

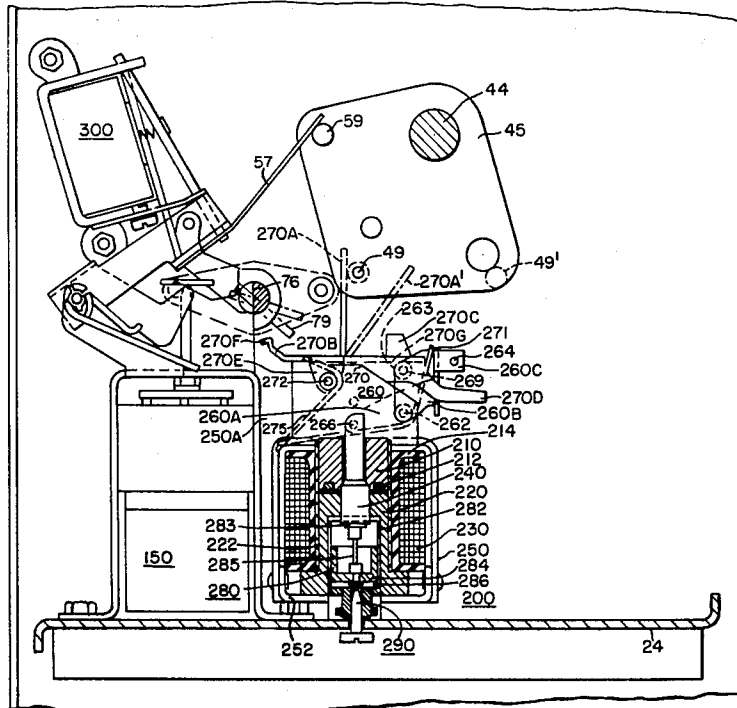
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[56] **References Cited**
UNITED STATES PATENTS
 1,874,797 8/1932 Pavitt 335/20
 2,840,663 6/1958 Horn 335/174
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[54] **CIRCUIT BREAKER INCLUDING IMPROVED
 UNDERVOLTAGE TRIP MEANS**
8 Claims, 7 Drawing Figs.

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 335/174
 [51] Int. Cl. H01h 83/12
 [50] Field of Search 335/20,
 155, 174

ABSTRACT: A circuit breaker comprising separable or relatively movable contact means, and operating means releasable to open said contact means, and an undervoltage device responsive to a predetermined loss of voltage to actuate the release of said operating means to open said contact means upon said loss of voltage.



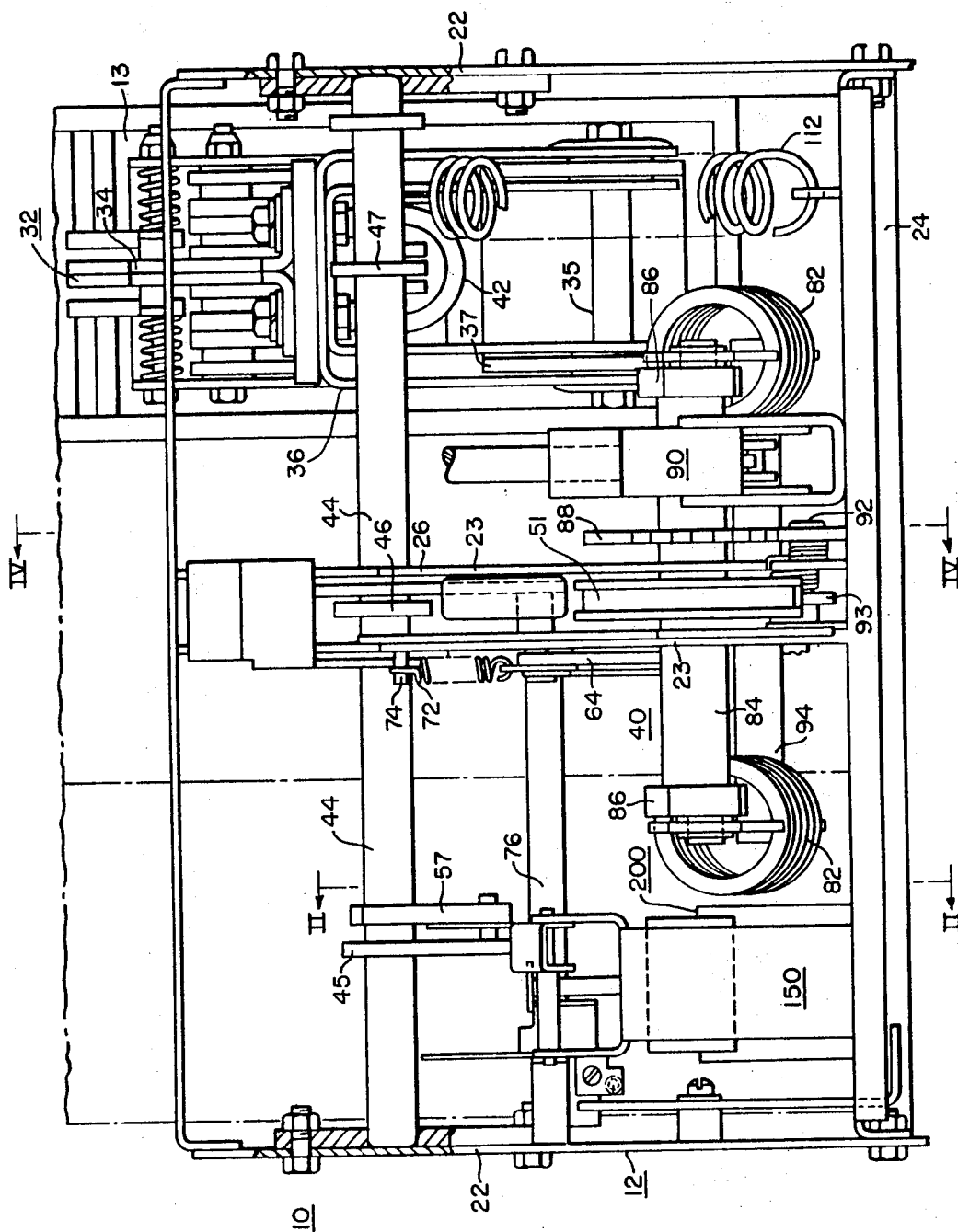
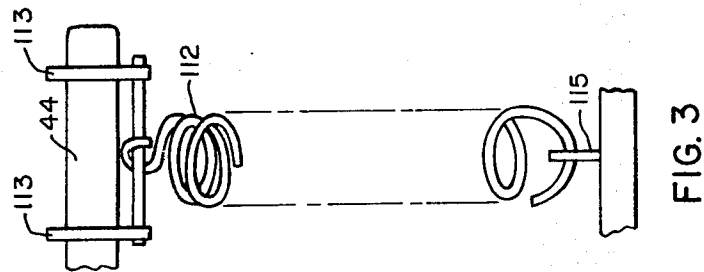
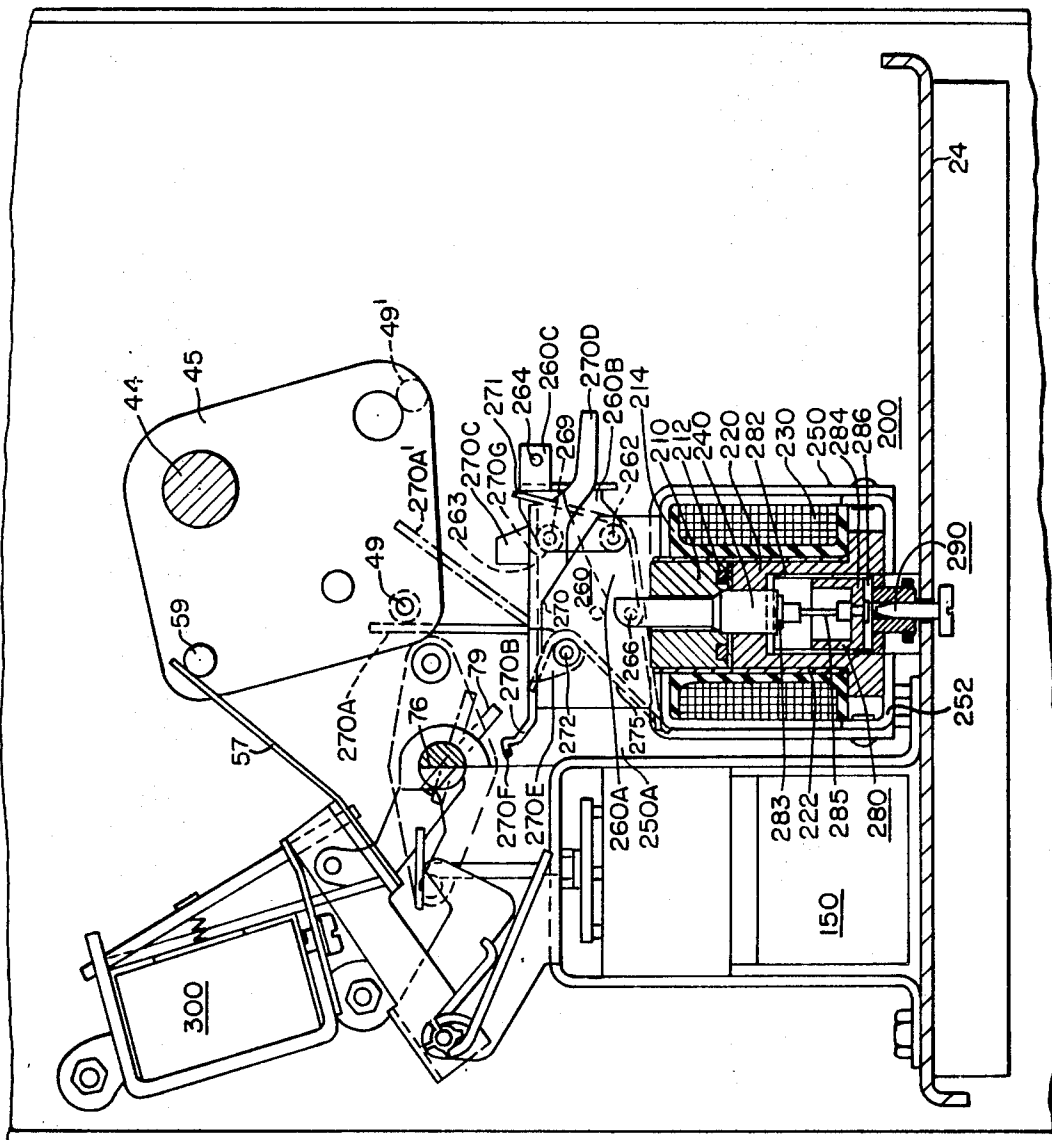


