Aug. 2, 1938. A. C. SCHWAGER ET AL 2,125,465

AUTOMATIC RECLOSING CIRCUIT BREAKER

Filed May 18, 1936 4 Sheets-Sheet 1

Fig. 2.

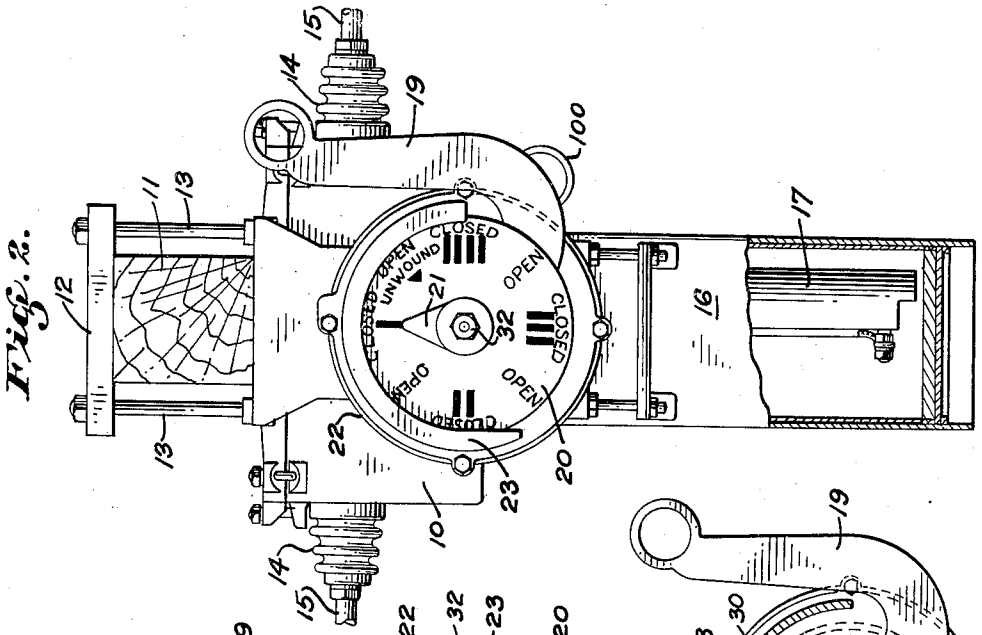


Fig. 4.

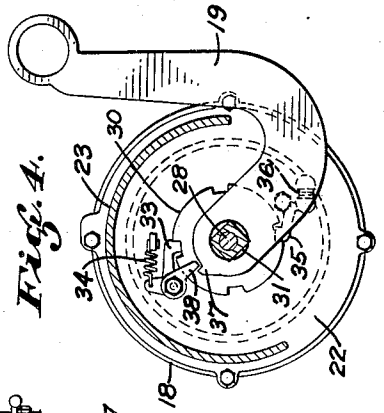
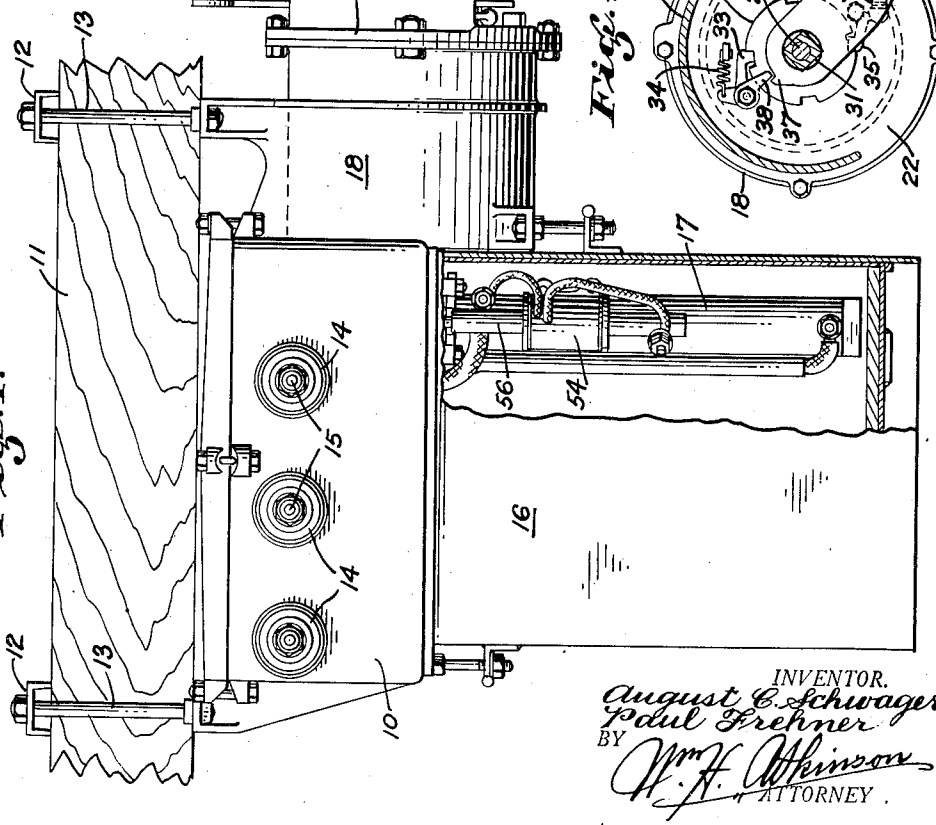


Fig. 1.



