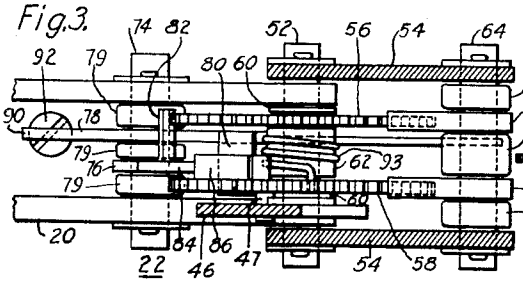
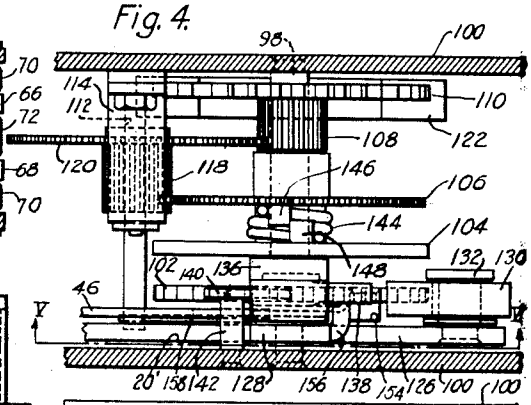
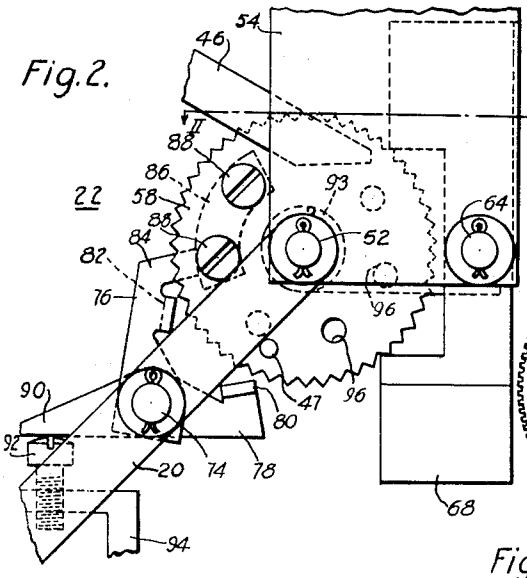
June 26, 1956 H. L. RAWLINS ET AL 2,752,452

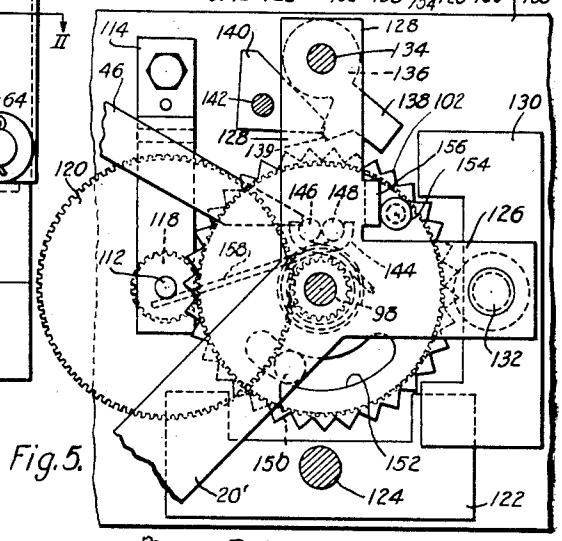
CIRCUIT INTERRUPTERS

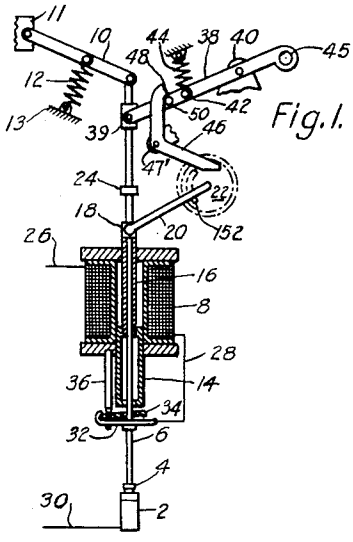
Filed Dec. 11, 1943

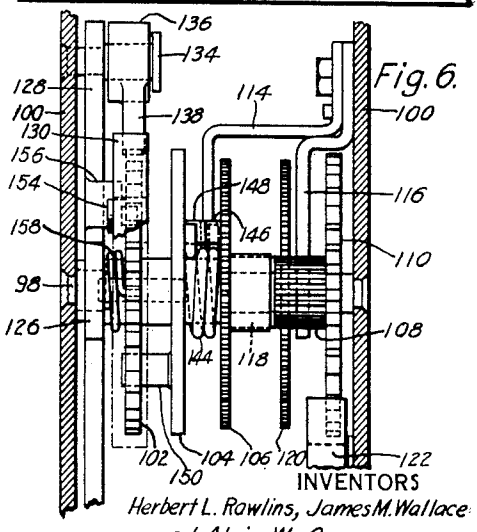












INVENTORS

Herbert L. Rawlins, James M. Wallace and Alvin W. Ogg

BY

Ralph W. Swingle

ATTORNEY

United States Patent Office 2,752,452 Patented June 26, 1956

2,752,452

CIRCUIT INTERRUPTERS

Herbert L. Rawlins, Pittsburgh, James M. Wallace, Braddock, and Alvin W. Ogg, Swissvale, Pa., assignors to Westinghouse Electric Corporation, East Pittsburgh, Pa., a corporation of Pennsylvania

Application December 11, 1943, Serial No. 513,860

31 Claims. (Cl. 200—89)

This invention relates generally to electric circuit interrupters, and more particularly to interrupters of the type which are capable of automatically reclosing the circuit after a circuit interrupting operation.

