

TITLE OF THE INVENTION

CIRCUIT BREAKER

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention concerns a circuit breaker and, more in particular, it relates to a circuit breaker suitable to preventing generation of arcs, simplifying a structure and remarkably decreasing the number of parts.

Description of the Related Art

A typical existent circuit breaker comprises a pair of fixed contact-movable contact, an arc extinguishing device, an opening/closing mechanism for rotating the movable contact, a manually operated handle and the like, in which a tripping mechanism is actuated if a current exceeding a rated value should flows in an electric path and the opening/closing mechanism operates such that the movable contact is apart from the fixed contact to cut off the electric current. For the connection between the end of the movable contact and the electric path, a bendable flexible conductor formed by braiding metal wires into a mesh-like arrangement is used so that rotation gives no effect on the electric connection. A toggle link is used for the opening/closing mechanism to transmit the movement of

the tripping mechanism or the handle to the movable contact.

Further in a current limiting structure utilizing electromagnetic repulsive force, contacts are disposed on both ends of a movable contact pivoted at a center and two fixed contacts are opposed to the contacts respectively. Then, if a large current should flow in the electric path of both of the contacts which are normally in contact, the movable contact rotates by the electromagnetic repulsive force exerting between the contacts to open from the fixed contacts. The constitution has such a structure that the movable contact effects rotational operation only by the electromagnetic repulsive force.

In the prior art described above, since the flexible conductor is used for wiring between the movable contact and the electric path, a number of steps for the fabrication of connection portions for the mesh-like metal wires is required to increase the cost, and the flexible conductor involves a drawback that the life for bending cycles is relatively short and the cross sectional area is decreased due to the mesh-like shape to increase the density of current passing therethrough thereby tending to cause heat generation. Further, since the toggle link is used for the opening/closing

mechanism, there is a problem that the structure is complicate and the number of parts is increased.

In the case of using the arc extinguishing device as a countermeasure for arcs upon breaking, the number of parts is increased, the size of products is enlarged and, further, since it takes much time for attracting to transfer generated arcs to arc extinguishing grips, there is a limit for the current limiting performance.

In the current limiting structure using the electromagnetic repulsive force, since the conductor of the movable contact passes through the rotational center of the contact, it involves a problem that an insulation distance along the rotational driving axis of the movable contact can not be ensured easily, and an electric insulation distance between phases is reduced in a polyphase circuit breaker.

SUMMARY OF THE INVENTION

An object of the present invention is to provide a circuit beaker capable of improving the breaking performance by suppression for the generation of arcs, simplifying the structure and remarkably reducing the number of parts.

The present invention, for attaining the foregoing object, comprises a power source side first fixed conductor, a load side second fixed conductor, an intermediate fixed conductor interposed between the fixed conductors, and a first movable conductor and a second movable conductor disposed, respectively, between each of the power source side and the load side fixed conductors and the intermediate fixed conductor, in which a serial electric path is constituted with each of the conductors.

A preferred embodiment may comprise an opening/closing mechanism for opening/closing the first and the second movable conductor, respectively, between the power source side first fixed conductor and the intermediate fixed conductor, and between the intermediate fixed conductor and the load side second fixed conductor substantially simultaneously and, further, may comprise one or more of the intermediate fixed conductors.

Further, the circuit breaker according to the present invention comprises a movable conductor rotating around a rotational axis, a first fixed conductor opposed to one end of the movable conductor, a second fixed conductor opposed to the other end of the movable conductor, a contact portion disposed so as to

electrically connect the first fixed conductor, the movable conductor and the second fixed conductor in series, and an opening/closing means for rotating the movable conductor so as to open the contact portion simultaneously, in which the movable conductor is disposed at a position spaced apart from the axial center or at a position spaced apart from the rotational center of the opening/closing means.

Further, for attaining the foregoing object, a circuit breaker according to the present invention comprises a holding member for holding the movable contact, an operation handle rotatably disposed in coaxial with the rotational axis of the holding member for effecting opening/closing operation for the first movable contact and the second movable contact, a tripping means that operates based on the output of the overcurrent detection means, an energizing means for energizing the holding member in a tripping direction and an engaging means for engaging the holding member to the operation handle, in which the holding member operates in a tripping direction independently of the operation of the operation handle by the energizing means when the tripping means releases the engagement of the engaging means.

Since the movable conductors are disposed between the first fixed conductor and the intermediate fixed conductor and between the intermediate fixed conductor and the second fixed conductor, respectively, so as to open/close the fixed conductor and the intermediate fixed conductor, and the intermediate fixed conductor and the second fixed conductor, the opening/closing mechanism can be constituted only with rigid conductor, so that flexible conductors required for electrical connection for existent movable conductors are no more required. Since the opening/closing mechanism opens the movable conductors relative to the first fixed conductor and the intermediate fixed conductor, and to the intermediate fixed conductor and the second fixed conductor substantially simultaneously, the opening distance for each of the contacts can be decreased.

Further, since a plurality of contacts connected in series are opened simultaneously, the total opening speed between the contacts can be increased to improve the current limiting effect thereby suppressing the generation of arcs at each of the contacts. Since the opening/closing mechanism is adapted to open/close by the rotational movement or the linear movement of the movable conductor or to open/close by the couple of

forces acting on the movable conductor, no toggle link is necessary, thereby enabling to reduce the number of parts and simplify the structure.

Further, since the movable conductor is disposed so as to rotate around the rotational axis and situated at a position spaced apart from the axial center or at a position spaced apart from the rotational center of the opening/closing means, an insulation distance between the poles can be maintained.

The operation handle is rotatably disposed in coaxial with the rotational axis of the holding member and, normally, engaged to the holding member by the engaging means. Thus, when the operation handle is rotated, the holding member can be rotated simultaneously thereby enabling to effect opening/closing operation of the first movable contact and the second movable contact. Further, while the holding member is energized by the energizing means in the tripping direction, it is normally engaged by the engaging means to the operation handle, so that tripping is not conducted. Upon overcurrent, the tripping means operates based on the output of the overcurrent detection means to release the engagement of the engaging means. Thus, the holding member is energized by the energizing means to operate in the tripping

direction independently of the operation of the operation handle. Therefore, even if the operation handle is locked in an ON state, tripping can be conducted reliably.

