March 31, 1953 E. T. McCURRY ET AL 2,633,514

CIRCUIT RESTORER

Filed April 6, 1948 2 SHEETS—SHEET 1

Fig. 1.

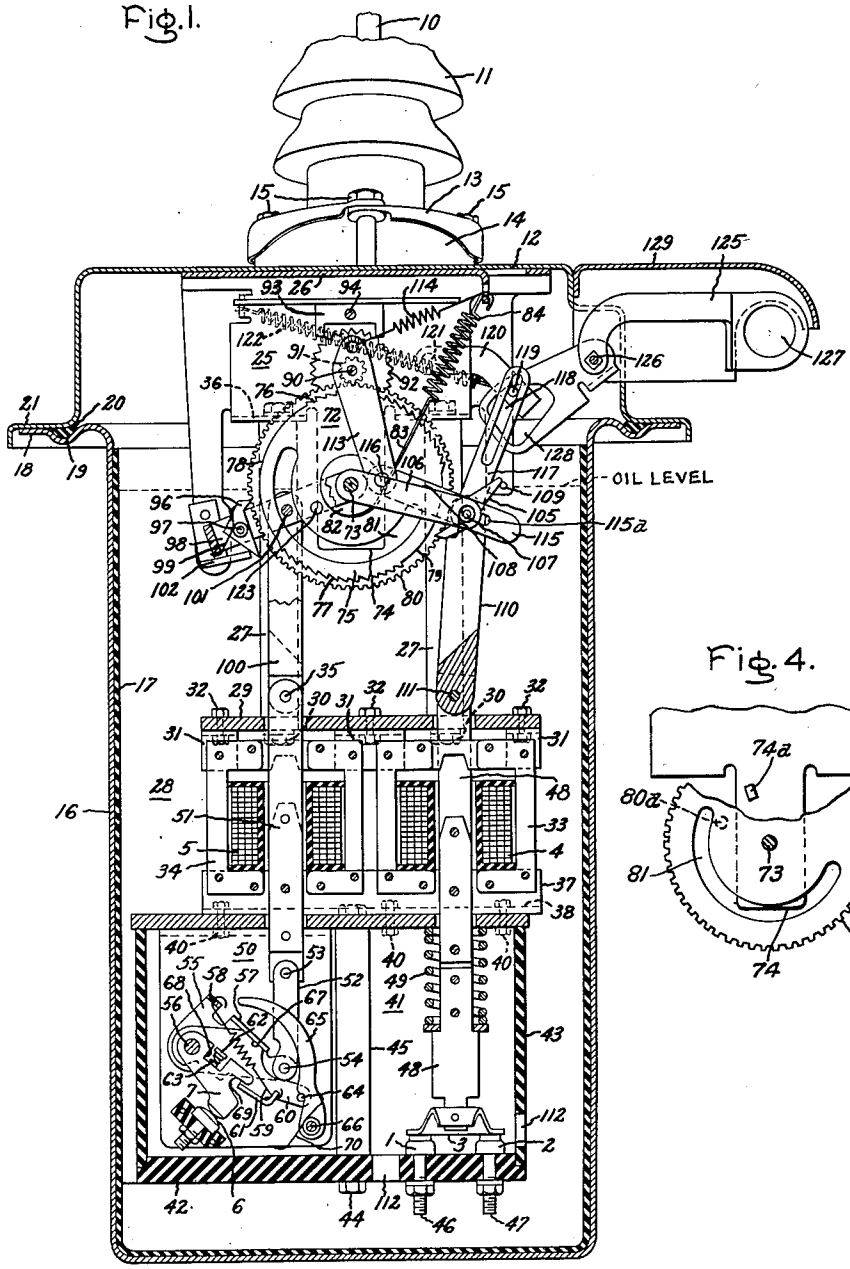


Fig. 4.

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2 SHEETS—SHEET 2

Fig. 2.

