

[54] **CIRCUIT INTERRUPTER WITH
OVERCENTER SPRING CHARGING
MEANS**

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[58] Field of Search200/153 SC, 70, 153 H;
185/37

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Primary Examiner—Robert K. Schaefer

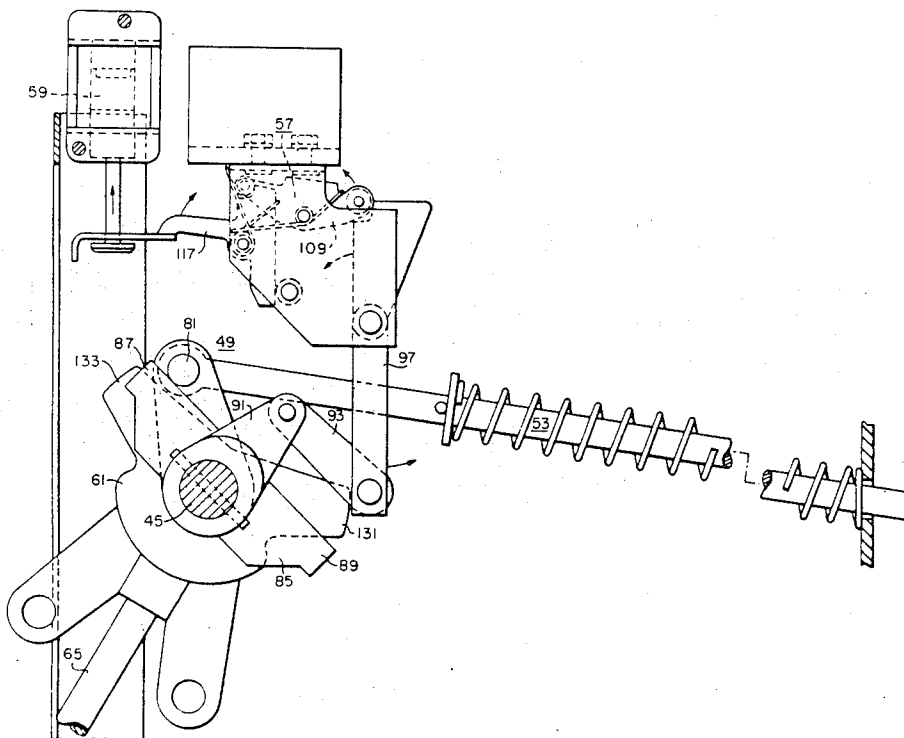
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[57] **ABSTRACT**

A circuit interrupter having stored energy overcenter spring operating means for operating the interrupter between open and closed positions and having auxiliary spring closing means for overcoming electromagnetic "blow-out" forces incurred by fault current.

