

CIRCUIT BREAKER

TECHNICAL FIELD

[0001] The present disclosure generally relates to a technical field of electrical switch, and more particularly, to a circuit breaker.

BACKGROUND

[0002] A circuit breaker, as a protection element of a power transmission and distribution system, may switch off a circuit timely when a fault current occurs in the circuit so as to protect an entirety of the circuit and relevant electrical loads. Usually, the circuit breaker has an overload protection function, a short circuit protection function and a residual current protection function. As rapid development of the power transmission and distribution system, the circuit breaker is required to present a higher reliability of breaking and a smaller volume.

[0003] Currently, a commonly used structure of the circuit breaker includes at least one contact mechanism that may be arranged to be connected or disconnected, an open-and-close mechanism, a tripping unit, an arc-extinguishing mechanism and a main spring which functions in cooperation with the open-and-close mechanism and the tripping unit. The open-and-close mechanism is constituted by an operating component and a link mechanism, wherein the main spring of the circuit breaker may exert a force on the link mechanism when the operating mechanism is operated, so the contact mechanism may be connected or disconnected manually or by means of the tripping unit when a fault occurs in the circuit.

[0004] In practical application, in order to ensure breaking performance of the circuit breaker, it is usual to increase the volume of the circuit breaker or a length of a movable contact of the contact mechanism so as to maintain a large open distance between the movable contact and a fixed contact of the contact mechanism or increase a space to install the arc-extinguishing mechanism. However, it is ultimately necessary to increase the volume of the circuit breaker to improve the breaking performance of the circuit breaker in the above approaches, which may reduce a reliability of closing of the circuit breaker on one hand and

reduce a market demand of the circuit breaker on the other hand.

[0005] Therefore, it is desirable to provide a new circuit breaker.

SUMMARY

[0006] In view of one or more of the above problems, one aspect of the disclosure provides a circuit breaker comprising a movable contact, a fixed contact, a rotatable shaft and an operating mechanism, wherein: the movable contact is operable to rotate around a rotation center of the rotatable shaft with respect to the fixed contact, and a circuit is switched on or off by connecting or disconnecting the movable contact and the fixed contact; the operating mechanism comprises an upper link, a lower link and a handle, wherein the upper link is operable to rotate around an end of the upper link under the drive of the handle, another end of the upper link is rotatably connected to an end of the lower link via a link hinge shaft, and another end of the lower link is hinged to the rotatable shaft, so that the upper link and the lower link are operable to drive the rotatable shaft to bring the movable contact to rotate; there is a predetermined ratio between a working length of the upper link and a working length of the lower link and between the working length of the upper link and a distance from a hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft, so that a rotation angle larger than 30° of the movable contact is formed after the movable contact and the fixed contact are disconnected.

[0007] In one aspect of the disclosure, the ratio between the working length of the upper link and the working length of the lower link is larger than 0.78, and the ratio between the working length of the upper link and the distance from the hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft is larger than 1.28.

[0008] In one aspect of the disclosure, the ratio between the working length of the upper link and the working length of the lower link is 0.95, and the ratio between the working length of the upper link and the distance from the hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft is 1.57.

[0009] In one aspect of the disclosure, the circuit breaker further comprises a jump pin rotatably arranged within the circuit breaker, wherein an end of the upper link is hinged to the jump pin and a limit slideway is arranged on the jump pin, the limit slideway limiting a

motion range of the link hinge shaft with a limit surface and thus limiting a motion range of the upper link.

[0010] In one aspect of the disclosure, the circuit breaker further comprises a jump pin hinge shaft to connect the jump pin, wherein the jump pin hinge shaft is operable to prevent the upper link from continuing rotating when the movable contact and the fixed contact are connected.

[0011] In one aspect of the disclosure, the circuit breaker further comprises an anti-reverse movement component arranged on the movable contact, wherein the anti-reverse movement component is operable to rotate along with the movable contact and prevent an electric arc, which is produced when the movable contact and the fixed contact are disconnected, from moving towards the operating mechanism.

[0012] In one aspect of the disclosure, the anti-reverse movement component is an arc-shaped plate having a concave cambered surface and a convex cambered surface that are opposite to each other.

[0013] In one aspect of the disclosure, the circuit breaker further comprises a guide component contacting a surface of the anti-reverse movement component so as to guide the movement of the anti-reverse movement component.

[0014] In one aspect of the disclosure, the guide component is arranged on the rotatable shaft and has a convex cambered guide surface, the concave cambered surface sliding approximately on the convex cambered guide surface when the anti-reverse movement component rotates along with the movable contact.

[0015] In one aspect of the disclosure, the guide component has a concave cambered guide surface, the convex cambered surface sliding approximately on the concave cambered guide surface when the anti-reverse movement component rotates along with the movable contact.