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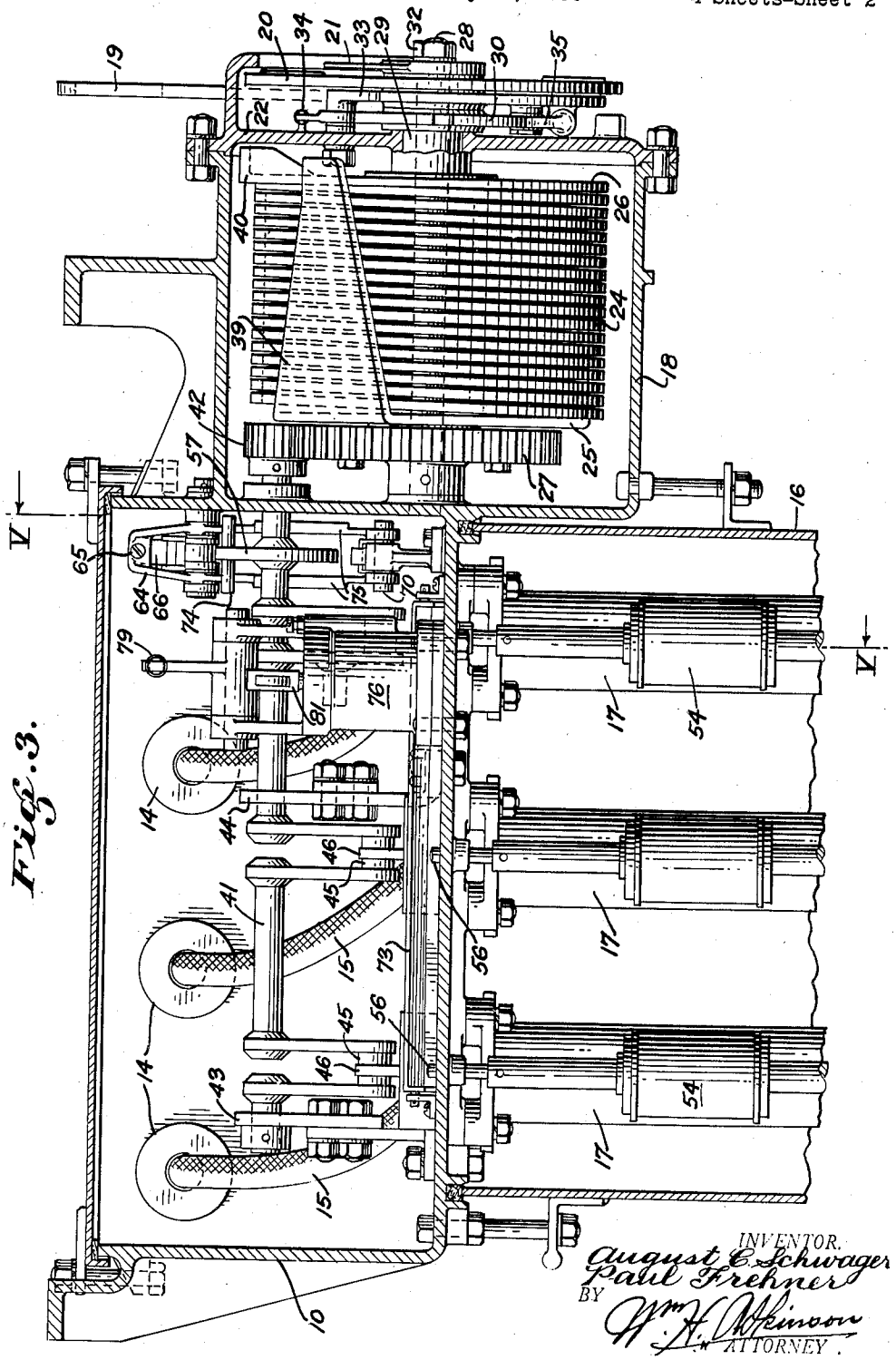

Fig. 3.

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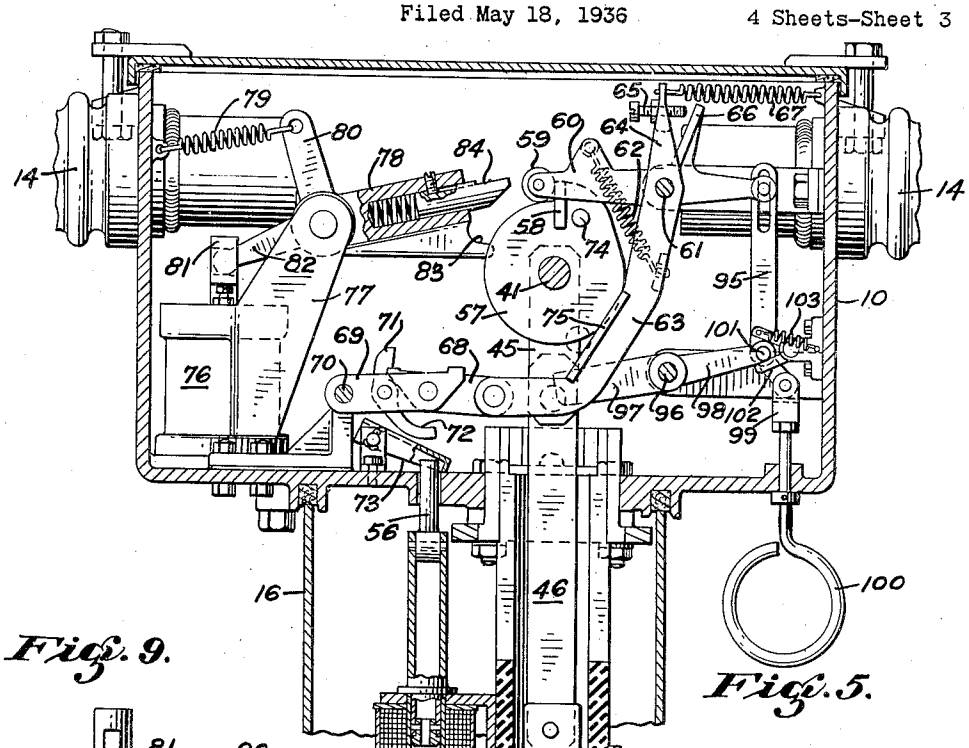
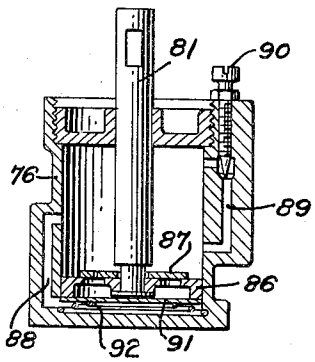
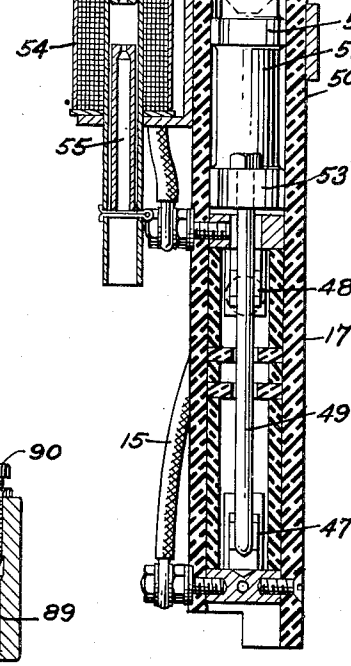


Fig. 9.

Fig. 5.





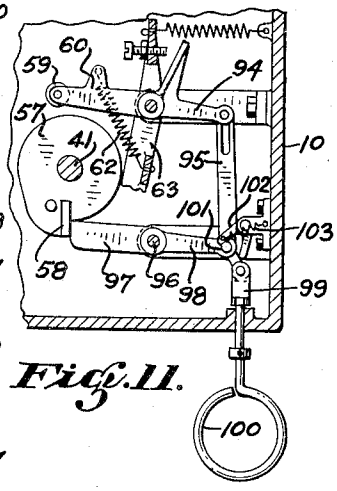


Fig. 10.

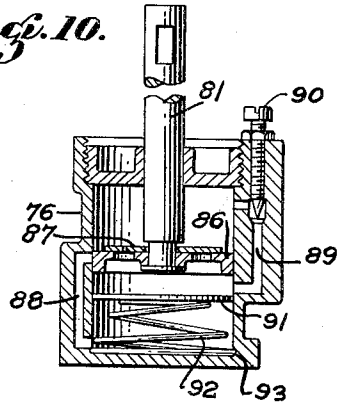


Fig. 11.

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Fig. 6.