According to the present invention, it is possible to obtain a circuit breaker capable of improving the breaking performance by the suppression for the generation of arcs, simplifying the structure and remarkably reducing the number of parts.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view illustrating an inner constitution of a circuit breaker as a first embodiment according to the present invention.

Fig. 2 is a cross sectional view illustrating an inner constitution of a circuit breaker as a first embodiment according to the present invention.

Fig. 3 is a circuit diagram illustrating an equivalent circuit upon short circuit of a circuit breaker as a first embodiment according to the present invention.

Fig. 4 is a characteristic curve illustrating a relationship between an arc voltage and time of a circuit breaker as a first embodiment according to the present invention.

Fig. 5 is a characteristic curve illustrating a current limiting effect of a circuit breaker as a first embodiment according to the present invention.

Fig. 6 is a perspective view illustrating an inner constitution of a circuit breaker as a second embodiment according to the present invention.

Fig. 7 is a cross sectional view illustrating an inner constitution of a circuit breaker as a second embodiment according to the present invention.

Fig. 8 is a perspective view illustrating an appearance of a circuit breaker as a second embodiment according to the present invention.

Fig. 9 is a perspective view illustrating a state of mounting a circuit breaker as a first embodiment according to the present invention to a distribution board.

Fig. 10 is a perspective view illustrating an inner constitution of a circuit breaker as a third embodiment according to the present invention.

Fig. 11 is a perspective view illustrating a contact constitution of a circuit breaker as a third embodiment according to the present invention.

Fig. 12 is a perspective view illustrating a contact constitution of a circuit breaker as a third embodiment according to the present invention.

Fig. 13 is a perspective view illustrating an inner constitution of a circuit breaker as a fourth embodiment according to the present invention.

Fig. 14 is a perspective view illustrating a constitution for a rotary member of a circuit breaker as a fifth embodiment according to the present invention.

Fig. 15 is a perspective view partially in cross section illustrating an ON state of a circuit breaker in a sixth embodiment according to the present invention.

Fig. 16 is a perspective view illustrating a constitution of a holding member and an operation handle of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 17 is a perspective view partially in cross section illustrating an OFF state of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 18 is a perspective view partially in cross section illustrating a TRIP state of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 19 is a perspective view illustrating an engaging state of an engaging means of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 20 is a perspective view illustrating a disengaging state of an engaging means of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 21 is a perspective view illustrating an engaging state of an engaging means of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 22 is a perspective view illustrating a disengaging state of an engaging means of a circuit breaker in the sixth embodiment according to the present invention.

Fig. 23 is a perspective view partially in cross section illustrating an ON state of a circuit breaker in a seventh embodiment according to the present invention.

Fig. 24 is a side elevational view illustrating a state of a mechanical portion in an ON state of the circuit breaker in the seventh embodiment according to the present invention.

Fig. 25 is a perspective view partially in cross section illustrating an OFF state of the circuit breaker in the seventh embodiment according to the present invention.

Fig. 26 is a perspective view partially in cross section illustrating a TRIP state of the circuit breaker

in the seventh embodiment according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Preferred embodiments of the present invention will now be explained with reference to Fig. 1 to Fig. 26.

A first embodiment of the present invention will be explained with reference to Fig. 1 to Fig. 5 and Fig. 9.

Fig. 1 and Fig. 2 show the constitution of a circuit breaker in this embodiment. In this embodiment, a rotary member 4 as a holding member made of an insulating material is rotatably journaled in a box by a bearing 4c provided about at a central portion of the box. The box comprises a casing 1, a mold cover 2 and side plates 2a. Fig. 1 shows a state in which the side plates 2a are detached. The bearing 4c is formed to the inner surface of the mold cover 2 and the side plates 2a. In a method of assembling parts such as the rotary member 4 into the casing 1 and covering them with the mold cover 2 and the side plates 2a, the mold cover 2 and the side plates 2a may be integrated previously, or in a method of assembling parts such as the rotary member 4 from the side way and covering them with the

side plates 2a, the casing 1 and the mold cover 2 may be integrated previously.

A movable contact base 5a as a first movable conductor and a movable contact base 5b as a second movable conductor are fixedly supported by the rotary member 4. The movable contact bases 5a and 5b are mounted to the rotary member 4 by seizing with protrusions 4d, 4e formed to the rotary member 4, or by fitting into grooves formed in the rotary member 4, in which the movable contact bases 5a and 5b are fixed to the rotary member 4 by the resiliency of the protrusions 4d, 4e of the rotary member 4 or by screw setting to the rotary member 4. In this embodiment, the protrusion 4d is disposed at the back of contacts 6 of the movable contact bases 5a and 5b, while the protrusion 4e is disposed on the same side as the contacts 6 for seizing the movable contact bases 5a and 5b between them. The protrusion 4d functions also as a backing member to prevent deformation of each of the movable contact bases by the pressure of contact. Each of the movable contact bases 5a and 5b has contacts 6 as movable contacts attached on both ends by means of silver soldering, caulking or the like. The rotary member 4 rotates around a rotational center 4a as the center, and the rotational center 4a is formed integrally with the

rotary member 4 or formed with a pin passing through the rotary member 4. An operation handle 3 is mounted to the rotary member 4 with a top end being protruded out of the mold cover 2, and the rotary member 4 rotates around the rotational center 4a as the center by ON, OFF operation of the operation handle 3 (clockwise for OFF and counterclockwise for ON in Fig. 1). In this embodiment, since the constitution of terminals, the operation handle and the outer profile are made compatible with those of the existent circuit breaker, there is no restricting condition in view of using the circuit breaker and conveniency in use is not deteriorated.