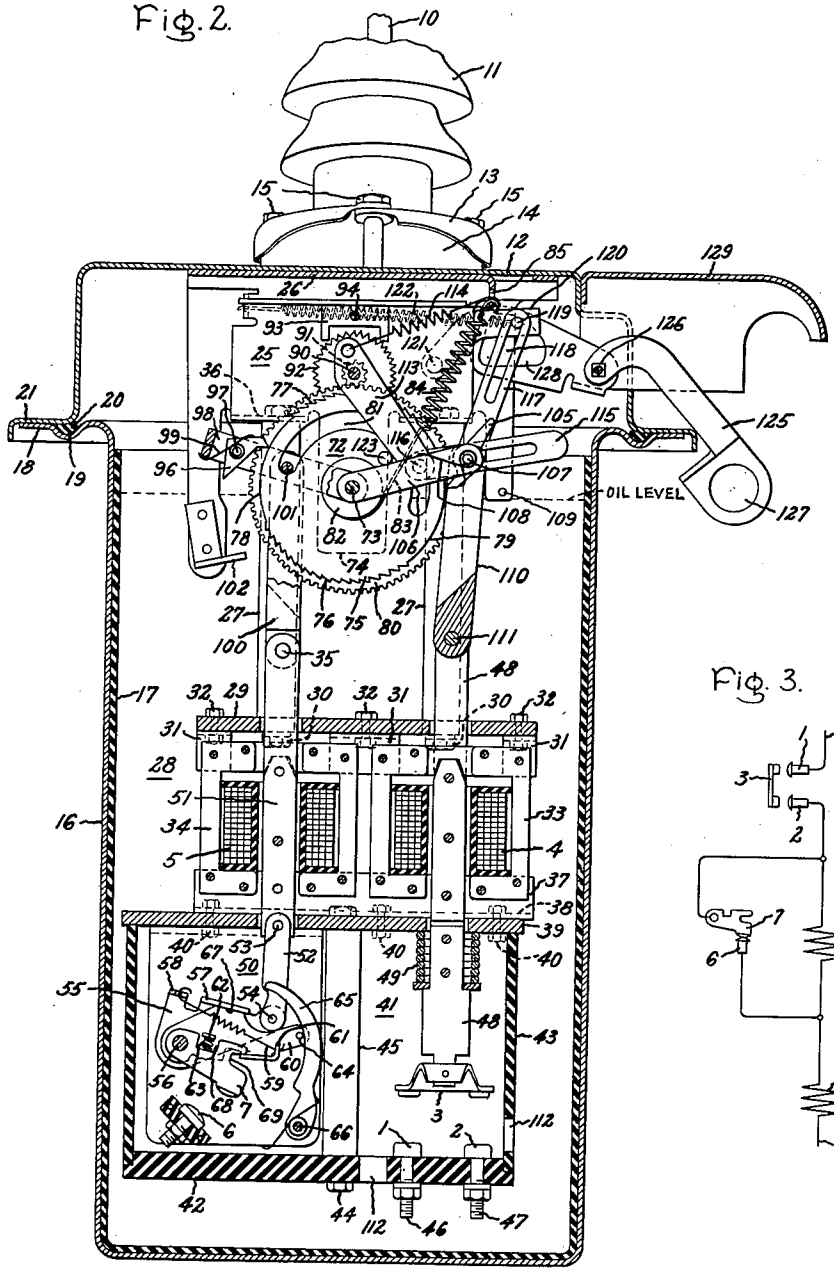


Fig. 3.

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UNITED STATES PATENT OFFICE

2,633,514

CIRCUIT RESTORER

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Application April 6, 1948, Serial No. 19,364

10 Claims. (Cl. 200—89.4)

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This invention relates to electric circuit breakers and more particularly to automatically operable circuit breakers of the reclosing type.

Our invention is related somewhat to the devices disclosed in application Serial Number 19,249, filed April 6, 1948, now Patent No. 2,599,294, dated June 3, 1952, Thumin, and in application Serial Number 19,280, filed April 6, 1948, now Patent No. 2,612,574, dated September 30, 1952, Wyman, both of which are assigned to the same assignee as this application.

It is well known that fault conditions occurring on electric transmission and distribution circuits may be due to temporary causes such as lightning or in some cases such conditions may be more or less permanent in nature where the cause is not self-clearing such as would be the condition when a foreign object such as a tree limb becomes attached to the line. Experience has shown that a very large percentage of the order from 85 to 90 per cent of all faults are temporary or non-persistent in nature.

It is highly desirable in power distribution circuits to incorporate fuses and reclosing circuit breakers into the system in such a way as to achieve maximum protection per dollar of equipment cost. To this end it is necessary that reclosing devices have precise and unchanging time current characteristics to permit the use of a large number of fuses in constructions with reclosing circuit breakers so as to achieve optimum protection per dollar of investment in protective equipment.

Accordingly, it is an object of our invention to provide an automatically operable reclosing circuit interrupter having precise time current characteristics which are relatively constant irrespective of ambient conditions thereby making possible year-round coordination of recloser to fuses and of recloser to recloser.

Another object of our invention is the provision of a reclosing device which is inherently capable of opening instantly for a preselected number of opening operations and thereafter to open a predetermined number of times with time-delay.

Still another object of our invention is the provision of a recloser having a relatively fast-operating resetting mechanism for the purpose of keeping the device in readiness for rapidly recurring line faults.

A further object of our invention is the provision of a reclosing device which automatically locks open after a predetermined number of opening operations where the fault condition is of a persistent nature.

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A still further object of our invention is the provision of an automatically operable reclosing device which can be readily converted from the locked-open type to the locked-closed type.

Still another object of our invention is to provide a reclosing device having a main operating coil and a relay coil for positively advancing a timing mechanism to a predetermined locked-open or, if desired, to a locked-closed condition.

Still another object of our invention is the provision of an operating mechanism for a reclosing circuit interrupter wherein the mechanism includes a member which is rotatable in response to preselected opening operations occurring during a persistent fault on the circuit to be controlled to achieve time-delayed opening for such preselected operations.

Another object of our invention is the provision of an operating mechanism for a reclosing circuit breaker wherein the mechanism is provided with a member which is rotatable in response to closing operations of the device to achieve time-delayed closing of the circuit breaker.