9 Claims, 10 Drawing Figures



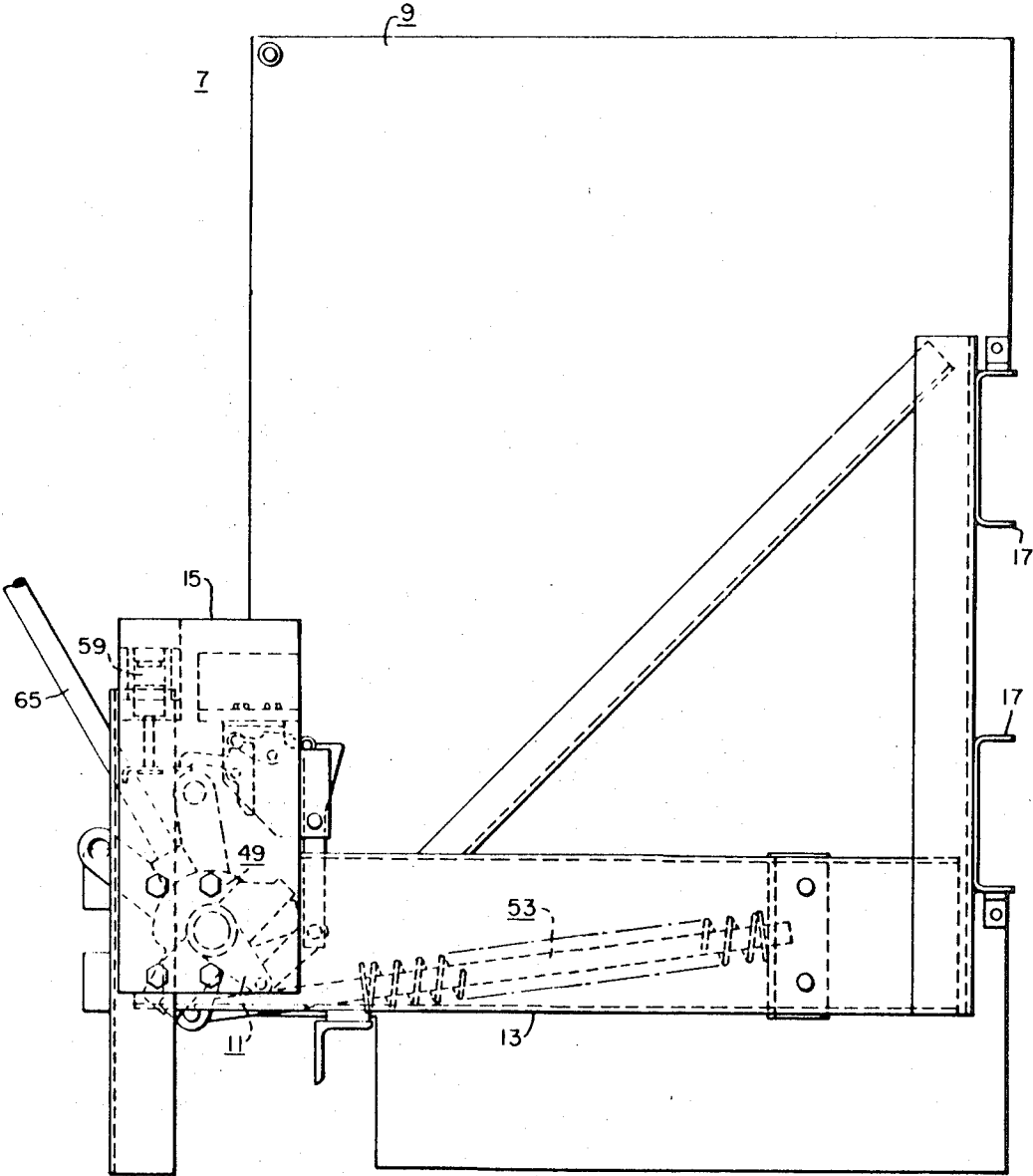
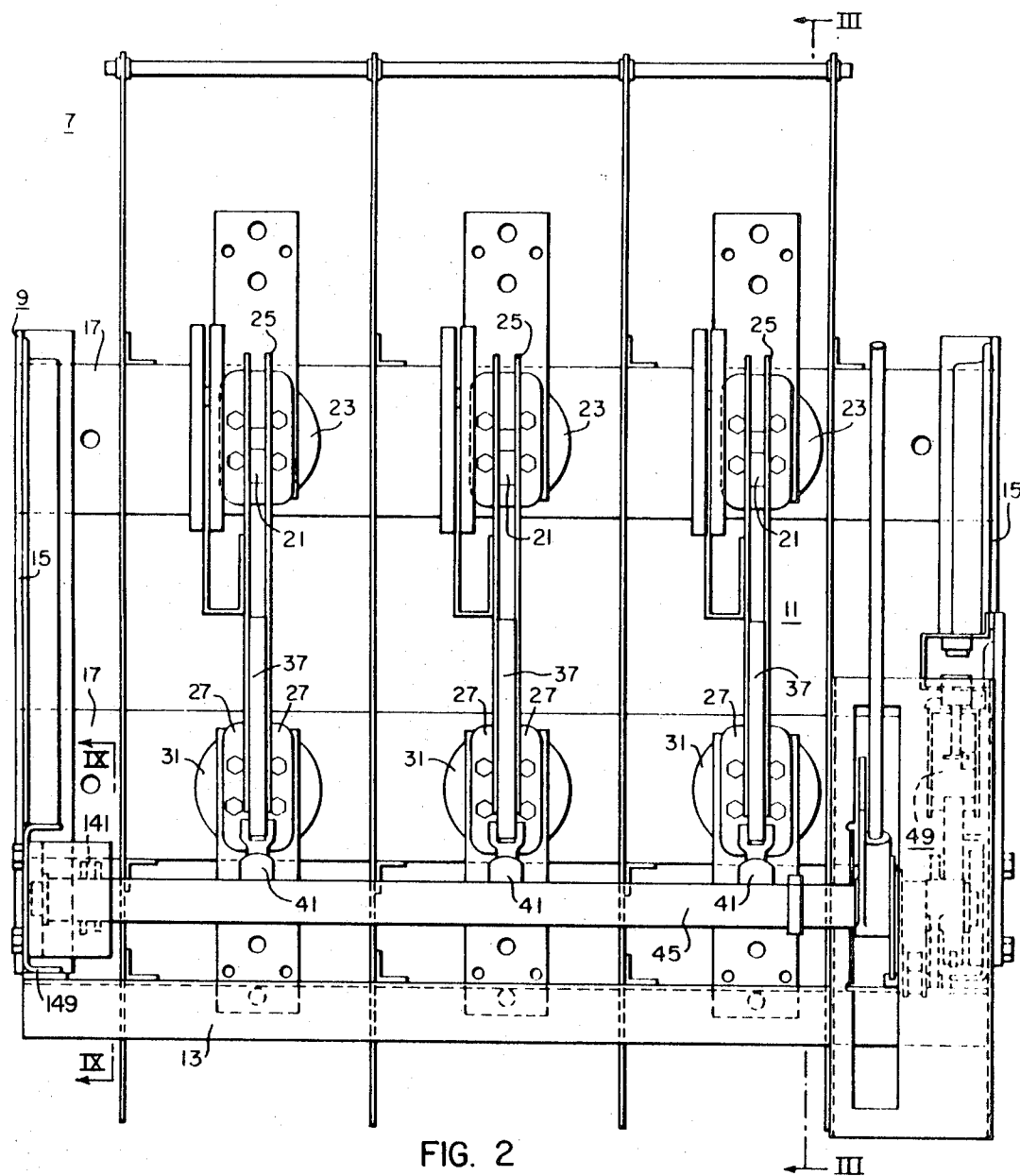


