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TITLE OF THE INVENTION

CIRCUIT BREAKER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to circuit breakers. More particularly, the present invention relates to a circuit breaker that incorporates a mechanism for detaching a movable contact from a fixed contact when a short-circuit current is detected.

Description of the Related Art

Figure 9 is a cross section of a circuit breaker including a conventional mechanism for removing a movable contact from a fixed contact. As illustrated, the circuit breaker includes an operating lever 42, a movable contact 43 having a movable point 44 provided on one end thereof, and a fixed contact 45 having a fixed point 46 provided on an end thereof. Also provided in the circuit breaker is a make-and-break mechanism 7 for bringing the movable point 44 of the movable contact 43 into contact with the fixed point 46 of the fixed contact 45 by switching the toggle lever 42 from the off position to the on position. Furthermore, the breaker includes a tripping device 48 for detaching the movable point 44 from the fixed point 46 when a short-circuit current is detected typically by a bimetal type short-circuit current detector.

As the demand for circuit breakers with higher reliability and shorter breaking time, conventional breakers increases, such as the one described above, can no longer meet the more stringent requirements.

SUMMARY OF THE INVENTION

In view of the above-identified problems, an object of the present invention is to provide a circuit breaker with higher reliability than that of conventional breakers.

Another object of the present invention is to provide a circuit breaker that can break the circuit in less time than conventional breakers.

The above objects and other related objects are realized by the invention, which provides a circuit breaker including a movable contact; a



fixed contact; a toggle switch; a make-and-break mechanism responsive to operation of the toggle switch for bringing the movable contact into contact with the fixed contact and detaching the movable contact from the fixed contact; and disconnecting means for causing the make-and-break mechanism to detach the movable contact from the fixed contact. The disconnecting means includes a tripping device for causing the make-and-break mechanism to detach the movable contact from the fixed contact; a pivot lever for operating the tripping device by its pivotal movement; and at least one bimetallic short-circuit current detector and at least one electromagnetic short-circuit current detector for detecting a short-circuit current occurring in the circuit and operating the tripping device. In this device, at least the electromagnetic short-circuit current detector operates the tripping device by rotating the pivot lever so that the make-and-break mechanism detaches the movable contact from the fixed contact.

According to one aspect of the present invention, each of the at least one electromagnetic short-circuit current detectors comprises a first magnetic element provided on the movable contact and a second magnetic element provided on the pivot lever so as to oppose the first magnetic element, the first and second magnetic elements rotating the pivot lever by the interaction therebetween.

According to another aspect of the present invention, electric current flows through a conductor placed in the circuit between the first and second magnetic elements such that when a short-circuit current or an excess current flows through the conductor, the second magnetic element is drawn by electromagnetic effect toward the first magnetic element to rotate the pivot lever.

According to still another aspect of the present invention, when the second magnetic element is drawn by electromagnetic effect toward the first magnetic element, the first and second magnetic elements and the conductor are at least partially oriented substantially parallel to one another. Furthermore, the first magnetic element has an approximately L-shaped cross section orthogonal to the horizontal direction so as to half surround the conductor.

According to yet another aspect of the present invention, the conductor constitutes at least part of the bimetallic short-circuit current detector.



In accordance with another aspect of the present invention, each of the at least one electromagnetic short-circuits current detectors comprises a magnetic coil provided on one end of the movable contact and a plunger inserted in the magnetic coil and the interaction between the magnetic coil and the plunger causes the plunger to come into contact with and rotate the pivot lever.

In one practice, the circuit breaker further includes on one side of the pivot lever a projection with which the plunger comes into contact when moving in the magnetic coil by said interaction, thereby rotating the pivot lever.

In another practice, the pivot of the pivot lever is provided on the make-and-break mechanism.

To carry out the invention in one preferred mode, the make-and-break mechanism includes a link pin which serves as the pivot of the pivot lever.

BRIEF DESCRIPTION OF THE DRAWINGS

For a fuller understanding of the nature and objects of the present invention, reference should be made to the following detailed description and the accompanying drawings, in which:

Figure 1 is a cross section of a circuit breaker according to the present invention in the off position;

Figure 2A shows essential elements of the circuit breaker of Figure 1 when the breaker is in the on position;

Figure 2B is a cross section of a portion of the circuit breaker of Figure 1 taken along line M-M;

Figure 3 illustrates the operation of the circuit breaker of Figure 1;

Figure 4 illustrates a variation of Figure 1;

Figure 5 is a cross section of another circuit breaker embodying the present invention when the breaker is in the off position;

Figure 6 shows essential elements of the circuit breaker of Figure 5 when the breaker in the on position;

Figure 7 illustrates the operation of the circuit breaker of Figure 5;

Figure 8 illustrates a variation of Figure 5; and

Figure 9 is a cross section of a conventional circuit breaker.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Preferred embodiments according to the present invention will be described hereinafter with reference to the attached drawings. Figures 1 to 3 illustrate a circuit breaker of a first embodiment in accordance with the present invention, in which Figure 1 is a cross section of the circuit breaker in the off position; Figure 2 shows the essential elements of the circuit breaker in the on position; Figure 3 illustrates how the circuit is opened.