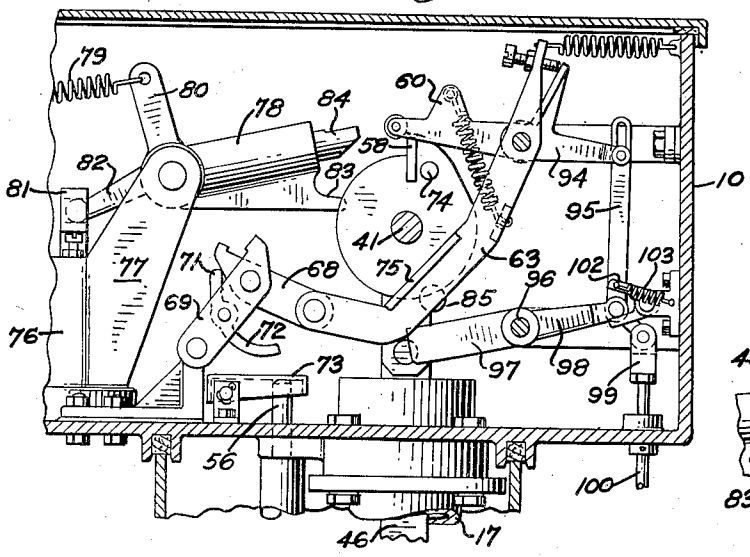


Fig. 7.

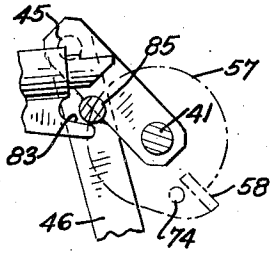


Fig. 12.

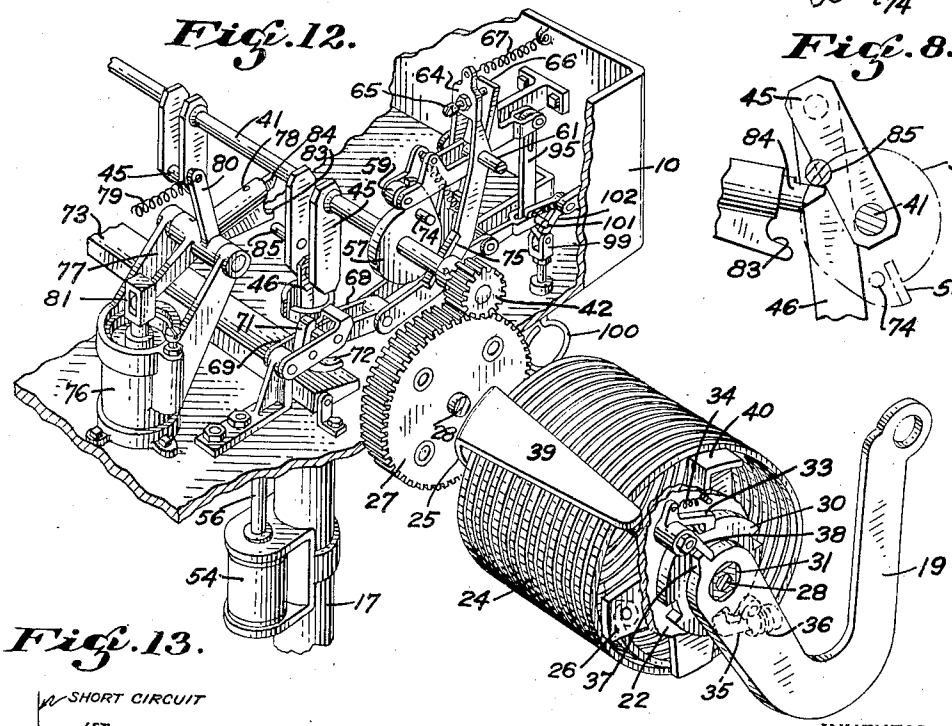
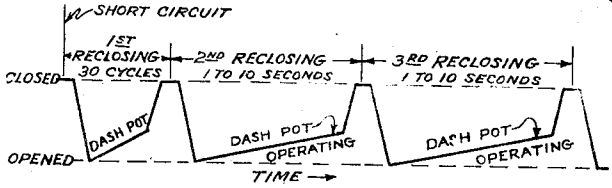


Fig. 8.

Fig. 13.



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UNITED STATES PATENT OFFICE

2,125,465

AUTOMATIC RECLOSING CIRCUIT BREAKER

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Application May 18, 1936, Serial No. 80,327

12 Claims. (Cl. 200—89)

The present invention relates to circuit breakers, and more particularly to a circuit breaker of the so-called reclosing type, which is adapted to automatically open the circuit upon the occurrence of an overload or fault and subsequently reclose the circuit.

An object of the invention is to provide a reclosing circuit breaker for power systems that will provide overload protection with automatic reclosures at predetermined intervals and be reliable and efficient in operation.

Another object of the invention is to provide an automatic reclosing circuit breaker in which the operation thereof is carried out by mechanical means without resort to the use of an electric motor.

Another object of the invention is to provide a new and novel form of automatic reclosing circuit breaker which is particularly adapted to a pole or tower mounting.

Another object of the invention is to provide in an automatic reclosing circuit breaker and time delay means, which upon the occurrence of two successive reclosing operations will serve to delay the second reclosing operation for a period of time greater than that of the first reclosing operation.

Another object of the invention is to provide an operating mechanism for an automatic reclosing circuit breaker, which will simultaneously control the operation of three circuits by means of a single operating spring and trip mechanism.

Another object of the invention is to provide an automatic circuit interrupting and reclosing circuit breaker, which can be mounted in an elevated position convenient to a transmission system, and which can be controlled manually in a simple manner by an operator on the ground therebelow.

Another object of the invention is to provide a new and novel form of spring operating means for a pole type automatic reclosing circuit breaker, which can be wound by an operation without requiring a climbing of the pole.

Another object of the invention is to provide a spring operating mechanism for an automatic reclosing circuit breaker of the pole type, having indicating means visible from a distance to indicate the condition of the mechanism.

Another object of the invention is to provide an automatic reclosing circuit breaker, which can be regulated to provide a predetermined number of reclosing operations upon the occurrence of a sustained overload.

Another object of the invention is to provide a time delay mechanism in an automatic reclosing circuit breaker of the character described, which may be adjusted to prevent a reclosing of the circuit until after predetermined time intervals.

A further object of the invention is to provide, in combination with an automatic reclosing circuit breaker, a trip mechanism whereby the circuit breaker may be operated under manual control from its closed to its opening position and vice versa.

Other objects and advantages will be in part pointed out hereinafter, and in part evident to those skilled in the art, after an examination of the accompanying drawings, wherein there is shown by way of illustration and not of limitation, preferred embodiments of the several features of this invention.

In the drawings:

Figure 1 is a side elevation of a reclosing circuit breaker constructed in accordance with this invention, which is particularly adapted to a pole mounting,

Figure 2 is an end elevation of the switch illustrated in Figure 1,

Figure 3 is a sectional view taken longitudinally through the circuit breaker illustrated in Figure 1, showing the arrangement of the interior mechanism,

Figure 4 is a fragmentary view partially in section, taken from Figure 2, with the indicating dial and pointer removed therefrom,

Figure 5 is a transverse sectional view taken along line V—V of Figure 3, looking in the direction of the arrows,

Figure 6 is a partial view similar to Figure 5, showing the trip mechanism in its releasing position,

Figures 7 and 8 are fragmentary views showing the cooperative relation between the time delay means respectively during a first and subsequent circuit reclosing operations,

Figures 9 and 10 are sectional views showing the time delay dashpot in two operative positions,

Figure 11 is a fragmentary sectional view showing the manually controllable features of the trip mechanism,

Figure 12 is a fragmentary perspective view with the spring driving means displaced to disclose the details of construction, and

Figure 13 is a diagram or chart representing a typical performance of the circuit breaker upon a sustained short circuit.