The invention is particularly disclosed herein as embodied in an automatic reclosing circuit breaker which is mounted in a relatively small casing so as to be adapted for mounting on a pole, cross-arm or the like, wherein this invention has certain novel features of cooperation; however, it should be understood that the invention may be used for other types of circuit interrupters as well.

In reclosing interrupters, it is necessary that an appropriate time delay be provided at least on certain selected circuit-interrupting operations, and preferably on each reclosing operation. Heretofore it has been a problem to obtain the proper time delay on these operations of a circuit interrupter, because it is desirable that the time delay be predetermined to enable proper coordination with other protective equipment. Another requirement of apparatus of this type is that the time delay on circuit opening operations be applied only to selected operations in any sequence of closely successive circuit interrupting operations; thus, it is often desirable that there be no time delay on the first interrupting operation and that the remaining interrupting operations of that sequence operate only with a time delay.

Circuit interrupters of this type are constructed to automatically interrupt the circuit a predetermined number of times in response to predetermined electrical conditions, and to then automatically remain open. This has introduced the added problem of providing suitable integrating means for counting successive operations of the breaker, which will automatically reset in the event said predetermined conditions clear up before the breaker has completed said predetermined number of closely successive circuit interruptions. This also means that the timing sequence of circuit interrupting operations must reset so that the same sequence will be obtained in response to the occurrence of said predetermined electrical conditions at a later time.

In view of the foregoing, one object of this invention is to provide novel means for obtaining predetermined time delay on both circuit-opening and circuit-closing operations of an interrupter of the type described.

Another object of this invention is to provide a novel arrangement of separate means for obtaining predetermined time delay on circuit-opening and closing operations of an automatic reclosing interrupter, wherein the time-delay means for the closing operation also integrates to control lock-out of the interrupter in response to a predetermined number of closely successive circuit interrupting operations.

Another object of this invention is to provide a novel arrangement of separate means for obtaining predetermined time delay on circuit-opening and closing operations of an automatic reclosing interrupter, wherein one of the time-delay means is operative only on selected operations in any sequence of closely successive operations of the interrupter.

Another object of this invention is to provide novel time-delay means for delaying operation of an interrupter of the type described, wherein the time delay means is operative only on selected operations in any sequence of closely successive operations of the interrupter.

Another object of this invention is to provide a novel arrangement of mechanical timing means for delaying both the circuit-opening and closing operations of an automatic reclosing circuit interrupter.

Another object of this invention is to provide in an automatic reclosing circuit breaker novel means providing different time characteristics for successive circuit-interrupting operations in any series of closely successive circuit-interrupting operations.

A more specific object of this invention is to provide an automatic reclosing circuit breaker with novel means for effecting a first substantially instantaneous circuit opening operation and a second time-delayed circuit opening operation in any series of closely successive circuit interrupting operations.

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

Figure 1 is a diagrammatic view of a circuit breaker embodying the invention;

Fig. 2 is an elevation of the timing mechanism;

Fig. 3 is a section view of the timing mechanism shown in Fig. 2 taken substantially on the line II—II of Fig. 2;

Fig. 4 is a view similar to Fig. 3 but illustrating a modified type of timing mechanism;

Fig. 5 is a section taken substantially on the line V—V of Fig. 4; and

Fig. 6 is a transverse section of the structure shown in Figs. 4 and 5, with the mechanism shown in elevation, and looking in a direction from the right of Fig. 5.

The particular circuit-breaker construction shown in Fig. 1 includes a relatively fixed contact **2** and a movable contact **4** mounted on a contact-operating rod **6**, which is mounted for longitudinal sliding movement. The contact rod **6** extends through a solenoid coil **8**, and is pivotally connected at its upper end with a reclosing lever **10** which, in turn, is pivoted on suitable supporting structure **11**. A reclosing tension spring **12** reacts between reclosing lever **10** and a suitable support **13** to bias the reclosing lever in a clockwise direction so as to bias movable contact **4** into engagement with fixed contact **2**. A generally cylindrical core **14**, which may be of any desired magnetic material, such as soft iron, is slidably mounted upon an intermediate portion of contact rod **6**, and is secured at its upper end to an actuating sleeve **16** also slidably mounted on contact rod **6**. The actuating sleeve **16** is provided at its upper end with a collar **18**, to which are pivoted a pair of actuating levers **20**, one on each side of collar **18**. The actuating levers **20** are for the purpose of actuating time-delay and integrating mechanism **22**, which will be hereinafter fully described. Contact rod **6** is provided with an integral stop collar **24** for limiting upward movement of actuating sleeve **16** on contact rod **6**.

Solenoid coil **8** in this particular type of circuit breaker, is connected in series in the circuit between terminal conductors **26** and **30**, by a flexible conductor **28** joining the solenoid coil and latch support **32** fixed on the contact rod. The circuit through the breaker thus proceeds from one terminal conductor **26** through solenoid coil **8**, conductor **28**, contract rod **6**, movable contact **4**, and fixed contact **2** to the other terminal conductor **30**. Preferably, actuating sleeve **16** is of a non-magnetic material, such as copper or brass, so that it will not be affected by energization of the coil.

