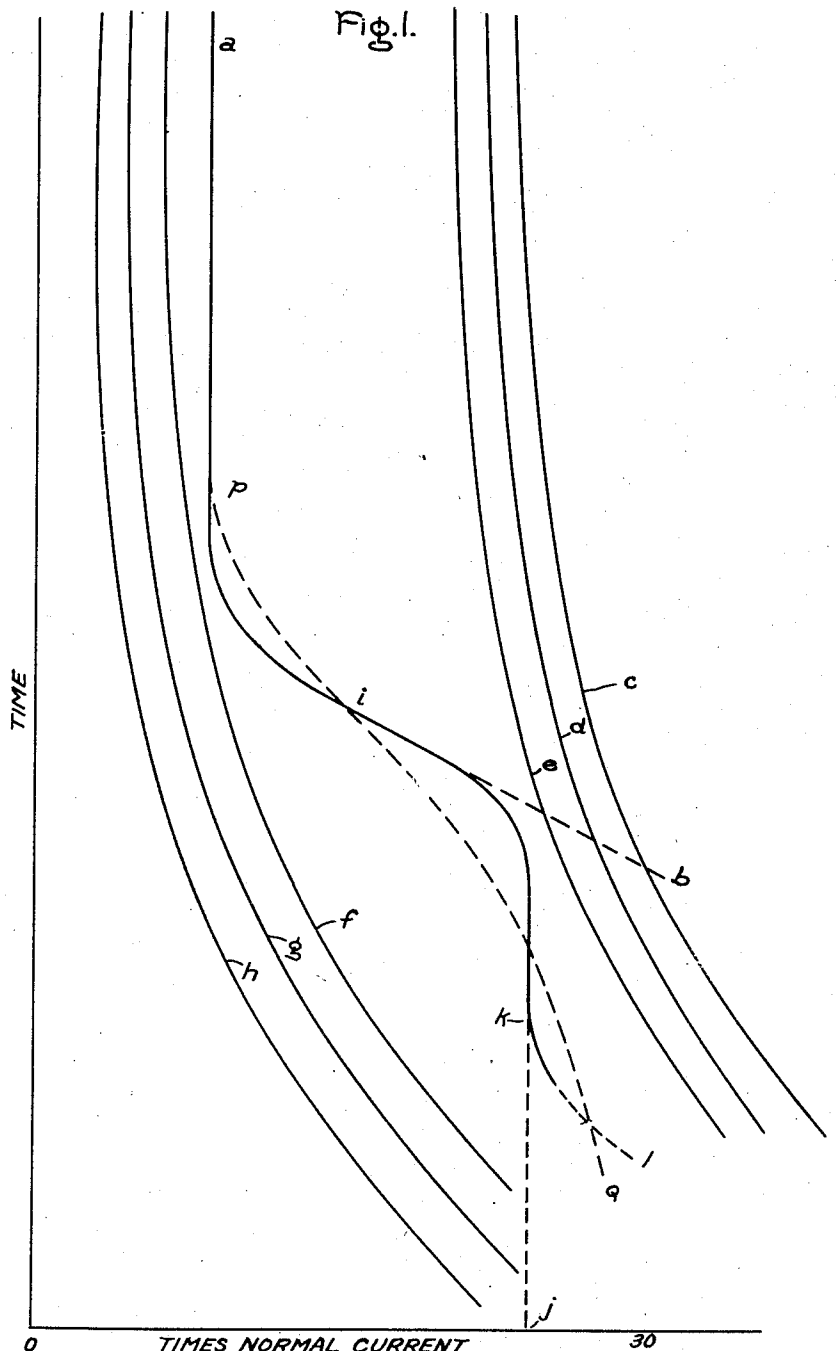
May 20, 1952 J. A. OPPEL 2,597,024

CIRCUIT RESTORER

Filed April 6, 1948 2 SHEETS—SHEET 1

Fig. 1.



Inventor:
John A. Oppel,
by Ernest C. Britton
His Attorney.