A fixed contact base 8 as a first fixed conductor has a power source side terminal 8a disposed at one end, and a contact 6 as a fixed contact attached at the other end by means of silver soldering, caulking or the like at a position opposing to the movable contact of the movable contact base 5a. An intermediate fixed contact base 7 as an intermediate fixed conductor is fixed below the rotary member 4 to the casing 1 and has contacts 6 as the fixed contacts attached on both ends by means of silver soldering, caulking or the like at the position opposing to the movable contacts of the movable contact bases 5a and 5b. A portion of the

casing 1 for disposing the intermediate fixed contact base 7 is recessed so as to facilitate positioning upon attachment. In addition, since the plate thickness is reduced as compared with other portions, heat generated from the intermediate fixed contact base can be dissipated effectively to an equipment attaching plate 80 upon attachment to the equipment attaching plate 80 in a distribution board as shown in Fig. 9. A load side conductor 9 as a second fixed conductor has a contact 6 as a fixed contact attached at one end by means of silver soldering, caulking or the like at a position opposing to the movable contact of the movable contact base 5b, and a load side terminal 9a disposed at the other end. The fixed contact base 8, the movable contact bases 5a, 5b, the intermediate fixed contact base 7 and the load side conductor 9 are formed each in the shape of a flat plate made of a rigid electroconductive material, for example, a flat copper bar or the like. The electroconductive material is not restricted only to copper but may be other metals such as a copper alloy, for example, iron-incorporated copper or aluminum so long as the material is a good electric and heat conductor and has an appropriate elasticity capable of wiping contacts. In this embodiment, the power source side terminal 8a, and the load side

terminal 9a have terminal metals 10 clamped respectively by screwing for fixing terminals of wirings 82, 84 connected thereto upon attachment to the distribution board.

The load side conductor 9 extends to the load side passing through a current transformer 11 at the midway from the fixed contact to the load side terminal 9a for detecting the current of the electric path. The output of the current transformer 11 is supplied to an overcurrent detection circuit 12. The overcurrent detection circuit 12 has a circuit structure, for example, as disclosed in Japanese Patent Laid-Open Sho 57-170023 and generates an output for driving an overcurrent tripping device 13 when a state in which the current of the electric path, that is, a current flowing in the load side conductor 9 exceeds a rated value continues for more than a period of time determined by time delay characteristic. The overcurrent tripping device 13 has a constitution described, for example, in Japanese Patent Laid-Open Sho 59-189529, in which a plunger 13a is normally attracted by the attraction force of a permanent magnet and the plunger 13a protrudes when the attraction force of the permanent magnet is reduced being excited reversely by the output of the overcurrent detection circuit 12 and pushes the

driving portion 4b of the rotary member (not illustrated in Fig. 1) to rotate the rotary member 4 clockwise and open the contacts at four positions substantially simultaneously.

Fig. 1 shows an "ON" state of the circuit breaker and in a case of manual "OFF" operation from this state, the operation handle 3 is displaced rightwardly in the drawing to open the movable contacts and the fixed contacts at four positions substantially simultaneously by the clockwise rotation of the rotary member. The manual "ON" operation is conducted by the operation opposite to "OFF" operation, in which the operation handle 3 is displaced from an OFF position leftwardly in the drawing to put the movable contacts and the fixed contacts at four positions into contact simultaneously by the counterclockwise rotation of the rotary member.

In this embodiment, since the fixed contact base 8, movable contact bases 5a and 5b, the intermediate fixed contact base 7 and the load side conductor 9 are each in the shape of the flat plate made of the rigid electroconductive material, flexible wire conductors used in most of existent circuit breakers can be saved, thereby eliminating problems in the existent circuit breakers, for example, loosening or disconnection of the

flexible wire conductors that limit the life of the circuit breaker.

In this embodiment, the contact opening/closing mechanism is made rotary with a serial 4-point contact structure. The toggle link or the like is unnecessary in the rotary type and the mechanical portion of the circuit breaker can be greatly simplified to improve the assembling performance and reduce the cost of products. Further, since the mechanical portion is greatly simplified, the life of the circuit breaker can be extended.

Further, since the serial 4-point contact structure greatly reduces the arc energy upon pole-opening, generation of arcs at each of the contacts can be suppressed thereby enabling to save the arc distinguishing device or greatly reduce the size of the arc distinguishing device. Further, upon breaking of short circuiting current, since the short circuiting current is greatly suppressed by the serial 4-point contact structure, there is no restriction on user's selection for wiring support structure, heat capacity of load equipment and upper and lower rank breakers, to provide a great user's merit.

The breaking phenomenon upon breaking the short circuiting current by the circuit breaker will be explained with reference to Fig. 3 to Fig. 5.

When a short circuit accident should occur in the circuit, a large current flows in the circuit. An arc voltage is generated between the contacts when the contacts are opened repulsively by the large current to suppress the short circuiting current. This is referred to as current limitation, and the mechanism of the circuit breaker operates subsequently to share the recovery voltage between the contacts to complete breaking.

Fig. 3 shows a circuit diagram for an equivalent circuit upon occurrence of the short circuit accident. In this case, the following equation is established.

[Formula 1]

$$e_0 \sin(\omega t + \theta) = L \frac{di}{dt} + Ri + v_a \dots \text{(Formula 1)}$$

where:

i	: short circuiting current	(A)
e ₀	: power source voltage amplitude	(V)
R	: circuit resistance	(Ω)
L	: circuit inductance	(H)
v _a	: arc voltage	(V)

ω : power source voltage angular frequency (Hz)

θ : short circuit phase (rad)

The arc voltage v_a undergoes the effect, most significantly, of the displacement of the movable contact base. As a result of various experiments, the arc voltage is approximated as shown in Fig. 4, which is represented by the formulae (2), (3) and (4).

