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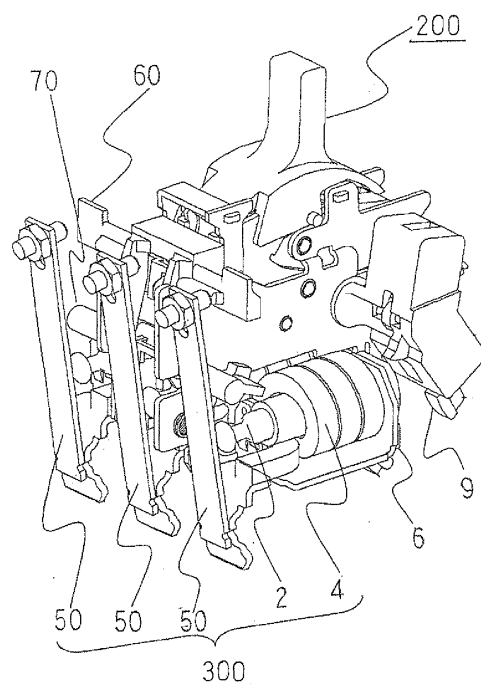
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(54) **Circuit breaker**

(57) An electromagnetic device for instantaneous trip use in a circuit breaker includes: a coil; an insulation pipe, a fixed core, a movable core moving in the insulation pipe by a magnetic flux generated by the coil to operate a trip device; a spring for biasing the movable core, a yoke whose one end is provided at the outside end of the fixed core, and the other end is provided on the side of the movable core; and a stator having a stator contact, and being a conductive plate jointed to an end of the coil, engaging the fixed core, and fixed to the yoke. The stator forms a current path between the stator contact and the joint section with the coil for current circulation in the direction same as the current flow to the coil.

Fig. 4



Description

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] The present invention relates to a circuit breaker and, more specifically, to an electromagnetic device for instantaneous trip use in the circuit breaker.

DESCRIPTION OF THE RELATED ART

[0002] Exemplified here is an electromagnetic device for instantaneous trip use (hereinafter, simply referred to as electromagnetic device) in a circuit breaker described in Patent Document 1 (JP-A-8-306295). With such an electromagnetic device including a plurality types of electromagnetic coils, design twists are added to how to wind a coil and in what shape a core is for winding of the coil, for example, to reduce the size of the electromagnetic device and to enable manufacturing using an automatic coil winder.

SUMMARY OF THE INVENTION

[0003] With an electromagnetic device for use in a circuit breaker, generally, the number of winding turns of a coil is limited depending on the spatial capacity for placement of the electromagnetic device, and the cross-sectional area of a conductor. The device design of a high rated current requires a thick conductor, and when such a device design is with a low instantaneous-trip current value, the spatial capacity is limited for placement of the device, thereby failing to increase the number of winding turns of the coil.

[0004] The invention is proposed to solve the problems described above, and an object thereof is to provide a small-sized high-performance circuit breaker including an electromagnetic device that can, by a shape change of a component originally provided therein, increase a rated current value within any existing limited space, and generate a trip force equal in value to the previous with a low instantaneous trip current value.

[0005] In a circuit breaker provided with an open-close mechanism section, a trip device including an electromagnetic device for instantaneous trip use, and an open-close contact section, the electromagnetic device for instantaneous trip use is configured to include: a coil; an insulation pipe provided inside of the coil, a fixed core provided at one end in the insulation pipe, a movable core that is inserted into the insulation pipe, and moves in the insulation pipe by a magnetic flux generated by the coil to operate the trip device; a spring provided between the movable core and the fixed core for biasing the movable core, a yoke whose one end is located at the outside end portion of the fixed core, and the other end is located on the side of the movable core; and a stator having a stator contact coming close to and moving away from a

contact of a movable element, and being a conductive plate jointed to an end of the coil, engaging the fixed core, and fixed to the yoke. The stator forms a current path between the stator contact and the joint section with the coil for current circulation in the direction same as the current flow to the coil.

[0006] In the previous setup space, with an electromagnetic device of the invention, a magnetic flux to be generated by circulation of a current in a stator is added to a magnetic flux to be generated by a coil. This accordingly increases the electromagnetic force acting on a movable core. Such effects can increase the actual specification range, e.g., the instantaneous-trip current value can be set lower than the previous value. Moreover, because the electromagnetic force will be large with an allowance, the number of winding turns of the coil can be favorably reduced so that the resulting circuit breaker can include the electromagnetic device reduced in size as such.