[0016] In the circuit breaker in accordance with embodiments of the disclosure, by changing the ratios between the working lengths of respective links of the link mechanism in the operating mechanism for driving the movable contact and the fixed contact to connect and disconnect, the rotation angle of the movable contact is increased and thus the open distance between the movable contact and the fixed contact when they are disconnected is increased,

so that the breaking performance and the reliability of breaking of the circuit breaker are effectively improved while miniaturization of the circuit breaker is accomplished.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] The disclosure may be better understood from the following description of implementations of the disclosure in conjunction with the accompany drawings.

[0018] Other features, purposes and advantages of the disclosure will become apparent from reading detailed description of non-restrictive embodiments of the disclosure in conjunction with the accompanying drawings, wherein a same or similar reference number refers to a same or similar feature.

[0019] FIG. 1 is an internal structure diagram of a circuit breaker in a closing state in accordance with an embodiment of the disclosure.

[0020] FIG. 2 is a structure diagram of a movable contact in the circuit breaker shown in FIG. 1.

[0021] FIG. 3A is a structure diagram of an anti-reverse movement component in a shaft side direction in the circuit breaker shown in FIG. 1, and FIG. 3B is a structure diagram of the anti-reverse movement component in another shaft side direction in the circuit breaker shown in FIG. 1.

[0022] FIG. 4 is a structure diagram of a rotatable shaft in the circuit breaker shown in FIG. 1.

[0023] FIG. 5 is a structure diagram of a holding component in the circuit breaker shown in FIG. 1.

[0024] FIG. 6 is a closing state diagram of an operating mechanism in the circuit breaker shown in FIG. 1 in the closing state.

[0025] FIG. 7 is a structure diagram of a jump pin in accordance with an embodiment of the disclosure.

[0026] FIG. 8 is an internal structure diagram of the circuit breaker in an opening state in accordance with an embodiment of the disclosure.

[0027] FIG. 9 is an opening state diagram of the operating mechanism in the circuit breaker shown in FIG. 1 in the opening state.

[0028] FIG. 10 is a movement diagram of stress states of a link mechanism in the circuit breaker shown in FIG. 1.

[0029] FIG. 11A is a simplified diagram of a link mechanism in which ratios of working lengths of respective links are set to selected parameters, and FIG. 11B is a simplified diagram of a link mechanism in which the ratios of the working lengths of respective links are set the same as prior art.

DETAILED DESCRIPTION

[0030] Exemplary embodiments and features of various aspects of the disclosure will be described below. In the following detailed description, many specific details are provided in order to provide comprehensive understanding of the disclosure. However, it is obvious to those ordinary skilled in the art that the disclosure may be practiced without some of the specific details. The following description of embodiments is intended to provide better understanding of the disclosure by illustrating examples of the disclosure. In the following description and the accompany drawings, well known structures and techniques are not illustrated in order to avoid unnecessarily obscuring the disclosure. Moreover, in order for clarity, some area and thickness of a layer are exaggerated. A same reference number refers to a similar or same structure in the accompany drawings, so their detailed description will be omitted. Moreover, the described features, structures or characteristics may be incorporated into one or more embodiments as appropriate. An orientation word occurring in the following description indicates a direction shown in an accompany drawing, and is not used to limit a specific structure of a circuit breaker of the disclosure.

[0031] FIG. 1 is an internal structure diagram of a circuit breaker 100 in a closing state in accordance with an embodiment of the disclosure. The circuit breaker 100 includes a movable contact 21, a fixed contact 22, an operating mechanism 30, a tripping unit and an arc-extinguishing mechanism. The movable contact 21 and the fixed contact 22 are electrically connected to a power supply terminal and a load terminal respectively to form a main circuit of the circuit breaker 100. The tripping unit is connected to the main circuit of the circuit breaker 100, and it may protect respective components and loads in a circuit by timely disconnecting the movable contact 21 and the fixed contact 22 with a tripping action

when a fault current occurs in the circuit. The operating mechanism 30 may be operated to disconnect the movable contact 21 and the fixed contact 22 as required so as to cut off a current in the main circuit of the circuit breaker 100 and thus protect subordinate electrical appliances and loads.

[0032] Specifically, the circuit breaker 100 has a housing 11, as an external protection structure, made of insulating materials. The housing 11 includes a base 11a and a cover body 11b, and the base 11a and the cover body 11b together form an accommodation space, in which respective components of the circuit breaker 100 are accommodated.

[0033] A first terminal 12 and a second terminal 13, which are corresponding to the power supply terminal and the load terminal respectively, are arranged within the housing 11. The first terminal 12 and the second terminal 13 are respectively arranged at two edges opposite to each other of the housing 11, so that they may be electrically connected to external conductors conveniently. Furthermore, in another embodiment, the first terminal 12 and the second terminal 13 may also not be arranged at the two edges opposite to each other of the housing 11. For example, the first terminal 12 and the second terminal 13 may be arranged at a same edge or other parts within the housing, as long as the circuit breaker may be electrically connected to external power supplies and loads.