[Formula 2]

For $0 \leq t \leq t_1$

$v_a = 0$ (Formula 2)

[Formula 3]

For $t_1 < t \leq t_2$

$v_a = v_0 + a(t - t_1)$ (Formula 3)

[Formula 4]

For $t_2 < t$

$v_a = v_0 + a(t - t_1) + b(t - t_2)^2$... (Formula 4)

The current limiting value at each time is calculated as shown by the formulae (5), (6) and (7).

[Formula 5]

For $0 \leq t \leq t_1$

$$i(t) = \frac{e_0}{\sqrt{R^2 + \omega^2 L^2}} \left\{ \sin(\omega t + \gamma - \phi) - e^{-\frac{R}{L}t} \sin(\theta - \phi) \right\} \dots \text{(Formula 5)}$$

where $\phi = \tan^{-1} \frac{\omega L}{R}$

[Formula 6]

For $t_1 < t \leq t_2$

$$i(t) = \frac{e_0}{\sqrt{R^2 + \omega^2 L^2}} \left\{ \sin(\omega t + \theta - \phi) - \epsilon^{-\frac{R}{L} t} \sin(\theta - \phi) \right\} \\ - \frac{v_0}{R} \left\{ 1 - \epsilon^{-\frac{R}{L}(t-t_1)} \right\} - \frac{a}{R} \left[(t-t_1) - \frac{L}{R} \left\{ 1 - \epsilon^{-\frac{R}{L}(t-t_1)} \right\} \right] \\ \dots \text{ (Formula 6)}$$

[Formula 7]

For $t_2 < t$

$$i(t) = \frac{e_0}{\sqrt{R^2 + \omega^2 L^2}} \left\{ \sin(\omega t + \theta - \phi) - \epsilon^{-\frac{R}{L} t} \sin(\theta - \phi) \right\} \\ - \frac{v_0}{R} \left\{ 1 - \epsilon^{-\frac{R}{L}(t-t_1)} \right\} - \frac{a}{R} \left[(t-t_1) - \frac{L}{R} \left\{ 1 - \epsilon^{-\frac{R}{L}(t-t_1)} \right\} \right] \\ - \frac{b}{R} \left[(t-t_2)^2 - \frac{2L}{R}(t-t_2) + \frac{2L^2}{R^2} \left\{ 1 - \epsilon^{-\frac{R}{L}(t-t_2)} \right\} \right] \\ \dots \text{ (Formula 7)}$$

The formulae (5), (6) and (7) are obtained by subtracting formulae v_0 , $a(t - t_1)$, and $b(t - t_2)^2$ representing the limiting current by the generation of the arc voltage from the current in a case no arc voltage is generated (estimated short circuiting current).

The limiting current is represented by the formulae (8), (9) and (10).

[Formula 8]

Limiting current iv_0 with v_0

$$iv_0 = \frac{v_0}{R} \left\{ 1 - e^{-\frac{R}{L}(t-t_1)} \right\} \dots \text{(Formula 8)}$$

[Formula 9]

Limiting current ia with $a(t - t_1)$

$$ia = \frac{a}{R} \left[(t-t_1) - \frac{L}{R} \left\{ 1 - e^{-\frac{R}{L}(t-t_1)} \right\} \right] \dots \text{(Formula 9)}$$

[Formula 10]

Limiting current ib with $b(t - t_2)^2$

$$ib = \frac{b}{R} \left[(t-t_2)^2 - \frac{2L}{R} (t-t_2) + \frac{2L^2}{R^2} \left\{ 1 - e^{-\frac{R}{L}(t-t_2)} \right\} \right] \dots$$

(Formula 10)

From the foregoing, the current limiting value in each time assuming the estimated short circuiting current as i_0 with iv_0 , ia and ib is as shown by the formulae (11), (12) and (13), and iv_0 , ia and ib limit the estimated short circuiting current as shown in Fig. 5.

[Formula 11]

For $0 \leq t \leq t_1$

$$i = i_0 \dots \dots \dots \text{(Formula 11)}$$

[Formula 12]

For $t_1 < t \leq t_2$

$$i = i_0 - (iv_0 + ia) \dots \dots \dots \text{(Formula 12)}$$

[Formula 13]

For $t_2 < t$

$$i = i_0 - (iv_0 + ia + ib) \dots \dots \dots \text{(Formula 13)}$$

Further, both sides of the formula (1) are multiplied by i and integrated as far as the completion of breaking, as shown in the formula (14).

[Formula 14]

$$\begin{aligned} \int_0^{t_s} e_0 i \sin(\omega t + \theta) dt &= L \int_0^{t_s} i \frac{di}{dt} \cdot dt + R \int_0^{t_s} i^2 dt + \int_0^{t_s} v_a i dt \\ \text{circuit} & \\ \text{energy:energy} &= \frac{1}{2} L [i^2]_0^{t_s} + R \int_0^{t_s} i^2 dt + \int_0^{t_s} v_a i dt \\ \text{supplied from} & \\ \text{power source} &= \underbrace{R \int_0^{t_s} i^2 dt}_{\substack{\text{energy consumed} \\ \text{in the circuit} \\ \text{generally} \\ \text{referred to as} \\ \text{passage } i^2 t}} + \underbrace{\int_0^{t_s} v_a i dt}_{\substack{\text{arc energy:energy} \\ \text{consumed in FFB arc} \\ \text{extinguishing} \\ \text{chamber}}} \end{aligned}$$

... (Formula 14)

$$\left(\begin{aligned} \text{Where} \\ \frac{1}{2} L [i^2]_0^{t_s} &= \frac{1}{2} L [i^2]_0^{t_n} + \frac{1}{2} L [i^2]_{t_n}^{t_s} \\ &= \underbrace{\frac{1}{2} L i_0^2}_{\text{accumulation}} - \underbrace{\frac{1}{2} L i_0^2}_{\text{discharge}} \\ &= 0 \end{aligned} \right)$$

As can be seen from the formula (14), the energy supplied from the power source is divided into an energy consumed in the circuit and an arc energy that can be consumed in a circuit breaker arc extinguishing chamber.

