

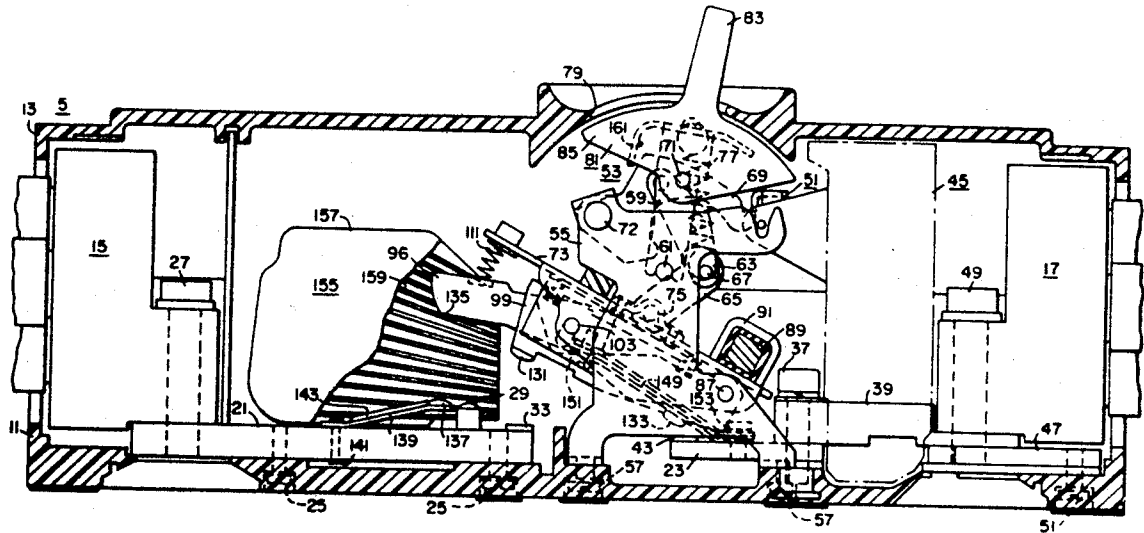
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 [21] Appl. No. **700,248**
 [22] Filed **Jan. 24, 1968**
 [45] Patented **Feb. 2, 1971**
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[54] **CIRCUIT BREAKER WITH IMPROVED CONTACT STRUCTURE**
25 Claims, 11 Drawing Figs.
 [52] U.S. Cl..... **200/146,**
335/16, 335/195
 [51] Int. Cl..... **H01h 33/12**
 [50] Field of Search..... **200/146;**
335/15, 16, 195, 220

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ABSTRACT: A circuit breaker is provided with an improved contact structure of the type comprising a movable support and a contact arm movably supported on the support with current responsive magnetic means for providing contact pressure.



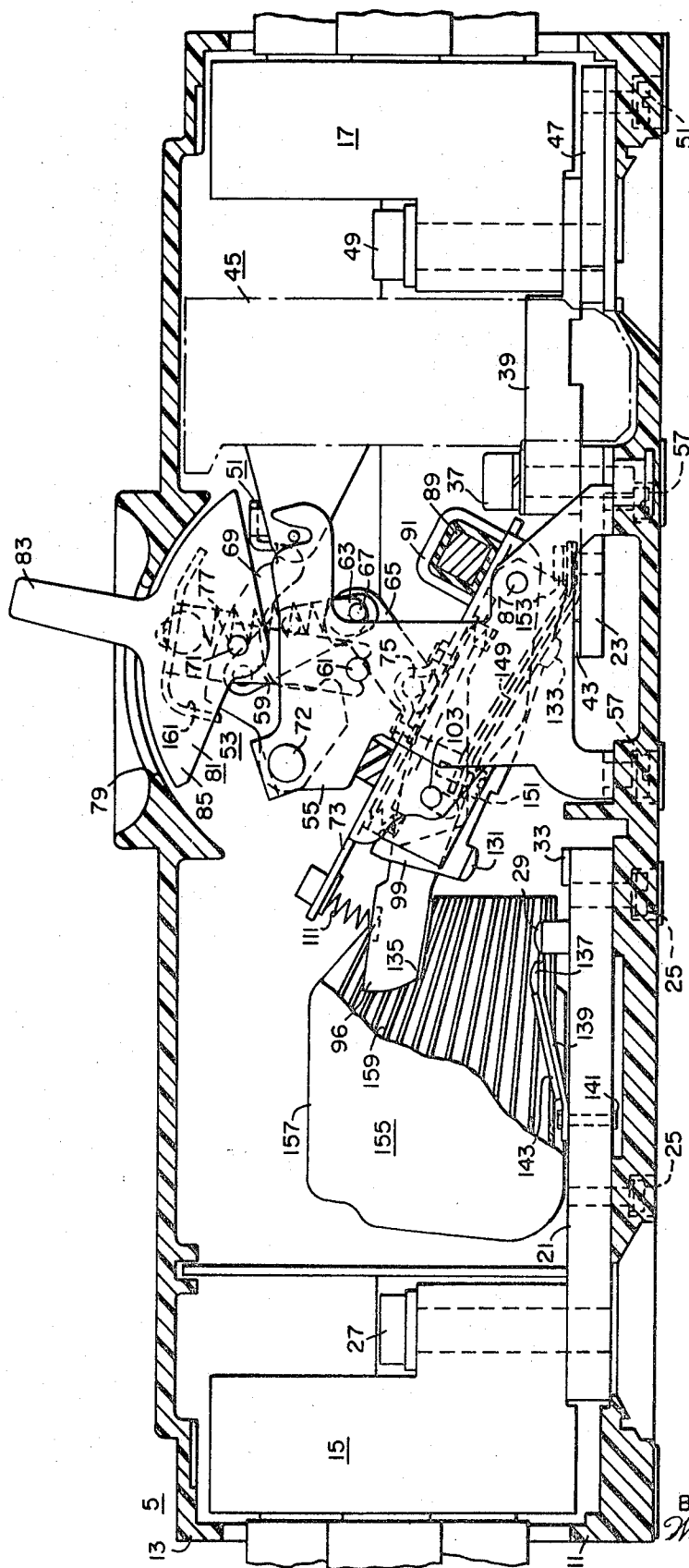


FIG. 1.

