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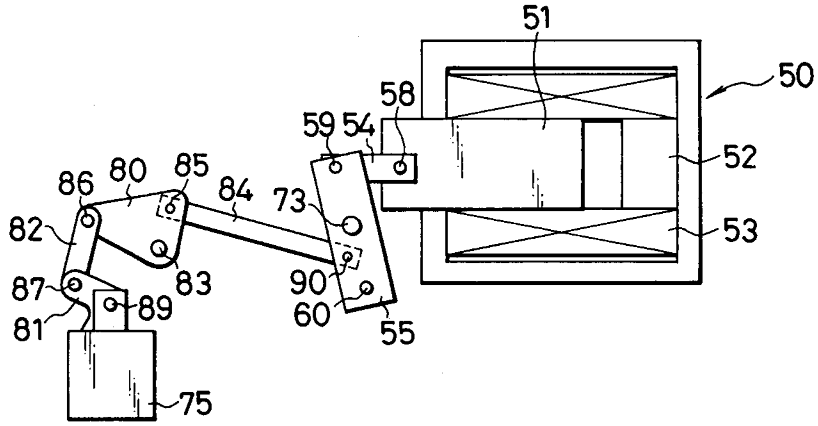
(54) Reset mechanism for a small-power tripping device for a circuit breaker.

(57) In a small-power tripping device for a circuit breaker having a closing device provided with a first lever (55) which is rotated when a movable core (51) of a closing device is attracted to a fixed core (52) upon excitation of a closing coil (53) to close the circuit breaker; a reset lever (81) of the small-power tripping device (75) is connected to said first lever (55) to move together with said first lever (55) thereby to reset the small-power tripping device when the circuit breaker is closed.

FIG. 4



EP 0 542 274 A1

The present invention relates to a tripping device for a circuit breaker used in electric power systems.

Fig. 11 shows a circuit breaker with a prior-art tripping device. As illustrated, it comprises a fixed contact 1, a movable contact 2, an insulating link 3, a pole shaft lever 4 for the circuit breaker operating mechanism, links 5 and 6, a trip latch 7, a closing cam 8, a trip pin 9 having a part with a semi-circular cross section, an opening spring 10, a roller 11 mounted on a pin connecting the links 5 and 6, floating pins 12, 13, 14, IS and 16, and fixed pins 17, 18 and 19.

Fig. 14 and Fig. 15 are side views showing the structure of the small-power tripping device. Fixed cores 32 are attached to opposite sides of a permanent magnet 31. A movable core 33 is mounted in such a manner that it can contact the fixed cores 32. A trip rod 34 has a first or lower end connected to the movable core 33, and extends through a hole provided in the permanent magnet 31, and a flange 34a at a second or top end of the trip rod 34 is disposed to engage a lever 35 mounted to a trip pin 9, which is also shown in Fig. 11.

A compression spring 36 is provided to be compressed when the movable core 33 is raised, and urges the movable core downward when it is compressed. Coils 37 are wound on the fixed cores 32. When a current is made to flow through the coils 37, magnetic fluxes generated thereby in the fixed cores 32 cancel the magnetic flux in the fixed cores 32 due to the permanent magnet 31, so that the magnetic attracting force acting on the movable core 33 is substantially reduced, being overcome by the force of the spring 36, which lowers the movable core 33, separating it from the fixed cores 32. The small-power tripping device is housed in a case 38.

Fig. 16 shows the structure of the resetting section.

In this figure, the trip pin 9 and the case 38 are the same ones as those in Fig. 14. A leaf spring 40 is mounted to the tip of a reset lever 39. A lever 41 is fixed to the pin 18, and rotates together with the pole shaft lever 4 shown in Fig. 11.

The operation of the prior-art tripping device resetting mechanism will now be described.

The small-power tripping device shown in Fig. 14 is a tripping device of the type in which it operates with a small energy. The movable core 33 is normally held by the permanent magnet 31. For tripping the circuit breaker, the small-power tripping device is made to operated by supplying an electric current to its coils 37. The small-power tripping device is then reset. This resetting is also made during the opening of the circuit breaker, specifically during a latter part of the opening operation.

More specifically, in the state in which the circuit breaker is closed, the movable core 33 is attracted to the fixed cores 32 and there is a gap between the lower surface of the flange 34a of the trip rod 34 and the lever 35, as illustrated in Fig. 14. In this state, the lever 35 does not receive a force from the trip rod 34 of the small-power tripping device, and the trip pin 9 and a trip latch 7 are maintained in an engaged state as illustrated in Fig. 11, and the circuit breaker is maintained in the closed state.

For tripping the circuit breaker, a signal or current is supplied from a control device, not shown, to the coils 37 of the small-power tripping device of Fig. 14, so that the magnetic flux of the coils 37 cancels the magnetic flux of the permanent magnet 31 thereby to lower the attracting force of the fixed cores and the compression coil spring 36 pushes down the movable core 33. By virtue of this action, the flange 34a of the trip rod 34 moves down to kick the lever 35 so that the trip pin 9 rotates counterclockwise as shown in Fig. 15. The engagement between the semi-circular latch of the trip pin 9 and the trip latch 7 is thereby broken, and the trip latch 7 rotates clockwise about the pin 19. In consequence, the link 6 moves in the direction of arrow A in Fig. 11, and the roller 11 provided at the junction with the link 5 moves along the periphery of the closing cam 8 and falls in a dent part 8a. Simultaneously with this, the link 5 releases the pole shaft lever 4 connected thereto, the insulating link 3 and the movable contact 2 connected thereto. The movable contact 2 is pulled by the opening spring 10 via the insulating link 3 and the floating pin 12, so that the movable contact 2 is rotated counterclockwise about the fixed shaft 17, with its contact part 2a at its upper end being separated from the fixed contact 1. At this time, the pole shaft lever 4 is rotated clockwise about the fixed shaft 18. This rotation of the pole shaft lever 4 is accompanied with rotation of the lever 41, which is utilized for resetting of the small-power tripping device, as will later be described in further detail.