[0007] The foregoing and other objects, features, and advantages of the present invention will become more apparent from the following detailed description of the present invention when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008]

FIG. 1 is an external perspective view of a circuit breaker of a first embodiment of the invention;

FIG. 2 is a perspective view of components, i.e., an open-close mechanism section, a trip device, and a base chassis, with a cover removed from the circuit breaker of the first embodiment;

FIG. 3 is a perspective view of the components, i.e., the open-close mechanism section, and the trip device, when the circuit breaker of the first embodiment is in the ON state;

FIG. 4 is a perspective view of the components, i.e., the open-close mechanism section, and the trip device, when the circuit breaker of the first embodiment is in the trip state;

FIG. 5 is an exploded side view of an electromagnetic device for use in the circuit breaker of the first embodiment;

FIG. 6 is a front view of a stator of the electromagnetic device for use in the circuit breaker of the first embodiment;

FIGS. 7A to 7C are diagrams illustrating a part of an assembly process for the electromagnetic device to be used in the circuit breaker of the first embodiment; FIGS. 8A to 8C are other diagrams illustrating a part of the assembly process for the electromagnetic device to be used in the circuit breaker of the first embodiment;

FIGS. 9A and 9B are still other diagrams illustrating a part of the assembly process for the electromag-

netic device to be used in the circuit breaker of the first embodiment;

FIGS. 10A and 10B are diagrams showing the electromagnetic device to be used in the circuit breaker of the first embodiment;

FIG. 11 is a side view of a combined structure of the electromagnetic device and a movable element for use in the circuit breaker of the first embodiment;

FIGS. 12A to 12D are each a diagram showing a stator of an electromagnetic device for use in a circuit breaker of a second embodiment of the invention;

FIG. 13 is a front view of a movable element of the electromagnetic device for use in the circuit breaker of the second embodiment;

FIG. 14 is a diagram illustrating the operation of the stator of the electromagnetic device for use in the circuit breaker of the second embodiment; and

FIG. 15 is another diagram illustrating the operation of the stator of the electromagnetic device for use in the circuit breaker of the second embodiment.

DETAILED DESCRIPTION

First Embodiment

[0009] Described now is a circuit breaker of a first embodiment of the invention. Note that, in the accompanying drawings, components under the same reference numeral mean they are the same or equivalent. FIG. 1 is an external perspective view of a three-phase circuit breaker (hereinafter, simply referred to as circuit breaker) of the first embodiment of the invention. FIG. 2 is a perspective view of components, i.e., an open-close mechanism section, a trip device, and a base chassis, with a cover removed from the circuit breaker.

[0010] In FIGS. 1 and 2, a circuit breaker 100 is configured to include an open-close mechanism section 200, a trip device 300, an open-close contact section (not shown), and a circuit interrupter (not shown). The circuit interrupter is housed in a base chassis 40, which is configured by substrates 101 and intermediate substrates 102. The substrates 101 and 102 are all made of an insulation material. The remaining components, i.e., the open-close mechanism section 200, the trip device 300, and the open-close contact section, are fixed to and held by the intermediate substrates 102. A cover 111 made of an insulation material is detachably attached to the base chassis 40.

[0011] FIG. 3 is a perspective view of the components, i.e., the open-close mechanism section 200 and the trip device 300, when the circuit breaker 100 is in the ON state. FIG. 4 is a perspective view of the components, i.e., the open-close mechanism section 200 and the trip device 300, when the circuit breaker 100 is in the trip state.

[0012] In FIGS. 3 and 4, exemplified is a case where a load circuit being a three-phase electric circuit connected with the circuit breaker 100 is provided with a load

current of a predetermined value or higher, i.e., an overload current for a predetermined length of time or longer. In this case, a bimetal 50 configuring time-limit trip means in the trip device 300 changes in shape by bending by a predetermined amount in the right side of the drawing. Such a shape change accordingly operates a trip bar 60 of the open-close mechanism section 200, and a latch 70 coming in contact with the trip bar 60 is thus rotated, thereby tripping the open-close mechanism section 200. As such, three movable-element contacts 9 having been in contact with three stator contacts 6 of the open-close contact section are opened away from one another. The three stator contacts 6 are those respectively connected to R, S, and T three-phase conductors (not shown) of the load circuit.

[0013] When the flow of a short-circuit current is provided, a large magnetic force is generated in an electromagnetic coil 4 of the electromagnetic device configuring the instantaneous trip means in the trip device 300. A movable core 2 moving in the coil 4 is pulled toward the right side of the drawing so that the movable core 2 rotates the latch 70. With the latch rotated as such, the open-close mechanism section 200 is tripped, thereby opening away the stator contacts 6 and the movable-element contacts 9 of the open-close contact section from one another.

[0014] Described next in detail is the electromagnetic device being a main part of the invention by referring to FIGS. 5 to 11. FIG. 5 is an exploded side view of the electromagnetic device for use in the circuit breaker of the first embodiment of the invention. This electromagnetic device is configured by components including an insulation pipe 1, the movable core 2, a spring 3, the coil 4, a stator 5, the stator contacts 6, a yoke 7, and a fixed core 8.