The purpose of the present invention is to provide a reclosing circuit breaker which is particularly adapted to provide overload protection in a

transmission line with automatic reclosures at predetermined intervals, and to this end the circuit breaker is so constructed that it will automatically open the circuit upon the occurrence of an overload or fault, and immediately thereafter reclose the circuit so that should the fault be cleared the circuit will be immediately reestablished. In the event that the overload or fault still exists on the circuit at the time of the first reclosing, the circuit breaker is adapted to again open the circuit and after a predetermined time delay again reclose the circuit, this operation being repeated through two or more reclosing operations, after which the circuit breaker will lock open should the fault or overload remain on the circuit.

For the purpose of a detailed description of the invention, there is shown in the drawings a circuit breaker which is particularly adapted for use upon a pole or tower.

In Figures 1 and 2 of the drawings, the numeral 10 designates a suitable supporting housing, in and upon which the operative elements of the circuit breaker are mounted. The housing 10 is here shown as mounted in a suspended manner upon a wooden cross arm 11, such as is provided upon transmission line poles. The housing in this instance being secured upon the cross arm 11 by means of straps 12 and bolts 13. Extending from opposite sides of the housing 10 there are three insulating bushings 14 through which line conductors 15 are adapted to enter and connect with the terminals of the circuit breaker. Secured in a removable manner below the enclosing housing 10 there is an insulating oil containing tank 16 in which three circuit interrupting elements 17 of the expulsion type are submerged. The details and construction of these circuit interrupting elements 17 will be described in more detail hereinafter as the description proceeds.

At one end of the enclosing housing 10 there is an extension 18 which is adapted to support and enclose a spring motor which will supply the operating energy for the switch. The spring motor enclosed within the extension 18 will be described in more detail in connection with Figure 3 of the drawings. It will be sufficient to here state that the spring motor is so mounted within the extension 18 that one end thereof may be turned by means of a lever 19 to wind up the spring and store energy for the operation of the circuit breaker. The lever 19 is so arranged that it can be conveniently operated from the ground by means of a standard switch hook. Associated with the spring motor and disposed at the end of the extension 18 there is a dial plate 20 and an indicating pointer 21 which serves to indicate the wound condition of the spring motor. The dial plate 20 and the pointer 21 are mounted outside of a cover plate 22 at the end of the extension 18, and this cover plate 22 carries an outwardly extending shroud 23 which is disposed in a protecting manner over the dial 20 and its pointer 21.

Reference is now made to Figure 3 of the drawings for a more complete description of the spring motor which is enclosed within the extension 18. As here shown, the spring motor comprises a helical spring 24 which is disposed between relatively movable end plates 25 and 26. The end plate 25 carries a gear 27, together with which it is secured non-rotatably upon a centrally disposed shaft 28, and the end plate 26 is rotatably mounted upon the shaft 28. In this arrangement, the opposite ends of the helical spring 24 are firmly attached respectively to the end plates 25 and 26, so that when a relative angular displacement occurs between these two end plates, the spring will be either wound or unwound, depending upon which plate is moved and in which direction the movement occurs. The end plate 26 carries an outwardly extending collar 29 which is journaled within the cover plate 22, and upon the outer end of this collar 29 there is a notched spring retaining disc 30. This notched spring retaining disc 30 is better shown in Figure 4 of the drawings. As illustrated in this latter figure of the drawings, it will be noted that the extending collar 29 has a squared extension 31, upon which the notched disc 30 and the indicating dial 20 are non-rotatably mounted. The spring winding lever 19 is shown in this figure of the drawings, as rotatably mounted upon the squared portion of the extending collar 29. The shaft 28 is journaled at this end in the extending collar 29, and at its outer extremity it carries the pointer 21, which is secured thereupon by means of a nut 32.

As better shown in Figure 4 of the drawings, the end cover 22 carries a pivotally mounted dog 33, which is held in cooperating relation with the notched disc 30 by means of a spring 34. The spring winding lever 19 is here shown as having a reversely disposed similar dog 35, which is biased into an opposite notch of the notched disc 30 by means of a spring 36. The lever 19 is also shown as having a dog releasing projection 37 at its end, which is adapted to engage a lifting arm 38 carried by the first mentioned dog 33. With this arrangement it will be seen that when the spring winding lever 19 is pulled down, as suggested, with a standard switch hook, the notched disc 30 will be rotated one-quarter of a revolution. This will rotate the end plate 26 and the attached end of the helical spring 24 through a corresponding angular movement, after which the spring 24 will be held in this wound condition by means of the dog 33. In the arrangement shown, four complete operations of the spring winding lever 19 will serve to fully wind the spring 24 and provide sufficient stored energy to complete three reclosings and four openings of the circuit breaker.

As a means to prevent a reclosing of the circuit breaker and/or an inoperative condition of the spring 24 with the circuit breaker closed, the end plate 25 is provided with an overhanging arm 39, which is adapted to engage a stop 40 formed upon the end plate 26. As here illustrated, the helical spring 24 is shown as in a position where it is capable of producing a final opening operation of the circuit breaker. In other words, as here shown, the spring 24 has operated the circuit breaker through three reclosing operations, and as it now stands, the spring 24 is only capable of opening the switch. This arrangement insures that the energy storing spring 24 can only become unwound insofar as its operation is concerned when the circuit breaker is in its open circuit position.

The energy which is stored in the helical spring 24 is applied to the switch mechanism by means of a crank shaft 41 which is driven by a gear 42 thereupon that meshes with the gear 27 carried by the end plate 25 and the shaft 28. The shaft 41 is journaled in a partition extending between the supporting housing 10 and the spring enclosing extension 18, and at its far end it is supported upon a bearing 43. An additional bearing 44

is also shown as disposed intermediate the ends of the crank shaft 41. The diameter of the gear 42 is one-fourth that of the gear 27. Consequently, the gear 42 will impart one complete revolution to the crank shaft 41 for each quarter revolution of the gear 27. Since the crank shaft 41 is required to make only three and one-half revolutions to complete three reclosings and a final opening of the circuit, it will be seen that the gear 27 with the end plate 25 will be required to rotate only seven-eighths of a complete revolution to dissipate the operating energy stored in the spring 24. After this, the spring 24 can be again fully wound by four downward operations of the rewinding lever 19, as previously described. The crank shaft 41 is shown in Figure 3 of the drawings as having three cranks 45, each one of which is connected through a connecting rod 46 to a circuit interrupting element 17.