Still another object of our invention is to provide an operating mechanism for a reclosing circuit breaker wherein the mechanism is provided with an opening relay and a rotatable member which is rotated during certain opening operations performed by the opening relay and which is rotated during closing operations of the circuit breaker where persistent faults are encountered for the purpose of accomplishing a final lock-out or, if desired, a locked-closed condition of the circuit breaker.

Further objects and advantages of our invention will become apparent as the following description proceeds and the features of novelty which characterize our invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

For a better understanding of our invention, reference may be had to the accompanying drawings in which Fig. 1 is an elevational view in section of an electric circuit breaker embodying our invention wherein the various parts are shown in the positions which they occupy when the circuit breaker is closed; Fig. 2 is an elevational view in section of a circuit breaker embodying our invention wherein the various elements are shown in the positions which they occupy when the circuit breaker is automatically locked-open after a predetermined number of opening and closing operations occurring during a persistent fault, Fig. 3 is a wiring diagram showing schematically the electric circuit embodied in the

device shown in Figs. 1 and 2, and Fig. 4 is a detail view showing an arrangement for locking the contacts closed after a predetermined number of operations.

Referring now to the drawings, the circuit shown in Fig. 3 comprises a pair of main contacts 1 and 2, a bridging member 3, and a main operating coil 4 for opening the circuit through the main contacts 1 and 2 by moving the bridging member 3 out of engagement with the main contacts. A relay coil 5 controls the opening of normally closed relay contacts 6 and 7. One end 8 and the other end 9 of the circuit shown in Fig. 3 are connected to the two terminals of the recloser, only one of which is shown in the drawings and which is designated by the numeral 10. It will be seen that main operating coil 4 is short circuited by relay contacts 6 and 7 during normal service conditions and that relay coil 5 carries line current if main contacts 1 and 2 are in engagement with bridging member 3. Thus excessive current will activate relay coil 5 which will open its contacts 6 and 7 thereby placing main operating coil 4 in the circuit which will move the bridging member 3 out of engagement with contacts 1 and 2 to complete an interrupting operation. Terminal 10 and the other terminal of the device, not shown, are both enclosed within insulators such as 11 which are mounted to the cover plate 12 of the device by means of adapter elements 13 and 14 and by the bolts 15. The operating mechanism is completely enclosed within a metallic tank 16 which has an insulating lining 17 covering its inner surface. The tank 16 contains an insulating fluid. The cover 12 may be secured to the tank 16 by any suitable means such as by a plurality of bolts which are not shown. Formed into the flange 18 of the tank 16 is a peripheral groove 19. A washer 20 is disposed within the groove 19 and bears against the flange 21 of the cover 12 to seal the tank and thereby to prevent the leakage of oil from within the tank 16 through the engaging surfaces of the flanges 18 and 21.

It is evident from Figs. 1 and 2 that the operating mechanism embodying our invention depends from and is supported by the cover 12. The circuit breaker is supported on a distribution circuit pole or the like by means of suitable studs or bands, not shown, which are welded or otherwise secured to the outer surface of the tank 16. Thus it will be seen that the whole mechanism may be removed from the tank 16 by simply lifting the cover upwardly.

For the purpose of supporting the mechanism, a substantially U-shaped supporting structure 25 is used. The supporting structure 25 incorporates the base member 26 therein which base member is secured by welding or otherwise to plate 12. Since Figs. 1 and 2 are both sectional views, the base member 26 appears in section and the forward prong of the U does not appear. At the lower edge of each prong of the supporting structure 25, there is a projection 36 to which is bolted the supporting arms 27. Secured to the lower ends of the arms 27 is the assembly generally indicated at 28. The assembly 28 includes a supporting plate 29 to which the supporting arms 27 are secured by any suitable means such as the nuts 30. Secured to the supporting plate 29 by means of bolts such as 32 are a plurality of L-shaped members 31. Secured to the L-shaped arms 31 are the laminated structures 33 and 34 which support the main operating coil winding 4 and the relay coil winding 5 respectively. Secured to the lower end of the laminations 33 and 34 is member 37 having the projections 38. Secured to the member 37 there is shown the supporting plate 39 which is bolted as at 40 to the projections 38 of the member 37. The interrupting chamber generally indicated at 41 comprises a lower plate 42 constructed of insulating material and the side wall 43 which also is constructed of insulating material. The plate 42 is supported by the bolts 44 and the supporting plate 39. Bolts 44 preferably should be insulated by any suitable means such as by the insulating sleeve 45. The main interrupting contacts 1 and 2 are disposed within the arcing chamber 41 and are supported on the bottom plate 42 thereof by means of terminal bolts 46 and 47. The bridging member 3 is secured to armature 48 by any semi-rigid construction which is adequate to achieve a wiping engagement and disengagement between the bridging member 3 and contacts 1 and 2. Suitably arranged oil expulsion ports 112 are disposed in the walls of the arcing chamber 41. For the purpose of biasing the bridging member 3 toward its closed position, the compressional spring 49 is used.

The relay contacts 6 and 7 are operated by the mechanism generally indicated by the numeral 50 in such a way as to delay the opening of the contacts 6 and 7 until the armature 51 of the relay has been moved upwardly to a point near the end of its opening stroke for purposes which will become apparent as the description proceeds.

