Dec. 21, 1965 J. W. MAY ETAL 3,224,280

STORED ENERGY OPERATING MECHANISM FOR CIRCUIT BREAKER

Filed April 7, 1964 3 Sheets-Sheet 1

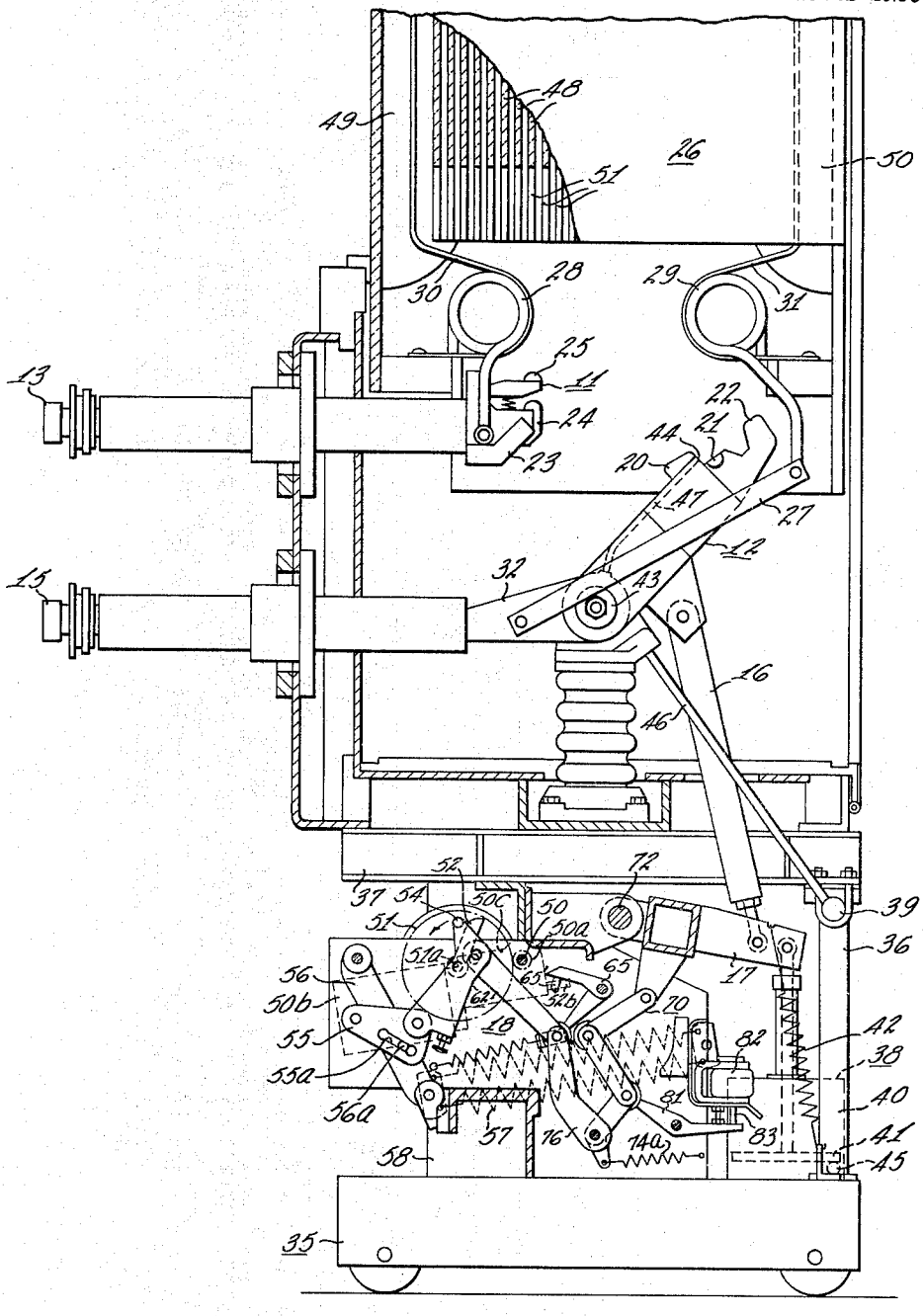

Fig. 1

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STORED ENERGY OPERATING MECHANISM FOR CIRCUIT BREAKER

Filed April 7, 1964 3 Sheets-Sheet 2

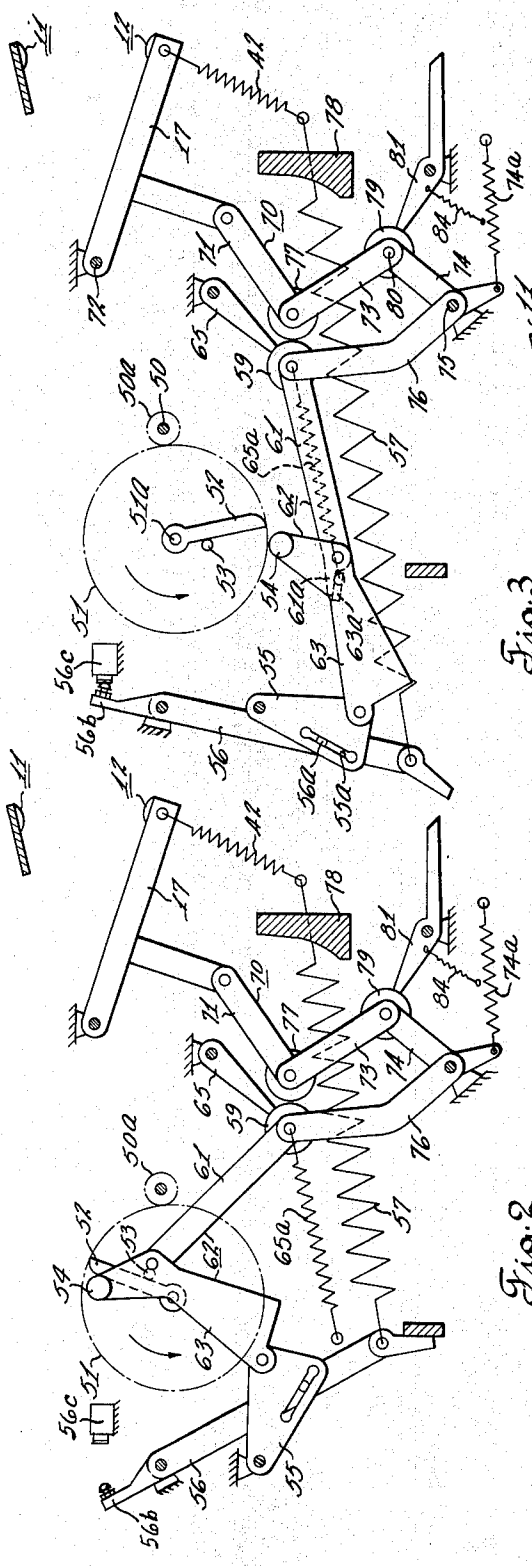

Fig. 2

Fig. 3

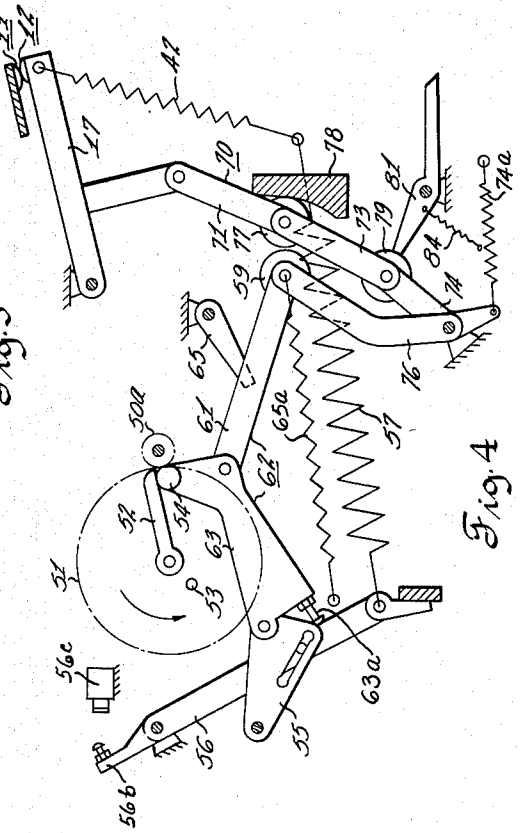

Fig. 4

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STORED ENERGY OPERATING MECHANISM FOR CIRCUIT BREAKER

Filed April 7, 1964 3 Sheets-Sheet 3

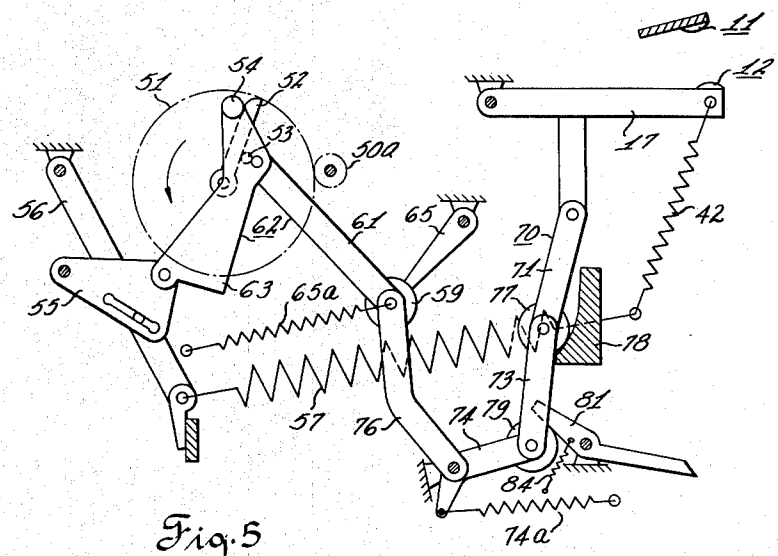

Fig. 5

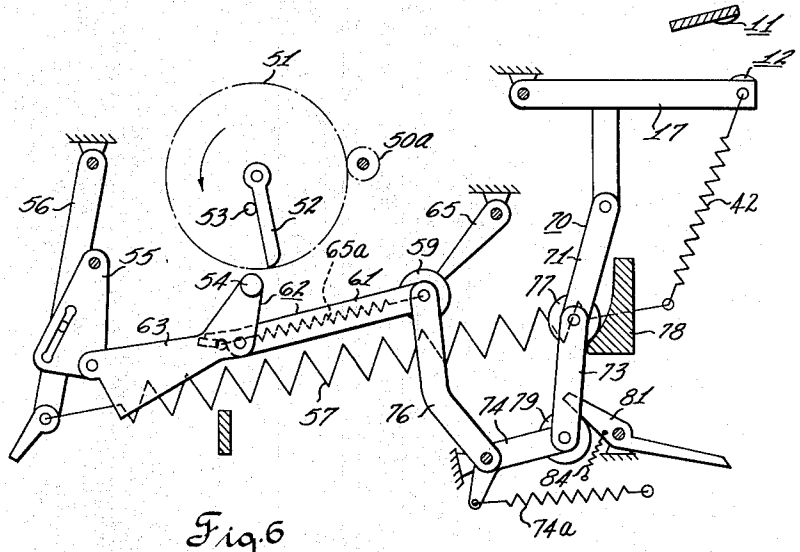

Fig. 6

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3,224,280

STORED ENERGY OPERATING MECHANISM FOR CIRCUIT BREAKER

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9 Claims. (Cl. 74—2)

This invention relates to stored energy type of operating mechanisms which may be used with an electric circuit breaker. More particularly, the invention relates to improved means for controlling the operation of such a mechanism.

In the operation of circuit breakers toggles for effecting tripping and closing of the contacts have long been employed in various combinations with different types of latching and tripping arrangements. In some instances it is important to