FIG. 1



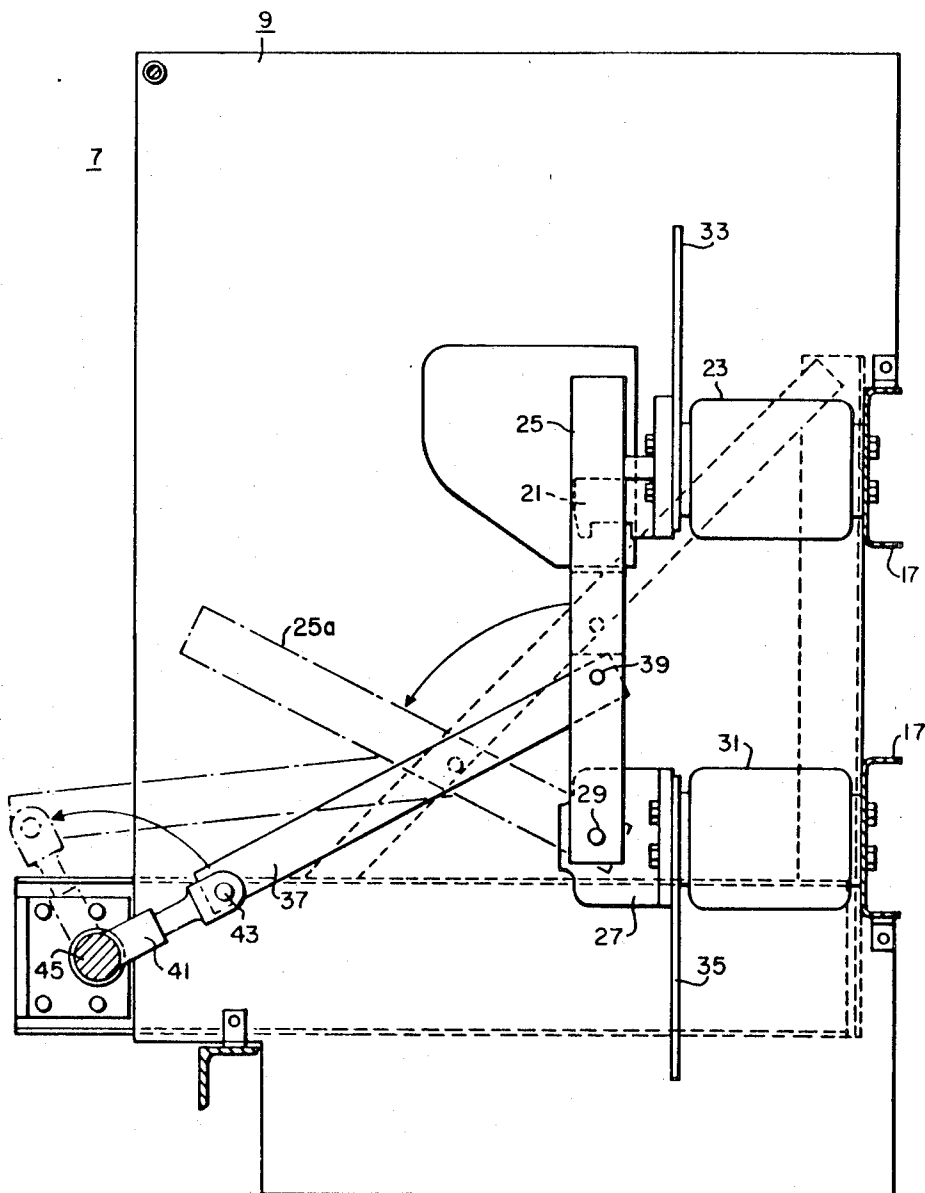
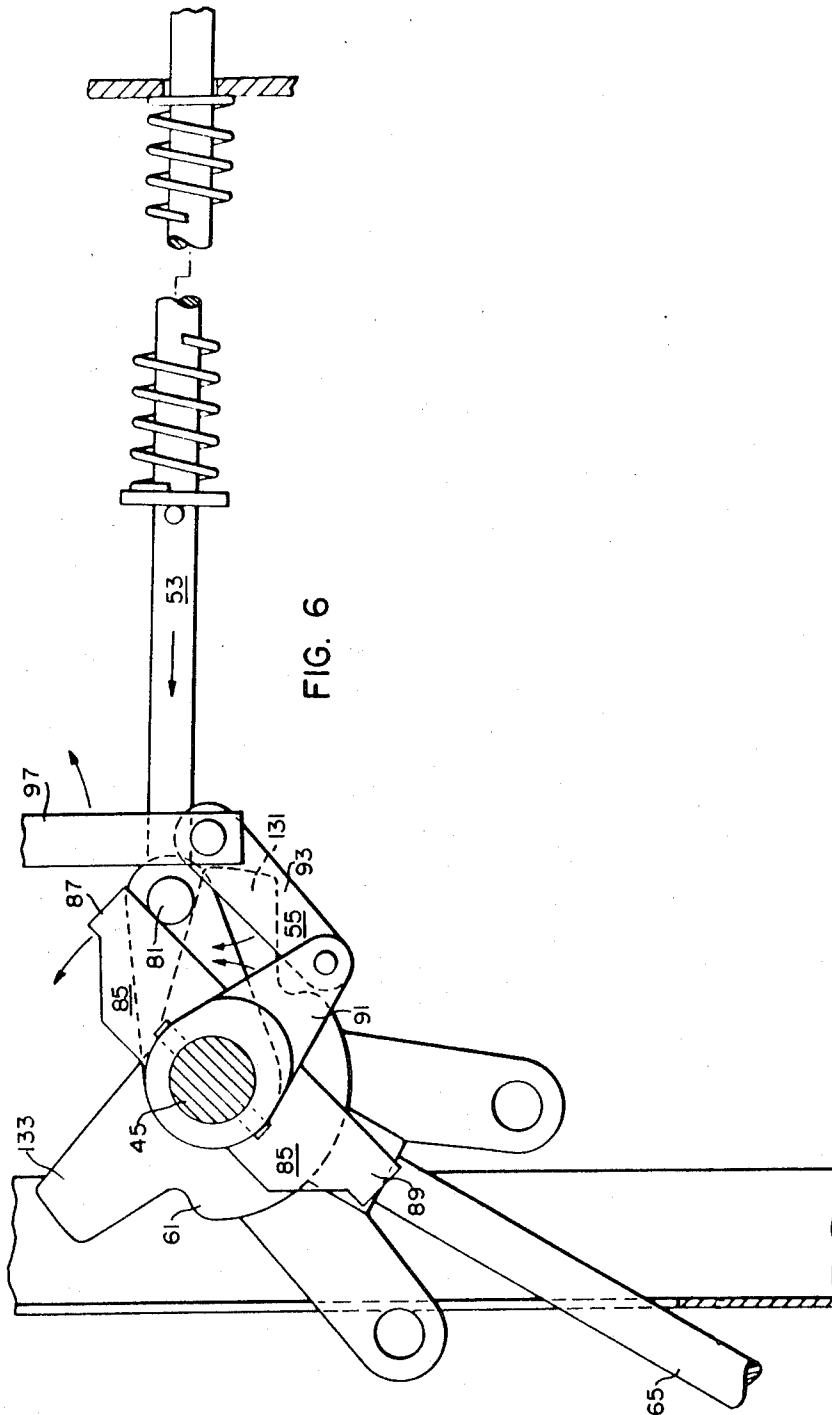


