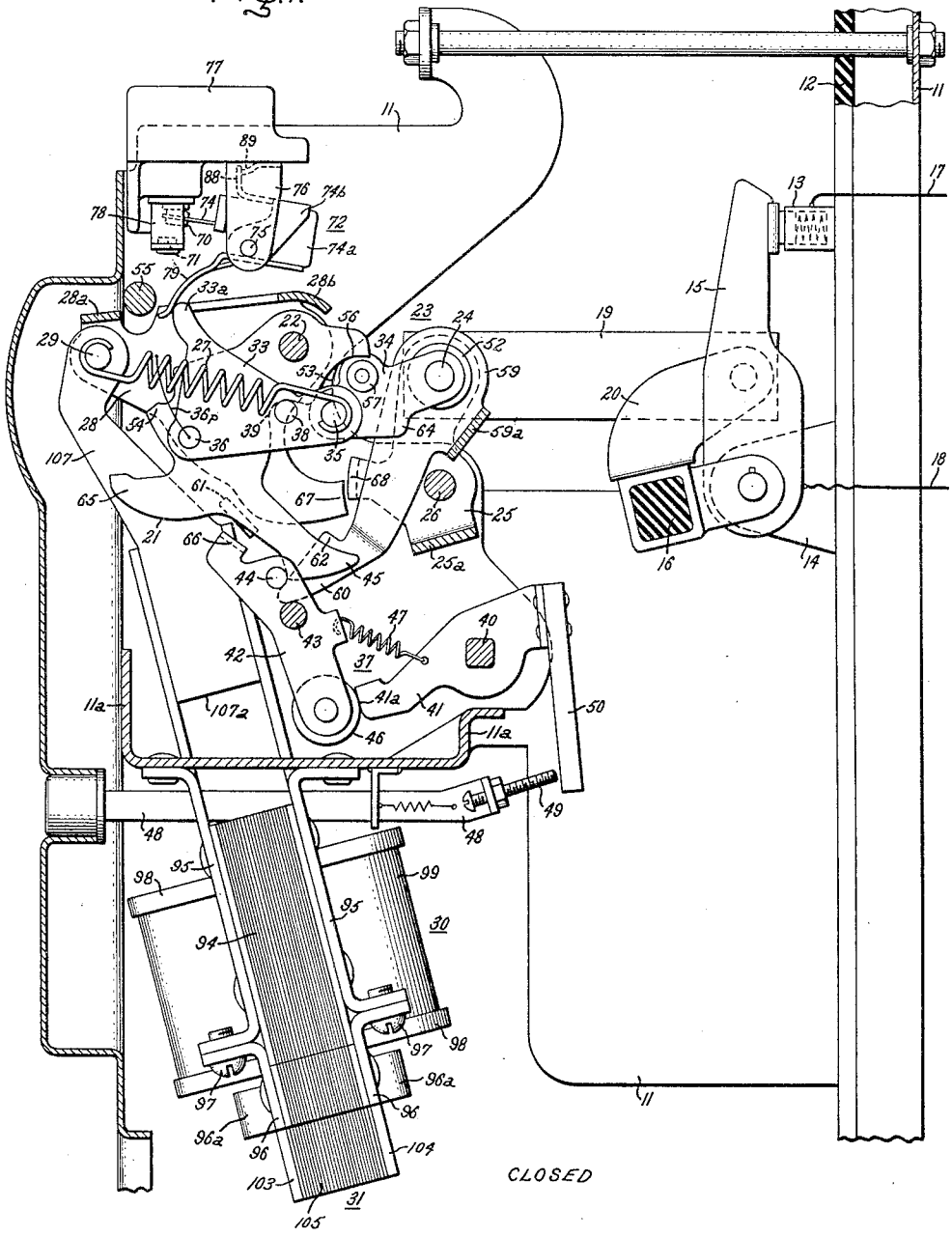
Nov. 22, 1960 L. L. BAIRD 2,961,510

OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

Filed Feb. 4, 1959 5 Sheets-Sheet 1

Fig. 1.



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OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

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Fig. 2.

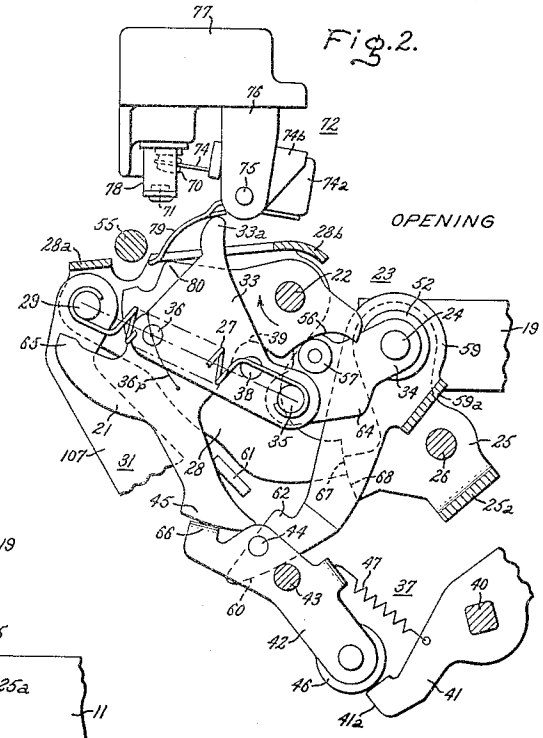


Fig. 4.

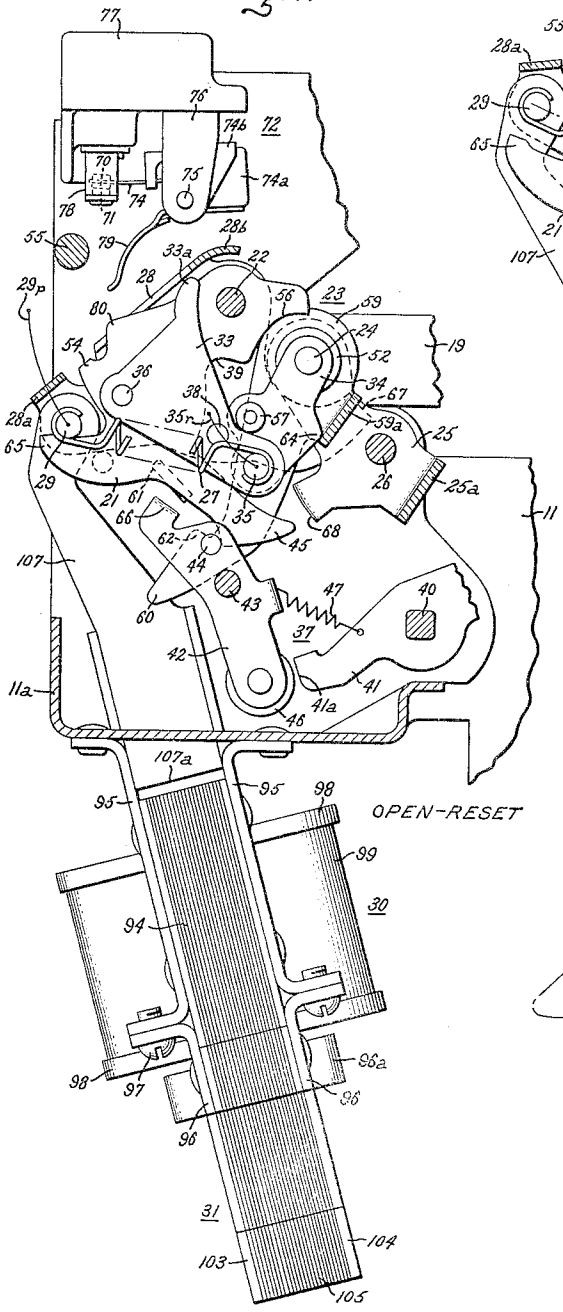
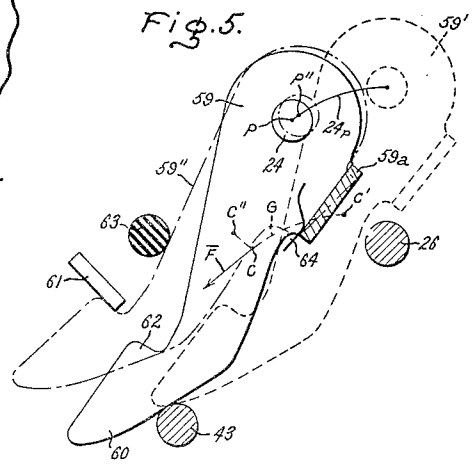


Fig. 5.



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OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

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Fig. 3.

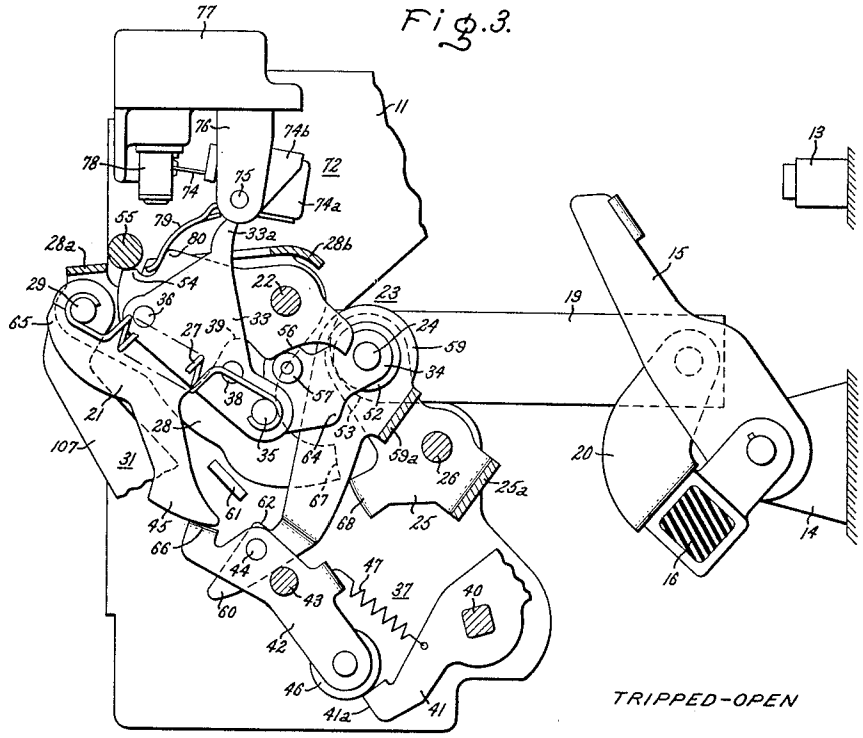
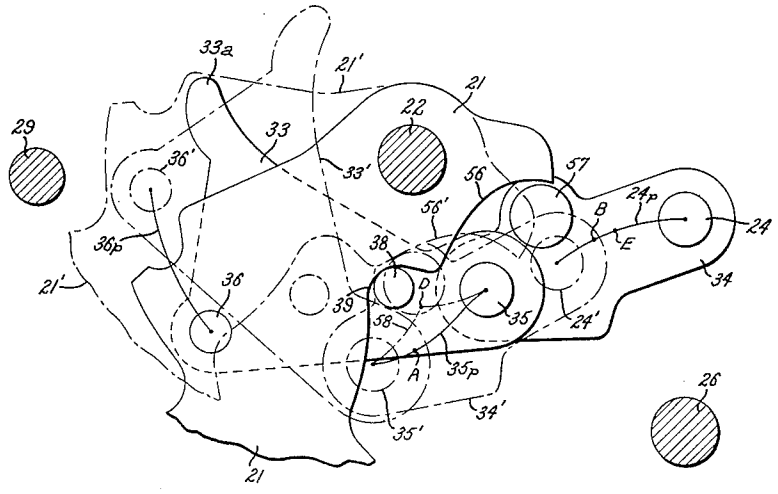


Fig. 3a.



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OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

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Fig. 6.

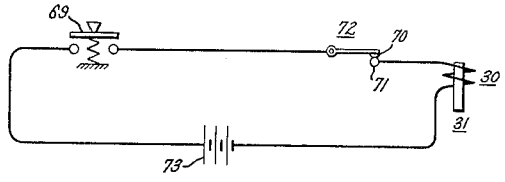


Fig. 7.