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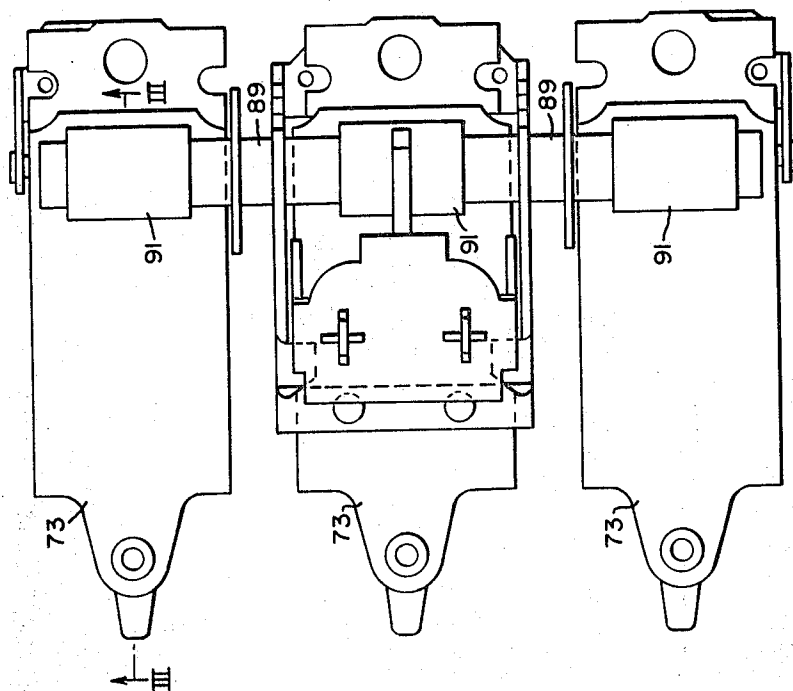


FIG. 2.

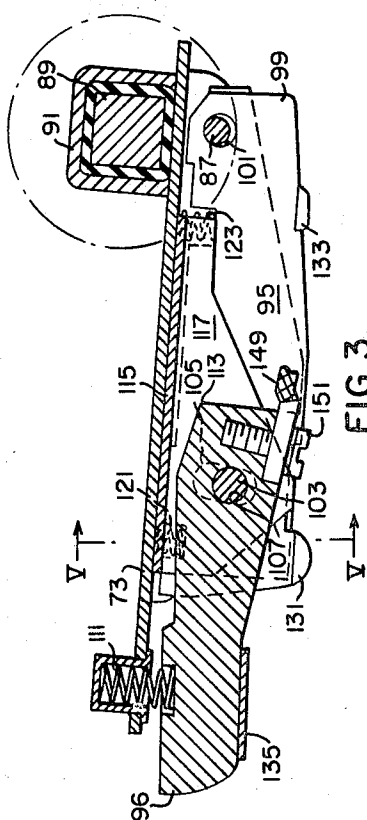


FIG. 3.

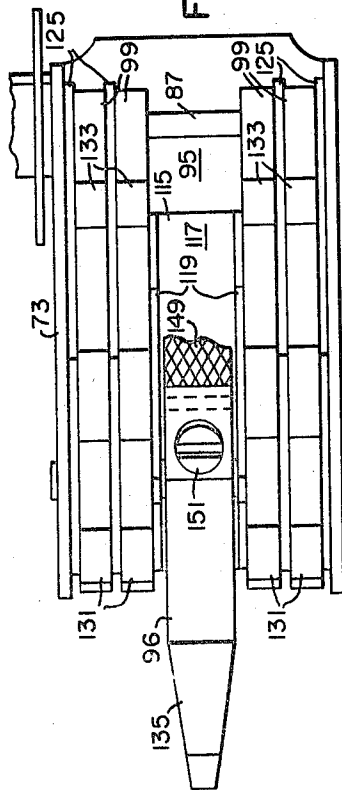


FIG. 4.

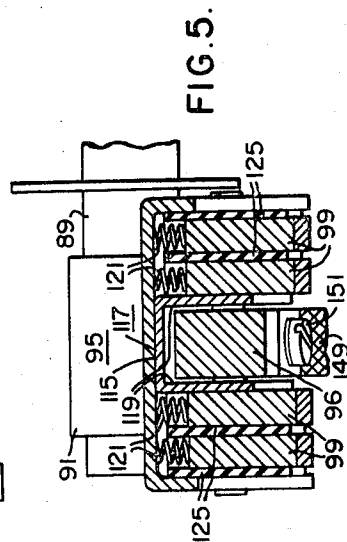


FIG. 5.

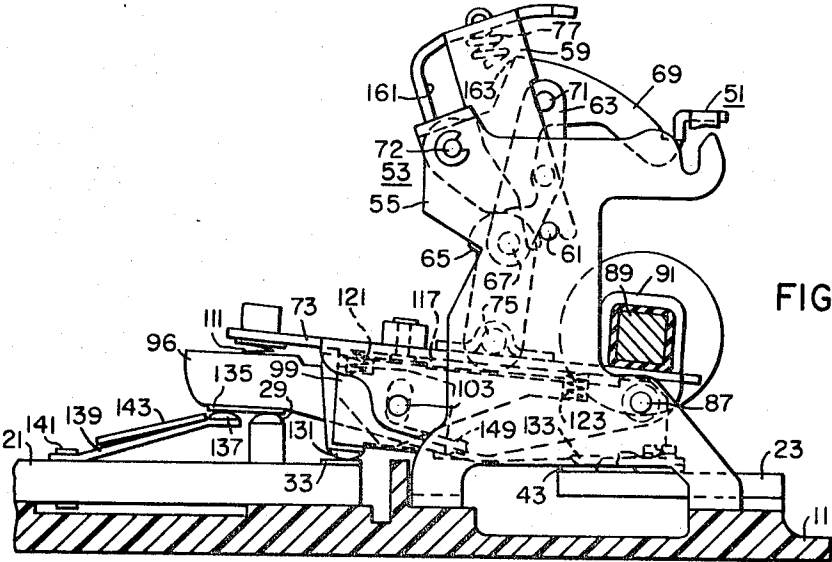


FIG. 6.

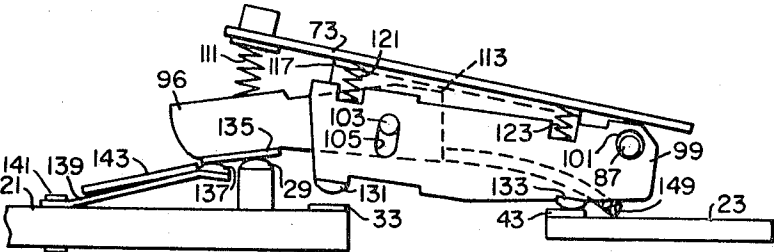


FIG. 7.

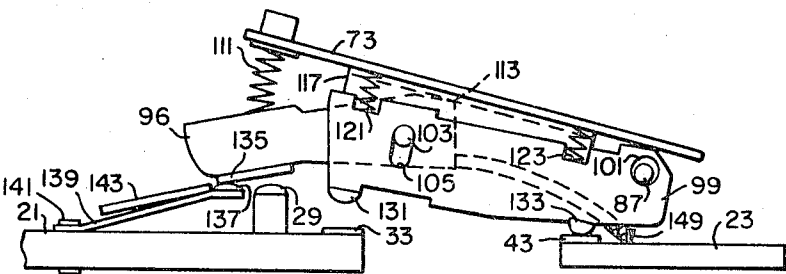


FIG. 8.

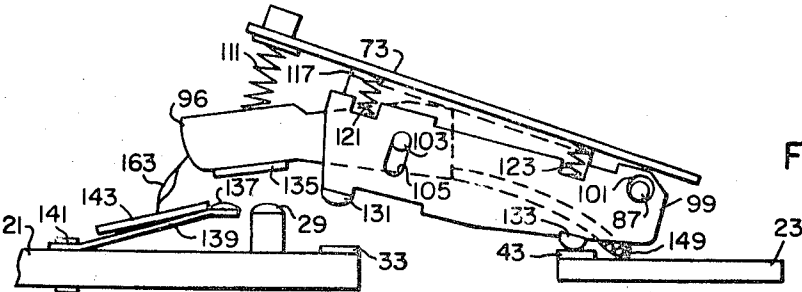


FIG. 9.