May 20, 1952 J. A. OPPEL 2,597,024

CIRCUIT RESTORER

Filed April 6, 1948 2 SHEETS—SHEET 2

Fig. 2.

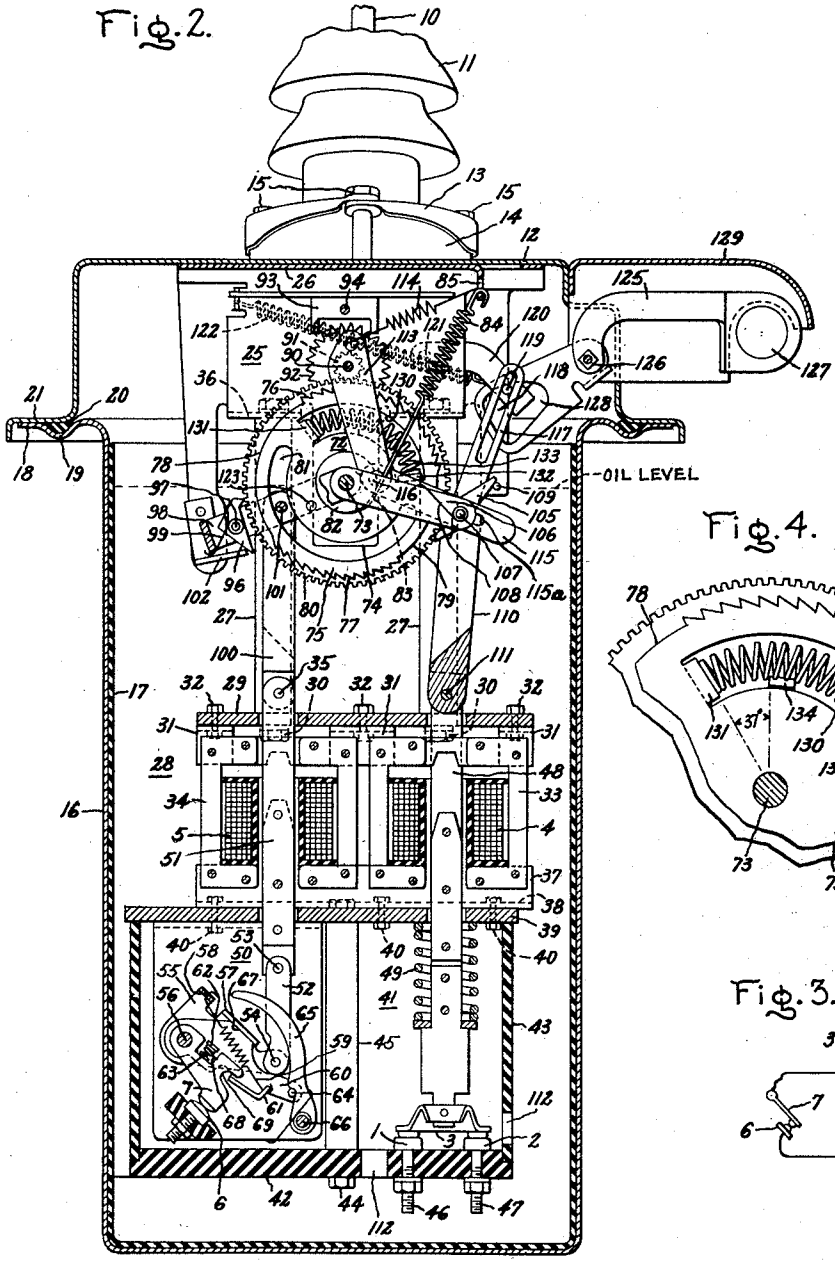


Fig. 4.

Fig. 3.

Inventor:
John A. Oppel,
by Ernest C. Britton
His Attorney.

