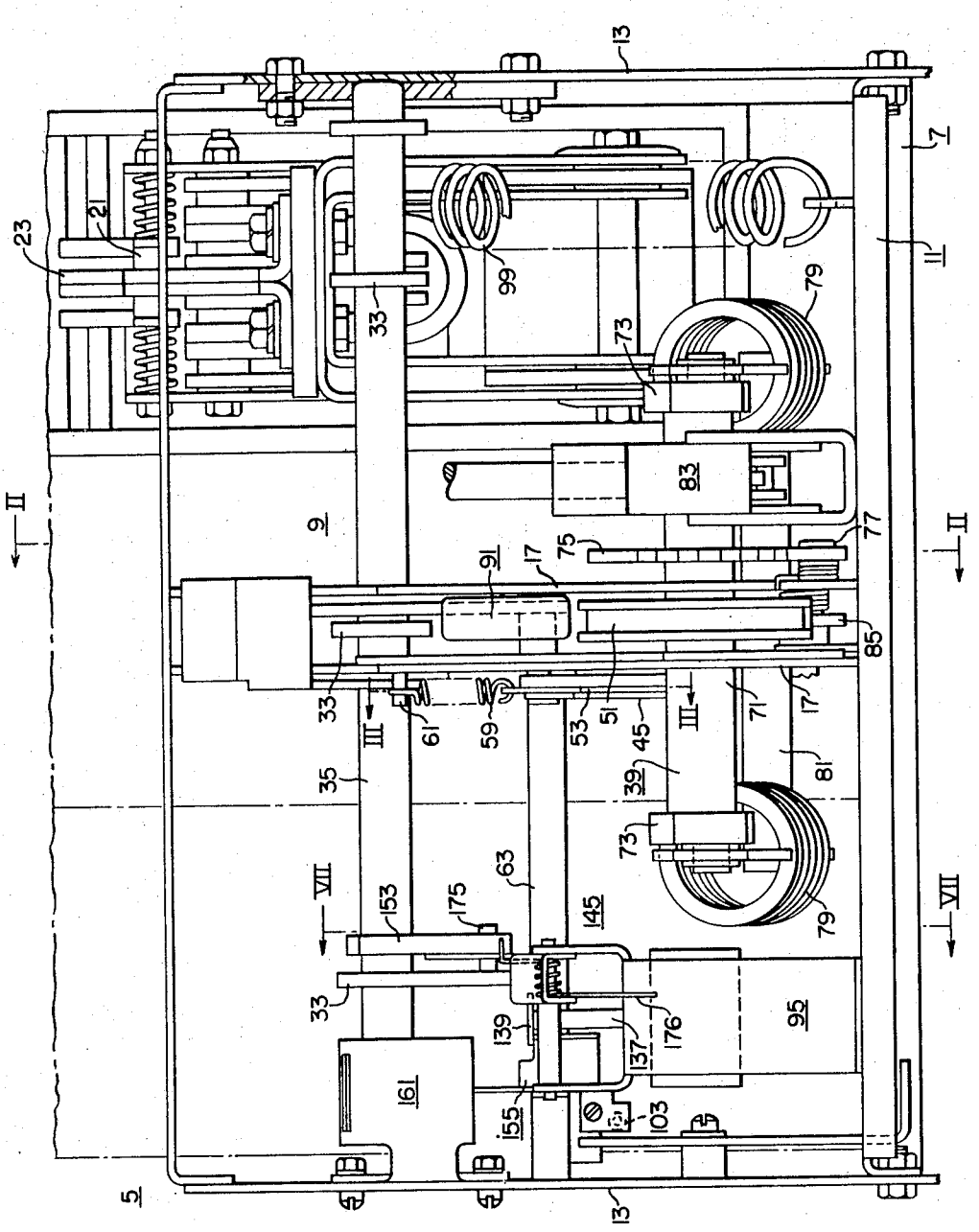
Dec. 1, 1970 N. J. PATEL 3,544,931

CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

Filed Oct. 24, 1968 5 Sheets-Sheet 1

FIG. 1.



WITNESSES

Theodore F. Wrobel

James F. Young

INVENTOR

Nagar J. Patel

BY

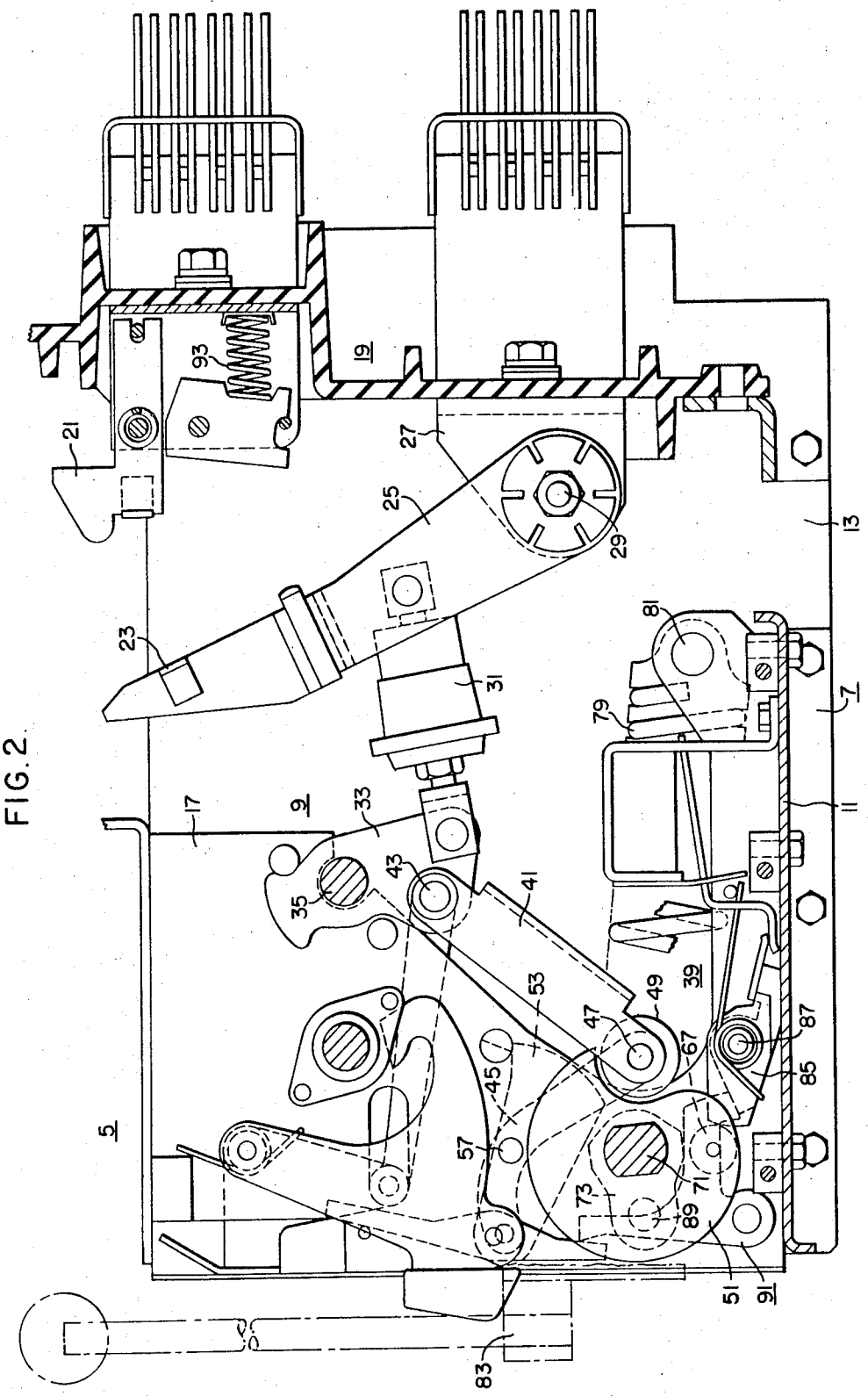
William A. Elchik

ATTORNEY

CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

Filed Oct. 24, 1968 5 Sheets-Sheet 2

FIG. 2.



CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

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FIG. 7.

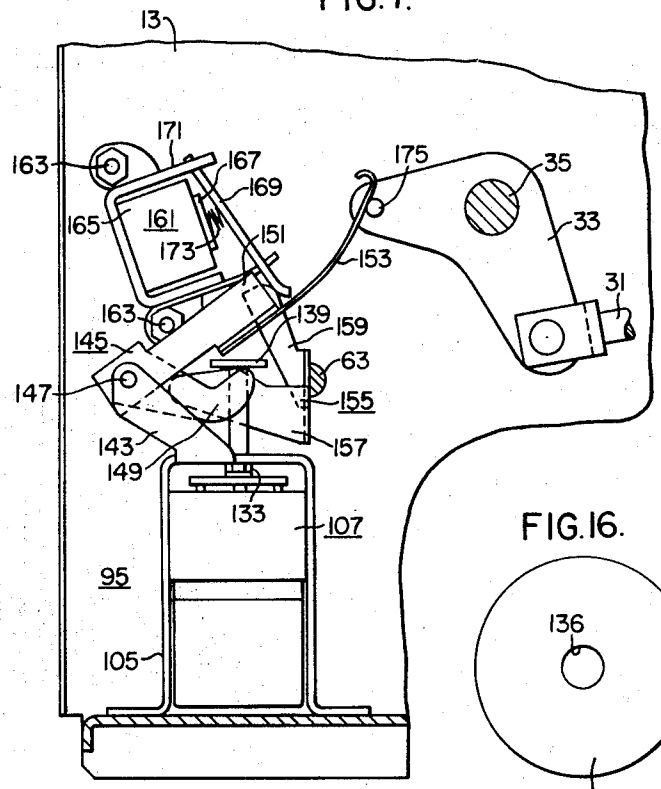


FIG. 14.

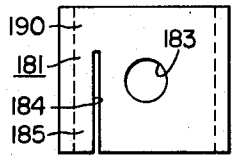


FIG. 13.

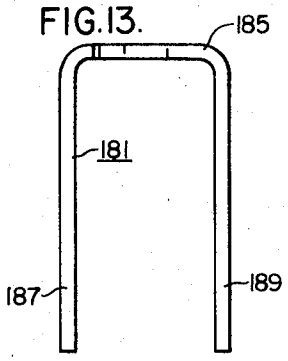


FIG. 16.

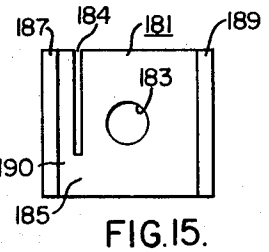


FIG. 15.

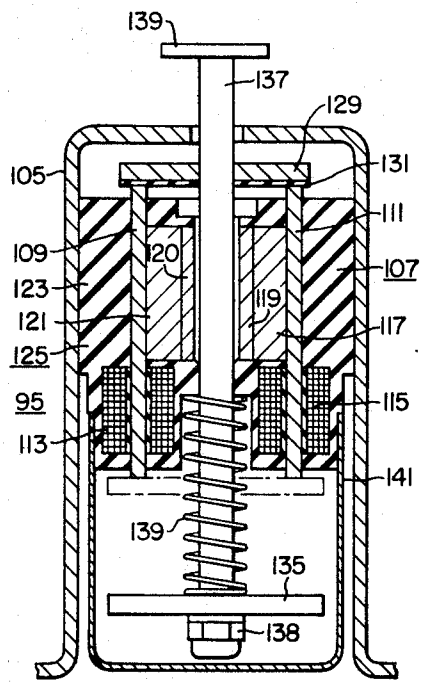


FIG. 12.

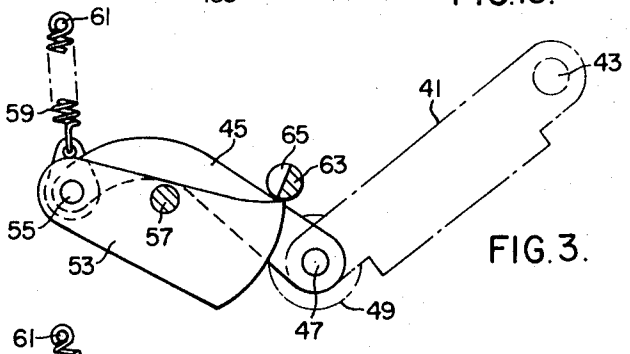


FIG. 3.

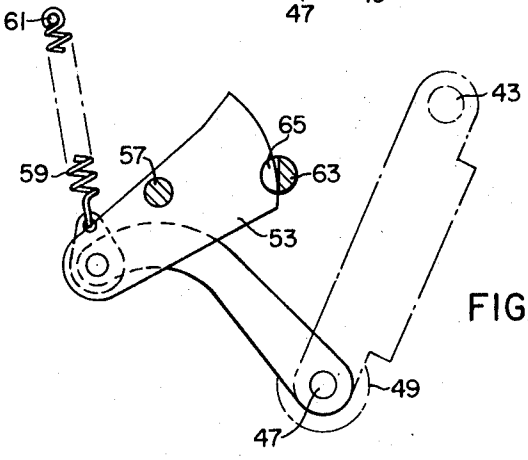


FIG. 4.

CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

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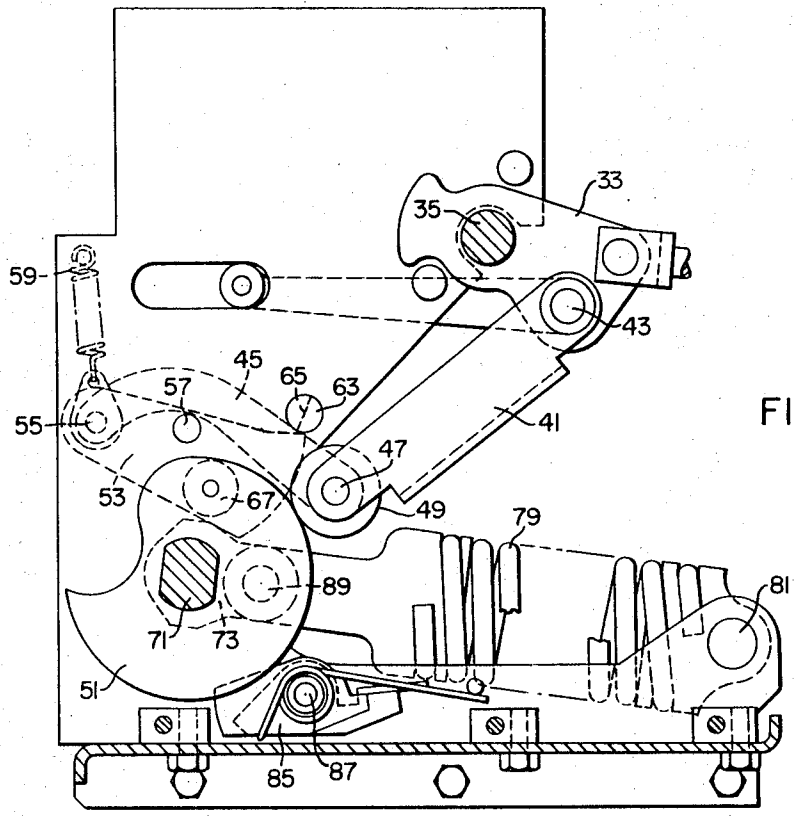


FIG. 5.