FIG. 1



CIRCUIT BREAKER INCLUDING IMPROVED UNDervOLTAGE TRIP MEANS

CROSS REFERENCES TO RELATED APPLICATIONS

Certain inventions either disclosed in the present application or related to those disclosed in the present application are disclosed in copending applications Ser. No. 770,305 filed Oct. 24, 1968 by Edmund W. Kuhn now U.S. Pat. No. 3,544,932, Ser. No. 770,296 filed Oct. 24, 1968 by Fred Bould et al. and Ser. No. 770,236 filed Oct. 24, 1968 by Nagar J. Patel now U.S. Pat. No. 3,544,931 which are all assigned to the same assignee as the present application.

BACKGROUND OF THE INVENTION

This invention relates to circuit breakers and more particularly to circuit breakers including undervoltage trip devices of the electromagnetic type for actuating the operation of such circuit breakers or which trip the circuit breaker upon an undervoltage condition.

Certain problems arise in providing a circuit breaker including an undervoltage trip device of the electromagnetic type where the operating coil of such a device is continuously energized as long as the applied voltage remains within a normal operating range to thereby retain an associated movable magnetic member or armature in a predetermined operating position against the force or torque exerted on the movable magnetic member by an associated biasing means, such as a spring. One reason that problems in such equipment result is because certain tripping forces or torques are required which must be released by the operation of an undervoltage trip device in order to actuate the operating means or mechanism of associated circuit breaker to effect an opening operation or to trip the associated circuit breaker. In order to limit the size and weight of such an undervoltage trip device, relatively complicated mechanical latching systems have been proposed or have been employed in the past to reduce the forces or torques which must be opposed by an electromagnetic undervoltage trip device during its normal operating condition. On the other hand, if the undervoltage trip device is required to provide forces or torques which directly oppose the tripping forces required to actuate the associated operating means or mechanism to open or trip the associated circuit breaker, then the size and weight of the required undervoltage trip device will be substantially increased. Examples of known undervoltage trip devices of the different types described are disclosed in U.S. Pat. Nos. 2,060,492 which issued Nov. 10, 1936 to L. W. Dyer, 2,697,418 which issued Dec. 14, 1954 to T. W. Slebodnik, 2,904,730 which issued Sept. 15, 1959 to H. L. Peek and 2,912,544 which issued Nov. 10, 1959 to B. A. Piteo, Jr. et al. These known circuit breaker structures which include undervoltage device of the different types described have certain disadvantages in that they either involve relatively complicated mechanical latching systems associated with the undervoltage trip device or else the forces or torques which are directly opposed by the undervoltage trip device require that the size and weight of the undervoltage trip device be increased compared with those which are required in an undervoltage trip device for a circuit breaker which includes means for reducing the forces or torques which are opposed by the undervoltage trip device.