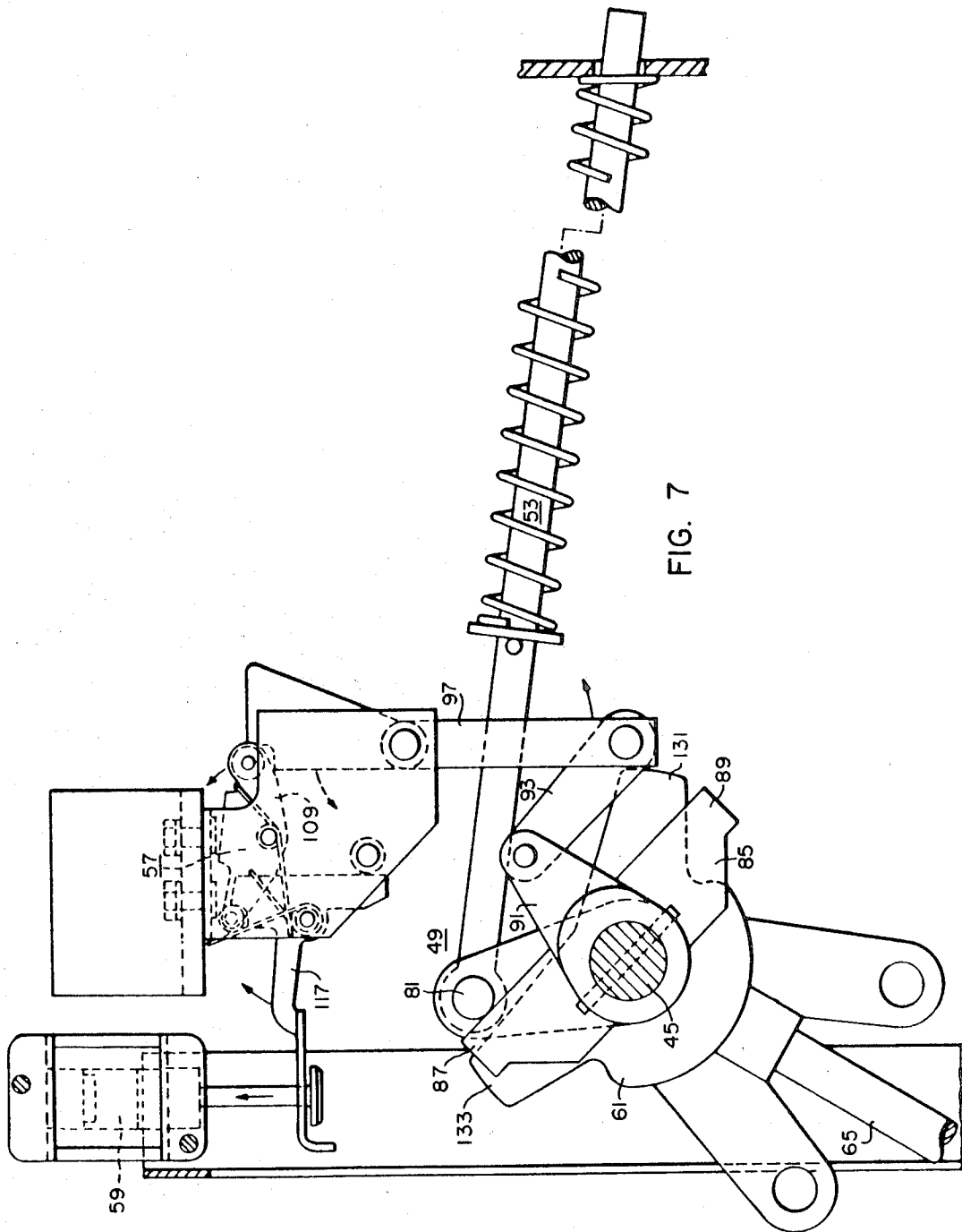
FIG. 3



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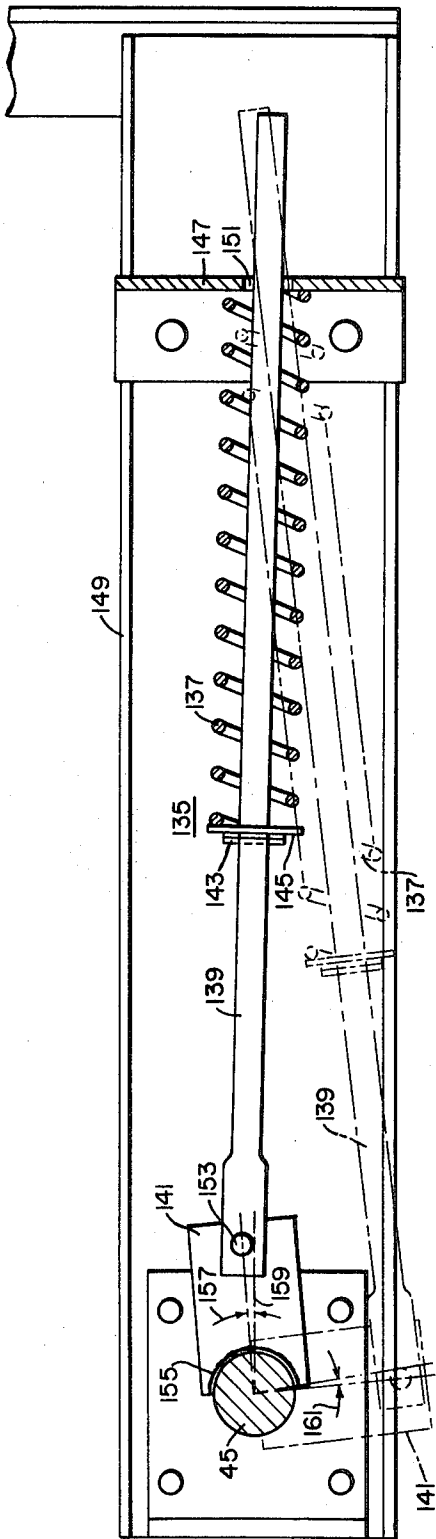
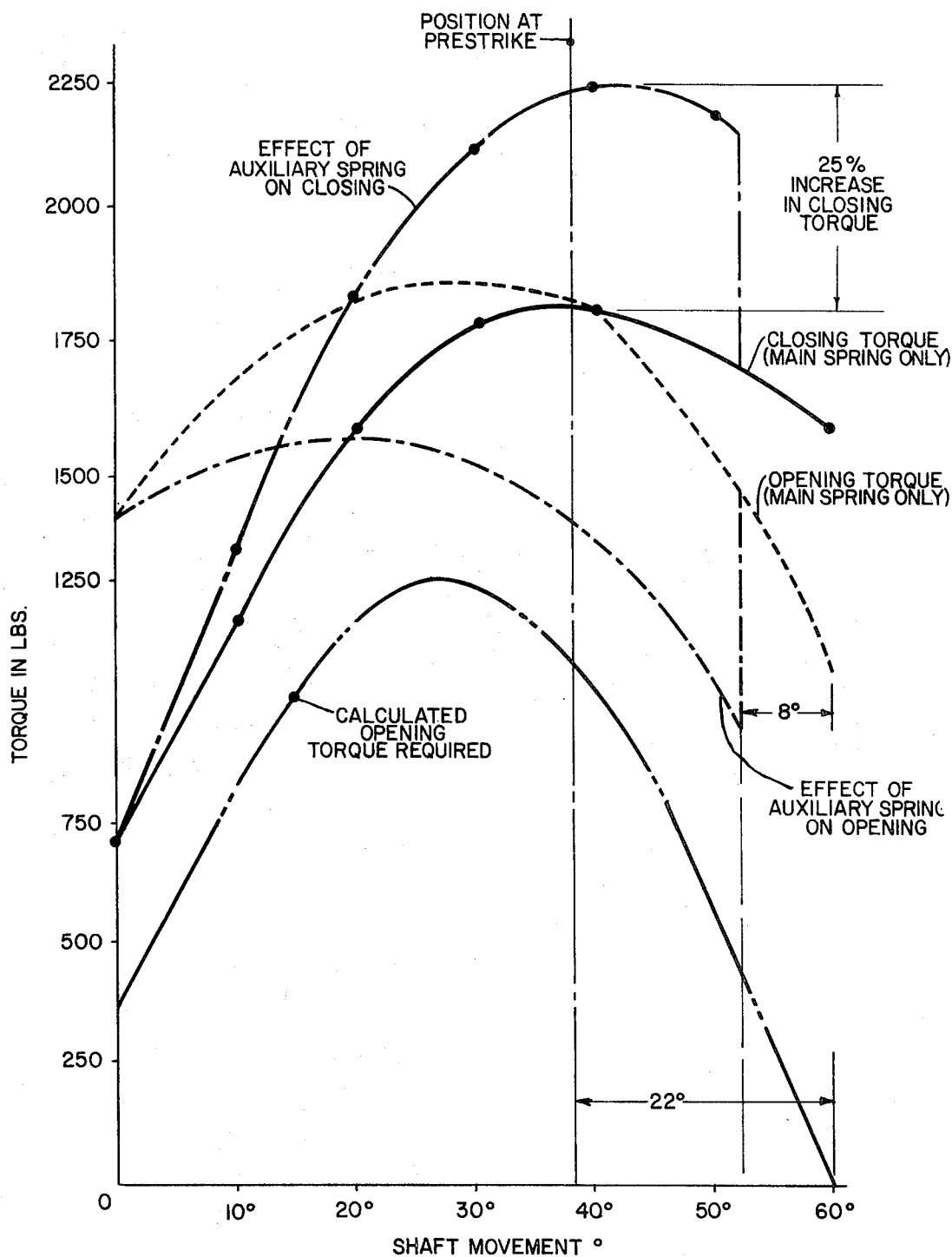