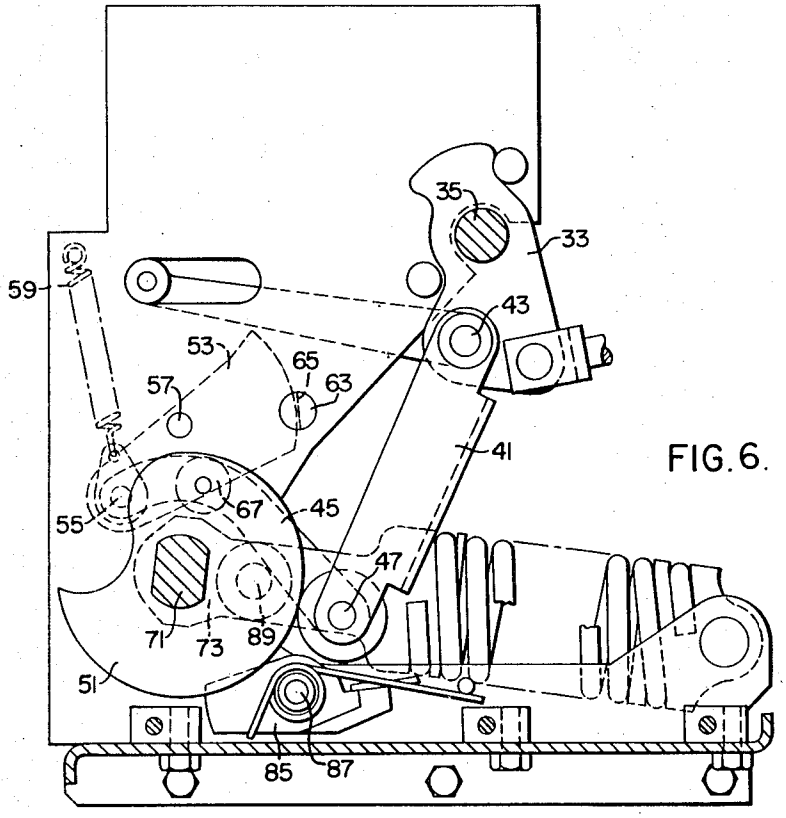


FIG. 6.

CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

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FIG. 8.

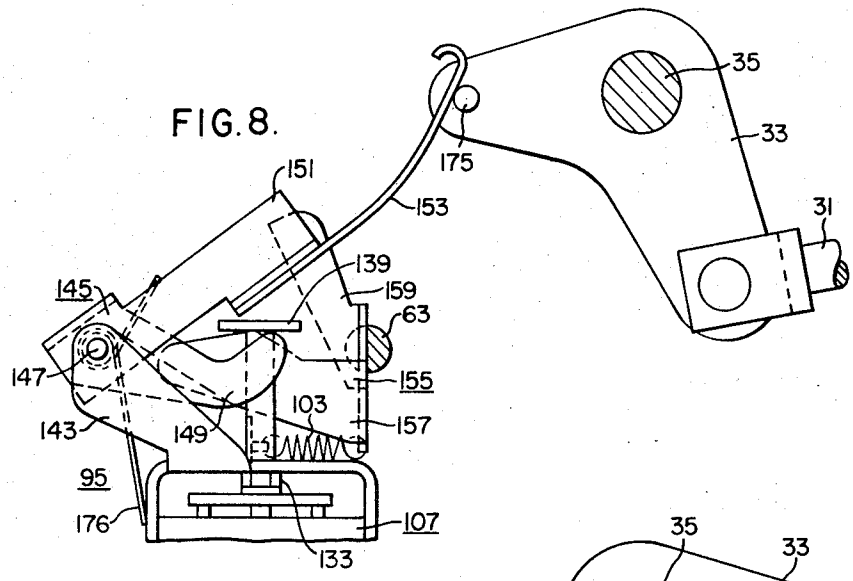
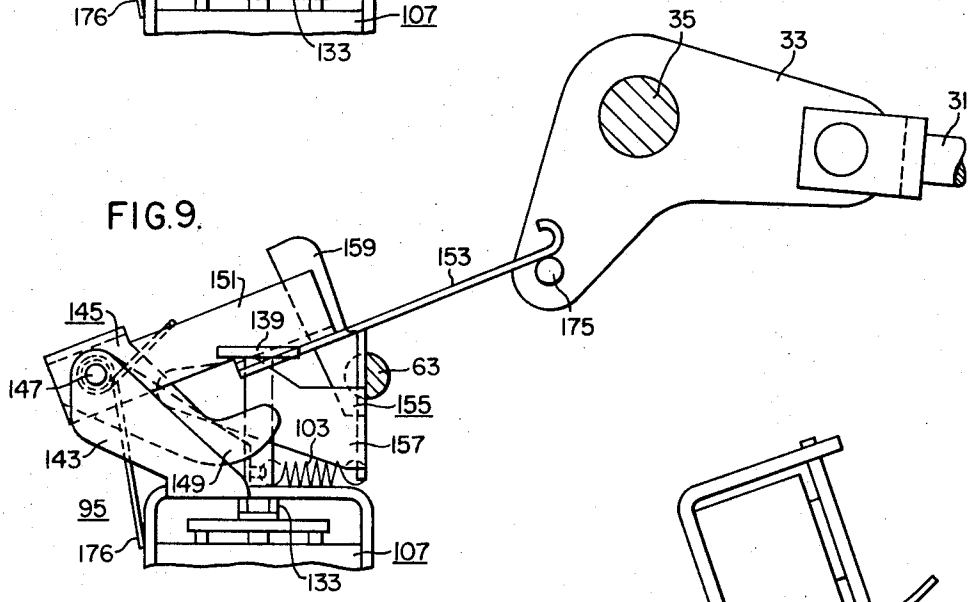


FIG. 9.



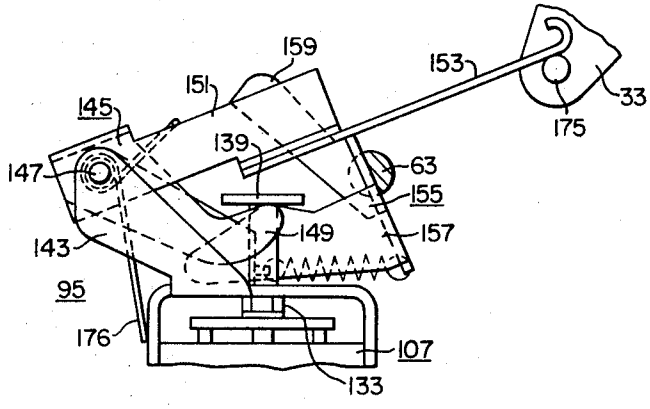


FIG. 10.

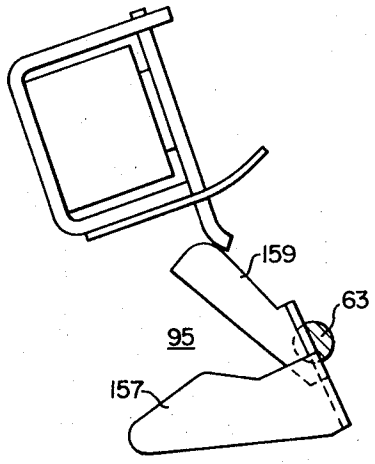


FIG. 11.