Patented May 20, 1952

2,597,024

UNITED STATES PATENT OFFICE

2,597,024

CIRCUIT RESTORER

John A. Oppel, Aldan, Pa., assignor to General Electric Company, a corporation of New York

Application April 6, 1948, Serial No. 19,213

4 Claims. (Cl. 200—89)

1

My invention relates to circuit interrupters and more particularly to operating mechanisms for circuit breakers of the automatically operable reclosing type. More specifically, my invention is an improvement on the operating mechanism disclosed in application Serial Number 19,364, filed April 6, 1948, McCurry et al., which is assigned to the assignee to whom this application is assigned. My invention, furthermore, is related to application Serial Number 19,258, filed April 6, 1948, Oppel et al., and is an improvement on the device of application Serial Number 19,340 filed April 6, 1948, Quinn, which are both assigned to the assignee to whom this application is assigned. My invention is also related to application Serial Number 19,280, filed April 6, 1948, Wyman, and application Serial Number 19,249, filed April 6, 1948, Thumim, both of which are assigned to the same assignee as this application.

In operating mechanisms for reclosing circuit breakers of the type disclosed in the above-mentioned application of McCurry et al. in which provision is made for both instantaneous and time-delayed opening operations, it is possible that the time-delayed opening operations, though fully capable of proper functioning for moderately excessive fault currents, may be too prolonged where the magnitude of the fault current is of the order from, say, 15 to 30 times the normal full-load rating of the device. The above-mentioned application of Quinn discloses means for greatly decreasing the opening time of an operation, which normally would be time-delayed, provided the fault current is very large of the order of 15 to 30 times the normal full-load current rating of the interrupter and thereby improves the possibilties of proper coordination betwen the recloser and fuses or other interrupting devices disposed in the line between the source of power and the particular recloser. My invention further modifies the time current characteristic of a recloser to make possible better coordination between the recloser and fuses or other interrupting devices disposed between the recloser and the load centers.

A principal object of my invention is the provision of an operating mechanism for electric circuit reclosers having improved time current characteristics.

A further object of my invention is to provide a reclosing circuit breaker such as that disclosed in the above application of McCurry et al. which has greatly improved time current characteristics without interference with the normal sequence of operations which eventually result in a final lockout or locked-closed operation.

2

Still another object of my invention is to retain the advantages to be derived from the use of a recloser operating mechanism of the type disclosed in the above-mentioned application of Quinn and at the same time to provide such a mechanism with means for increasing the time-delay occurring for certain preselected opening operations if the fault current happens to be in excess of a predetermined relatively high value of the order of, for instance, 25 or more times the normal rated current carrying capacity of the device.

A still further object of my invention is the provision of an operating mechanism of the type disclosed in the above-mentioned application of Quinn wherein better coordination between the recloser and fuses or other interrupting devices disposed in the line between the particular recloser and the load centers is achieved.

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

For a better understanding of my invention, reference may be had to the accompanying drawings in which Fig. 1 is a family of curves showing the time current characteristics of a reclosing circuit breaker embodying my invention as well as the time current characteristic curves of fuses which are coordinated with the recloser; Fig. 2 is an elevational view in section of a recloser embodying my invention; Fig. 3 is a schematic representation of the circuit incorporated in the recloser shown in Fig. 2 and in which Fig. 4 is an enlarged elevational view of a small portion of Fig. 2.

In electric distribution systems it is desirable to obtain the maximum protection possible per dollar of investment in protective equipment. Frequently it proves feasible in a particular distribution system to combine automatically operable reclosing devices and fuses. Fuses may be inserted into the line between the source of power and the recloser and may also be placed in the line between the recloser and the load.

With reference to Fig. 1, the dotted line curve *pq* represents desired time current characteristic curves for the recloser while the curve *aib* represents the time current characteristic of a reclosing device such as that disclosed in the above-mentioned application of McCurry et al. The curve *aij* represents the time current characteristic of a device such as that disclosed in the above-mentioned application of Quinn. The

curves *c*, *d* and *e* represent the time current characteristics of fuses inserted in the line between the source of power and the particular reclosing device. The longer time characteristics of the fuses will delay the operation thereof until the recloser will have had an opportunity to open the circuit. The curves *f*, *g* and *h* represent the time current characteristics of fuses inserted into the system at points between the load centers and the particular recloser. The shorter time characteristic of this latter group of fuses will permit a particular fuse to blow and thereby disconnect the faulted load center from the system without causing the recloser to operate.