SUMMARY OF THE INVENTION

In accordance with the invention, a circuit breaker includes relatively movable or separable contact means, an operating means or mechanism which is releasable for opening said contact means and an undervoltage trip device which is responsive to a predetermined loss of voltage for actuating the release of said operating means to open said contact means. The operating means of the circuit breaker includes a trip shaft which is disposed in a first operating position to latch the operating means of the circuit and which is movable to a second tripping position to release the operating means to actuate the opening of the associated contact means. The un-

der voltage trip device comprises an electromagnet which includes a magnetic member which is movable from a first operating position to a second operating position in response to a predetermined loss of voltage. The undervoltage trip device of the circuit breaker includes a latching member, more specifically a bellcrank lever, which is operatively connected to the movable magnetic member of the undervoltage trip device. The latching member is maintained in a first operating position when the associated movable magnetic member is in its corresponding first operating position and is rotatably supported to move to a second corresponding operating position when said magnetic member moves to its second operating position. The latching member and the associated movable magnetic member are biased to their second operating positions, respectively, by a biasing means, more specifically a torsion spring, upon the above-mentioned loss of voltage.

In order to actuate the release of the operating means of the circuit breaker when the movable magnetic member of the undervoltage trip device is actuated to its second operating position mentioned above by the associated biasing means, an actuating or tripping member is releasably latched in a first operating or set position by the latching member associated with the undervoltage trip device, as long as the latching member is retained in its first operating position. The actuating or tripping member is movable to a second operating position when the associated latching member is actuated or moved to its second operating position, under the influence of the associated biasing means, to release said actuating member. A second separate biasing means is provided for biasing the actuating member to its second operating position when the actuating member is released by the associated latching member. An extending member is disposed on the trip shaft of the circuit breaker to be engaged by the actuating or tripping member during the movement of the actuating member from its first operating position to its second operating position. The trip shaft is thus actuated by the actuating member to its second tripping position to release the associated operating means which then actuates the opening of the contact means of the circuit breaker. The torque exerted on the latching member in its first operating position through the associated actuating member by the second biasing means is substantially negligible to thereby limit the force or torque which is normally opposed by the electromagnet of the undervoltage trip device to the force or torque due to only the first-mentioned biasing means which is associated with the latching member.

In a specific embodiment disclosed, the movable magnetic member of the undervoltage trip device is operatively connected to the associated latching member by an elongated operating rod which is pivotally connected to the latching member.

BRIEF DESCRIPTION OF THE DRAWINGS

For a better understanding of the invention, reference may be had to the preferred embodiment, exemplary of the invention, shown in the accompanying drawings in which:

FIG. 1 is an end elevational view, with certain parts broken away, of a circuit breaker embodying the invention;

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

FIG. 3 is a fragmentary view illustrating an opening spring which forms part of the circuit breaker shown in FIG. 1;

FIG. 4 is a sectional view, with certain parts left out for the sake of clarity, taken generally along the line IV—V of FIG. 1 illustrating the positions of certain parts when the separable contact means of the circuit breaker are open and the closing springs of the circuit breaker are charged;

FIG. 5 is a partial view similar to FIG. 4, illustrating the positions of certain parts when the separable contact means of the circuit breaker are closed;

FIG. 6 is a view similar to FIG. 5 illustrating the instantaneous positions of the parts just after the separable contact means of the circuit breaker are tripped or opened and prior to the resetting of the parts which occurs during a complete opening operation of the circuit breaker if the closing springs of the circuit are charged or after the circuit breaker is opened and the closing springs of the circuit breaker are then charged; and

FIG. 7 is a perspective view of a part of the undervoltage trip device shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and FIGS. 1 and 4 in particular, there is illustrated a circuit interrupter, more specifically a three-phase or three-pole circuit breaker 10 embodying the principles of the invention. The circuit breaker 10 may be of the type which is described in greater detail in copending application Ser. No. 770,296 previously mentioned. The circuit breaker 10 may be mounted on a rigid housing or framework 12 which supports the elements or parts of the circuit breaker 10 and which, as illustrated, comprises a metallic baseplate 24, a pair of spaced metallic sideplates 22 which are secured to the flanges provided on the baseplate 24, a pair of metallic, spaced, intermediate or centerplates 23 which also are secured to the baseplates 24 and a rear wall structure which may include a plurality of electrically insulating support members 13 which are rigidly secured to the sideplates 22 and the baseplates 24, such as described in greater detail in copending application Ser. No. 770,149 filed Oct. 24, 1968 by Fred Bould and which is assigned to the same assignee as the present application.

Each pole unit of the three-pole circuit breaker 10 includes a stationary contact assembly 32 and a movable contact assembly 34 which are shown only for the right-hand pole unit of the circuit breaker 10 in FIG. 1 for the sake of clarity and which may be of the type described in greater detail in copending application Ser. No. 770,297 filed Oct. 24, 1968 by Fred Bould and assigned to the same assignee as the present application. As illustrated, the movable contact assembly 34 of each pole unit of the circuit breaker 10 is supported on an electrically conducting contact or switch arm 36, as best shown in FIG. 4 which is rotatably supported on an electrically conducting support member 37 by a suitable pivot support member 35. It is to be noted that each of the stationary contact assemblies 32, as shown in FIG. 4, include one or more compression springs 33 which assist during an opening operation of the circuit breaker 10, as will be explained hereinafter.

In order to simultaneously actuate the contact arms 36 of the respective pole units of the circuit breaker 10 between open and closed positions, the operating means or mechanism of the circuit breaker 10 includes an electrically insulating connecting member 42 for each of the pole units of the circuit breaker 10. One end of each connecting member 42 is pivotally connected to the associated contact arm 36, while the other end of each connecting member 42 is pivotally connected to one of the pole unit levers 45, 46 and 47 which are welded or otherwise secured to a common jackshaft or tie bar 44 and spaced from one another along the length of said jackshaft, as shown in FIG. 1. As shown in FIG. 1, the jackshaft 44 extends transversely across all three pole units of the circuit breaker 10 and is pivotally supported for rotation about its own axis by the sideplates 22 and the intermediate plates 23 of the framework 12. It is to be noted that the stationary contact assembly of the left-hand and middle pole units of the circuit breaker 10 would be identical to those of the right-hand pole unit of the circuit breaker 10 which is shown in detail in FIGS. 1 and 4.