FIG. 9

FIG.10



CIRCUIT INTERRUPTER WITH OVERCENTER SPRING CHARGING MEANS

CROSS REFERENCE TO RELATED APPLICATION

Certain parts of the herein disclosed circuit breaker are disclosed in copending patent application of Norman Davies, entitled "Circuit Interrupter," Ser. No. 106,328, filed Nov. 4, 1971.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to circuit interrupters and more particularly to circuit interrupters of the type comprising a stored energy overcenter spring operating means for operating the circuit interrupter between open and closed positions and having additional auxiliary spring means for operating to the closed position.

2. Description of the Prior Art

Circuit breakers and disconnects must have the ability to be closed safely on a fault. Thus quick closing of the contacts independent of the speed of the operating handle is essential to reduce the time of arcing and to ensure that the switch is fully closed to allow for the fault current to flow through all available contact surfaces, because of the inevitable configuration of the fixed and moving contacts of the switch. The fault current sets up an electromagnetic "blow-out" force which is proportional to the square of the current. Unless the spring operating the mechanism is of such a magnitude as to overcome the "blow-out" force at the point of contact engagement during closing, the disconnect will not fully close and the contacts will be unable to carry the fault current for which reasons severe damage occurs.

To ensure successful fault closing capability, a powerful operating spring has become an inherent feature of circuit interrupters and particularly indoor disconnects. Inasmuch as the spring is also used to open the disconnect, high opening speeds are attained. In addition, most of the operating springs of the disconnects are manually charged. Since the manual effort of charging the springs limits the maximum size of the springs to be used, there is a problem in obtaining higher fault closing ratings for this type of circuit interrupter or disconnect.

SUMMARY OF THE INVENTION

It has been found in accordance with this invention that the foregoing problem may be overcome by providing biasing spring means or an auxiliary compression spring attached to the main drive shaft of the disconnect and so arranged as to provide additional energy to the shaft during the closing stroke, thereby counteracting the electromagnetic "blow-out" force and allowing the disconnect to fully close. The auxiliary spring is charged during the opening stroke of the disconnect so that it is ready for the next closing operation. The auxiliary spring is attached to the main drive shaft independently of the main operating spring, the latter of which is used for both closing and opening stroke and the only effort required by an operator is to charge the main operating spring. Manifestly, the advantage of the auxiliary spring assembly is the increased closing energy obtained without the need for additional manual operating effort.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side elevational view, with parts broken away, of a circuit interrupter constructed in accordance with the principles of this invention;

FIG. 2 is a front view of the circuit interrupter illustrated in FIG. 1;

FIG. 3 is a sectional view taken generally along the line III—III of FIG. 2;

FIG. 4 is a front view, with parts broken away, illustrating the operating mechanism shown in FIG. 2;

FIG. 5 is a sectional view taken generally along the line V—V of FIG. 4, with the parts being shown in the spring-discharged closed position;

FIG. 6 is a view of certain parts disclosed in FIG. 5 with the parts being shown in the spring-charged closed position;

FIG. 7 is a view similar to FIG. 5 with the parts being shown in the spring-discharged open position;

FIG. 8 is a view similar to FIG. 6 with the parts being shown in the spring-charged open position;

FIG. 9 is a vertical sectional view, taken on line IX—IX of FIG. 2; and

FIG. 10 is a graph showing the effects of torque upon rotation of the drive shaft under varying conditions.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to the drawings, there is shown, in FIGS. 1 and 2, a circuit interrupter 7 comprising support means 9 and a circuit-interrupter structure 11 supported on the support means 9. The support means 9 comprises backplate means 13 and a pair of side plate means 15, connected to the backplate means 13. A pair of elongated channel members 17 are supported on the side plate means 15 for supporting the terminals of the circuit interrupter.

