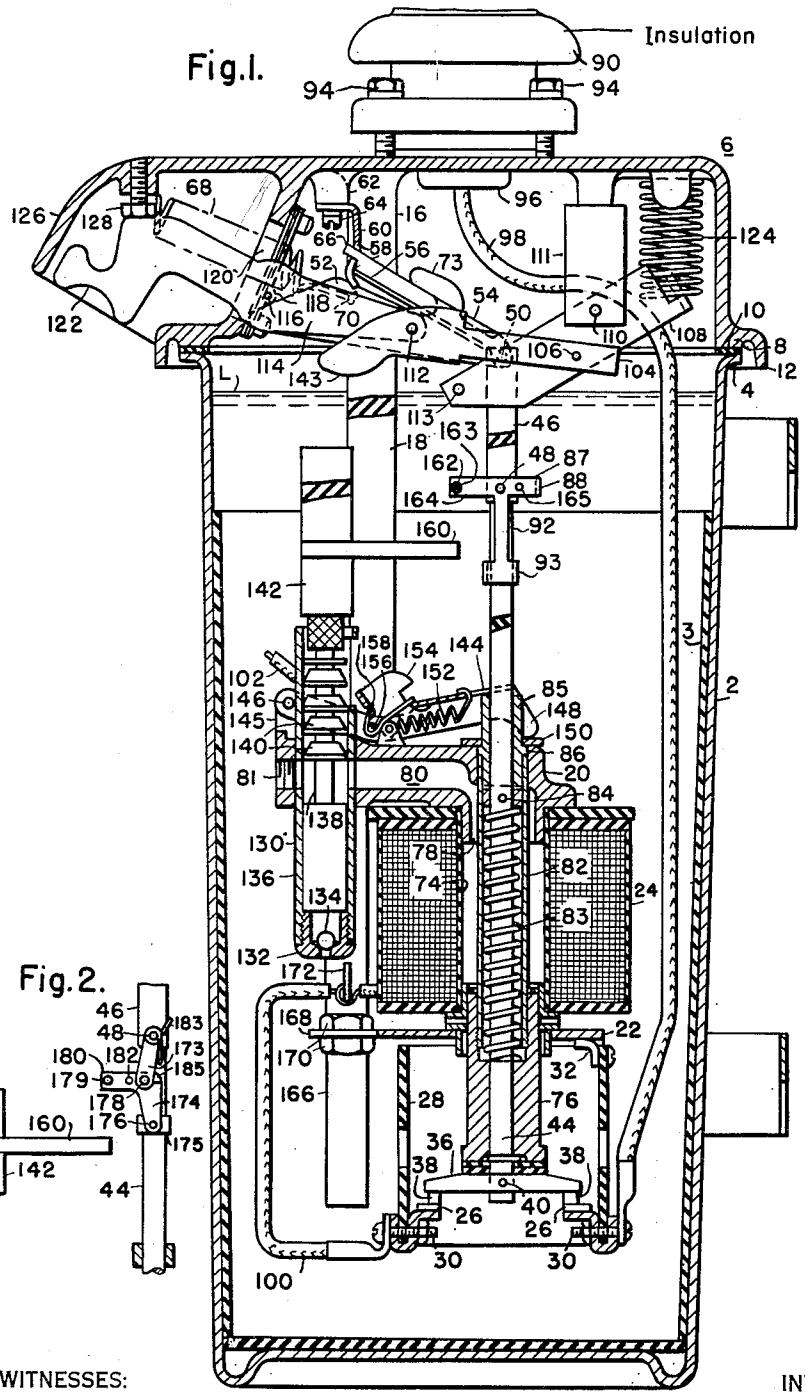

Fig. 2.

WITNESSES:

E. A. McCloskey.

F. V. Giolma

INVENTOR

James M. Wallace.

BY Arthur T. Stratton

ATTORNEY

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CIRCUIT INTERRUPTERS

James M. Wallace, Pittsburgh, Pa., assignor to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application August 18, 1951, Serial No. 242,465

14 Claims. (Cl. 200—89)

My invention relates generally to circuit interrupters, and it has reference in particular to circuit interrupters of the class known as automatic reclosing circuit breakers.

While it is more or less generally customary to have automatic reclosing circuit breakers open and reclose a predetermined number of times if a fault persists on a circuit, and then lock open until an investigation is made, other arrangements are sometimes desired. For example, it may be desirable to have the reclosing circuit breaker open and reclose a predetermined number of times in an effort to clear the fault, and then have it lock closed in order to force a fuse cutout or the like to blow and remove the faulted section from the circuit.

Accordingly, it is an object of my invention to provide novel means in an automatic reclosing circuit breaker for effecting separation of the breaker contacts and reclosing thereof a predetermined number of times by electroresponsive means and for thereafter rendering the electroresponsive means ineffective to effect separation of the contacts.