Figure 1 shows a double-pole four-terminal circuit breaker in cross section embodying the present invention when the circuit breaker is in the off position. In the drawing, reference numeral 2 denotes an operating lever (toggle switch) and reference numeral 3 denotes a movable contact having a movable point 4 provided on an end thereof. The circuit breaker also includes a fixed contact 5 having a fixed point 6 provided on an end thereof and a make-and-break mechanism 7. Referring to Figure 2A, when the circuit breaker is placed in the on position by operating the lever 2, the make-and-break mechanism 7 brings the movable contact 3 into contact with the fixed contact 6 to close the circuit.

Reference numeral 8 denotes a tripping device for opening the circuit by forcibly detaching the movable point 4 from the fixed point 6. As shown in Figure 2A, the tripping device 8 is mounted on the base of the circuit breaker by means of a pivot 19. When the operating lever 2 is thrown to the on position, the make-and-break mechanism 7 is activated, thus bringing the movable contact 3 into contact with the fixed contact 5. At the same time, the tripping device 8 engages a latch 12 to maintain the device in the on position. When a short-circuit current is detected by either or both of the two types of short-circuit current detectors (described in detail below) incorporated in the breaker, the tripping device 8 trips the circuit breaker in response to the detection.

One of the two types of short-circuit current detector is a bimetallic strip 13 provided for each of the two poles. When a short-circuit current or excess current flows therethrough, the strips 13 deforms to press against and tilt a first projection 8b formed on the top portion of the tripping device 8. When either one of the bimetallic strips 13 deforms in the above-described manner, the latch 12 is disengaged from the tripping device 8 activating the make-and-break mechanism 7 to detach the movable contact 3 from the fixed





contact 5 while switching the operating lever 2 to the off position.

Referring to Figures 2A and 2B, the circuit breaker further includes a first magnetic element 16 and a second magnetic element 17 which together form the second short-circuit current detector. The first magnetic element 16, along with the movable contact 3 and the bimetallic strip 13, has its lower end secured to the base of the circuit breaker. As shown in Figure 2B (a cross sectional view taken along line M-M of Figure 2B), the upper portion of the element 16 has an L-shaped cross section extending in parallel to the bimetallic strip 13. The second magnetic element 17 is mounted on a resin pivot lever 9 at one end thereof and the other, free end is positioned opposite the L-shaped portion of the first magnetic element 16 across the bimetallic strip 13. It should be noted that in this embodiment, the first and second magnetic elements and the pivot lever 9 are provided only for the front pole as seen in Figure 2A, but not for the rear pole.

The pivot lever 9 is mounted on a link pin 11 of the make-and-break mechanism 7 the rear portion of which forms a pivot 15 for the operating lever 2 (see Figure 1). By rotating on the link pin 11, an upper portion of the pivot lever 9 abuts against a second projection 8a provided on the tripping device 8 and pushes it to forcibly place the switch in the off position.

With reference to Figure 3, the operation of the second short-circuit current detector is explained hereinafter. When the breaker is closed, current runs through the fixed contact 5 and the movable contact 3, reaching a twist conductor 14 via the bimetallic strip 13. This creates a magnetic field around the bimetallic strip 13. Due to the first magnetic element 16 half surrounding the bimetallic strip 13, the magnetic flux density is unevenly distributed in the magnetic field. If a short-circuit current flows, the second magnetic element 17 is drawn toward the first magnetic element 16 as indicated by arrow A due to the uneven distribution of magnetic flux density, thereby rotating the plate 9, to which the second magnetic element 17 is attached, about the link pin 11. This in turn abuts the plate 9 against the projection 8a and thus tilts the tripping device 8 in the direction indicated by arrow B.

As described above, the second short-circuit current detector operates the tripping device 8 to detach the movable point 4 from the fixed point 6, thus opening the circuit in the same manner as is by the bimetallic strip 13. However, the circuit breaking operation performed by the second short-circuit



current detector is advantageous that it requires less time than by the bimetallic strip 13 since the second detector employs electromagnetic force. Furthermore, the overall reliability of the circuit breaker is increased by using more than one type of short-circuit current detector.

Figure 4 illustrates a variation of the first embodiment in which the pivot lever 9 is supported on a separate pivot 20 at the top portion of a support column 10, rather than on the common link pin/pivot 11(15). As in this case, the pivot 20 of the pivot lever 9 may be separately provided from the pivot 15 of the operating lever 2. Alternatively, the pivots 15 and 20 may be mounted on common element of the make-and-break mechanism 7 as in the first embodiment. The configuration of the first embodiment, sharing a common element, requires fewer elements and thus reduces the assembly time as well as the number of manufacturing steps.

It should be noted that the first magnetic element 16 does not need to have an L-shaped horizontal cross section; for example, a U-shaped cross section that surrounds the bimetallic strip 13 will also be effective.