The mechanism 50 incorporates the link 52 which is pivotally connected as at 53 to the relay armature 51. The lower end of link 52 is pivoted at 54 to the member 55 which in turn is pivoted to a fixed member 56 secured to the arcing chamber wall 43 or which may be supported in any other suitable manner. It will be observed that the member 55 is constructed with the projection 57 extending along a portion of its upper edge and also that the member 55 is provided with an apertured projection 58 which serves as a means for mounting one end of the tension spring 59. Also pivotally mounted at 56 is a member 60. Disposed on the lower surface of the member 60 is an apertured projection 61 to which is attached the other end of the spring 59. Member 60 is also provided with a projection 62 which engages one end of the compression spring 63. The member 60 is also provided with a projecting pin 64 which engages a curved surface of the curved member 65 which is mounted to a fixed pivot 66 which pivot may be secured to the wall 43 of the arcing chamber. Spring 70 serves to bias the member 65 for rotation in the counter-clockwise direction against the pin 64 mounted on the member 60. It will be observed that the surface 67 of the member 60 engages the projection 57 on the member 55 in both Figs. 1 and 2. The contact 7 is pivotally mounted at 56 and is provided with a recess 68 into which the projection 62 on the member 60 is movable. The bottom of the recess 68 affords a surface against which the small compression spring 63 is allowed to bear. The contact arm 7 is also constructed with a recess 69 which cooperates with the projection 61 on the member 60.

The operation of the delayed-action switch 50 is as follows: Whenever the relay coil 5 is sufficiently energized to impart upward movement to its armature 51, the link 52 is elevated carrying

with it the right hand end of the member 55. This motion of member 55 allows the projection 57 on the member 55 to move away from the surface 67 of the member 60, and, as the member 55 is rotated counterclockwise about the pivot 56, the spring 59 is elongated somewhat and a counter-clockwise movement is thereby exerted on the member 60. Member 60 is prevented from rotating in the counter-clockwise direction, however, for a short time due to the engagement of the pin 64 on member 60 with the curved cam-like surface of the curved member 65. As the arm 52 continues upwardly, the forwardly projecting pin 54 eventually engages the curved member 65 and causes such member to be rotated in the clockwise direction about its fixed pivot 66. This clockwise rotation of the member 65 will cause the pin 64 to ride over the curved cam-like surface of the member 65 due to the pull of tension spring 59 and will permit counter-clockwise rotation of the member 60 about fixed pivot 56. This counter-clockwise rotation of member 60 will cause the contact arm 7 to be rotated counter-clockwise due to the engagement of the projection 61 on the member 60 with the upper edge of the recess 69 in the contact arm 7. In this way the contacts 6 and 7 are separated thereby removing the short circuit from around the main operating coil 4 which thereby causes the fault current to flow through coil 4 and initiates an opening operation of the bridging member 3.

When relay armature 51 is allowed to descend as will be more fully explained hereinafter, the link 52 moves downwardly thereby causing the member 55 to be rotated clockwise. The projection 57 on the member 55, which is in engagement with the surface 67 of the member 60, causes the member 60 to be rotated clockwise about the pivot 56. The projection 61 on the member 60 causes the contact arm 7 to move clockwise about the pivot 56 and eventually causes the contact 7 to engage the contact 6. In the meantime the pin 64 on the member 60 will have moved along the curved surface of the member 65 from the position shown in Fig. 2 to that shown in Fig. 1. The compression spring 63 provides the necessary pressure to hold contacts 6 and 7 closed under normal conditions. It transmits the force from link 60 to contact 7.

It is apparent that the delayed-action switch 50 will maintain the contacts 6 and 7 in engagement during the initial portion of a circuit opening operation and will permit the contacts to separate when the relay armature 51 has moved to a point very near to the end of its stroke.

The timing mechanism embodied in our invention is generally designated by the numeral 72 which mechanism will now be described. The numeral 73 designates a fixed shaft which is supported at the front and rear by a journal engagement in projecting portions 74 which are formed integrally with the downwardly extending arms of the generally U-shaped supporting structure 25.

As pointed out above, only the rear one of these downwardly projecting arms is shown and is in broken lines in the drawings. Rotatable about the shaft 73 is a ratchet wheel 75 which has notched portions 76 and 77 about its periphery and which also is constructed with the smooth or unnotched portions 78 and 79. Also rotatable about the shaft 73 and secured to the ratchet wheel 75 by any suitable means such as by rivets is a gear wheel 80 whose entire periphery is

provided with gear teeth. Both the ratchet wheel 75 and the gear wheel 80 are provided with an arcuate slot 81 for a purpose which will be apparent as the description proceeds. Secured to the ratchet wheel 75 and rotatable about shaft 73 as a center point is a drum 82 on the periphery of which is wound the lower end 83 of spring 84, affixed to some point on the periphery of drum 82. The opposite end of spring 84 is attached to aperture 85 in a down-turned portion of the supporting plate 26. The tension spring 84, as will be evident from the drawings, is adapted to exert a counter-clockwise turning moment on the ratchet wheel 75 and the gear wheel 80 and is for the purpose of resetting the ratchet and gear wheels as will be more fully understood as the description proceeds.