Accordingly, the movable contact 2 of the circuit breaker is opened. Before the subsequent closing, the small-power tripping device needs is reset, i.e., returned to the original position, the position it assumed before the operation.

In the illustrated small-power tripping device, the resetting is conducted in the following manner. That is, during the opening of the circuit breaker, an auxiliary switch, not shown, is used to interrupt the current to the coils 37, and, when the lever 41 rotates together with the pole shaft lever 4 as described above, the reset pin 41a of the lever 41 pushes the leaf spring 40 to drive the reset lever 39, thereby to lift the trip rod 34 and the movable core 33, compressing the spring 36. The movable core 33 is therefore attached to the fixed cores 32, and is maintained in this state until a current is thereafter supplied to the coils 37.

As long as the circuit breaker is in the open state, the trip rod 34 is kept lifted by the reset lever 39.

Because the resetting is made at the time of opening the circuit breaker, the prior art mechanism described above is associated with the following problems:

(a) The force required for operation is large, so that a small-power tripping device capable of high-speed operation could not be obtained. Of the energy required for closing a circuit breaker and the energy required for opening the circuit breaker, the latter is smaller in general. The reason is that during closing the circuit breaker, an electromagnetic force is exerted on the contacts of the circuit breaker, so additional force is required to overcome the electromagnetic force. Moreover, part of the energy for closing the circuit breaker must be stored in a spring which is utilized during opening of the circuit breaker. In addition, the electromagnetic force, which opposes the closing, assists the opening.

Under such circumstances, the force of the opening spring 36 shown in Fig. 14 could not be made larger because the resetting of the small-power tripping device is conducted at the time of opening the circuit breaker.

The tripping force provided by the small-power tripping device is therefore small, and it was difficult to obtain a small-power tripping device capable of high-speed operation.

(2) Provision of the small-power tripping device lowers the speed of opening the contacts.

As described in the section of the description of the operation, the conventional small-power tripping device drives the reset lever 39 at the time of opening the circuit breaker. This means that additional force is required at the time of opening the circuit breaker, and the speed of opening the contact is lowered.

For the reasons set forth above at (1) and (2) above, the prior-art mechanism could not be used in a circuit breaker having a large operating force and a high contact-opening speed.

Thus, the prior-art small-power tripping device could be used for a low-voltage, air circuit breaker which do not require a high contact-opening speed, but could not be used for circuit breaker for a direct-current, high-speed circuit breaker which is used in a direct-current, railway power substation and is required to open contact before the short-circuit current of the circuit reaches the final value. Incidentally, it is required that the contact-opening time of a direct-current high-speed circuit breaker be on the order of 5 ms, which is less than half the contact-opening time of ordinary circuit breaker.

However, as described above, the holding in the normal state is achieved by an attracting force of a permanent magnet, so no energy is consumed for holding the circuit breaker, and the holding state is terminated by a small coil-operating current and can be driven by an output current of an electronic control device, so the setting of the operating conditions and the like can be made with a high accuracy, and the maintenance is easy, and it has been desired that the small-power tripping device be also used in a direct-current, high-speed circuit breaker.

Further problems of the prior-art resetting device is as follows:

(3) The resetting operation is not stable.

At the time of resetting, the reset lever 39 lifts the trip rod 34 with engagement of the flange 34a and one end of the reset lever 39. This engagement is only with one end of the reset lever 39, so that the structure is liable to unsatisfactory resetting.

(4) The reset stroke is not uniform.

The resetting is made on the basis of the difference between the force of the leaf spring 40 and the force of the compression spring 36, so that when the balance of force collapses due to deterioration of the spring, for example, the resetting force and the stroke can vary.

For the reasons set forth above at (3) and (4), the prior-art mechanism cannot be applied to circuit breakers which require stable resetting action and is free from deterioration.

SUMMARY OF THE INVENTION

An object of the invention is to increase the speed of operation of a small-power resetting device for a circuit breaker.

Another object of the invention is to provide a mechanism that can provide a larger force for resetting of a small-power tripping device.

Another object of the invention is to stabilize the resetting operation of a small-power tripping device.

A further object of the invention is to eliminate or reduce the effect of deterioration.

The invention provides a small-power tripping device for a circuit breaker having a closing device provided with a first lever (55) which is rotated when a movable core (51) of a closing device is attracted to a fixed core (52) upon excitation of a closing coil (53) to close the circuit breaker;

CHARACTERIZED IN THAT:

a reset lever (81) of the small-power tripping device (75) is connected to said first lever (55) to move together with said first lever (55) thereby to reset the small-power tripping device when the circuit breaker is closed.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a side view showing a circuit breaker operating mechanism, in an open state, of an embodiment of the invention.

Fig. 2 is a side view showing the circuit breaker operating device, in an open state assumed during the process of closing operation.

Fig. 3 is a side view showing circuit breaker operating mechanism, in a closed state.

Fig. 4 is a side view showing a reset mechanism for a small-power tripping device, in a disengaged state assumed both before closing operation and before tripping operation.

Fig. 5 is a side view showing the reset mechanism, in an engaged stated assumed during the process of resetting operation.

Fig. 6 is a partially sectional view showing the small-power tripping device, in a separated state assumed before resetting.

Fig. 7 is a partially sectional view along line VII-VII in Fig. 1.

Fig. 8 is a sectional view along line VIII-VIII in Fig. 7 showing the small-power tripping device in an attracted state assumed during the process of resetting.

Fig. 9 is a sectional view showing the small-power tripping device in an attracted state assumed when resetting is completed.

Fig. 10 is a transition diagram showing how the circuit breaker, the small-power tripping device and the reset mechanism change their states.

Fig. 11 is a side view of a prior-art tripping mechanism before tripping.

Fig. 12 is a side view of the prior-art tripping mechanism in the process of tripping.