In accordance with my invention, I provide means for modifying the curve *aij* obtained with the device of the above-mentioned Quinn application by causing such curve to assume the shape *aikl* and thereby I avoid the possibility of a failure of coordination between fuses having characteristics such as *f*, *g* and *h* and the time-delayed opening operations of the recloser and I thereby provide a device having time current characteristics more closely approximating the desired characteristics represented by the curve *pq* than has been possible heretofore.

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.

With reference to Fig. 2, terminal 10 and the other terminal of the device, now 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 Fig. 2 that the operating mechanism embodying my 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 Fig. 2 is a sectional view, 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 a 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 counterclockwise 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 and a counterclockwise moment is thereby exerted on the member 60. Member 60 is prevented from rotating in the counterclockwise direction, however, 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 counterclockwise rotation of the member 60 about fixed pivot 56. This counterclockwise rotation of member 60 will cause the contact arm 7 to be rotated counterclockwise 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 downwardly along the curved surface of the member 65 to the position shown in Fig. 2.

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 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 is a gear wheel 80 whose entire periphery is provided with gear teeth. The ratchet wheel 75 and the gear wheel 80 are interconnected by means of a spring as will be more fully explained hereinafter. 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 a flexible cord 83, one end of which is affixed to some point on the periphery of drum 82 and the other end of which is tied to the tension spring 84. 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 counterclockwise turning moment on the ratchet wheel 75 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 80 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 inter-relate 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. 2, 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 inter-relating the closing operations of the armature 48 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, a linkage mechanism is provided 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, the arm 113 will be rotated by the pin 123 in the counterclockwise 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 115a in link 115 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 117 upwardly. Movement to the right of link 115 together with upward motion of link 110 cause the right-hand end of link 115 to collide with pin 119. This collision will rotate the arm 120 in the counterclockwise direction about fixed pivot 121. This movement of arm 120 will move the spring 122 over center. The spring 122 will cause further counterclockwise movement of the arm 120 about its pivot 121.

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. 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 and if it is desired to manually open the breaker, a rod 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 and the device will be locked-open.

If the device is locked-open manually or automatically 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 the device 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 described above and shown in Fig. 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. 2, 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 counterclockwise 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 wheet 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 arm 115 to move downwardly. Because the pawl 105 is in engagement with the toothed section 76 of the ratchet wheel 75, downward 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 counterclockwise direction to the reset position as shown in Fig. 2 by the action of spring 84 and flexible lead 83.

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 96 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 preceding 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 contracts 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 96 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 clockwise from the position shown in Fig. 2 to a position of engagement with the arm 113 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 counterclockwise rotation of the member 113 about its fixed supporting pin 90 which operation is followed immediately by an opening operation which elevates the armature 48. The link 115 then collides with the pin 119 and rotates the member 120 to its locked-out position.

In accordance with my invention, I have provided means for permitting the ratchet wheel 75 to rotate independently of the gear wheel 80, even though the pawl 96 is in engagement with the toothed section of the ratchet wheel 75, provided the fault current is in excess of a predetermined relatively large value. As is more clearly shown in Fig. 4, I provide an arcuate slot 130 in both the ratchet wheel 75 and in the gear wheel 80 which slots coincide when the mechanism parts occupy the positions shown in Figs. 2 and 4. Secured to the ratchet wheel 75 in the left hand end of the arcuate slot therein is a tab 131 which projects rearwardly into the slot 130 in the gear wheel 80. Secured to the gear wheel 80 in the right hand end of the slot 130 therein is a tab 132 which projects forwardly into the slot 130 in the ratchet wheel 75. Disposed between the tabs 131 and 132 with its axis about mid-way between the rear surfaces of the ratchet wheel 75 and the front surface of the gear wheel 80, I provide collapsible member in the form of a precharged compression spring 133. The spring 133 is the only means for interconnecting the gear wheel 80 and the ratchet wheel 75. In other words, the gear 80 is free to rotate about the shaft 73 except for the fact that it is connected, as explained above, to the time-delaying oscillatory member 93 and except for the fact that the spring 133 is so constructed and arranged as to be precharged a predetermined amount in such a direction as to exert a moment on the ratchet wheel 75 which tends to rotate that wheel in the counterclockwise direction and which exerts a moment on the gear wheel 80 which tends to rotate that wheel in the clockwise direction. The ratchet and gear wheels are maintained in the positions shown in Figs. 2 and 4 by the tabs 131 and 132 which engage the left and right hand ends of the gear and ratchet wheels respectively.