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3,544,931

CIRCUIT BREAKER WITH IMPROVED TRIP MEANS

Nagar J. Patel, East McKeesport, Pa., assignor to Westinghouse Electric Corporation, Pittsburgh, Pa., a corporation of Pennsylvania

Filed Oct. 24, 1968, Ser. No. 770,236
Int. Cl. H01h 9/20
U.S. Cl. 335—174 10 Claims

ABSTRACT OF THE DISCLOSURE

A circuit breaker comprises improved trip means automatically operable to open the breaker upon the occurrence of overload current conditions. A magnetic trip device comprises a movable keeper connected to an actuator which, when the movable keeper is released, moves as a unit to engage a trip extension that is carried on the breaker trip shaft to move the trip shaft and thereby effect opening of the breaker contacts. A magnetic trip device comprises a generally U-shaped unitary magnetic member and a movable keeper opposite the ends of the legs of the generally U-shaped unitary magnetic member with the bight portion of the generally U-shaped unitary magnetic member serving as a fixed keeper.

CROSS-REFERENCES TO RELATED APPLICATIONS

This invention is an improvement over the invention disclosed in the application of Edmund W. Kuhn entitled "Circuit Breaker With Improved Trip Means," Ser. No. 770,305, filed Oct. 24, 1968. The circuit breaker herein disclosed is more specifically described in the application of Fred Bould et al. entitled "Circuit Breaker," Ser. No. 770,296, filed Oct. 24, 1968.

BACKGROUND AND OBJECTS OF THE INVENTION

For certain applications of circuit breakers, it is desirable to provide a flux-transfer trip device of the type comprising a plurality of magnetic circuits with means for transferring magnetic flux from a first circuit to a second circuit to effect release of a movable keeper in the first circuit to thereby effect a tripping operation of the circuit breaker. An object of this invention is to provide an improved circuit breaker comprising a flux-transfer trip device and improved means providing a cooperative relationship between the movable keeper of the trip device and the operating mechanism of the circuit breaker.

Another object of this invention is to provide a circuit breaker with an improved flux-transfer type trip device that comprises a unitary U-shaped magnetic member, that serves as the pole pieces and fixed keeper, and that is constructed to to provide a magnetic circuit through the bight portion thereof that has a higher reluctance than another magnetic circuit that extends through portions of the legs of the U-shaped member and through a magnetic movable keeper that engages the free ends of the legs of the U-shaped member.

A more general object of this invention is to provide a circuit breaker with an improved flux-transfer type trip device that is reliable in operation and relatively easy to manufacture and to assemble into operating relationship with parts of the circuit breaker.

SUMMARY OF THE INVENTION

An improved circuit breaker comprises a flux-transfer type trip device that, when pulsed by a momentary low energy electrical signal supplied under abnormal or overload conditions, will effect a tripping operation of the circuit breaker. The trip device comprises a pair of spaced

magnetic pole pieces with a movable keeper positioned at the back end of the pole pieces and a fixed keeper positioned at the front end of the pole pieces. A permanent magnet structure is supported between the pole pieces and between the fixed and the movable keepers in order to supply magnetic flux. With the movable keeper in the set position the large majority of magnetic flux from the permanent magnet structure operates through a low reluctance magnetic circuit, that comprises the movable keeper, to work to maintain the movable keeper in the set position. The remainder of magnetic flux passes through a higher reluctance magnetic circuit that includes the fixed keeper. The pole pieces and magnetic structure are encapsulated in an insulating casing. An actuator is operatively connected to the movable keeper and extends through an opening in the trip device to the front end of the trip device where the actuator is formed with a head portion. A kick-out spring is supported in the opening in the trip device around the actuating rod to bias the movable keeper and actuating rod toward a tripping position. A pair of coils are connected in series and to the magnetic device in order to buck the magnetic flux through the low-reluctance magnetic circuit to thereby effect a transfer of magnetic flux to the higher-reluctance magnetic circuit to effect release of the movable keeper. Upon release of the movable keeper, the kick out spring biases the movable keeper and actuating rod to a tripping position. The trip device comprises a trip member that is fixedly secured to a rotatable trip shaft of the circuit breaker and that is positioned under the head of the actuating rod. When the actuating rod is operated downward upon release of the movable keeper the head thereof engages the trip member to rotate the trip shaft to effect a tripping operation of the circuit breaker. The trip device also includes a resilient bell-crank type reset member that is pivotally supported at the front end of the trip device. The bell-crank type resilient reset member comprises a first leg that is positioned under the head of the actuating rod and a resilient second leg that extends into the path of movement of a lever member that moves with the movable contact between the open and closed positions. When the circuit breaker is tripped the lever member moves to the open position engaging the resilient leg of the bell-crank type resilient reset member to pivot the reset member to a resetting position during which movement the other leg of the reset member engages the head of the actuating rod to pull the rod up to the reset position and to permit the trip member, that is fixedly secured to the trip shaft, to move back to the reset position under the bias of a reset spring. With the mounting of the trip member on the trip shaft and with the provision of a pivotally supported bell-crank type resilient reset member connected to the front of the trip device, the construction and positioning of parts is less critical and the trip device is readily assembled into operative relationship with the breaker. The trip member is provided with another leg that is actuated by a separate solenoid that may be remotely controlled to provide a shunt trip device. In one embodiment of the invention the pole pieces and fixed keeper are formed as a unitary U-shaped member of magnetic material with the higher reluctance path through the fixed keeper or bight portion being provided by forming a portion of reduced cross section in the bight portion of the unitary U-shaped member. This construction eliminates the need of a separate fixed keeper and makes the unit less sensitive to manufacturing and assembly variations.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an end view, with parts broken away, of a circuit breaker constructed in accordance with principles of this invention;

FIG. 2 is a sectional view taken generally along the line II—II of FIG. 1;

FIG. 3 is a sectional view, with parts left out for the purpose of clarity, taken generally along the line III—III of FIG. 1;

FIG. 4 is a view similar to FIG. 3 illustrating the parts in the tripped position;

FIG. 5 is a view similar to FIG. 2, of part of the operating mechanism shown in FIG. 2, with the parts being shown in the spring-discharged contact-closed position;

FIG. 6 is a view similar to FIG. 5 with the parts being shown in the spring-discharged contact-open position;

FIG. 7 is a sectional view taken generally along the line VII—VII of FIG. 1;

FIG. 8 is a partial view similar to FIG. 7, on an enlarged scale relative to FIG. 7, with the circuit breaker in the open position and the trip device in the reset position;

FIG. 9 is a view similar to FIG. 8 with the circuit breaker in the closed position and the trip device in the reset position;

FIG. 10 is a view similar to FIGS. 8 and 9 with the trip device in the tripped position just prior to opening of the circuit breaker;

FIG. 11 is a partial view illustrating the actuating position of the shunt-trip device;

FIG. 12 is a sectional view of part of the trip device seen in FIG. 7;

FIG. 13 is an end elevational view of a U-shaped magnetic member that serves as the pole pieces and fixed keeper in one embodiment of the invention;

FIG. 14 is a top plan view of the member shown in FIG. 13;

FIG. 15 is a bottom plan view of the member shown in FIG. 13; and

FIG. 16 is a top plan view of the movable keeper shown in FIG. 12.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, there is shown in FIGS. 1 and 2 a three-pole circuit breaker **5** comprising a housing structure **7** and a circuit-breaker structure **9** supported on the housing structure **7**. The circuit breaker **5** is more specifically described in the above-mentioned application of Fred Bould et al., Ser. No. 770,296, filed Oct. 24, 1968.

The housing structure **7** comprises a metallic base plate **11**, a pair of spaced metallic side plates **13** secured to flanges of the base plate **11**, a pair of metallic spaced center plates **17** secured to the base plate **11** and a back wall structure indicated generally at **19**.