A second embodiment of the present invention is explained with reference to Figures 5 to 7, in which Figure 5 is a cross section of a circuit breaker in the off position; Figure 6 shows essential elements of the circuit breaker in the on position; Figure 7 illustrates how the circuit is opened. Since similar or identical reference characters designate similar or identical parts throughout the drawings, the description thereof is hereby omitted.

In this embodiment, a bimetallic strip 13 is provided as a first short-circuit current detector for the rear pole as seen in the figures while a combination of a plunger 30 and a magnetic coil 31 is provided as a second short-circuit current detector for the front pole.

The upright magnetic coil 31 has one end thereof secured to the support of the movable contact 3 with another, upper end connected to the twist conductor 14, which is in turn connected to a load terminal. The plunger 30 is vertically reciprocably inserted in the magnetic coil 31. A projection 29a is provided on one side of the pivot lever 29 above the top end of the plunger 30.

According to the above-described structure, current carried through the movable contact 3 flows through the magnetic coil 31, causing the plunger 30 to generate a magnetic field with uneven distribution of magnetic flux

density around the coil. If a short-circuit current is present, the plunger 30 moves upward to the center of the coil 31, with its top end abutting against the projection 29a in the direction indicated by arrow C of Figure 7. This in turn rotates the plate 29 about the link pin 11. Then, as in the first embodiment, the tripping device 8 is pushed in the direction indicated by arrow B to break the circuit.

As in this embodiment, different types of short-circuit current detector may be provided for the two poles, with a combination of a coil and a plunger as a second short-circuit current detector.

Figure 8 illustrates a variation of the embodiment of Figures 5 to 7 in which the pivot lever 29 is supported on a separate pivot 32 at the top portion of a support column 10, rather than on the common link pin/pivot 11(15) as in the circuit breaker of Figure 4.

As should be clearly understood from the foregoing description, the embodiments can effectively achieve the objects of the present invention of providing a circuit breaker with higher reliability that can break the circuit in shorter time than conventional breakers.

It should be noted that although a bimetallic strip is used for each of the two poles, the pole with the first and second magnetic elements need not be provided with a bimetallic strip; a simple metal conductor will also suffice. Moreover, as other elements, such as the operating lever and the tripping device, may be modified, altered, and changed without departing from the scope or spirit of the essential characteristics of the present invention, it is to be understood that the above embodiments are only an illustration and not restrictive in any sense. The scope or spirit of the present invention is limited only by the terms of the appended claims.

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WHAT IS CLAIMED IS:



1. A circuit breaker, comprising:
 - a movable contact;
 - a fixed contact;
 - a toggle switch;
 - a make-and-break mechanism responsive to operation of the toggle switch for bringing the movable contact into contact with the fixed contact and detaching the movable contact from the fixed contact; and
 - disconnecting means for causing the make-and-break mechanism to detach the movable contact from the fixed contact, the disconnecting means comprising
 - a tripping device for causing the make-and-break mechanism to detach the movable contact from the fixed contact;
 - a pivot lever for operating the tripping device by its pivotal movement; and
 - at least one bimetallic short-circuit current detector and at least one electromagnetic short-circuit current detector for detecting a short-circuit current occurring in the circuit and operating the tripping device, wherein at least the electromagnetic short-circuit current detector operates the tripping device by rotating the pivot lever so that the make-and-break mechanism detaches the movable contact from the fixed contact.
2. A circuit breaker in accordance with claim 1, wherein each of the at least one electromagnetic short-circuit current detectors comprises a first magnetic element provided on the movable contact and a second magnetic element provided on the pivot lever so as to oppose the first magnetic element, the first and second magnetic elements rotating the pivot lever by the interaction therebetween.
3. A circuit breaker in accordance with claim 2, wherein electric current flows through a conductor placed in the circuit between the first and second magnetic elements such that when a short-circuit current or an excess current flows through the conductor, the second magnetic element is drawn by electromagnetic effect toward the first magnetic element to rotate the pivot



lever.

4. A circuit breaker in accordance with claim 3, wherein when the second magnetic element is drawn by electromagnetic effect toward the first magnetic element, the first and second magnetic elements and the conductor are at least partially oriented substantially parallel to one another and further wherein the first magnetic element has an approximately L-shaped cross section orthogonal to the horizontal direction so as to half surround the conductor.

5. A circuit breaker in accordance with claim 3, wherein the conductor constitutes at least part of the bimetallic short-circuit current detector.

6. A circuit breaker in accordance with claim 1, wherein each of the at least one electromagnetic short-circuits current detectors comprises a magnetic coil provided on one end of the movable contact and a plunger inserted in the magnetic coil, the interaction between the magnetic coil and the plunger causing the plunger to come into contact with and rotate the pivot lever.

7. A circuit breaker in accordance with claim 6 further comprising on one side of the pivot lever a projection with which the plunger comes into contact when moving in the magnetic coil by said interaction, thereby rotating the pivot lever.

8. A circuit breaker in accordance with any one of claims 1 to 7, wherein the pivot of the pivot lever is provided on the make-and-break mechanism.

9. A circuit breaker in accordance with any one of claims 1 to 7, wherein the make-and-break mechanism includes a link pin which serves as the pivot of the pivot lever.

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