The speed of rotation of ratchet wheel 75 and of gear wheel 80 is governed by an escapement mechanism which will now be described. Secured to the downwardly extending arms 25 of the supporting structure having the base 26 is a shaft 90. Rotatable on shaft 90 is a pinion 91, the teeth of which engage the teeth of the gear 80 at all times. Secured to the pinion 91 and rotatable therewith is a ratchet wheel 92 which cooperates with the oscillatory escapement member 93 which is pivoted at its center point to the pin 94 which pin is secured to the supporting arms 25. Rotation of gear 81 will cause rotation of pinion 91, ratchet wheel 92 and the interaction between the teeth of the ratchet wheel 92 and the projections of the oscillatory member 93 will afford a time-delaying action in a manner well known in the art.

In order to interrelate the opening operations of the relay armature 51 and the ratchet wheel 75, an opening pawl 96 is used. Pawl 96 is pivotally mounted at 97 to the arm 98. A torsional spring 99 is used to bias pawl 96 for rotation about pivot 97 in the clockwise direction so that, unless prevented from doing so, the pawl 96 will engage the periphery of the ratchet wheel 75. The arm 98 is U-shaped and the prongs thereof are pivotally mounted at their right hand ends on the shaft 73. The arm 98 is connected to the member 100 by a pin 101 which is interposed between and secured to the front and rear prongs of the U-shaped member 98 and which pin is adapted to ride in the arcuate slots 81 in both the ratchet wheel and the gear wheel. The lower end of the member 100 is pivotally connected to the armature 51 by any suitable means such as by the pin 35.

In order to cause the pawl 96 to become disengaged from the periphery of the ratchet wheel 75 when the arm 98 is in the position shown in Fig. 1, a projection 102 is provided which is secured by any suitable means to a downwardly extending portion of one or both the arms of the U-shaped supporting structure 25.

For the purpose of interrelating the closing operations of the armature 46 and the ratchet wheel 75 and the gear wheel 80, a closing pawl 105 is provided. Pawl 105 is pivotally mounted to arm 106 by any suitable means such as by a pin 107. The pawl 105 is biased for rotation about pivot pin 107 in the clockwise direction by means of a torsional spring 108. Arm 106 is pivotally supported at its left hand end on the shaft 73. In order to cause the pawl to move out of engagement with the periphery of the ratchet wheel 75 during a circuit closing operation, a pin 109 is provided which is supported by a downwardly extending portion of one or both the arms

of the supporting structure 25. A link 110 is connected at its upper end to the arm 106 by the pin 107 and at its lower end a pivotable connection 111 serves to connect the link 110 to the armature 48 which is disposed within the main opening coil 4.

For the purpose of automatically locking the interrupter contacts in the open position after the circuit breaker has performed a predetermined number of opening and closing operations, we have provided a linkage mechanism which will now be described. An arm 113 is rotatable about the fixed shaft 90 and is apertured at its upper end for connection to the tension spring 114 which biases the arm 113 for rotation in the clockwise direction. The arm 115 is pivotally connected at its left hand end to the lower end of the arm 113 by a pin 116. Arm 117 is pivotally connected to the right hand end of the arms 115 and 106 by a pivotal connection to the pin 107. Arm 117 is provided with a slot 118 through which the pin 119 is slidable. Pin 119 is mounted on an arm 120 which is pivoted at 121 to the supporting structure 25. A tension spring 122 is connected at its left hand end to the supporting structure 25 and at its right hand end to the pin 119. A pin 123 is secured to the ratchet wheel 75 and hence is rotatable therewith. When the mechanism is operated so as to advance the pin 123 from the closed position of the recloser as shown in Fig. 1 to the open position of the device as shown in Fig. 2, the arm 113 will be rotated by the pin 123 in the counter-clockwise direction about its supporting shaft 90 against the action of the tension spring 114. This action causes the link 115 to be moved to the right. The slot 115*a* in link accommodates the pin 107 and allows this motion to the right of link 115 to take place. Immediately following this motion to the right of link 115, link 110 will be moved upwardly due to the final opening operation which will move the slotted link 115 upwardly so that engagement of the pin 119 with the upper surface of link 115 will rotate the arm 120 in the counter-clockwise direction about fixed pivot 121. This movement of arm 120 will move the spring 122 over center. The spring 122 will cause further counter-clockwise movement of the arm 120 about its pivot 121. It will be apparent, therefore, that the position of the arm 120 as shown in Fig. 2 together with the action of spring 122 will prevent downward motion of the link 117, the link 110, armature 112, and the contact bridging member 3, whereby the mechanism will be effectively locked open.

For the purpose of closing the main contacts after the breaker is locked-out and for the purpose of manually opening the main contacts, the arm 125 is provided which is pivoted to a fixed member 126. Circular opening 127 is incorporated in the right hand end of the arm 125 and an opening 128 is incorporated in the left hand end of the member 125. If the breaker is closed as shown in Fig. 1 and if it is desired to manually open the breaker, a rod or other device having a hooked end is manually inserted into the opening 127 and then pulled downwardly. This downward motion of the right hand end of member 125 causes upward motion of the left hand end of member 125. When the lower surface of the opening 128 engages pin 119, the link 117, the link 110, the armature 48, and the bridging member 3 are all elevated and the parts assume the contact open position shown in Fig. 2 and the device will be locked open.