It will be apparent that, if the counterclockwise moment exerted on the ratchet wheel 75 is of a proper value, the time-delayed opening operation of the pawl 96, the link 100, the armature 51 and the contact 7 will proceed with time-delay if the fault current on the line, and hence the force exerted by coil 5, is below a predetermined amount and the gear wheel 80 and associated time-delaying mechanism will be operated. Otherwise stated, the curve *aii* of Fig. 1 will be the same as the curve *aib* of Fig. 1 in so far as the common portion *ai* of these two curves is concerned.

If, however, the fault current is of the order of a higher value than indicated by the point *i*, the upward force exerted by armature 51 through link 100 on pawl 96 will be sufficient to overcome more rapidly the counterclockwise moment exerted by the spring 133 on the ratchet wheel 75. The ratchet wheel, therefore, will be free to rotate in the clockwise direction more rapidly while the gear wheel 80 and the associated time-delaying mechanism will operate at a rate corresponding to the force exerted by the spring

133. Otherwise stated, the characteristic curve of the recloser will follow the line *ij* rather than the line *ib* due to the action of the parts as thus far described.

The functional operation of the mechanism as thus far described is similar to that of the arrangement disclosed in the above-mentioned application of Quinn although the construction is different.

As was pointed out above, it is desirable to provide good coordinating possibilities between the particular recloser and the fuses or other interrupting devices disposed in the line between the load centers and the particular recloser. Otherwise stated, it is desirable to prevent the intersection of the curves *f*, *g* and *h* of Fig. 1 with the curve *aij* of that figure. For this purpose I cause the portion *kj* of the curve *aikj* to assume the position *kl* so that the recloser characteristic curve for time-delayed opening will follow the line *aikl* and thereby I accomplish better coordination possibilities between the particular recloser and the interrupting devices having characteristics such as *f*, *g* and *h* disposed in the line between the load centers and the particular recloser.

For this purpose I allow the ratchet wheel **75** to proceed without time-delay from the escapement where the fault current is excessively high for a portion only of the upward motion of the pawl **96** and then I provide means for introducing time-delay for the remainder of the upward opening motion of the pawl **96**. In a particular construction where the full rotation of the arm **98** and ratchet wheel **75** is about 46° during opening, I have found it desirable to permit rotation of the ratchet wheel **75** without appreciable time-delay for about 37° and thereafter to introduce time-delaying action for the remaining 9° of the opening rotation of the ratchet wheel **75**.

In the particular embodiment of my invention shown in Figs. 2 and 4, I achieve the above results by securing a stop **134** on the gear wheel **80** in such a way that the stop is disposed in the path of movement of the tab **131** mounted on the ratchet wheel **75**. Thus the ratchet wheel **75** is free to move clockwise when currents are excessively high while the gear wheel **80** remains relatively stationary until the tab **131** on the ratchet wheel **75** collides with the stop **134** on the gear wheel **80**. After the engagement of tab **131** and stop **134**, the ratchet and gear wheels will move in unison with time-delay for the remainder of the opening rotation of these wheels. The curve *aikl* will represent the time current characteristic of the device and better coordination between the recloser and devices having the characteristics *f*, *g* and *h* will be possible.