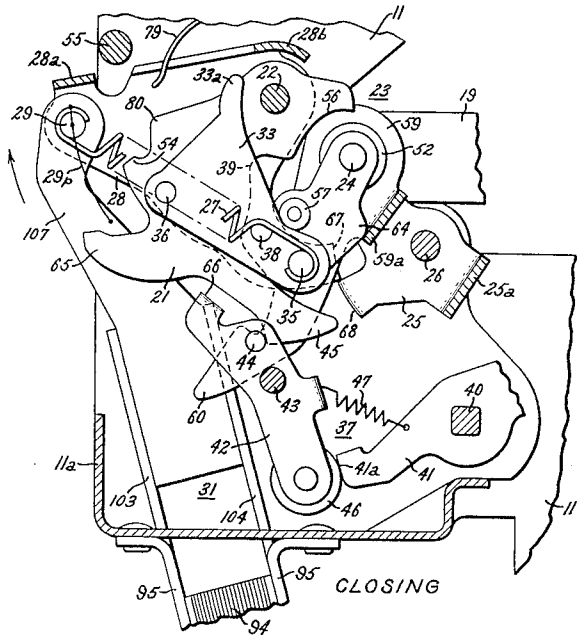
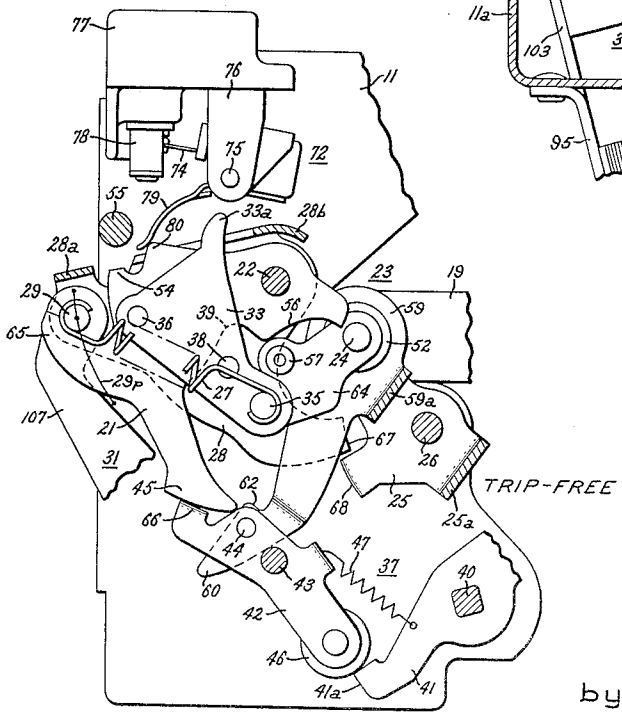


Fig. 8.



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OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

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Fig. 9.

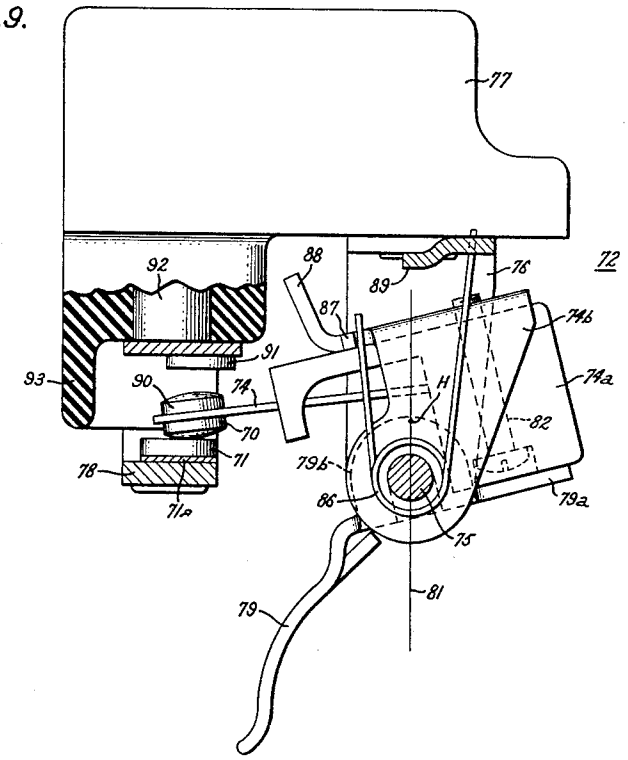
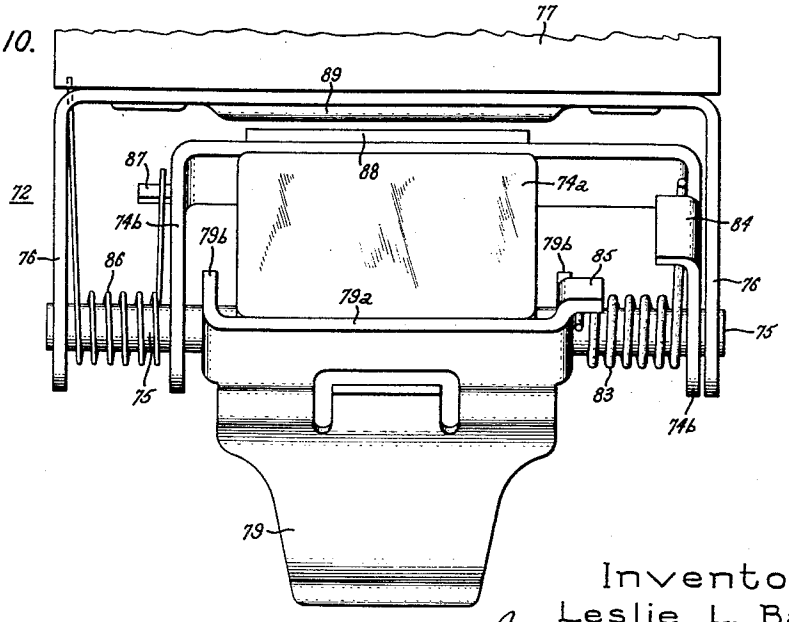


Fig. 10.



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2,961,510

OPERATING MECHANISM FOR AN ELECTRIC CIRCUIT INTERRUPTER

Leslie L. Baird, Swarthmore, Pa., assignor to General Electric Company, a corporation of New York

Filed Feb. 4, 1959, Ser. No. 791,106

35 Claims. (Cl. 200—106)

This invention relates to an electric circuit interrupter or breaker, and more particularly it relates to a circuit breaker operating mechanism wherein a spring is arranged to release stored energy to the mechanism for obtaining quick-action circuit closing and opening operations.

Such stored energy mechanisms are commonly used in low-voltage air circuit breakers for driving a movable switch member between open and closed circuit positions. Mechanical energy is first accumulated in the spring by the controlled action of a movable operating member connected thereto. By moving the operating member from a reset position to an operated position with the mechanism in a releasably latched condition, the spring is stressed and accumulates energy the release of which imparts quick and positive switch closing movement to the mechanism.

The latched condition of a typical operating mechanism of this type is maintained by a latch which releasably restrains one member of the mechanism in a predetermined latched position. An unlatching operation enables the one member to move to an unlatched position, whereupon the operating mechanism collapses and circuit opening movement of the switch member is effected. In order subsequently to reset the mechanism in preparation for another closing operation, the one member is returned to its latched position.

It has been proposed to utilize electroresponsive means for moving the operating member of the above-described mechanism from reset to operated positions, thereby charging the mechanism spring. With this arrangement it is necessary to provide suitable switching means, such as a cutoff switch, for automatically deenergizing the electroresponsive means at the appropriate moment during the closing operation.

A general object of the present invention is to provide an improved circuit breaker operating mechanism of this type.

It is a more specific object of the invention to provide a circuit breaker having an operating mechanism of this type wherein the deenergization of the electro-responsive means is delayed until the final stages of the switch closing movement of the mechanism, thereby ensuring that the movable switch member of the breaker will close, and wherein reenergization of the electroresponsive means is prevented as long as the switch member is in its closed circuit position.

Another object of this invention is the provision of a breaker operating mechanism having means for maintaining the electroresponsive means deenergized whenever the aforesaid one member is in its unlatched position, thereby ensuring that the movable switch member is in its open circuit position and the mechanism is resetting before the electroresponsive means can be reenergized.

Still another object is the provision of an improved operating mechanism wherein the electroresponsive means is deenergized before the operating member reaches its operated position in the event that a closing operation

is attempted with the mechanism in an unlatched condition.

It is still another object of the invention to provide an improved electric switch comprising separable contacts and a control arm therefor, the control arm being adapted in cooperation with the above-described operating mechanism to actuate the contacts for deenergizing the electroresponsive means, wherein there is negligible tendency for the contacts to separate prematurely due to the shock of the operating member attaining its operated position during a normal closing operation.

A further object is the provision of an improved circuit breaker operating mechanisms having inertia actuated, gravity resetting means responsive to the opening velocity of the switch member for preventing appreciable rebound of the switch member from its open circuit position.

The operating mechanism described generally above may comprise a toggle having one end connected to the switch member of the circuit breaker and having its other end supported by a guide member which is disposed for movement from a latched position, where it is releasably held by suitable latch means, to an unlatched position. An overcenter spring interconecting the operating member and the toggle is effective in response to movement of the operating member to its operated position with the guide member in its latched position to produce snap-action switch closing movement of the toggle, and the same spring is also effective in response to guide releasing operating by the latch means with the operating member in its operated position to drive the guide member to its unlatched position and produce switch opening movement of the toggle.

It is another object of the present invention to provide an improved operating mechanism of this type having means for obtaining a substantially uniform rate of energy release by the overcenter spring throughout the opening operation, whereby the switch member moves smoothly to its open circuit position from which its rebound is resisted by a relatively high force gradient exerted by the spring.

In carrying out my invention in one form, I provide a circuit interrupter including a movable switch member, an operating mechanism connected to the switch member and a movable operating member. The operating mechanism includes a guide member disposed to be releasably restrained in a latched position by suitable latching means and a spring connected to the operating member, the spring being arranged to release stored energy for imparting quick-action switch closing movement to the mechanism in response to movement of the operating member from a reset position to an operated position with the guide member in its latched position. The mechanism is arranged to undergo switch opening movement in response to subsequent release of the guide member by the latching means. Movement of the operating member is obtained by electroresponsive means, such as a solenoid and cooperating armature. I provide means responsive to the switch closing movement of the mechanism for deenergizing the electroresponsive means, the deenergizing means also being responsive to the switch opening movement of the mechanism thereby preventing the initiation of a subsequent closing operation until the operating mechanism is being reset by the return of the guide member to its latched position.

In one aspect of my invention, the aforesaid deenergizing means comprises an electric switch having a shaft supported by a base member which is subject to mechanical shock when the operating member of the circuit interrupter attains its operated position. An assembly is pivotally supported by the shaft and includes an electric contact normally disposed in engagement with a cooperating

electric contact mounted on the base, the contacts being electrically connected in series relationship in the energizing circuit of the electro-responsive means. The assembly also includes a control arm disposed in cooperation with the operating mechanism for actuating the movable contact to a disengaged position. I distribute the total mass of the assembly so that its center of gravity lies approximately in the plane of the principal vibratory motion of the axis of the shaft with the movable contact in its engaged position, whereby the tendency for the assembly to move pivotally on the shaft upon the occurrence of the aforesaid mechanical shock is minimized.

In another aspect of my invention, I provide means for preventing appreciable rebound of the circuit interrupter switch member from its open circuit position upon the completion of circuit opening movement thereof. This rebound preventing means comprises an elongated member pivotally connected to the switch member and means for guiding the elongated member so that it travels with essentialy translational motion from first to second positions in response to movement of the switch member from closed to open positions. I distribute the mass of the elongated member with its center of gravity located so that the kinetic energy of this member at the moment it reaches its second position will cause rotation of the member into interlocking engagement with a fixedly disposed rigid member which prevents movement of the elongated member directly toward its first position, thereby preventing appreciable rebound of the switch member, and so that the force of gravity action on the elongated member returns it to its second position when the aforesaid kinetic energy has been dissipated.

In still another aspect of my invention, the circuit interrupter operating mechanism comprises the aforesaid guide member, a toggle having one end connected to switch member and its other end connected to the guide member, and an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its operated position with the guide member in its latched position to produce snap-action switch closing movement of the toggle. The overcenter spring is also effective in response to guiding releasing operation of the latching means to drive the guide member to an unlatched position and produce snap-action switch opening movement of the toggle. I provide means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation.

The invention will be better understood and its various objects and advantages will be more fully appreciated from the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a side elevation of a circuit interrupter having an operating mechanism constructed in accordance with a preferred embodiment of the invention, the circuit interrupter being shown in its closed circuit position;

Fig. 2 is a fragmentary side elevation of the circuit interrupter of Fig. 1 showing the operating mechanism intermediate its closed and tripped-open positions during the opening operation of the interrupter;

Fig. 3 is a simplified side elevation of the circuit interrupter of Fig. 1 with the operating mechanism and the switch member of the interrupter being shown in tripped-open positions;

Fig. 3*a* is an enlarged fragmentary side view of the operating mechanism constructed in accordance with the preferred embodiment of my invention, the mechanism being shown both in its closed position (solid lines) and its tripped-open position (broken lines).

Fig. 4 is a partial side elevation of the circuit interrupter of Fig. 1 showing the operating mechanism in its open-reset position;

Fig. 5 is an enlarged side view of the anti-rebound member of the operating mechanism showing this member in three different positions;

Fig. 6 is a diagrammatic representation of the energizing circuit for the closing solenoid;

Fig. 7 is a side elevation of the operating mechanism shown intermediate its open-reset and closed positions just prior to snap-action switch closing movement thereof;

Fig. 8 is a fragmentary side elevation of the circuit interrupter of Fig. 1 showing the operating mechanism during a trip-free operation which results when a closing operation is attempted with the mechanism unlatched;

Fig. 9 is an enlarged side elevation partly in section, of the electric switch shown in Figs. 1–4 and 8 for controlling the energization of the closing solenoid; and

Fig. 10 is a rear elevation of the electric switch of Fig. 9.