If the device is locked open manually or automatically so that the parts occupy the position shown in Fig. 2, to close the contacts, it is only necessary to elevate the right hand end of the member 125 thereby rotating the arm 120 in a clockwise direction about its pivot 121 which action permits the arm 117, the arm 110, the armature 48 and the bridging member 3 to be lowered to close the contacts under the action of biasing spring 49. In order to cover the opening in the cover 12 through which the member 125 extends, we provide a covering shield 129.

It will be understood that our invention could be adapted to perform, within limits, a relatively wide range of opening and closing operations wherein certain of these operations would be time-delayed and wherein certain others could be made to occur almost instantly. For persistent faults the particular embodiment of our invention described above and shown in Figs. 1 and 2 is adapted to perform a first instantaneous opening operation followed by a time-delayed closing operation, a second instantaneous opening operation followed by a time-delayed closing operation, a third opening operation which is time-delayed followed by a third time-delayed closing operation, and a fourth opening operation which is time-delayed followed by a final lock-out operation.

Assuming that the interrupter is closed as shown in Fig. 1, a fault condition on the circuit controlled by the device will cause an excess amount of current to flow through the relay coil 5 which will immediately cause its armature 51 to move upwardly. As the armature 51 moves upwardly, the arm 98 will move clockwise about the shaft 73 and the pawl 96 will become disengaged from the projecting member 102. Torsional spring 99 will rotate pawl 96 in the clockwise direction causing the pawl to engage the smooth portion 78 of the ratchet wheel 75. Hence, pawl 96 will be free to slide along the ratchet wheel 75 without appreciable impediment, and the armature 51 and parts associated therewith will move rapidly in the upward direction. Near the end of the upper limit of travel of the armature 51, the contacts 6 and 7 will open as previously explained, the short circuit around main operating coil 4 will thereby be removed and the main coil 4 will be forced to carry the full amount of the fault current. This current will cause the armature 48 to move rapidly upward against the bias of spring 49. Upward movement of armature 48 will elevate the arm 110 and in turn cause the pawl 105 to move upwardly in a counter-clockwise direction with respect to the ratchet wheel 75. Bridging member 3 will move out of engagement with contacts 1 and 2 and the circuit will be interrupted. When this opening movement has progressed a slight distance, the pawl 105 will become disengaged from the stop 109 and the torsional spring 108 will rotate the pawl 105 in a clockwise direction about the pivot 107. This clockwise rotation of pawl 105 will cause the pawl to engage the smooth portion 79 of the ratchet wheel 75 for a limited time. When the armature 48 has reached the limit of its upward travel, the pawl 105 will engage the toothed section 76 of the ratchet wheel 75. The bias of spring 49 together with the weight of the parts will automatically cause the armature 48, the bridging member 3, the connecting link 110, pawl 105 and armature 115 to move downwardly. Because the pawl 105 is in engagement with the toothed section 76 of the ratchet wheel 75, down-

ward motion of pawl 105 will cause clockwise rotation of the ratchet wheel 75 and the gear wheel 80. Rotation of gear wheel 80 will rotate the ratchet wheel 92 through the pinion 91 and time-delay will be achieved by the oscillatory motion of the member 93 about the perimeter of the ratchet wheel 92. Thus, the closing operation of the device will be time-delayed a predetermined amount. If the fault condition should have cleared itself, the bridging member 3 will remain in engagement with the contacts 1 and 2 and the ratchet wheel 75 and the gear wheel 80 will be rotated in a counter-clockwise direction to the reset position as shown in Fig. 1 by the action of spring 84.

Should the fault persist, however, another opening operation will be initiated. The smooth portion 78 of the ratchet wheel 75 is sufficiently long to afford no opposition to upward opening movement of the opening pawl 95 during the second opening operation. The device, therefore, will open substantially instantaneously as previously described and will reclose with time-delay as already described since the pawl 105 will still be operating on the notched section 76 of the ratchet wheel.

Should the fault condition persist after the second reclosing operation, the relay coil 5 will elevate its armature 51 but at a slower rate because the preceeding two time-delayed reclosing operations will have been sufficient to advance the ratchet wheel 75 in a clockwise direction to a point where the notched portion 77 of the ratchet wheel 75 will be presented for engagement with the pawl 96. Further upward motion of armature 51, connecting link 100, arm 98 and pawl 96 will cause the ratchet wheel 75 and the gear wheel 80 to rotate in a clockwise direction. This clockwise rotation rotates the ratchet wheel 92 through the pinion 91 and, as previously explained, time-delay will be achieved through the oscillatory action of the escapement member 93. When the armature 51 has reached a point near the end of its upward travel, the relay contacts 6 and 7 will be opened as previously described and main coil 4 will be energized thereby elevating bridging member 3 to open the circuit. The two reclosing operations performed with time-delay and the one opening time-delayed operation thus far described will not have been sufficient to advance the notched section 76 of the ratchet wheel 75 beyond the pawl 105 and so the pawl 105 will engage the notched section 76 of wheel 75 and permit the main contacts to close with time-delay as previously described.