[0034] An end of the fixed contact 22 faces the movable contact 21 and is provided with a fixed contact point 221, and another end of the fixed contact 22 extends towards the first terminal 12 and is electrically connected to the first terminal 12. An end of the movable contact 22 is rotatably held within the housing 11 by a rotatable shaft 34, and another end of the movable contact 22 is provided with a movable contact point 211. The movable contact 21 is electrically connected to the second terminal 13 so that the main circuit of the circuit breaker 100 is formed between the first terminal 12 and the second terminal 13. The movable contact point 211 and the fixed contact point 221 function together as open-and-close contact points for controlling switch-on or switch-off of the main circuit. Specifically, an end of the fixed contact 22 is electrically connected to the first terminal 12, and an outer surface formed by a folding structure at another end of the fixed contact 22 is provided with the fixed contact point 221, so that the fixed contact point 221 is electrically connected to the first terminal 12. FIG. 2 is a structure diagram of the movable contact 21 in accordance with an embodiment of

the disclosure. An end, which is to be connected to the fixed contact 22, of the movable contact 21 is a contact end 215, and another end, which is away from the contact end 215 and connected to the rotatable shaft 34, of the movable contact 21 is a fixed end 216. An arc-isolation component 23 is arranged near the contact end 215 and around the movable contact 21 by three sides to prevent an electric arc, which is produced when the movable contact 21 and the fixed contact 22 are disconnected, from moving towards the movable contact 21 from the fixed contact point 221 and thus avoid damaging of the movable contact 21 by the electric arc, wherein damaging of the movable contact 21 may lead to reduction of lifetime of the movable contact and reduction of final stress between the movable contact point and the fixed contact point.

[0035] In accordance with embodiments of the disclosure, an exemplary single-pole circuit breaker is illustrated in the accompany drawings. The circuit breaker may also be a multi-pole circuit breaker, in which respective contact mechanisms corresponding to circuit branches of the circuit are arranged in parallel on the base. For example, the circuit breaker may be a three-pole circuit breaker, and three contact mechanisms and three pair of terminals and so on are necessary for the circuit having three circuit branches, wherein respective contact mechanisms may be the same with each other. In the multi-pole circuit breaker, the rotatable shaft may be arranged orthogonally to respective contact mechanisms, so that the rotatable shaft brings respective contact mechanisms to rotate. Here, the operating mechanism may be connected to the movable contact and the fixed contact at an intermediate position so as to drive the rotatable shaft to rotate.

[0036] In accordance with an embodiment of the disclosure, an anti-reverse movement component 70 is arranged on the movable contact 21 to prevent the electric arc, which is produced when the movable contact 21 and the fixed contact 22 are disconnected, from moving towards the operating mechanism 30 (i.e., preventing the electric arc from moving towards the rotatable shaft 34 and the link mechanism). FIG. 3A is a structure diagram of the anti-reverse movement component 70 in a shaft side direction in the circuit breaker 100 in accordance with an embodiment of the disclosure, and FIG. 3B is a structure diagram of the anti-reverse movement component 70 in another shaft side direction. Specifically, the anti-reverse movement component 70 is an arc-shaped plate having a

concave cambered surface 73a and a convex cambered surface 73b, wherein an opening 71, through which the movable contact 21 passes, is arranged at an intermediate position near a narrower edge of the anti-reverse movement component 70, and the anti-reverse movement component 70 is arranged on the movable contact 21 along a longitudinal direction thereof via the opening 71, so that the anti-reverse movement component 70 is operable to rotate along with the movable contact 21. An area below the opening 71 of the anti-reverse movement component 70 may block the electric arc from moving towards the operating mechanism 30. In order to avoid large fluctuations of the anti-reverse movement component 70 when it rotates along with the movable contact 21, the opening 71 is arranged exactly corresponding to the shape of the movable contact 21. After the anti-reverse movement component 70 is installed, the anti-reverse movement component 70 is at an end near the fixed end 216 of the arc-isolation component 23, a top edge of the opening 71 is hanged onto a top surface 214 of the movable contact 21, and the arc-isolation component 23 may function as a limit component to prevent the anti-reverse movement component 70 from separating from the movable contact 21 from the contact end 215 along the longitudinal direction of the movable contact 21, so the movable contact 21 may fix the anti-reverse movement component 70 without any additional limit structure.

[0037] In order to avoid large fluctuations of the anti-reverse movement component 70 when it rotates along with the movable contact 21, guide components corresponding to the concave cambered surface 73a and the convex cambered surface 73b of the anti-reverse movement component 70 are arranged to guide the movement of the anti-reverse movement component 70 in an arc track. The guide components are arranged at both sides of the anti-reverse movement component 70 along the longitudinal direction of the movable contact 21 and they contact surfaces of the anti-reverse movement component 70 in two directions and thus guide the movement of the anti-reverse movement component 70. In accordance with an embodiment of the disclosure, a guide component is provided with a convex cambered guide surface 352 corresponding to the concave cambered surface 73a, the convex cambered guide surface guiding the movement of the anti-reverse movement component 70 on the side of the concave cambered surface 73a. Specifically, the rotatable shaft 34 for bring the movable contact 21 to rotate is arranged below the operating mechanism 30, and the