[0015] The coil 4 consists of winding turns of a conductor of the rectangular cross section. The stator 5 being the characteristic part of the invention is connected to an end of the coil 4. As shown in FIG. 6, the stator 5 is configured by a conductive plate having the flat plane substantially in the shape of a question mark, i.e., the shape of connecting a ring-shaped portion 5a and a linear portion 5b. The ring-shaped portion 5a is partially cut, i.e., has a cut portion 5c, and is hereinafter simply referred to as ring-shaped portion 5a. Note here that the expression of "in the shape of a question mark" means that a current path is in the shape of a question mark. Alternatively, the ring-shape portion 5a may be in the shape of a complete ring, i.e., without the cut portion 5c, with the cut portion 5c filled with an insulation material, for example. The linear portion 5b of the stator 5 is provided with the stator contacts 6. Note here that a reference numeral 11 denotes a current path for a current flow circulating from the stator contacts 6 of the stator 5 along the ring-shaped portion 5a.

[0016] FIGS. 7A to 7C are each a diagram showing the connection state between the stator 5 and the coil 4. Specifically, FIG. 7A is a front view, FIG. 7B is a side

view, and FIG. 7C is a perspective view. As shown in FIGS. 7A to 7C, as to the stator 5, an end portion adjacent to the cut portion 5c is electrically and mechanically jointed by welding firmly to an end of the coil 4. This jointed section 14 is located on the plane facing the direction opposite to the stator contacts 6, thereby easing the assembly. Moreover, the current path 11 is so formed that the ring-shaped portion 5a is coaxial with the coil 4, and the flow of a current is directed in the same direction as for the coil 4.

[0017] FIGS. 8A to 8C are each a diagram showing the state in which the fixed core 8 or others are combined with the yoke 7. Specifically, FIG. 8A is a front view, FIG. 8B is a side view, and FIG. 8C is a perspective view. The yoke 7 supporting the fixed core or others is made of a magnetic material, and is in the substantially lateral U shape when viewed from the side. An end of the yoke 7 is formed with an aperture, and the yoke 7 is so disposed that the center of this aperture comes at the axial core of the coil 4. The ring-shaped portion 5a of the stator 5 is disposed on the aperture portion of the yoke 7, and the fixed core 8 is swaged at one end thereof in the internal space of the ring-shaped portion 5a, thereby firmly fixing together the fixed core 8, the stator 5, and the yoke 7. The fixed core 8 protrudes from an end of the yoke 7 toward the inside of the coil 4.

[0018] FIGS. 9A and 9B are each a diagram showing the state in which the insulation pipe 1, the movable core 2 or others are combined with the coil 4, the yoke 7, and others. Specifically, FIG. 9A is a side view, and FIG. 9B is a perspective view. The insulation pipe 1 has an end being an open end 1a, and the remaining end thereof is an aperture with a diameter smaller than that of the open end 1a. The insulation pipe 1 is inserted therein with the movable core 2 that can move along the axis of the pipe, and the spring 3 for biasing the movable core 2 (FIGS. 9A and 9B do not show the spring 3). An end of the movable core 2 is protruding from the small-diameter aperture of the insulation pipe 1, and the small-diameter section restricts the movable core 2 not to fall off from the insulation pipe 1.

[0019] During assembly, the insulation pipe 1 is inserted into the coil 4. The other end of the yoke 7 is formed with a section for insertion of the insulation pipe 1. With the movable core 2 and the spring 3 provided inside, the insulation pipe 1 is inserted into the coil 4 in the direction of an arrow of FIGS. 9A and 9B in such a manner that the side of the open end 1a is opposed to the fixed core 8. After being inserted as such, the insulation pipe 1 is positioned in the diameter direction by the open end 1a snapping to the fixed core 8. The other end of the insulation pipe 1 is fixed by hooking a nail portion 1b provided to the insulation pipe 1 to the yoke 7. The components 1 to 8 are assembled together as such, and the electromagnetic device of FIGS. 10A and 10B is completed. Note here that FIG. 10A is a side view of the electromagnetic device, and FIG. 10B is a perspective view thereof.

[0020] FIG. 11 is a diagram showing the positional re-

lationship between the stator 5 of the electromagnetic device, and a movable element 16 of the open-close mechanism section 200. The movable element 16 is provided to rotate about a rotation axis 16a in such a manner that the movable-element contacts 9 move close to and away from the stator contacts 6. Herein, a reference numeral 17 denotes a path for a current flowing to the movable element 16.

[0021] In the electromagnetic device of the circuit breaker configured as such, the coil 4 and the stator 5 are being electrically connected by the jointed section 14. With such a configuration, when the movable-element contacts 9 and the stator contacts 6 are in the state of closure, the flow of a current is directed from the movable element 16 along the current path 17 of the movable element 16, and then from the movable-element contacts 9 to the stator contacts 6, is directed to go through the ring-shaped portion 5a along the current path 11 of the stator 5, thereby reaching the coil 4 through the jointed section 14. At this time, a magnetic flux to be generated along the axis of the coil 4 is a combination of a one-turn magnetic flux to be generated by the current circulating in the ring-shaped portion 5a of the stator 5, and a magnetic flux to be generated by the current flowing to the coil 4.