Another object of my invention is to provide in an automatic reclosing circuit breaker for utilizing adjustable motion transmitting means for effecting separation of contacts of the breaker in response to a predetermined number of operations of electroresponsive means as a result of overcurrent conditions, and for subsequently rendering the motion transmitting means ineffective to effect further separation of said contacts in response to continued operations of the electroresponsive means.

Yet another object of my invention is to provide in an automatic reclosing circuit breaker for utilizing adjustable connecting means between electroresponsive means and contacts of the breaker for effecting separation of said contacts in response to a predetermined number of overcurrent conditions, and for rendering said connecting means ineffective to separate said contacts after a predetermined number of separations.

It is also an object of my invention to provide in an automatic reclosing circuit breaker for having an operation counter selectively responsive to predetermined circuit conditions to either trip the breaker and lock it open or lock it closed, by controlling an operating connection between the breaker contacts and the breaker operating means.

Figure 1 is a substantially central vertical section view of a circuit breaker constructed in accordance with this invention; and

Fig. 2 is a partial side elevational view of a portion of a breaker operating mechanism showing a modification of the invention.

The breaker shown in Fig. 1 of the drawing is illustrated as being mounted in a metal tank 2 having a closed bottom wall and an open top. Preferably, the tank is adapted to be lined at least over the bottom wall and up to a point adjacent the open top of the container with a liner 3 of insulating material, such as fiber or the like, and is filled up to the level L with liquid, preferably a liquid having arc extinguishing ability, such as oil.

The upper end of tank 2 is provided with an outwardly extending flange 4 on which the flange 8 of a cover casting 6 is adapted to be seated, preferably with a resilient gasket 10 interposed therebetween. Flange 8 of cover casting 6 may be provided with an integral lip 12, and the cover may be secured to the tank in any desired manner, such, for example, as by clamps (not shown) securing the cover to the flange 4 on the tank.

The breaker contacts and certain of the contact actuating mechanism are adapted to be supported in tank 2 from cover casting 6 by means of a pair of integral supporting lugs 16 (only one of which is shown) depending from the top wall of the cover casting and adapted to engage insulating spacer rods 18 having threaded studs (not shown) engaging threaded openings in rods 18 and lugs 16, and supporting casting 20. A supporting plate 22 may be supported in a similar manner from casting 20, so that a solenoid coil 24 may be mounted between casting 20 and supporting plate 22, with the central opening in the coil aligned with openings provided in casting 20 and plate 22.

Spaced stationary contacts 26 of the breaker are each supported from plate 22 by an arc extinguishing tube 28 of insulating material, such as fiber, with the stationary contacts being secured on tube 28 by means of screws 30, and with the upper end of the tube 28 having brackets 32 by means of which the tube is secured to supporting plate 22.

Stationary contacts 26 are adapted to be closed by engagement therewith of a bridging contact 36 having contact tips 38 at opposite ends thereof for engagement with the stationary contacts, respectively. Bridging contact 36 is supported substantially centrally thereof on a slidable contact actuating rod 44 by pivot pin 40, for limited pivotal movement about a transverse avis on contact actuating rod 44. Contact rod 44 being mounted for longitudinal sliding movement through coil 24 and the aligned openings in plate 22 and casting 20, it will be observed that bridging contact 36 is free to adjust itself to the stationary contacts by restricted pivotal movement about its pivot mounting 40. Contact rod 44 may be of an insulating material, such as fiber or a molded insulating material.

The upper end of contact actuating rod 44 has a pair of connecting links 46, which may be of an insulating material similar to that of the contact rod, and which are positioned one at each side thereof and pivoted thereon as by a pivot pin 48, with the upper ends of these connecting links mounted on a common pivot pin 50 for a pair of toggle levers 52 and 54. Toggle levers 52 and 54 are both formed of sheet material, with lever 54 being bent to substantially channel form with outwardly extending flanges 56 adapted to be received at the free ends thereof in recesses 58 provided in the spaced downwardly depending fingers of an angled supporting bracket 60 which, in turn, is secured as by a screw 64 to a lug 62 integral with the cover casting. Preferably, the base of the channel part of toggle lever 54 is extended at 66 through the space between the supporting fingers of bracket 60, and at the other end of lever 54 the sides of the channel formation thereof are extended to be mounted on pivot pin 50. A coil tension spring 68 has one end hooked into an opening 70 provided in toggle lever 52, and has the opposite end thereof hooked over an integral spring support on the cover casting.