rotatable shaft 34 is operable to take its rotation center as a first fixed pivot “O” to bring the movable contact 21 to rotate. FIG. 4 is a structure diagram of the rotatable shaft 34 in accordance with an embodiment of the disclosure. In the example shown in FIG. 4, the rotatable shaft 34 may bring the movable contacts 21 of the multi-pole circuit breaker to rotate, and the rotatable shaft 34 is provided with an auxiliary guide component 35 corresponding to the movable contact 21 at each pole. The auxiliary guide component 35 is fan structures protruding on the rotatable shaft 34, and they may be an organic whole with the rotate shaft 34 or a structure separate from the rotate shaft 34. The convex cambered guide surface 352 is formed by two edges, which are at an end away from the rotatable shaft 34, of the fan structure of the auxiliary guide component 35, and a holding groove 351 is formed between the fan structures to accommodate the movable contact 21. The fixed end 216 of the movable contact 21 is in elastic connection with the rotatable shaft 34 via fixing holes 212 and 213 and a contact spring , so that the movable contact 21 is allowed to have an elastic movement contrary to a contact direction between the movable contact 21 and the fixed contact 22 and asynchronous with the rotatable shaft 34 when the movable contact 21 and the fixed contact 22 are completely connected, or an elastic movement towards a disconnecting position and asynchronous with the rotatable shaft 34 when a large short-circuit current occurs in the circuit. Meanwhile, the radian of the convex cambered guide surface 352 is set to be corresponding to the arc of the concave cambered surface 73a of the anti-reverse movement component 70, so that the concave cambered surface 73a slides approximately on the convex cambered guide surface 352 when the anti-reverse movement component 70 rotates along with the movable contact 21. So the anti-reverse movement component 70 will not fluctuate when rotating and the pressure on the movable contact 21 will not be influenced by the fluctuations of the anti-reverse movement component 70. That is, the anti-reverse movement component 70 is more steadily connected and the components such as the rotatable shaft and the link mechanism may be effectively protected from the electric arc.

[0038] In the above embodiments, the auxiliary guide component 35 is the fan structures, and it has the holding groove 351 for accommodating the movable contact 21 and provides a sliding track, which guide the movement track of the anti-reverse movement component 70, for the anti-reverse movement component 70 by means of surfaces protruding

on the rotatable shaft 34. However, the disclosure is not limited to the above embodiments. In another embodiment, the auxiliary guide component may also be a semi-circle or rectangle double-slideway structure protruding on the rotatable shaft 34 or another structure having sliding guide surfaces, and it may also implement installation of the movable contact 21 and guide the movement track of the anti-reverse movement component 70.

[0039] In accordance with an embodiment of the disclosure, the guide component also guides the movement of the anti-reverse movement component 70 on the side of the convex cambered surface 73b by means of a concave cambered guide surface 82. FIG. 5 is a structure diagram of the holding component 80 in the circuit breaker 100 in accordance with an embodiment of the disclosure. Specifically, the holding component 80 is a plate-shaped structure of insulating materials, and it is arranged near the contact end 215 of the movable contact 21 within the housing 11. There is a slender cut 81 corresponding to the width of the movable contact 21 on the holding component 80, the slender cut making the upper part of the holding component 80 become a connective structure and making the lower part of the holding component 80 become a divided structure. The contact end 215 of the movable contact 21 is operable to longitudinally stretch into the cut 81 and is always held within the cut 81 when the movable contact 21 rotates around the first fixed pivot “O”. Two support plates protruding on a surface of the holding component 80 are arranged opposite to the rotatable shaft 34, and the concave cambered guide surfaces 82 corresponding to the convex cambered surface 73b are formed on extending edges of the two support plates. When the movable contact 21 and the holding component 80 are mounted together, the convex cambered surface 73b of the anti-reverse movement component 70 approximately matches the concave cambered guide surface 82, so that the convex cambered surface 73b slides approximately on the concave cambered guide surface 82 when the anti-reverse movement component 70 rotates along with the movable contact 21. So the anti-reverse movement component 70 will not fluctuate when rotating and the pressure on the movable contact 21 will not be influenced by the fluctuations of the anti-reverse movement component 70. That is, the sliding guide track formed by the convex cambered guide surface and the concave cambered guide surface provides a movement constraint and guidance for the anti-reverse movement component 70 when it rotates along with the movable contact 21, so the

anti-reverse movement component 70 is more steadily connected and the components such as the rotatable shaft and the link mechanism may be effectively protected from the electric arc.

[0040] In the above embodiments, the anti-reverse movement component 70 is the arc-shaped plate for preventing the electric arc, which is produced when the movable contact and the fixed contact are disconnected, from moving towards the operating mechanism. However, the structure of the anti-reverse movement component is not limited to the above structure. In another embodiment, according to actual installment space or structure requirements, the anti-reverse movement component may also be a flat plate shaped structure or another plate or block shaped structure, which may also prevent the electric arc produced when the movable contact and the fixed contact are disconnected from moving towards the operating mechanism.