From the foregoings, the performance of the circuit breaker to the breaking is determined by the rise of the arc voltage (t_1 , t_2 , a , b) and the heat capacity of the arc extinguishing chamber.

Accordingly, for improving the breaking performance, at least the rise of the arc voltage may be made earlier, and the breaking performance is improved remarkably in the circuit breaker of the serial multi contact structure.

Simply, in the serial 2-contact structure of an identical constitution, generation of the arc energy is suppressed to about $1/2$ for the entire 2-contacts according to the numerical calculation approximating the arc voltage, and it may suffice to consume $1/4$ arc energy per one arc extinguishing device.

Further, since the arc energy is decreased by the thus increased number of contacts, the actual breaking distance is decreased as a number of pair of contacts is increased as compared with a required breaking distance to the rated current as shown in Table 1.

[Table 1]

Relation Between the Number of Contacts and the Breaking Distance of Circuit Breaker (For 30A Frame)

Rated current (frame)	Required breaking distance (mm)	Number of contact (number of contact pair) (N)	Breaking distance for each contact (B/N) (mm)	Actual breaking distance (B) (mm)
30A	12	1	12	12
"	"	2	5.4	10.8
"	"	4	2.42	9.7
"	"	6	1.45	8.7

Actual breaking distance = necessary breaking distance
 $\times 0.9(N-1)$

A second embodiment of the present invention will now be explained with reference to Fig. 6 to Fig. 8. In the first embodiment (Fig. 1 and Fig. 2), an example of a single pole circuit breaker is shown. In this embodiment, 2-pole product is constituted in one box comprising a casing 21, a mold cover 22 and side plates 2a, by disposing a fixed contact base 8 as a first fixed conductor, a movable contact base 5a as a first movable conductor, an intermediate fixed contact base 7 as an intermediate fixed conductor, a movable contact base 5b as a second movable conductor, and a load side conductor 9 as a second fixed conductor for each pole in parallel on both sides of a rotary member

24. In this embodiment, insulation barriers 22a are formed between the power source side terminals 8a and the load side terminals 9a respectively, for inter-phase insulation between two poles. As shown in Fig. 7, the rotary member 24 is pivoted rotatably at a rotational center 24a by a bearing 24c formed to the inner surface of the mold cover 22 and the side plates 2a. The movable contact bases 5a and 5b are mounted to the rotary member 24 by being seized with protrusions 4d, 4e (not illustrated in Fig. 6) formed to the rotary member 24 in the same manner as in the first embodiment. Also in this embodiment, the protrusion 4d is disposed at the back of the contacts 6 of the movable contact bases 5a and 5b, the protrusion 4e is disposed on the same side as the contacts 6, and the movable contact bases 5a and 5b are seized between them (not illustrated in Fig. 6). Also in this embodiment, a current transformer 11 is mounted to the load side conductor 9, the output of the current transformer 11 is supplied to an overcurrent detection circuit 12, and an overcurrent tripping device 13 is driven by the output of the overcurrent detection circuit 12 upon overcurrent state thereby protruding a plunger 13a to push a driving portion 4b of the rotary member 24 and rotate the rotary member 24 clockwise to

open the contacts at four positions substantially simultaneously.

Constitutions for other portions are basically identical with those in the first embodiment. In this embodiment, the movable contact bases 5a, 5b for 2-poles can be operated simultaneously by one rotary member 24. This can be further developed easily into applications for 3-pole and 4-pole products and can cope sufficiently with also with the 3-pole structure employed generally. Fig. 8 shows the appearance of 3-pole structure in addition to 2-pole structure.

A third embodiment according to the present invention will be explained with reference to Fig. 10 to Fig. 12. This embodiment shows an example of further improving the breaking performance by making the contact structure as a current limiting repulsion type. The entire structure of this embodiment is shown in Fig. 10. This embodiment has the same parts and same constitution as those in the first embodiment, except for a fixed contact base 28, an intermediate fixed contact base 27, a load side conductor 29, casing 31 and a mold cover 32. In this embodiment, a U-shaped groove is formed near the fixed contact for each of the fixed conductors of the fixed contact base 28, the intermediate fixed contact base 27 and the load side conductor 29 so as to surround

the fixed contact such that the direction of the current is reversed to the direction of the current in the movable conductor, and lugs 28b, 27a, 29b are formed respectively to the inside of the U-shaped grooves. The lugs 28b, 27a, 29b can reverse the current passing directions to each other between the opposing fixed conductor and the movable conductor, so that repulsive force can be exerted between the fixed and the movable contacts under the effect of the electromagnetic force upon passage of a large current (upon generation of a short circuiting current), to make the pole opening early thereby providing a remarkable effect of suppressing the short circuiting current (current limitation). Fig. 11 shows a detail for the portion A. The portion A shows an opposed portion between the intermediate fixed contact base 27 and the movable contact base 5a in which the direction B_1 of the current flowing in the movable contact base 5a and the direction B_2 of the current flowing in the lug 27a are reversed to each other by the effect of the U-shaped groove and the lug disposed to the intermediate fixed contact base 27, to generate electromagnetic repulsive force. Further, in addition to the U-shaped groove, the current limiting repulsion structure may be constituted also as shown in Fig. 12 by bending the intermediate fixed contact base

27 in a U-shaped configuration, and reversing the direction B_1 of the current flowing in the movable contact base 5a to the direction B_2 of the current flowing in the U-shaped bent lug 27a, thereby generating electromagnetic repulsive force.

A fourth embodiment according to the present invention will be explained with reference to Fig. 13. In this embodiment, three movable conductors 55a, 55b and 55c and two intermediate fixed conductors 57a, 57b are contained in a box comprising a casing 51 and a mold cover 52. In this embodiment, there are three pair of contacts to improve the breaking performance. Other portions are identical with those in the first embodiment.