Fig. 13 is a side view of the prior-art tripping mechanism after tripping.

Fig. 14 is a side view showing a small-power tripping device, before tripping, used in the prior-art tripping mechanism.

Fig. 15 is a side view showing the small-power tripping device, after tripping, used in the prior-art tripping mechanism.

Fig. 16 is a side view showing the small-power tripping device, in the process of resetting, used in the prior-art tripping mechanism.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

An embodiment of the invention will now be described with reference to Fig. 1 to Fig. 10.

Fig. 1, Fig. 2 and Fig. 3 show a circuit breaker incorporating the small-power tripping device and a reset mechanism for the small-power tripping device.

Referring first to Fig. 1, Fig. 2 and Fig. 3, the circuit breaker comprises a fixed contact 1 and a movable contact 2.

A first or upper terminal 49 of the circuit breaker is connected to the fixed contact 1.

A second or lower terminal 69 of the circuit breaker is connected via a conductor 70 to a flexible conductor 71. The lower terminal 69 extends through a current detector 72.

The circuit breaker is provided with a closing electromagnet 50, which includes a movable core 51, a fixed core 52, and a closing coil 53. The circuit breaker also comprises a link 54 for connecting the movable core 51 with an auxiliary lever 55. A main lever 56 is connected via a link 57 to the lever 55. The movable core 51 and the link 54 are connected via a floating pin 58. The link 54 and the lever 55 are connected via a floating pin 59. The lever 55 and the link 57 are connected via a floating pin 60. The link 57 and the main lever 56 are connected via a floating pin 61.

The main lever 56 is mounted in such a manner that it can rotate about a fixed pin 62, and the movable contact 2 is mounted to an upper part of the main lever 56 by means of a floating pin 63 in such a manner that it can rotate about the pin 63. A roller 64 is mounted to a lower part of the movable contact 2, and is so disposed as to engage with a latch 65 when the circuit breaker is in the closed state.

An opening tension spring 66 is mounted to the movable contact 2 to pull the upper end of the movable contact 2 rightward in Fig. 1, Fig. 2 and Fig. 3 to thereby urge the movable contact 2 to rotate clockwise. The rightward movement of the upper end of the movable contact 2 is limited by a stopper 68.

The lever 55 rotates about a fixed pin 73, while the latch 65 rotates about a fixed pin 74. A tension spring 48 is provided to pull the ping 60 rightward as seen in Fig. 1, Fig. 2 and Fig. 3 to thereby urge the main lever 56 to rotate counterclockwise.

Another tension spring 68 is provided to pull the lower end of the main lever 56 rightward as seen in Fig. 1, Fig. 2 and Fig. 3 to thereby urge the main lever 56 to rotate counterclockwise.

A small-power tripping device 75 is in engagement with the latch 65 via a trip rod 34.

Fig. 4 and Fig. 5 show a reset mechanism. This reset mechanism is incorporated in the circuit breaker in Fig. 1, Fig. 2 and Fig. 3, but parts not relevant for the description of the reset mechanism are not illustrated for simplicity of illustration. The pins 73 and 90 and the lever 55 are the same ones as those shown in Fig. 1, Fig. 2 and Fig. 3.

A lever 80 is rotatable about a fixed pin 83, and is connected to the lever 55 by means of floating pins 85 and 90, and a link 84. A reset lever 81 for the small-power tripping device is connected to the lever 80 by means of a link 82, and floating pins 86 and 87. The reset lever 81 is provided with a roller 100 at one end thereof is rotatable about a fixed pin 89 on a support 103.

Fig. 6, Fig. 7, Fig. 8 and Fig. 9 show details of the small-power tripping device 75.

The reset lever 81, the link 82, and the pins 87 and 89 were also shown in Fig. 4 and Fig. 5 and were briefly described.

The small-power tripping device 75 also comprises a permanent magnet 31, fixed cores 32 mounted to both sides of the permanent magnet 32, and a movable core 33. The trip rod 34 is fixed by screw to the movable core 33 at about the center of the movable core 33 as seen in the direction of the trip rod 34. The trip rod 34 extends through a guide 101 and guided when it moves up and down being driven by the movable core 33. Opening compression springs 36 are provided on the respective sides of the permanent magnet 31 and engage with respective sides of the movable core 33 to urge the movable core 33 to move upward. Supports 102 guide the compression and expansion of the springs 36 and the up and down movement of the movable core 33. Coils 37 are wound on the respective fixed cores 32. A case 38 encloses the permanent magnet 31, the fixed cores 32, the coils 37 and the movable core 33, as well as the springs 36. The guide 101 is fixed to the case 32, by means not illustrated.

The movable core 33 has a lower surface 33a facing the fixed cores 32, and an upper surface 33b which includes a substantially flat part 33c. The pin 89 about which the reset lever 81 rotates is provided at a position above the upper surface 33b of the movable core 33 or farther away from the fixed cores 32 than the flat part of 33c the upper surface 33b of the movable core 33.

Further details of the reset lever 81 and the roller 100, and the movable core 33 and associated parts of the small-power resetting device are better seen from Fig. 7. As illustrated, the reset lever 82 comprises a first part 81a, a second part 81b, and a bridging part 81c connecting first ends of the first and second parts 81a and 81b. The first and second parts 81a and 81b have like profiles as seen in the direction normal to the page of Fig. 6. The bearing 101 extends between the first and second parts 81a and 81b.

The support 103 comprises a first part 103a and a second part 103b which are fixed to and extend from the case 38, near opposite side walls 38a and 38b of the case 38. The first and second parts 81a and 81b are rotatably supported by the first and second parts 103a and 103b of the support 103 via first and second parts 89a and 89b of the pin 89.