reclose the circuit breaker contacts very shortly after they trip open. This is a complex problem in some trip free operating mechanisms where tripping allows the toggles to collapse thereby rendering the toggles incapable of transmitting closing thrust until reset. Since the resetting operation takes some time, there is a delay in reclosing the breaker after tripping.

Heretofore, some reclosing mechanisms employed hydraulic or pneumatic motors which required the reversal of piston action before the resetting operation could be completed and this also restricted the reclosing time of the breaker. Solenoid operating mechanisms have been used in place of hydraulic or pneumatic motors and, although the force output characteristics of a solenoid is ideal, the solenoid is useless if its source of electrical energy is temporarily lost. Furthermore, a solenoid increases in both cost and sluggishness with increase in size.

Stored energy closing devices have been provided which closely duplicate the increasing force characteristics of a solenoid closing mechanism. This type of device not only overcomes the problem of cost and time delay aforesaid but also is ready for use if electrical power to the closing motor is temporarily lost. In one type of stored energy operating mechanism for circuit breakers employs a relatively movable contact structure. A tripping means is arranged for controlling the contact structure and comprises a first collapsible toggle having one link thereof connected to the contact structure. Spring means are provided for causing collapse of the first toggle and actuation of the contact structure in a given direction. Means including a latch are provided for preventing collapse of the first toggle. A further means associated with the latch is utilized for releasing the latch at a particular time. Actuating means comprising a second overcenter toggle are provided for driving the first toggle to its overcenter position to actuate the contact structure in a second direction and to charge the spring means. The second toggle engages the knee of the first toggle during movement of the second toggle to its overcenter position and actuates the first toggle to its overcenter position. In this type of operating mechanism the decaying force characteristics of force transmitting springs are matched to the increasing force characteristics of a toggle operating means. Thus, the force necessary at the end of the closing stroke of the circuit breaker contacts can readily overcome the high magnetic forces encountered when closing in against a short circuit current without producing damaging contact velocities when closing in against a no load condition.