It will be observed that in the closed circuit position of the breaker illustrated in Fig. 1 of the drawing, the line of action of toggle spring 68 is below the pivot supporting recesses 58 for toggle lever 54, and accordingly, the toggle spring acts to bias bridging contact 36 into engagement with stationary contacts 26 of the breaker, under a predetermined pressure. However, as soon as contact

operating rod 44 moves upwardly to separate the bridging contact from the fixed contacts of the breaker, toggle lever 54 will pivot about recesses 58 and the line of action of toggle spring 68 will thus be caused to approach that pivot point, so that in response to a very small contact separation the line of action of toggle spring 68 will pass through pivot recesses 58 which is the on-center position of the resilient toggle arrangement comprising toggle levers 52 and 54 and toggle spring 68. As a practical matter, the opening movement of the contacts necessary to move toggle levers 52 and 54 to the on-center position mentioned above may be made very small, in one operative device being on the order of one-quarter of an inch. When toggle levers 52 and 54 reach their on-center position referred to above, further relative movement of the two toggle levers in the same direction is prevented because the upper edge of toggle lever 52 engages the base of the central channel formation of toggle lever 54. Moreover, since the point at which toggle spring 68 is hooked into opening 70 of lever 52 then substantially coincides with recesses 58 in which toggle lever 54 pivots during contact opening movement, it will be apparent that the remainder major part of contact opening movement will occur substantially uninfluenced by toggle spring 68.

Substantially the reverse of the above operation occurs when contact operating rod 44 moves downwardly to close the circuit from the full open contact position, because during the first and major part of contact closing movement, levers 52 and 54 will be in engagement, so that such movement will be uninfluenced by toggle spring 68. However, as soon as pivot 50 passes below a line drawn from the remote end of toggle spring 68 through pivot recesses 58 for link 54, toggle spring 68 will then be effective to move the toggle levers toward the position shown in Fig. 1, and the force exerted by toggle spring 68 then tending to close the contacts will continue to increase as toggle levers 52 and 54 move further away from their on-center positions. While it is preferred when toggle levers 52 and 54 are in engagement, that these levers be engaged as closely as possible to their on-center position, so that toggle spring 68 is ineffective to bias the contacts in either direction, rather than risking that the engagement occur at a position slightly overcenter from that shown in Fig. 1, it may be desirable to make the engagement occur just prior to attainment by levers 52 and 54 of their on-center position. When this is done, toggle spring 68 will exert some slight bias tending to close the contacts, and this may be desirable in some cases. It will be noted that toggle lever 52 is provided with an integral hook 73 for limiting its separation from toggle lever 54.

The circuit breaker thus far described and the manual operating mechanism thereof is substantially identical with that described and claimed in the copending application Serial No. 719,572 of Herbert L. Rawlins and James M. Wallace, entitled Circuit Interrupter, and filed on December 31, 1946, now Patent No. 2,622,167, Dec. 16, 1952. Instead of using the dashpot arrangement therein described, the dashpot arrangement of the present invention is similar to that described in copending application Serial No. 719,524 (24,719) of James M. Wallace et al., filed on December 31, 1946, now Patent No. 2,626,329, Jan. 20, 1953, entitled Circuit Interrupter, both applications being assigned to the assignee of the present invention.

As in the Wallace et al. application, the solenoid coil 24 previously mentioned is adapted to be energized under certain conditions for automatically opening the circuit breaker contacts. The central opening through coil 24 preferably is provided with a cylindrical sleeve 74 in which a solenoid core 76 is adapted to be slidably mounted in a piston-like manner. The sleeve 74 communicates with an annular passage 78 in the casting, which connects with a passage 80 having a threaded end opening 81 for receiving a plug (not shown) if all time delay operation of the breaker is desired.

A contact actuating sleeve 82 is telescoped over contact actuating rod 44 and its lower end is received in core 76 and preferably threadably mounted therein. A coil compression spring 83 is provided within actuating sleeve 82 on contact actuating rod 44 and is adapted to react between a shoulder in the core and a pin 84 extending transversely through actuating rod 44. A bushing 85 surmounts the sleeve 82 and is provided with a flange 86.

The circuit through the circuit breaker thus far described may now be traced from the point where it enters tank 2 through one of a pair of terminal bushings 90 (only one being shown), with each bushing secured to cover castings 6 as by bolts 94, and each being provided with a conductor element which extends through the bushing and emerges from a reduced extension 96 of the bushing seated in an opening provided in the top wall of cover casting 6, and proceeds by conductor 98 directly to one fixed contact 26 of the breaker. When the contacts are in engagement, the circuit then proceeds through bridging contact 36 to the other fixed contact 26, and then by way of a conductor 100 to one terminal of solenoid coil 24. The other terminal of coil 24 is adapted to be connected by a conductor 102 to the conducting means in the other terminal bushing 90. It will be apparent that solenoid coil 24 in this embodiment of the invention is connected in series in the circuit through the circuit breaker so as to be energized at all times when the circuit breaker is closed, an amount dependent upon the value of current flowing in the circuit.