The circuit-breaker structure **9** is a three-pole structure comprising a stationary contact **21** and a movable contact **23** for each pole unit. Each of the movable contacts **23** is supported on a conducting contact arm **25** that is pivotally supported on a terminal conductor **27** by support means **29**. In each pole unit, a separate insulating connecting member **31** is pivotally connected at one end thereof to the contact arm **25** and at the other end thereof to a lever **33** that is welded to a common jack shaft or tie bar **35**. As can be seen in FIG. 1, the jack shaft **35** extends across all of the poles of the circuit breaker, and there is a separate lever **33** for each pole unit welded to the jack shaft **35**. Only one of the contact structures is shown in FIG. 1. The contact structures for the centerpole and for the left-hand (FIG. 1) pole are left off of the drawing in FIG. 1 merely for the purpose of clarity. It can be understood that the contact structures for all three pole units are the same as the one contact structure shown in FIGS. 1 and 2.

The jack shaft **35** is supported for pivotal movement, about the elongated axis thereof, on the side plates **13** and center plates **17**. The connecting members **31**, levers **33** and jack shaft **35** are part of a stored-energy spring closing mechanism **39** that is operable to close the contacts **23, 21**. The mechanism **39** comprises a link member **41** that is pivotally connected, at one end thereof, to the lever **33** of the centerpole unit by means of a pin **43**. The link **41** is pivotally connected, at the other end thereof, to a link **45** by means of a knee pivot pin **47**. A roller member **49**, that serves as a cam follower, is mounted on the pin **47** to cooperate with a closing cam **51**. A link **45** is pivotally connected at the other end thereof to a latch member **53** by means of a pin **55** (FIG. 3). The latch member **53** is mounted for pivotal movement about a fixed pivot **57** that is supported on the left-hand (FIG. 1) center plate **17**. A tension spring **59** is connected at one end thereof to a stationary pin **61**, and operatively connected to the pin **55** at the other end thereof in order to reset the linkage following a tripping operation in a manner to be hereinafter described. As can be seen in FIGS. 3 and 4, the latch member **53** engages a trip shaft **63** that is a rod with a cut-out portion **65** near where the latch **53** engages the periphery of the trip shaft **63**. The cut-out portion **65** is provided so that when the trip shaft **63** is rotated in a counterclockwise direction the latch member **53** will be free to move to the tripped position seen in FIG. 4. The trip shaft **63** is supported for pivotal movement about the elongated axis thereof between one of the center plates **17** (FIG. 1) and one of the side plates **13**.

As can be seen in FIG. 1, the closing cam **51** comprises a pair of twin cam plates and a center spacer plate sandwiched together. The center spacer plate does not fill the space between the twin cam plates, and a roller latch member **67** (FIG. 2) is rotatably supported on and between the twin plates of the cam **51**. The cam member **51** is fixedly secured to a crank-shaft **71** that is rotatably supported on suitable bearings that are secured to the center plates **17**. A pair of crank arms **73** are fixedly mounted on the crank-shaft **71** in proximity to the opposite ends of the crank-shaft **71**. A ratchet member **75** (FIG. 1) is fixedly mounted on the crank-shaft **87**, and a pawl **77** is supported on one center plate to cooperate with the ratchet **75**. A separate tension spring **79** is operatively connected at one end thereof to each of the crank arms **93**. Each of the tension springs **79** is connected, at the other end thereof, to a rod **81** that is secured to the center plates **17**. A handle operating mechanism, indicated generally at **83**, is provided for manually charging the closing springs **79**. The handle operating mechanism **83** is more specifically described in the above-mentioned application of Fred Bould et al., Ser. No. 770,296, filed Oct. 24, 1968. A latch member **85** (FIG. 2) is pivotally mounted on a pin **87** and biased in a clockwise (FIG. 2) direction to the latching position wherein the latch **85** engages the roller **67** to latch the closing cam **51** and crank-shaft **71** to prevent counterclockwise movement of the closing cam **51** and crank-shaft **71**.

The circuit breaker is shown in FIG. 2 in the contact-open position with the stored energy closing springs **79** in the charged condition. As shown in FIG. 2, the spring support pins **89** of the movable ends of the tension springs **79** are below a line through the center of the spring support rod **81** and the center of the crank-shaft **71** so that the charged tension springs **79** are operating to bias the crank-shaft **71** in a counterclockwise direction. Counterclockwise movement of the crank-shaft **71** is prevented by the engagement of the latch member **85** with the latch roller **67** that is mounted on the closing cam **51**. The latch member **85** is manually operated to the unlatching position by operation of closing means indicated generally at **91** and more specifically described in the above-mentioned application of Fred Bould et al., Ser. No. 770,296, filed Oct. 24, 1968. As can be seen in FIG. 2, the roller **49** is positioned in a depression of the surface of the closing cam **51**. When it is desired to close the circuit breaker, the closing means **91** is manually operated to pivot the latch **85** (FIG. 2) in a counterclockwise direction to thereby release the roller **67**. When the roller **67** is released, the closing cam **51** and crank-shaft **71** are free

to rotate in a counterclockwise direction, and the closing springs **79**, operating on the crank arms **73**, operate to rotate the crank-shaft **87** from the charged position seen in FIG. 2 to the discharged positions seen in FIG. 5. With the latch **53** (FIG. 3) engaging the trip shaft **63** to prevent counterclockwise movement of the latch **53**, the closing cam **51** will force the roller **49**, and the link **41**, to the closed position. During this closing movement of the link **41**, the lever **33** (FIG. 2) of the center pole unit is forced in a counterclockwise direction to rotate the jack shaft **35** to the closed position seen in FIG. 5. As the jack shaft **35** rotates to the closed position all three of the levers **33** of the three pole units are moved with the jack shaft to the closed position forcing the connecting members **31** of the three pole units to force the contact arms **25** of the three pole units about the pivots **29** to the closed position wherein the movable contacts **23** engage the stationary contacts **21**. This closing movement compresses back-up springs **93** in the three pole units. As can be understood with reference to FIG. 5, the engagement of the closing cam **51** with the roller **49** serves to prop the link member **41** in the closed position to thereby maintain the jack shaft **35** and contacts in the closed position.

With the contacts in the closed position and the closing springs discharged (FIG. 5) the circuit breaker may be automatically tripped open, in response to an overload above a predetermined value in any of the pole units, by operation of trip means indicated generally at **95** (FIG. 1), that will be hereinafter more specifically described. When actuated, the trip means **95** operates to rotate the trip shaft **63** in a counterclockwise direction from the latching position seen in FIGS. 3 and 5 to the unlatched or tripped positions seen in FIGS. 4 and 6. When the trip shaft **63** is rotated counterclockwise to the tripped position, the trip shaft moves to permit the latch member **53** to move in the notch **65** thereby permitting the latch member **53** to move in a counterclockwise direction about the pivot **57**. The compressed contact springs **93** and an opening spring **99** then operate to move the contact arms **25** toward the open position which movement occurs because the pivot **55** is free to move from the position seen in FIG. 3 to the position seen in FIG. 4 so that the link **45** can move to the tripped position with the toggle **45, 41** collapsing to permit the lever **33** to move in a clockwise direction to the tripped open position. As can be understood with reference to FIGS. 2, 5 and 6 movement of the trip shaft **63** to the tripped position permits the members **41, 45, 53** to move to the tripped position wherein the roller **49** and link **41** no longer restrain the lever **33** in the closed position, and the springs **93, 99** operate to move the jack shaft **35** and the three contact arms **25** to the tripped-open position illustrated in FIG. 6.

The circuit breaker is trip free and the operator cannot manually restrain the breaker in a closed position when an overload occurs in any of the pole units.