In one version of this type of operating mechanism the closing springs are charged by pivoting a walking beam by means of a spiral cam. As the cam rotates, the walking beam drops off the high point of the cam and

moves into position on a prop latch. Since the closing springs are held in charged condition through a system of at least three links and one toggle, close tolerances of parts has to be maintained. Furthermore, since the trip-free latch does not reengage until the closing springs are being recharged, the closing toggle of the four bar linkage is able to collapse.

In accordance with the present invention, a new and improved operating mechanism is provided in which the closing springs are charged by a rotating gear to drive a free swinging crank to force a two-link toggle overcenter. This permits a prop to bear gradually the increased force of the closing spring as it is charged from no load to full load without shock or impact and also eliminates the need for extremely close tolerances. In addition, the trip-free latch resets instantaneously after opening of the circuit breaker, regardless of the position of the charging springs because the spring charging toggle links collapse immediately after closing and do not interfere with the four bar linkage in any position.

It is, therefore, one object of this invention to provide a new and improved actuating means.

Another object of this invention is to provide a new and improved stored energy type of operating mechanism employing a new arrangement for controlling the operation of this mechanism and for charging the closing springs.

A further object of this invention is to provide a new and improved stored energy type of operating mechanism which is relatively simple nad inexpensive to manufacture and operates to prevent circuit breaker pumping in the event the breaker is closed on a fault.

A still further object of this invention is to provide a new and improved stored energy type of operating mechanism which can be successfully operated by a small electric motor of minimum size and force output.

A still further object of this invention is to effect high speed resetting of the circuit breaker mechanism which does not interfere with the opening of the breaker but is capable of providing resetting forces which are maintained at a high level from the instant of tripping until resetting is completed.

Objects and advantages other than those set forth will be apparent from the following description when read in connection with the accompanying drawings, in which:

FIG. 1 is a view in vertical cross section of a magnetic blowout type of circuit breaker employing the present invention;

FIG. 2 illustrates schematically the condition of the circuit breaker operating mechanism wherein the contacts are open, the closing spring is discharged, the opening spring is discharged, prop latch closed, and trip latch closed;

FIG. 3 illustrates schematically the condition of the circuit breaker operating mechanism wherein the contacts are open, the closing spring is charged, the opening spring is discharged, prop latch closed, and trip latch closed;

FIG. 4 illustrates schematically the condition of the circuit breaker operating mechanism wherein the contacts are closed, the closing spring is discharged, the opening spring is charged, prop latch open, and trip latch closed;

FIG. 5 illustrates schematically the condition of the circuit breaker operating mechanism wherein the contacts are open, the closing spring is discharged, the opening spring is discharged, prop latch closed, and trip latch open; and

FIG. 6 illustrates schematically the condition of the circuit breaker operating mechanism wherein the contacts are open, the closing spring is charged, the opening spring is discharged, prop latch closed, and trip latch open.

Referring more particularly to the drawings by characters of reference, FIG. 1 illustrates a magnetic blowout type of circuit breaker employing an arc chute into which the arc is forced by the magnetic blowout field and extinguished. The power circuit to be interrupted includes relatively movable contacts between which the arc is formed when the contacts separate at the entrance to the arc chute. Specifically, the contacts comprise a fixed contact structure **11** and a coacting movable contact structure **12**. The fixed contact structure is electrically connected to a lead in conductor stud **13** defining one terminal of the breaker, and the movable contact structure **12** comprising a pivoted switch arm having an arcing contact mounted at one end thereof is electrically connected to a conductor stud **15** defining the other breaker terminal. The pivoted contact structure **12** is suitably operated between open and closed circuit positions by an operating rod **16** that is connected through a crank **17** to a motor drive actuating means **18**.