For any given rating of circuit breaker, solenoid coil 24 is designed to become sufficiently energized when the load current in the circuit exceeds its rating as to attract core 76 and move it upwardly within the sleeve 74. Core 76 will move upwardly relatively rapidly if the passage 80 is open, and slowly if it is closed, since it is necessary to displace the liquid in sleeve 74 above the core, either through the opening 81 or through the relatively small clearance between the core 76 and sleeve 74. Accordingly, if the opening 81 is open, as shown, opening movement of the core will not be slowed up by the aforesaid dashpot action, and opening movement thereof may be relatively rapid. When core 76 commences its upward travel, bridging contact 36 being held engaged by toggle spring 68 does not move, so that spring 83 is compressed until it is substantially solid.

In accordance with this invention, a releasable motion transmitting connection is provided between core 76 and contact rod 44. While the connections hereinafter specifically disclosed are of the mechanical type, characterized by their simplicity, reliability of operation and particular features of cooperation with parts of the specific operating mechanism disclosed, other types of releasable motion transmitting connections, such as a hydraulic type of connection, may be employed to advantage with corresponding variations in this operating mechanism to accommodate the same, or with other types of operating mechanisms. The mechanical connection shown in Fig. 1 has but a single movable part comprising, for example, a T-shaped knock-off link 92 which is pivotally mounted on the contact rod 44 by pin 48, having a crossarm 87 with a depending stem 88 the lower end of which is disposed to be engaged by the bushing 85 to move the rod 44 upwardly and reduce the contact pressure of spring 68. The knock-off link 92 may be of a double construction, having one crossarm and stem on each side of the rod 44, the crossarms being, for example, connected by a transverse web 93 at the right hand end.

As soon as actuating rod 44 moves upwardly, the force exerted by toggle spring 68 begins to decrease and in a very short distance has substantially no value at all, so that the remaining major part of the circuit opening movement of bridging contact 36 occurs extremely rapidly due to expansion of spring 83.

When the breaker contacts have attained their full open circuit position, the parts associated therewith are biased to return by gravity, and as previously pointed out, they may also be biased by toggle spring 68 if it is desired to stop relative movement of toggle levers 52 and 54 just short of attaining their on-center position during opening of the contacts. In either case, the closing bias is relatively light and will not be opposed by the dashpot action of core 76 if the passage 80 is open. Accordingly, the return movement will be substantially under the influence of gravity until pivot point 50 moves below a line extending through pivot recesses 58 and the fixed end of spring 68 at bracket 72, whereupon bridging contact will be rapidly moved to effect a snap-action closing of the breaker contacts by toggle spring 68.

In order to limit the number of operations of the circuit breaker in close succession upon the occurrence of a continuing overload on the circuit and to provide for manual operation, means are provided for holding the breaker contacts open in response to the occurrence of a predetermined number of closely succeeding circuit interrupting operations, which means can be manually actuated. This means comprises a toggle lever 104 pivoted at one end as at 106 on a U-shaped spring lever 108 which, in turn, is pivotally supported as at 110 between the legs of a U-shaped supporting bracket 111 secured to cover casting 6. The other end of toggle lever 104 is pivoted, as by a pivot pin 112, to the adjacent end of a second toggle lever 114, and this, in turn, is mounted on a pivot pin 116 intermediate its ends, with the pin 116 being mounted in a bracket 118 secured to the adjacent wall of cover casting 6. A slot 120 is provided through the cover casting 6 for receiving the other end of toggle lever 114 which acts as a manual operating handle at the exterior of the circuit breaker casing, being provided with an angled hook end 122. A coil compression spring 124 is mounted to react between the bight of lever 108 and cover casting 6. Normally, toggle levers 104 and 114 are held by spring 124 with pivot 112 below the center line connecting pins 106 and 116, with the outer end of lever 114 positioned in and beneath an integral hood 126 on cover casting 6, in engagement with an adjustable stop screw 128 mounted in the hood.

In the position of toggle levers 104 and 114 illustrated, they have no effect on operation of the circuit breaker, as previously described, being normally inactive in this respect. However, lever 108 has a transverse connecting pin 113 extending beneath toggle levers 52 and 54. Accordingly, if it is desired to manually open the circuit breaker contacts, a hook stick or similar operating member may be engaged with the upper side of angle hook 122 of toggle lever 114 and pulled downwardly to rotate the toggle lever in a counterclockwise direction about its supporting pivot 116 to move toggle levers 104 and 114 overcenter in an upward direction, and in doing this, pin 113 engages toggle levers 52 and 54, and moves them upwardly in a counterclockwise direction, thus carrying contact actuating rod 44 upwardly to separate bridging contact 36 from stationary contacts 26. The contacts will be held open by spring 124 which maintains toggle levers 104 and 114 in their upper overcenter position. In thus manually opening the circuit after toggle spring 68 is moved to its on-center position, it will be observed that the spring 124 is only required to maintain the contacts of the breaker open against the relatively light closing bias due to gravity, and such light bias as may be due to toggle spring 68 in the event that toggle levers 52 and 54 are stopped just prior to reaching their on-center position.