The roller 100 is also split into first and second parts 100a and 100b, which are respectively supported by like ends of the first and second parts 81a and 81b of the reset lever 81. The first and second parts 100a and 100b are coaxial with each other and have an identical radius so that they are brought into and separated from the flat part 33c of the upper surface 33b of the movable core 33 substantially simultaneously as the reset lever 81 rotates counterclockwise and clockwise, respectively. The first and second parts 100a and 100b are in contact with the flat part 33c of the upper surface 33b of the movable core at points opposite to each other with respect to the center of the movable core 33 as seen in the direction of the trip rod 34. Because of such disposition of the first and second parts 100a and 100b of the roller 100, the movable core 33 is pushed with higher stability than if it is pushed with a single roller, and the stability of the resetting action is improved.

The operation of the above described tripping device will now be described. Fig. 10 is a diagram showing transition between various states of the contact operating mechanism including the closing electromagnet 50, the small-power tripping device and the reset mechanism. At the time of tripping, the small-power tripping device changes from an "attracted" state shown in Fig. 9 to a "separated" state" shown in Fig. 6, and the movable contact 2 changes from a closed state shown in Fig. 3 to an open state shown in Fig. 1, while the reset mechanism remains in a "disengaged" state shown in Fig. 4 as well as Fig. 9 and Fig. 6. Closing of the circuit breaker is accomplished in two steps. In a first step, the reset mechanism changes from the disengaged state shown in Fig. 4 and Fig. 6 to an "engaged" state shown in Fig. 5 and Fig. 8, and the small-power resetting device changes from the separated state shown in Fig. 6 to the attracted state shown in Fig. 8, and the movable contact 2 remains in the open state as seen in Fig. 1 and Fig. 2, although the closing electromagnet 50 changes from a "separated" state shown Fig. 1 and an "attracted" state shown in Fig. 2 and some of the components (levers, links, etc.) connected to the electromagnet 50 change their states from Fig. 1 to Fig. 2. In a second step, the reset mechanism changes from the engaged state shown in Fig. 5

and Fig. 8 to the disengaged state shown in Fig. 4 and Fig. 9, the small-power resetting device remains in the attracted state shown in Fig. 8 and Fig. 9, and the closing electromagnet changes from the attracted state shown in Fig. 2 to the separated state shown in Fig. 3, and the movable contact 2 changes from the open state shown in Fig. 2 to the closed state shown in Fig. 3. The above-outlined operation will next be described in detail.

In the state shown in Fig. 3, the movable contact 2 is in the closed position, i.e., the contact part 2a at the upper part the movable contact 2 is in contact with the contact part 1a of the fixed contact 1. The illustrated state is maintained when no current is supplied to the coil 53 and the roller 64 at the lower end of the movable contact 2 is in engagement with the step part 65a of the latch 65. That is, when no current is supplied to the coil 53, the fixed core 52 does not attract the movable core 51, so that by virtue of the closing spring 67 and the returning spring 48, the lower end of the lever 55 is pulled rightward as seen in Fig. 3, the lower end of the lever 56 is pulled rightward to rotate the main lever 56 counterclockwise about the fixed pin 62, the pin 63 connecting the main lever 56 and the movable contact 2 is moved leftward. Consequently, the movable contact 2 is rotated counterclockwise about the roller 64 engaging with the step part 65a of the latch 65, and the upper part of the movable contact 2 is moved leftward, so that the contact part 2a at the upper part of the movable contact 2 is pressed against the contact part 1a of the fixed contact 1. Although the opening spring 66 is urging the upper part of the movable contact 2 rightward, its force alone is not enough to overcome the above mentioned leftward urging, by virtue of the springs 67 and 48.

When the movable contact 2 is in the closed position shown in Fig. 3, the reset mechanism is in the disengaged state shown in Fig. 4, while the small-power tripping device 75 is in the attracted state shown in Fig. 9.

In the disengaged state shown in Fig. 4, the reset lever 81 is in the position illustrated and the roller 100 mounted on the reset lever 81 is disengaged from the movable core 33.

In the attracted state illustrated in Fig. 9, no current is supplied to the coils 37, and the movable core 33 is attracted to the fixed cores 32 because of the magnetic flux in the fixed cores 32 from the permanent magnet 31. The force of the springs 36 urging the movable core 33 upward is suppressed by the attracting force due to the permanent magnet 31. The trip rod 34 is therefore in the retracted position as shown in Fig. 9.

The tripping operation of the circuit breaker is as follows: When a current is supplied to the coils 37, the magnetic flux created by the coils 37 in the fixed cores 32 cancels, at least partially, the magnetic flux from the permanent magnet 31, so that the movable core 33 is separated from the fixed cores 32, by virtue of the force of the springs 36, and the trip rod 34 thereby pushes the latch 65, which thereby rotates clockwise about the pin 74 so that the roller 64 is disengaged from the step of the latch 65, permitting clockwise rotation of the movable contact 2 about the pin 62. This rotation involves rightward movement of the upper part of the movable contact 2, being urged by the opening spring 66, and leftward movement of the lower part of the movable contact 2, being urged by the springs 67 and 48. The force of the springs 67 and 48 that has prevented rightward movement of the upper end of the movable contact 2, is no longer able to do so because the part of the movable contact 2 connected by the pin 63 with the main lever 56 is free to move leftward. As a result, the contact part 2a at the upper part of the movable contact 2 is thereby separated from the contact part 1a of the fixed contact 1, and moves until it abuts on the stopper 68.

When the movable contact 2 is in the open state as illustrated in Fig. 1 and the closing electromagnet 50 is in the separated state as shown in Fig. 1, the reset mechanism is in the disengaged state shown in Fig. 4, and the small-power tripping device 75 in the separated state shown in Fig. 6.

In the open state shown in Fig. 1, the movable contact 2 is separated from the fixed contact 1.

In the separated state shown in Fig. 6, the trip rod 34 is lifted, and as the upper end of the movable contact 2 is pulled by the spring 66 rightward, as shown in Fig. 1, the step part 65a of the latch and the roller 64 at the lower end of the movable contact 2 are left disengaged as shown in Fig. 1.