In order to simultaneously close the separable contact means 32 and 34 of all three pole units of the circuit breaker 10, the operating means or mechanism of the circuit breaker 10 includes a stored energy spring closing mechanism 40 which is actuable to close said contact means and which may

be of the type which is described in greater detail in copending application Ser. No. 770,296 previously mentioned. As shown in FIGS. 1 and 4, the closing mechanism 40 includes a link member 48 which is pivotally connected at one end thereof to the lever 46 of the center or middle pole unit of the circuit breaker 10 by means of a pivot pin 52. The other end of the link 48 is pivotally connected to a link 62 by means of a knee pivot pin 56 to form a collapsible toggle means. A roller 58 is rotatably supported on the pivot pin 56 to cooperate with a closing cam 54 and functions as cam follower. The other end of the link 62 is pivotally connected by means of a pivot pin 78 to a latch member 64 which is mounted for pivotal movement about a fixed pivot pin 66 which, in turn, is mounted on the left-hand centerplate 23 of the framework 12, as viewed in FIG. 1. In order to assist in resetting the closing mechanism 40 following a tripping operation of the circuit breaker 10, a tension spring 72 is connected at one end to the pivot pin 78 which connects the latch member 64 and the link 62 and at the other end to a stationary pin 74 which is also mounted on the left-hand centerplate 23 of the framework 12, as viewed in FIG. 1. As shown in FIG. 5, the latch member 64 normally engages a trip shaft 76 which includes a cutout or notch portion 76A adjacent to the point where the latch member 64 normally engages the periphery of the trip shaft 76. The trip shaft 76 is supported for pivotal movement about its own axis between one of the centerplates 23 and one of the sideplates 22, as shown in FIG. 1. When the trip shaft 76 is rotated in a counterclockwise direction from the position shown in FIG. 5 to the position shown in FIG. 6, the latch member 64 will be free to rotate to the tripped position shown in FIG. 6.

More specifically, the closing cam 54 of the closing mechanism 40 is fixedly secured to a crankshaft 84 which is rotatably supported on suitable bearings which are secured, in turn, to the centerplates 23 of the framework 12. A pair of crank arms 86 are fixedly mounted on the crankshaft 84 adjacent to the opposite ends of said crankshaft, as shown in FIG. 1. In addition, the closing mechanism 40 includes, as illustrated, a ratchet member 88 which is fixedly mounted on the crankshaft 84 and a pawl 92 which is supported on one of the centerplates 23 to cooperate with the ratchet member 88. In order to provide the stored energy which is required during a closing operation of the circuit breaker 10, a separate tension spring 82 is operatively connected at one end thereof to each of the crank arms 86 with the other ends of said springs being connected to a rod 94 which is supported on the centerplates 23. In order to manually charge the closing springs 82 where desired, a handle operating mechanism 90 may be provided, as described in greater detail in copending application Ser. No. 770,296 previously mentioned. In order to retain the closing cam 54 in the predetermined operating position which is shown in FIG. 4, a roller latch member 102 may be rotatably supported on the closing cam 54. As described in the last-mentioned application, a latch member 93 (FIG. 1) may be pivotally mounted on a fixed pivot pin (not shown) and biased to a latching position wherein the latch member 93 engages the roller 102 on the closing cam 54 to latch the closing cam 54 and the crankshaft 84 to thereby prevent counterclockwise movement of said cam and said crankshaft under the influence of the closing springs 82.

The contact means 32 and 34 of the respective pole units of the circuit breaker 10 are shown in the open circuit operating positions in FIG. 4 and the closing cam 54 is shown in the operating position which corresponds to a charged condition of each of the stored energy closing springs 82. As explained in detail in copending application Ser. No. 770,296 previously mentioned, when the closing springs 82 are charged and the closing cam 54 is in the operating position shown in FIG. 4, the closing springs 82 operate to bias the crankshaft 84 and the closing cam 54 in a counterclockwise direction with respect to the axis of the shaft 84. Counterclockwise movement of the crankshaft 84 under the influence of the closing springs 82 is prevented by the engagement of the latch member 93 with the latch roller 102 which is mounted on the

closing cam 54, as previously mentioned. The latch member 93 may be manually operated to the unlatching position by the operation of a closing means indicated generally at 103, as described in greater detail in the last-mentioned copending application. As shown in FIG. 4, the roller 58 on the knee pivot pin 56 of the toggle links 48 and 62 is positioned in a depression which is provided on the closing cam 54 when the contact means of the circuit breaker 10 are opened and the closing springs 82 are charged.

During a closing operation of the circuit breaker 10, the closing means 103 may be manually operated to actuate the latch 93 in such a direction as to release the roller 102 on the closing cam 54. When the roller 102 is released, the closing cam 54 and the crankshaft 84 are free to rotate in a counterclockwise direction, as viewed in FIG. 4, and, under the influence of the closing springs 82, the closing cam 54 will actuate the roller 58 along with the toggle links 48 and 62 to the positions shown in FIG. 5 which correspond to the overall closed-circuit operating condition of the circuit breaker 10 assuming that the latch member 64 engages the trip shaft 76, as shown in FIGS. 4 and 5, to prevent counterclockwise movement of the latch member 64. During a closing movement of the link 48, the lever 46 of the center pole unit of the circuit breaker 10 is actuated in a counterclockwise direction to rotate the jackshaft 44 to a position which corresponds to the closed position of the circuit breaker 10. As the jackshaft 44 rotates to a closed position, all three of the levers 45, 46 and 47 of respective pole units are simultaneously moved with the jackshaft 44 to thereby actuate the contact arms 36 of the respective pole units to the closed operating positions whereby each of the movable contact assemblies 34 engages the associated stationary contact assemblies 32. The closing movements of the movable contact assemblies 34 serve to compress the associated springs 33 where provided in the corresponding stationary contact assemblies 32 in their respective pole units. As explained in detail in the copending application Ser. No. 770,296 previously mentioned, the engagement of the closing cam 54 with the roller 58 serves to prop the link member 48 in the closed operating position to thereby maintain the jackshaft 44 and the associated contact means 32 and 34 of the circuit breaker 10 in the closed operating positions.