[0022] The magnetic flux being a combination result of the two magnetic fluxes as such passes through the movable core 2 in the insulation pipe 1, and the movable core 2 is thus electromagnetically pulled. The movable core 2 is on standby at the position slightly protruding from the insulation pipe 1 by being biased by the spring 3, and when the movable core 2 is located at this position, only a part of the magnetic flux to be generated by the stator 5 and the coil 4 passes therethrough. When the movable core 2 is started to be electromagnetically pulled, the electromagnetic force to be acted on the movable core 2 to pull it into the coil 4 is increased as the amount of displacement of the movable core 2 is increased. This is because, as the movable core 2 is displaced toward the center of the coil, the magnetic lines of force going therethrough are increased. In response to such an increase of the electromagnetic force as a result of the increase of the amount of displacement, once the operation of pulling the movable core 2 is started, the movable core 2 is moved in a stroke to the completion position against the biasing force of the spring 3. The movable core 2 moved as such rotates the latch 70 of the trip bar 60 in charge of the trip operation of the circuit breaker, thereby performing the trip operation.

[0023] According to the first embodiment, by changing the shape of a stator that is originally provided, the resulting stator 5 can serve as a current path for the circulation current for generating a magnetic flux. This accordingly enables to increase the electromagnetic force to a further degree without increasing the number of winding turns of a coil of the electromagnetic device. On the other hand, when there is no need to increase the electromagnetic force, the electromagnetic device can be reduced

in size because the number of winding turns of a coil can be reduced. Herein, as described above, because the current path of the stator 5 is required to serve only as a one-turn coil, the cut portion 5c may be filled with an insulation material, for example. If this is the configuration, the resulting stator 5 can be increased in mechanical strength.

Second Embodiment

[0024] FIGS. 12A to 12D each show a stator 500 of an electromagnetic device of a circuit breaker in a second embodiment of the invention. Specifically, FIG. 12A is a front view, FIG. 12B is a side view, FIG. 13C is a plan view, and FIG. 12D is a perspective view.

[0025] In the second embodiment, a movable element and a stator are so disposed as to oppose each other as shown in FIG. 11. Such a configuration is aimed to increase the force of moving away the movable-element contacts 9 and the stator contacts 6 from one another when a large amount of current flows from the movable element to the stator using the repulsion between the movable element and the stator by the current respectively flowing thereinto.

[0026] FIGS. 13 to 15 are each a diagram for illustrating the operation principles of repulsion. The portion showing the vector component A (downward arrow of FIG. 13) of a current flowing along the current path 17 of the movable element 16 is opposite in direction of current flow to the portion showing a backward vector component B (upward arrow of FIG. 14) of a current flowing through the stator 5, and thus the repulsion occurs therebetween. In consideration thereof, the space between the movable element 16 and the stator 5 is reduced. On the other hand, the portion showing the vector component A of a current flowing to the movable element 16 is the same in direction of current flow as the portion showing the vector component C (downward arrow of FIG. 15) of a current flowing to the stator 5, and thus the force is generated to pull those portions close to each other. In consideration thereof, the space between the movable element 16 and the stator 5 is increased. Specifically, the stator is so configured as shown in FIG. 12.

[0027] As shown in FIGS. 12A to 12D, the stator 500 is so bent as to generate a height difference S to a ring-shape portion 500a on the center line of a linear portion 500b. In FIG. 12B, R1 and R2 each denote a distance between the plane of the stator 500 and the movable element 16, i.e., the space R1 is for the portion showing the backward vector component B of a current, and the space R2 is for the portion showing the vector component C of a current. The height difference S is so provided at the center of the ring-shape portion 500a of the stator 500 as to establish $R1 < R2$. The remaining configuration is the same as that of the first embodiment.

[0028] In the second embodiment, the shape of a stator is so changed that the portions opposing each other are disposed close to each other when the vector component

of a current flowing to the movable element is opposite in direction to the vector component of a current circulating in the stator, and such opposing portions are disposed away from each other when the vector component of the current flowing to the movable element is the same in direction as the vector component of the current circulating in the stator. Such a shape change favorably brings the effects that the electromagnetic repulsion increases the trip operation force of the movable element. The electromagnetic repulsion here is proportional to the square of the value of a current induced between the movable element and the stator, and is inversely proportional to the distance therebetween. Such effects are additionally provided to the effects achieved in the first embodiment.

[0029] Various modifications and alterations of the present invention will be apparent to those skilled in the art without departing from the scope and spirit of the present invention, and it should be understood that this is not limited to the illustrative embodiments set forth herein.