A fifth embodiment according to the present invention will be explained with reference to Fig. 14. In this embodiment, the structure of the rotary member is replaced from a disc-like shape in other embodiments into a rotary member 74 of a substantially X-shaped configuration. A rotational center 74a of the rotary member 74 is pivoted rotatably such as by bearings 4c, 24c like that in other embodiments. The rotary member 74 has protrusions 74d, 74e formed thereon for seizing the movable contact bases 5a and 5b. The protrusion 74d is disposed at the back of the contacts 6 of the movable

contact bases 5a and 5b while the protrusion 74e is disposed on the same side as the contact 6. The protrusion 74d functions also as a backing member to prevent the deformation of each of the movable contact bases by the pressure of contact. For other portions, those in any one of the first to the third embodiments may be used.

A sixth embodiment according to the present invention will be explained with reference to Fig. 15 to Fig. 22.

Fig. 15 shows a constitution of a circuit breaker in this embodiment, Fig. 15 shows an ON state. The circuit breaker in this embodiment comprises, at the inside of a box having a casing 101 and a mold cover 102, a fixed contact base 111 as a first fixed conductor connected at one end to a power source terminal 111-a and having at the other end a first fixed contact 112-a, a conductor 113 as a second fixed conductor connected at one end to a load terminal 113-b and having at the other end a second fixed contact 112-b, a movable contact base 105 having a first movable contact 106-a and a second movable contact 106-b opposed to the first fixed contact 112-a and the second fixed contact 112-b respectively, a rotor 104 as a holding member disposed rotatably around a rotational axis 104-b as a center for holding the

movable contact base 105 such that the first movable contact 106-a and the second movable contact 106-b can be brought into contact with and apart from the first fixed contact 112-a and the second fixed contact 112-b, an operation handle 103 rotatably disposed in coaxial with the rotational axis of the rotor 104 for effecting opening/closing operation for the first movable contact 106-a and the second movable contact 106-b, a current transformer 114 and an overcurrent detection circuit 115 as an overcurrent detection means for detecting an overcurrent state in an electric path from the power source terminal 111-a to the load terminal 113-b, a trip unit 116 as a tripping means that operates based on the output of the overcurrent detection means, a torsion spring 107 as an energizing means for energizing the rotor 104 in a tripping direction and a hook 108 as an engaging means for engaging the rotor 104 to the operation handle 103.

ON-OFF operation of the circuit breaker is conducted by the operation handle 103 protruding out of the mold cover 102. As shown in Fig. 16, the operation handle 103 has an handle operation portion 103-a formed to an upper portion, a protrusion 103-c disposed therebelow as a center of rotation and, further, an extension 103-b extended further rightward, a groove

103-d being disposed to the top end of the extension 103-b. The protrusion 103-c is fitted rotatably to the rotor 104. The rotor 104 is rotatably disposed around a projection 104-b as a center, and the torsion spring 107 is provided to a fitting portion between the handle 103 and the rotor 104, so that the rotor 104 is energized to rotate clockwise by the torsion spring 107 when the handle is secured. An extension 104-c is formed to the right top end of the rotor 104 like that in the operation handle 103, and a groove 104-d is formed to the extension 104-c for attaching a hook 108. The hook 108 is pivotally supported by a pin 110. Further, the hook 108 is energized clockwise as viewed from above by a spring 109. The hook 108 has driving portion 108-b formed at one end and a hook engaging portion 108-a formed at the other end. In a usual state, the hook engaging portion 108-a protrudes from the groove 104-d toward the operation handle 103 being energized by the spring 109, and the rotor 104 is engaged to the operation handle 103 and operates rotationally together with the operation handle 103. The rotor 104 has the movable contact base 105 having the movable contact 106-a and 106-b along one of chords for a circle having the rotational center 104-b as the center. The rotor 104 has a protrusion 104-a so as to cover a portion of a

base end of the operation portion 103-a of the operation handle 103 on the extension side. In this embodiment, letters "ON" are indicated on the protrusion 104-a such that the letters can be seen through an opening for the handle in the cover 102 in the ON state. Letters "OFF" are indicated on a base end 103-e of the operation handle 103 opposed to the extension of the operation portion 103-a, such that the letters can be seen through the opening for the handle of the cover 102 in the "OFF" state. Further, letters "TRIP" are indicated on a base end 103-f of the operation handle 103 on the extension side of the operation portion 103-a, which are usually concealed by being covered with the protrusion 104-a of the rotor 104 but the letters can be seen through the opening for the handle of the cover 102 in the TRIP state by the movement of the protrusion 104-a.

As shown in Fig. 15, the fixed contact base 111 has the power source terminal 111-a attached at one end, extends substantially in a Z-shaped configuration and has a fixed contact 112-a attached at the other end. On the other hand, the conductor 113 has the load terminal 113-b disposed at one end, extends substantially in an L-shaped configuration and has the fixed contact 112-b attached at the other end. The fixed contact 112-a and the fixed contact 112-b are attached at positions

opposing to the movable contacts 106-a and 106-b at the same pitch as the mounting pitch for the movable contacts. In Fig. 15, the rotor 104 rotates clockwise to open the contacts. For making the movable contacts 106-a, 106-b apart from the fixed contacts 112-a, 112-b by the rotation of the rotor 104, the movable contact base 105 may be attached to a right-half portion in view of the center for one of chords of a circle having a radius equal with a distance from the center as the rotational center 104-b of the rotor 104 substantially to the surface of the movable contact 106-a. The longitudinal size of the movable contact base 105 (direction from the movable contact 106-a to 106-b) is set to less than one-half length of the chord.

At the inner surface of the cover 102, a protrusion 101-b is formed for abutment of the extension 103-b so as to stop the rotation of the handle 103 upon ON to OFF transfer. The protrusion 101-b is not illustrated in Figs. 17 and 18.