[0041] FIG. 6 is a closing state diagram of the operating mechanism 30 in the circuit breaker 100 in the closing state in accordance with an embodiment of the disclosure. The operating mechanism 30 includes a handle 311, a lever 38, a jump pin 37, a link mechanism and a main spring (not shown). Specifically, the lever 38 may be rotatably arranged within the housing 11 and detachably connected to the handle 311; the jump pin 37 may be rotatably connected within the housing 11 and hinged to the upper link 32; the handle 311 stretches out of the top surface of the cover body 11b so that the lever 38 may be pushed to rotate by an external force.

[0042] In accordance with an embodiment of the disclosure, there are two link mechanisms, which are symmetrically connected to the jump pin 37. Specifically, each link mechanism includes an upper link 32 and a lower link 33 that are mutually interactive, wherein an end of the upper link 32 is rotatably supported by a second fixed pivot “C” and another end of the upper link 32 is rotatably hinged to the lower link 33 via a link hinge shaft 36, a center of which is a movable pivot “B”.

[0043] FIG. 7 is a structure diagram of the jump pin 37 in accordance with an embodiment of the disclosure. In accordance with an embodiment of the disclosure, a limit slideway is arranged on the jump pin 37, the limit slideway limiting axial movement of the link hinge shaft 36 and a motion range of the link hinge shaft 36 under the drive of the main spring and thus limiting a motion range of the upper link 32. Specifically, the jump pin 37 has

two connecting sidewalls that are symmetric with each other; two limit slideways corresponding to the link mechanisms on the two sides are arranged on the connecting sidewalls. As shown in FIG. 7, a lateral limit surface 371 is used to limit the axial movement of the link hinge shaft 36 so as to avoid axial wobbles of the link hinge shaft 36; a front limit surface 372 is used to limit the upper link 32 to make the upper link to stop at an opening position; a back limit surface 373 is used to limit the upper link 32 to make the upper link to stop at a closing position; in such a way, exact positioning of the opening and closing positions of the link mechanism may be implemented. In accordance with an embodiment, the jump pin 37 is rotatably arranged within the housing 11 via a jump pin hinge shaft 39, which also functions as a limit structure in groove-matching with the upper link 32 to make the upper link 32 to stop at the closing position in place of the back limit surface 373. The lower link 33 is hinged to the rotatable shaft 34 by a pin shaft passing through a connecting hole 353 (as shown in FIG. 4) on the auxiliary guide component 35, so the rotatable shaft 34 may bring the movable contact 32 to rotate. A driving end of the main spring (not shown) is fixed to a spring mount (not shown) on the lever, and a driven end of the main spring is connected to the link hinge shaft 36. The main spring exerts a straining force on the link hinge shaft 36 so that the link mechanism is operable to drive the rotatable shaft 34 to bring the movable contact 21 to rotate.

[0044] The working principle of the operating mechanism 30 is described below in conjunction with FIGs. 1, 6, and 8-10. FIG. 8 is an internal structure diagram of the circuit breaker 100 in an opening state in accordance with an embodiment of the disclosure. FIG. 9 is an opening state diagram of the operating mechanism 30 in the circuit breaker 100 in the opening state in accordance with an embodiment of the disclosure. FIG. 10 is a movement diagram of stress states of the link mechanism in accordance with an embodiment of the disclosure.

[0045] In order to clearly describe actions of the operating mechanism 30 to control the movable contact 21 and the fixed contact 22 to connect and disconnect, the actions of the operating mechanism 30 may be simplified as stress states of the link mechanism shown in FIG. 10. In FIG. 10, point “G” corresponds to a connecting point on the driving end of the main spring, point “C” corresponds to the second fixed pivot of the upper link 32, point “B”

corresponds to a hinge point of the link hinge shaft 36 between the upper link 32 and the lower link 33, point “A” corresponds to a hinge point between the lower link 33 and the rotatable shaft 34 (i.e., a hinge position of the rotatable shaft 34), and point “O” corresponds to a rotation center line of the rotatable shaft 34 and also is the first fixed pivot. Positions of the first fixed pivot “O” and the second fixed pivot “C” are fixed, so a four-link movement mechanism is constituted by CB, BA, OA and CO, wherein the working length of the upper link 32 is the length of a line between the hinge point of the upper link 32 and the link hinge shaft 36, and the working length of the lower link 33 is the length of a line between the link hinge shaft 36 and the hinge position “A” of the rotatable shaft 34. Correspondingly, in FIG. 10, line GB, line GB1 and line GB’ respectively correspond to pulling force lines (axes) of the main spring to the link hinge shaft 36 when the link mechanism moves to the opening position, an intermediate position and the closing position; line CA, line CA1 and line CA’ correspond to different connecting structures of the link mechanism under the pull force of the main spring to the link hinge shaft 36 when the link mechanism moves to the opening position, the intermediate position and the closing position; line OA, line OA1 and line OA’ correspond to the opening position, the intermediate position and the closing position of a pivot lever formed by a distance from the hinge position between the lower link 33 and the rotatable shaft 34 to the rotation center “O” of the rotatable shaft 34 under the drive of the main spring when the link mechanism moves to the opening position, the intermediate position and the closing position, the lines also corresponding to the three positions of the movable contact. An angle (i.e., $\angle OAA'$ in FIG. 10) from the closing position to the opening position of the movable contact 21 (i.e. the pivot lever) is a rotation angle of the movable contact in the circuit breaker. The larger the rotation angle of the movable contact is, the larger the open distance between the movable contact and the fixed contact is when the movable contact and the fixed contact are disconnected.