The operation for closing the circuit breaker is performed in two steps - in first and second steps, as mentioned above. During the closing of the circuit breaker, resetting of the small-power tripping device is also conducted.

More specifically, the first step is as follows: When a current is supplied from a power source, not shown, to the coil 53 of the closing electromagnet 50, the movable core 51 is attracted to the fixed core 52 as shown in Fig. 2, and the lever 55 connected via the link 54 to the movable core 51 rotates clockwise about the fixed pin 73. The main lever 56 connected to the lever 55 via the link 57 and the floating pins 60 and 61 rotates clockwise about the fixed pin 62. When the main lever 56 rotates and the pin 63 moves rightward in the drawings. Because the opening tension spring 66 is pulling the upper part of the movable contact 2 rightward in the drawings, and because the upper part of the movable contact 2 is engaging with the stopper 68 to prevent further rightward movement of the upper part of the movable contact 2, the upper part of the movable contact 2 does not move even if the pin 63 moves rightward. As a result, the lower end of the movable contact 2, with the roller 64, moves moves rightward.

As the roller 64 at the lower part of the movable contact 2 moves rightward, and as the latch 65 is resiliently urged by a spring, not shown, to rotate counterclockwise about the pin 74, the roller 64 rolls over the upper surface 65b of the latch 65, and comes to engagement with the step part 65a of the latch 65. Because of the above-described operation, the contact operating mechanism changes its state from that shown in Fig. 1 to that shown in Fig. 2, and the reset mechanism changes its state from that shown in Fig. 4 to that shown in Fig. 5.

Simultaneously with the above operation, resetting of the small-power tripping device is conducted in the manner described next. The current to the coils 37 is interrupted when the tripping is completed. The clockwise rotation of the lever 55 is transmitted via the link 84 to the lever 80, which thereby rotates counterclockwise about the fixed pin 83, and the reset lever 81 for the small-power tripping device connected to the lever 80 via the link 82 then rotates counterclockwise about the fixed pin 89. Accordingly, the roller 100 mounted at the tip of the reset lever 81 as shown in Fig. 6 moves along an arc, and pushes the movable core 33 downward, compressing the spring 36, and bringing the movable core 33 toward fixed cores 32. In this way, the rotation of the reset lever 81 is converted to a translation movement of the movable core 33. The fixed cores 32 are magnetized by the permanent magnet 31, so as the movable core 32 is brought near the fixed cores 32, the movable core 33 is attracted to and held by the fixed cores 32. Simultaneously therewith, the movable core 33 compresses the opening springs 36 to store energy which will later be used for tripping the circuit breaker. The state which results when the above operation is completed is shown in Fig. 2, Fig. 5 and Fig. 8.

The above described operation is followed by the operation of the second step which includes driving of the movable contact 2 to the closed position. That is, when the movable core 51 contacts the fixed core 52 as shown in Fig. 2, a limit switch, not shown, is operated, to cause a control device to operate and interrupt the current of the closing coil 53.

When the current of the closing coil 53 is interrupted, the fixed core 52 loses the attracting force, and the movable core 51 begins returning to the separated state (shown in Fig. 3), by virtue of the returning tension spring 48, and the mechanism tends to return to the open position that it assumed before the closing operation. Since however the step part 65a of the latch 65 and the roller 64 are now in engagement, the movable contact 2 rotates about the roller 64, so that the contact part 2a at the upper part of the movable contact 2 contacts the contact part 1a of the fixed contact 1, and assumes the closed state shown in Fig. 3. This completes the closing operation. Thus, the contact operating mechanism and the movable contact 2 change their state from that shown in Fig. 2 to Fig. 3.

During the above closing operation of the movable contact 2, the small-power tripping device 75 performs the following operation and assumes a stand-by state, i.e., a state ready for tripping upon excitation of the coil 37. That is, when the current of the closing coil 53 is interrupted, the fixed core 52 loses the attracting force, as described above, and the movable core 51 is returned to the separated state shown in Fig. 3 by virtue of the returning tension spring 48, while the reset mechanism changes its state from that shown in Fig. 5 to that shown in Fig. 4. When the lever 55 rotates counterclockwise, the lever 80 connected to the lever 55 via the link 84 rotates clockwise, and the reset lever 81 connected to the lever 80 rotates clockwise about the fixed pin 89, i.e., changing from the state shown in Fig. 8 to the state shown in Fig. 9. As a result, the roller 100 moves, sliding against the surface of the movable core 33, to be separated from the movable core 33. The movable core 33 however is kept attracted to the fixed cores 32 because of the magnetic flux from the permanent magnet 31. This completes the resetting of the small-power tripping device.

In the above embodiment, the closing device is of a solenoid type. But the closing device may alternatively of a spring-driven type.

In the above embodiment, the reset mechanism of the small-power tripping device is connected to the lever of the closing device. But it may alternatively be connected to any other lever, link, rod, or any other member of the closing device.

In the above embodiment, the tripping device is a small-power tripping device utilizing a permanent magnet, but the invention is applicable to tripping devices of other types, e.g., mechanical types.

The tripping device described above has the following advantages:

First, an operating force at the time of closing the circuit breaker is used for resetting the small-power tripping device, so the opening energy of the small-power tripping device can be made larger, and the small-power tripping device can be used for a circuit breaker which is required to open the contacts at a high speed, such as a direct-current, high-speed circuit breaker.

In the past, a circuit breaker, such as a direc-tcurrent, high-speed circuit breaker, having an electromagnetic tripping device, utilized a holding electromagnet which is bulky and heavy, so the circuit breaker was bulky and heavy. Because the small-power tripping device can be used, as described above, the size and weight of the circuit breaker can be reduced.

In addition, since the small-power tripping device can be driven with a signal of a small power, it can be used in conjunction with an electronic control device. As a result, the accuracy of operation can be improved.

Furthermore, the reset lever rotates and the roller at a tip of the reset lever moves along an arcuate path to push the movable core, so the stroke of the movable core is made constant, without being affected by aging or deterioration.