FIG. 1 illustrates the movable contact structure **12** in contact open position, the coacting main and arcing contacts **20** and **22**, respectively, of the movable contact structure **12** being spaced apart from corresponding main and arcing contacts **23** and **25**, respectively, of the fixed contact structure **11**. A pair of lugs **21** (one of which is shown in FIG. 1) is integrated with arcing contact **22** and extends from opposite sides of a web portion of arcing contact **22**. Lugs **21** together with the web portion of the arcing contact **22** form an engaging surface which coacts with that of a block of insulating material **24** on the stationary contact structure **11** to limit overtravel of the movable contact structure **12** in the closing direction. In breaker closed position the stationary arcing contact **25** is shunted by stationary main contact **23**. Opening of the breaker by the clockwise rotation of the breaker movable contact structure **12** causes, in the sequence named, separation of the main current carrying contacts **20**, **23** and the arcing contacts **22**, **25**. The power arc is formed at the entrance of an arc chute **26**.

Arc chute **26** is illustrated as being provided with magnetic blowout means comprising blowout coils **28** and **29** arranged so as to cause the arc formed between the contacts **22** and **25** to be blown by the magnetic field into arc chute **26**. Blowout coil **28** is connected at one end thereof to a conductive arc runner **30** and at the other end thereof immediately adjacent main contact **23**. Blowout coil **29** is connected at one end thereof to a conductive arc runner **31** and at the other end thereof to a lower terminal extension **32** through a conductive bar **27**.

Upon separation of the arcing contacts **22** and **25** in a circuit interrupting action the arc terminal is transferred from stationary arcing contact **25** to arc runner **30**, thereby inserting blowout coil **28** in the arcing circuit traced from the point of connection of blowout coil **28** on the upper terminal block immediately adjacent main contact **23** through blowout coil **28** to arc runner **30**, through the arc to movable arcing contact **22**. As the arc, now established between arc runner **30** and the movable arcing contact **22**, is attenuated by the clockwise rotation of contact structure **12**, the arc envelops the lowermost portion of arc runner **31** thereby transferring the arc terminal from arcing contact **22** to arc runner **31** and inserting blowout coil **29** in the arcing circuit. The arcing circuit is now completed through the bar **27** which connects the blowout coil **29** with the lower terminal extension **32**.

The arcing contact structure and the arc chute of the circuit breaker structure are mounted on a supporting structure comprising a fabricated vehicular base structure **35**. Mounted on base structure **35** is the circuit breaker operator **18** which may be a motor driven circuit breaker movable contact actuating means. A pair of dual purpose substantially vertical or diagonal tubular members **36** (one of which is shown in FIG. 1) are provided on base structure **35**. Members **36** are connected to a horizontally arranged manifold **39** which supports a pair of

horizontal cross bracing means **37** (only one of which is show in FIG. 1). The circuit breaker elements comprising the movable contact mechanism of the circuit breaker and the arc chute are mounted on the horizontal cross bracing means **37** and the manifold **39**. Members **36** in addition to supporting the circuit breaker, further collect and distribute to a zone of arc initiation fluid under pressure from a source of fluid under pressure such as a suitable pneumatic means **38** used for aiding in cooling and extinguishing an arc drawn by the circuit breaker elements between the arcing contacts.

This pneumatic means may be an air pump comprising a cylinder **40** mounted on base structure **35** and a piston **41** movable in cylinder **40**. Piston **41** is biased in contact opening direction by an operating spring **42** which is one means for opening the circuit breaker. The motor operating means **18** through crank **17** returns piston **41** to its upper position simultaneously with a circuit breaker closing operation, thereby placing spring **42** under tension so it is capable of again opening the circuit breaker contacts. Any suitable means such as pipe connections **45** may be used for connecting the substantially vertically arranged tubular members **36** to the source of fluid under pressure, namely cylinders **40**. For the purpose of aiding in the interrupting of the arc the switch arm or movable contact structure **12** is connected to piston **41** through operating rod **16** and crank **17**. Upon the movement of contact structure **12** from closed to open circuit position under the action of springs **42**, piston **41** is actuated and moved from the top of cylinder **40** to the bottom of cylinder **40**. This movement of piston **41** causes air in cylinder **40** under piston **41** to flow through pipe connections **45**, tubular member **36**, manifold **39**, tubular member **46**, bearing **43**, tubular member **47** and nozzle **44** to the zone of arc initiation.

Arc chute **26** is provided with a group of slotted, spaced insulating plates **48** arranged to extend longitudinally of the axis of the chute and transversely to the arc at the arc receiving end thereof and a pair of chimney vents **49** and **50** arranged longitudinally of the axis of the chute one adjacent each of the arc runners **30** and **31**. The insulating barrier plates **48** may be arranged in a combination having a plurality of types of barrier plates having different geometrical configurations. Slots **51** of barrier plates **48** are aligned at their upstream ends adjacent the zone of arc initiation to form an arc passage. As well known in the art, the slots may be arranged in staggered relationship at their downstream ends. This out of registry or staggered relationship of the slots causes the formation of a zigzag shaped arc path.