The circuit-interrupter structure 11 comprises three stationary contacts 21 (FIGS. 2 and 3) supported on three spaced insulating members 23 that are supported on one of the back support channel members 17. A separate movable contact arm 25 is provided to cooperate with each of the stationary contacts 21. Each of the contact arms 25 comprises a pair of spaced contact members (FIG. 2) that comprise contact portions that engage the opposite sides of the associated stationary contact 21 in the closed position of the contacts. Each of the contact arms 25 is supported for pivotal movement on a separate conducting terminal 27 by means of a pivot pin 29. Each of the terminals 27 is supported on an insulating support 31 that is in turn supported on one of the channel support members 17. In each pole unit a terminal plate 33 is connected to the contact 21 and a terminal plate 35 is connected to the terminal 27 to enable connection of the pole unit in an electric circuit.

In each pole unit an elongated link 37 (FIG. 3) is pivotally connected at one end thereof to the movable contact arm 25 by means of a pivot pin 39 and at the other end thereof to a member 41 by means of a pivot pin 43. Each of the members 41 is an integral part of an elongated operating shaft 45. As can be understood with reference to FIGS. 2 and 3, the operating shaft 45 is supported on the side plate means 15 for rotational movement about the elongated axis thereof. The circuit interrupter is shown in full lines in FIG. 3 in the closed position. Upon counterclockwise movement of the op-

erating shaft 45 to the open position shown in broken lines, the three links 37 of the three pole units are moved to move the contact arms 25 to the open position shown in broken lines. Reverse or clockwise movement of the operating shaft 45 from the position shown in broken lines operates through the links 37 to move the three contact arms 25 from the open position shown in broken lines to the closed position shown in full lines.

An operating mechanism 49 (FIGS. 2, 4 and 5) is provided for operating the operating shaft 45 between the closed and open positions. The operating mechanism 49 comprises drive means 51, an overcenter spring structure 53, a latch linkage 55, a latch structure 57, and a trip device 59.

The drive means 51 comprises a drive member 61 supported on the operating shaft 45 for rotational movement relative to the operating shaft 45. The drive member 61 is provided with an opening 63 for receiving a crank rod 65 that can be placed into the opening 63 in order to crank the drive member 61 between the open and closed positions.

The overcenter spring structure 53 comprises an elongated rod 67 that extends at one end thereof through an opening 69 in a stationary plate 71 that is connected on the side plate means 15. A pin 73 and washer 75 are supported on the rod 67. An overcenter spring 77 is supported on the rod 67 between the washer 75 and the plate 71. The rod 67 is pivotally connected at the other end thereof to a member 79 by means of a pin 81. As can be understood with reference to FIG. 4, the pin 81 extends out through opposite sides of the member 79. The member 79 is supported on the operating shaft 45 for rotational movement relative to the operating shaft 45. A member 85 is fixedly secured to the operating shaft 45. The member 85 is provided with an extension 87 at one side of the operating shaft and an extension 89 at the other side of the operating shaft 45.

The member 85 is also provided with an integral extension or toggle link 91 that serves as one link of a toggle of the latch linkage 55 in a manner to be hereinafter described. The other toggle link is a member 93 that is pivotally connected at one end thereof to the part 91 by means of a pivot pin 95 and at the other end thereof to an elongated link 97 by means of a pivot pin 99. The link 97 is pivotally supported, intermediate the ends thereof, on a stationary support bracket 101 by means of a pin 103. The support bracket 101 is suitably secured to the side plate means 15. The link 97 is provided with a notch 105 at the upper end thereof that engages a roller 107 of a roller latch 109. The roller latch 109 is pivotally supported on the bracket 101 by means of a pin 111. The roller latch 109 is provided with a roller 113 at the other end thereof that engages in a notch 115 of a latch member 117 that is pivotally supported on the bracket 101 by means of a pivot pin 119. A torsion spring 121 biases the roller latch 109 in a clockwise direction to the latching position seen in FIG. 5, and a torsion spring 123 biases the latch 117 in a counterclockwise direction to the latching position seen in FIG. 5. The latch 117 is provided with an extension 127 that can be manually moved to pivot the latch 117 in a clockwise direction in order to operate the interrupter in a manner to be hereinafter described. The extension 127 may also be actuated by the electromagnetic trip 59 that comprises a plunger 129 that is raised

when the electromagnet 59 is energized to thereby automatically move the latch 117 in a clockwise (FIG. 5) direction to the actuated position.

The circuit interrupter is shown in the spring discharged closed position in FIGS. 1-5. In order to operate the circuit interrupter to the open position, the crank rod 65 is placed in the opening 63 (FIG. 5) of the drive member 61, and the crank rod 65 is manually cranked from the spring-discharged closed position seen in FIG. 5 to the spring-charged closed position seen in FIG. 6. During this movement, an extended part 131 of the drive member 61 engages the pin 81 (FIGS. 4 and 5) to drive the intermediate member 79 and spring rod 67 from the spring-discharged closed position seen in FIG. 5 to the overcenter spring-charged closed position seen in FIG. 6. During this movement, the spring 77 is charged and near the end of this movement, the spring rod 67 passes overcenter relative to the axis of the operating shaft 45 whereupon the spring 77 starts to discharge driving the pin 81 against the extended part 87 of the member 85 to bias the member 85 and the operating shaft 45, to which the member 85 is secured, in a counterclockwise (FIG. 6) direction toward the open position seen in FIG. 7. The overcenter spring structure 53 is latched in this spring charged closed position (FIG. 6) by the latch linkage 55 (FIG. 5) which prevents counterclockwise rotation of the operating shaft 45 and by the latch structure 57 which latches the latch linkage 55 in the position seen in FIG. 5. In this position, it is noted that a toggle 91, 93 of the latch linkage 55 is underset or collapsed in a downward (FIGS. 5 and 6) direction. The parts will remain in the spring charged closed position seen in FIG. 6 until release of the latch linkage 55. Thus, energy is stored for a closing operation. In order to close the circuit interrupter with the spring 77 in the charged position seen in FIG. 6, the latch member 117 (FIG. 5) is pivoted in a clockwise (FIG. 5) direction manually, by lifting the part 127, or electromagnetically by operation of the electromagnet 59 to move the plunger 129 upward to lift the part 127. During this movement, the latch 117 moves to release the roller 113 from the notch 115 permitting the roller latch 109 to rotate in a counterclockwise (FIG. 5) direction about the pin 111. This movement permits the roller 107 to move out of the notch 105 permitting the elongated link 97 to pivot in a counterclockwise direction about the pivot pin 103. This movement releases the toggle 91, 93 to release the operating shaft 45 whereupon the charged spring 77 discharges driving the rod 67 from the spring charged closed position seen in FIG. 6 to the spring discharged open position seen in FIG. 7 with the pin 81 (FIGS. 4, 6 and 7) operating against the extended part 87 of the member 85 to drive the member 85, and the operating shaft 45 to which the member 85 is secured, in a counterclockwise direction from the spring-charged closed position seen in FIG. 6 to the spring-discharged open position seen in FIG. 7. During this movement, the operating shaft 45 rotates from the closed position seen in full lines in FIG. 3 to the open position seen in broken lines in FIG. 3 moving the links 37 of the three pole units to the position seen in broken lines in FIG. 3 to thereby move the three contact arms 25 to the open position seen in broken lines in FIG. 3. Upon movement of the parts from the spring charged closed position seen in FIG. 6 to the spring discharged open position seen in FIG. 7, the toggle 91, 93 is moved from the col-