Moreover, when the roller at the tip of the reset lever comprises two roller parts which are disposed on opposite sides of the center of the movable core, as in the illustrated embodiment, the stability of resetting action is improved.

Claims

1. A small-power tripping device for a circuit breaker having a closing device provided with a first lever (55) which is rotated when a movable core (51) of a closing device is attracted to a fixed core (52) upon excitation of a closing coil (53) to close the circuit breaker;

CHARACTERIZED IN THAT:

a reset lever (81) of the small-power tripping device (75) is connected to said first lever (55) to move together with said first lever (55) thereby to reset the small-power tripping device when the circuit breaker is closed.

2. A device according to claim 1, wherein

said circuit breaker has a fixed contact (1) and a movable contact (2);

said fixed contact has a contact part (1a);

said movable contact (2) has a contact part (2a) at a first end thereof to contact said fixed contact (1), and a roller (64) provided at a second end thereof;

said roller (64) engages with a latch (65) operative responsive to tripping action of said small-power tripping device; and

said movable contact (2) is mounted via a pin (63) to a second lever (56) which in turn is connected to said first lever (55).

3. A device according to claim 2, wherein

when said contact part (2a) of said movable contact (2) is in contact with said fixed contact (1) said latch (65) is in a latching state in which said roller (64) on said second end of said movable contact (1) is latched by said latch (65);

when said small-power tripping device is actuated said latch (65) is rotated in a first direction to release the latching of said roller (64);

said movable contact (2) being rotated in a first direction when said latching is released, so that said contact part (2a) of said movable contact (2) is separated from said contact part (1a) of said fixed contact (1); and

when said movable core (51) is attracted to said fixed core (52), said movable contact (2) is rotated in a second direction and said roller (64) on said second end of said movable contact (2) is thereby latched by said latch (65).

4. A device according to claim 2 or 3, wherein said small-power tripping device comprises:

a permanent magnet (31);

a fixed core (32) coupled to said permanent magnet to permit passage of magnetic flux from said permanent magnet (31);

a trip rod (34);

a movable core (33) connected to said trip rod (34);

said reset lever (81) being provided with a roller (100) at one end of the reset lever (81) which, when said reset lever (81) rotates in a first direction, pushes the movable core (33) to said fixed core (32):

said movable core (33) being kept attracted by said fixed core (32) because of the magnetic flux from said permanent magnet (31) once it is brought near said fixed core (32) being pushed by said roller (100) of said reset lever (81);

a coil (37) wound on said fixed core (32) such that when an electric current is made to flow through said coil (37) a magnetic flux generated in said fixed core (32) because of the current at least partially cancels the magnetic flux from the permanent magnet (31) so that the force of attracting said movable core (33) is reduced;

a compression spring (36) urging said movable core (33) away from said fixed core (32) so that when the force of attracting said movable core (33) is reduced due to the current through said coil (37) said movable core (33) is moved away from said fixed core (32) provided that the movable core (33) is not pushed by said roller (100) of said reset lever (81);

wherein

during resetting said reset lever (81) is rotated in said first direction so that said movable core (33) is pushed toward said fixed core (32) and is attracted to said fixed core (32);

when said reset lever (81) is then rotated in a second direction opposite to said first direction to release said movable core (33) said movable core (33) is kept attracted to said fixed core (32);

at the time of tripping the electric current is made to flow through said coil (37) so that said movable core (33) is moved away from said fixed core (32) to drive said trip rod (34), which in turn rotates said latch (65) in said first direction to release the latching thereby causing separation of said movable contact (2) from said fixed contact (1).

5. A device according to claim 4, further comprising:

a movable core (51) connected to said first lever (55);

a fixed core (52);

a coil (53) wound on said fixed core (52) such that when an electric current is made to flow through said coil (53) said movable core (51) is attracted to said fixed core (52) to thereby rotate said first lever (55) in a first direction, said rotation of said first lever (55) causing rotation of said movable contact (2) in said first direction and separation of said contact part (2a) of said movable contact (2) from said fixed contact (1) provided that said second end of said movable contact (2) is latched by said latch (65).

6. A device according to claim 4, wherein

said movable core (33) has a first surface (33a) facing said fixed core (32) and a second surface (33b) opposite to said first surface (33a), said first surface having a substantially flat part (33c);

said reset lever (81) rotates about an axis fixed relative to said fixed core (32) and at a position farther from said fixed core (32) than said substantially flat part (33c) of said second surface (33b) of said movable core (33);

as said reset roller (81) is rotated in said first direction, said roller (100) is brought into contact with said flat part (33c) of said second surface (33b) of said movable core (33) and then pushes said movable core (33) toward said fixed core (32); and