The operating mechanism **18** comprises a driving shaft **50** having fixedly mounted thereon a pinion **50***a*. Shaft **50** is understood to be rotated by means of a motor **50***b* through a suitable gear train **50***c* or by means of a manually rotatable crank or handle **52***b*. Pinion **50***a* engages and drives a spur gear **51** which is rotatable about a shaft **51***a*. A free swinging driving crank or cam **52** is rotatable about shaft **51***a* and is adapted to be driven in a counterclockwise direction by a pin **53** mounted on the face of spur gear **51**. Upon counterclockwise rotation of spur gear **51**, pin **53** thereon engages driving crank **52** and causes it to rotate. Driving crank **52** engages a roller **54** which is mounted on a toggle link **63** of an overcenter toggle **62**. Toggle link **63** is pivotally connected at one end to a toggle plate **55** which has a slot **55***a* for accommodating a pin **56***a* on a bar or member **56**. Toggle plate **55** is provide to connect toggle **62** to bar **56** in such a manner as to allow for some play in the connection and to aid in force transmission as hereinafter described. Plate **55** is pivotally mounted to the supporting frame as shown in FIG. 2 and is understood to lie in a different plane than bar **56** so that bar **56** can move therepast to various operating positions. Bar **56** is pivotally supported at one end on the supporting frame and is connected at its other end to a load spring means or closing spring **57**. En-

gagement of crank **52** with roller **54** as gear **51** rotates causes toggle **62** to move from its fully collapsed position, shown in FIG. 2, to its extended position, shown in FIG. 3. As FIG. 3 shows, link **63** of toggle **62** is provided with an abutment or projection **63***a* which engages an end portion **61***a* of link **61** to prevent downward collapse of toggle **62** as the latter is moved to extended position. As FIG. 4 shows, link **63** of toggle **62** is provided with a member **63***a*, which is in the form of an adjustable screw, which is adapted to be struck by bar **56** near the end of the discharge stroke in order to force toggle **62** upward.

The motion of bar **56** to the left extends or charges load spring means (stored energy device) **57** which is attached at one end to the frame and at its other end to the bar. A latch roll **59** is rotatably attached to the end of a link **61** of toggle **62**. As spring means **57** is being charged by the movement of bar **56** to the position shown in FIG. 3, latch roll **59** of toggle **62** engages a prop latch **65** which holds the fully charged spring latched and ready to be discharged to perform a useful function, for example, closing of the movable cooperating contact structures **11** and **12** of the circuit breaker. Prop latch **65** comes into engagement with latch roll **59** due to the action of a tension spring **65***a* which moves link **62** from the position shown in FIG. 4 to the position shown in FIG. 5. The prop latch **65** may be released or tripped by a solenoid mechanism (not shown) upon movement of its armature **65'**. The release of prop latch **65** from its position shown in FIG. 3 permits bar **56** to move to the right as shown in the drawings under the force of spring means **57**. As FIG. 6 shows, after gear **51** has stopped rotating, crank **52** must be moved to a position where it is in readiness for the next cycle of operation. As FIG. 4 shows, this comes about when toggle **62** collapses and in doing so strikes the free swinging crank **52** and swings it counterclockwise so that it comes to rest against pin **53**. Once the stored energy of load spring means **57** has been released the spring means can again be recharged automatically by motor **50***b* or manually by the handle **52***b* as explained above.

After the crank **52** has rotated past roller **54** and spring means **57** has been fully charged and the prop latch **65** has held it in position, motor **50***b* is deenergized by a suitable switch (not shown) mechanically associated with and responsive to the position of toggle **62**. It is to be understood that in practice operating mechanism **18** is provided with a suitable supporting frame and that the frame and mechanism are attachable and removable as a unit from circuit breaker housing **58**.

As shown in FIGS. 3 and 6 contact structures **11** and **12** are in their contact open position when the stored energy spring means **57** is charged. Spring means **57** is connected to the contact structures **11** and **12** by means of an overcenter toggle **70**. One link **71** of toggle **70** is connected to crank **17** which is pivotally mounted at **72** to the frame of the circuit breaker operating mechanism which is attached to the housing **58** of the circuit breaker structure. The other link **73** of toggle **70** is pivotally mounted on one end of crank **74** which in turn is pivotally mounted at point **75** to the housing of the circuit breaker structure. An arm **76** is pivotally mounted at one end to the frame of the circuit breaker structure at point **75** and is pivotally connected at its other end to the roller end of overcenter toggle **62**.