lapsed or downward underset position seen in FIG. 6 to the collapsed or upward underset position seen in FIG. 7 during which movement the link 97 is moved first in a counterclockwise direction as the toggle 91, 93 moves to the erected position and then in a clockwise direction as the toggle 91, 93 collapses to the upward underset position seen in FIG. 7. This movement automatically resets the toggle link 97 in the position seen in FIG. 7, and the springs 121, 123 automatically reset the latches 109, 117 respectively in the latching position seen in FIG. 7.

In order to manually operate the circuit interrupter from the spring-discharged open position seen in FIG. 7 to the spring-discharged closed position seen in FIG. 5, the circuit interrupter is first operated to the spring-charged open position seen in FIG. 8. With the circuit interrupter in the position seen in FIG. 7, the crank 65 is moved from the position seen in FIG. 7 to the position seen in FIG. 8. During this movement, the drive member 61 is moved with the projecting portion 133 thereof operating against the pin 81 (FIGS. 7 and 4) to drive the member 79 and the rod 67 from the spring-discharged open position seen in FIG. 7 to the spring-charged open position seen in FIG. 8. During this movement, the rod 67 goes overcenter relative to the axis of the operating shaft 45 and the spring 77, which is charged during the early part of this movement, starts to discharge forcing the rod 67 and member 79 in a counterclockwise (FIG. 8) direction. This movement is limited by the engagement of the pin 81 with the projecting part 89 of the member 85, that is secured to the operating shaft 45, and with the latch linkage 55 latched by means of the latch structure 57, the parts are latched in the stored-energy spring-charged open position seen in FIG. 8. In order to release the stored energy and close the circuit breaker, the part 127 of the latch member 117 is lifted, either manually or electromagnetically, to rotate the latch 117 in a clockwise direction to release the roller 113 from the notch 115 to release the roller latch member 109 permitting counterclockwise movement of the roller latch member 109. Upon release of the roller latch member 109 the roller 107 moves out of the notch 105 of the link 97 to permit counterclockwise movement of the link 97. This movement permits the toggle 91, 93 to move from the upward underset position seen in FIG. 7 to thereby permit clockwise movement of the operating shaft 45. The spring 77 discharges moving the rod 67 from the spring-charged open position seen in FIG. 8 to the spring-discharged closed position seen in FIG. 5. During this movement, the operating shaft 45 rotates in a clockwise (FIG. 3) direction to move the links 37 and the three contact arms 25 from the open position seen in broken lines in FIG. 3 to the closed position seen in full lines in FIG. 3. During this movement to the closed position, the movement of the operating shaft 45, operating through the toggle 91, 93 first moves the link 97 in a counterclockwise direction as the toggle 91, 93 moves to the erected position and then the link 97 is moved in a clockwise direction as the toggle 91, 93 moves to the downward underset position seen in FIG. 5. This movement moves the link 97 to the latching position seen in FIG. 5, and the springs 121,

123 operate to automatically reset the roller latch member 109 and latch member 117 in the latched position seen in FIG. 5. The circuit interrupter may then be operated to the spring-charged closed position seen in FIG. 6 and to the spring-discharged open position seen in FIG. 7 in the same manner as was hereinbefore described.

The latch linkage 55, the latch structure 57, and the trip device 59 are employed to retain the circuit interrupter in the spring-charged open position (FIG. 8) as well as in the spring-charged closed position (FIG. 6), and to release or trip the interrupter to the spring-discharged (open or closed) positions. However, it is noted that the circuit interrupter may be used without the latch linkage, the latch structure, and the trip device in which case the circuit interrupter immediately moves from the spring-charged to the spring-discharged positions as the pivot pin 81 passes through the location of alignment of the axis of the rod 67 and the shaft 45.

The circuit interrupter 7 thus far described is entirely set forth in the above-mentioned application Ser. No. 106,328. In addition, the circuit interrupter 7 includes an auxiliary spring structure or biasing spring means generally indicated at 135 (FIG. 9). The auxiliary spring structure 135 includes a compression coil spring 137, a spring lever or rod 139, and link means or member 141. In addition, the auxiliary spring structure 135 includes holding means such as a spiro pin 143 which extends through a hole in the rod 139, and a spring backup member such as a steel washer 145 which is held against the pin 143 by the spring 137. The right end of the spring 137 when in compression, as shown in solid lines in FIG. 9, is pressed against a spring support bracket 147 which in turn is secured to a frame member 149 of the support means 9 (FIG. 2). The spring support bracket 147 includes an aperture 151 through which the right end portion of the rod 139 extends in a loosely fitting manner. The left end of the rod 139, as viewed in FIG. 9, is pivotally attached such as by a pivot end 153 to the link means or member 141 which member is secured to the operating shaft 45 in a suitable manner such as by a weld 155. Though one member 141 is shown in FIG. 9, two spaced members 141 are preferred with the pivoted joint between the rod 139 and the pin 153 disposed between the members 141. Accordingly, rotation of the shaft 45 through an angle of approximately 90° causes the member 141 to move between the solid line and dotted line positions as shown. In the lowermost position of the rod 139 wherein the member 141 extends generally downwardly from the shaft 45, the spring 137 is in the expanded or discharged position which position corresponds to the discharged closed position of the overcenter spring 77 (FIG. 5).