With the circuit breaker in the tripped-open position seen in FIG. 6, the breaker is reset and the closing springs **79** are charged by operation of the manual operating means **83** (FIG. 1). In order to reset the circuit breaker and charge the closing springs **79**, an operator cranks the manually operable means **83** to rotate the crank-shaft **71** through an angle of more than 180° from the spring-discharged position seen in FIG. 6 to the spring-charged operating position seen in FIG. 2. As the crank-shaft **71** moves to the position seen in FIG. 2, the roller **49** rides off of the peak of the cam **51** into the depression seen in FIG. 2. When the roller **49** is free to move into the depression of the cam **51**, the spring **59** biases the latch **53** clockwise to move the latch **53** to the reset position pulling the links **45, 41** and the roller **49** to the reset position wherein the roller **49** is positioned in the depression of the cam **51** (FIG. 2). When the latch **53** (FIGS. 3 and 4) moves out of the notch **65** of the trip shaft **63**, a spring **103** (FIG. 1) operates to rotate the trip shaft **63** clockwise from the position seen in FIG. 4 to the position seen in FIG. 3 whereupon the periphery of the trip shaft **63** again latches the latch member **53** to latch the parts in the reset position seen in FIGS. 2 and 3. As the crank-shaft **71** moves over the 184° line from the position seen in FIG. 6 to the position seen in FIG. 2, the springs **79**, which are moved overcenter, take over to bias the crank-shaft **71** in a counterclockwise (FIG. 2) direction, and the roller **67** engages the latch **85** to latch the crank-shaft **71** in the charged position seen in FIG. 2 wherein the circuit breaker is prepared (FIG. 2) for another closing operation.

When the circuit breaker is in the contact-closed position with the stored energy closing springs **97** discharged the spring closing means can be manually operated to the charged position by the operation of the manually operable means **83** (FIG. 1) during which operation the crank-shaft **71** is rotated through an angle of slightly more than 180° (approximately 184°) to charge the springs **79** during which movement the roller **49** rides on a fixed-radius surface of the cam **51** from the position seen in FIG. 5 to a position just short of the peak of the cam surface of the cam member **51**. This charging operation is more specifically described in the above-mentioned application of Fred Bould et al. Ser. No. 770,296, filed Oct. 24, 1968.

With the parts in the contact-closed spring-charged position, the following sequence of operations can occur: Upon the occurrence of an overload of a predetermined value, the trip means **95** is operated to automatically rotate the trip shaft **63** to the unlatching position to release the latch member **53** and permit collapse of the toggle **41, 45** to effect an opening operation in the same manner as was hereinbefore described. With the toggle **41, 45** collapsed, the resetting spring **59** operates to draw the roller **49** into the depression of the cam **51** resetting the linkages **53, 41, 45**, and the trip shaft **63**, into the position seen in FIG. 2. The parts at the end of this tripping operation will be in the position seen in FIG. 2 wherein the mechanism is reset and relatched, and wherein the roller member **49** is in the depression of the cam **51** so that the parts are prepared for an mmediate closing operation. Thus, at the expiration of the tripping operation, when the closing springs **79** are charged, an operator can immediately press the closing means **91** to move the latch **85** (FIG. 2) to release the roller **67** whereupon the circuit breaker will be operated from the position seen in FIG. 2 to the closed position seen in FIG. 5 in the same manner as was hereinbefore described. With the parts in the closed position seen in FIG. 5, if an overload above the predetermined value occurs in any of the pole units, the trip means **95** will be automatically operated to rotate the trip shaft **63** to the tripped position to effect a tripping operation in the same manner as was hereinbefore described wherein the parts move to the position seen in FIG. 6. With the parts in the position seen in FIG. 6, another operation of the manual operating means **83** (FIG. 1) will be required in order to charge the closing springs **79** to provide a closing operation. Thus, when the circuit breaker is in the contact-closed spring-charged position, the circuit breaker can be tripped and then closed and then tripped again in rapid sequence.

The trip device **95** (FIGS. 7 and 12) comprises a housing **105** and a magnetic device **107** supported on the housing **105**. The magnetic device **107** comprises a pair of magnetic steel pole pieces **109, 111**, a conducting coil **113** around the pole piece **109**, a conducting coil **115** around the pole piece **111** and four permanent magnet members **117, 119, 120, 121**. The members **109, 111, 113, 115, 117, 119, 120** and **121** are all potted in an insulating epoxy resin **123** which encapsulates these members and supports them as a unitary structure. The permanent magnet members **117, 119, 120, 121** form a permanent magnet structure indicated generally at **125** which is formed of the four members merely to facilitate assembly using readily available magnet members. The permanent magnet structure **125** is a rubber bonded barium ferrite permanent

magnet material that is available under the trade name "Plastiform." A magnetic steel fixed keeper **129** is fixedly secured to the front end of the pole pieces **109, 111** with an insulating sheet **131** sandwiched between the fixed keeper **129** and pole pieces **109, 111** to provide a gap between the fixed keeper **129** and pole pieces **109, 111**. The fixed keeper **129** and insulating sheet **131** are supported on the magnetic device by means of a pair of bolts **133** that extend through openings in the members **129, 131** and that are secured in the epoxy resin **123**. A magnetic steel movable keeper **135** is provided to cooperate with the pole pieces **109, 111** at the back end of the pole pieces. As can be seen in FIG. 12, the fixed keeper **129**, insulating sheet **131**, epoxy resin **123**, and movable keeper **135** are provided with an aligned opening, and an elongated actuating rod **137**, having an actuating head **139** at the upper end thereof, extends through the opening in these members. A nut **138** is secured at the lower end of the rod **137**. A kick-out spring **139** is positioned on the rod **137** between the movable keeper **135** and a shoulder portion of the epoxy resin **123** to bias the movable keeper **135** and rod **137** toward the released tripping position seen in full lines in FIG. 12. A cup member **141** is secured at the lower end of the epoxy resin **123** to enclose the movable keeper **135** and rod **137** to prevent the collection of dust in this area. As can be understood with reference to FIGS. 7 and 12, the housing member has flanges at the outer ends of the legs thereof which are secured to the base plate **11** (FIG. 1) of the circuit breaker housing structure. An inverted generally U-shaped supporting bracket **143** (FIG. 7) is fixedly secured to the bight portion of the member **105** and a resilient bell-crank reset member **145** is pivotally supported on and between the legs of the support bracket **143** by means of a pin **147**. The bell-crank reset member **145** comprises a rigid lower leg **149** that is positioned under the actuating head **139** of the rod **137**, and a rigid upper leg **151** that supports a resilient leaf spring member **153** at the free end thereof. A trip member **155**, comprising a lower leg **157** that is positioned under the actuating head **139** of the rod **137** and an upper leg **159**, is fixedly secured to the trip shaft **63** at a notch portion of the trip shaft. A shunt-trip device **161** is fixedly secured to one of the side plates **13** by means of a pair of bolts **163**. The shunt-trip device **161** comprises a coil **165**, a yoke **167** and an armature **169**. The armature **169** is pivotally supported on one leg of a U-shaped bracket **171** and biased to the unactuated position seen in FIG. 7 by means of a spring **173**. The armature **169** is positioned adjacent the leg **159** of the trip member **155**. As can be seen in FIG. 7, the lever **33** for the left-hand (FIG. 1) pole unit is shaped with an extension that receives a rigid pin **175** that is fixedly secured to the lever **33** to cooperate with the leaf spring **153** in a manner to be hereinafter described.