Claims

1. A circuit breaker, comprising:

an open-close mechanism section (200);
a trip device (300) including an electromagnetic device for instantaneous trip use; and
an open-close contact section, wherein
the electromagnetic device for instantaneous trip use includes:

a coil (4);
an insulation pipe (1) provided in the coil (4);
a fixed core (8) provided at one end of the insulation pipe (1);
a movable core (2) to be inserted into the insulation pipe (1), and is moved in the insulation pipe (1) by a magnetic flux generated by the coil (4) to operate the trip device (300);
a spring (3) provided between the movable core (2) and the fixed core (8) to bias the movable core (2);
a yoke (7) whose one end is provided at an outside end portion of the fixed core (8), and the other end is provided to a side of the movable core (2); and
a stator (5; 500) having a stator contact (6) coming close to and moving away from a contact (9) of a movable element (16), and being a conductive plate jointed to an end of the coil (4), engaging the fixed core (8), and fixed to the yoke (7), and
the stator (5; 500) forms a current path between the stator contact (6) and a joint section (14) with the coil (4) for current circula-

tion in a direction same as a current flow to the coil (4).

2. The circuit breaker according to claim 1, wherein the stator (5; 500) is a conductive plate substantially in the shape of a question mark connecting a linear portion (5b; 500b) including the stator contact (6) and a ring-shaped portion (5a; 500a) including a cut portion (5c; 500c).

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3. The circuit breaker according to claim 1, wherein a same line carries thereon a center axis of the coil (4), a center of a current path circulating the current to the stator (5; 500), and a center axis of the fixed core (8).

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4. The circuit breaker according to claim 1, wherein the stator contact (6) is disposed on a plane opposite to a plane on which the stator (5; 500) is jointed to the coil (4).

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5. The circuit breaker according to claim 1, wherein in a vector component of the current circulating in the stator (500) from the movable element (16) via the stator contact (6), a portion of the stator (500) through which a current of a vector component opposite in direction to a vector component of a current flowing to the movable element (16) is disposed with a small space from the movable element (16), and a portion of the stator (500) through which a current of a vector component same in direction as a vector component of a current flowing to the movable element (16) is disposed with a large space from the movable element (16).

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6. The circuit breaker according to claim 5, wherein a height difference is provided between the portion of the stator (500) through which the current of the vector component opposite in direction to the vector component of the current flowing to the movable element (16) and the portion of the stator (500) through which the current of the vector component same in direction as the vector component of the current flowing to the movable element (16).