Referring now to Fig. 1, I have shown an electric circuit breaker or interrupter comprising a frame member **11** supporting a base member **12** of electric insulating material, a relatively stationary contact or switch member **13** mounted on the base, a bracket **14** mounted on the base in spaced relation to the stationary contact member, a movable contact or switch member **15** pivotally supported by bracket **14** and disposed in cooperative relationship with the stationary switch member **13**, and actuating means such as a crossbar **16** coupled to the movable switch member **15** for moving this member into and out of circuit-making engagement with the stationary switch member **13**. Movement of the switch member **15** into and out of engagement with the member **13** closes and opens, respectively, an electric circuit represented by conductors **17** and **18**. The components **13**, **14** and **15** comprise the contact structure of one pole unit of an alternating or direct current circuit interrupter, and other pole units substantially identical to that shown could be mounted on the frame member **11** for gang operation by the common crossbar **16**. The particular contact structure that has been shown in the drawings for the purpose of illustrating a preferred embodiment of the present invention is the subject matter of my copending patent application S.N. 764,642 filed on October 1, 1958, and assigned to the assignee of the present invention.

Movement of the switch member **15** between its closed circuit position (Fig. 1) and its open circuit position (Fig. 3) is controlled by an operating mechanism which is connected to the switch member by means of an elongated connecting member **19** pinned to a link **20** which in turn is firmly affixed to the crossbar **16**. The operating mechanism comprises a plurality of interconnected movable members one of which is a guide member **21** pivotally mounted on the frame member **11** by means of a rod **22** fixedly supported thereby. The remaining members constitute a force-transmitting linkage mechanism **23** pivotally fastened by a pin **24** to the connecting member **19** and hence to the movable switch member **15**. The pin **24** is supported for movement along a predetermined-arcuate path by an output crank **25** of the mechanism which is pivotally mounted on the frame member **11** at **26**. The various illustrated parts of the operating mechanism, with the exception of the guide member **21**, preferably are provided in identical pairs so that the entire mechanism is symmetrical with respect to a vertical plane parallel to the plane of the drawings, with the guide member **21** being disposed in the plane of symmetry. The output crank **25** actually is a U-shaped member the two identical, spaced-apart upstanding parts of which are rigidly interconnected by a transverse part **25***a*.

The operating mechanism also includes at least one helical tension spring **27** arranged to release stored energy to the mechanism for imparting quick-action switch closing and opening movement thereto. Accumulation of energy in the spring **27** is controlled by a movable operating member **28** which is pivotally mounted on the

frame member **11** by means of the rod **22** affixed thereto. The operating member **28** preferably comprises two identical upstanding parts, only the far one being shown rigidly interconnected by a pair of transverse sections **28***a* and **28***b*. The spring **27** interconnects the operating mechanism and a laterally extending pin **29** carried by the operating member **28**.

The operating member **28** is disposed for pivotal movement between two different angular positions at opposite ends of its normal range of movement: a first or reset position shown in Fig. 4, and a second or operated position shown in Fig. 1. While moving to its second or operated position with the operating mechanism in a releasably latched condition (the latching means is described in detail hereinafter), the operating member will stress or charge the spring **27** and will effect release of energy thus stored in the spring for producing switch closing movement of the mechanism. In order to obtain this movement of the operating member **28**, suitable electro-responsive means such as the solenoid **30** and cooperating armature **31** shown in Figs. 1 and 4 may be employed, or the operating member may be coup'ed to a suitably disposed manually operable handle, not shown.

In the illustrated embodiment of the invention, the operating mechanism includes a toggle comprising two links **33** and **34** pivotally joined by a pin **35** which forms the knee of the toggle. (Actually, as has been pointed out hereinbefore, the links **33** and **34** are provided in identical pairs, and the near one of the links **34** is omitted in the drawings for the sake of clarity.) The spring **27** functions as an overcenter spring, and one end of the spring is connected to the pin or toggle knee **35**. One end of the toggle, specifically the right-hand end of the link **34** as viewed in the drawings, is connected to the pin **24** and hence to the switch member **15** for moving the switch member betwen its open and closed circuit positions. The other end of the toggle, specifically the left-hand end of link **33**, is supported by a pin **36** for movement between two different positions.

The pin **36** is connected to the guide member **21**. As the guide member moves pivotally between predetermined latched and unlatched positions, the pin **36** is carried along a predetermined arcuate path **36***p* (Fig. 1) with respect to the axis of the supporting rod **22**. In Figs. 1 and 4 the guide member and lever **21** is shown in its latched position where it is releasably restrained by a latch identified generally by the reference number **37**.

In order to close the circuit interrupter, the operating mechanism is arranged to move the switch member **15** from its open circuit position to its closed circuit position with quick and positive action. This is accomplished by moving the operating member **28** from its first or reset position (Fig. 4) toward its second or operated position (Fig. 1) in response to which the overcenter spring **27** is stretched or charged and moves over center with respect to the toggle link **33**. The spring force being exerted on the toggle knee **35** will now produce in toggle link **33** a counter clockwise torque tending to straighten the toggle from its initially collapsed condition shown in Fig. 4. Upon release of energy stored in the spring, the toggle knee is pulled upward and the toggle undergoes snap-action switch closing movement which rotates the output crank **25** clockwise and drives the switch member **15** to its closed position.

The closed position of the operating mechanism, as can be seen in Fig. 1, is determined by the engagement of a pin **38** protruding laterally from toggle link **33** with an interfering stop surface **39** of the guide member **21**, the guide member at this time being firmly held in its latched position by the latch **37**. Suitable stop and blocking means, to be described hereinafter, are respectively provided for definitely determining the second position of the operating member **28** and for preventing the return of the operating member to its first position as long as the switch member **15** is closed. As is evident in Fig. 1,

the second postion of the operating member **28** is so located in relation to the toggle after undergoing switch closing movement thereof that the line of action of the overcenter spring force intersects the path **36***p* to be followed by the pin **36** during subsequent movement of the guide member **21** to its unlatched position. In the closed position of the operating mechanism there is still a substantial amount of energy remaining in the overcenter spring **27**, since not all of the stored energy was given up by this spring while effecting the above-described closing operation.

As is clearly shown in Fig. 1, the overcenter spring **27** exerts a force on the guide member **21**, by way of toggle link **33** and the pins **36** and **38**, tending to drive this member in a clockwise direction from its latched position. It is the function of the latch **37** to prevent such movement by the guide member until a circuit opening operation of the interrupter is desired. The latch comprises a transversely extending trip shaft **40** supported by the frame member **11** for rotary movement between a normal position shown in Figs. 1 and 4 and a trip position shown in Figs. 2 and 3. A radially protruding portion or prop **41** of the trip shaft **40** cooperates with an intermediate latch member or catch **42** for releasably restraining the guide member **21** in its latched position with the trip shaft in its normal position.

The latch member **42** is pivotally mounted intermediate its ends on a transverse rod **43** which is supported by the frame **11**. On one side of the rod **43** this member is provided with a stud **44** disposed in self-releasing engagement with the heel of an integral leg **45** of the guide member **21**. With the trip shaft **40** in its normal position, the stud **44** of the intermediate latch member **42** is firmly held in engagement with leg **45** of the guide member, thereby maintaining the guide member in its latched position, by the prop **41** which abuts a roller **46** carried by the latch member on the other side of rod **43**. The latch member **42** preferably comprises two similar parts (only the near one being shown) that are firmly joined by the stud **44** and the axle of the roller **46**. A tension spring **47** is provided for biasing the trip shaft **40** in a clockwise direction to its normal position and for biasing the intermediate latch member or catch **42** in a clockwise direction into self-releasing engagement with the guide member **21**.

The intermediate latch member **42** with its roller **46** and the prop **41** are constructed and arranged so that the resultant force of action and reaction therebetween is directed normal to the axis of rotation of the trip shaft **40**. To accomplish this result in the illustrated embodiment of the invention, the prop surface **41***a* abutting the roller **46** is conformed to a circumferential section of a right cylinder whose axis is the axis of shaft **40**. Consequently, the line of action of the resultant force transmitted by the prop **41** to the trip shaft, in order to restrain the guide member **21** in its latched position against the force of overcenter spring **27**, intersects the axis of the trip shaft **40** and has no moment arm with respect thereto. This arrangement helps to eliminate accidental unlatching operation by the latch **37** upon the occurrence of any relatively sudden and severe mechanical shock to the circuit interrupter. The prop **41** is in compression and free of bending stresses, whereby any tendency to distort adversely the circumferential surface **41***a* is relieved.

In order to open the circuit interrupter, the operating mechanism is arranged to move the switch member **15** from its closed circuit position to its opened circuit position with quick and positive action in response to toggle releasing operation of the latching means. The opening operation is initiated by rotating the trip device **40** in a counterclockwise direction from its normal position (Fig. 1) to its tripped position (Figs. 2 and 3). For this purpose any suitable means may be used, such as, for example the schematically illustrated manually operable trip bar **48**. Longitudinal movement of the trip bar **48**

to the right, as viewed in Fig. 1, causes an adjustable-length terminal portion 49 of this bar to strike and tilt a paddle member 50 which is rigidly affixed to the trip shaft 40. As a result, the trip shaft is rotated counterclockwise and the prop 41 is pivoted away from the roller 46 of intermediate latch member 42. The force necessary to accomplish this result is significantly less than the force being exerted at this time by the overcenter spring 27 because of the favorable force amplifying leverage system formed by the interengaging pivotally supported members 50, 41, 42 and 21 of the latching means.

The removal of prop 41 from abutting relationship with roller 46 enables the intermediate latch member 42 to move counterclockwise about rod 43 in accordance with the force applied at its stud 44 by the leg 45 of guide member 21, whereupon the guide member is no longer restrained in its latched position. The overcenter spring 27 is effective in response to this guide releasing operation of the latch 37 to drive the guide member to its unlatched position (Fig. 3) thereby enabling the operating mechanism to undergo switch opening movement. As the spring releases energy during the opening operation, the toggle knee 35 is pulled to the left (as viewed in Fig. 1) and the pin 36 carried by the guide member moves upward along its arcuate path 36*p*. When the pin 36 has passed through the line of action of the overcenter spring 27 (the operating mechanism is shown at this instant in Fig. 2), the toggle collapses and undergoes snap-action switch opening movement. During this action the output crank 25 is rotated counterclockwise and the movable switch member 15 is driven to its open circuit position.

The operating mechanism is shown in a collapsed, tripped-open condition in Fig. 3. As can be seen in this figure, the open position of the switch member 15 and the corresponding position of the mechanism output crank 25 are determined by the engagement of a bushing 52 located on pin 24 with a concave stop surface 53 of the frame member 11. The guide member 21 is here in its unlatched position which is determined by the engagement of a shoulder 54 of the guide member with suitable stop means such as the illustrated rod 55. The rod 55 is rigidly affixed to the frame 11 and blocks further clockwise movement of the guide member 21 about its pivot 22. Since one end of the toggle is connected to the pin 24 and the opposite end is connected through pin 36 to the guide member 21, the position of the toggle knee 35 at this time is necessarily fixed. For reasons which will be explained hereinafter, the operating mechanism is only momentarily in the position in which it is shown in Fig. 3.

During the above-described opening operation, the toggle knee 35 is forced to follow a relatively linear path from its position shown in Fig. 1 to its position shown in Fig. 3. This is accomplished by providing suitable camming means controlled by movement of the guide member 21 and disposed in cooperation with the toggle. Preferably the camming means comprises a concave camming surface 56 of the guide member 21 which engages a roller 57 connected to the toggle link 34 while the guide member is moving toward its unlatched position. As a result, the movement of the toggle is controlled in a manner to obtain a substantially uniform rate of energy release by the overcenter spring 27 throughout the opening operation, and the spring will manifest a relatively high force gradient in resisting rebound of the movable switch member 15 from its open circuit position.

This feature of my invention can be better understood by referring to Fig. 3*a* and the following explanation. In Fig. 3*a* the toggle links and the guide member in their respective "closed" positions (as in Fig. 1) are shown by solid lines and identified by the reference numbers used hereinbefore. The same members after being moved to their predetermined "tripped-open" positions (as in Fig. 3) have been shown in Fig. 3*a* by dot-dash lines and identified by the same reference numbers primed. The pin 29 to which one end of the overcenter tension spring 27 is connected is shown in section at a stationary point, because the operating member 28 does not move from its second or operated position while the operating mechanism is undergoing switch opening movement. In the interest of clarity neither the overcenter spring nor the operating member have been shown in Fig. 3*a*.