Assuming that the contact means 32 and 34 of the circuit breaker 10 are in the closed positions as just indicated and that the closing springs 82 of the circuit breaker 10 are discharged, the circuit breaker 10 may be automatically tripped or actuated open in response to an overload current above a predetermined value in any of the pole units of the circuit breaker 10 by the operation of the trip means indicated generally at 150 in FIGS. 1 and 2 which may be of the type described in detail in copending applications Ser. Nos. 770,236, 3,544,931 and 770,305, 3,544,932 previously mentioned. When actuated, the trip means 150 operates to rotate the trip shaft 76 in a counterclockwise direction from the latching position shown in FIG. 5 to the unlatched or tripped position shown in FIG. 6. When the trip shaft 76 is rotated to the trip position shown in FIG. 6, the latch member 64 is no longer retained in the position shown in FIG. 5 and is free to move in the notch 76A of the trip shaft 76 about the pivot pin 66 to the tripped position shown in FIG. 6. When the latch member 64 is released as shown in FIG. 6, the compressed contact springs 33 and an opening spring 112 which is operatively connected between a pair of levers 113 on the jackshaft 44 and a fixed supporting member 115, as shown in FIG. 3, are then effective to then actuate the contact arms 36 toward the open positions indicated in FIG. 4 since the knee pivot pin 56 is free to move from the position shown in FIG. 5 to the position shown in FIG. 6 with the toggle links 48 and 62 collapsing to permit the pole unit lever 46 to move in a clockwise direction to the tripped open position shown in FIG. 4. In summary, the movement or rotation of the trip shaft 76 to the trip position shown in FIG. 6 permits the toggle links 48 and 62, as well as the latch member 64, to move to the tripped positions

in which the roller 58 and the link 48 no longer retain the pole unit lever 46 in the closed position and the springs 33 and 112 operate to move the jackshaft 44 and the contact arms 36 to the tripped open positions illustrated in FIG. 4 for the right-hand pole unit shown in FIG. 1. It is to be noted that the circuit breaker 10 is trip free since the operator cannot manually restrain the circuit breaker 10 to remain in a closed operating position when an overload occurs in any of the pole units of the circuit breaker 10 and the latch member 64 is released. In summary, the first trip means 150 is energizable to actuate an opening operation of the circuit breaker 10 in response to predetermined overload conditions in the electrical circuit which is being protected by the circuit breaker 10, as explained in detail in copending application Ser. No. 770,236, 3,544,931 previously mentioned.

When the circuit breaker 10 is in the open operating condition indicated in FIG. 6, and the closing springs 82 are discharged, the circuit breaker 10 is reset and the closing springs 82 are charged by the operation of the manual operating means 90, as explained in detail in copending application Ser. No. 770,296 previously mentioned. In order to reset the circuit breaker 10 and to charge the closing springs 82, an operator cranks the manually operable means 90 to rotate the crankshaft 84 from a position which is angularly disposed from that shown in FIG. 4 to the spring-charged operating position shown in FIG. 4. As the crankshaft 84 moves to the position shown in FIG. 4, the roller 58 rides or moves off the peak portion of the closing cam 54 into the depression shown in FIG. 4. When the roller 58 moves into the depression of the closing cam 54, the spring 72 shown in FIG. 6 actuates or biases the latch member 64 in a clockwise direction, as viewed in FIG. 6, to move the latch member 64 to the reset position shown in FIG. 5 and also actuates the toggle links 48 and 62 as well as the roller 58 to their reset positions shown in FIGS. 4 and 5 wherein the roller 58 is positioned in the depression of the closing cam 54. When the latch member 64 moves out of the notch portion 76A of the trip shaft 76 to the position shown in FIG. 5, a biasing spring 63 actuates the trip shaft 76 through an extending arm 77 which is mounted on the trip shaft 76 to rotate the trip shaft 76 clockwise from the position shown in FIG. 6 to the position shown in FIG. 5 in which the periphery of the trip shaft 76 once again latches the latch member 64 to thereby latch the associated parts of the circuit breaker 10 in the reset positions shown in FIGS. 4 and 5. As the crankshaft 84 moves to the position shown in FIG. 4, the closing springs 82 are moved to overcenter positions to thereby bias the crank shaft 84 in a counterclockwise direction, as viewed in FIG. 4, and the roller 102 engages the latch 93 to latch the crankshaft 84 in the charged position shown in FIG. 4 wherein the circuit breaker 10 is ready for another closing operation.

When the circuit breaker 10 is in a closed-circuit operating condition with the separable contact means 32 and 34 closed and with the closing springs 82 discharged, the closing mechanism 40 can be manually actuated to the spring-charged operating condition by the operation of the manually operable means 90. During such a manual charging operation, the crankshaft 84 is rotated through an angle of approximately 184° to charge the closing springs 82, as explained in detail in copending application Ser. No. 770,296 previously mentioned. During this movement of the crankshaft 84, the roller 58 rides on a fixed radius portion of the closing cam 54 to an operating position just short of the peak portion of the cam surface of the closing cam 54.

It is to be noted when the separable contact means 32 and 34 of the circuit breaker 10 are closed and the closing springs 82 of the circuit breaker 10 are in charged operating conditions, the circuit breaker 10 is capable of a sequence of operations in which the circuit breaker 10 is first tripped open then closed and then tripped again as described in copending application Ser. No. 770,236 now Pat. No. 3,544,931 previously mentioned.

In general, the undervoltage trip device 200, as best shown in FIG. 2 is operatively connected to the operating means of the circuit breaker 10 to actuate the operating means of the circuit breaker 10 to open the separable contact means 32 and 34 of the circuit breaker 10 upon a predetermined loss of voltage applied to the undervoltage trip device or when the voltage applied to the undervoltage trip device decreases below a predetermined value or below a predetermined normal operating range. The voltage to which the undervoltage trip device 200 responds to actuate an opening operation of the circuit breaker 10 may be either the line voltage of the electrical circuit in which the circuit breaker 10 is connected to protect such an electrical circuit or the voltage to which the undervoltage trip device responds may be any control voltage associated with either the circuit breaker 10 or other equipment associated with the circuit breaker 10. It is also to be understood that the voltage to which the undervoltage trip device 200 responds may be an alternating current voltage in certain applications or it may be a unidirectional or direct current voltage in other applications.

More specifically, the undervoltage trip device 200 includes a bracket member or base member 252 which may be secured to and supported by the baseplate plate 24 of the framework 12 of the circuit breaker 10 and an upper generally U-shaped frame member 250 on which the parts of the trip device 200 are mounted. The frame 250 also includes a pair of upwardly extending sidewall members, as indicated at 250A, which are spaced from one another to support certain parts of the undervoltage trip device 200, as will be explained hereinafter.

The undervoltage trip device 200 includes a voltage coil or operating coil 230 which may be connected across the electrical circuit which is being protected by the circuit breaker 10 and which includes a plurality of electrical conductor turns which may be wound on electrically insulating spool or coil form, as indicated at 214.

The undervoltage trip device 200, as shown in FIG. 2, also includes a stationary or fixed magnetic structure which is generally hollow cylindrical or tubular in configuration and which is formed from a soft magnetic material, such as a suitable steel or iron. It is to be noted that the upper portion of the stationary magnetic structure 220 extends axially inside an associated tubular sleeve or liner 222 which is formed from a suitable nonmagnetic material, such as brass, and which is disposed to extend axially through the central opening or bore of the spool 214 on which the coil 230 is disposed. The upper portion of the stationary magnetic structure 220 extends axially only partially through the tubular sleeve 222 as shown in FIG. 2.