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Fig. 1

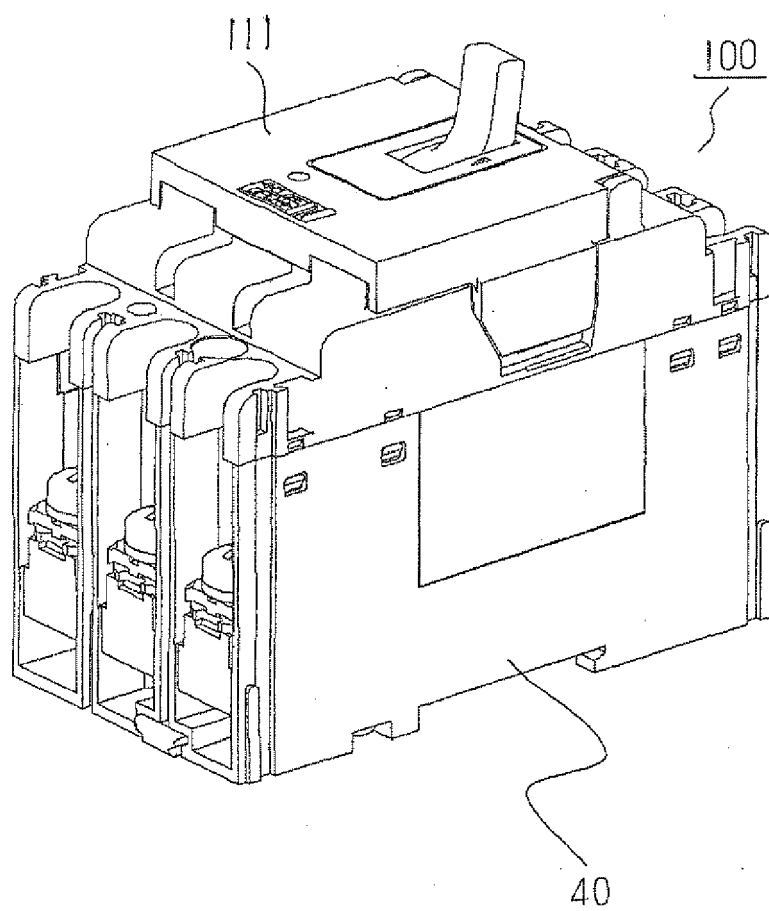


Fig. 2

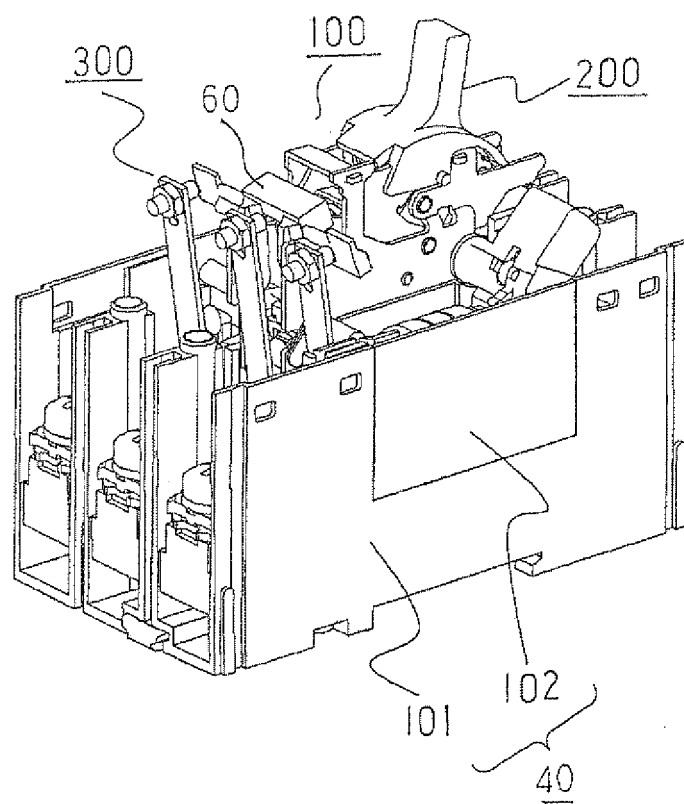


Fig. 3

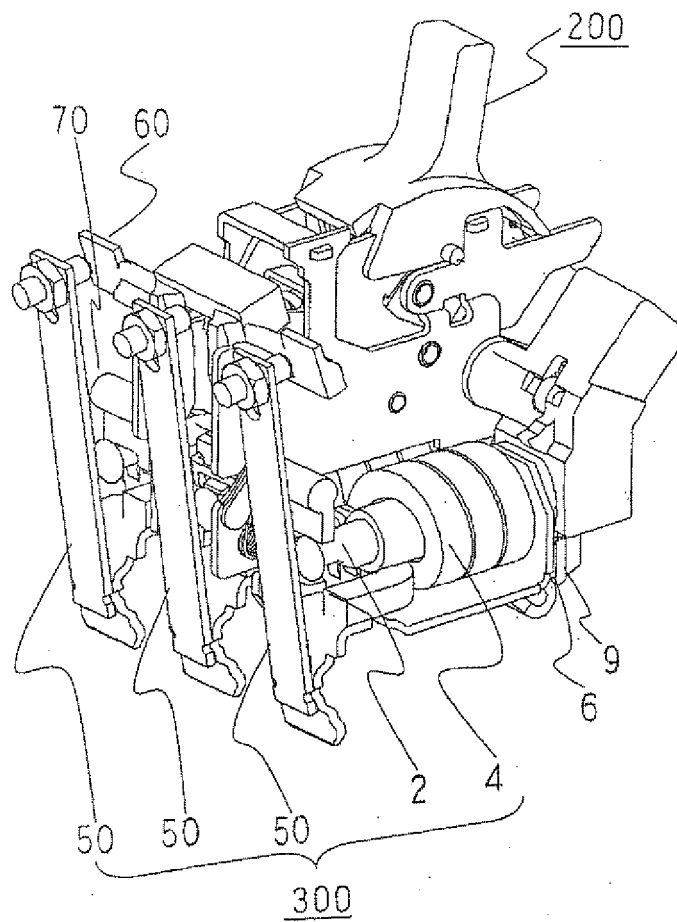


Fig. 4

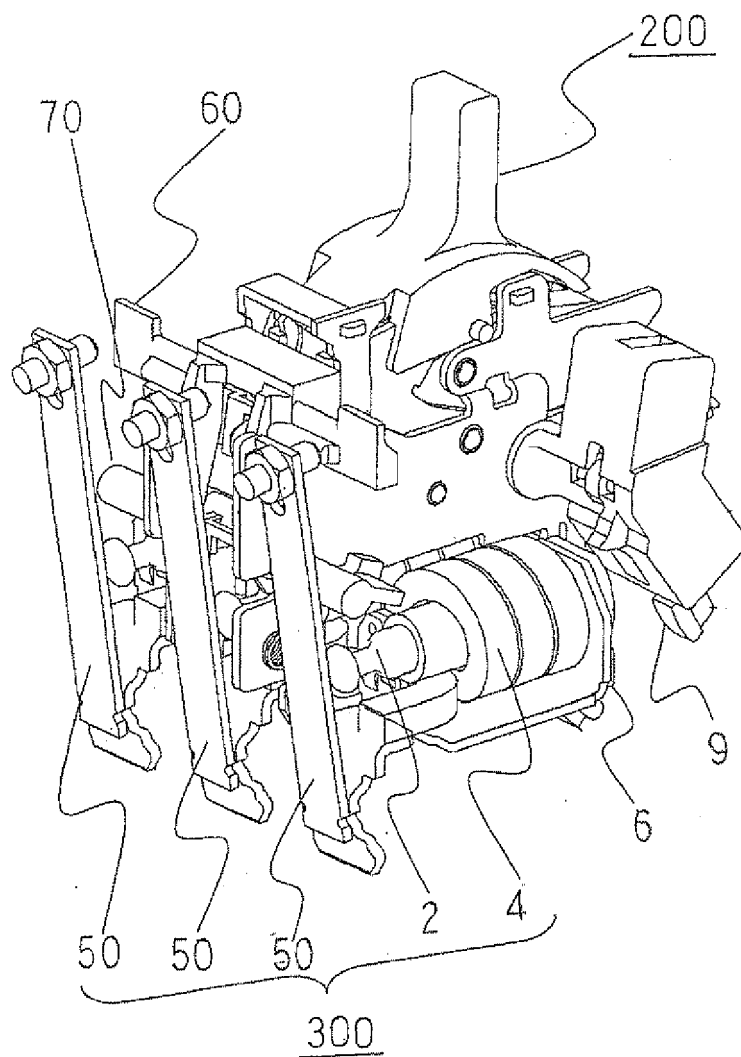


Fig. 5

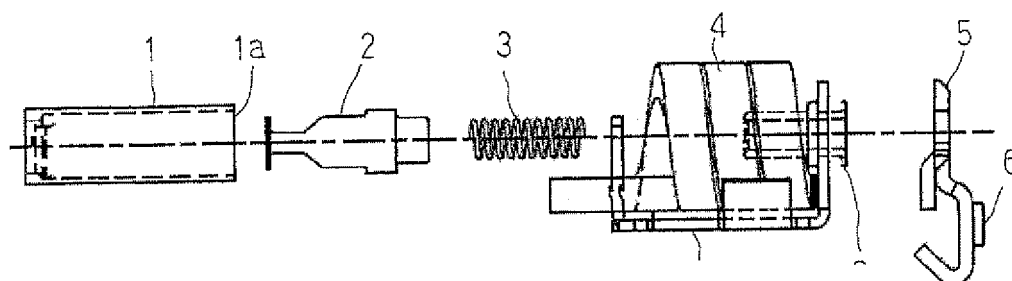


Fig. 6

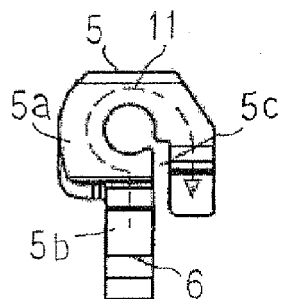


Fig. 7A

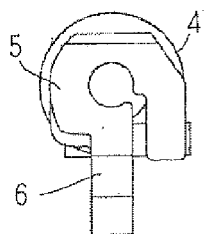


Fig. 7B

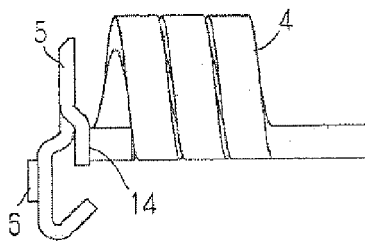


Fig. 7C