Referring to FIG. 9, the jack shaft **35** and lever **33** are in the contact-closed position and the trip device **95** is in the reset position with the trip shaft **63** in the reset latched position. The bell-crank resilient reset member **145** is pivoted clockwise, by means of a torsion spring **176**, to the position shown wherein the resilient leaf-spring **153** resets on the pin **175**. The trip device **95** is in the reset position in which position the movable keeper **135** (FIG. 12) engages the pole pieces **111, 109** (as shown in broken lines in FIG. 12) to maintain the actuating rod **137** in the upper reset position shown in FIG. 9. The trip device **95** comprises two magnetic circuits. With the movable keeper **135** in the reset position engaging the pole pieces **111, 109**, the permanent magnet structure **125** supplies magnetic flux which passes through the pole piece **109**, movable keeper **135**, pole piece **111** and through the magnet structure **125**. Part of the magnet flux generated by the magnet structure **125** passes through another magnetic circuit which includes the magnet structure **125**, the pole piece **109**, the gap **131**, the fixed keeper **129**, the gap **131**, the pole piece **111** and through the magnet structure **125**. Because the gap **131** provides a higher reluctance path through the magnetic circuit that includes the fixed keeper **129**, when the movable keeper **135** is in the reset position the greater portion of the magnetic flux generated by the magnet structure **125** passes through the one circuit including the movable keeper **135** and the remainder of the magnetic flux passes through the other circuit that includes the fixed keeper **129**. Thus, with the movable keeper **135** in the reset position, and with the coils **113, 115** not energized, the magnetic flux works to maintain the movable keeper **135** in the reset position.

The coils **113, 115** are connected in electrical series and pulsed by means of a DC current in response to abnormal or overload conditions in any of the three pole units of circuit breaker by means of an overcurrent protective device of the type specifically described in the patent application of John David Watson et al., Ser. No. 765,584, filed Oct. 7, 1968. The polarity of the coils **113, 115** is such that when the coils are pulsed the current in the coils serves to buck the magnetic flux in the circuit through the movable keeper **135** to raise the reluctance of the circuit in the movable keeper **135** whereupon magnetic flux transfers to the magnetic circuit through the fixed keeper **129**. Thus, when the coils **113, 115** are pulsed the movable keeper **135** is released such that the charged spring **139** biases the movable keeper **135** and actuating rod **137** downward to the tripping position seen in full lines in FIG. 12 and illustrated in FIG. 10. As can be understood with reference to FIGS. 9 and 10, when the trip device **95** is operated to the tripping position the actuating rod **137** moves downward and the actuating head **139** thereof engages the leg **157** of the trip member **155** to pivot the trip shaft **63** in a counterclockwise direction from the position seen in FIG. 9 to the position seen in FIG. 10. This movement of the trip shaft moves the notch portion **65** (FIG. 3) from the position seen in FIG. 3 to the position seen in FIG. 4 to effect a tripping operation of the circuit breaker in the same manner as was hereinbefore described. The parts are shown in FIG. 10 at the instant that the trip shaft **63** is moved to the tripping position and just prior to the actual movement of the contacts to the open position since the lever **33** is still shown in the closed position in FIG. 10. Upon movement of the trip shaft **63** to the tripping position seen in FIG. 10, the circuit breaker will be tripped open and the lever **33** will move from the closed position seen in FIG. 10 to the open position seen in FIG. 8 in the same manner as was hereinbefore described. As the lever **33** pivots to the open position seen in FIG. 8, the pin **175** will operate against the resilient leaf spring **153** to pivot the bell-crank resilient reset member **145** from the position seen in FIG. 10 to the reset position seen in FIG. 8 during which movement the leg **149** of the bell-crank reset member **145** engages the actuating head **139** of the actuating rod **137** to move the rod **137** upward to the reset position wherein the movable keeper **135** again engages the pole pieces **109, 111**. With the actuating head rod **137** in the upper position seen in FIG. 8, the trip shaft **63** is free to be reset in the same manner as was hereinbefore described. When the movable keeper **135** is moved to the tripped position seen in FIG. 12, the greater portion of magnetic flux generated by the magnet structure **125** passes through the pole piece **111**, air gap **131**, fixed keeper **129**, gap **131**, pole piece **111** back through the magnet structure **125**, and a small portion of magnetic flux will leak through the air gap through the magnet structure **125**, pole piece **109**, gap at the lower end of the magnet structure, pole piece **111**, to the magnet structure **125**. The coils **113, 115**, which were only momentarily pulsed to effect a tripping operation, are not energized when the circuit breaker is tripped and they will not be energized when the circuit breaker is reclosed unless there is an abnormal or overload condition in one of the pole units that would operate the protective relay to again energize the coils **113,**

115. Thus, when the movable keeper 135 is reengaged, in the reset position, with the pole pieces 109, 111, magnetic flux will automatically transfer from the higher reluctance magnetic circuit that includes the fixed keeper 129 and gap 131 back through the lower reluctance magnet circuit that includes the movable keeper 135 so that the greater portion of the magnetic flux supplied by the magnet structure 125 will again work to hold the movable keeper 135 in the reset position until the coils 113, 115 are again pulsed. Thus, as the circuit breaker moves to the open position seen in FIG. 8, the lever 33 will operate against the leaf spring 153 to operate the bell-crank reset member 145 to thereby lift the actuating rod 137 to the reset position, and the magnetic flux will automatically operate to maintain the movable keeper in the reset position. When the circuit breaker is closed following an automatic tripping operation the lever 33 moves from the open position seen in FIG. 8 to the closed position seen in FIG. 9, and the bell-crank resilient reset member 145 will pivot clockwise (FIG. 8) to the position seen in FIG. 9 under the bias of the spring 103. With the trip shaft 63 latched, the leg portion 157 of the trip member 155 is again positioned under the actuating rod 137 where the leg 157 may be engaged by the actuating head 139 to effect a tripping operation in the same manner as thus hereinbefore described.

The shunt trip device 161 is provided to enable an operator to trip the breaker by energizing the coil of the shunt trip device from a remote location. As can be seen in FIG. 7, the shunt trip 161 is in the unactuated position with the spring member 173 biasing the armature 169 in a counterclockwise direction about the pivot of the armature 169 on the leg of the bracket 171. The coil 165 of the shunt trip 161 is connected to a suitable power source, and a well known type of normally open push-button switch may be connected to effect energization of the coil 165 from a remote location. Thus, when it is desired to trip the breaker, an operator can operate the switch to energize the coil 165 whereupon the armature 169 is attracted toward the yoke 167 against the bias of the spring 173 during which movement the armature 169 engages the leg 159 of the trip member 155 to pivot the trip shaft 63 from the reset position seen in FIG. 7 to the tripped position seen in FIG. 11. Upon movement of the trip shaft 63 to the tripped position seen in FIG. 11, the circuit breaker will be tripped in the same manner as was hereinbefore described.

Referring to FIGS. 13–15, there is shown therein a unitary inverted U-shaped magnetic steel member 181 having an opening 183 and a slot 184 in the bight portion 185 thereof. The unitary U-shaped magnetic member 181 may be used in the magnetic device 95 (FIG. 12) in place of the members 109, 111, 131, 129. In this embodiment, the opposite legs 187 and 189 of the member 181 serve as the pole pieces of the magnetic device; and the bight portion 185 serves as the fixed keeper. Except for the use of the member 181 in place of the members 109, 111, 131, 129, the magnetic device is the same as that specifically shown in FIG. 12. The opening 183 is provided for receiving the actuating rod 137. The slot 184 provides a portion of reduced cross section (opposite the end of the slot) at 190 in order to provide that the magnetic circuit through the fixed keeper 185 will have a higher reluctance than the magnetic circuit through the movable keeper 135. The U-shaped member 181, which takes the place of the four members 109, 111, 131, 129, is a unitary structure that is more economically manufactured and assembled into the magnetic device 95. The magnetic device with the member 181 therein, in place of the four members 109, 111, 131, 129, operates in the circuit breaker in the same manner as was hereinbefore described with reference to FIGS. 1–12.