Upon the passage of currents through solenoid coil 8 greater than a predetermined value, to energize the coil sufficiently to move core 14 upwardly, it will be observed that the core 14 will be moved upwardly without any movement of movable contact 4, but timing and integrating mechanism 22 will be actuated because of the movement of actuating levers 20 with sleeve 16. This upward movement of core 14 will continue until stop collar 24 on the contact rod 6 is engaged, whereupon movable contact rod 4 will be moved away from fixed contact 2 against the bias of reclosing spring 12. It will be observed that when the contacts have been separated to the full extent possible by solenoid core 14, they may still separate a further amount because of the lost motion between contact rod 6 and solenoid core 14. Such further contact separation may be obtained by the pressure developed by the arc struck upon initial separation of the contacts, as is disclosed in J. M. Wallace Patent No. 2,333,604, issued November 2, 1943, on Circuit Interrupters, and assigned to the same assignee as this invention.

In order to maintain the contacts separated the farthest distance apart which they attain during a circuit interrupting operation, a pivoted latch lever 34 is provided on latch support 32, and this is apertured to receive both contact rod 6 and a latch rod 36, which is suitably mounted, for example on the flange of solenoid 8. The arrangement is such that the aperture in latch plate 34 freely receives rod 36 during upward movement of contact rod 6 when the latch plate is in a substantially horizontal position. However, upon downward movement of the contact rod, the aperture in latch plate 34 for rod 36 will bind against opposite sides of the rod and prevent downward movement of the contact rod until the latch is released by movement of the outer end of latch plate 34 downwardly. Preferably, a light coil spring is provided for latch plate 34 to continually bias it upwardly. For a more detailed description of this type of latch, reference is hereby made to the above-mentioned Wallace patent. Accordingly, after a circuit-interrupting operation, the reclosing spring will be inoperative to reclose the contacts because of latch plate 34. However, solenoid core 14 will slowly descend at a rate governed by timing mechanism 22, until it finally engages latch plate 34 to release the latch and permit the contact 4 to move downwardly at the same rate as the solenoid core. It will be noted that the lower end of rod 36 is reduced in section so that latch plate 34 will be ineffective to hold contact 4, for a short distance prior to engagement with contact 2. This provides for a fast final movement of contact 4 into engagement with contact 2, to preclude or at least minimize the effects of arcing during the reclosing operation.

In the event an overload or short circuit appears on the circuit which does not clear, it is undesirable that the breaker should continue opening and closing the circuit indefinitely, and since most self-clearing faults will have cleared after the second reclosing operation of a breaker of this type, means are provided for maintaining the breaker contacts separated after a predetermined number of closely successive circuit interrupting operations, for example, after three such operations. To this end, a lockout and resetting lever 38 is pivotally mounted on a suitable support 40, and is pivoted to a collar 39 slidably mounted on contact rod 6 adjacent the upper end thereof. The lever 38 is biased for movement in a clockwise direction by a tension spring 44, engageable with a pin 42 on the lever. Lever 38, however, is normally held against movement under the influence of spring 44 by a bell-crank latch lever 46 pivotally mounted on a fixed support, as at 47', and having a latching end 48 engageable over a pin 50 provided on lockout lever 38. Latch lever 46 has the other arm extending into proximity with mechanism 22, so as to be released by

the mechanism in response to a predetermined number of closely successive circuit-interrupting operations, in a manner to be hereinafter more fully described. It will be apparent that upon counterclockwise rotation of lever 46, lockout lever 38 will be released and moved in a clockwise direction to separate contact 4 from contact 2, and thus maintain the breaker in an open circuit position. In order to lock out the breaker in this manner, spring 44 must be considerably stronger than reclosing spring 12. It will be noted that lockout lever 38 is provided with a hookeye 45 at the outer end thereof for engagement by a hook stick, or other operating means, to reclose the breaker manually.

The mechanism 22 is more particularly shown in Figs. 2 and 3, wherein it will be observed that actuating levers 20 for the mechanism are pivotally mounted on a shaft 52, which extends between, and is mounted in spaced supporting plates 54. Between actuating levers 20 and supporting plates 54, there is also rotatably mounted on shaft 52 a pair of ratchet wheels 56 and 58. Washers 60 are provided for spacing the ratchet wheels from actuating levers 20, and a spacer sleeve 62 is provided intermediate the ratchet wheels for spacing them from each other. A second shaft 64 extends between and is mounted in supporting plates 54 at one side of shaft 52, for the purpose of pivotally supporting a pair of inertia escapement members 66 and 68. The escapement members are spaced from supporting plates 54 by spacer collars 70, and are spaced from each other by a spacer sleeve 72 mounted between them.

A shaft 74 extends between and is mounted in actuating levers 20 at a point adjacent the ratchet wheels, and this shaft supports a pair of pawl levers 76 and 78. The pawl levers are spaced from actuating levers 20 and from each other by interposed spacer disks 79 mounted on the shaft 74. Pawl lever 78 is mounted adjacent ratchet wheel 56, and is provided with a laterally extending pawl portion 80 extending into proximity with ratchet wheel 58, so as to be engageable therewith under certain conditions, to be described. Pawl lever 76 is mounted adjacent ratchet wheel 58 but is provided with a laterally extending pawl portion 82 which extends into proximity with ratchet wheel 56 for cooperation therewith. Pawl lever 76 is also provided with an angularly extending nose portion 84 which, in the position of the parts illustrated, is adapted to engage a cam block 86 mounted on the inner face of ratchet wheel 58, for example, as by a pair of screws 88. Pawl lever 78 is provided with a tail portion 90, adapted in the position of the parts illustrated, to engage an adjustable stop screw 92 which is mounted in a suitable support 94. A return spring 93 is coiled about shaft 52 and reacts between spacer 72 and ratchet wheel 58, to maintain the ratchet wheel in the position shown with stop pin 47 on the wheel in engagement with actuating lever 20.