In order to actuate the operating means of the circuit breaker 10, the undervoltage trip device 200 also includes a movable magnetic member or armature 210 which is generally hollow cylindrical or tubular in configuration and is disposed to extend axially at least partially inside the tubular sleeve 222 in which the upper portion of the stationary magnetic structure 220 is disposed. Where desired, the movable magnetic member 210 may include a shading ring or electrically conducting shorted turn 212 at the lower end thereof which may be formed from a suitable electrically conducting material, such as copper. In addition, the movable magnetic member 210 may also include a radially extending, nonmagnetic gap depending upon the type of voltage application. In an alternating current voltage application where the voltage applied to the operating coil 230 is of the alternating current type, the lower end of the movable magnetic member 210 normally engages the upper end of the stationary magnetic structure 220 which functions as a seat for the movable magnetic member 210. In direct current applications where the voltage applied to the operating coil 230 is of a unidirectional or direct current type, a washer of nonmagnetic material, such as brass, may be disposed between the movable magnetic member 210 and the stationary magnetic structure 220 to provide a predetermined nonmagnetic gap between the movable magnetic member 210 and the stationary magnetic structure 220

to facilitate the release of the movable magnetic member 210 during the operation of the undervoltage trip device 200.

In order to operatively connect the undervoltage trip device and the operating means of the circuit breaker 10, the trip device 200 includes an elongated operating rod or plunger 240 which, as shown in FIG. 2, is disposed to extend axially through substantially aligned central openings provided in the upper portion of the stationary magnetic structure 220 and the movable magnetic member 210. The operating rod or plunger 240 is formed from a suitable nonmagnetic material, such as brass. It is to be noted that the lower portion of the plunger 240 is larger than the central opening provided in the movable magnetic member 210 in order to actuate the plunger 240 downwardly when the movable magnetic member 210 is attracted to the stationary magnetic structure 220 and to assist in retaining the movable magnetic member 210 in assembled relation with the plunger 240. It is also to be noted that a predetermined radial clearance or spacing is provided between the upper portion of the plunger 240 and the central opening provided in the movable magnetic member 210 in order to permit certain relative movements of the parts of the undervoltage trip device 200, as will be explained hereinafter.

Where desired, a time delay means 280 may be provided at the lower end of the undervoltage trip device 200, as shown in FIG. 2. Such a time delay means or dashpot 280 may be required in certain applications in order to provide a predetermined time delay in the response of the undervoltage trip device 200 before the undervoltage trip device 200 actuates an opening operation of the circuit breaker 10.

More specifically, the time delay means 280 includes a tubular member 282 which may be formed from a suitable nonmagnetic material, such as glass, and which is disposed to extend axially inside the central opening of the stationary magnetic structure 220. A piston member 284 may be disposed to move axially inside the tubular member 282 and may be formed from a suitable material, such as graphite. The piston member 284 may be connected to the lower end of the plunger 240 by suitable means, such as a connecting rod 285 which extends axially into a central threaded opening provided at the lower end of the plunger 240 and additionally retained in assembled relation with the plunger 240 by suitable means, such as a lock washer 283.

The needle valve means 290 as illustrated is adjustable and is provided to control admission of air into the space below the piston member 284 which is necessary to overcome the vacuum which results when the piston member 284 attempts to move upwardly from the position shown in FIG. 2 during the operation of the trip device 200, as will be explained hereinafter.

The upper end of the plunger 240 of the undervoltage trip device 200 is pivotally connected to a latching member 260 which is formed as a bellcrank lever. More specifically, a pivot pin 266 is disposed to pass through a transverse opening provided at the upper end of the plunger 240 and an opening provided in the leg portion 260A of the latching member 260. The latching member 260 is rotatably supported on a fixed pivot pin 262 which, in turn, extends between and is supported by the spaced sidewall portions 250A of the frame 250, as shown in FIG. 2. The upper leg portion 260B of the latch member 260 carries a latching roller 263 which is rotatably supported on the upper leg portion 260B by a suitable pin 269 which is mounted on the upper leg portion 260B. The latching member 260 also includes a projecting portion 260C which projects laterally from the upper leg portion 260B of the latching member 260 toward the right as shown in FIG. 2 and has mounted thereon a projecting pin 264 which is actuated during the resetting of the latch member 260, as will be explained hereinafter.

In order to bias the latching member 260 in a clockwise direction about the pivot pin 262 and to thereby bias the plunger 240 and the movable magnetic member 210 of the undervoltage trip device 200 in an upward direction, as viewed in FIG. 2, against the force exerted on the movable magnetic

member 310 by the undervoltage trip device 200, a suitable biasing means, more specifically a torsion spring 271, is disposed on the pivot pin 262 with one end of the torsion spring 271 bearing against the upper leg portion 260B of the latching member 260 and the other end of the torsion spring 271 bearing against the top of the frame 250, as shown in FIG. 2.

In order to actuate the operating means of the circuit breaker 10 in response to the operation of the undervoltage trip device 200, the undervoltage trip device 200 includes an actuating or tripping member 270 which is normally maintained or latched in the operating position shown in FIG. 2 by the latching member 260. More specifically, the actuating member 270 is rotatably supported by a pivot pin 272 which extends between and is, in turn, supported by the upwardly extending wall portions 250A of the frame 250. The pivot pin 272 also extends or passes through a pair of downwardly extending spaced portions 270E of the actuating member 270. The actuating member 270 also includes a projecting arm 270G which is normally engaged by the latching roller 263 on the latching member 260 to maintain the actuating member 270 in the position shown in FIG. 2.

In order to actuate the movement of the trip shaft 76 in response to a predetermined loss of voltage applied to the operating coil 230 of the undervoltage trip device 200, the actuating member 270 includes a projecting arm 270B which projects to the left, as viewed in FIG. 2, and includes an arcuate portion 270F which is disposed to engage a projecting or extending arm 79, which is provided on the trip shaft 76, during the operation of the undervoltage trip device 200, as will be explained hereinafter. It is to be noted that the configuration of the arcuate portion 270F insures that the force applied to the extending arm 79 by the actuating member 270 is in a generally perpendicular direction with respect to the extending arm 79.

In order to bias the actuating member 270 in a generally clockwise direction about the pivot pin 272, a suitable biasing means, more specifically a torsion spring 275, is disposed on the pivot pin 272 with one end of the spring 275 bearing against the actuating member 270 and the other end of the spring 275 bearing against the top of the frame 250, as shown in FIG. 2.