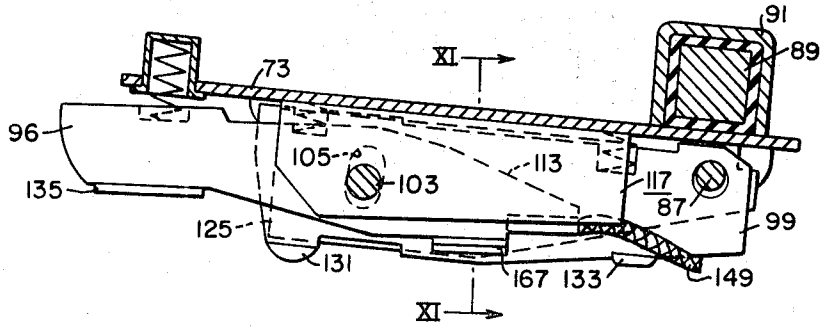


FIG. 10.

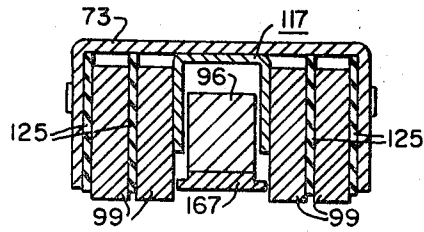


FIG. 11.

CIRCUIT BREAKER WITH IMPROVED CONTACT STRUCTURE

CROSS-REFERENCES TO RELATED APPLICATIONS

Certain features disclosed herein are disclosed in the application of Eugene J. Walker et al., Ser. No. 700,251, filed concurrently herewith. This invention is an improvement over circuit breakers of the general type disclosed in the copending application of Albert R. Cellerini et al., Ser. No. 542,536, filed Apr. 14, 1966 which application was refiled on Oct. 4, 1968 as a continuation application Ser. No. 765,143 which issued on May 19, 1970 as U.S. Pat. No. 3,513,275.

BACKGROUND OF THE INVENTION

In certain circuit breakers the movable contact structure comprises a movable support with an arcing contact arm and a plurality of main contact arms supported on the movable support. The contact structure is constructed such that during opening operations the arcing contact arm moves, relative to the movable support to provide that the arcing contact will disengage after disengagement of the main contacts so that arcs will be drawn on the arcing contacts. With the main contact arms and arcing contact arm providing parallel current paths, the magnetic forces generated by current in the parallel paths tend to squeeze the contact arms together. It is desirable to provide means for preventing an application of force or side thrust against the arcing contact arm from the main contact arms when the contact arms are squeezed together so that the arcing contact arm will be free to move relative to the movable support during opening operations. Thus, an object of this invention is to provide an improved circuit breaker with a movable support carrying a plurality of contact arms, including an arcing contact arm, with means preventing an application of force or side thrust against the arcing contact arm from the other contact arms when the contact arms are drawn together whereby the arcing contact arm is free to move relative to the support during opening operations which means provide a magnetic force operating on the arcing contact arm to provide contact pressure between the movable arcing contact and the associated stationary contact.

Another object of this invention is to provide a circuit breaker with a movable support carrying a plurality of contact arms, including an arcing contact arm, and with improved electromagnetic holddown means operating on only the arcing contact arm particularly under high-current conditions.

Another object of the invention is to provide an improved circuit breaker with current responsive magnetic means for biasing a movable contact into engagement with a stationary contact.

A general object of this invention is to provide an improved circuit breaker with improved contact means.

SUMMARY OF THE INVENTION

A circuit breaker comprises a support arm with a pair of bridging main contact arms supported on the support arm for limited movement relative to the support arm. An arcing contact arm is supported on the support arm between the main contact arms for limited pivotal movement relative to the support arm. A rigid U-shaped member is fixedly supported on the support arm with the opposite legs thereof positioned on opposite sides of the arcing contact arm to prevent an application of force or side thrust against the arcing contact arm from the main contact arms when the contact arms are drawn together under high-current conditions so that the arcing contact arm will be free to pivot on the movable support during opening operations of the breaker. In one embodiment the U-shaped rigid separating member is used as a magnetic frame and an armature is connected to the arcing contact arm to be drawn toward the U-shaped magnetic member under high-current conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a side sectional view, with parts broken away, of a circuit breaker embodying the principle features of this invention;

FIG. 2 is a top plan view of the movable contact device of the circuit breaker of FIG. 1;

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

FIG. 4 is a bottom plan view, with parts broken away, of the contact structure of FIG. 3;

FIG. 5 is a sectional view taken generally along the line V-V of FIG. 3;

FIG. 6 is a sectional view, with parts broken away, illustrating the contact means and part of the operating mechanism from the center pole of the three-pole circuit breaker of FIG. 1;

FIGS. 7, 8 and 9 are side views, with parts broken away, illustrating three different positions of the contact structures during an opening operation of the circuit breaker;

FIG. 10 is a view similar to FIG. 3 of a contact structure modified to include electromagnetic contact-pressure means; and

FIG. 11 is a sectional view taken generally along the line XI-XI of FIG. 10.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawings, there is shown, in FIG. 1, a molded case or insulating housing type circuit breaker 5. The circuit breaker 5 comprises an insulating housing comprising a molded insulating base 11 and a molded insulating cover 13. Suitable insulating barrier means separates the housing 11, 13 into three adjacent insulating compartments for housing the three pole units of the multipole circuit breaker in a manner well known in the art. In each pole unit, a pair of solderless terminals 15, 17 are provided at the opposite ends of the associated compartment to enable connection of the circuit breaker in an electric circuit.

In each of the three pole-unit compartments of the circuit breaker there is a rigid stationary conductor 21 and a rigid stationary conductor 23. The conductor 21 is secured to the base 11 of the insulating housing by means of threaded bolts 25. The terminal 15 is secured to the conductor 21 by means of a bolt 27. A stationary contact 29 is welded or otherwise fixedly secured to the front of the conductor 21. A stationary contact 33 is welded or otherwise fixedly secured to the front of the conductor 21 adjacent the space between the spaced conductors 21, 23. The rigid conductor 23 is secured to the insulating base 11 by means of a bolt 37 that passes through an opening in a rigid conductor 39 and through an opening in the conductor 23, which bolt 37 is threaded into an opening in the housing base 11. A stationary contact 43 is welded or otherwise fixedly secured to the front of the conductor 23 adjacent the space between the spaced conductors 21, 23. The conductor 39 is a rigid conductor that passes through an opening in a removable trip device 45. The trip device 45 is energized by current in the conductor 39 to effect tripping operations in response to overload currents. The conductor 39 is secured to the conductor 23 and base 11 at one end thereof by means of the bolt 37. The conductor 39 is secured at the other end thereof, to a rigid conductor 47 by means of a bolt 49 that passes through a vertical opening in the terminal 17 and through an opening in the conductor 39 and that is threaded into a suitable tapped opening in the rigid conductor 47. The conductor 47 is fixedly secured to the base 11 by means of bolts 51. The bolt 49 secures the terminal 17 and conductor 39 to the conductor 47. Except for the openings therein for receiving the mounting members, the rigid conductors 21, 23, 39, 47 are solid rigid conducting members.