In the operation of the mechanism described above, actuating levers 20 will be rotated in a clockwise direction about shaft 52 during a circuit opening operation of the breaker shown in Fig. 1, and during this movement of the actuating levers, ratchet wheel 56 will not be moved because pawl portion 82 is maintained out of engagement therewith by the engagement of nose 84 with cam block 86 on ratchet wheel 58. However, upon reclosing of the circuit breaker, actuating levers 20 will rotate in the opposite direction back to the full line position shown on the drawings, and during this movement pawl portion 80 of lever 78 will engage ratchet wheel 58, so that the reclosing movement of the circuit breaker will be delayed by inertia escapement member 68. This counterclockwise rotation of ratchet wheel 58 will move it to a position wherein cam block 86 no longer engages nose 84 of pawl lever 76. However, the counterclockwise advancement of ratchet wheel 58, during reclosing of the circuit breaker, has stressed coil

spring 93, so that if the breaker remains closed ratchet wheel 58 will be slowly returned to its original position by coil spring 93. However, if the overload or short circuit has not cleared upon the first reclosure of the circuit breaker, it will immediately reopen and this time pawl portion 82 of lever 76 will engage ratchet wheel 56, and the second opening operation of the breaker will be delayed by escapement member 66. Upon the subsequent reclosing operation of the breaker, ratchet wheel 58 not having had time enough to return to its original position, will be advanced a further amount. After the second reclosure of the circuit breaker, ratchet wheel 58 may reset if the overload or short circuit has cleared, in the same manner as after the first reclosure. However, if the overload or short circuit has not cleared upon the second closely successive circuit closing operation, the breaker will again reopen and again the opening operation will be delayed by escapement member 66, because pawl portion 82 is again permitted to engage ratchet wheel 56. Upon the occurrence of overloads or short circuits which are not self-clearing, the circuit breaker will continue to open and reclose in the manner described above for the second opening and reclosing operation until ratchet wheel 58 is advanced in a counterclockwise direction sufficiently to cause engagement of stop pin 47 with lockout latch lever 46, to release the latch lever and permit tension spring 44 to hold the breaker contacts open, against the bias of reclosing spring 12.

It will be observed that with the mechanism illustrated in Figs. 2 and 3, the first circuit interrupting operation will always be substantially instantaneous in character because escapement member 66 has no delaying action since pawl portion 82 cannot engage ratchet wheel 56. However, on any closely succeeding circuit interrupting operations, separation of the contacts will be delayed a time predetermined by the characteristics of escapement member 66. It will also be noted that an entirely separate escapement member 68 is provided for delaying each circuit reclosing operation, and that this member also determines whether or not ratchet wheel 56 and escapement member 66 will be effective to delay a circuit-interrupting operation, in accordance with the position of ratchet wheel 58. The ratchet wheel 58 for delaying the reclosing operation is biased to reset, so that the particular circuit interrupting operations in any sequence of closely successive circuit interrupting operations which are to be delayed, will always be the same in any such series of closely successive interrupting operations. The time delay ratchet wheel 58 for the reclosing operation thus integrates or counts the number of closely successive circuit interrupting operations, so that after a predetermined number of such operations, it is effective to cause the operation of lockout means for maintaining the breaker contacts separated. It should be noted that pairs of apertures 96 are provided about ratchet wheel 58, so that an additional cam block 86 may be mounted thereon for preventing the operation of the circuit-interrupting time delay means, or the position of cam block 86 may be changed, so that instantaneous circuit interrupting operation will be provided at other than the first interrupting operation of any series of closely successive interrupting operations. With the arrangement illustrated, the first circuit-interrupting operation will occur instantaneously, and the remaining closely successive interrupting operations will be delayed by escapement member 66. By merely changing the location of cam block 86, any other circuit-interrupting operation in any series of closely successive interrupting operations may be made instantaneous in character, or by adding one or more cam blocks, any desired circuit-interrupting operation in any series may be made instantaneous in character, with the remaining operation being delayed by escapement member 66.

In Figs. 4 to 6, a modified form of mechanism is

illustrated, wherein an actuating lever 20' is pivotally mounted on a shaft 98 extending between and supported by a pair of spaced supporting plates 100. Referring to Fig. 4, shaft 98 also has rotatably mounted thereon a ratchet wheel 102, a drive disk 104, a gear 106, a pinion 108, and an escapement wheel 110 integral with pinion 108. A second shaft 112 is supported from one supporting plate 100 as by brackets 114 and 116, and this shaft rotatably supports a gear 120 having an integral pinion 118. Pinion 118 is positioned to mesh with gear 106 on shaft 98, and gear 120 is positioned to mesh with pinion 108. This gear train forms, in effect, a movement multiplying gear drive between gear 106 and escapement wheel 110. An inertia escapement member 122 is pivotally supported on a supporting plate 100 as by a pivot 124, for controlling the rate of movement of escapement wheel 110.