It will also be apparent that the incremental angular displacement of the ratchet wheel **75**, due to the rotation of the wheel by the closing pawl **105** and by the opening pawl **96**, will remain unaffected so that any predetermined sequence of opening and closing operations will proceed, as explained above. to a final lock-out or lock-closed condition of the device.

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

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

1. An operating mechanism for an electric circuit reclosing device having relatively movable contacts comprising first means responsive to fault currents for opening said contacts, second means for imparting closing movement to said contacts, a rotatable member, means responsive to preselected closely succeeding opening operations of said first means for rotating said rotatable member, means responsive to operation of said second means for rotating said rotatable member, a timing mechanism, resilient means interposed between said timing mechanism and said rotatable member, said resilient means being yieldable to render said timing mechanism ineffective to delay the initial opening movement of said first means when the fault current is in excess of a predetermined value, said resilient means being effective to cause operation of said timing mechanism to delay the opening operation of said first means when the fault current is below a predetermined value, and stop means for establishing a direct mechanical connection between said rotatable member and said timing mechanism after the initial opening movement of said first means when the fault current is in excess of a predetermined value.

2. An operating mechanism for an electric circuit reclosing device having relatively movable contacts comprising first means responsive to fault currents for opening said contacts, second means for imparting closing movement to said contacts, a movable member, means responsive to preselected closely succeeding opening operations of said first means for moving said movable member, means responsive to operation of said second means for moving said movable member, a timing mechanism, resilient means interposed between said timing mechanism and said movable member, said resilient means being yieldable to render said timing mechanism ineffective to delay the initial opening movement of said first means when the fault current is in excess of a predetermined value, said resilient means being effective to cause operation of said timing mechanism to delay the opening operation of said first means when the fault current is below a predetermined value, and stop means for establishing a direct mechanical connection between said movable member and said timing mechanism after the initial opening movement of said first means when the fault current is in excess of a predetermined value.

3. An operating mechanism for an electric circuit reclosing device having relatively movable contacts comprising electromagnetic means for imparting opening movement to said contacts, relay means responsive to fault currents for initiating operation of said electromagnetic means, a ratchet wheel, an opening pawl movable in response to operation of said relay for rotating said ratchet wheel during preselected closely succeeding opening operations of said relay, a timing device, and resilient means interconnecting said ratchet wheel and said timing device, said resilient means being effective to permit predetermined opening movement of said relay without causing operation of said timing device when the fault current is in excess of a predetermined amount, said resilient means being effective to cause operation of said timing device and delayed opening operation of said relay for

a substantial portion of the opening operation of said relay when the fault current is less than said predetermined value, and stop means for establishing a direct mechanical connection between said ratchet wheel and said timing device after the initial opening movement of said relay when the fault current is in excess of said predetermined value.

4. An operating mechanism for an electric circuit reclosing device having relatively movable contacts comprising electromagnetic means for imparting opening movement to said contacts, relay means responsive to fault current for initiating operation of said electromagnetic means, means for imparting closing movement to said contacts, a ratchet wheel, an opening pawl movable in response to operation of said relay for rotating said ratchet wheel during preselected closely succeeding opening operations of said relay, a closing pawl movable with a movable one of said contacts for rotating said ratchet wheel in response to closing movement of said contacts, a timing device, and resilient means interconnecting said ratchet wheel and said timing device, said resilient means being effective to permit predetermined opening movement of

said relay without causing operation of said timing device when the fault current is in excess of a predetermined amount, said resilient means being effective to cause operation of said timing device and delayed opening operation of said relay for a substantial portion of the opening operation of said relay when the fault current is less than said predetermined value, and stop means for establishing a direct mechanical connection between said ratchet wheel and said timing device after the initial opening movement of said relay when the fault current is in excess of said predetermined value.

JOHN A. OPPEL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,123,288	Hellmund	Jan. 5, 1915
2,069,082	Walle	Jan. 26, 1937
2,311,714	Thompson	Feb. 23, 1943
2,464,303	Gesellschap	Mar. 15, 1949
2,487,025	Matthews	Nov. 1, 1949