The removable trip device 45 is a thermal-magnetic trip device comprising a latch structure 51 that is automatically operated in response to an overload current through any of the pole units of the circuit breaker in order to effect tripping

operations of the circuit breaker in a manner to be hereinafter more specifically described. The trip device 45 is of the type described in the patent to A. R. Cellerini et al., U.S. Pat. No. 3,141,081.

A single operating mechanism 53, for controlling all three pole units, is mounted in the center pole unit of the circuit breaker. The operating mechanism 53 comprises a supporting frame 55 that comprises spaced supporting plate parts, which supporting frame 55 is secured to the molded insulating base 11 by means of a plurality of bolts 57. The operating mechanism 53 comprises a pivoted forked operating lever 59 that is supported for pivotal movement about supporting pins 61 that are supported on the frame 55. A toggle comprises an upper toggle link 63 and a lower toggle link 65 which links are pivotally connected by means of a knee pivot pin 67. The upper toggle link 63 is pivotally connected to a movable releasable member or trip member 69 by means of a pin 71. The trip member 69 is pivotally supported on the frame 55 by means of a pivot pin 72. The lower toggle link 65 is pivotally connected to a movable contact support member 73 of the center pole unit by means of a pin 75. A pair of overcenter tension springs 77 are supported at one end on the knee pivot 67 and at the other end on the operating lever 59. The insulating housing 11, 13 is provided with an opening 79 at the front thereof, and an insulating handle member 81 comprises an external handle part 83 that protrudes out through the opening 79 for manual operation. The handle part 83 is an insulating part molded integral with an insulating arcuate shield part 85 that substantially closes the opening 79 in all positions of the handle 83.

The contact support member 73 (FIGS. 3-5) comprises an inverted generally U-shaped rigid metallic support member that is supported for pivotal movement about a pin 87 (FIG. 3) that passes through openings in the opposite legs of the support member 73 and that is supported on the spaced plate parts of the associated supporting frame 55. The frames 55 are not of identical construction in that only the frame 55 in the center pole supports an operating mechanism. It is to be noted, however, that there is a supporting frame in each pole unit for supporting the associated pin 87. The contact supporting member 73 is fixedly connected to an insulating tie bar 89 by means of a metallic supporting bracket 91. The contact support members 73 for the three pole units are all connected to the common tie bar 89 for simultaneous operation in a manner to be hereinafter described.

As is best seen in FIGS. 3-5, the contact support member 73 is part of a movable contact structure 95 that comprises a rigid conducting arcing contact arm 96 and four rigid conducting bridging main contact arms 99. The pin 87, which is supported on the associated supporting frame, extends through openings in the opposite legs of the U-shaped contact support member 73 to pivotally support the support member 73. As can be seen in FIG. 3, the pin 87 also extends through openings 101 in the main contact arms 99. Another pin 103 extends through elongated slots 105 (FIG. 3) in the four main contact arms 99 to also provide support for the main contact arms 99. The openings 101 are larger in diameter than the pin 87 and the slots or openings 105 are elongated in the direction shown for a purpose to be hereinafter more specifically described. The pin 103 also extends through an opening 107 (FIG. 3) in the arcing contact arm 96 with the pin fitting snugly in the opening 107 so that the arcing contact arm 96 is supported for pivotal movement about the pin 103. A coil spring 111 biases the arcing contact member 96 in a counterclockwise direction about the pin 103. Counterclockwise movement of the arcing contact arm 96 is limited by engagement of an end portion 113 thereof with the bight portion 115 of a U-shaped rigid separating member 117. As can be seen in FIGS. 4 and 5, the U-shaped separating member 117 comprises the bight portion 115 and a pair of opposite legs 119. The U-shaped separating member 117 is a rigid metallic member that is welded or otherwise fixedly secured, at the bight portion 115 thereof, to the U-shaped contact support

member 73. A separate pair of coil springs 121, 123 is positioned between each main contact arm 99 and the bight portion of the contact support member 73 to bias the main contact member 99 to provide contact pressure in the closed position of the contacts. As can be seen in FIGS. 4 and 5, there is a flat insulating sheet 125 between each of the outer main contact arms 99 and the associated leg of the contact support member 73, and a separate flat insulating sheet member 125 between each pair of adjacent main contact arms 99. The insulating sheet members 125 serve to space the adjacent main contact arms 99 from each other and to space each of the outer main contact arms 99 from the associated leg of the contact support member 73. As can be seen in FIG. 5, each of the insulating spacing sheet members 125 extends upward a sufficient distance to prevent lateral movement of the springs 121, 123 to capture the springs 121, 123 in place. As can be seen in FIG. 7, each of the springs 121 and 123 fits within a separate slot in the associated main contact arm 99 which slots serve to prevent movement of the springs in the direction of elongation of the associated main contact member 99. As can be seen in FIG. 5, the springs of the main contact arms 99 that are adjacent the opposite sides of the arcing contact arm 96 are captured against lateral movement in one direction by the associated insulating member 125 and from lateral movement in the other direction by the associated leg of the U-shaped separating member 117. Each of the main contact arms 99 is provided with a contact 131 at one end thereof for cooperating with the associated contact 33 (FIG. 1) and with a contact 133 in proximity to the other end thereof for cooperating with the associated stationary contact 43. The arcing contact arm 96 is provided with a contact 135 for cooperating with the contact 29 (FIG. 1) and for cooperating with a contact 137 that is supported on the free end of a resilient conducting contact support member 139 that is supported on the conductor 21 by means of a pair of rivets 141. An arc runner 143 is supported on the front side of the resilient conductor 139. The arc runner 143 and resilient conducting support 139 are more specifically described in the pending application of Eugene J. Walker et al., Ser. No. 700,251 filed Jan. 24, 1968. The arcing contact arm 96 is electrically connected to the rigid conductor 23 by means of a flexible conductor 149 that is connected to one end thereof to the arcing contact arm 96 by means of a screw 151 and at the other end thereof to the conductor 23 by means of a screw 153.

In each pole unit there is an arc-extinguishing structure 155 comprising an insulating casing 157 and a plurality of stacked spaced magnetic arc plates 159. The arc plates 159, in top plan view, are generally U-shaped structures supported with the openings aligned and positioned such that the movable arcing contact arm 96 moves within the aligned openings during opening and closing operation of the contacts. During opening of the contacts, the magnetic field around the arc drawn between the separating contacts, operating on the magnetic plates 159, draws the arc inward (to the left as seen in FIG. 1) toward the bight portions of the U-shaped plates where the arc is broken up into a plurality of serially related arc portions to be extinguished in a manner well known in the art.