Actuating lever 20' is provided at the outer end thereof with a pair of divergent arms 126 and 128, which form, in effect, a Y with lever 20' adjacent the timing mechanism. Supporting arm 126 carries an inertia escapement member 130 pivotally mounted thereon as at 132. Escapement member 130 is positioned to cooperate with ratchet wheel 102 to govern the rate of movement thereof. The other supporting arm 128 has a pivot pin 134 at the outer end thereof, for pivotally supporting the bearing portion 136 of latch 138. Latch 138 is provided with a nose 139 for a purpose to be hereinafter described. A generally triangular shaped latched member 140 is pivotally mounted as at 142, on a supporting plate 100, and the function of this latch will also be hereinafter described in detail. A coil spring 144, positioned between disk 104 and gear 106 forms the drive connection between the disk and gear by virtue of having the ends of the spring laterally bent to engage one side of a lug 148 integral with disk 104, and the opposite side of a lug 146 integral with gear 106. Actuating disk 104 has an actuating pin 150 projecting laterally from one side thereof towards ratchet wheel 102, so as to be received in an annular slot 152 provided in the ratchet wheel. Ratchet wheel 102 has a stop pin 154 projecting from the side thereof adjacent atcuating lever 20', and in the normal position of the parts is adapted to engage a laterally projecting integral extension 156 on supporting arm 128 of the actuating lever to determine the normal position of ratchet wheel 102. A return spring 158 is provided about shaft 98, between actuating lever 20' and ratchet wheel 102, and reacting between the ratchet wheel and shaft 112 to normally maintain the ratchet wheel stop pin 154 in engagement with extension 156, and to return the ratchet wheel to this position after it has been advanced in a clockwise direction.

Upon a circuit-interrupting operation, actuating lever 20' will be rotated in a clockwise direction, and this will permit pawl latch 138 to engage ratchet wheel 102 and rotate it in a clockwise direction with the actuating lever. This will not have any delaying action on the first circuit-interrupting operation, because escapement member 130 for wheel 102 is moved with the wheel, and ratchet wheel 110 is not moved because drive pin 150 remains stationary because of slot 152. Upon reclosure of the circuit breaker and consequent counterclockwise movement of the actuating lever 20', latch 140 engages ratchet wheel 102 preventing counterclockwise movement of the wheel, so that escapement member 130 working along the ratchet wheel will delay this movement of actuating lever 20'. It will be observed that when the actuating lever returns to the position shown in Fig. 5, bearing part 136 engages latch 140 to release ratchet wheel 102, and permit the wheel to be returned to its original position by return spring 158. Release of latch 140 by counterclockwise movement thereof, also releases pawl latch 138, by engagement of lever 140 with nose 139 of pawl lever 138. Accordingly, the ratchet wheel 102 after a first circuit interrupting and subsequent reclosing operation will reset slowly to the position shown in Fig. 5 if the overload or

short circuit which caused the first interruption clears upon reclosure, its rate of movement being governed by escapement member 130. However, if the fault does not clear, the breaker will immediately reopen before ratchet wheel 102 has time to reset, and this time drive pin 150, being adjacent the right-hand end of slot 152, as viewed in Fig. 5, will be dragged along in a clockwise direction with ratchet wheel 102 to thereby drive the gear train through spring 144 and cause rotation of escapement wheel 110 and consequent delay of the second circuit opening operation by escapement member 122. Upon a second reclosure of the circuit, ratchet wheel 102 is again held by latch 140 at its further advanced position, while escapement member 130 delays this second reclosing operation. At the end of this operation, latch 140 and pawl lever 138 are again released to permit resetting of ratchet wheel 102, in the event the fault has cleared. However, if the fault has not cleared, the circuit breaker will continue to open and reclose the circuit with each opening and reclosing operation being delayed in the same manner as for the second opening and reclosing operations. For sustained faults, this will continue until stop pin 154 on ratchet wheel 102 is advanced into engagement with lockout latch 46 to cause release of this latch and consequently free spring 44 for operation to maintain the circuit-breaker contacts separated.

Pretensioned drive spring 144 permits the breaker to open faster than would normally be permitted by escapement member 122 on extremely high current faults, when a very large force is exerted by solenoid 8. On such high current faults the ends of the spring may be separated allowing quicker opening on operations which would normally be delayed by escapement member 122. This is of advantage in that it is often desirable to permit fast opening of the breaker on heavy current faults. It should be noted that this will not affect the integrating of ratchet wheel 102 because during the reclosing operation wheel 102 is held by latch 140, at the position to which it has been advanced, long enough to permit spring 144 to move pin 146 back adjacent pin 154 so that spring 144 cannot have any effect on the rate of return of wheel 102.

From the foregoing, it will be apparent that this invention, by the provision of separate time-delay escapement members for the opening and reclosing operations of a circuit breaker, respectively, permits widely different timing periods for these two operations of the breaker. In fact, nearly any desired time may be obtained merely by employing an escapement member of the proper mass. The time delay in either the circuit interrupting or reclosing operations may be varied without affecting the time of the other operation merely by varying the mass of the inertia member controlling the time of that particular operation. In the particular embodiments of the invention disclosed, the arrangements are such that a constant time delay is provided on each reclosing operation of the breaker, whereas the first interrupting operation in any series of closely successive circuit interrupting operations is instantaneous in character, and the next closely succeeding interrupting operations occur only after a predetermined time delay. However, this may be varied with the structure disclosed in Figs. 2 and 3, by varying the number or positions of cam block 86. In each embodiment of the invention disclosed, one of the time-delay means forms an integrator or counting device for causing lockout of the breaker in response to a predetermined number of closely successive circuit-interrupting operations. In the event of a number of closely successive circuit-interrupting operations less than this predetermined number, the device resets so that in the event of a fault occurring at a later time the same predetermined number of closing successive circuit-interrupting operations must occur prior to lockout. Moreover, this resetting of the counting means also resets the timing mechanism, so that in any series of closely successive circuit interrupting operations, the time characteristics of the