Reference is now made to Figures 5 and 6 of the drawings for a description of the circuit interrupting means and the trip mechanism which serves to control the operation of the crank shaft 41 in response to a fault and/or overload condition upon the circuit under control. Upon referring particularly to Figure 5 of the drawings, it will be noted that the circuit interrupting elements 17 are of the so-called expulsion type. In the arrangement shown, the circuit interrupting elements 17 each comprise a pair of spaced stationary contacts 47 and 48, between which there is movably mounted a contact bridging conductor 49. The contact 47 is shown as mounted in a stationary position at the lower end of a suitable insulating and supporting tube 50, and the contact 48 is shown as secured within the tube 50 at a point spaced upwardly from the contact 47. The contact 48 is of such a character that the movable bridging conductor 49 is adapted to slide freely therethrough when it is moved into and out of contact making engagement with the lower contact 47. The movable contact bridging conductor 49 is carried by a piston-like plug 51, which reciprocates freely within the insulated contact supporting tube 50 as the crank shaft 41 imparts movement thereto through the connecting rod 46. The piston-like plug 51 has flutted guide collars 52 and 53 which permit the insulating oil to flow therethrough and not retard its movement. As shown, the parts are in a circuit closing position and with the trip mechanism in its normal operating condition.

In connection with each of the circuit interrupting elements 17, there is a suitable overload solenoid 54. One terminal of the overload solenoid 54 is connected to the transmission circuit and its other side is connected to the contact 48. The terminal 47 is connected by means of the cable 15 to the other side of the transmission circuit. In other words, the overload solenoid 54 is connected in series with the circuit interrupting contacts of the circuit breaker. At this point it should be stated, however, that in some cases the solenoid may be energized from the secondary of a transformer, the primary of which is connected in series with the circuit breaker contacts. The solenoid 54 has a movable armature 55 which is adapted to engage a push rod 56 which operates the trip mechanism when a fault or overload condition occurs in the circuit to be controlled by the circuit breaker.

In addition to operating the circuit interrupting elements 17, the crank shaft 41 also carries a disc 57 upon which there is formed an outwardly extending stop plate 58. The stop plate 58 extends outwardly from the periphery of the disc 57, where it is adapted to engage a roller 59 carried by a bifurcated latching member 60. As shown, the latching member 60 is pivotally mounted upon a shaft 61 and is biased into a latching position by means of a spring 62. Associated with the latching member 60 there is a downwardly depending bifurcated lever forming member 63, which is likewise pivotally mounted upon the shaft 61. The lever forming member 63 has an upwardly extending end 64 having an adjustable stud 65 which engages an upstanding arm 66 carried by the latching member 60. The bifurcated lever forming member 63 is biased for rotation in a clockwise direction by means of a spring 67, which is mounted under tension between the upstanding arm 64 and a side wall of the supporting housing 10. At the lower end of the bifurcated lever 63 there is a pair of connected and overlapping links 68 and 69, the latter one of which is pivotally secured upon a stationary shaft 70. The overlapping links 68 and 69 are so disposed with relation to each other that they provide a collapsible toggle arrangement. In connection with this toggle arrangement, the link 69 carries a latch 71 which is normally operative to maintain the toggle formed by the links 68 and 69 in an extended position. Extending downwardly upon the latch 71, there is an arm 72 which is adapted to render the latch 71 inoperative and permit a collapse of the toggle arrangement formed by the links 68 and 69 upon the occurrence of a fault or overload on the circuit. Since the circuit breaker, because of its three-phase character, has three overload solenoids 54, one for each phase of the circuit, there is associated with the downwardly depending arm 72 of the latch 71 a longitudinally extending and pivotally mounted rocker bar 73 which is adapted to be rocked upwardly by any one of the solenoids 54. This rocker bar 73 extends over the three push rods 56 and beneath the downwardly depending arm 72. When the bar 73 is rocked upwardly by an actuation of any one of the overload solenoids 54, it will exert a pressure upon the downwardly depending arm 72 and rotate the latch 71 and thus release the toggle formed by the links 68 and 69. This will cause the toggle formed by the links 68 and 69 to collapse, and as a result the bifurcated lever 63 will rotate clockwise and lift the latching bar 60 out of latching engagement with the stop plate 58 carried by the disc 57, as will be readily understood. This releasing operation of the latching bar 60 will permit the shaft 41 to make one complete revolution providing, of course, the energy storing spring 24 is wound sufficiently to impart a complete revolution to the crank shaft 41. As illustrated in Figures 2, 3 and 12 of the drawings, the energy storing spring 24 is shown as wound only sufficiently to impart a one-half revolution to the shaft 41, and as a result the shaft 41 will complete but a one-half revolution when the extending arm 39 upon the plate 25 engages the stop plate 40 upon the end plate 26 of the spring motor mechanism.

At this point is should be explained that the spring motor mechanism has been shown in the drawings in its final operation performing condition in order to better illustrate the functional relation between the extending arm 39 upon the end plate 25 and the stop 40 upon the end plate 26. This is to permit a predetermined winding of the spring 24 to insure a final positive actuation thereof, and at the same time prevent an overrunning of the spring motor which might

result in the circuit breaker remaining in a circuit closing position after the spring 24 has dissipated its entire switch operating energy. Under normal operating conditions it will be understood that when fully wound the helical spring 24 will impart three and one-half complete revolutions to the crank shaft 41.

In order to reset the latching mechanism and insure a stopping of the crank shaft 41 upon each revolution thereof, and with the circuit breaker in its circuit closing position, the disc 57 carries an axially extending reset bar 74. As is better shown in Figure 3 of the drawings, the reset bar 74 is adapted to engage flanged surfaces 75 formed upon the bifurcated downwardly extending lever forming member 63. The reset bar 74 is disposed outwardly with respect to the crank shaft 41, where it will engage the flanged surfaces 75 and move the lever forming member 63 counterclockwise a distance sufficient to straighten and latch the toggle mechanism formed by the links 68 and 69. This operation will cause the latching member 60, under the influence of the spring 62, to assume its normal latching position. This latch resetting operation of the reset bar 74 will be better understood from an inspection of Figure 6 of the drawings, wherein the toggle mechanism formed by the links 68 and 69 is shown as collapsed and the flanged surfaces 75 upon the lever forming member are shown as disposed in their innermost position with respect to the crank shaft 41. When the bifurcated lever forming member 63 is in the position shown, the flanged surfaces 75 thereupon will be disposed in the path of the reset bar 74 as it moves around with the disc 57 to complete a reclosing operation of the circuit breaker. In the event that the fault or overload is overcome by an opening of the circuit, it will be understood that the trip mechanism will be latched in its operative position by the latch 71, and as a result the circuit breaker will be stopped in its next closed position, as shown in Figure 5 of the drawings, following each resetting of the toggle formed by the links 68 and 69. If the fault or overload should continue during the above operation of the reset bar 74, the latch 71 of the toggle links 68 and 69 will be held in its inoperative position by the rocker bar 73, and as a result the toggle will again collapse and prevent a dropping of the latching member 60. This will permit the crank shaft 41 to complete another reclosing operation of the circuit breaker. If the short circuit or fault is removed from the circuit by this operation of the circuit breaker, the rocker bar 73 will drop down, and as a result the latch 71 will come into operation and lock the links 68 and 69 in toggle forming relation and maintain the downwardly depending lever 63 in a position which will release the latching member 60 and permit it to stop rotation of the shaft 41 with the circuit breaker in its circuit closing position. From this description of the latching mechanism it will be apparent, in the event that the overload or fault is removed from the transmission line by a single opening of the circuit breaker, that the circuit breaker will remain in its circuit closing position upon the first reclosing thereof. It will also be apparent that in the event the overload or fault continues, the latching mechanism will be rendered entirely inoperative and permit the spring 24 to rotate the shaft 41 through three complete reclosing operations and a final opening operation of the circuit breaker.