The specific operation of this type of circuit breaker operating mechanism 53 and trip device 45 is more specifically described in the patent to A. R. Cellerini, U.S. Pat. No. 3,141,081. Thus, only a brief description of the operation is given herein.

The circuit breaker as shown in FIG. 1 in the open or "off" position. In order to close the circuit breaker the handle 83 is moved in a counterclockwise direction about the pivot 61 from the open or "off" position to the closed or "on" position. During this movement, the springs 77 are moved to erect the toggle 63, 65 to thereby rotate the contact support member 73 of the center pole unit in a counterclockwise direction about the pivot 87 to the closed position seen in FIG. 6. With the three contact support members 73 being connected to the tie bar 89 for simultaneous movement, this movement of the con-

tact support member 73 in the center pole unit operates through the tie bar 89 to simultaneously move all three of the contact support members 73 to the closed position. When it is desired to manually open the circuit breaker, the handle 83 is moved in a clockwise direction about the pivot 61 to the open or the "off" position seen in FIG. 1. This movement serves to move the overcenter springs 77 to cause collapse of the toggle 63, 65 to thereby move the contact support member 73 of the center pole unit about the associated pivot 87 to the open position seen in FIG. 1. This movement, because all of the support members 73 are supported for simultaneous movement on the tie bar 89, moves all three of the contact support members 73 to the open position. Each of the movable contact support members 73 moves about the associated pivot pin 87 with all of the movable contact members 73 moving about a common axis.

When the circuit breaker is in the closed position, and an overload current above a certain predetermined value occurs in any of the three pole units, the trip device 45 is operated to automatically release the latch structure 59 to thereby release the trip member 69. Upon release of the trip member 69, the springs 77 act to rotate the trip member 69 in a counterclockwise (FIG. 1) direction about the pivot 72 to cause collapse of the toggle 63, 65 and movement of the three contact support members 73 to the open position in a manner well known in the art. Upon tripping movement of the circuit breaker the handle structure is moved to an intermediate position between the "on" and "off" positions to provide a visual indication that the circuit breaker has been tripped. The circuit breaker is trip free in that the circuit breaker will trip open even if the handle is manually held in the "on" position.

It is necessary to reset and relatch the circuit breaker mechanism, following an automatic opening or tripping operation, before the contacts can be closed. Resetting and relatching is effected by moving the handle 83 clockwise (FIG. 1) to the extreme "off" or open position. During this movement, a shoulder projection 161 on the operating lever member 59 engages a shoulder part 163 on the trip member 69 to move the trip member 69 in a clockwise direction. At the end of this movement, the free or latching end of the trip member 69 is reengaged with the latch structure 51 in a well-known manner. The circuit breaker can then be manually operated to the closed position by operation of the handle 83.

The contacts are shown in FIG. 6 in the closed position. In this position, the spring 111 biases the arcing-contact arm 96 in a counterclockwise direction about the pin 103 to provide contact pressure between the arcing contact 135 and the contacts 29, 137. The contact 137 is biased against the contact 135 by the resilient conducting support 139. Each pair of springs 121, 123 biases the associated main contact arm 99 downward to provide contact pressure between the contacts 131, 23 and between the contacts 133, 43.

In the closed position of the contacts, the circuit through each pole unit extends from the terminal 17 (on the right FIG. 1) through the conductor 39, the conductor 23, the stationary contact 43, the contacts 133 of the four main contact arms 99, the main contact arms 99, the contacts 131 of the four main contact arms 99, the stationary contacts 33, the conductor 21 to the other terminal 15. The four main contact arms 99 carry most of the current in the closed position of the contacts. A parallel current path bridges the conductors 23 and 21 through the flexible conductor 149, the arcing contact arm 96, and the contacts 135, 29 to the conductor 21. In addition to the current that passes from the arcing contact arm 96 through the contacts 135, 29 to the conductor 21, a parallel conducting path extends from the arcing contact arm 96 through the contact 135, the contact 137, the flexible conductor 139 to the conductor 21. Because the contacts 131, 33 and 133, 43 are relatively low resistance contacts relative to the contacts 135, 29 and 137, most of the current bridging the conductors 23, 21 in the closed position of the contacts flows through the four main contact arms 99.

During an opening operation of the circuit breaker, the contact support member 73 moves in a clockwise (FIG. 1) direction about the pivot 87. As can be seen in FIG. 6, the contacts are in the closed position. During the opening operation, the parts first move to the position shown in FIG. 7 in which position the contacts 131, 23 have separated before the contacts 133, 43 separate and before the contacts 135, 137, 29 separate. During this initial movement, the pin 103 moves in the slots 105 from the lower end of the slots (FIG. 6) to the upper end of the slots with the springs 121 biasing the main contact arms 99 downward until the pins 103 engage the upper ends of the slots whereupon the contact arms 99 move with the contact support member 73. When the contacts 131, 23 separate, the current is all carried by the arcing contact arm 96 and flexible conductor 149 since the current flow through the main contact arms 99 is interrupted at this time. During this movement from the FIG. 6 to the FIG. 7 position, the spring 111 biases the arcing contact arm 96 in a counterclockwise direction about the pin 103 so that the arcing contact 135 remains in engagement with the stationary contacts 29, 137. As the opening movement continues, the part 113 of the arcing contact arm 96 engages the separating member 117 to limit counterclockwise movement of the arcing contact arm 96 about the pin 103 whereupon the arcing contact arm 96 will then move as a unit with the contact support member 73 to the position shown in FIG. 8 with the contact 135 separating from the contact 29. The contact 137 is mounted on a resilient conducting leaf spring support 139 which support 139 is positioned such that when the contacts are in the closed position the support 139 is biased downward by the engagement of the contacts 135, 137. Thus, as the contacts reach the position seen in FIG. 8 the contact 137, under the bias of the leaf spring conducting support 139, follows the contact 135 a short distance to provide that the contacts 135, 137 are the last current-carrying contacts to separate during an opening operation. Upon further movement of the parts to the position seen in FIG. 9, the full current is interrupted between the contacts 135, 137 and an arc 163, which is drawn between these separating contacts, is drawn along the arc runner 143 into the arc extinguishing structure 155 (FIG. 1) where the arc is broken up by the arc plates 159 into a plurality of serially related arcs to be extinguished in a manner well known in the art. The operation of the arc runner 143 is more specifically described in the above-mentioned copending patent application of Eugene J. Walker et al., Ser. No. 700,251 filed Jan. 24, 1968. In moving to the full open position, from the position seen in FIG. 9 to the position seen in FIG. 1, the contacts 133, 43 separate; but since the main contact arms 99 are not carrying current, there is no arc drawn between these separating contacts.