In order to reset the undervoltage trip device 200 during an opening operation of the circuit breaker 10, the actuating member 270 includes an upwardly projecting arm 270A which is disposed in the path of movement of the resetting pin 49 which is mounted on the left-hand pole unit lever 45 of the circuit breaker 10. In addition, the actuating member 270 includes a projecting arm 270D which projects to the right, as viewed in FIG. 2, and which is provided to reset the latching member 260 during an opening operation of the circuit breaker 10 by engaging the pin 264 which is disposed on the projecting arm 260C of the latching member 260 as previously described.

In order to prevent the projecting arm 270G of the actuating member 270 from moving to a position underneath the latching roller 263 on the latching member 260, the upwardly projecting portion 270C is provided on the actuating member 270. The upwardly projecting portion 270C prevents the upper leg portion 260B of the latching member 260, as well as the roller 263, which is mounted on the upper leg portion 260B from rotating to a position over or on top of the projecting arm 270G of the actuating member 270 as viewed in FIG. 2.

It is important to note that the biasing spring 275 is a relatively stronger spring than the biasing spring 271 which is provided to bias the latching member 260, as previously described, in order that the forces or torques applied to the extending arm 79 on the trip shaft 76 will be sufficient to actuate the release of the operating means of the circuit breaker 10 in response to the operation of the undervoltage trip device 200 and also to limit the forces or torques which must be opposed by the operation of the undervoltage trip device 200 which

normally opposes the force or torque exerted on the latching member 260 by the biasing spring 271. It is also important to note that the torque or turning moment exerted on the latching member 260 by the relatively stronger torsion spring 275 through the actuating member 270 and the roller 263 on the latching member 260 is substantially negligible normally in the operating position shown in FIG. 2 because the moment arm of the force or torque exerted on the latching member 260 by the force transmitted from the torsion spring 275 through the actuating member 270 with respect to the axis of rotation of the latching member 260 at the pivot pin 262 is negligible.

In the operation of the undervoltage trip device 200, as long as the voltage applied to the operating coil 230 of the undervoltage trip device 200 remains in a normal operating range or above the predetermined minimum value to which the trip device 200 responds, the force or torque exerted on the latching member 260 by the undervoltage trip device 200 due to the electromagnetic forces which result from the magnetic fluxes produced by the current through the coil 230 are greater than the forces or torques exerted on the latching member 260 by the torsion spring 271.

When the voltage applied to the operating coil 230 of the trip device 200 decreases below a predetermined value or predetermined normal operating range, the torque or turning moment exerted on the latching member or bellcrank lever 260 by the torsion spring 271 becomes greater than the torque or turning moment exerted on the latching member 260 by the electromagnetic forces which result during the operation of the undervoltage trip device 200. As previously mentioned, as long as the actuating member 270 is normally latched by the latching member 260, as shown in FIG. 2, the turning moment or torque exerted on the latch member 260 by the relatively stronger torsion spring 275 is substantially negligible. As the latching member 260 starts to rotate in a clockwise direction about the pivot pin 262, the moment arm of the force exerted by the relatively stronger torsion spring 275 on the latching member 260 increases from a negligible value, the movement or rotation of the latching member 260 is accelerated as the moment arm through which the force exerted by the spring 275 acts increases, and the corresponding torque or turning moment exerted on the latching member 260 by the spring 275 rapidly increases.

When the latching roller on the latching member 260 clears the projecting arm 270G on the actuating member 270, the actuating member 270 then rotates in a clockwise direction about the pivot pin 272 under the influence of the relatively stronger torsion spring 275. As the actuating member 270 rotates in a clockwise direction from the normal position shown in FIG. 2, the arcuate portion 270F on the projecting arm 270B engages the projecting arm 79 on the trip shaft 76 to thereby rotate or actuate the trip shaft 76 in a counter-clockwise direction about its own axis, as viewed in FIG. 2. The trip shaft 76 then releases the latching member 64, as previously described and assuming that the contact means 32 and 34 of the respective pole units of the circuit breaker were previously in a closed circuit condition, the operating means or mechanism of circuit breaker 10 will then actuate the separable contact means 32 and 34 to the open positions shown in FIG. 4, as previously described. During an opening operation of the circuit breaker 10, the respective pole unit levers 45, 46 and 47 will rotate in clockwise directions, as viewed in FIGS. 2 and 4, from angular positions which are displaced from those shown in FIGS. 2 and 4 to the positions shown in FIGS. 2 and 4 under the influence of the opening spring 112 and the compression springs 33 of the respective pole units, as previously described.

During an opening operation of the circuit breaker 10, the left-hand pole unit lever 45, as shown in FIG. 2, will rotate in a clockwise direction with the resetting pin 49 on the lever 45 moving from the position indicated in phantom at 49' in FIG. 2 to the position indicated in solid line in FIG. 2 to engage the upwardly projecting arm 270A and to actuate the projecting

arm 270A from the trip position indicated at 270A' in FIG. 2 to the position indicated at 270A in FIG. 2 to thereby reset the actuating arm 270 from the trip position indicated in phantom at FIG. 2 to the normal position indicated in FIG. 2. As the actuating member 270 is actuated by the resetting pin 49 on the left-hand pole unit lever 45 as just indicated, the projecting arm 270D on the actuating member 270 will engage the pin 264 on the latching member 260 to thereby reset or actuate the latching member 260 from the trip position which is angularly spaced from that shown in FIG. 2 in a counterclockwise direction to thereby reset the latching member 260 to its normal operating position, as shown in FIG. 2. As the latching member 260 moves in a counterclockwise direction about its pivot pin 262, the plunger 240, as well as the movable magnetic member 210, will also be reset to the normal operating positions shown in FIG. 2. If the voltage applied to the operating coil of the undervoltage trip device 200 has been restored prior to the resetting of the parts of the trip device 200 as just described, the movable magnetic member 210 will be attracted to the stationary magnetic structure 220 to thereby relatch the actuating member 270 in its normal operating position shown in FIG. 2. The airgap between the movable magnetic member 210 and the stationary magnetic structure 220 will thus be reduced to a normal negligible value. It is important to note that during the operation of the undervoltage trip device 200 as just described, the arcuate configuration of the portion 270F of the actuating member 270 insures that the torque or turning moment exerted on the extending arm 79 and the trip shaft 76 by the biasing spring 70 is at substantially a maximum value without any reduction due to the frictional forces that might otherwise result if the arcuate portion were not provided on the projecting arm 270B.