In order to control the above operations and prevent a too rapid reclosing of the circuit, the present invention also provides means by which the speed of the first and subsequent reclosing operations of the circuit breaker may be regulated. This is accomplished in the present embodiment of the invention by resort to a dashpot 76 of special construction. Associated with the dashpot 76 and pivotally mounted upon brackets 77, there is an outwardly extending member 78 which is biased in an operative position by means of a spring 79 connected between a wall of the supporting housing 10 and an arm 80 carried by the member 78. Projecting rearwardly from the pivotal point of the member 78 and engaging a piston rod 81 of the dashpot 76, there is an arm 82, and at the outer end of the pivotally mounted member 78 there is a fixed pin engaging projection 83. Disposed above and slidably mounted upon the member 78 there is a second projection 84. The projection 83 is normally disposed in the path of a pin 85 carried by the first crank upon the crank shaft 41, and the movable projection 84 is adapted to be brought into cooperating relation with the pin 85 in the event of a sustained overload which would require more than one reclosing operation of the circuit breaker. The second or slidably mounted projection is such that it can be effectively engaged by the pin 85 only when the pivotal member 78 is in its depressed position. The manner in which the projection 83 cooperates with the pin 85 upon a first reclosing of the circuit breaker is illustrated in Figure 7 of the drawings, and the manner in which the second or slidable projection 84 cooperates with the pin 85 upon a second or subsequent successive reclosing operation of the circuit breaker is clearly illustrated in Figure 8 of the drawings.

The retarding action provided by the dashpot 76 and the pivotally mounted member 78 will be better understood from a description of the dashpot in connection with Figures 9 and 10 of the drawings. As shown in these figures of the drawings, the dashpot 76 has a double range of operation. In other words, it is adapted to permit a rapid downward swing of the pivotal member 78 for a first reclosing of the circuit breaker, and in the event of a sustained overload, it is adapted to retard the second and subsequent reclosings of the circuit breaker for a greater period of time. As shown, the dashpot comprises a single oil containing chamber in which there is a perforated piston 86 cooperating with which there is a perforation closing plate 87. Formed around the lower operating range of the piston 86 there is a constant flow by-pass conduit 88, and disposed adjacent the upper operating range of the piston 86 there is a by-pass conduit 89 which is controllable by a valve screw 90. Cooperating with the piston 86 and fixed in the lower end of the piston 76 there is an auxiliary piston forming plate 91 which is biased upwardly by means of a spring 92, as shown in Figure 10 of the drawings. The spring 92 is fixed to the bottom of the dashpot 76 by means of an engaging recess 93 and at its upper end it is secured to the plate 91. With this arrangement it will be seen that when the piston 81 is pulled upwardly, oil will by-pass through the conduit 88 in an unrestricted manner and permit a substantially unretarded downward movement of the pivotal member 78 into a position where the projection 83 will release the pin 85 upon the crank of the shaft 41 and permit the circuit breaker contacts to close. At this point the piston 81 of the dashpot 76 will start its downward move-

ment, but its return action will be retarded by virtue of an engagement between the piston 86 and the auxiliary piston forming plate 91, and as a result the pivotal member 78 will not return as rapidly to the position illustrated in Figures 5 and 6 of the drawings. The timing of the return stroke of the piston rod 81 is such that should the latching mechanism be rendered inoperative due to a sustained overload, the slidably mounted projection 84 upon the pivotal member 78 will be disposed in the path of the pin 85 upon the crank 45, as shown in Figure 8 of the drawings. In the event of a second successive reclosing of the circuit breaker and an engagement of the pin 85 with the slidable projection 84, the upper range of operation of the dashpot 76 will come into operation. Under these conditions the upward movement of the piston 86 will be retarded as determined by the setting of the valve screw 90 which controls the by-pass 89. In practice it is intended that adjustment of the valve screw 90 will be regulated to provide for a delay of from one to ten or more seconds in all subsequent successive reclosings of the circuit breaker.

The above describes the details of construction and mode of operation of the several aspects of the present invention which provide for the automatic operation desired. In addition to the automatically controlled features which operate responsive to line circuit conditions, the present invention also contemplates employment of a novel arrangement in the latching mechanism which will permit a manual control of the circuit breaker. This feature of the present invention is clearly illustrated in Figures 5, 6 and 11 of the drawings. As shown in these figures of the drawings, the latching member 60 has a rearwardly extending arm 94 which is engaged by a slotted vertically disposed link 95. Disposed below the latching member 60 and pivotally mounted upon a shaft 96, there is a stop bar 97 which is adapted to move upwardly and into the path of the stop plate 58 carried by the disc 57 where it will stop a rotation of the shaft 41 with the circuit breaker contacts in their open circuit position. The stop bar 97 has a rearwardly extending arm 98 to which the link 95 is also pivotally attached, and connected to the lower end of the link 95 there is a clevis 99 which is carried by the shank of a switch hook operating ring 100. The shank of the ring 100 extends through the bottom wall of the supporting housing 10, and the ring is disposed externally thereof where it may be conveniently engaged by a pole type switch hook. At the end of the arm 98 there is an outwardly projecting pin 101 which is engaged by a forked over-center latching member 102 that serves to retain the link 95 in its raised or lowered position as determined by an operation of the ring 100. The over-center latching member 102 has a biasing spring 103 which serves to hold it in either one of its extreme positions. With this arrangement it will be seen that when the link 95 is pulled downwardly the latching member 60 will be pulled out of engagement with the stop plate 58 and at the same time the stop bar 97 will be moved into stopping relation with the stop plate 58. This will permit a one-half revolution of the crank shaft 41 and stop the circuit breaker in its open circuit position. Upon a reverse movement of the link 95, it will be seen that the stop bar 97 will be rotated out of stopping engagement with the stop plate 58 and at the same time the latching member 60 will be permitted to move downwardly under the influence of the spring 62 and stop rotation of the crank shaft 41 with the circuit breaker in its circuit closed position. This arrangement provides a convenient means for an operator to open and/or close the switch manually without climbing the pole or tower upon which the circuit breaker is mounted.

Reference is now made to Figures 12 and 13 of the drawings for a description of the automatic operation of the circuit breaker contemplated by this invention. For the purpose of describing the operation, it will be assumed that the energy storing spring 24 is fully wound. Under these conditions the stop forming extension 39 which is carried by the switch mechanism driving gear 27 will be in a position one-quarter of a revolution clockwise from where it is shown in Figure 12 of the drawings, and the stop plate 40 will be in the position where it is illustrated. In other words, the stop forming extension 39 will be disposed at the other side of the stop plate 40. Under the assumed condition the other apparatus illustrated in Figure 12 of the drawings will be in the positions shown. That is to say, the circuit breaker will be in its circuit closing position, which is its normal operating condition.