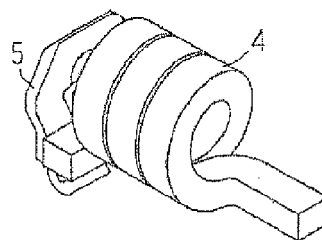


Fig. 8A

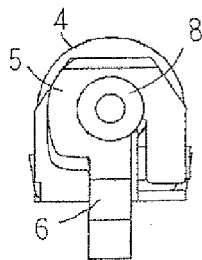


Fig. 8B

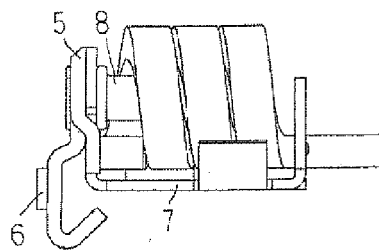


Fig. 8C

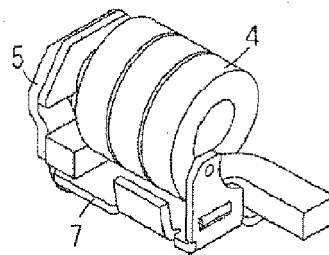


Fig. 9A

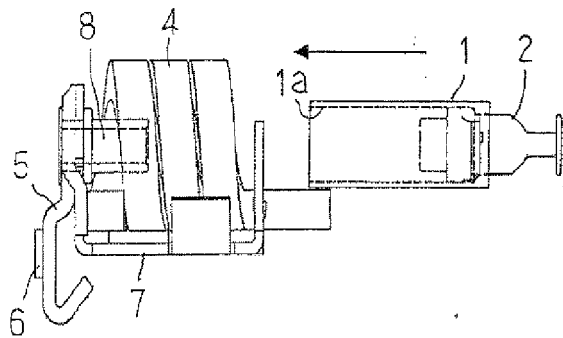


Fig. 9B

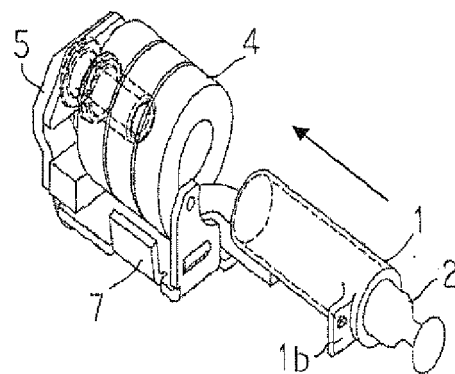


Fig. 10A

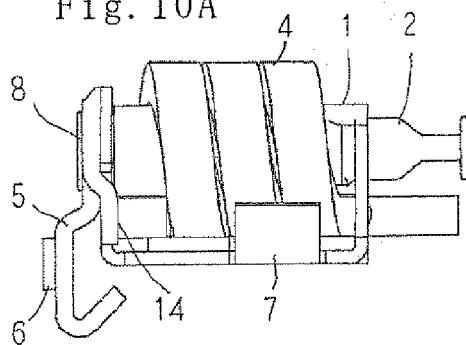


Fig. 10B

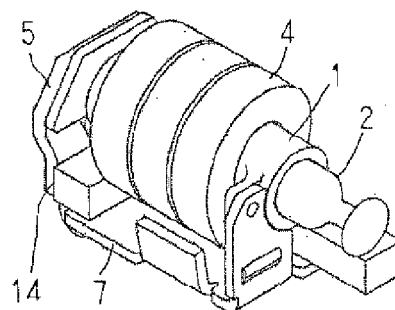


Fig. 11

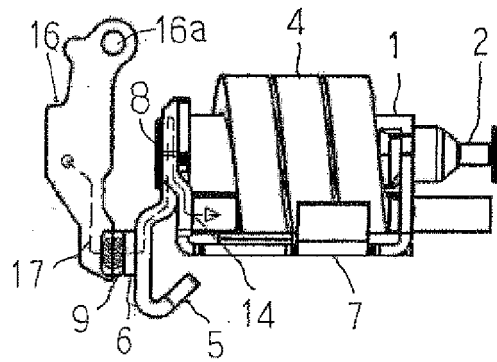


Fig. 12C