It is important to note that during the operation of the undervoltage trip device 200, the movable magnetic member 210 is retained in assembled relation between the enlarged portion of the plunger 240 and the pivot pin 266 which pivotally connects the plunger 240 to the latching member 260. As previously mentioned, the radial clearance between the upper portion of the plunger 240 and the center opening in the movable magnetic member 210 is provided to allow the rectilinear or straight line movement of the movable magnetic member 210 inside the guide sleeve 222 and to permit the relative movements of the plunger 240 which are necessary because of the operative connection between the plunger 240 and the latching member or bellcrank lever 260 which rotates about its own pivot support pin 262. In other words, the radial clearance between the upper portion of the plunger 240 and the central opening of the movable magnetic member 210 is necessary to permit the limited rotation of the latching member 260 and the corresponding movements of the plunger 240.

It is also important to note that during any opening operation of the circuit breaker 10 which is actuated by the operation of the undervoltage trip device 200, as just described, the movable magnetic member 210 is reset to its normal operating position as shown in FIG. 2 and the effective impedance of the undervoltage trip device is maintained at a value which prevents damage to the operating coil 230 in the event that the voltage applied to the operating coil 230 has been restored to its normal operating range and current is again flowing in the coil of the undervoltage device 200. If the movable magnetic member 210 were not reset to its normal operating position during an opening operation, the effective impedance of the undervoltage trip device 200 would be reduced or decreased to permit overload currents which might otherwise flow in the coil 230 when the voltage is restored to the operating coil 230 again.

Where the time delay means 280 is provided, the upward movement of the plunger 240 and the movable magnetic member 210 are delayed, as determined by the adjustment or setting of the needle valve means 290, whenever the predetermined loss of voltage occurs and the movable magnetic member 210 tends to move upwardly under the influence of

the biasing spring 271 through the force or torque transmitted by the latching member 260 and the plunger 240.

Referring to the trip means 150 previously mentioned, it is to be noted that the left-hand pole unit lever 45 shown in FIG. 2 also carries a resetting pin 59 which is employed to actuate a resetting member 57 which forms part of the trip means 150, as described in detail in copending application Ser. No. 770,236 now U.S. Pat. No. 3,544,931 previously mentioned.

Where desired, a trip device 300 may also be disposed adjacent to the left-hand pole unit lever 45, as shown in FIG. 2, and employed to remotely actuate a tripping operation of the circuit breaker 10. As shown in FIGS. 1 and 2, the undervoltage trip device 200 is also disposed adjacent to the left-hand pole unit lever 45 and adjacent to the trip means 150.

In the overall operation of the circuit breaker 10 which includes the undervoltage trip device 200 as previously described in detail, it is important to note that as long as the voltage supplied to the operating coil 230 of the trip device 200 is less than a minimum predetermined value or lower predetermined normal operating range, the trip shaft 76 of the circuit breaker 10 will be actuated to a trip position by the force exerted on the extending arm 79 by the actuating member 270 and the torsion spring 275. In other words, an operator cannot actuate the circuit breaker to a closed-circuit condition until the voltage is restored to the operating coil 230 of the undervoltage trip device 200 and the actuating member 270 is restored to its normal operating position to permit the reset of the associated parts of the circuit breaker 10, as previously described.

A circuit breaker including an improved undervoltage trip device, as disclosed has several important advantages. For example, the force or torque which is opposed by the electromagnet which forms part of the undervoltage trip device 200 is limited to substantially only the forces or torques exerted on the latching member 260 by the relatively lighter torsion spring 271. The torque or turning moment exerted on the latching member 260 by the relatively stronger torsion spring 275, which actuates a tripping or opening operation of the circuit breaker 10 through the operating means or mechanism of the circuit breaker 10, is limited to a substantially negligible turning moment or torque on the latching member 260 by the arrangement of the applicant's invention. On the other hand, the relatively greater forces or torques required to actuate the release of the operating means or mechanism of the circuit breaker are reliably and positively released by the actuation of the latching member 260 during the operation of undervoltage trip device 200 as previously described. In addition, the operating coil 230 of the undervoltage trip device 200 is protected from the overload conditions or damage which might otherwise result due to the effective impedance of the undervoltage device 200 when the voltage is restored to its normal value by the resetting of the parts of the undervoltage trip device during an opening operation of the circuit breaker 10, as previously described in detail. Finally, by limiting the forces which must be opposed by the electromagnet which forms part of the undervoltage trip device 200, the relative size and weight of the undervoltage trip device 200 are substantially reduced or limited.

I claim as my invention:

1. A circuit breaker comprising relatively movable contact means, operating means releasable to effect opening of said contact means, a trip shaft disposed in a first position to latch said operating means and movable to a second tripping position to release said operating means, an undervoltage trip device comprising an electromagnet including a magnetic member movable from a first position to a second position in response to a predetermined loss of voltage, a latching member operatively connected to said magnetic member, said latching member being maintained in a first position when said magnetic member in a first position and being rotatably supported to move to a second position when said magnetic member moves to its second position, first means for biasing said latching member and said magnetic member to their

second positions, respectively, upon said loss of voltage, an actuating member releasably latched in a first position by said latching member when said latching member is in its first position and movable to a second tripping position when said latching member moves to its second position to release said actuating member, second means for biasing said actuating member to its second position when said latching member releases said actuating member, an extending member disposed on said trip shaft and engaged by said actuating member during the movement of said actuating member from its first position to its second position to actuate said trip shaft to said second tripping position to release said operating means, the torque exerted on said latching means in its first position through said actuating member by second biasing means being substantially negligible.

2. The combination as claimed in claim 1 wherein said latching member comprises a bellcrank lever.

3. The combination as claimed in claim 1 wherein said magnetic member is operatively connected to said latching member by an elongated operating rod.

4. The combination as claimed in claim 1 wherein said actuating member is rotatably supported and includes a projecting arm, said arm being engaged by said operating means during the opening of said contact means to reset said actuating member to a position adjacent to its first position.

5. The combination as claimed in claim 2 wherein said actuating member is rotatably supported and includes a project-

ing arm, said arm being engaged by said operating means during the opening of said contact means to reset said actuating member to a position adjacent to its first position.

6. The combination as claimed in claim 4 wherein said actuating member includes an additional projecting portion and said latching member includes a projecting portion disposed in the path of movement of said additional projecting portion of said actuating member, said projecting portion of said latching member being engaged by said actuating member during the resetting of said actuating member to thereby reset said latching member and said magnetic member to substantially their first positions, respectively.

7. The combination as claimed in claim 5 wherein said actuating member includes an additional projecting portion and said latching member includes a projecting portion disposed in the path of movement of said additional projecting portion of said actuating member, said projecting portion of said latching member being engaged by said actuating member during the resetting of said actuating member to thereby reset said latching member and said magnetic member to substantially their first positions, respectively.

8. The combination as claimed in claim 5 wherein said magnetic member is operatively connected to said latching member by an elongated operating rod, said rod being pivotally connected to said bellcrank lever adjacent to one end of said bellcrank lever.

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