During the opening operation, the left end of the toggle connected to pin 36 is guided along the predetermined arcuate path 36*p*, and the right or output end of the toggle connected to pin 24 is moved along the arcuate path 24*p*. The path 24*p* is determined by the output crank (not shown in Fig. 3*a*) which is pivotally supported at 26. Movement of pin 24 along path 24*p* to its open position 24′ produces the opening movement of switch member 15 to which it is positively connected. The path 35*p* followed by the toggle knee 35 is determined by the camming action of the interengaging camming surface 56, which is integrally associated with the guide member 21, and roller 57, which is rotatably supported by toggle link 34 intermediate its ends. The camming surface 56 is contoured and the roller 57 is disposed so that the camming action therebetween directs the toggle knee along the relatively linear path 35*p* during the opening operation.

The overcenter spring is connected between pin 29 and the toggle knee 35. By controlling the switch opening movement of the toggle in the manner described above, the energy given up by the spring per unit of distance moved by the pin 24, and consequently per unit of angular movement traversed by the switch member 15 while opening, is substantially constant throughout the opening operation. That this action results in a substantially uniform rate of energy release by the spring 27 is demonstrated in Fig. 3*a* where point A on path 35*p* indicates the position of the toggle knee 35 when the pin 36 is passing through the line of action of the spring force, at which point snap-action opening begins. See also Fig. 2. At this moment the pin 24 will be at point B on path 24*p*. With the toggle knee at A, the spring is approximately 62 percent discharged (i.e., the spring has shortened approximately 62 percent of the total amount by which its length will change while effecting the switch opening movement of the mechanism), and at the same moment the movable switch member will be approximately 67 percent open. Thus slightly over one-third of the energy originally available remains in the spring to effect the last one-third of the switch opening operation.

This feature of my invention is important because it ensures maximum available opening action of the circuit interrupter switch member 15 throughout the opening operation. Without this feature, the toggle knee 35, while traveling to its fixed position 35′, would follow the 2-step path identified in Fig. 3*a* by the reference number 58. Point D on the path 58 indicates the position in which the toggle knee would be located at the moment when snap-action opening begins, and at the same moment the pin 24 would be at a point E. It can be observed that at this moment the switch member is only half-way open while the overcenter spring is already nearly 75 percent discharged. By controlling the toggle movement in accordance with my invention, the movable switch member 15 is moved smoothly to its open circuit position without any point of hesitation, and the tendency for the switch member to rebound from its open position is resisted by a force gradient appreciably greater than that obtainable if the toggle knee were permitted to follow path 58.

When the overcenter spring 27 alone is imparting switch

opening movement to the above-described operating mechanism, rebound of the movable switch member **15** from its open circuit position upon completion of its circuit opening movement presents no special problem. However, the arrangement of the contact structure of the circuit interrupter is such that when current of short-circuit magnitudes is interrupted, strong magnetic forces augmenting the spring force will drive the switch member **15** to its open position with exceptionally high speed. In accordance with my invention, appreciable rebound of the switch member under these conditions is prevented by inertia actuated means which will now be described in detail.

The inertia actuated means referred to above comprises an elongated anti-rebound member **59** pivotally connected near its upper end, as viewed in Figs. 1–4, to the pin **24** and hence, by way of the connecting member **19**, link **20** and crossbar **16**, to the movable switch member **15**. Member **59** preferably comprises two identical parts (the side elevation of only the far one being shown in Figs. 1–5) which are rigidly interconnected by a transverse part **59***a*. The member **59** is pivotally movable in a vertical plane about the axis of pin **24**, and this axis is moved along a predetermined arcuate path in the vertical plane during circuit opening movement of the switch member **15**. A lower edge **60** of the anti-rebound member **59** slidably engages the upper surface of the transverse rod **43**, whereby the member **59** is supported in a predetermined inclined position, in which it is shown in Fig. 1, whenever the switch member **15** is in its closed circuit position.

In response to movement of the switch member to its open circuit position, the anti-rebound member **59** is moved to a predetermined second position (shown in Fig. 3) substantially parallel to its first inclined position. During this movement the member **59** is guided by the rod **43**. The edge **60** of member **59** is so configured in relation to the rod **43** that member **59** travels with essentially translational motion to its second position even through the axis of pin **24**, to which it is pivotally connected, is moving through an arcuate path. A rigid stop member **61** is fixedly disposed on the frame member **11** in spaced relation to a cooperating hook-like portion **62** of the anti-rebound member **59** protruding laterally from the distal end thereof. The member **59** is free to rotate in a clockwise direction from its second position, and upon undergoing such rotation the portion **62** of member **59** engages in interlocking relation the stop member **61** thereby preventing movement of the member **59** directly toward its first position (Fig. 1). This prevents appreciable rebound of the switch member **15** towards its closed circuit position.

The mass of the anti-rebound member **59** is distributed so that its center of gravity is located at the point indicated by the reference letter C in Fig. 5. Fig. 5 is an enlarged view of the member **59** showing it in three different positions. With the circuit interrupter closed this member will be in its first position which is shown in Fig. 5 by a broken line identified as **59′** with the interrupter opened the anti-rebound member is in its second position shown by solid line **59**; and its position after being rotated clockwise into interlocking engagement with the fixed member **61** is shown by the dot-dash line identified by the reference character **59″**. The force of inertia effective at the conclusion of the translation movement of the anti-rebound member is indicated by the vector $\bar{F}$ which is tangent to the arcuate path G along which the center of gravity travels while moving from its first position C′ to C.

It can be observed in Fig. 5 that the force $\bar{F}$ establishes a clockwise torque or moment in the anti-rebound member **59** tending to rotate this member about its pivotal axis P to its position **59″**. This torque is opposed by a counterclockwise torque established by the force of gravity which has been effective to hold the edge **60** of member **59** against the guiding rod **43**. The inertial force is relatively large since the opening speed of the movable switch member is very high and the moment arm of this force is relatively long. Consequently, the inertial torque will easily overcome the gravitational torque and produce clockwise rotation of member **59**. A yieldable buffer or cushion **63** is provided for the purpose of elastically stopping the clockwise rotation of the anti-rebound member. With the member in its rotated position **59″**, its center of gravity is at C″ and the gravitational force acting thereon returns the member to its second or static position.

The operation of the rebound preventing means will now be summarized with reference to Fig. 5 during a circuit opening operation, the pin **24** moves quickly along the arcuate path **24***p* to its solid-line position where it is abruptly stopped due to the engagement of bushing **52** with stop surface **53** (see Fig. 3). Simultaneously the anti-rebound member **59** is guided translationally to its solid-line position. When member **59** reaches this position, its kinetic energy will impart clockwise rotation thereto and its hook-like portion **62** begins swinging in the direction of member **61**. At the same moment the pin **24**, and hence the movable switch member of the circuit interrupter, will begin rebounding, and therefore the axis of rotation of the anti-rebound member **59** will start moving back along path **24***p*. The relative masses and shapes of the various moving parts of the illustrated structure are selected so that the time required for the portion **62** to move into engagement with the fixed member **61** approximately coincides with the time that elapses while the axis of rotation is rebounding to the point designated P″. Further rebounding movement of the mechanism and the switch member is abruptly halted by the interlocking engagement of **61** and **62**. When the kinetic energy of the member **59** has been dissipated, the force of gravity will automatically return this member to its static position.

The above-described action requires no springs or other extrinsic biasing means. By guiding the anti-rebound member for translation motion, very little space is needed in order to carry out the operation. Optimum coordination between the movement of the anti-rebound member and the rebound of the switch member is obtained in accordance with my invention, since the energy available for propelling the former in a clockwise direction into rebound-preventing engagement with the fixed member **61** is directly responsive to the opening velocity of the latter. In other words, the greater the opening speed of the switch member and severity of its rebound tendency, the more rapid is the clockwise rotation of the member **59** which prevents appreciable rebound.

In order to successfully carry out a subsequent circuit interrupter closing operation it is necessary to ensure that the anti-rebound member **59** is not rotated clockwise into interlocking engagement with the fixed member **61** due to mechanical shock. For this purpose I provide a protrusion **64** on the lower edge of the toggle link **34** which is disposed in the position indicated in Figs. 4 and 5 when the operating mechanism is in its open-reset position. In this position the protrusion **64** is located in the path followed by part **59***a* of the member **59** during clockwise rotation thereof. Consequently, should the anti-rebound member **59** bounce off the rod **43** during the initial phase of the closing movement of the switch member **15**, the protrusion **64** will block the member **59** before its hook-like portion **62** can reach the fixed member **61**. With this arrangement the inertia actuated, gravity reset anti-rebound member **59** cannot impede normal closing of the circuit interrupter.

The circuit interrupter operating mechanism, in the illustrated embodiment of the invention, is automatically moved by the overcenter tension spring **27** from its

stripped-open position of Fig. 3 to its open-reset position shown in Fig. 4. This is accomplished by arranging the mechanism in accordance with the principle fully explained and claimed in United States Patent 2,866,872 issued to W. Turner on December 30, 1958. If automatic reset is not desired, as in the case of some manually operable circuit interrupters, the operating mechanism can be arranged differently so that movement of an operating handle is required to accomplish the resetting operation. Regardless of whether it is effected automatically by the spring 27 or manually by other means, the resetting operation is basically the same; the operating member 28 is returned to its first or reset position, the guide member 21 is simultaneously driven to its latched position, and the toggle is moved in its collapsed condition to the position in which it is shown in Fig. 4.

With the operating mechanism in its tripped-open position, as can be seen in Fig. 3, the overcenter spring 27 is exerting a force on the operating member 28 tending to move this pivotally mounted member in a counterclockwise direction toward its first or reset position. Counterclockwise movement of the operating member carries pin 29 along a predetermined arcuate path 29*p* shown in Fig. 4. An arm 65 of the guide member 21 is disposed, with the guide member in its unlatched position, immediately below the laterally extending pin 29. While the operating member is being moved from its first to its second positions, the pin 29 engages the upper surface of arm 65 and drives the guide member 21 in a counterclockwise direction about its pivot 22 to its latched position. While moving toward its latched position, the guide member, being pinned at 36 to the toggle link 33, impels the toggle to its open-reset position shown in Fig. 4. In attaining this position, the toggle knee 35 has followed a path 35*r* which progressively converges with the arcuate path 29*p* of pin 29. Therefore the over-center tension spring 27, which is connected between pin 29 and toggle knee 35, progressively shortens during the resetting operation and releases energy for returning the operating member 28 to its first position and for driving the guide member 21 to its latched position.

During the resetting operation of the mechanism, the latch 37 is also reset thereby releasably restraining the guide member 21 in its latched position. When the guide member is in its unlatched position (Fig. 3), and during the initial movement of this member toward its latched position, the intermediate latch member 42 is held in a tilted position against the force of its bias spring 47 by the guide member leg 45 whose lower surface slidably engages a cooperating extension 66 of the member 42. The leg 45 slides across the top of stud 44 as the guide member approaches its latched position and finally passes beyond this stud, whereupon the intermediate member 42 is free to pivot clockwise on rod 43 in accordance with its bias and the stud 44 moves into self-releasing engagement with the heel of leg 45. This enables the trip shaft 40 to return to its normal position, and the prop 41 moves into its abutting disposition with respect to the roller 46 of latch member 42. See Fig. 4. When the operating member 28 is subsequently moved toward its second or operated position, member 42 will tilt slightly into engagement with prop 41 and the latch 37 is again effective to restrain the guide member 21 in its latched position.

The above-described resetting operations cannot take place until the movable switch member 15 of the circuit interrupter has moved from its closed circuit position to its open circuit position. This is due to the provision of blocking means for positively preventing movement of the operating member 28 from its second or operated position to its first or reset position whenever the switch member is closed. Since the operating member is blocked in its second position with the switch member closed, the only way the circuit interrupter can be opened is by actuating the latching means in consequence of which the operating member is permitted to return to its first position.

The blocking means preferably comprises a pair of cooperating blocking elements 67 and 68 associated with the operating member 28 and the mechanism output crank 25, respectively. As can be seen in Fig. 1, the blocking element 67 is an integral limb of the operating member having a blunt end and generally curved edges disposed for movement along a predetermined arcuate path in accordance with the pivotal movement of the operating member 28 between its first and second positions. The cooperating element 68 comprises a lug extending transversely from a projection of the output crank for movement about pivot 26 in response to circuit opening and closing movement of the switch member 15. In other words, the blocking element 68 is actuated by movement of pin 24 which physically interconnects the output end of the toggle and the movable switch member 15.

By moving the operating member 28 from its first position shown in Fig. 4 to its second position shown in Fig. 1, a snap-action switch closing operation of the mechanism is effected. The blocking element 68 is accordingly moved into the predetermined path of movement of the blocking element 67 where, as best seen in Fig. 1, it interferes with the blunt end of element 67 and positively blocks the operating member 28 in its second position. When later the latching means is operated to release the toggle, the mechanism undergoes switch opening movement during which the element 68 is moved out of the aforesaid predetermined path to unblock the operating member 28, as shown in Fig. 3. Only now can a resetting operation be undertaken and the operating member moved to its first position (Fig. 4).