During closing operations, the reverse sequence takes place. As the contacts move from the FIG. 1 to the FIG. 9 position, the contacts 133, 43 will be the first to engage. In moving from the FIG. 9 to the FIG. 8 position, the arcing contact 135 will first engage the stationary arcing contact 137 and thereafter the resilient leaf spring conductor 139 will be biased downward to the FIG. 7 position during which movement the arcing contact 135 engages the contact 29. When the arcing contact 135 engages the contact 29, further movement of the contact support 73 will cause the arcing contact arm 96 to pivot about the pin 103 against the bias of the spring 111. Upon further movement of the contact support member 73, the contacts 131, 23 will be the last to engage. The pin 103 is at the upper portion of the slots 105 upon the initial engagement of the contacts 131, 23, and as the contact support member 73 moves to the fully closed position, the springs 121, 123 are charged and the pin 103 moves downward in the slots 105 from the position seen in FIG. 7 to the position seen in FIG. 6. As can be understood with reference to the drawings, the slots 105 are elongated in a generally upper direction, and these slots are slanted relative to the direction of movement of the pin 103 so that the pin 103 will cam the main contact members 99 backward, (to the right as seen in FIG. 6), in the

direction of elongation of the main contact members 99, a slight distance from the time that the contacts 131, 23 first engage until the contacts reach the fully closed position seen in FIG. 6 wherein the pins 103 have moved downward in the slots 105. This camming action on the main contact arms 99 serves to provide a wiping action between the contacts 131, 23 and between the contacts 133, 43 to clean the contacts during operation of the circuit breaker. It can be understood that during opening operations there is a wiping action between the contacts 131, 23 and between the contacts 133, 43 since during the initial opening movement of the contact support member 73 the springs 121, 123 bias the main contact members 99 downward until the pin 103 reaches the top of the slots 105 during which movement the contact members 99 are cammed forward (to the left as seen in FIG. 7) a slight distance while the contacts 131, 23 are engaged and while the contacts 133, 43 are engaged, with the contacts 131, 23 and the contacts 133, 43 separating when the pin 103 reaches the top of the slots 105 to pull the main contact arms 99 toward the open position in the manner hereinbefore described.

As can be seen in FIG. 3, each opening 101 in each of the main contact arms 99 is larger in diameter than the pin 87 to permit the camming movement, of the main contact arms, that causes the wiping action.

As can be understood with reference to FIGS. 3-5, there are five parallel current paths through the movable contact structure in the closed position of the contacts. Four of these parallel current paths are through the main contact members 99, and the fifth parallel current path is through the flexible conductor 49 and the arcing contact arm 96. As can be seen in FIGS. 3 and 4, a part of the arcing contact arm 96 is positioned between the inner pair of main contact arms 99. When a tripping overload current occurs in the closed position of the contacts, the high current flowing through the parallel paths generates electromagnetic forces which draw the parallel conductors toward each other so that the inner pair of main contact arms 99 are forced toward the arcing contact arm 96. Since it is important to provide that the arcing arm 96 pivot freely about the pin 103 during the opening operations in order to provide the proper opening sequence of contacts so that the arc will be drawn between the contact 135 and the contact 137, rather than between the contacts 131 and 23, separating means is provided for preventing a side thrust of force from the main contact arms 99 against the arcing contact 96, which side thrust could provide friction that might interfere with the free pivoting movement of the arcing contact arm 96. The rigid U-shaped separating member 117 prevents the application of this side thrust force against the arcing contact arm 96. As can be seen in FIG. 5, the U-shaped separating member 117 is welded or otherwise fixedly secured, at the bight portion thereof, to the contact support member 73 with the opposite legs of the separating member 117 extending downward on opposite sides of the arcing contact arm 96 so that there is a leg 119 of the U-shaped separating member 117 between each of the main contact arms 99 of the inner pair of main contact arms 99 and the arcing contact arm 96. Thus, when the inner pair of main contact arms 99 are moved sideways toward the arcing contact arm 96, this movement will be limited by the engagement of the inner pair of main contact arms 99 with the legs 119 of the separating member 117 to prevent the application of side thrust against the arcing contact arm 96 whereby the arcing contact arm 96 will be free to pivot about the pin 103 without encountering resistance from frictional forces that might otherwise be applied against the sides of the arcing contact arm 96. The U-shaped separating member 117 also cooperates with the insulating barriers 125 to capture the springs 121, 123 of the inner pair of main contact arms 99 in place against lateral movement in the manner hereinbefore described.

Another embodiment of the invention is illustrated in FIGS. 10 and 11 wherein like reference characters are applied to like parts. In the embodiment of FIGS. 10 and 11 the arcing contact arm 96 is constructed to receive a magnetic armature 167

that is fixedly secured to the lower part of the contact arm 96 on the side of the pivot 103 that is opposite the side that supports the arcing contact 135. The rigid U-shaped separating member 117 is of magnetic iron. Upon the occurrence of current flow the members 117, 167 provide a magnetic circuit around the contact arm 96. In the closed position of the contacts, when the current increases toward a tripping value, the armature 167 is attracted to the U-shaped magnetic member 117 to increase contact pressure between the contact 135 and the contacts 137, 29 to offset blowoff forces between these contacts and to provide an additional force holding the arcing contact arm 96 downward as the contact support member 73 starts to open to increase the reliability that the above-mentioned opening sequence of the contacts will occur. When the part 113 of the arcing contact arm 96 engages the separating member 117, the arcing contact arm 96 will move as a unit with the contact support member 73 to the open position. It is noted that since both the magnetic members 117, 167 are mounted to move with the contact support member 73, the electromagnet 117, 167 does not resist opening movement after the part 113 of the contact arm 96 engages the separating member 117. It is also to be noted that the magnetic members 117, 167 form a magnetic circuit around only the arcing contact arm 96, and not around the main contact arms 99. Thus, in the closed position of the contacts when most of the current flows through the main contact arms 99 the magnetic circuit through the iron members 117, 167 does not generate as much undesirable heat as would be the case if the magnetic circuit was constructed around all of the movable contact arms in each pole unit including the main contact arms.

We claim:

1. A circuit breaker comprising contact means, said contact means comprising a stationary contact structure and a movable contact structure, said movable contact structure comprising a movable support, a main contact arm supported on said movable support, main contact means on said main contact arm, an arcing contact arm supported on said movable support and comprising a portion positioned along side at least a part of said main contact arm, arcing contact means on said arcing contact arm, in the closed position of said contact means the current through said contact means comprising a first current path through said main contact arm and a second current path through said arcing contact arm which first and second current paths are parallel and in the same direction through said portion of said arcing contact arm and said part of said main contact arm whereby electromagnetic forces generated by current through said movable contact structure provides a side thrust between said main contact arm and said arcing contact arm, during opening operations of said contact means said arcing contact arm moving relative to said main contact arm, a separating member of magnetic material supported on said movable support and preventing an application of the force of said side thrust against said arcing contact arm from said main contact arm, current responsive magnetic means operating on said arcing contact arm under high current conditions to bias said arcing contact means against said stationary contact structure, said current responsive magnetic means comprising said separating member of magnetic material.

2. A circuit breaker according to claim 1, said arcing contact arm being supported for limited pivotal movement on said movable support, and during said opening operations said arcing contact arm pivoting on said movable support to disengage said arcing contact means from said stationary contact means after said main contact means has disengaged from said stationary contact means.