The conductor 113 passes through the current transformer 114 between the fixed contact 112-b and the load terminal 113-b, by which current in the electric path from the power source terminal 111-a to the load terminal 113-b is detected. Further, the overcurrent detection circuit 115 is attached to the conductor 113,

and an output in accordance with the value of the main circuit current of the transformer 114 is inputted to the overcurrent detection circuit 115. When the overcurrent detection circuit 115 detects the overcurrent, it generates an output for tripping and the output is supplied to a trip unit 116. For the trip unit 116, a magnetic tripping device or the like is generally used so that tripping can be conducted with less energy and, for example, a unit of releasing a plunger attracted by a permanent magnet by reverse excitation to protrude an actuator portion 116-a is used. In this embodiment, the actuator portion 116-a is situated so as to abut against the driving portion 108-b of the hook 108.

Further, a spring 130 is mounted to the handle 103 for snap action upon ON, OFF operation and the other end of the spring 130 is caught on the protrusion 101-a of the casing 101.

Fig. 17 shows the OFF state of the circuit breaker in this embodiment. OFF operation is conducted by turning down the handle operation portion 103-a rightwardly from the state shown in Fig. 15. When the handle operation portion 103-a is turned rightwardly, the entire movable portion shown in Fig. 16 such as the handle 103, the rotor 4 and the hook 108 rotate

clockwise around the protrusion 104-b of the rotor 104 fitted to the casing 101 as the center of rotation. By the rotation of the handle 103, the upper end of the spring 117 moves rightwardly and, when the center line of the spring 117 goes beyond the center of the protrusion 104-b of the rotor, the entire movable portion rotates quickly only by the resiliency with the direction of the spring force. When the rotation of the movable portion further proceeds, the handle portion 103-b abuts against the protrusion 101-b of the casing to stop the rotation.

Fig. 18 shows a TRIP state of the circuit breaker of this embodiment. The current of the main circuit is detected by the current transformer 114 and the output thereof is transmitted to the overcurrent detection circuit 115. If a current exceeding a rated current flows to the main circuit, the value of the overcurrent is judged by the overcurrent detection circuit 115 and a trigger of a characteristic defined in a reverse time manner is sent as an output for tripping from the overcurrent detection circuit 115 to the trip unit 116. The actuator portion 116-a of the trip unit 116 pops out by the trigger and pushes the driving portion 108-b of the hook 108. Fig. 19 to Fig. 22 show the operation of the hook 108. Fig. 19 and Fig. 21 show

the state of the hook 108 in the ON, OFF state of the circuit breaker. Fig. 19 shows the state of the hook 108 on the rotor 104 and Fig. 21 shows the engaged state between the hook 108 and the groove 103-d of the handle. In this state, since the driving portion 108-b undergoes no pressing of the actuator portion 116-a, the hook engaging portion 108-a protrudes from the groove 104-d of the rotor 104 as shown in Fig. 19 and engages the groove 103-d of the handle as shown in Fig. 21. The pin 110 is not illustrated in Fig. 19 and the rotor 104 is not illustrated in Fig. 21. Fig. 20 and Fig. 22 show the state of the hook 108 in the TRIP state of the circuit breaker. Fig. 20 is a view showing the state of the hook 108 on the rotor 104 and Fig. 22 shows an engaged state between the hook 108 and the groove 103-d of the handle. If an overcurrent flows, the driving portion 108-b of the hook 108 is urged by the popping out actuator portion 116-a, the hook 108 rotates in the direction opposite to the energizing direction of the spring 109 around the pin 110 as the rotational center (counterclockwise as viewed from above) as shown in Fig. 20, the hook engaging portion 108-a leaves the groove 103-d of the handle as shown in Fig. 22 and engagement between the handle 103 and the rotor 104 is released. Subsequently, the rotor 104 rotates clockwise by the

force of the spring 130 around the fitting portion with the handle protrusion 103-c as the rotational center, by which the movable contacts 106-a, 106-b leave the fixed contacts 112-a, 112-b to provide a contact-open state thereby breaking the circuit. In this case, since the rotor 104 can operate in the tripping direction independently of the operation of the operation handle 103, tripping can be conducted if the operation handle 103 is locked in the ON state, to obtain a trip free circuit breaker.

Further, the protrusion 104-a moves in this case only by the rotation of the rotor 104 and concealed letters "TRIP" at the base end 103-f of the operation handle 103 are indicated through an opening (edges) for the handle of the cover 102.

In this embodiment, it is possible to remarkably decrease the number of parts for the mechanical portions and improvement of the assembling performance and, further remarkable reduction of the product cost can be attained. Further, improvement of the reliability of the products due to the decrease for the number of parts can also be attained.

Then, a circuit breaker in a seventh embodiment according to the present invention will be explained with reference to Fig. 23 to Fig. 26. This embodiment

is to be applied for a type of relatively large size (225A frame to 400A frame).

Fig. 23 and Fig. 24 show an entire constitution and a constitution for a main portion in the ON state in which contacts are closed, respectively.

The circuit breaker in this embodiment comprises a fixed contact base 211 as a power source side first fixed conductor, a conductor 213 as a load side second fixed conductor, a fixed contact base 207 as an intermediate fixed conductor interposed between the first fixed conductor and the second fixed conductor, a movable contact base 205 as a first movable conductor disposed between the fixed contact base 211 and a fixed contact base 207, a movable contact base 206 as a second movable conductor disposed between the fixed contact base 207 and the conductor 213, and a rotor 204 as a holding member rotatably disposed for holding the movable contact bases 205, 206. Further, it comprises a heater 122 and bimetals 125, and a fixed core 123 and a movable core 124 as an overcurrent detection means for detecting an overcurrent state in an electric path from the fixed contact base 211 to a conductor 213, and a hook 208 as a tripping means that operates based on the output of the overcurrent detection means, in which the rotor 204 operates in a tripping direction independently

of the operation of the operation handle 230 upon operation of the tripping means.