Thus, the blocking means which became effective during the closing operation to releasably restrain the operating member 28 in its second position, is moved only in response to a subsequent opening operation to free the operating member for return to its first position. The blocking means is arranged so that movement of the operating member 28 toward its first position is permitted only after the snap-action switch opening movement of the toggle has been initiated and the movable switch member 15 is substantially fully opened, whereby in the illustrated embodiment of the invention the automatic resetting operation cannot begin until after the opening operation is practically completed.

With the operating mechanism in its open-reset position, the circuit interrupter can be closed by energizing the illustrated electromagnetic means which will move the operating member 28 from its first to its second position. The energizing circuit for the electromagnetic means includes, for example, a suitable control switch 69, a pair of separable electric contacts 70 and 71 of a cutoff switch 72, and the coil of solenoid 39 all connected in series circuit relationship to a suitable source of control power 73 in the manner shown diagrammatically in Fig. 6. Closing the control switch enables current to flow through the solenoid coil, and the resulting force of magnetic attraction causes the armature or plunger 31 to move upwardly from the position in which it is shown in Fig. 4. This drives the operating member 28 toward its second position in response to which energy is accumulated in the overcenter spring 27 and a switch closing force is exerted on the toggle.

The actual snap-action switch closing movement of the toggle cannot take place before the operating member 28 reaches a predetermined point near its second position such as is shown in Fig. 7. This is due to the provision of blocking means for releasably restraining the movable switch member 15 in its open circuit position until the operating member is moved passed the aforesaid predetermined point, whereupon the switch member is re-

leased and the toggle is able to undergo switch closing movement in accordance with the force being exerted by the overcenter spring.

The predetermined point at which the blocking means becomes ineffective and energy stored in the spring is first released for imparting switch closing movement to the mechanism is selected in the illustrated embodiment of my invention, for example, so that the operating member must be moved through approximately 97 percent of its total range of movement in order to reach this point. This ensures that the overcenter spring **27** will be substantially fully charged with the maximum amount of energy being stored therein before any of its energy is released. Thus the closing and subsequent opening and resetting operations of the circuit interrupter will be unaffected in the event control power should fail while the movable switch member is closing. By providing a definite, fixed release point, the blocking means also ensures that a substantially constant amount of closing energy is always available each time the circuit interrupter is closed and regardless of the speed with which the operating member **28** is moved to its second position.

The blocking means preferably comprises the same pair of cooperating blocking element **67** and **68** described hereinbefore. The blocking element **68**, which is associated with the output end of the toggle, is disposed for movement along a predetermined arcuate path about pivot **26** during closing movement of the switch member **15**. With the operating member **28** in its first angular position and during most of the movement of this member toward its second position, as clearly indicated in Figs. 4 and 7, the blocking element **67** is disposed in this predetermined path and the element **68** is positively blocked by the lower edge thereof, whereby appreciable switch closing movement of the toggle is prevented.

When the operating member approaches its second position, it passes through the position in which it is shown in Fig. 7 (line **29***p* in Fig. 7 representing the path being followed by the laterally extending pin **29** carried by the operating member), and it will be observed that the tension spring **27** has moved overcenter with respect to the toggle link **33** at this point. As the operating member proceeds beyond this point, it causes the blunt end of element **67** to move beyond element **68** which will now be able to travel freely along its predetermined path. In this manner the blocking means consistently operates near the end of the movement of the operating member toward its second position to free the toggle and to effect release of energy stored in the spring **27** for producing switch closing movement of the operating mechanism, whereupon the closing operation is completed.

As the circuit interrupter operating mechanism is undergoing switch closing movement, the element **68** moves into its blocking position (Fig. 1) wherein it releasably restrains the operating member **28** in its second position. It is important that the electromagnetic means which has moved the operating member to its second position remain energized until this blocking action has taken effect, thereby maintaining the operating member in its second position while the switch closing movement of the mechanism is getting underway. In order to accomplish this result, the cutoff switch **72**, which controls the energization of the solenoid **30**, is arranged to be actuated in response to the switch closing movement of the mechanism. This will ensure that the operating member **28** is blocked in its second position and that the spring energy has been released for imparting irreversible switch closing movement to the operating mechanism before the solenoid is deenergized.

The cutoff switch **72**, as is shown in Figs. 1–4, comprises a resilient switch arm **74** supporting the electric contact **70** at one end and pivotally connected at its other end to a transverse shaft **75**. The shaft **75** is

suspended between two spaced-apart supporting elements **76** (only the near one being shown) fastened to a base member **77**, and the cooperating electric contact **71** is mounted on a bracket **78** also fastened to the base member **77**. The base member **77** is located above the operating mechanism of the circuit interrupter where it is affixed to the frame **11**. A broad cantilever control arm **79** is yieldably coupled to the switch arm **74** and depends from the cutoff switch in cooperation with the operating mechanism for actuating the separable contacts **70** and **71**. Suitable spring means is provided for biasing the interconnected switch and control arms **74** and **79** in a counterclockwise direction about the shaft **75** to predetermined normal positions wherein the contact **70** is maintained in an engaged position with respect to contact **71**, as can be seen in Fig. 4.

The control arm **79** of the cutoff switch **72** is located so as to be mechanically independent of the armature **31** of the electromagnetic means. In order that switch **72** may be actuated in response to switch closing movement of the operating mechanism, its control arm is disposed for engagement by an upwardly extending appendage **33***a* of the toggle link **33**. The final stage of a closing operation involves the straightening of the toggle with snap-action, and the toggle link **33** is abruptly pivoted counterclockwise on pin **36** from the position shown in Fig. 7 to the position shown in Fig. 1. As a result, appendage **33***a* of link **33** engages the control arm **79** and tilts this arm in a clockwise direction about shaft **75** to an actuated position, thereby causing separation of the cooperating contacts **70** and **71**. See Fig. 1. The contact **70** has been moved to a disengaged position thereby opening the energizing circuit for the solenoid **30** and deenergizing the electromagnetic means. The operating member **28**, which was being upheld in its second position by the armature **31**, is now releasably restrained in this position by the abutting blocking elements **67** and **68**, and the armature **31** cannot return to its original position shown in Fig. 4.

As long as the circuit interrupter is closed, the control arm **79** of the cutoff switch is held in its actuated position, thereby preventing reenergization of the electromagnetic means, by the operating mechanism acting through link **33**. The control arm is also disposed for engagement by a protrusion **80** of the guide member **21** in response to switch opening movement of the operating mechanism, whereby control arm **79** is maintained in its actuated position, and energization of the solenoid **30** is prevented, with the mechanism in its tripped-open position (Fig. 3). Upon operation of the latch **37** with the circuit interrupter closed, the guide member **21** is driven in a clockwise direction about pivot **22** to its unlatched position and protrusion **80** moves into engagement with control arm **79**. At the same time the toggle is collapsing and appendage **33***a* of toggle link **33** rides along the curved underside of arm **79** while holding this arm in its actuated position.

The operating mechanism is arranged so that during the initial portion of its switch opening movement the appendage **33***a* of link **33** is maintaining the control arm **79** in its actuated position, while during the remaining portion of this movement the protrusion **80** of guide member **21** will prevent the control arm from returning to its normal position, whereby the cooperating electric contacts **70** and **71** are caused to be separated throughout the opening operation. This is best illustrated in Fig. 2 which shows the mechanism at a point during its opening operation where protrusion **80** is about to engage arm **79** before the appendage **33***a* disengages it.

The cutoff switch **72** will not reset to permit subsequent energization of the solenoid **30** until a resetting operation of the mechanism is underway, as indicated by counterclockwise movement of the guide member **21** toward its latched position. This ensures that before the solenoid can again be energized the movable switch mem-

ber 15 is fully open and the condition of the operating mechanism and the armature 31 will be proper for a normal closing operation. During the resetting operation, the protrusion 80 of the guide member 21 drops away from the control arm 79 thereby enabling the control and switch arms 79 and 74 to move to their normal positions in accordance with their bias, whereupon contact 70 engages contact 71 to set up the energizing circuit for the solenoid 30 (Fig. 4).

If a circuit interrupter closing operation is attempted while the operating mechanism is unlatched, the separable contacts 70 and 71 of the cutoff switch 72 will be actuated, in accordance with my invention, before the operating member 28 reaches its second or operated position. As a result the solenoid 30 is deenergized before the armature 31 reaches the upper, fully attracted limit of its travel, thereby minimizing the heating of the solenoid coil and lessening the impact which occurs when the armature impels the substantially unloaded operating member 28 to its second position under these conditions. Such a "trip-free" operation of the mechanism is illustrated in Fig. 8.

In Fig. 8, the armature of the electromagnetic means has driven pin 29 of the operating member 28 upward along its predetermined arcuate path 29*p* to the position shown, and the position of the operating member is now intermediate its first position (Fig. 4) and its second position (Fig. 1). The latch 37 has been operated, either before or at any time during movement of the operating member 28 toward its second position, to release the guide member 21. This has enabled the overcenter spring 27 to drive the guide member in a clockwise direction toward its unlatched position. The guide member moves conterminously with the operating member 28 because both of these members are pivotally supported on the same rod 22 and the upper surface of the arm 65 of member 21 engages the pin 29 of member 28. Consequently, as the operating member 28 is moved toward its second position, the toggle moves in a collapsed condition, the overcenter spring 27 cannot accumulate closing and tripping energy, and closing movement of the circuit interrupter switch member is prevented.

While the guide member 21 is thus being moved toward its unlatched position, the protusion 80 thereof engages the control arm 79 of the cutoff switch 72 thereby moving this arm to its actuated position, in which it is shown in Fig. 8, and deenergizing the electromagnetic means. It can be observed that actuation of the cutoff switch has been accomplished while the operating member 28 is still moving toward its second position, in contrast to a normal closing operation when the cutoff switch is not actuated until after the operating member 28 has reached its second position. After deenergization of the electromagnetic means at the conclusion of a trip-free operation, the various parts of the circuit interrupter will automatically reset in the manner already described.

During a normal closing operation, as has been explained in detail hereinbefore, the armature 31 of the electromagnetic means drives the operating member 28 to its second position in response to which the overcenter spring 27 imparts switch closing movement to the operating mechanism, and the cutoff switch 72 is arranged to be actuated during the switch closing movement of the mechanism for deenergizing the electromagnetic means. Since the base 77 of the cutoff switch is mounted on the frame member 11 of the circuit interrupter, it receives a relatively sudden and severe mechanical shock upon the operating member attaining its second position. The cooperative electric contacts 70 and 71 of the cutoff switch must remain engaged when this shock occurs, because, as pointed out hereinbefore, it is important that the electromagnetic means remain energized to hold the operating member in its second position while switch closing movement of the mechanism is getting underway. In accordance with my invention, the cutoff switch 72 is designed so that its actuation is not effected by shock, and premature separation of the contacts 70 and 71 is avoided.

As viewed in the drawings, the armature or plunger 31 travels in a generally vertical direction while moving the operating member 28 toward its second or operated position, and the mechanical shock occasioned by the armature 31 and the operating member 28 being abruptly stopped in their positions shown in Fig. 1 will cause the frame member 11 to shake or vibrate vertically. The shaft 75 is supported by the base 77 of the cutoff switch 72 is so oriented that it vibrates laterally as a result of this shock, the principal vibratory motion of the axis of shaft 75 defining a generally vertical plane. This plane of lateral vibration is represented by the trace 81 in Fig. 9 which is an enlarged side elevation of the cutoff switch.

In accordance with my invention, the total mass of the assembly pivotally supported by the shaft 75, i.e. the interconnected switch and control arms 74 and 79, is distributed so that its center of gravity H lies approximately in the plane 81 when the arms are in their normal positions. See Fig. 9. In other words, although the arms 74 and 79 when in their normal positions are asymmetrically disposed with respect to the plane 81, their respective masses are so distributed that the center of gravity of the physical system formed by their combination lies approximately in this plane of lateral vibration. Consequently, the parts of the pivotally movable assembly 74, 79 located on opposite sides of the plane 81 will be substantially equally accelerated from rest upon the occurrence of the aforesaid mechanical shock, and no appreciable net moment is established in this assembly, with respect to shaft 75, by the resulting inertial forces acting thereon. This minimizes any tendency on the part of the switch arm 74 to move pivotally about the axis of shaft 75 while the shaft is vibrating laterally, and the movable electric contact 70, which is located at the distal end of arm 74, will have negligible tendency to move relative to the cooperating contact 71 with which it is engaged.