Now, if an overload or a fault should occur upon the line in which the circuit breaker is connected, one or more of the overload solenoids 54 upon the circuit interrupting elements 17 will operate and move the rocker bar 73 so as to release the latch 71 which holds the toggle formed by the links 68 and 69 in their extended position. This will cause the toggle so formed to collapse and as a result the downwardly extending bifurcated lever member 63 will rotate clockwise and exert a pressure upon the arm 66 of the latching member 60. This will raise the latching roller 59 and release the stop plate carrying disc 57. As soon as the disc 57 is thus released, the shaft 41 will rotate counterclockwise in response to the energy supplied through the gears 27 and 42 by the spring 24. This rotation of the shaft 41 will transmit a reciprocating movement to the bridging conductor 49 through the connecting link 46, and when a one-half revolution of the shaft 41 has been completed, the circuit will be fully opened. During this one-half revolution of the shaft 41 it will be understood that the reset bar 74 will have engaged the downwardly depending lever forming member 63 and reset its retaining toggle mechanism. If the overload or fault is eliminated by this opening of the circuit breaker, the latch bar 60 will drop down and stop the shaft in the position shown. During this half revolution of the shaft 41 the pin 85 upon the crank 45 will engage the fixed projection 83 upon the dashpot controlled pivotal member 78 and move the pivotal member 78 into the position illustrated in Figure 8 of the drawings, from which position, under the assumed conditions, it will slowly return to the position illustrated in Figure 7, under control of the dashpot 76. If the overload or fault is of a continuing character and is not removed from the line by the first opening of the circuit breaker, the rocker bar 73 will be held in its uppermost position, as shown in Figure 6 of the drawings, and as a result the toggle mechanism will not be latched in its extended position. Consequently the downwardly depending lever member 63 will follow the reset bar 74 in its rotation and hold the latching member 60 in its raised position. Under these conditions, the dashpot control pivotal member 78 will

have been retarded in its upward movement, and as a result the pin 85 upon the crank 45 will engage the upper or slidable projection 84 upon the pivotal member 78. This will bring the upper range of the dashpot 76 into operation, and as a result the second and subsequent successive reclosing operations of the circuit breaker will be retarded for a definite longer period of time, depending upon the setting of the valve screw 90 upon the dashpot 76. The operation of the circuit breaker under a sustained overload with three complete reclosings and four openings of the circuit is graphically illustrated in Figure 13 of the drawings. In this diagram the circuit breaker is illustrated at the left of the diagram as in its closed position. Upon the occurrence of a short circuit, the circuit breaker will immediately open and reclose with but very little retarding action by the dashpot 76. During the first reclosing only the first range of operation of the dashpot 76 will come into operation. After the pin 85 upon the crank 45 leaves the lower projection 83 upon the dashpot controlled member 78 the bridging conductor 49 will move rapidly into its circuit closing position. The first reclosing of the circuit breaker is almost instantaneous. The diagram is taken from an actual performance, wherein the first reclosing of the circuit breaker occurred within thirty cycles, or in other words, in one-half second. After the first reclosing the circuit breaker immediately reopened and its next reclosing operation was delayed by the dashpot 76, this delay being caused by an engagement of the pin 85 upon the crank 45 with the slidable projection 84 upon the dashpot controlled member 78. This engagement between the projection 84 and the pin 85 brings the upper and controlled range of the dashpot 76 into operation. As shown in the diagram, the second reclosing may occur in from one to ten or more seconds. The third reclosing operation of the circuit breaker is substantially similar to that of the second reclosing. After the third reclosing of the circuit breaker the spring motor and its associated mechanism will be in the position illustrated in Figure 5 of the drawings, and as a result if the circuit breaker is not latched in on the third reclosing thereof, the spring 24 will rotate the gear 27 and produce a further one-half revolution in the shaft 41. This will move the bridging contact 49 into its circuit opening position with respect to the contacts 47 and 48. At the same time the extending arm 39 carried by the end plate 25 and the gear 27 will engage the stop plate 40 and the spring 24 will be rendered inoperative to exert any further energy upon the switch operating mechanism. At this time it will be understood, as previously suggested, that the spring 24 will have been initially wound in the assembling operation, and as a result it will still retain a considerable amount of stored energy. The reason for the initial winding of the spring 24 is to insure a positive operation thereof during the last eighth revolution which is used to finally open the circuit breaker.

In connection with the above operation it will be understood that when the spring 24 is fully wound, the index IIII upon the dial plate 20 will be at the top of the dial, and consequently as the spring 24 unwinds, the pointer 21 will indicate the number of opening operations still remaining in the spring 24. As shown, the dial 20 and the pointer 21 are in the relative positions assumed when the spring is in the condition illustrated in the drawings. That is to say, the pointer 21 indicates that the switch is capable of one more circuit opening operation. After this occurs the pointer 21 will come to rest at the dart marked Open unwound.

While we have, for the sake of clearness and in order to disclose the invention so that the same can be readily understood, described and illustrated specific devices and arrangements, we desire to have it understood that this invention is not limited to the specific means disclosed, but may be embodied in other ways that will suggest themselves to persons skilled in the art. It is believed that this invention is new and it is desired to claim it so that all such changes as come within the scope of the appended claims are to be considered as part of this invention.

Having thus described our invention, what we claim and desire to secure by Letters Patent is—

1. In an automatic reclosing circuit breaker, the combination of a pair of spaced stationary contacts having a movable bridging conductor forming a circuit therebetween, a mechanical operating means adapted to move said contact bridging conductor with respect to said contacts, an energy storing spring adapted to impart operative energy for a succession of operations of said mechanical operating means, stop means for preventing the transmission of energy from said spring to said operating means, overload current responsive means adapted to render said stop means inoperative upon a sustained overload and permit said operating means to operate and move said contact bridging member from its contact bridging position to a full open circuit position and back to its initial contact bridging position a plurality of times, whereby a series of circuit opening and reclosing operations of the contact bridging member will result, and time delay means cooperating with said mechanical operating means adapted to produce a time delay in all but the first reclosing operation of the contact bridging member.

2. In an automatic reclosing circuit breaker, the combination of a pair of spaced stationary contacts having a movable bridging conductor forming a circuit therebetween, a mechanical operating means adapted to move said contact bridging conductor with respect to said contacts to open and reclose the circuit between said contacts, an energy storing spring adapted to impart sufficient operative energy to said mechanical operating means for a plurality of operations of said bridging member, stop means for preventing the transmission of energy from said spring to said operating means, overload current responsive means adapted to render said stop means inoperative upon a sustained overload and permit said operating means to operate and move said contact bridging member from its contact bridging position to a full open circuit position and back to its initial contact bridging position a plurality of times, whereby a series of circuit opening and reclosing operations of the contact bridging member will result, a time delay means cooperating with said mechanical operating means adapted to produce a time delay in the reclosing operations of the above cycle, and means associated with said time delay means adapted to produce a greater time delay in the latter of two successive reclosing operations in a single operating cycle.