3. A circuit breaker according to claim 1, a pair of said main contact arms supported on said movable support on opposite sides of said arcing contact arm with said arcing contact arm comprising a portion positioned alongside at least a part of each of said main contact arms, and said member of magnetic material being a rigid generally U-shaped member fixedly supported on said movable support with the opposite legs thereof

positioned on opposite sides of said arcing contact arm and with each of said opposite legs being positioned between said arcing contact arm and one of said main contact arms.

4. A circuit breaker according to claim 3, said arcing contact arm being supported for limited pivotal movement on said support, and during said opening operations said arcing contact arm pivoting a limited movement on said support relative to said main contact arms which limited pivoting movement provides that said arcing contact means will disengage from said stationary contact means after said movable contact means has disengaged from said stationary contact means.

5. A circuit breaker according to claim 1, said member of magnetic material being a first member of magnetic material fixedly supported on said movable support, a second member of magnetic material fixedly supported on said arcing contact arm cooperating with said first member of magnetic material to provide a magnetic circuit around said arcing contact arm separate from said main contact arm, and said magnetic circuit operating to draw said arcing contact arm toward said stationary contact means under high-current conditions.

6. A circuit breaker comprising contact means, said contact means comprising a stationary contact structure and a movable contact structure, said movable contact structure comprising a movable support, a main contact arm supported on said movable support, support for limited movement relative to said movable support and relative to said main contact arm, a first magnetic member supported on said movable support, a second magnetic member supported on said arcing contact arm to provide a magnetic circuit through said first and second magnetic members around said arcing contact arm separate from said main contact arm, in the closed position of said contacts the current through said arcing contact arm generating magnetic flux in said magnetic circuit to draw said first and second magnetic members toward each other to force said arcing contact arm against said stationary contact structure.

7. A circuit breaker according to claim 6, a pair of said main contact arms supported on said movable support with each of said main contact arms being supported on a different side of said arcing contact arm, said first and second magnetic members forming a magnetic circuit around said arcing contact arm separate from both of said main contact arms.

8. A circuit breaker according to claim 7, said arcing contact arm being supported for limited pivotal movement on said movable support, an arcing contact on said arcing contact arm on a first side of the pivot of said arcing contact arm, and said second magnetic member being positioned on said arcing contact arm on the side of said pivot opposite said first side.

9. A circuit breaker according to claim 8, said first magnetic member comprising a U-shaped magnetic member supported on said movable support with the opposite legs thereof positioned on opposite sides of said arcing contact arm and with each of the said opposite legs being positioned between said arcing contact arm and the adjacent main contact arm.

10. A circuit breaker comprising a pair of spaced stationary conductors, a stationary contact on a first of said stationary conductors, a movable contact structure comprising a movable contact arm and a movable contact on said movable contact arm, a flexible conductor electrically connecting said movable contact arm with the second of said stationary conductors, a movable contact support, pivot support means supporting said movable contact arm for a limited generally pivotal movement on said movable contact support, spring means biasing said movable contact arm about said pivot support means toward said stationary contact, stop means limiting movement of said movable contact arm on said movable contact support about said pivot support means toward said stationary contact, means supporting said movable contact support for movement between open and closed positions, in the open position of said contacts said spring means biasing said movable contact arm on said movable contact support about said pivot support means which movement is limited by said stop means:

during closing operations of said circuit breaker said movable contact arm moving unitarily with said movable contact support until said movable contact engages such stationary contact and thereafter said movable contact support moving to the fully closed position charging said spring means as said movable contact arm moves relative to said movable contact support on said pivot support means;

during opening operations of said circuit breaker said movable contact support member moving toward the open position an initial movement as said charged spring means discharges with said movable contact in engagement with said stationary contact and with said movable contact arm moving relative to said movable contact support on said pivot support means until said relative movement of said movable contact arm is limited by said stop means and thereafter said movable contact support carrying said movable contact arm therewith as a unit to the fully open position;

said circuit breaker comprising means operating upon the occurrence of overload current conditions above a predetermined value to effect automatic opening of said contacts; and

magnetic means other than said flexible conductor on said movable contact structure responsive to current flow in said movable contact arm, said movable contact being on said movable contact arm on a first side of said pivot support means, said magnetic means operating on said movable contact arm on the second side of said pivot support means opposite said first side, and upon the occurrence of overload current conditions when said contacts are automatically opened said magnetic means operating to bias said movable contact arm to provide contact pressure between said movable contact and said stationary contact as said movable contact support moves said initial movement toward the open position while said charged spring means discharges with said movable contact in engagement with said stationary contact and with said movable contact arm moving relative to said movable contact support on said pivot support means until said relative movement of said movable contact arm is limited by said stop means and thereafter said movable contact support carrying said movable contact arm therewith as a unit to the fully opened position.

11. A circuit breaker according to claim 10, said magnetic means comprising a first member of magnetic material on said contact support member and a second member of magnetic material on said movable contact arm which first and second members of magnetic material provide a magnetic circuit around said movable contact arm responsive to the current flow in said movable contact arm.

12. A circuit breaker according to claim 10, said movable contact structure comprising main movable contact means supported on said movable contact support, in the closed position of said movable contact structure said main movable contact means on said movable contact support being in a closed position to carry current between said spaced stationary conductors, and during opening operations of said circuit breaker said main movable contact means moving to an open position to transfer current to said movable contact arm as said movable contact arm pivots on said pivot support means said limited movement of said movable contact arm relative to said movable contact support.

13. A circuit breaker according to claim 12, said magnetic means on said movable contact structure comprising a first member of magnetic material on said movable contact support and a second member of magnetic material on said movable contact arm which first and second members of magnetic material provide a magnetic circuit around said movable contact arm responsive to current flow in said movable contact arm.

14. A circuit breaker according to claim 10, said magnetic means comprising an inverted generally U-shaped first

member of magnetic material supported at the bight portion thereof on said movable contact support with the opposite legs thereof extending downwardly on opposite sides of said movable contact arm on said second side of said pivot support means, said magnetic means comprising a second member of magnetic material supported on said movable contact arm on said second side of said pivot support means cooperating with said first member of magnetic material to provide a magnetic circuit around said movable contact arm on said second side of said pivot support means which magnetic circuit is responsive to the current flow in said movable contact arm to bias said movable contact arm about said pivot support means to provide contact pressure between said movable contact and said stationary contact.

15. A circuit breaker according to claim 14, said spaced stationary conductors comprising main stationary contact means, said movable contact structure comprising main movable contact means supported on said movable contact support, in the closed position of said movable contact structure said main movable contact means being in a closed position carrying current between said stationary conductors, during opening operations of said movable contact structure said main movable contact means moving to an open position to transfer current to said movable contact arm while said movable contact arm pivots on said pivot support means said limited pivotal movement during which limited pivotal movement said magnetic means responsive to the current flow in said movable contact arm biases said movable contact into engagement with said stationary contact, and during closing operations of said circuit breaker said movable contact engaging said stationary contact before said main contact means reaches its closed current carrying position and thereafter said movable contact structure moving to the fully closed position as said movable contact arm pivots said limited pivotal movement on said movable contact support during which limited pivotal movement said magnetic means operates on said movable contact arm in response to the current flow in said movable contact arm to bias said movable contact into engagement with said stationary contact.