With the breaker contacts maintained at their open-circuit position following the manual circuit opening operation described above, it will be apparent that the outer end of toggle lever 114 will project below hood 126 of cover casting 6 so as to provide a readily visible indication that the breaker contacts are maintained at open circuit position. It will further be apparent that the breaker contacts may then be closed only by manual operation of toggle lever 114 in the opposite direction, that is, by exerting an upward force on the outer end of the toggle lever by engagement of a hook stick or the like with the underside of hook 122, to rotate lever 114 in a clockwise direction to move it and toggle lever 104 back overcenter to the position illustrated on the drawing. This manual operation of toggle lever 114 does not directly close the breaker contacts, but merely permits closure of the contacts in the manner previously described, that is, initial closing movement of the contacts being due to the bias of gravity and possibly some slight bias due to toggle spring 68, until bridging contact 36 is closely adjacent stationary contacts 26, when toggle spring 68 is moved below its on-center position and suddenly becomes effective to finally move the contacts into engagement rapidly. It will be observed that on manual opening of the circuit, the full force of spring 124 becomes effective to open the contacts as soon as levers 104 and 114 move overcenter, and actual opening of the contacts by spring 124 is independent of the operating hook stick. Similarly in manually resetting toggle levers 104 and 114 there is no possibility that withdrawal of the hook stick after resetting can disturb the position of the toggle levers because in resetting the hook stick engages only a lower edge surface of hook 122.

An integrating mechanism for automatically moving toggle levers 104 and 114 upwardly overcenter and thus preventing reclosure of the circuit breaker in response to a predetermined number of closely successive circuit interrupting operations is provided, comprising a cylindrical tube 130 clamped or otherwise secured in a lateral extension of casting 20 at the top of solenoid coil 24, and this tube has a plug 132 threaded into the lower end thereof with the plug having a small central opening controlled by a ball-check valve 134, which permits flow of fluid into the lower end of tube 130 but prevents out-flow. An integrating piston 136 is mounted in tube 130 and normally rests on the upper end of plug 132, being provided with a reduced extension 138 at the upper end thereof having a plurality of spaced circuit flanges 140 forming rack teeth thereon, and having an elongated extension 142 of insulating material on the extreme outer end thereof which is positioned below an extension 143 on toggle lever 104. A pawl lever 144 is pivotally mounted at one end as at 146, this end of pawl lever 144 being split, with legs located at each side of the tube 130 and with pivot 146 supported on spaced supporting flanges 145 integral with casting 20. Pawl lever 144 has a connecting web intermediate its ends, and at the other end thereof the sides of the lever are extended outwardly and laterally as at 148, to normally be in engagement with a washer 150 mounted on actuating tube 82 in engagement with shoulder 86 adjacent the outer end of this tube. Pawl lever 144 is normally biased into engagement with washer 150 by a coil tension spring 152 hooked over the remote edge of the web of the pawl lever at one end and anchored to an ear integral with casting 20 at its other end. Pawl lever 144 is provided with a pawl member 154 pivoted thereon as at 156, and biased by a spring 158 in a counterclockwise direction to a position wherein a portion of pawl member 154 engages the connecting web of pawl lever 144.

The tube 130 intersects the passage 80 of the dashpot and has lateral openings coinciding therewith, and the piston 136 acts as a valve to control venting of the passage. With the piston, as shown, the dashpot vents freely and operation of the breaker is rapid. When the piston 136 is moved upwardly by the pawl 154 it first partially, and then, subsequently, completely blocks the passage 80, so as to delay operation of the armature 76 slightly, at first, and then subsequently with an inverse time current characteristic.

While the invention has been illustrated in the present instance as utilizing an integrating mechanism of the type shown in the copending Wallace et al. application, Serial No. 719,524 hereinbefore referred to, it may also be used with one of the type shown in the copending Wallace application Serial No. 719,572, also hereinafter referred to, or with other types of counting mechanisms and lockout mechanisms.

To provide for locking the breaker closed after a predetermined number of operations, three, for example, in accordance with the specific form of this invention disclosed in Fig. 1, an arm **160** may be provided on the extension **142** for engaging a transverse pin **162** extending through aligned openings in the adjacent ends **164** of the crossarms **87** of lever **86**. Openings **165** may be provided in the other end of the crossarms **87** to receive the pin **162** when it is removed from its location **163** so as to have the breaker lock open after a predetermined number of operations.