The handle 230 is reinforced with a handle lever 117 made of metal in view of the large operating force of a large-sized device, in which an U-shaped groove 117-a of the handle lever fits a protrusion 118-a of the fixed frame 118 as the base for attaching the mechanism portion and rotates around the protrusion 118-a as a rotational center. Further, a hook 208 is supported at a hole 208-a of the hook by a pin to the fixed frame 118 and made rotatable. Further, a hook top end 208-b engages a trip metal 119. The trip metal 119 is supported by a pin to the fixed frame 118 and made rotatable like that the hook 208. The other end of the trip metal 119 engages an interlock plate 120. The trip metal 119 and the interlock plate 120 are energized clockwise by a spring 132. Further, the rotational center 204-a of the rotor 204 also fits the fixed frame 118, and a movable contact base 205 having two movable contacts 112-a, 112-b and a movable contact base 206 having movable contacts 112-c, 112-d attached, respectively, on each of the ends are mounted to the rotor 204 so as to abut against the fixed contacts 112 attached to the fixed contact base 211 and the second fixed contact base 207.

The fixed contact 112-d attached to the top end of the conductor 213 abuts against the movable contact 106-d at the final end. The other end of the conductor 213 is joined with the heater 122 and the other end of the heater constitutes a load side terminal base 122-b. Further, a fixed core 123 and the movable core 124 are disposed so as to surround the conductor, bimetals 125 are joined to the heater 122 and an adjusting screw 126 is attached to the top end of the bimetals 125.

Further, a spring 130 is engaged between the handle lever 117 and the rotor 204.

Further, a hook 108 and a rotor 204 constitute a link by the lever 133.

Then, Fig. 25 shows the OFF state in which the contacts are open. For the OFF operation, when the handle 230 is operated rightwardly in the same manner as in the sixth embodiment, the rotor 204 rotates clockwise to open the contacts by the direction of the force of the spring 130.

Then, Fig. 26 shows a TRIP state. If an overcurrent flows in the main circuit, the bimetals 125 are heated by the heater 122 to distort the bimetals 125 by a current in an overload region, or the movable core 124 is attracted by the fixed core 123 in a short circuit current region, by which the interlocking plate

120 is rotated counterclockwise to disengage from the trip metal 119, and the trip metal 119 rotates also clockwise. By the rotation, engagement with the hook top end 208 is released and the hook 108 rotates around 208-a as the center, and the rotor 204 rotates clockwise by the lever 133 that connects the hook 208 with the rotor 204, to open the contacts. The handle 230 and the handle lever 117 rotate rightwardly around the protrusion 118-a of the fixed frame 118 as the center, abut against the protrusion 208-b of the hook, and stop between ON and OFF positions and the handle 230 indicates TRIP display at a neutral position.

This embodiment has a structure suitable to a circuit breaker of a relatively large capacity and, since the overcurrent detection system is mechanical, it can be constituted at a relatively reduced cost. Further, since it is of a four-contact system, high breaking performance can be attained.



WHAT IS CLAIMED IS

1. A circuit breaker comprising a first fixed conductor on a power source side, a second fixed conductor on a load side, an intermediate fixed conductor interposed between the first fixed conductor and the second fixed conductor, a first movable conductor disposed between said first fixed conductor and said intermediate fixed conductor and a second movable conductor disposed between said intermediate fixed conductor and said second fixed conductor.

2. A circuit breaker as defined in claim 1, wherein an opening/closing mechanism is provided for opening/closing, respectively, said first and said second movable conductors between said first fixed conductor and said intermediate fixed conductor and between said intermediate fixed conductor and said second fixed conductor substantially simultaneously.

3. A circuit breaker as defined in claim 2, wherein said first and said second movable conductors are attached each in a electrically insulated state to a holding member made of a substantially insulative material, and said opening/closing mechanism is adapted such that said movable conductor is rotated by rotating movement of said holding member around a rotational axis



thereby effecting opening/closing operation between each of the fixed conductors and said movable conductors.

4. A circuit breaker comprising a first fixed conductor on a power source side, a second fixed conductor on a load side, one or more (by the number of N) of the intermediate fixed conductors interposed between the first fixed conductor and the second fixed conductor and one or more (by the number of $N+1$) of movable conductors disposed between each of said fixed conductors.

5. A circuit breaker comprising a box, a movable conductor rotating around a rotational axis in said box, a power source side first fixed conductor opposed to one end of the movable conductor, a load side second fixed conductor opposed to the other end of said movable conductor, contact portions disposed near the side edges for each of conductors so as to electrically connect said first fixed conductor, said movable conductor and said second fixed conductor in series, and an opening/closing operation means for rotating said movable conductor so as to conduct opening/closing for each of said contact portions substantially simultaneously, in which said opening/closing operation means is provided with an operation lever extended from the top surface of said box toward outside of the box.



6. A circuit breaker as defined in claim 5, wherein said movable conductor is disposed at a position spaced apart from said rotational axis such that no electric conductor is disposed near said rotational axis.

7. A circuit breaker comprising a first fixed conductor on a power source side, a second fixed conductor on a load side, a movable conductor disposed between said first fixed conductor and said second fixed conductor, a holding member for holding the movable conductor, an operation handle for effecting opening/closing operation for an electric path from said first fixed conductor to said second fixed conductor, an overcurrent detection means for detecting an overcurrent state in said electric path and a tripping means that operates based on the output of the overcurrent detection means, in which said holding member is operated in a tripping direction independently of the operation of said operation handle upon operation of the tripping means.

8. A circuit breaker comprising a first fixed conductor on a power source side, a second fixed conductor on a load side, a intermediate fixed conductor disposed between said first fixed conductor and second fixed conductor, a first movable conductor disposed between said first fixed conductor and said intermediate



fixed conductor, a second movable conductor disposed between said intermediate fixed conductor and said second fixed conductor, an operation handle for effecting opening/closing operation for an electric path from said first fixed conductor to said second fixed conductor, an overcurrent detection means for detecting an overcurrent state in said electric path and a tripping means that operates based on the output of the overcurrent detection means, in which said holding member operates in a tripping direction independently of the operation of said operation handle upon operation of the tripping means.