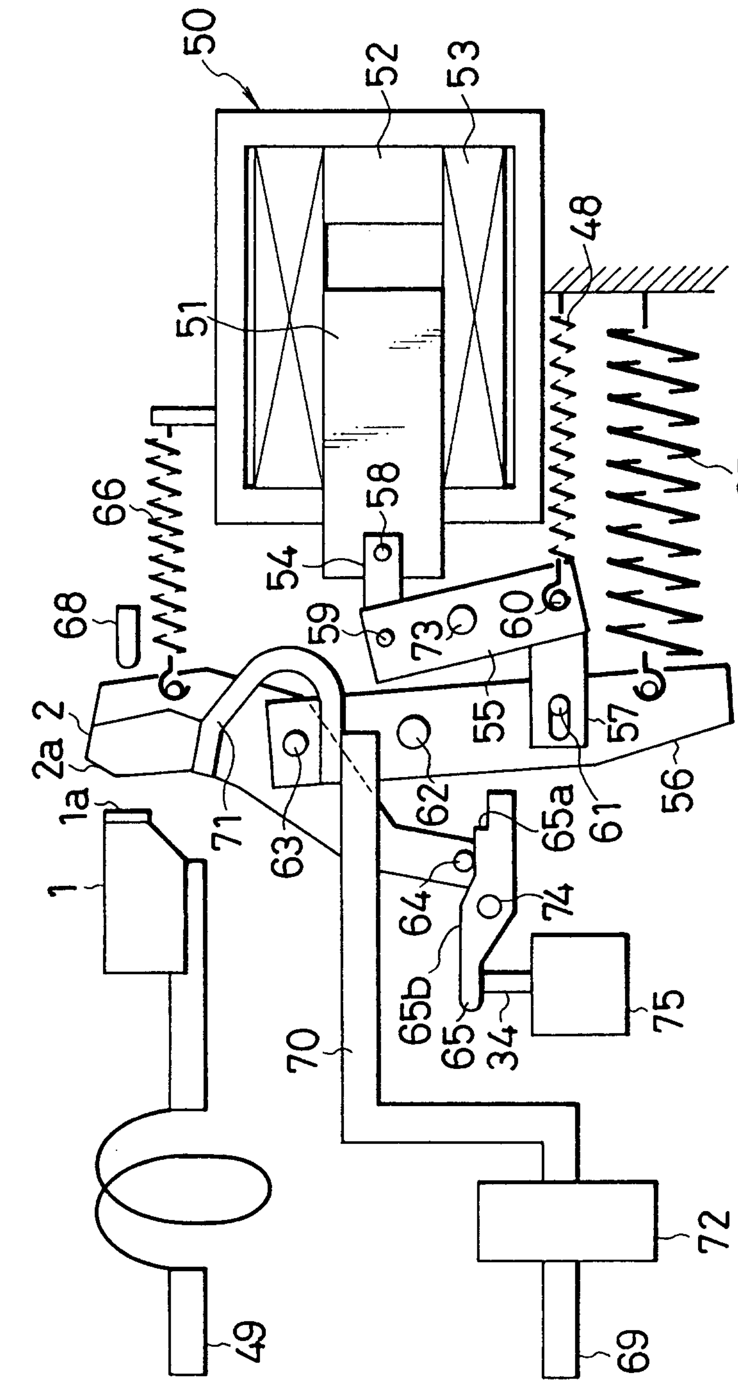
as said reset lever (81) is rotated in said second direction said roller (100) is moved away from said substantially flat surface of said second part of said movable core (33).

7. A device according to claim 6, wherein

said trip rod (34) connected to and extends from said movable core (33), at a point substantially at a center of the movable core as seen in the direction of said trip rod (34); and

said roller (100) comprises first and second roller parts each in the form of a roller, coaxial with each other and having the same radius, and brought into contact with and separated from said substantially flat surface of said second part of said movable core substantially at the same time at points opposite to each other with respect to said center of said movable core.

FIG. 1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65b
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FIG. 2