[0046] The link mechanism may be switched to the closing position or the opening position by rotating the handle 311 to the connecting position (shown in FIG. 6) or the disconnecting position (shown in FIG. 9). The link mechanism switches the circuit breaker 100 to the closing state or the opening state by switching between the opening position and the closing position, and makes the movable contact 21 and the fixed contact 22 to connect or

disconnect in cooperation with the main spring. Specifically, when the link mechanism of the operating mechanism 30 needs to move from the opening position to the closing position, the handle 311 is pushed from the disconnecting position shown in FIG. 9 to the connecting position shown in FIG. 6. At this point, the main spring may bring the upper link 32 and the lower link 33 from a bending state shown in FIG. 9 to an extending state shown in FIG. 6 firstly by exerting the pulling force on the link hinge shaft 36 so as to bring the rotatable shaft 34 and the movable contact 21 to rotate anticlockwise and thus make the movable contact 211 and the fixed contact 221 to connect. Correspondingly, the pulling force of the point “G” to the point “B” makes the upper link and lower link at the bending position being pulled together and thus moves from the bending position CB and BA to the intermediate position CB1 and A1B1 and then to the extending position CB’ and A’B’. Conversely, when the link mechanism of the operating mechanism 30 needs to move from the closing position to the opening position, the handle 311 is pushed from the connecting position shown in FIG. 6 to the disconnecting position shown in FIG. 9. At this point, the main spring may bring the upper link 32 and the lower link 33 to move from the extending state shown in FIG. 6 to the bending state shown in FIG. 9 firstly by exerting the pulling force on the link hinge shaft 36 so as to bring the rotatable shaft 34 and the movable contact 21 to rotate clockwise and thus make the movable contact 211 and the fixed contact 221 to disconnect. In contrary to the movement diagram shown in FIG. 10, in FIG. 9, the pulling force of point “G” to point “B” makes the upper link and lower link move from the extending position CB’ and A’B’ to the intermediate position CB1 and A1B1 and then to the bending position CB and AB.

[0047] In accordance with an embodiment of the disclosure, the operating mechanism 30 in the circuit breaker 100 may set the rotation angle of the movable contact to a degree larger than 30° by setting ratios between the working lengths of respective links of the link mechanism to predetermined ratios, so a larger open distance between the movable contact 21 and the fixed contact 22 when they are disconnected may be obtained without increasing the volume of the circuit breaker and the breaking performance of the circuit breaker may be effectively improved.

[0048] FIG. 11A is a simplified structure diagram of a link mechanism in which ratios of the working lengths of respective links are set to selected parameters. FIG. 11B is a

simplified structure diagram of a link mechanism in which ratios of the working lengths of respective links are set the same as prior art. In the link mechanism in prior art shown in FIG.11B, the rotation angle of the movable contact is 30° , the ratio of the working lengths of CB and AB is 0.78, and the ratio of the working lengths of CB and OA is 1.28.

[0049] In order to increase the rotation angle of the movable contact 21, in an embodiment of the disclosure, the ratio between the working lengths of the upper link 32 and the lower link 33 of the link mechanism (i.e., the ratio of the working lengths of CB and AB shown in FIG.11A) is set to a value larger than 0.78, and the ratio between the working length of the upper link 32 and the distance from the hinge position A of the rotatable shaft 34 to the first fixed pivot O (i.e., the ratio between the lengths of CB and OA) is set to a value larger than 1.28. In an embodiment of the disclosure, the working lengths of respective links are selected according to predetermined ratios between the working lengths of respective links. As shown in FIG.11A, the ratios between the working lengths of respective links are shown in Table 1:

[0050] Table 1

	BC/AB	BC/OA	AB/OA	CO/OA
The invention	0.95	1.57	1.66	2.53
Prior art	0.78	1.28	1.65	2.46

[0051] The rotation angle of the movable contact, a swing angle of the upper link 32 ($\angle BCB'$) and the ratio therebetween, which are calculated according to the working lengths of respective links shown in FIG. 11, are shown in Table 2:

[0052] Table 2

	Swing angle of upper link	Rotation angle of movable contact	Ratio of angles
The invention	36°	58.5°	1.63
Prior art	35.5°	30°	0.85