Should the fault still persist, the interrupter will open with time-delay as described above in connection with the third opening operation since the pawl 95 will still be in a position to engage the toothed section 77 of the ratchet wheel 75. Upon completion of this fourth and final opening operation, the pin 123 will have been advanced from the position shown in Fig. 1 to the position shown in Fig. 2 and the lock-out linkage will proceed to force the arm 120 over center to achieve final lock-out as already described. Briefly stated, the engagement of the pin 123 with the arm 113 causes counter-clockwise rotation of the member 113 about its fixed supporting pin 99 and movement to the right of link 115 which operation is followed immediately by an opening operation which elevates the armature 48, the link 116, the link 117 and the link 115 upwardly. With link 115 in the position shown in Fig. 2 the right-hand end thereof is in a position to collide with pin 119 causing rotation of the member 120 to its locked-out position.

It will be evident to those skilled in the art that the device is readily adaptable to being converted from a locked-open device to a locked-closed device. For this purpose it is only necessary to dispose a fixed pin such as 74*a* on any fixed structure, such as the portion 74 of supporting structure 25, in such a position that it will engage a pin 80*a* disposed on the ratchet wheel 75 or the gear wheel 80 so that immediately after the device has performed the desired number of opening and closing operations, the pin on the gear or on the ratchet wheel will engage the fixed stop so as to prevent upward motion of the armature 51 and parts associated therewith thereby preventing the opening of the contacts 6 and 7. In Fig. 4, the pin 80*a* is shown on the gear 80 but of course could be on the ratchet wheel 75, in which event the pin 74*a* would be mounted on the forward member 74 not shown. In this way a fault condition on the circuit is forced to either burn itself off or to blow an appropriate fuse or, in the event of fuse failure, to trip a station breaker.

If the recloser is operated to final lockout and is then manually closed, the mechanism will not trip on account of transient inrush currents because the opening pawl 105 will be in engagement with the ratchet wheel so that the ratchet wheel cannot reset to the position shown in Fig. 1. Thus opening subsequent to a manual closing operation will be time-delayed and useless tripping, due to transient currents, will be avoided.

While we have shown and described a particular embodiment of our invention, it will be obvious to those skilled in the art that various changes and modifications may be made without departing from our invention in its broader aspects and we, therefore, intend in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of our invention.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. An electric circuit reclosing device comprising relatively movable interrupting contacts, electro magnetic means for opening said contacts, a relay having an armature and a pair of normally closed control contacts in shunt with said electromagnetic means and being operable responsive to predetermined circuit fault conditions for opening said control contacts to cause operation of said means for opening said interrupting contacts, means for closing said interrupting contacts, timing means including a rotatable member having smooth and notched portions about its periphery, means for determining the velocity of rotation of said member, an opening pawl directly attached to and movable with said armature of said relay and engageable with said rotatable member to cause rotation thereof when said pawl is in engagement with a notched portion of said rotatable member but not when said pawl is in engagement with a smooth portion of said rotatable member thereby accomplishing substantially instantaneous and time delayed opening operations respectively of said interrupting contacts, and a closing pawl connected to and movable with a movable one of said interrupting contacts, said closing pawl being engageable with said rotatable member to cause rotation of said rotatable member due to engagement with a notched portion of said ro-

tatable member to accomplish time delayed closing operations of said interrupting contacts.

2. An electric circuit reclosing device comprising relatively movable contacts, means for opening said contacts, means for closing said contacts, control relay means having a coil and an armature and being responsive to predetermined fault conditions for initiating a circuit opening operation by said means for opening said contacts, a rotatable member having smooth and notched portions about its periphery, means for determining the velocity of rotation of said rotatable member, an opening pawl directly attached to and movable with said armature, said opening pawl being adapted to cause rotation of said member whenever during an opening operation said opening pawl is in engagement with a notched portion of said member thereby to accomplish time delayed opening of said contacts, and a closing pawl interconnected with and movable with a movable one of said contacts, said closing pawl being adapted to cause rotation of said member whenever during a closing operation said closing pawl is in engagement with a notched portion of said member thereby to accomplish time delayed closing of said contacts.

3. An electric circuit reclosing device comprising relatively movable contacts, main current responsive means for opening said contacts, relay means including an operating winding and an armature for initiating a contact separating operation by said main current responsive means, means for imparting closing movement to said contacts, a rotatable member, means for controlling the velocity of rotation of said member, means movable with a movable one of said contacts for engaging said rotatable member to cause rotation thereof during closing movement of said contacts, opening control means movable with said armature for engaging said rotatable member, fixed stop means, and an interference member movable with said rotatable member and engageable with said stop means after predetermined rotation of said rotatable member, said opening control means being effective upon engagement with said rotatable member to prevent opening movement of said armature after engagement between said stop means and said interference member.