Additional details of the cutoff switch 72 have been shown in Figs. 9 and 10 and will now be described. The switch arm 74 includes a block 74*a* of insulating material to which the resilient portion of the arm is suitably anchored. The block 74*a* is securely fastened by means of a bolt 82 or the like to the bight of a generally U-shaped metallic portion 74*b* of the armature, and the upstanding legs of 74*b* are pivotally connected to the shaft 75. The control arm 79 includes a generally flat portion 79*a* and a pair of spaced-apart ears 79*b* having openings through which the shaft 75 passes. The flat portion 79*a* is clamped firmly but yieldably against the block 74*a* of the switch arm 74 by the action of the relatively stiff torsion spring 83 as best seen in Fig. 10. This spring applies pressure at two lugs 84 and 85, respectively associated with one leg of 74*b* and an ear 79*b*, so as to urge the switch and control arms 74 and 79 in opposite directions about the shaft 75. The flat portion 79*a* of arm 79 and the block 74*a* of arm 74 are thus held firmly together with the shaft 75 serving as a fulcrum for both arms, and the arms are pivotally movable as a unit.

The unit assembly comprising arms 74 and 79 is biased in a counterclockwise direction to its normal position, as viewed in Fig. 9, by another torsion spring 86 which is weaker than spring 83. One end of the spring 86 is fixedly restrained and its other end acts through a lug 87 associated with the other leg of 74*b* to establish in switch arm 74 a counterclockwise torque with respect to shaft 75. This biasing torque is transmitted to the control arm 79 by means of the spring 83. Upon actuation of the cutoff switch 72 in the manner described hereinbefore, the control arm 79 is moved in a clockwise direction to its actuated position. As a result the switch arm 74 is carried in a clockwise direction against its bias until such movement is stopped by a lip 88 of 74*b* engaging an

abutting shelf 89 mounted on the base 77 of the switch (see Fig. 1). At this point, the spring 83 will yield to permit further clockwise movement of the control arm 79, thereby providing for overtravel by the control arm.

Actuation of the cutoff switch 72 causes the normally engaged contacts 70 and 71 thereof to separate. The relatively stationary contact 71 is preferably attached to a conductive leaf spring 71*a* mounted on the bracket 78, the leaf spring 71*a* being in a deflected state when the contact 70 is in its engaged position as shown in Fig. 9. This enables contact 71 to follow the contact 70 during the initial portion of the clockwise movement of the switch arm 74, thereby delaying separation of the contacts and contributing to the desired shock resistance of the structure.

Another electric contact 90 is provided on the resilient switch arm 74 for engaging a cooperating stationary electric contact 91 when the cutoff switch has been actuated. The contact 91 is connected to a conductive stud 92 disposed in an insulator 93 depending from the base 77. The electric contacts 70, 71, 90 and 91 are connected by means of flexible conductors or the like to suitable terminals or connection posts (not shown) adapted for electrical connection to external circuits. As mentioned earlier, the separable contacts 70 and 71 are serially connected in the energizing circuit for the solenoid 30, and these contacts must be engaged, as they are with the circuit interrupter operating mechanism in its open-reset position (Fig. 4), before the solenoid can be energized.

When energized, the solenoid 30 will produce a magnetic field. A magnetizable yoke 94 provides physical support for the solenoid and forms a part of the magnetic circuit for its field. The yoke 94 comprises a plurality of iron laminations stacked between a set of hangers 95, and the hangers 95, as can be seen in Figs. 1 and 4, are provided with mounting feet securely fastened by rivets or the like to the underside of a horizontal channel element 11*a* of the circuit interrupter frame member 11. Preferably the yoke is made in two separate parts, the bottom part including supporting elements 96 which are respectively fastened to the hangers 95 by bolts 97. This enables the hollow spool 98 on which the solenoid coil 99 is wound to be conveniently clamped between the two parts of the yoke 94 as indicated in the drawings.

The yoke 94 includes a pole piece (not shown) which extends into the solenoid spool 98 at its upper end. The width of the pole piece is less than the corresponding distance between the spool sidewalls, whereby ample passage ways are provided on opposite sides of the pole piece, respectively, for a pair of generally longitudinally movable, spaced-apart elongated metallic strips 103 and 104. The strips 103 and 104 comprise part of the armature or plunger 31 which is disposed within the solenoid 30 for longitudinal movement under the influence of the force of magnetic attraction.

A laminated, magnetizable core piece 105 of the plunger 31 is sandwiched between the strips 103 and 104, near their lower ends, where it is securely attached by means of recessed-head rivets or the like. The core piece 105 comprises another portion of the magnetic circuit for the magnetic field produced by the solenoid 30 when energized, and, in cooperation with the yoke 94, it is disposed for movement into the lower end of the solenoid spool 98 in accordance with the magnetic force exerted by the field. For this purpose the laminae comprising the bottom part of the yoke 94 are discontinued immediately beneath the opening through the spool 98, and the supporting elements 96 are appropriately bowed at 96*a*. The strips 103 and 104 of the plunger 31 extend upwardly through the solenoid spool passing on opposite sides of the core piece of the yoke 94, and are rigidly joined at their upper ends to an armature extension 107 which in turn is positively connected by means of the pin 29 to the operating member 28 of the circuit interrupter operating mechanism.

Upon energization of the solenoid coil 99, the core piece 105 of armature 31 is moved by the forces of magnetic attraction in a generally longitudinal direction from a lower or normal position shown in Fig. 4 to an attracted position at the upper limit of its longitudinal movement, shown in Fig. 1. The magnetic force is transmitted by way of the armature extension 107 to the operating mechanism whose member 28 is thereby driven from its first or reset position to its second or operated position, and as a result the circuit interrupter is closed. The operating member 28 is stopped in its second position, beyond which it cannot be moved, by the abrupt interengagement within the solenoid 30 of the care piece of armature 31 and the pole piece of yoke 94 occurring when the armature attains its attracted position. This is the stop means for the operating member referred to hereinbefore. The force of gravity assists in returning the armature 31 to its normal position during the previously described resetting operation of the mechanism, and the normal position of the armature is determined by the interengagement of the bottom edge 107*a* of the armature extension 107 with the top of yoke 94.

Having described in detail the circuit interrupter structure illustrated in the drawings, its mode of operation will now be summarized. With the circuit interrupter switch member 15 in an open circuit position and the operating mechanism in its reset condition, as is shown in Fig. 4, the contacts 70 and 71 of the cutoff switch 72 are in engagement and a closing operation may be initiated by operating the external control switch 69 to energize the solenoid 30. The plunger 31 is raised from its normal position by the resulting force of magnetic attraction, and the operating member 28 is driven in a clockwise direction about its pivot 22 toward its operated position. This stretches the tension spring 27 which consequently accumulates closing, tripping and resetting energy. The spring is carried overcenter with respect to the toggle link 33 of the mechanism, and a closing force is exerted on the toggle.

During this portion of the closing operation the toggle is substantially immovable, and consequently the switch member 15 cannot be moved to its closed circuit position, because the toggle link 33 is being held stationary by the guide member 21 which is releasably restrained in its latched position by the latch 37, and the toggle link 34 is being held stationary by the blocking action of elements 67 and 68 which prevent appreciable clockwise movement of the output crank 25 to which the link 34 is pinned. As the operating member 28 approaches its operated position, it reaches a point just beyond the position in which it is shown in Fig. 7 and the blocking element 67 is moved out of engagement with the element 68. The output crank 25 is now free to move clockwise about its pivot 26, and the spring 27 immediately releases stored energy as snap-action switch closing movement is imparted to the operating mechanism.

Early during this switch closing movement of the mechanism, the blocking means 67, 68 becomes effective to prevent the return of the operating member 28 toward its reset position. The solenoid 30 will remain energized, thereby upholding the operating member in its operated position, until the separable contacts 70 and 71 of the cutoff switch are actuated by the control arm 79 upon engagement thereof by appendage 33*a* of the operating mechanism during the final stage of its switch closing movement. See Fig. 1.

To initiate an opening operation, the trip shaft 40 is rotated counterclockwise from its normal position thereby removing the prop 41 from roller 46. As a result, the latch 37 releases the guide member 21 which is forthwith driven in a clockwise direction about its pivot 22 by the action of the tension spring 27. This enables the spring to release opening energy, and the mechanism undergoes switch opening movement thereby pulling the

switch member 15 to its open circuit position shown in Fig. 3. As the guide member is moving to its unlatched position, the toggle link 33 moves through the centerline of the spring 27 (Fig. 2) at which point snap-action collapse of the toggle takes place.

During the course of the switch opening movement of the operating mechanism, the concave camming surface 56 of the guide member 21 engages roller 57 of the toggle and controls the movement thereof, whereby a substantially uniform rate of energy release by the spring 27 is obtained throughout the opening operation. At the conclusion of the opening operation, the anti-rebound member 59 is actuated by its own inertia into rebound-preventing engagement with the fixed stop member 61, the blocking element 68 has moved out of engagement with the cooperating element 67 thereby releasing the operating member 28 for return to its reset position, and the cutoff switch 72 remains actuated due to the engagement of its control arm 79 by protrusion 80 of the guide member 21 when in its unlatched position. See Fig. 3.

The operating mechanism, in this particular embodiment of the invention, automatically undergoes a resetting operation immediately following the above-described opening operation. The force of spring 27 applied to the operating member 28 tends to move this member in a counterclockwise direction toward its reset position, and by means of pin 29 acting on the guide member arm 65, the guide member 21 is simultaneously propelled in a counterclockwise direction toward its latched position. This causes the toggle knee 35 to follow a path which progressively converges with the path 29*p* of pin 29, thereby enabling the spring 27 to give up still more energy for effecting the resetting operation.

When the guide member 21 reaches its latched position, the latch 37 is automatically reset by the action of its biasing spring 47 which tilts the intermediate latch member 42 clockwise so that its stud 44 engages the heel of the guide member leg 45, whereupon the trip shaft 40 returns to its normal position. See Fig. 4. The cutoff switch 72 is now reset, the operating member 28 is in its reset position, and the plunger 31 has returned to its normal position in readiness for another closing operation.

While I have shown and described a preferred form of my invention by way of illustration, many modifications will occur to those skilled in the art. I therefore contemplate by the claims which conclude this specification to cover all such modifications as fall within the true spirit and scope of my invention.

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

1. In a circuit interrupter: a movable switch member; a toggle comprising a pair of links pivotally joined to form a knee, one end of the toggle being connected to the switch member; latching means for releasably restraining the other end of the toggle in a latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position to produce snap-action switch closing movement of the toggle; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the electroresponsive means, said control arm being disposed in cooperation with one of said toggle links for actuating said contacts and thereby deenergizing the electroresponsive means in response to said snap-action switch closing movement of the toggle.

2. In a circuit interrupter: a movable switch member; a releasably latched operating mechanism connected to the switch member, said mechanism including a spring arranged to release stored energy for producing switch closing movement of the mechanism; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy in the spring and to effect said release of stored energy by the spring; electromagnetic means for moving the operating member comprising a solenoid and a magnetizable plunger coupled to the operating member and disposed for moving said operating member to its second position upon energization of the solenoid; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the solenoid, said control arm being disposed in cooperation with the operating mechanism for actuating said contacts and thereby deenergizing the solenoid in response to said switch closing movement by said mechanism.

3. In a circuit interrupter: a movable switch member; a releasably latched operating mechanism connected to the switch member and including a spring arranged to release stored energy for producing switch closing movement of the mechanism; electromagnetic means for controlling the accumulation of energy in the spring comprising a solenoid for producing a magnetic field when energized and an elongated magnetizable armature disposed for longitudinal movement in accordance with the magnetic force of said field, said armature being coupled to the spring for stressing the spring and thereby accumulating energy therein while undergoing said longitudinal movement upon energization of the solenoid; and means including a pair of separable electric contacts actuated by a control arm mechanically independent of said armature for controlling the energization of the solenoid, said control arm being disposed for engagement by said operating mechanism upon switch closing movement thereof for causing said contacts to separate thereby deenergizing the solenoid.

4. In a circuit interrupter: a movable switch member; a releasably latched force-transmitting linkage mechanism connected to the switch member; a helical spring having one end connected to the mechanism and arranged to release energy to the mechanism for imparting switch closing movement thereto; electromagnetic means for controlling the accumulation of energy in the spring comprising a solenoid for producing a magnetic field when energized and a magnetizable armature disposed for movement in accordance with the magnetic force of said field, said armature being coupled to the other end of the spring for stressing the spring upon energization of the solenoid; and means for controlling the energization of the solenoid comprising a pair of cooperating electric contacts disposed for relative movement, means for moving one of the contacts from a disengaged position to an engaged position with respect to the other contact, and a control arm disposed for movement in response to said switch closing movement for actuating said one contact to its disengaged position thereby to deenergize the solenoid.

5. In a circuit interrupter: a switch member movable between open and closed circuit positions; a toggle having one end connected to the switch member; latching means for releasably restraining the other end of the toggle in a latched position; an operating member disposed for movement from first to second predetermined positions; electroresponsive means for moving the operating member when energized; an overcenter spring interconnecting the operating member and the toggle to exert a switch closing force on said toggle during movement of the operating member toward its second position; blocking means effective during said operating member movement to prevent movement of the switch member to its closed position until the operating member reaches a point near its second position, whereupon the blocking means is rendered ineffective to prevent movement of the switch member and the toggle is able to undergo snap-action switch closing movement in accordance with the

force being exerted by the overcenter spring; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the electroresponsive means, said control arm being disposed for movement in response to said snap-action switch closing movement of the toggle to actuate said contacts thereby deenergizing the electroresponsive means.