When the circuit breaker operates to open the circuit, washer **150** will be carried upwardly with actuating sleeve **82** and bushing **85** and will thus carry the free end of pawl lever **144** upwardly with it to move pawl member **154** into engagement with the upper one of flanges **140** on integrating piston **136** to thus carry the piston upwardly a predetermined distance. When the breaker recloses following such a first circuit interrupting operation, integrating piston **136** is left at the position to which it was advanced, since pawl member **154** is free to disengage circular flanges **140**, and if the breaker remains closed, integrator piston **136** will slowly reset to the position shown in Fig. 1 due to leakage of liquid in cylinder **30** below piston **136** through the relatively small clearance between the cylinder and piston. However, if the breaker immediately reopens after a first opening and reclosing operation, piston **136** remains in its advanced position and pawl member **154** this time will engage the next lower circular flange **140** on the integrator piston and raise the piston a further amount. Subsequent reclosing will result then in leaving piston **136** at this further advanced position from which it eventually will reset if the breaker remains closed, and in which it effectively blocks the passage **80**. However, in the event of a continuing overload, the breaker will again open and reclose these operations now being delayed by the dashpot action of the armature core **76** in the sleeve **74**, and the pawl member **154** advances integrator piston **136** an amount sufficient to cause the arm **160** to engage the transverse pin **162** of the T-shaped knock-off link **92** when the breaker recloses, thereby rotating it in a clockwise direcion about pivot **48**. This removes the lower end of the stem **88** from the path of the bushing **85** so that the motion transmitting link **92** is ineffective to move the contact rod upward when the armature **76** is again actuated upwardly. The breaker thereupon remains locked closed, so as to insure blowing fuses in a faulty branch circuit to clear the system.

If it is desired to have the circuit breaker lock open, after a predetermined number of operations, instead of having it lock closed, the pin **162** is removed from the adjacent ends **164** of the crossarm **87** and is placed in openings **165**. The breaker thereupon opens and closes as hereinbefore described, except in that the knock off link **92** is not actuated by the arm **160**, but remains operative, as shown. The breaker thereupon continues to open, and the piston **136** advances until the extension **142** thereof engages the extension **143** of toggle lever **104** and moves this lever upwardly overcenter, so that toggle spring **124** will open the contacts if they have not already been opened by the armature **76**, and maintain them open, assist in opening them, or merely maintain them separated in the manner previously described, all depending on the particular adjustment of the integrator extension **142**. It is thus apparent that toggle levers **104** and **114** will be automatically moved upwardly overcenter to maintain the breaker contacts separated, only in response to a predetermined number of closely successive circuit opening and closing operations, usually four such operations. However, in the event a lesser number of closely successive opening and closing operations occurs, the integrating mechanism will reset and the breaker contacts will be automatically held open, only when the aforesaid predetermined number of opening and closing operations occurs in close succession at a later time. Obviously, after the breaker contacts have been automatically actuated to a position where they are held open by toggle spring **124**, they can be reclosed only by manual operation of toggle lever **114** in the manner previously described. As previously stated, the motion transmitting means has been described in the present instance as being of a releasable mechanical type, which, because of its simplicity and ease of manufacture, is particularly adaptable to the breaker construction disclosed. It will be realized that other types of transmitting means are equally within the concept of the invention, those of the fluid operated type being particularly advantageous with hydraulically operated mechanism and within the concept of the present invention.

A protective gap device **166** preferably of the expulsion type may be provided to prevent operation of the breaker on voltage surges, with the outer tube of the arrester mounted intermediate its ends on an extension **168** of supporting plate **22** at the underside of solenoid coil **24**, being secured thereto as by nuts **170** threaded on the arrester tube. One terminal **172** of the arrester may be connected with conductor **100** and one terminal of solenoid coil **24**, with the other terminal of the arrester (not shown) connected with the other terminal of coil **24** and conductor **102**. This arrester and its particular manner of mounting and connection with this type of apparatus is more particularly disclosed and claimed in Patent No. 2,550,124 on Overvoltage Protective Devices, filed August 30, 1946, and assigned to the same assignee of this invention. As stated above, the purpose of providing an arrester **166** connected in the manner described herein and in the aforesaid copending application is to provide a by-pass to protect solenoid coil **24** on voltage surges such, for example, as those due to lightning strokes, which are not overloads on the circuit and, consequently, it is not desired that the breaker open on such surges.

Referring to Fig. 2, it will be seen that instead of a T-shaped link **92**, another form of mechanical releasable motion transmitting connection may be employed which also has certain advantages in connection with the specific form of operating mechanism disclosed. This form of connection includes toggle means comprising a pair of links **173** and bell cranks levers **174** may be utilized for selectively locking the contacts of the breaker closed after a predetermined number of operations. For example, a collar **175** may be slidably disposed on the contact rod **44** having one end of each of the bell crank levers **174** pivotally connected thereto on opposite sides by a pivot **176**. Links **173** may be disposed on opposite sides of the rod **44** and pivotally mounted at one end to pivot **48** connecting rod **44** to links **46**, and connected at the other ends to levers **174** in toggle relation by a pivot **178**. A transverse pin **179** may be disposed in openings adjacent the projecting ends of the arm **180** of bell crank levers **174** for engagement by arm **160** of the integrating mechanism, so as to rotate the levers **174** clockwise about pivot **178**. The collar **175** may thereupon slide upwardly on the rod **44** so that engagement of the collar by the bushing **85** will no longer be effective to separate the contacts. The pin **179** may be disposed in openings **182** when it is not desired to lock the breaker closed. The extension **142** thereupon engages the extension **143** of the toggle lever **104** to trip the breaker and lock it open, as described hereinbefore. A

spring 183 biases the links 173 in a clockwise direction about pivot 48 against a stop 185 to normally maintain the toggle mechanism in motion transmitting relation. The manner of operation of this embodiment of the invention is substantially identical with that of the invention described in connection with Fig. 1 of the drawing.