4. In an electric circuit reclosing device, relatively movable interrupting contacts, electromagnetic means for imparting opening movement to said contacts, control relay means responsive to predetermined circuit fault conditions for causing energization of said electromagnetic means to open said contacts, automatically operable means for closing said contacts, timing means including a rotatable member, means movable with said control relay means for engaging and rotating said rotatable member when said member occupies predetermined angular positions to cause delayed operation of said electromagnetic means but not when said member is in an angular position other than said predetermined positions, said last named means being incapable of moving independently of said control relay, and means movable with a movable one of said contacts for engaging and rotating said rotatable member during closing operations of said device for delaying closing operations of said contacts.

5. In an electric circuit reclosing device, relatively movable interrupting contacts, electromagnetic means for imparting opening movement to said contacts, control relay means responsive to predetermined circuit fault conditions for causing energization of said electromagnetic means to open said contacts, automatically operable means for closing said contacts, timing means including a rotatable member, means movable with said control relay means for engaging and rotating said rotatable member when said member occupies predetermined angular positions to cause delayed operation of said electromagnetic means but not when said member is in an angular position other than said predetermined positions, said last named means being incapable of moving independently of said control relay, means movable with a movable one of said contacts for engaging and rotating said rotatable member during closing operations of said device for delaying closing operations of said contacts, and means operable in response to a predetermined total rotational movement of said member for locking said contacts in the open circuit position.

6. In an electric circuit reclosing device, relatively movable interrupting contacts, electromagnetic means for imparting opening movement to said contacts, control relay means responsive to predetermined circuit fault conditions for causing energization of said electromagnetic means to open said contacts, automatically operable means for closing said contacts, timing means including a rotatable member, means movable with said control relay means for engaging and rotating said rotatable member when said member occupies predetermined angular positions to cause delayed operation of said electromagnetic means but not when said member is in an angular position other than said predetermined positions, said last named means being incapable of moving independently of said control relay, means movable with a movable one of said contacts for engaging and rotating said rotatable member during closing operations of said device for delaying closing operations of said contacts, said last named means being incapable of moving independently of said movable one of said contacts, and means operable in response to a predetermined number of operations of said contacts for preventing further automatic operation of said device.

7. An electric circuit reclosing device comprising relatively movable main contacts movable between open and closed positions, relay means including control contacts and an armature operable in response to predetermined conditions of current in said device, main current responsive means for imparting opening movement to said main contacts in response to operation of said control contacts, means for closing said main contacts, a member adapted for incremental movement, means movable with said armature for causing movement of said member, said last named means being incapable of moving independently of said armature, means operable in response to closing movement of said main contacts for causing movement of said member, said last named means being incapable of moving independently of a movable one of said main contacts, and means responsive to a predetermined movement of said member for causing said main contacts to occupy a predetermined position.

8. An electric circuit reclosing device comprising relatively movable main contacts movable between open and closed positions, relay means including control contacts and an armature operable in response to predetermined conditions

of current in said device, main current responsive means for imparting opening movement to said main contacts in response to operation of said control contacts, means for closing said main contacts, a member adapted for incremental movement, means movable with said armature for causing movement of said member, means operable in response to operation of said means for closing said main contacts for causing movement of said member, a lockout linkage biased toward a normal position and movable to an operated position in response to predetermined advancement of said member, an element of said linkage being movable in response to relative movement of said main contacts, and lockout means movable from a normal position to an operated position by said element in response to opening movement of said main contacts after said linkage including said element has been moved to its operated position.

9. An electric circuit reclosing device comprising relatively movable main contacts movable between open and closed positions, relay means including control contacts and an armature operable in response to predetermined conditions of current in said device, main current responsive means for imparting opening movement to said main contacts in response to operation of said control contacts, means for closing said main contacts, a member adapted for incremental movement, means movable with said armature for causing movement of said member during opening movement of said armature, means operable in response to operation of said means for closing said main contacts for causing movement of said member, a lockout linkage biased toward a normal position and movable to an operated position in response to predetermined advancement of said member, an element of said linkage being movable in response to relative movement of said main contacts, a toggle mechanism biased toward one position and operable to an operated position by said element after movement of said linkage to an operated position and in response to opening movement of said main contacts, and means responsive to movement of said toggle to its operated position for restraining said main contacts in the open position.

10. An electric circuit reclosing device comprising relatively movable main contacts movable between open and closed positions, relay means including control contacts and an armature operable in response to predetermined conditions of current in said device, main current responsive means for imparting opening movement to said main contacts in response to operation of said control contacts, means for closing said main contacts, a member adapted for incremental movement, means movable with said armature for causing movement of said member, means operable in response to operation of said means for closing said main contacts for causing movement of said member, a lockout linkage biased toward a normal position and movable to an operated position in response to predetermined advancement of said member, an element of said linkage being movable in response to relative movement of said main contact a toggle mechanism biased toward one position, and operable to an operated position by said element after movement of said linkage to an operated position and in response to opening movement of said main contacts, means responsive to movement of said toggle to its operated position for restraining said main contacts in the open position, manual means for moving said toggle to its operated position, said toggle being operative to effect opening of said contacts when moved to its operated position by said manual means.

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