In the upper position, the auxiliary spring structure 135 is in the fully charged position with the spring 137 compressed between the holding pin 143 and the bracket 147. The fully charged position is produced by the opening stroke of the main shaft 45 as it is rotated counterclockwise; that is, when the movable contact arm 25 moves counterclockwise from the solid-line closed position with the stationary contacts 21 (FIG. 3) to the broken line position 25a of the contact arm 25.

In the fully charged position of the auxiliary spring structure 135, the axis of the pin 153 is located at an angle 157 (FIG. 9) of about 8° above a line 159 which

line represents an alignment of the axis of the operating shaft 45 and the rod 139 which alignment occurs momentarily as the rod is moved to the charged position. When the disconnect is tripped to rotate the movable contact 25 to the closed (solid line) position of FIG. 3, the shaft 45 rotates clockwise through the 8° arc 157 during the initial closing action. As the pin 153 moves below the alignment line 159, the fully-charged spring 137 discharges to provide additional torque upon the shaft 45, whereby the movable contact arm 25 is closed with greater momentum than would otherwise be provided by only the overcenter spring 77.

However, as the movable contact arm 25 contacts the stationary contact 21, the shaft 45 enters its final rotation movement and the spring 137 has completed its discharge to its fully expanded position so that the spring 137 provides no torque over the final movement or arc 161 (FIG. 9) of rotation of the shaft 45 at that position of the shaft 45. The disconnect is virtually closed and in fact only about 2° from its final position. The purpose of the foregoing feature is to insure that the auxiliary spring structure 135 is inactive at or during the initial period (8° rotation) of the opening stroke so that all of the energy available from the main or overcenter spring structure 53 is used to overcome the static friction of the system. On the closing stroke, the maximum torque provided by the auxiliary spring structure 135 is at the disconnect pre-strike position at which the electromagnetic "blow-out" force is at a maximum value.

A graphical representation of the energy provided to drive the disconnect blade or arm 25 is shown in FIG. 10 in which the various curves are derived from calculations made on a typical mechanism. It is noted that by using the auxiliary spring structure 135 the available closing torque at the pre-strike position is increased by approximately 25 percent. Conversely, the opening torque is reduced appropriately. However, there is still sufficient torque to open the disconnect. From the curves in FIG. 10 the maximum torque produced by the main spring 77 is approximately 1800 in. lbs. Accordingly, the effort required to charge the spring 77 with a 30 inch crank rod 55 would be 60 lbs.

Although the biasing spring structure disclosed in FIG. 9 is a compression spring 137 that is compressed to a fully charged position, it is recognized within the skill of the art that a tension spring may be substituted for the spring 137 and the rod 139, which substitute spring would be in tension in the fully charged position. Such a tension spring would extend between the bracket 147 and the pin 153 where, in the charged position, the member 141 would extend upwardly above the shaft 45.

Accordingly, the auxiliary or biasing spring assembly satisfies or overcomes problems inherent in some prior art structures of circuit interrupters. The addition of an auxiliary spring assembly to the conventional toggle spring mechanism, enables the mechanism to provide increased torque to overcome the high electromagnetic "blow-off" forces when the disconnect is closed onto a fault. Thus, the fault closing rating or capability of the disconnect is increased. Moreover, the additional energy is obtained with no increase in manual operating effort. Finally, the construction of the auxiliary spring is such that it provides a very low torque producing feature at the end or final portion of the closing stroke, whereby the main spring provides maximum energy to

overcome static friction of the system on the opening stroke of the disconnects operation.

What is claimed is:

1. A circuit interrupter comprising a stationary contact and a movable contact, an operating shaft supported for rotation between open and closed positions to move the movable contact between open and closed positions relative to the stationary contact, an overcenter spring structure operatively connected to the operating shaft, drive means operable from a first position to a second position to move the overcenter spring structure from a spring discharged open position to a spring charged open position, the overcenter spring structure being movable to a spring discharged closed position for driving the operating shaft to the closed position, the drive means being operable from the second position to the first position to move the overcenter spring structure from the spring discharged closed position to a spring charged closed position, the overcenter spring structure being movable to a spring discharged open position for driving the operating shaft to the open position, biasing overcenter spring means operatively connected to the operating shaft and being movable between spring charged and spring discharged positions, one of which positions corresponds to one of the open and closed positions of the operating shaft, the other of which positions corresponds to the other of the open and closed positions of the operating shaft, the biasing overcenter spring means being chargeable only upon rotation of the operating shaft to the open position, and the biasing overcenter spring means being operable only to move the contacts to the closed position.

2. The circuit interrupter of claim 1 in which the biasing spring means is operatively connected to the operating shaft and is movable to a spring charged open position upon movement of the overcenter spring structure to the spring charged open position, and the biasing spring means is movable to a spring discharged closed position upon movement of the overcenter spring structure to the spring discharged closed position.

3. The circuit interrupter of claim 1 in which the operating shaft is rotatable in a first direction from the open position to the closed position and the operating shaft is rotatable in a second direction opposite the first direction from the closed position to the open position.

4. The circuit interrupter of claim 1 in which the biasing spring means comprises a link and spring means, the link being mounted on the operating shaft for pivotal movement between first and second positions to rotate the operating shaft between the open and closed positions, and the spring means having one end pivotally connected to the link.

5. The circuit interrupter of claim 4 in which the spring means comprises a compression spring and a spring supported rod, the rod being pivotally attached to the link and having spring-stop means spaced from the link, the spring being compressible to a charged position on the rod and on the side of the spring-stop means remote from the link upon movement of the overcenter spring structure to the spring discharged open position, and the spring being actuated to a discharged position upon movement of the overcenter spring structure to the spring discharged open position.

6. The circuit interrupter of claim 5 in which the link and rod are substantially aligned when the spring is in

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the charged position and are disposed at substantially right angles when the spring is in the discharged position.

7. The circuit interrupter of claim 1 in which the biasing spring means attains its completely discharged position before the operating shaft attains its completely closed position.

8. The circuit interrupter of claim 1 in which the biasing spring means is completely discharged before the

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movable contact reaches the completely closed position with respect to the stationary contact.

9. The circuit interrupter of claim 5 in which the compression spring has a length shorter than the effective movement of the operating shaft, whereby a reduced force is required to recharge the spring charged open position.

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