[0053] As can be seen from Tables 1 and 2, when the ratio between the working length of the upper link 32 and the working length of the lower link 33 (i.e., the ratio between the lengths of CB and AB in the figures) is set to 0.95, and the ratio between the working

length of the lower link 33 and the distance from the hinge position of the rotatable shaft to the first fixed pivot “O” (i.e., the ratio between the lengths of CB and OA) is set to 1.57, the link mechanism is operable to increase the rotation angle of the movable contact and thus improve the breaking performance and the reliability of breaking of the circuit breaker 100 meanwhile optimizing a transfer efficiency of the force of the main spring by the link mechanism. When the ratio between the lengths of the upper link CB and the lower link AB is larger than 0.78, the ratio between the rotation angle of the movable contact 21 and the swing angle of the upper link 32 is larger than that in prior art. That is, as compared with a circuit breaker having a same volume in prior art, the circuit breaker in accordance with embodiments of the disclosure may obtain a larger rotation angle of the movable contact with a smaller swing angle of the upper link. Therefore, the circuit breaker in accordance with embodiments of the disclosure is operable to obtain a larger open distance of the contact mechanism when the contact mechanism is disconnecting and considerably improve the breaking performance of the circuit breaker meanwhile keeping a relatively small volume.

[0054] Of course, in the above embodiments, the circuit breaker 100 makes the rotation angle of the movable contact larger than 30° by setting the ratio of the working lengths of the upper link 32 and the lower link 33 to a value larger than 0.78 and setting the ratio between the working length of the upper link 32 and the distance from the first fixed pivot “O” to the hinge position A of the rotatable shaft 34 to a value larger than 1.28. However, the disclosure is not limited to the above embodiments. In another embodiment, the ratio between the working lengths of the upper link and the lower link and the ratio between the working length of the upper link and the distance from the first fixed pivot “O” to the hinge position A of the rotatable shaft 34 may be adjusted to another ratio by changing the ratios between the working lengths of respective links of the link mechanism, as long as the rotation angle larger than 30° of the movable contact is ensured.

[0055] For the movement diagram of stress states of the link mechanism shown in FIG. 10, the transfer efficiency of the pulling force of the main spring by the four-link mechanism may be calculated, wherein the transfer efficiency includes a transfer efficiency when the four-link mechanism is at a start position (when the contact mechanism is at the disconnecting state) and a transfer efficiency when a closing dead center is arrived at (when

the contact mechanism is connected).

[0056] Method for calculating the transfer efficiencies are the following: in order to calculate the transfer efficiency of the pulling force of the main spring by the four-link mechanism, it is assumed that the link mechanism arrives at the opening position, and F is a driving force of the main spring to the four-link mechanism. When the circuit breaker switches from the opening state to the closing state, as long as the axis of the main spring (i.e., the action line of F) is higher than the upper link 32 (i.e., CB as shown in the figure), the four-link mechanism is driven, wherein the position of the dead center is a position at which the main spring may transfer a maximum driving torque to the rotatable shaft 34.

[0057] According to the geometric relations and force transfer states shown in FIG. 10, assuming that F is one unit force, then the calculation formula of the transfer efficiency of the pulling force of the main spring is the following:

[0058]
$$M = \frac{F \times \sin[\angle 1] \times \sin[\angle 2]}{\sin[\angle 3]} \times d(OA) \quad (1)$$

[0059] When the link mechanism arrives at the extending position, the driving force of the main spring to the link mechanism is F' , the calculation formula of which is the following:

[0060]
$$F' = d\left(\frac{GB' - d_0}{GB - d_0}\right) F \quad (2)$$

[0061] Therefore, the calculation formula of the transfer efficiency of the pulling force of the main spring is the following:

[0062]
$$M' = \frac{F' \times \sin[\angle 4] \times \sin[\angle 5]}{\sin[\angle 6]} \times d(A'O) \quad (3)$$

[0063] In the above formulas, $\angle 1$ and $\angle 2$ are an angle between CB and F and an angle between AB and OA respectively and they are acute angles; $\angle 4$ and $\angle 5$ are an angle between CB' and F' and an angle between A'B' and OA' respectively and they are acute angles; $d(OA)$, $d(OA')$, $d(GB)$ and $d(GB')$ are geometry distances; d_0 is an initial length of the main spring.

[0064] Two failure modes easily produced by the four-link mechanism in the circuit

breaker are the following: ① the handle rotates to the closing position and the four-link mechanism does not have a responsive action; ② the four-link mechanism does not arrive at a predetermined closing position (i.e., the extending position of the link mechanism) after performing a closing action (i.e., false closing).

[0065] By putting the selected working lengths of the links in the link mechanism shown in FIG.11A into the above formulas, the calculating result of the transfer efficiency of the pulling force by the link mechanism are shown in Table 3.