When prop latch **65** is released by the solenoid mechanism (not shown) and rotates clockwise it releases latch roller **59**. Roller **59** and link **61** of overcenter toggle **62** rotate clockwise coming in contact with a roller **77** which interconnects links **71** and **73** and forms the knee of overcenter toggle **70**. Latch roller **59** drives roller **77** and overcenter toggle **70** past its overcenter position until roller **77** reaches arcuate stop **78** as shown in FIG. 4. The movement of toggle **70** to its overcenter position causes crank **17** to rotate counterclockwise to cause engagement of the contact structures **11** and **12**.

At the instant that overcenter toggle **70** is moved to its overcenter position against stop **78**, latch roll **79** mounted on pin **80** interconnecting link **73** of toggle **70** and crank **74** engages a prop latch **81** affixed to the housing of the circuit breaker, thus holding the contact structures **11** and **12** closed against the force of their contact opening spring **42**. Spring **42** which is diagrammatically illustrated as being connected between crank **17** and the housing of the circuit breaker structure is charged by the contact closing mechanism described. Upon release of toggle **70** from its overcenter position by prop latch **81** spring **42** opens the contact structure. The prop latch **81** may be released or tripped by a solenoid mechanism **82** which upon movement of its armature **83** downward as shown in FIGS. 5 and 6 actuates the prop latch **81** to rotate it clockwise releasing latch roll **79**, thereby permitting the overcenter toggle **70** to collapse to the position shown in FIGS. 5 and 6. Upon deenergization of solenoid mechanism **82**, armature **83** assumes its normal position shown in FIG. 1 and spring **84** on latch prop **81** biases it back to its latch engaging position shown. Before spring **84** can return latch **81** to its normal position, a spring **74***a* connected to one end of crank **74** rotates crank **74** counterclockwise to effect collapse of toggle **70** to the position shown in FIG. 2. As previously stated, before toggle **70** can collapse, toggle **62** must be in collapsed condition.

In accordance with the invention claimed motor **50***b* is energized whenever the spring means **57** is discharged. This occurs by the use of an electrical switch **56***c* shown in FIGS. 2, 3 and 4, associated with the position of toggle **62**. More specifically, bar **56** which is movable by toggle **62** comprises a portion **56***b* which is adapted to move into and out of engagement with switch **56***c* to operate it. When switch **56***c* and portion **56***b* are disengaged, motor **50***b* is energized. When switch **56***c* and portion **56***b* are engaged, motor **50***b* is deenergized. Thus, motor **50***b* through its associated gearing **50***c* rotates gear **51** counterclockwise to drive crank **52** against latch roller **54**. This action first causes upward movement of toggle **62**, but as the clockwise rotation of bar **56** continues, toggle **62** is moved downwardly thereby charging spring means **57**. During the spring charging operation prop latch **65** holds latch roller **59** and toggle **62** in a given position and motor **50***b* drives gear **51** counterclockwise until it reaches the position shown in FIG. 3 whereupon motor **50***b* is deenergized. Upon release of latch prop **65** by a solenoid mechanism similar to mechanism **82**, toggle **62** moves from the overcenter toggle position shown in FIG. 3 thereby driving by means of latch roll **59** on toggle **62**, latch roller **77** and toggle **70** to their overcenter position against stop **78**. The movement of toggle **70** to its overcenter position causes the closing of the contact structures **11** and **12**.

As soon as the contact structures **11** and **12** have been closed and their opening spring **42** charged upon movement of toggle **62** from its overcenter position, motor **50***b* is energized and spring means **57** recharged. However, during the instant that toggle **62** remains in its discharged position as shown in FIG. 4, the contact structures **11** and **12** may be tripped open to the position shown in FIGS. 5 and 6 by energizing solenoid mechanism **82** resulting in clockwise rotation of prop latch **81**. Release of crank **74** causes clockwise rotation thereof under the force of spring **42** resulting in opening of contact mechanism **11** and **12** without interference with toggle **62**. The resulting trip free movement of contact mechanisms **11** and **12** is shown in FIG. 6.