I claim:

1. A circuit breaker comprising a stationary contact, a movable contact cooperable with said stationary contact, a circuit-breaker mechanism releasable to effect opening of said contacts, a trip shaft in a latching position latching said circuit-breaker mechanism and movable to a tripping position to release said circuit-breaker mechanism, a magnetic trip device comprising magnetic pole-piece means, a magnetic fixed keeper at one end of said pole-piece means, a magnetic movable keeper at the other end of said pole-piece means, an actuator connected to said movable keeper and movable with said movable keeper, biasing means biasing said actuator and movable keeper to a tripping position, a permanent magnet structure supplying magnetic flux that operates in a first magnetic circuit through said pole-piece means and said movable keeper to maintain said movable keeper in a set position against said pole-piece means, means for transferring magnetic flux from said first magnetic circuit to a second magnetic circuit which is through said pole-piece means and said fixed keeper to thereby effect release of said movable keeper, upon release of said movable keeper said biasing means biasing said movable keeper and said actuator to a tripping position wherein said movable keeper is spaced from said pole-piece means, a trip extension carried on said trip shaft, and upon movement of said movable keeper and actuator to said tripping position said actuator moving as a unit and engaging said trip extension to move said trip shaft to said tripping position to release said circuit-breaker mechanism.

2. A circuit-breaker according to claim 1, said magnetic device being constructed and arranged such that the magnetic reluctance in said second magnetic circuit is higher than the magnetic reluctance in said first magnetic circuit, said means for transferring magnetic flux from said first magnetic circuit to said second magnetic circuit comprising coil means energized upon the occurrence of overload current conditions to effect said transfer of magnetic flux, means automatically operating upon the occurrence of an opening operation of said circuit breaker to move said actuator and movable keeper back to the set position wherein said movable keeper engages said pole piece means, and upon movement of said movable keeper to said set position with said coil means deenergized magnetic flux automatically transferred from said second magnetic circuit to said first magnetic circuit to maintain said movable keeper in said set position.

3. A circuit breaker according to claim 2, said means for moving said movable keeper to said set position comprising a resilient reset member supported on said trip device, said circuit-breaker mechanism comprising a movable member movable between an open position and a closed position with said movable contact, and upon movement of said movable member to the open position during a tripping operation said movable member engaging said resilient reset member and operating said resilient reset member to operate said actuator and said movable keeper to said set position.

4. A circuit breaker according to claim 3, said magnetic device having opening means therein, said actuator comprising an elongated actuating rod having an actuating head at the front end thereof, means connecting said actuating rod to said movable keeper at the back end of said magnetic device, said resilient reset member comprising a bell-crank member supported on a fixed pivot on said front end of said magnetic device with a first leg of said bell-crank member being positioned under said actuating head and with a resilient leaf-spring member mounted on the second leg of said bell-crank member, and upon movement of said circuit breaker to said open position said rigid member moving against said leaf-spring to pivot said bell-crank member whereupon said first leg of said bell-crank member engages said actuating head to move said actuator and said movable keeper to the set position.

5. A circuit breaker according to claim 4, and said biasing means comprising a coil spring supported on said

actuating rod within said opening means which coil spring engages a fixed spring support at one end thereof and said movable keeper at the other end thereof to bias said movable keeper and actuating rod toward the tripping position.

6. A circuit breaker comprising a stationary contact, a movable contact cooperable with said stationary contact, a circuit-breaker mechanism releasable to effect automatic opening of said contacts, a trip shaft in a latching position latching said circuit-breaker mechanism and movable to a tripping position to release said circuit-breaker mechanism, a magnetic trip device comprising pole-piece means of magnetic material, a fixed keeper of magnetic material supported at a first end of said pole-piece means, a movable keeper of magnetic material at a second end of said pole-piece means opposite said first end, said magnetic device having opening means therein, an elongated actuating rod operatively connected at a first end thereof to said movable keeper and extending at the second end thereof past said fixed keeper, permanent magnet flux supplying means positioned between said fixed keeper and movable keeper and supplying magnetic flux that operates in a first magnetic circuit through said pole-piece means and said movable keeper to maintain said movable keeper in a set position against said pole-piece means, means for transferring magnetic flux from said first magnetic circuit to a second magnetic circuit which is through said pole-piece means and said fixed keeper whereupon said movable keeper is released, biasing means operating upon release of said movable keeper to move said movable keeper and said actuating rod to a tripping position, said actuating rod comprising an actuating head that operates to effect release of said circuit-breaker mechanism upon movement of said actuating rod to the tripping position, a resilient bell-crank reset member supported for movement about a fixed pivot, said bell-crank reset member comprising a first leg positioned under said actuating head and a second leg comprising a resilient portion, said circuit-breaker mechanism comprising a rigid member movable with said movable contact between open and closed positions and upon movement of said rigid member to the open position said rigid member engaging said resilient portion of said bell-crank reset member to pivot said bell-crank reset member to a resetting position during which movement said one leg of said bell-crank reset member engages said actuating head to move said actuating rod and said movable keeper to reset position.

7. A circuit breaker according to claim 6, said magnetic device being constructed and arranged such that the magnetic reluctance in said second magnetic circuit is higher than the magnetic reluctance in said first magnetic circuit, said means for transferring said magnetic flux from said first magnetic circuit to said second magnetic circuit comprising coil means energized upon the occurrence of overload current conditions to effect said transfer of magnetic flux, and upon movement of said movable keeper to said reset position magnetic flux automatically transferring from said second magnetic circuit to said first magnetic circuit to work through said movable keeper to maintain said movable keeper and actuating rod in said reset position.

8. A circuit breaker comprising a stationary contact, a movable contact cooperable with said stationary contact, an operating mechanism releasable to effect automatic opening of said contacts, a magnetic trip device comprising a generally U-shaped unitary member of magnetic material, said U-shaped unitary member of magnetic material comprising a bight portion and a pair of generally parallel legs, a movable keeper opposite the ends of said legs, permanent-magnet flux supplying means positioned between said bight portion and movable keeper to provide magnetic flux that operates in a first magnetic circuit through said legs and said movable keeper to maintain said movable keeper in a set position against said legs, biasing means biasing said movable keeper away from said set position, said permanent-magnet flux supplying means providing magnetic flux that operates in a second magnetic circuit through said legs and said bight portion, the magnetic reluctance in said second magnetic circuit being higher than the magnetic reluctance in said first magnetic circuit whereby the major portion of magnetic flux provided by said permanent magnet flux supplying means operates through said first magnetic circuit to maintain said movable keeper in said set position, means for effecting a transfer of magnetic flux from said first magnetic circuit to said second magnetic circuit to effect release of said movable keeper, and upon release of said movable keeper said biasing means biasing said movable keeper from said set position to a tripping position to effect release of said circuit-breaker mechanism.

9. A circuit breaker according to claim 8, said means for transferring magnetic flux from said first magnetic circuit to said second magnetic circuit comprising coil means energized upon the occurrence of overload current conditions to effect said transfer of magnetic flux, means automatically operating upon the occurrence of an opening operation of said circuit breaker to move said movable keeper back to the set position wherein said movable keeper engages said legs, and upon movement of said movable keeper to said set position with said coil means deenergized magnetic flux automatically transferring from said second magnetic circuit to said first magnetic circuit to work to maintain said movable keeper in said set position.

10. A circuit breaker according to claim 9, said bight portion of said U-shaped unitary member comprising a portion of reduced cross section to provide said higher-reluctance of said second magnetic circuit.

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BERNARD A. GILHEANY, Primary Examiner

H. BROOME, Assistant Examiner