From the foregoing, it is believed apparent that the structure disclosed herein provides in an automatic reclosing circuit breaker of the type having electrical means for causing opening of the breaker contacts and having the contacts biased to automatically reclose when the circuit is opened, means for releasably connecting the armature in motion transmitting relation with the contact rod. This means may selectively be rendered inoperative so that the breaker is locked closed or it may continue operative so that the integrating mechanism trips the breaker mechanism and locks it open.

With the particular motion transmitting means disclosed herein it is a relatively simple matter to set the breaker either for locking it closed after, for example, three operations, or locking it open after, for example, four operations. The removal of the transversee pin from the locked closed position to the locked open position, not only provides a convenient location for the pin, but also insures maintaining the motion transmitting means in the motion transmitting position so that it cannot be accidentally moved therefrom. Coordination with fuses or sectionalizing switches is thus easily attained.

My invention comprises the novel manner of actuating the contact rod by utilizing controllable motion transmitting means which is selectively operable to transmit motion for opening the contacts or not to, so as to leave them closed despite movement of the armature, whereas, certain other features disclosed herein are not my invention; the particular integrator structure including the pawl actuating means therefor comprising the invention of J. M. Wallace, A. W. Edwards, and J. Kraft being disclosed and claimed in their copending application Serial No. 719,524 (Case 24,719) filed concurrently herewith on Circuit Interrupters.

Having described a preferred embodiment of the invention in accordance with the patent statutes, it is desired that this invention be not limited to this particular construction inasmuch as it will be apparent, particularly to persons skilled in this art, that many modifications and changes may be made in this particular structure without departing from the broad spirit and scope of this invention. Accordingly, it is desired that the invention be interpreted as broadly as possible and that it be limited only as required by the prior art.

I claim as my invention:

1. An automatic reclosing circuit breaker comprising, separable contacts, an operating mechanism for said contacts, electroresponsive means movable in response to a predetermining value of overcurrent, motion transmitting means connected to the mechanism and normally positioned to be actuated by the electroresponsive means to normally transmit motion of the electroresponsive means to separate the contacts, time delay means operable to delay separation of said contacts, and cumulatively advanceable means operable in response to different predetermined numbers of contact separations to render the time delay means operable and the motion transmitting means inoperative to effect operation of the mechanism to separate said contacts in response to movement of said electroresponsive means.

2. In an automatic reclosing circuit breaker, separable contacts, electroresponsive means having a part movable in responsive to an overcurrent condition, releasable motion transmitting means normally connecting the electroresponsive means and the contacts for effecting separation of said contacts in response to movement of said movable part, dashpot means operable to delay separation of said contacts and means operable in response to different predetermined numbers of contact separations to variably vent the dashpot means and effect release of the releasable means whereby motion of said movable part is ineffective to effect separation of said contacts.

3. An automatic reclosing circuit breaker comprising, separable contacts, electroresponsive means having an armature movable relative to said contact means in response to an overcurrent condition, motion transmitting means operable to transmit motion of said armature to at least one of said contacts for effecting separation of said contacts, normally ineffective time delay means; and means operable in response to different predetermined contact separations for rendering the time delay means effective to delay separation of the contacts and the motion transmitting means ineffective to separate said contacts, while permitting motion of said armature.

4. In an automatic reclosing circuit breaker, separable contact means, an operating mechanism for said contact means electroresponsive means having an armature movable in response to a predetermined current condition, operating means normally adjustably positioned on the operating mechanism to be engaged by the armature disposed to provide an operating connection to effect separation of said contacts in response to movement of said armature, time delay means operable to delay separation of said contacts, and cumulatively advanceable counting means operable in response to different predetermined contact separations to render said time delay means operable and actuate said operating means to a different position in which it is ineffective to provide said operating connection.

5. A circuit interrupter comprising, separable contacts, electroresponsive means having an armature operable in response to a predetermined value of current, operating means normally conditioned to provide an operative connection between at least one of said contacts and the armature of said electroresponsive means for effecting separation of said contacts in response to operation of said electroresponsive means, dashpot means operable to delay movement of said armature, and means operable in response to different ones of closely successive separations of said contacts to delay the armature in different amounts and change the condition of said operating means to eliminate said operating connection following different predetermined numbers of closely successive operations of said electroresponsive means.