As noted from the drawing, approximately one revolution of gear **51** charges spring means **57**. The gear **51** is so provided that an equal torque is imposed on motor **50***b* for the whole of the revolutions in question. Energy is impressed on the spring at an equal rate throughout the charge revolution of motor **50***b*. Further by the

use of a double toggle mechanism in combination with spring stored energy devices the contact closing operation is accomplished by the release of energy from spring means 57. This occurs as toggle 70 is moved to its extended and overcenter position by toggle 62 as the latter is moved from its extended position by spring 57. Thus, as spring means 57 reaches its most weakened condition (its energy almost completely spent) the toggle mechanisms reach their highest mechanical advantage. A large contact closing force is available near contact closed position on springs which have given up most of their energy. It is to be noted that at the start of the discharge of spring 57, plate 55 is initially in the position with respect to toggle 62 as shown in FIG. 3. During discharge of spring 57, toggle 62 acts as a single member in transmitting force and plate 55 cooperates therewith in its toggle action. During discharge of spring 57, plate 55 pivots in a counterclockwise direction to afford an increasing mechanical advantage whereby the force on toggle 70 remains constant even though the force exerted by spring 57 is diminishing.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In an operating mechanism having a first toggle movable from a collapsed position to an overcenter position, actuating means for moving said first toggle to said overcenter position, said actuating means comprising, in combination, a second toggle movable from a collapsed position to an extended position, a spring operatively connected to said toggle and movable from discharged to charged condition by said second toggle as the latter moves to its extended position, releasable latching means for maintaining said second toggle in extended position and said spring in charged condition, and means for moving said second toggle from collapsed position to its extended position, said means comprising a gear rotatable about an axis and having a projection thereon, and a crank rotatable with respect to said gear about said axis and adapted to be engaged by and rotated by said projection on said gear, said crank being adapted to engage said second toggle to move said toggle to extended position.

2. In an operating mechanism having a first toggle movable from a collapsed position to an overcenter position, actuating means for moving said first toggle to said overcenter position, said actuating means comprising, in combination, a second toggle comprising two links and movable from a collapsed position to an extended position, a spring operatively connected to said second toggle and movable from discharged to charged condition by said second toggle as the latter moves to its extended position, releasable latching means for maintaining said second toggle in extended position and said spring in charged condition, a gear rotatable about an axis and having a projection thereon, a crank rotatable with respect to said gear about said axis and adapted to be engaged by and rotated by said projection on said gear, and crank engaging means on one link of said second toggle adapted to be engaged by said crank as the latter rotates to cause movement of said second toggle to its extended position.

3. The combination according to claim 2 wherein, upon release of said latching means, movement of said spring to discharged condition effects collapse of said second toggle and said crank engaging means comprises a portion which strikes said crank to move said crank into position for its next cycle of operation.

4. In an operating mechanism mounted on a support having a first toggle movable from a collapsed position to an overcenter position, actuating means for moving said first toggle to said overcenter position, said actuating means comprising, in combination, a second toggle comprising two links and movable from a collapsed position to an extended position, a member movable from one position to another, said member being operatively connected to one end of said second toggle, a spring connected at one end to said member and at its other end to said support and movable from discharged to charged condition by movement of said member from its one position to its other position, a gear rotatable about an axis and having a projection thereon, a crank freely rotatable with respect to said gear about said axis and adapted to be engaged by and rotated by said projection on said gear, means effecting rotation of said gear when said member moves to its said one position and for stopping rotation of said gear when said member moves to its said other position, crank engaging means on one link of said second toggle adapted to be engaged by said crank as the latter is rotated by said projection on said gear to cause movement of said second toggle to its extended position, and releasable latching means for maintaining said second toggle in its extended position and thereby maintaining said member in its said another position and said spring in charged condition.

5. The combination according to claim 4 wherein said crank and said crank engaging means comprise cooperating portions whereby upon movement of said second toggle from its extended position to its collapsed position, said cooperating portion on said crank engaging means strikes said cooperating portion on said crank to effect rotation of said crank to a position placing it in readiness for its next cycle of operation.

6. The combination according to claim 5 including means connected between said member and said second toggle for cooperating with the latter in moving said first toggle so that the force transmitted to said first toggle remains constant even as the energy of said closing spring diminishes.

7. The combination according to claim 1 including a member movable from one position to another and operatively connected to said second toggle and to said spring, said member being in said another position when said second toggle is extended and said spring is charged.

8. The combination according to claim 7 including means connected between said member and said second toggle for cooperating with the latter in moving said first toggle so that the force transmitted to said first toggle remains constant even as the energy of said closing spring diminishes.

9. The combination according to claim 8 wherein said means comprises a plate pivotable about a point, pivotably connected to said second toggle, and slidably connected to said member, said plate being adapted to transmit force from said member to said second toggle as said member moves from said other position to its said one position.

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MILTON KAUFMAN, *Primary Examiner.*