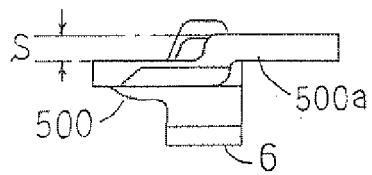


Fig. 12B

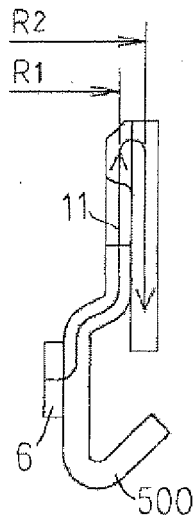


Fig. 12D

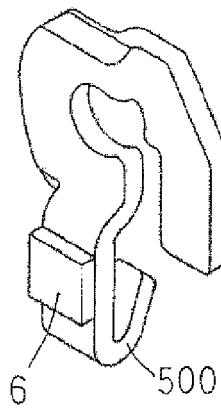


Fig. 12A

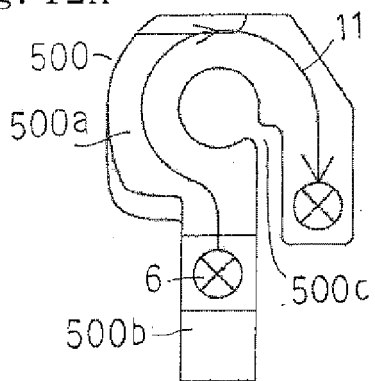


Fig. 13

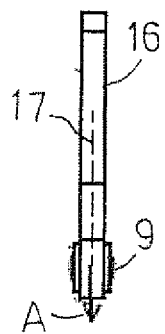


Fig. 14

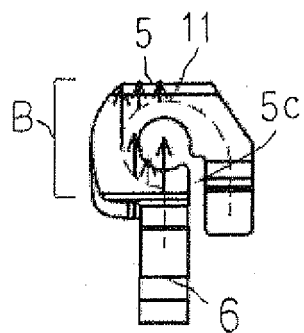
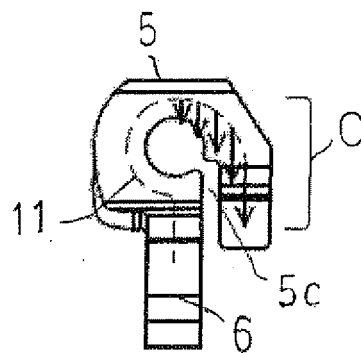


Fig. 15



REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

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