3. In a reclosing circuit breaker of the character described, the combination of circuit con-

trolling means adapted to be operated successively through a plurality of circuit opening and reclosing operations, means normally holding said circuit controlling means in its closed circuit position, a driving shaft having an end plate connected in driving relation with said circuit controlling means, a second plate axially displaced from said end plate and rotatable upon said driving shaft, a helical spring having a predetermined amount of stored energy disposed concentrically about said driving shaft between and attached at its ends to said plates, means for rotating said second plate about said shaft and holding it relative to said first plate, whereby energy will be stored in said spring, means for releasing said switch holding means and permitting said spring to apply its stored energy to the operation of said circuit controlling means, and means cooperating with said end plate and said second plate adapted to prevent a total dissipation of the energy stored in said spring.

4. In a reclosing circuit breaker of the character described, the combination of circuit controlling means adapted to be operated successively through a plurality of circuit opening and reclosing operations, a latching means normally holding said circuit controlling means in its closed circuit position, a driving shaft having an end plate connected in driving relation with said circuit controlling means, a second plate axially displaced from said end plate and rotatable upon said driving shaft, a helical spring having a predetermined amount of stored energy disposed concentrically about said driving shaft and attached at its ends to said plates and adapted to impart rotation to said driving shaft, means for rotating said second plate about said shaft and holding it relative to said first plate, whereby energy sufficient for a number of reclosing operations of said circuit controlling means will be stored in said spring, means for releasing said latching means and permitting said driving shaft to apply energy stored in said spring to the operation of said circuit controlling means, and means cooperating with said plates adapted to stop the operation of said circuit controlling means in its open circuit position after a predetermined number of reclosing operations.

5. In a reclosing circuit breaker of the character described, the combination of circuit controlling means adapted to operate successively through a plurality of circuit opening and reclosing operations, latching means adapted to normally hold said circuit controlling means in its closed circuit position, a driving shaft having one end connected in driving engagement with said circuit controlling means, a spring supporting member rotatably mounted upon the other end of said driving shaft, a helical spring having a predetermined amount of stored energy disposed concentrically about and attached at one end to said driving shaft and at its other end to said spring supporting member, means for rotating said spring supporting member about said shaft and holding it in a fixed position relative to said driving shaft, whereby the energy stored in said spring will be exerted upon said driving shaft, means for releasing said latching means and permitting said spring to rotate said driving shaft, and a stop upon said driving shaft adapted to engage said spring supporting member after said spring has completed its shaft rotating operation, whereby said spring will be maintained with a predetermined amount of stored energy.

6. In combination with a reclosing circuit breaker of the character described, the combination of a driving shaft, an end plate and driving gear attached to said shaft and adapted to rotate a switch operating shaft, a second plate axially displaced from said first plate and rotatable upon said shaft, a prewound helical spring having a predetermined amount of stored energy disposed concentrically about said shaft between and attached at its ends to said plates, ratchet means for rotating said second plate about said shaft relative to said first plate, whereby additional energy may be stored in said spring, means for releasing said spring to permit an application of its stored energy upon said driving shaft, and an extension upon said first plate adapted to engage said second plate after said spring has completed its energy supplying operation, whereby said spring will be maintained with a predetermined amount of stored energy.

7. In a spring motor for a reclosing circuit breaker, the combination of a partially wound helical spring, a circuit breaker operating means connected to one end of said spring, a winding plate attached to the other end of said spring, whereby additional operating energy may be stored in said spring by a further winding of same, and a stop means cooperating with the circuit breaker operating means and said winding plate adapted to prevent an operation of the circuit breaker after the additional operating energy has been dissipated from said spring.

8. In a spring motor for a reclosing circuit breaker, the combination of a partially wound helical spring, a circuit breaker operating means connected to one end of said spring, a winding plate attached to the other end of said spring, whereby additional operating energy may be stored in said spring by a further winding of same, and a stop means cooperating with the circuit breaker operating means and said winding plate adapted to stop the circuit breaker operating means with the circuit breaker in its open circuit position when the additional operating energy has been dissipated from said spring.

9. In a reclosing circuit breaker of the character described, the combination of a pair of spaced contacts, a contact bridging conductor associated with said contacts adapted to establish a circuit therebetween, a shaft having an eccentric crank connected in operative relation to said contact bridging conductor, an energy storing spring adapted to rotate said shaft, a stop means carried by said shaft adapted to prevent movement thereof under the influence of said spring, a latch cooperating with the stop means upon said shaft, a toggle means for holding said latch in its operative position, current responsive means adapted and arranged to collapse said toggle means and render said latch in operative and permit said shaft to rotate, and means carried by said shaft adapted to reset said toggle means after said shaft has made substantially one-half of a revolution, whereby said latch means will become effective to stop said shaft at the end of a complete circuit reclosing operation thereof.

10. In a reclosing circuit breaker of the character described, the combination of a pair of spaced contacts, a reciprocating plug-like conductor associated with said contacts and adapted to establish a circuit therebetween, a crank shaft having an eccentric crank connected through a link of said reciprocating conductor, an energy storing spring adapted to rotate said crank shaft, a radi-

ally extending stop means carried by said crank shaft adapted to prevent movement thereof under the influence of said spring, a latch cooperating with said radially extending stop means upon said crank shaft, a toggle means for holding said latch in its operative position, current responsive means adapted and arranged to collapse said toggle means and render said latch inoperative upon the event of an overload, and means carried by said crank shaft adapted to reset said toggle means when said crank shaft has made substantially one-half of a revolution, whereby said latch means will become effective to stop said crank shaft at the end of a complete circuit reclosing operation thereof.

11. In a reclosing circuit breaker of the character described, the combination of a pair of spaced contacts, a contact bridging conductor associated with said contacts and adapted to establish and break a circuit therebetween, a crank shaft having an eccentric crank operably connected to said contact bridging conductor, an energy storing spring adapted to rotate said crank shaft, a stop means carried by said crank shaft adapted to prevent movement thereof under the influence of said spring, a latch cooperating with said stop means upon said crank shaft, a toggle means for holding said latch in its operative position, overload current responsive means adapted and arranged to collapse said toggle means and render said latch inoperative and permit rotation of said crank shaft, means carried by said crank shaft adapted to reset said toggle means and render said latch means operative after said crank shaft has made substantially one-half of a revolution, whereby said latch means will become effective to stop said crank shaft at the end of a complete circuit reclosing operation thereof, manual means operating independently of said toggle means adapted to also render said latch inoperative, and a second latching means adapted to be simultaneously operated by said manual means to stop said crank shaft at the end of one-half a revolution thereof, whereby said contact bridging conductor will be stopped in its open circuit position with respect to said pair of spaced contacts.

12. In a reclosing circuit breaker of the character described, the combination of a pair of spaced contacts, a contact bridging conductor associated with said contacts and adapted to establish and break a circuit therebetween, a crank shaft having an eccentric crank operably connected to said contact bridging conductor, an energy storing spring adapted to rotate said crank shaft, a stop means carried by said crank shaft adapted to prevent movement thereof under the influence of said spring, a latch cooperating with the stop means upon said crank shaft, means for holding said latch in an operative position with respect to said stop means, whereby said latch means will be effective to stop said crank shaft at the end of a complete circuit reclosing operation thereof, manual means operating independently of said means for holding said latch adapted to render said latch inoperative, and a second latching means adapted to be simultaneously operated by said manual means to stop said crank shaft at the end of one-half a revolution thereof, whereby said contact bridging conductor will be stopped in its open circuit position with respect to said pair of spaced contacts.

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