[0066] Table 3

	Force torque of main spring at a start position	Force torque of main spring at dead center
The invention	0.84F	3.52F
Prior art	1.57F	4.37F

[0067] As can be seen, according to the calculation of the transfer efficiencies by the four-link mechanism in the disclosure and prior art, the transfer efficiency by the four-link mechanism is not less than 0.84F at a start position and is not less than 3.52F at the dead center, and the rotation angle of the movable contact is larger than 30° . Meanwhile, the circuit breaker 100 in accordance with embodiments of the disclosure may ensure that a ratio between the force torques transferred from the main spring to the rotatable shaft 34 at a initial stress state (at the moment that the fixed contact and the movable contact are connected) and a final stress state is larger than 1. Therefore, the link mechanism in the circuit breaker in accordance with embodiments of the disclosure may avoid the occurrence of the above two fault modes.

[0068] Other mechanisms such as the tripping unit and the arc-extinguishing mechanism and so on in the circuit breaker 100 and the working principles thereof are well known to those skilled in the art, so they are omitted.

[0069] To sum up, by changing the ratios between the working lengths of respective links in the operating mechanism for driving the movable contact and the fixed contact to connect and disconnect, the circuit breaker in accordance with embodiments of the disclosure optimizes the transfer efficiency of the pull force of the main spring by the link mechanism,

increases the open distance between the movable contact and the fixed contact when they are disconnected, and thus effectively improves the breaking performance and the reliability of breaking of the circuit breaker meanwhile minimizing the circuit breaker.

[0070] The disclosure may be implemented in other specific forms without departing the spirit and essence of the disclosure. Therefore, all respects of the present embodiments are considered as exemplary rather than limiting, and the scopes of the disclosure are defined by the accompany claims rather than the above description. Moreover, all variations falling within the meaning and equivalents of the claims are covered by the scopes of the disclosure. Different features appearing in different embodiments may be combined to achieve some beneficial effects. Those skilled in the art will understand and implement embodiments of other variations of the embodiments on the basis of studying the accompany drawings, the description and the claims.

CLAIMS:

1. A circuit breaker comprising a movable contact, a fixed contact, a rotatable shaft and an operating mechanism, wherein:

the movable contact is operable to rotate around a rotation center of the rotatable shaft with respect to the fixed contact, and a circuit is switched on or off by connecting or disconnecting the movable contact and the fixed contact;

the operating mechanism comprises an upper link, a lower link and a handle, wherein the upper link is operable to rotate around an end of the upper link under the drive of the handle, another end of the upper link is rotatably connected to an end of the lower link via a link hinge shaft, and another end of the lower link is hinged to the rotatable shaft, so that the upper link and the lower link are operable to drive the rotatable shaft to bring the movable contact to rotate;

there is a predetermined ratio between a working length of the upper link and a working length of the lower link and between the working length of the upper link and a distance from a hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft, so that a rotation angle larger than 30° of the movable contact is formed after the movable contact and the fixed contact are disconnected.

2. The circuit breaker of claim 1, wherein the ratio between the working length of the upper link and the working length of the lower link is larger than 0.78, and the ratio between the working length of the upper link and the distance from the hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft is larger than 1.28.

3. The circuit breaker of claim 2, wherein the ratio between the working length of the upper link and the working length of the lower link is 0.95, and the ratio between the working length of the upper link and the distance from the hinge point of the lower link and the rotatable shaft to the rotation center of the rotatable shaft is 1.57.

4. The circuit breaker of claim 1, further comprising a jump pin rotatably arranged within the circuit breaker, wherein an end of the upper link is hinged to the jump pin and a

limit slideway is arranged on the jump pin, the limit slideway limiting a motion range of the link hinge shaft with a limit surface and thus limiting a motion range of the upper link.

5. The circuit breaker of claim 4, further comprising a jump pin hinge shaft to connect the jump pin, wherein the jump pin hinge shaft is operable to prevent the upper link from continuing rotating when the movable contact and the fixed contact are connected.

6. The circuit breaker of claim 1, further comprising an anti-reverse movement component arranged on the movable contact, wherein the anti-reverse movement component is operable to rotate along with the movable contact and prevent an electric arc, which is produced when the movable contact and the fixed contact are disconnected, from moving towards the operating mechanism.

7. The circuit breaker of claim 6, wherein the anti-reverse movement component is an arc-shaped plate having a concave cambered surface and a convex cambered surface that are opposite to each other.

8. The circuit breaker of claim 7, further comprising a guide component contacting a surface of the anti-reverse movement component so as to guide the movement of the anti-reverse movement component.

9. The circuit breaker of claim 8, wherein the guide component is arranged on the rotatable shaft and has a convex cambered guide surface, the concave cambered surface sliding approximately on the convex cambered guide surface when the anti-reverse movement component rotates along with the movable contact.

10. The circuit breaker of claim 8, wherein the guide component has a concave cambered guide surface, the convex cambered surface sliding approximately on the concave cambered guide surface when the anti-reverse movement component rotates along with the movable contact.