circuit-opening operations will be the same, and the instantaneous and timed openings will occur in the same sequence. This is accomplished in the modification of the invention shown in Figs. 2 and 3, by having the connection of the time delay means for the interrupting operation controlled by the position of integrating ratchet wheel 58, and in the embodiment of invention shown in Figs. 4 to 6, by having a lost motion drive connection between the integrating ratchet wheel, and the timing means for circuit-opening operations.

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

We claim as our invention:

1. In an automatic reclosing circuit interrupter, separable contacts, a movable contact actuating member having lost motion relative to said contacts, means responsive to a predetermined electrical condition of the circuit for moving said member in a direction to separate said contacts to interrupt the circuit, means responsive to a circuit interrupting operation for automatically moving said member in an opposite direction to reclose said contacts, and separate time-delay means one of which has means to automatically mechanically connect it with said member in response to movement of said member in only one direction, and the other of which has means to automatically mechanically connect it with said member in response only to movement of said member in the opposite direction, so that the respective time delay means retard movement of said member in said respective opposite directions.

2. In an automatic reclosing circuit interrupter, separable contacts, a movable contact actuating member, means responsive to a predetermined electrical condition of the circuit for moving said member in a direction to separate said contacts to interrupt the circuit, means responsive to a circuit interrrupting operation for automatically moving said member in an opposite direction to reclose said contacts, separate time-delay means which are independent of any electrical condition of the circuit for opposing movement of said member in said opposite directions, respectively, and means for rendering one of said time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, of any series of closely successive cycles of operation.

3. In an automatic reclosing circuit interrupter, separable contacts, a movable contact actuating member, means responsive to a predetermined electrical condition of the circuit for moving said member in a direction to separate said contacts to interrupt the circuit, means responsive to a circuit interrupting operation for automatically moving said member in an opposite direction to reclose said contacts, separate time-delay means which are independent of any electrical condition of the circuit for opposing movement of said member in said opposite directions, respectively, and means for rendering the time-delay means delaying interrupting operations ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, of any series of closely successive cycles of operation.

4. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said con-

tacts, separate time delay means for delaying said interrupting and reclosing operations, respectively, means for rendering one of said time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, of any series of closely successive cycles of operation, and said means for rendering said one time delay means ineffective being adjustable so that it may be adjusted to render said one time delay means ineffective for any selected cycle of operation in any such series of closely successive cycles of operation.

5. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, separate time delay means for delaying said interrupting and reclosing operations, respectively, means for rendering the time delay means delaying interrupting operations ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, of any series of closely successive cycles of operation, and said means for rendering said one time delay means ineffective being so adjustable so that it may be adjusted to render said one time delay means ineffective for any selected cycle of operation in any such series of cycles of operation.

6. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means for delaying one of said operations of the interrupter, means for rendering said time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, of any series of closely successive cycles of operation, and said means for rendering said time delay means ineffective being adjustable so that it may be adjusted to render said time delay means ineffective for any selected cycle of operation in any such series of cycles of operation.

7. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means for delaying the interrupting operation of the interrupter, means for rendering said time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation, and said means for rendering said time delay means ineffective being adjustable so that it may be adjusted to render said time delay means either effective or ineffective for one or more interrupting operations in any such series of cycles of operation.

8. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts but having lost motion with respect to said contacts, and separate time delay means connected with said member by separate oppositely disposed one-way drive connections so that said time delay means are respectively effective upon movement of said member in opposite directions to delay said interrupting and reclosing operations, respectively.

9. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, separate time delay means connected with said member by separate oppositely arranged one-way drive connections so that said time delay means are, respectively, effective upon movement of said member in opposite directions to delay said interrupting and reclosing operations, respectively, and means responsive to a predetermined cycle of operation comprising an interrupting operation and subsequent reclosing operation for rendering one of said drive connections ineffective during a closely succeeding cycle of operation.

10. In an automatic reclosing circuit interrupter separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts but having lost motion with respect to said contacts, and a pair of escapement devices having oppositely disposed pawl and ratchet connections with said member for delaying said interrupting and reclosing operations, respectively.

11. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of escapement devices having pawl and ratchet connections with said members for delaying said interrupting and reclosing operations, respectively, and means for preventing engagement of one of said pawl and ratchet connections during a predetermined one of any series of closely successive cycles of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation.

12. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of escapement means each comprising a ratchet wheel and escapement controlling movement of the wheel, a pair of pawl means carried by said member for driving said wheels in response to movement of said member in said opposite directions, respectively, whereby each of said wheels is advanced a predetermined amount during a complete cycle of operation of said interrupter comprising an interrupting and succeeding reclosing operation, to thereby delay both the interrupting and reclosing operations, one of said wheels having a normal position at which its pawl means is disengaged, means biasing said one wheel to its normal position so that after advancement said wheel will be slowly reset to its normal position, and means governed by the position of said one wheel for determining whether the other pawl means will or will not be permitted to drive the other wheel, whereby said other wheel is rendered ineffective during at least one predetermined cycle of operation of any series of closely successive cycles of operation of said interrupter.

13. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of escapement means each comprising a ratchet wheel and escapement controlling movement of the wheel, a pair of pawl means

carried by said member for driving said wheels in response to movement of said member in said opposite directions, respectively, whereby each of said wheels is advanced a predetermined amount during a complete cycle of operation of said interrupter comprising an interrupting and succeeding reclosing operation, to thereby delay both the interrupting and reclosing operations, said reclosure delay wheel having a normal position at which its pawl means is disengaged, means biasing said reclosure delay wheel to its normal position so that after advancement said wheel will be slowly reset to its normal position, and means governed by the position of said reclosure delay wheel for determining whether the other pawl means will or will not be permitted to drive the interruption delay wheel, whereby said interruption delay wheel is rendered ineffective during at least one predetermined cycle of operation of any series of closely successive cycles of operation of said interrupter.

14. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of escapement means each comprising a ratchet wheel and escapement controlling movement of the wheel, a pair of pawl means carried by said member for driving said wheels in response to movement of said member in said opposite directions, respectively, whereby each of said wheels is advanced a predetermined amount during a complete cycle of operation of said interrupter comprising an interrupting and succeeding reclosing operation, to thereby delay both the interrupting and reclosing operations, said reclosure delay wheel having a normal position at which its pawl means is disengaged, means biasing said reclosure delay wheel to its normal position so that after advancement said wheel will be slowly reset to its normal position, means governed by the position of said reclosure delay wheel for determining whether the other pawl means will or will not be permitted to drive the interruption delay wheel, whereby said interruption delay wheel is rendered ineffective during at least one predetermined cycle of operation of any series of closely successive cycles of operation of said interrupter, and means adapted to be actuated by said reclosure delay wheel in response to a predetermined number of closely successive circuit interrupting operations to prevent reclosure of said contacts.

15. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of escapement means each comprising a ratchet wheel and escapement controlling movement of the wheel, a pair of pawl means carried by said member for driving said wheels in response to movement of said member in said opposite directions, respectively, whereby each of said wheels is advanced a predetermined amount during a complete cycle of operation of said interrupter comprising an interrupting and succeeding reclosing operation, to thereby delay both the interrupting and reclosing operations, one of said wheels having a normal position at which its pawl means is disengaged, means biasing said one wheel to its normal position so that after advancement said wheel will be slowly reset to its normal position, and cam means on said one wheel for disengaging the other pawl means from the other wheel at least at one position of said one wheel, whereby said other wheel is rendered ineffective during at last one predetermined cycle of operation of any series of closely successive cycles of operation of said interrupter.

16. In an automatic reclosing circuit interrupter, separable contacts, a movable contact actuating member, means responsive to a predetermined electrical condition of the circuit for moving said member in a direction to separate said contacts to interrupt the circuit, means responsive to a circuit interrupting operation for automatically moving said member in an opposite direction to reclose said contacts, separate time delay means which are independent of any electrical condition of the circuit for opposing movement of said member in said opposite directions, respectively, and means governed by the position of one of said time delay means for rendering the other of said time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation.

17. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, separate time delay means which are independent of any electrical condition of the circuit for delaying said interrupting and reclosing operations, respectively, one of said time delay means including a time delay member which is advanced from a normal position a predetermined amount during each cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, means biasing said member to slowly return to its normal position, and means governed by the position of said time delay member for rendering said other time delay means ineffective to perform any delaying action during at least one cycle of operation of said interrupter of any series of closely successive cycles of operation.

18. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, a pair of time delay devices for delaying said interrupting and reclosing operations, respectively, means mechanically connecting said time delay devices in series with said member including a lost motion connection between said devices, whereby one of said devices is ineffective to exert delaying action during a first cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation.

19. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, a member movable in opposite directions in response to separation and reclosure of said contacts, and a pair of time delay devices for delaying said interrupting and reclosing operations, respectively, means mechanically connecting said time delay devices in series with said member including a lost motion connection between said devices, whereby one of said devices is ineffective to exert delaying action during a first cycle of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation, and means biasing the other time delay device to slowly return to a normal position after a delaying operation so that said one device will be ineffective during the first cycle of operation of each series of closely successive cycles of operation of said interrupter.

20. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit

interruption for automatically reclosing said contacts, time delay means for delaying the interrupting operation of the interrupter, means for selectively rendering said time delay means ineffective to perform any delaying action during any predetermined one or more cycles of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation.

21. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means for delaying the interrupting operation of the interrupter, removable means adapted when mounted in operative position to render said time delay means ineffective to perform any delaying action during any predetermined one or more cycles of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation.

22. In an automatic reclosing circuit interrupter, separable contacts, means having a part which is moved in response to a predetermined electrical condition of the circuit for causing separation of said contacts to interrupt the circuit, said part being movable a predetermined amount in response to the occurrence of said condition before said contacts are caused to separate, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means having a portion adapted to be actuated by said part for delaying the rate of the aforesaid predetermined movement of said part to delay an interrupting operation of the interrupter, integrating means biased to a normal position and adapted to be advanced a predetermined amount during each cycle of operation of said interrupter comprising a circuit interrupting and succeeding closing operations, said integrating means having means to retard its return to normal position under the influence of its bias, and means controlled by the position of said integrating means for rendering said time delay means ineffective during any predetermined one or more cycles of operation of said interrupter in any series of closely successive cycles of operation.