6. A circuit interrupter comprising, separable contacts, electroresponsive means having an armature movable in response to a predetermined value of current, means pivotally connected to at least one of said contacts for providing an operating connection between said one of said contacts and said electroresponsive means, time delay means for delaying opening movement of said one contact, and means responsive to different predetermined numbers of contact separations for varying the delay of the time delay means and pivoting said pivotally mounted means to render it ineffective.

7. A circuit interrupter comprising, separable contacts, a contact rod movable to effect separation of said contacts, electroresponsive means having an armature slidably disposed on the contact rod and movable in response to a predetermined value of current, motion transmitting means including a member pivotally mounted on the contact rod and having a portion normally operable to engage the armature and provide an operative connection between the armature and the contact rod for actuating said rod in response to movement of said armature, and counting means operable in response to a predetermined number of closely successive movements of said armature to effect rotation of said member on its pivot to make said motion transmitting means inoperative to effect movement of the contact rod, without preventing movement of the armature.

8. An automatic reclosing circuit breaker comprising, separable contacts, a contact rod actuable to effect separation of said contacts, electroresponsive means having

an armature movable in response to a predetermined value of current, a bell crank lever pivotally mounted on the contact rod and having a portion disposed in one position of the lever to be engaged by the armature to actuate the rod, and means operable in response to a predetermined number of closely successive separations of said contacts to actuate said bell crank lever to another position in which said portion is not effectively engaged by the armature.

9. In an automatic reclosing circuit breaker, separable contacts, a contact rod actuable to effect separation of said contacts, electroresponsive means having an armature actuated in response to a predetermined value of current, a toggle mechanism including a lever mounted on the contact rod and having a portion engaged by the armature to provide a motion transmitting connection between the armature and the rod, and counting means operable in response to a predetermined number of operations of said electroresponsive means to collapse said toggle mechanism and render it inoperative to provide a motion transmitting connection between the armature and contact rod.

10. An automatic reclosing circuit breaker comprising, separable contacts, a contact operating rod for effecting separation of said contacts, electroresponsive means having an armature actuated in response to a predetermined value of current, lockout means operable to actuate said rod to effect separation of said contacts and maintain them separated, counting means operable in response to a predetermined number of closely successive separations of said contacts to operate said lockout means, releasable motion transmitting means operatively connected between the armature and the contact rod to effect separation of said contacts, and means removably positionable in different positions on said releasable motion transmitting means to selectively provide a connection between the counting means and the releasable means and prevent or effect release of said motion transmitting means before the counting means effects operation of said lockout means.

11. An automatic reclosing circuit breaker comprising, separable contacts, a contact rod actuable to effect separation of said contacts, means biasing said contacts to reclose, a toggle mechanism operable to effect movement of said contact rod to separate said contacts and maintain them open, motion transmitting means including a lever pivotally supported on the contact rod for actuating said rod to separate said contacts, electroresponsive means including an armature actuable in response to a predetermined value of current for actuating the motion transmitting means to actuate the contact rod, and means including a counter responsive to closely successive contact separations and a member disposable in one position for selectively actuating the lever on the contact rod after a predetermined number of contact separations to prevent the armature from actuating the contact rod and disposable in another position to effect operation of the toggle mechanism on a subsequent contact separation.

12. A circuit interrupter comprising separable contacts, lockout means for locking said contacts in a separated position, electroresponsive means operable in response to a predetermined circuit condition, motion transmitting means including a lever normally disposed in a position to transmit motion of the electroresponsive means for effecting separation of said contacts, and movable from said position to prevent the electroresponsive means from effecting separation of the contacts, counting means operable in response to closely successive operations of the electroresponsive means, and a pin removably disposed on the lever in one position to be engaged by the counting means for rendering the motion transmitting means ineffective to effect separation of said contacts, said pin being movable to another position to prevent movement of the lever from said motion transmitting position so as to effect further operation of the electroresponsive means to condition the counting means to effect operation of the lockout means to lock the contacts in the open position.

13. A reclosing circuit breaker comprising, separable contacts, electroresponsive means having an armature movable in response to a predetermined value of current, motion transmitting means having a part movable to and away from a motion transmitting position in which it transmits motion from the armature to effect separation of the contacts, counting means operable to move said part away from said motion transmitting position in response to a predetermined number of operations of the electroresponsive means, and a removable member movable from one position to another to selectively determine whether said part is moved from the motion transmitting position by the counting means or not.

14. A reclosing circuit breaker comprising, separable contacts, electroresponsive means operable in response to a predetermined value of current, motion transmitting means including a part movable into and out of a motion transmitting position to selectively effect an operating connection between the contacts and the electroresponsive means, counting means operable to move said part away from said motion transmitting position in response to closely successive operations of the electroresponsive means, and a member removably disposable in one of two positions to determine whether or not said part is moved by the counting means.

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