6. The circuit interrupter set forth in claim 5 in which the electroresponsive means comprises a solenoid and a magnetizable armature coupled to the operating member for moving the operaing member when magnetically attracted by the solenoid upon energization thereof.

7. In a circuit interrupter: a movable switch member; a releasably latched operating mechanism connected to the switch member and including a spring arranged to release stored energy to the mechanism for imparting switch closing movement thereto; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy by the spring; electromagnetic means for moving the operating member to its second position comprising a solenoid and a magnetizable plunger coupled to the operating member and disposed for longitudinal movement, thereby moving the operating member and stressing the spring, upon energization of the solenoid; and means for controlling the energization of the solenoid comprising a base member subject to mechanical shock when the operating member attains its second position, a shaft supported by the base member and oriented with respect thereto so as to vibrate laterally as a result of said mechanical shock, a relatively stationary electric contact mounted on the base member, an assembly pivotally supported by the shaft including another electric contact disposed for movement between engaged and disengaged positions with respect to the stationary contact upon pivotal movement of the assembly, said contacts being electrically connected in series relationship in the energizing circuit for the solenoid, and means biasing the assembly in a predetermined direction about the shaft thereby normally maintaining the movable contact in said engaged position, said assembly including a control arm disposed for movement in response to said switch closing movement by the operating mechanism for actuating the movable contact to said disengaged position, the total mass of the assembly being distributed so that its center of gravity lies approximately in the plane of lateral vibration of the shaft with the movable contact in said engaged position, whereby the tendency for the assembly to move pivotally on the shaft upon the occurrence of said mechanical shock is minimized.

8. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position with the guide member restrained in its latched position to produce snap-action switch closing movement of the toggle, said spring being effective during movement of the operating member toward its second position to drive the guide member toward its unlatched position in the event of guide releasing operation by the latch; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the electroresponsive means, said control arm being disposed in cooperation with the guide member for actuating said contacts and thereby deenergizing the electroresponsive means during movement of the guide member toward its unlatched position.

9. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; electromagnetic means for moving the operating member from first to second predetermined positions comprising a solenoid and a magnetizable armature coupled to the operating member for moving the operating member toward its second position in response to energization of the solenoid; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position with the guide member restrained in its latched position to produce switch-closing movement of the toggle, said spring being effective in response to movement of the operating member toward its second position with the guide member released by the latch to drive the guide member toward its unlatched position without causing switch closing movement of the toggle; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the solenoid, said control arm being disposed for engagement by said guide member during movement thereof toward its unlatched position for causing said contacts to separate thereby deenergizing the solenoid.

10. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; latching means for releasably restraining the other end of the toggle in a latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from its first to its second position with said other end of the toggle restrained in its latched position to move the toggle from a collapsed condition to a straightened condition by imparting snap-action switch closing movement thereto; means responsive to toggle releasing operation of the latching means during said operating member movement to move the toggle in its collapsed condition thereby preventing switch closing movement thereof; and means for controlling the energization of the electroresponsive means including a pair of separable electric contacts and a control arm movable from one position to another position to actuate the contacts and thereby deenergize the electroresponsive means, said control arm being disposed for movement to said other position in response to the movement of the toggle in its collapsed condition.

11. In a circuit interrupter: a movable switch member; a latch member; an operating mechanism connected to the switch member, said mechanism comprising a plurality of interconnected movable members, one of which is disposed to be releasably restrained in a latched position by the latch member, and a spring arranged to release stored energy for imparting switch closing movement to the mechanism, said mechanism being arranged to undergo switch opening movement in response to release of said one member by the latch; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy by the spring; electroresponsive means for moving the operating member to its second position when energized; and means for controlling the energization of the electroresponsive means including a pair of separable electric contacts actuated by a control arm, said control arm being disposed for engagement by said one member during said switch opening movement

of the operating mechanism for causing said contacts to be separated.

12. In a circuit interrupter: a switch member disposed for movement between open and closed circuit positions; a toggle comprising a pair of pivotally interconnected links, one end of the toggle being connected to the switch member; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position to produce snap-action switch closing movement of the toggle; means responsive to guide releasing operation of the latch to drive the guide member to its unlatched position for effecting switch opening movement of the toggle; means for energizing the electroresponsive means whenever switch closing operation is desired; and means for deenergizing the electroresponsive means comprising a pair of separable electric contacts actuated by a control arm, said control arm being disposed in cooperation with one of said toggle links to actuate said contacts and maintain the electroresponsive means de-energized whenever the switch member is in its closed circuit position and during an initial portion of said switch opening movement of the toggle, said control arm also being disposed in cooperation with the guide member to maintain said contacts actuated and thereby prevent energization of the electroresponsive means during the remaining portion of said switch opening movement of the toggle and for as long as the guide member is in its unlatched position.

13. In a circuit interrupter: a switch member disposed for movement between open and closed circuit positions; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; electromagnetic means for moving the operating member from first to second predetermined positions, said electromagnetic means comprising a solenoid and a magnetizable armature coupled to the operating member and disposed for moving said operating member to its second position upon energization of the solenoid; an overcenter spring interconnecting the operating member and toggle and effective in response to movement of the operating member to its second position to produce snap-action switch closing movement of the toggle, said over-center spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle; and means for controlling the energization of the solenoid including a pair of separable electric contacts and a control arm movable from one position to another position to actuate the contacts and thereby deenergize the solenoid, said control arm, in cooperation with the toggle, being disposed for movement to said other position in response to said snap-action switch closing movement of the toggle and, in cooperation with the guide member, being prevented from returning to said one position whenever the guide member is in its unlatched position.

14. In a circuit interrupter; a movable switch member; a toggle having one end connected to the switch member; latching means for releasably restraining the other end of the toggle in a latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position to produce snap-action switch closing movement of the toggle, said overcenter spring being effective to collapse the toggle in response to toggle releasing operation of the latching means; and means for controlling the energization of the electroresponsive means including a pair of separable electric contacts and a control arm movable from one position to another position to actuate the contacts and thereby deenergize the electroresponsive means, said control arm being disposed for movement to said other position in response to said snap-action switch closing movement of the toggle and being maintained in said other position in response to said toggle collapse.

15. In a circuit interrupter: a movable switch member; a latch member; an operating mechanism connected to the switch member, said mechanism comprising a plurality of interconnected movable members, one of which is releasably engageable by the latch member, and a spring arranged to release stored energy for imparting switch closing movement to the mechanism with said one member engaged by the latch, said mechanism being arranged to undergo switch opening movement in response to release of said one member by the latch; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy by the spring and to effect said release of stored energy; electroresponsive means for moving the operating member when energized; and means for controlling the energization of the electroresponsive means comprising a pair of separable electric contacts actuated by a control arm, said control arm being disposed for engagement by a member of said mechanism other than said one member to actuate said contacts and thereby deenergize the electroresponsive means in response to said switch closing movement of the mechanism, said control arm also being disposed for engagement by said one member to prevent energization of the electroresponsive means in response to said switch opening movement of the mechanism.

16. In a circuit interrupter; a switch member disposed for movement between open and closed circuit positions; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch for releasably restraining the guide member in its latched position; a movable operating member; electroresponsive means for moving the operating member from first to second predetermined positions when energized; an overcenter spring interconnecting the operating member and the toggle to exert a switch closing force on the toggle during movement of the operating member toward its second position; blocking means effective during said operating member movement to prevent movement of the switch member to its closed position until the operating member reaches a predetermined point near its second position, whereupon the blocking means is rendered ineffective to prevent movement of the switch member and the toggle is able to undergo snap-action switch closing movement in accordance with the force being exerted by the overcenter spring; means responsive to guide releasing operation of the latch to drive the guide member to its unlatched position for effecting switch opening movement of the toggle; and means for controlling the energization of the electroresponsive means including a pair of separable electric contacts and a control arm movable from one position to another position to actuate the contacts and thereby deenergize the electroresponsive means, said control arm in cooperation with the toggle, being disposed for movement to said other position in response to said snap-action switch closing movement of the toggle and, in cooperation with the guide member, being prevented from returning to said one position whenever the guide member is in its unlatched position.

17. The circuit interrupter of claim 16 in which the

electroresponsive means comprises a solenoid and a magnetizable armature coupled to the operating member for moving the operating member toward its second position in response to energization of the solenoid.

18. In a circuit interrupter: a movable switch member; a latch member; an operating mechanism connected to the switch member, said mechanism comprising a plurality of interconnected movable members, one of which is releasably engageable by the latch member, and a spring arranged to release stored energy for imparting switch closing movement to the mechanism with said one member engaged by the latch, said mechanism being arranged to undergo switch opening movement in response to release of said one member by the latch; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy by the spring; electroresponsive means for moving the operating member to its second position when energized; and means for controlling the energization of the electroresponsive means comprising a base member subject to mechanical shock upon attainment of said second position by the operating member, a shaft supported by the base member and oriented with respect thereto so as to vibrate laterally as a result of said mechanical shock, a relatively stationary electric contact mounted on the base member, a resilient switch arm pivotally supported by the shaft, said switch arm including another electric contact normally disposed in engagement with the stationary contact and said contacts being electrically connected in series relationship in the energizing circuit of the electroresponsive means, and a control arm coupled to the switch arm and pivotally movable from one position to another position to actuate the switch arm thereby separating the electric contacts and deenergizing the electroresponsive means, the mass of said switch and control arms being distributed so that collectively their center of gravity lies approximately in the plane of lateral vibration of the shaft with the control arm in said one position, whereby the tendency for the switch arm to move relative to the stationary contact upon the occurrence of said mechanical shock is minimized; said control arm, in cooperation with a member of said operating mechanism other than said one member, being disposed for movement to said other position in response to said switch closing movement of the mechanism and, in cooperation with said one member, being prevented from returning to said one position in response to said switch opening movement of the mechanism.

19. An electric switch comprising: a base member subject to mechanical shock; a shaft supported by the base member and oriented with respect thereto so as to vibrate laterally as a result of said mechanical shock; a relatively stationary electric contact mounted on the base member; a resilient switch arm pivotally supported by the shaft, said switch arm including another electric contact disposed for movement between engaged and disengaged positions with respect to the stationary contact upon pivotal movement of the switch arm; a cantilever control arm yieldably connected to the switch arm for actuation thereof; and means biasing the switch and control arms in a predetermined direction about the shaft thereby normally to maintain the movable contact in one of its two positions; the mass of said arms being distributed so that the center of gravity of the physical system formed by these interconnected arms lies approximately in the plane of lateral vibration of the shaft whenever the arms are disposed with said movable contact in said one position, whereby the tendency for the switch arm to move relative to the stationary contact upon the occurrence of said mechanical shock is minimized.

20. An electric switch comprising: a base member subject to mechanical shock; a shaft supported by the base member and oriented with respect thereto so that the principal vibratory motion of the axis of the shaft as a result of said mechanical shock defines a predetermined plane; a relatively stationary electric contact mounted on the base member; a resilient switch arm pivotally connected to the shaft, said switch arm including another electric contact disposed for movement between engaged and disengaged positions with respect to the stationary contact upon pivotal movement of the switch arm; a cantilever control arm coupled to the switch arm for actuation thereof; and means biasing the switch and control arms in a predetermined direction about the shaft to predetermined normal positions wherein the movable contact is maintained in one of its two positions; said switch and control arms when in their normal positions being asymmetrically disposed with respect to said predetermined plane and having their respective masses so distributed that collectively their center of gravity is disposed approximately in said predetermined plane, whereby the tendency for the switch arm to move relative to the stationary contact upon the occurrence of said mechanical shock is minimized.

21. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a movable guide member connected to the other end of the toggle and disposed to carry said other end along a predetermined path while moving from latched to unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; stop means disposed to determine said unlatched position of the guide member; an operating member disposed for movement from first to second predetermined positions; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position with the guide member in its latched position to produce snap-action switch closing movement of the toggle, said second position of the operating member being so located in relation to the toggle after said switch closing movement thereof that the line of action of the spring force intersects said predetermined path; said overcenter spring being effective in response to subsequent guide releasing operation of the latch to drive the guide member to its unlatched position and produce snap-action switch opening movement of the toggle; and means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation.

22. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a pivotally mounted guide member connected to the other end of the toggle and disposed to carry said other end along a predetermined arcuate path while moving between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; stop means disposed to determine said unlatched position of the guide member; a helical spring having one end connected to the toggle and the other end disposed at a predetermined point so located in relation to the toggle that the line of action of the spring force intersects said predetermined arcuate path, said spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce snap-action switch opening movement of the toggle; and cam means integrally associated with the guide member and disposed to engage the toggle while the guide member is moving toward its unlatched position for controlling the resulting movement of said one end of the spring in a manner to obtain a substantially uniform rate of energy release by the spring throughout the opening operation.

23. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and supported for movement between latched

and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; an operating member disposed for movement between first and second predetermined positions at opposite ends of its normal range of movement; stop means disposed to determine said second position of the operating member; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from its first to its second position with the guide member in its latched position to produce snap-action switch closing movement of the toggle, said overcenter spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle; means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation; and means for subsequently returning the operating member to its first position and for simultaneously driving the guide member to its latched position.

24. In a circuit interrupter: a switch member disposed for circuit opening and closing movement; a toggle having one end connected to the switch member; a movable guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; an operating member disposed for movement between first and second positions at opposite ends of its normal range of movement; stop means disposed to determine said second position of the operating member; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from its first to its second position to produce snap-action switch closing movement of the toggle; blocking means disposed to releasably restrain the operating member in its second position with the switch member closed; said overcenter spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle; means controlled by movement of the guide member toward its unlatched position to engage the toggle and control the resulting movement thereof in a manner to obtain a substantially uniform rate of energy released by the overcenter spring throughout the opening operation; said blocking means being arranged to free the operating member for return to its first position in response to the opening operation; and means for subsequently returning the operating member to its first position and simultaneously driving the guide member to its latched position.

25. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a movable guide member connected to the other end of the toggle and disposed to carry said other end along a predetermined path while moving between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; first stop means disposed to determine said unlatched position of the guide member; an operating member disposed for movement between first and second predetermined positions; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position with the guide member in its latched position to produce snap-action switch closing movement of the toggle; second stop means disposed to determine said second position of the operating member which position is so located in relation to the toggle after said switch closing movement thereof that the line of action of the force of the overcenter spring intersects the predetermined path of movement of said other end of the toggle; said overcenter spring being effective in response to subsequent guide releasing operation of the latch to drive the guide member to its unlatched position and produce snap-action switch opening movement of the toggle; means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation; and means for returning the operating member to its first position while simultaneously driving the guide member to its latched position.

26. In a circuit interrupter: a movable switch member; a toggle comprising a pair of pivotally interconnecting links, one end of the toggle being connected to the switch member; a roller rotatably supported by one of the toggle links; a guide member connected to the other end of the toggle and disposed for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; and an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from first to second predetermined positions with the guide member in its latched position to produce snap-action switch closing movement of the toggle, said overcenter spring being effective to drive the guide member to its unlatched position and produce switch opening movement of the toggle in response to subsequent guide releasing operation of the latch; said guide member including a concave camming surface disposed to engage said roller while moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation.

27. In a circuit interrupter: a movable switch member; a toggle comprising a pair of links pivotally joined to form a knee, one end of the toggle being connected to the switch member; a guide member connected to the other end of the toggle and supported for pivotal movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; a movable operating member; an overcenter spring interconnecting the operating member and the toggle knee and effective in response to movement of the operating member from first to second predetermined positions with the guide member in its latched position to produce snap-action switch closing movement of the toggle, said overcenter spring being effective in response to subsequent guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle; and a roller rotatably supported by one of said toggle links intermediate said one end and said knee; said guide member having a camming surface disposed to engage said roller while said guide member is moving pivotally toward its unlatched position, said camming surface being contoured so that the camming action of this surface forces the roller and consequently the toggle knee to follow relatively linear paths during the opening operation.

28. In a circuit interrupter: a switch member disposed for movement between closed and open circuit positions; latching means; an operating mechanism connected to the switch member and to the latching means, said mechanism being operable from a reset condition to a closed condition while releasably latched by the latching means for producing circuit closing movement of the switch member and being operable to an open condition in response to subsequent unlatching operation of the latching means for producing circuit opening movement of the switch member; means for preventing appreciable rebound of the switch member from its open circuit posi-

tion upon completion of said circuit opening movement comprising, an anti-rebound member pivotally connected to the switch member, said anti-rebound member being disposed in a first predetermined position with the switch member in its closed circuit position, means for guiding the anti-rebound member so that it travels with essentially translation motion from its first position to a second predetermined position in response to movement of the switch member from closed to open circuit positions, said anti-rebound member being rotatable from its second position in a predetermined direction with respect to the point of its pivotal connection to the switch member, and a cooperating member fixedly disposed to be engaged by the anti-rebound member upon rotation thereof for preventing movement of the anti-rebound member directly toward its first position and thereby preventing appreciable rebound of the switch member, said anti-rebound member having its center of gravity located so that its inertia at the moment of reaching its second position will cause said rotation and so that the force of gravity will return it to its second position; and means for effecting a resetting operation of said mechanism from its open condition to its reset condition; said mechanism including means disposed in cooperation with said anti-rebound member when the mechanism is in its reset condition to prevent said rotation of the anti-rebound member during the initial phase of the circuit closing movement of the switch member.

29. In a circuit interrupter: a switch member disposed for movement between closed and open circuit positions; an operating mechanism connected to the switch member for producing circuit opening movement thereof; and means for preventing appreciable rebound of the switch member from its open circuit position upon the completion of said circuit opening movement comprising, an anti-rebound member pivotally connected to the switch member, said anti-rebound member being disposed in a first predetermined position with the switch member in its closed circuit position, means for guiding the anti-rebound member so that it travels with essentially translational motion from its first position to a second predetermined position in response to movement of the switch member from closed to open positions, said guide means being disposed to permit rotation of the anti-rebound member from its second position in a predetermined direction with respect to the point of its pivotal connection to the switch member, and a cooperating member fixedly disposed to be engaged by the anti-rebound member upon rotation thereof for preventing movement of the anti-rebound member directly toward its first position and thereby preventing appreciable rebound of the switch member, the center of gravity of the anti-rebound member being located so that the kinetic energy of this member at the moment it reaches its second position produces said rotation and so that the force of gravity acting on this member returns it to its second position when said kinetic energy has been dissipated.

30. In a circuit interrupter: a switch member disposed for movement between closed and opened circuit positions at opposite ends of its normal range of movement; an operating mechanism connected to the switch member for producing circuit opening movement thereof; and means for preventing appreciable rebound of the switch member from its open circuit position upon the completion of said circuit opening movement comprising, an elongated member connected near an upper end thereof to the switch member for pivotal movement in a vertical plane, the axis about which said pivotal movement takes place being moved along in an arcuate path in said vertical plane in response to movement of the switch member from closed to open circuit positions, means for supporting the elongated member in a predetermined inclined position whenever the switch member is in its closed circuit position and for guiding the elongated member during movement of said axis so that it travels with essentially translational motion from its inclined position to another predetermined position substantially parallel to said inclined position, said supporting and guiding means being disposed to permit rotation of the elongated member from its other position in a predetermined direction about said axis, and a rigid member fixedly disposed for interlocking engagement, upon rotation of the elongated member, by a laterally protruding portion of the elongated member located near its other end, the elongated member being rotated in said predetermined direction by the force of inertia effective at the conclusion of said translational motion and being subsequently returned to said other position by the force of gravity.

31. In a circuit interrupter: a switch member movable between closed and open circuit positions; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and supported for movement between latched and unlatched positions; a latch disposed releasably to restrain the guide member in its latched position; an operating member disposed for movement between first and second predetermined position at opposite ends of its normal range of movement; stop means disposed to determine said second position of the operating member; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from its first to its second position with the guide member in its latched position to produce snap-action switch closing movement of the toggle, whereby the switch member is moved from open to closed circuit positions; said overcenter spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle, whereby the switch member is moved from closed to open circuit positions; means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation; means for preventing appreciable rebound of the switch member from its open circuit position at the conclusion of the opening operation comprising an anti-rebound member pivotally connected to the switch member, said anti-rebound member being guided for translational movement in response to the circuit opening movement of the switch member and being rotatable in a predetermined direction with respect to the point of its pivotal connection to the switch member with the switch member in its open circuit position, and a cooperating member fixedly disposed to be engaged by the anti-rebound member upon rotation thereof in said predetermined direction for preventing appreciable movement of the switch member toward its closed circuit position, and anti-rebound member having its center of gravity located so that its inertia at the conclusion of the opening operation will cause said rotation in opposition to gravitational force acting thereon; means for returning the operating member to its first position and for simultaneously driving the guide member to its latched position thereby resetting the toggle and the latch; and means associated with the toggle and disposed in cooperation with said anti-rebound member whenever the guide member is in its latched position and the switch member is in its open circuit position for preventing said rotation of the anti-rebound member during the initial phase of the circuit closing movement of the switch member.

32. In a circuit interrupter: a switch member movable between closed and open circuit positions; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and supported for movement between latched and unlatched

positions at opposite ends of its normal range of movement; a latch disposed releasably to restrain the guide member in its latched position; an operating member disposed for movement from first to second predetermined positions; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member to its second position with the guide member in its latched position to produce snap-action switch closing movement of the toggle, whereby the switch member is moved to its closed circuit position; said spring being effective in response to guide releasing operation of the latch to drive the guide member to its unlatched position and produce switch opening movement of the toggle, whereby the switch member is moved to its open circuit position; cam means integrally associated with the guide member and disposed to engage the toggle while the guide member is moving toward its unlatched position for controlling the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the spring throughout the opening operation; and means for preventing appreciable rebound of the switch member from its open circuit position at the conclusion of the opening operation comprising, an anti-rebound member pivotally connected to the switch member, said anti-rebound member being guided for translation motion in response to circuit opening movement of the switch member and being freely rotatable in a predetermined direction with respect to the point of its pivotal connection to the switch member when the switch member reaches its open circuit position, and a relatively rigid member fixedly disposed to be engaged by the anti-rebound member upon rotation thereof in said predetermined direction for preventing appreciable movement of the switch member toward its closed circuit position, said anti-rebound member having its center of gravity located so that its inertia at the conclusion of the opening operation will cause said rotation in opposition of the gravitational force acting thereon.

33. In a circuit interrupter: a movable switch member; a toggle having one end connected to the switch member; a guide member connected to the other end of the toggle and supported for movement between latched and unlatched positions; means for releasably restraining the guide member in its latched position comprising a pivotally mounted latch member biased into self-releasing engagement with the guide member when in its latched position and a trip member abutting the latch member for holding the latch member in engagement with the guide member, said trip member being mounted for pivotal movement with respect to an axis of rotation and being disposed in relation to said latch member so that the line of action of the resultant force at the abutting surfaces of these two members intersects said axis; an operating member disposed for movement between first and second predetermined positions at opposite ends of its normal range of movement; stop means disposed to determine said second position of the operating member; an overcenter spring interconnecting the operating member and the toggle and effective in response to movement of the operating member from its first to its second position with the guide member in its latched position to produce snap-action closing movement of the toggle, said overcenter spring being effective in response to pivotal movement of the trip member and the consequent release of the guide member to drive the guide member to its unlatched position and produce switch opening movement of the toggle; and means disposed in cooperation with the toggle and effective while the guide member is moving toward its unlatched position to control the resulting movement of the toggle in a manner to obtain a substantially uniform rate of energy release by the overcenter spring throughout the opening operation.

34. In a circuit interrupter: a movable switch member; an operating member movable between first and second predetermined positions; a releasably latched operating mechanism connected to the switch member, said mechanism including a spring connected to the operating member and responsive to movement of the operating member to its second position for first accumulated mechanical energy and then releasing stored energy to the mechanism for producing switch closing movement thereof, said mechanism being arranged to undergo switch opening movement when unlatched; means actuated in response to said switch closing movement of the mechanism for blocking the operating member in its second position until the mechanism undergoes said switch opening movement; electromagnetic means comprising a solenoid and a magnetizable armature coupled to the operating member and disposed for moving said operating member to its second position upon energization of the solenoid; and means including a pair of separable electric contacts actuated by a control arm for controlling the energization of the solenoid, said control arm being disposed for movement in response to said switch closing movement of the mechanism for actuating said contacts thereby to deenergize the solenoid.

35. In a circuit interrupter: a movable switch member; a latch member; an operating mechanism connected to the switch member, said mechanism comprising a plurality of interconnected movable members, one of which is disposed to be releasably restrained in a latched position by the latch member, and a spring arranged to release stored energy for imparting switch closing movement to the mechanism with said one member in its latched position, said one member being movable out of its latched position when released by the latch member thereby enabling said mechanism to undergo switch opening movement; a movable operating member connected to the spring and disposed for movement from first to second predetermined positions to control the accumulation of energy in the spring and to effect said release of energy stored therein; means actuated during said switch closing movement of the mechanism for blocking the operating member in its second position and for preventing return of the operating member to its first position until the mechanism undergoes said switch opening movement; electromagnetic means for moving the operating member comprising a solenoid and a magnetizable armature positively coupled to the operating member and disposed to move this member to its second position upon energization of the solenoid; and means for controlling the energization of the solenoid comprising a pair of separable electric contacts actuated by a control arm, said control arm being disposed in cooperation with a member of said mechanism other than said one member to actuate said contacts and thereby deenergize the solenoid in response to said switch-closing movement, said control arm also being disposed in cooperation with said one member to maintain said contacts actuated in response to said switch-opening movement and thereby prevent re-energization of the solenoid until said one member is subsequently returned to its latched position.

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