23. In an automatic reclosing circuit interrupter, separable contacts, means having a part which is moved in response to a predetermined electrical condition of the circuit for causing separation of said contacts to interrupt the circuit, said part being movable a predetermined amount in response to the occurrence of said condition before said contacts are caused to separate, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means having a portion adapted to be actuated by said part for delaying the rate of the aforesaid predetermined movement of said part to delay an interrupting operation of the interrupter, integrating means biased to a normal position and adapted to be advanced a predetermined amount during each cycle of operation of said interrupter comprising a circuit interrupting and succeeding closing operations, said integrating means having means to retard its return to normal position under the influence of its bias, means controlled by the position of said integrating means for rendering said time delay means ineffective during any predetermined one or more cycles of operation of said interrupter in any series of closely successive cycles of operation, and means responsive to advancement of said integrating means an amount greater than said predetermined amount to prevent reclosing of said interrupter.

24. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, means for normally delaying only predetermined circuit opening operations of said interrupter after the first circuit interrupting operation in any series of closely successive circuit interrupting operations, means responsive to a predetermined number of closely successive circuit interrupting operations to prevent reclosing of said contacts, and means responsive to operation of said reclosure-preventing means to temporarily render said delay means effective to delay a first circuit interrupting operation when said contacts are reset in closed circuit position.

25. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, means for normally delaying only predetermined circuit opening operations of said interrupter after the first circuit interrupting operation in any series of closely successive circuit interrupting operations, means responsive to a predetermined number of closely successive circuit interrupting operations to prevent reclosing of said contacts, manually operable means for effecting reclosure of said contacts following operation of said reclosure-preventing means, and means responsive to operation of said reclosure-preventing means to temporarily render said delay means effective to delay a first circuit interrupting operation when said contacts are manually reset to closed circuit position.

26. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means for delaying the interrupting operation of the interrupter, integrating means biased to a normal position and adapted to be advanced a predetermined amount during each cycle of operation of said interrupter comprising a circuit interrupting and succeeding closing operations, said integrating means having means to retard its return to normal position under the influence of its bias, means controlled by the position of said integrating means for rendering said time delay means ineffective during any predetermined one or more cycles of operation of said interrupter in any series of closely successive cycles of operation, means responsive to a predetermined number of closely successive circuit interrupting operations to prevent reclosing of said contacts, and means responsive to operation of said reclosure-preventing means for preventing return of said integrating means until said contacts are reclosed.

27. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means, means responsive to a predetermined cycle of operation of said interrupter comprising a circuit opening and succeeding closing operations for rendering said time delay means effective to delay the next succeeding circuit opening operation in any series of closely successive cycles of operation, and said means being adjustable to render said time delay means effective to delay the circuit opening operation in other cycles of operation in any such series.

28. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts, time delay means, removable means adapted when mounted in operative position to be responsive to a predetermined cycle of operation of said interrupter comprising a circuit opening and succeeding closing operations for rendering said time delay means effective to delay the next succeeding circuit opening operation in any series of closely successive cycles of operation.

29. In an automatic reclosing circuit interrupter, separable contacts, means having a part which is moved in response to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, said part being movable a predetermined amount in response to the occurrence of said condition before said contacts are caused to separate, means responsive to a circuit interruption for automatically reclosing said contacts, integrating means biased to a normal position and adapted to be advanced a predetermined amount during each cycle of operation of said interrupter comprising a circuit interrupting and succeeding closing operations, said integrating means having means to retard its return to normal position under the influence of its bias, time delay means having a portion adapted to be actuated by said part for delaying the rate of movement of said part in opposite directions, and means controlled by the position of said integrating means for rendering said time delay means effective during only certain cycles of operation in any series of closely successive cycles of operation.

30. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts a plurality of times if the predetermined electrical condition persists after the contacts are reclosed, time delay means for delaying the interrupting operation of the interrupter, means for selectively rendering said time delay means either effective or ineffective to delay the interrupting operation during one or more cycles of operation of said interrupter comprising an interrrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation, and said time delay means being effective to delay at least one interrupting operation in a cycle following the cycle in which the interrupting operation is not delayed when said selective means is set to render said time delay means ineffective during one or more cycles.

31. In an automatic reclosing circuit interrupter, separable contacts, means responsive to a predetermined electrical condition of the circuit for separating said contacts to interrupt the circuit, means responsive to a circuit interruption for automatically reclosing said contacts a plurality of times if the predetermined electrical condition persists after the contacts are reclosed, time delay means for delaying the interrupting operation of the interrupter, means for selectively rendering said time delay means either effective or ineffective to delay the interrupting operation during one or more cycles of operation of said interrupter comprising an interrupting operation and subsequent reclosing operation of any series of closely successive cycles of operation, and said time delay means being effective to delay at least one interrupting operation in a cycle following the cycle in which the interrupting operation is not delayed when said selective means is set to render said time delay means ineffective during one or more cycles, and integrating and lockout mechanism for counting the number of said cycles in any closely successive series and maintaining the contacts open without automatic reclosure after a predetermined number of cycles in a closely successive series.

References Cited in the file of this patent

UNITED STATES PATENTS

1,123,288	Hellmund	Jan. 5, 1915
1,648,508	Schweitzer	Nov. 8, 1927
1,868,256	Rippl	July 19, 1932
2,069,082	Walle	Jan. 26, 1937
2,311,714	Thompson et al.	Feb. 23, 1943
2,560,529	Van Ryan et al.	July 10, 1951