16. A circuit breaker comprising a pair of spaced stationary conductors, a stationary contact on a first of said stationary conductors, a movable contact structure comprising a movable contact arm and a movable contact on said movable contact arm, a movable contact support, a flexible conductor electrically connecting said movable contact arm with the second of said stationary conductors, pivot support means supporting said movable contact arm for limited pivotal movement on said movable contact support, spring means on said movable contact structure biasing said movable contact arm about said pivot support means toward said stationary contact, stop means limiting pivotal movement of said movable contact arm on said movable contact support about said pivot support means toward said stationary contact, means supporting said movable contact support for movement between open and closed positions, in the open position said spring means biasing said movable contact arm about said pivot support means toward said stationary contact which movement is limited by said stop means:

during closing operations of said circuit breaker said movable contact arm moving unitarily with said contact support member until said movable contact engages said stationary contact and thereafter said movable contact support moving to the fully closed position charging said spring means as said movable contact arm moves relative to said movable contact support on said pivot support means;

during opening operations of said circuit breaker said movable contact support moving toward the open position an initial movement as said charged spring means discharges with said movable contact in engagement with said stationary contact and with said movable contact arm moving relative to said movable contact support on said pivot support means until said relative movement is limited by

said stop means and thereafter said movable contact support carrying said movable contact therewith as a unit to the fully open position; and

said circuit breaker comprising means operating upon the occurrence of overload current conditions above a predetermined value to effect automatic opening of said contacts;

magnetic means on said movable contact structure, said magnetic means comprising a first magnetic member on said movable contact support and a second magnetic member on said movable contact arm, said movable contact being on said movable contact arm on a first side of said pivot support means, said first and second magnetic members providing a magnetic circuit around said movable contact arm on the second side of said pivot support means opposite said first side which magnetic circuit is responsive to current flow in said movable contact arm to bias said movable contact arm about said pivot support means to provide contact pressure between said movable and stationary contacts.

17. A circuit breaker according to claim 16, said spaced stationary conductors comprising main stationary contact means, main movable contact means supported on said movable contact support to cooperate with said main stationary contact means, during opening operations of said movable contact structure said main movable contact means disengaging from said main stationary contact means to transfer current to said movable contact arm as said movable contact arm moves said limited pivotal movement on said movable contact support, during closing operations of said movable contact structure said movable contact engaging said stationary contact before said main movable contact means fully engages said main stationary contact means and thereafter said movable contact arm moving said limited pivotal movement on said movable contact support as said main movable contact means moves into full engagement with said main stationary contact means.

18. A circuit breaker according to claim 17, said magnetic circuit around said movable contact arm operating on said movable contact arm separate from said main movable contact means, and said movable contact structure being supported for pivotal movement between open and closed positions.

19. A circuit breaker according to claim 17, said first magnetic member being a generally U-shaped magnetic member supported at the bight portion thereof on said movable contact support with the opposite legs thereof extending downwardly on opposite sides of said movable contact arm, said second magnetic member being supported on said movable contact arm to cooperate with said generally U-shaped first magnetic member to provide said magnetic circuit around said movable contact arm.

20. A circuit breaker according to claim 18, and said main contact means comprising a pair of bridging main contact members supported on opposite sides of said movable contact arm to engage said stationary main contact means and bridge said pair of spaced stationary conductors in the closed position of said movable contact structure.

21. A circuit breaker comprising a circuit-breaker structure, said circuit-breaker structure comprising a first stationary conductor, a second stationary conductor spaced from said first stationary conductor, an arc extinguishing structure, a first and arcing stationary contact means on said first stationary conductor in proximity to said arc-extinguishing structure, a second stationary contact means on said first stationary conductor, a third stationary contact means on said second stationary conductor:

a movable contact device, said movable contact device comprising a movable contact support, an arcing-contact support arm connected to said movable contact support for movement with said movable contact support between open and closed positions and for limited movement relative to said movable contact structure, a first and arcing movable contact on said arcing-contact sup-

port arm, contact-pressure spring means biasing said arcing-contact support arm relative to said movable contact support toward said first and arcing stationary contact means, a pair of bridging contact support arms supported on said movable contact support on opposite sides of said arcing-contact support arm for movement with said movable contact support between open and closed positions and for limited movement relative to said movable contact support, a separate second movable contact and a separate third movable contact on each of said bridging contact support arms, said contact-pressure spring means biasing said bridging contact support arms relative to said movable contact support toward said second and third stationary contact means;

said movable contact device being movable between closed and opened positions to close and open an electric circuit, in the closed position of said contacts said first and arcing movable contact engaging said first and arcing stationary contact means, said second movable contact engaging said second stationary contact means and said third movable contact engaging said third stationary contact means;

said movable contact structure comprising current-responsive magnetic means responsive to current flow in said arcing-contact support arm to bias said arcing-contact support arm to provide contact pressure between said first and arcing movable contact and said first and arcing stationary contact means;

said circuit breaker comprising trip means operating automatically upon the occurrence of overload current conditions above a predetermined value to effect automatic opening of said movable contact device; and

during said automatic opening of said movable contact device upon the occurrence of said overload current conditions said second movable contacts disengaging from said second stationary contact means as said arcing-contact support arm moves said limited movement relative to said movable contact support to transfer current to said arcing-contact support arm and after said limited movement of said arcing-contact support arm relative to said movable contact support is taken up said arcing-contact support arm moving as a unit with said movable contact

support to the open position.

22. A circuit breaker according to claim 21, said magnetic means comprising a first member of magnetic material supported on said movable contact support and a second member of magnetic material supported on said arcing-contact support arm providing a magnetic circuit responsive to current flow in said arcing-contact support arm to bias said arcing-contact support arm to provide contact pressure between said first and arcing movable contact and said first and arcing stationary contact means.

23. A circuit breaker according to claim 22, pivot support means supporting said arcing-contact support arm on said movable contact support for limited pivotal movement on said movable contact support relative to said movable contact support, said first and arcing movable contact being on said arcing-contact support arm on a first side of said pivot support means, said first and second magnetic members operating on said arcing-contact support arm on the second side of said pivot support means opposite the said first side, said first and second magnetic members operating in response to current flow in said arcing-contact support arm to bias said arcing-contact support arm about said pivot support means to provide said contact pressure between said first and arcing movable contact and said first and arcing stationary contact means.

24. A circuit breaker according to claim 23, said magnetic means comprising a first generally U-shaped magnetic member supported at the bight portion thereof on said support member with the opposite legs thereof extending on opposite sides of said arcing-contact support arm on said second side of said pivot support means, said magnetic means comprising said second member of magnetic material supported on said arcing-contact support arm on the said second side of said pivot support means to cooperate with said generally U-shaped member of magnetic material to provide a magnetic circuit around said arcing-contact support arm separate from said bridging contact support arms which magnetic circuit is responsive to current flow in said arcing-contact support arm.

25. A circuit breaker according to claim 24, and a flexible conductor connected at one end thereof to said arcing-contact support arm and at the other end thereof to said second stationary conductor to electrically connect said arcing-contact support arm to said second stationary conductor.

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