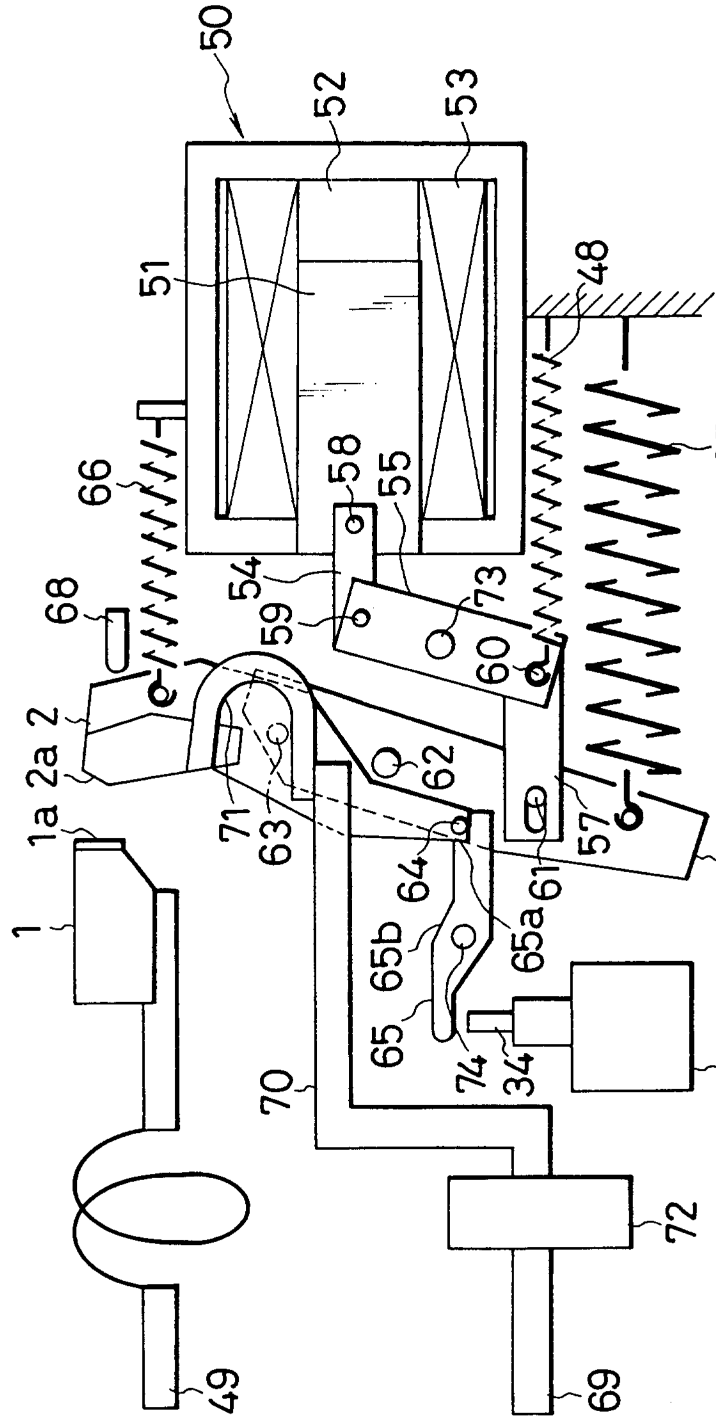
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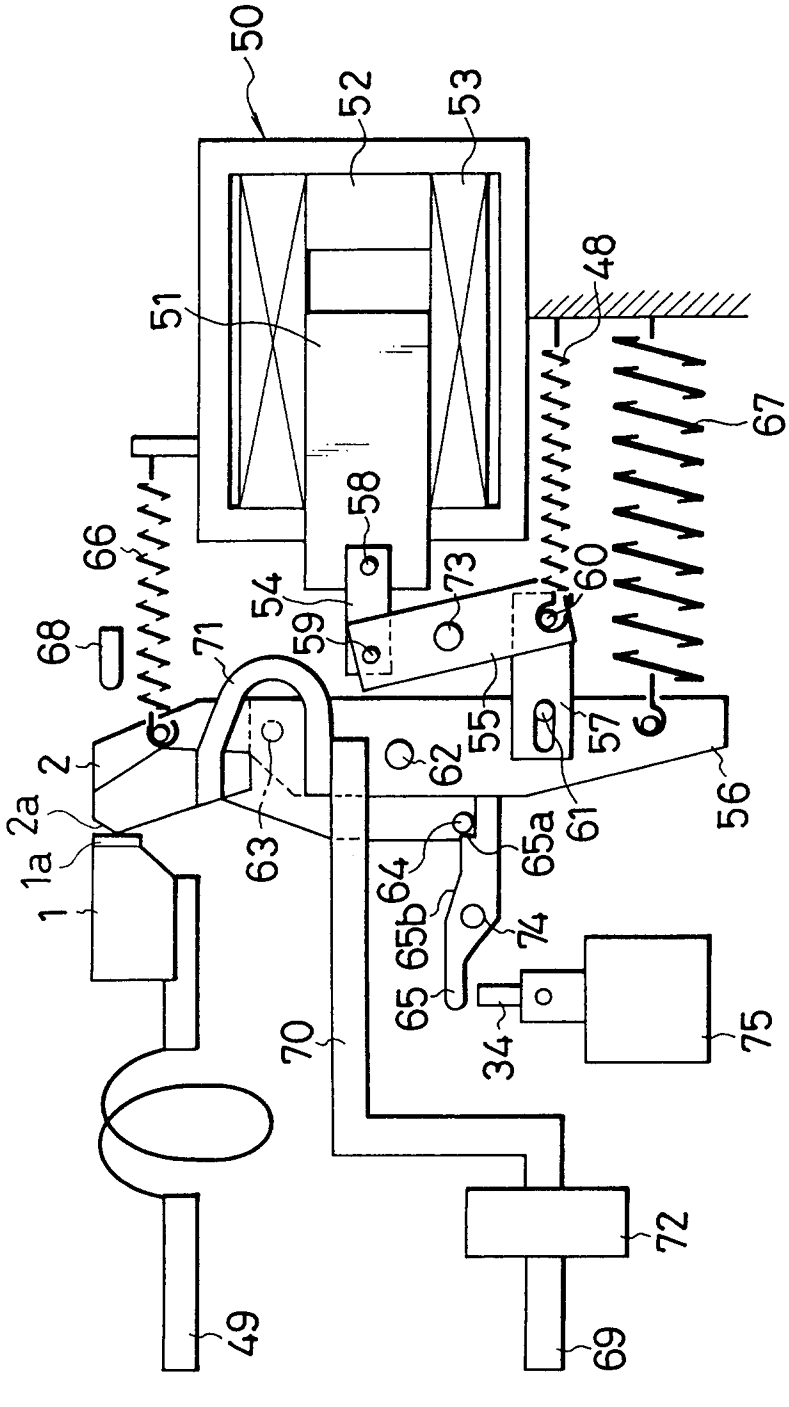
FIG. 3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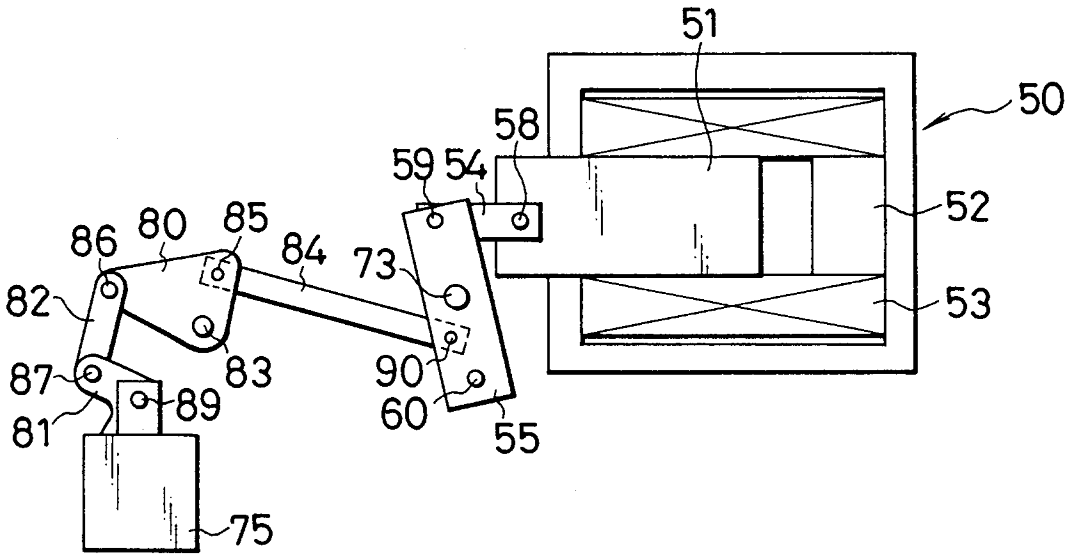
69

FIG. 4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81
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75

FIG. 5

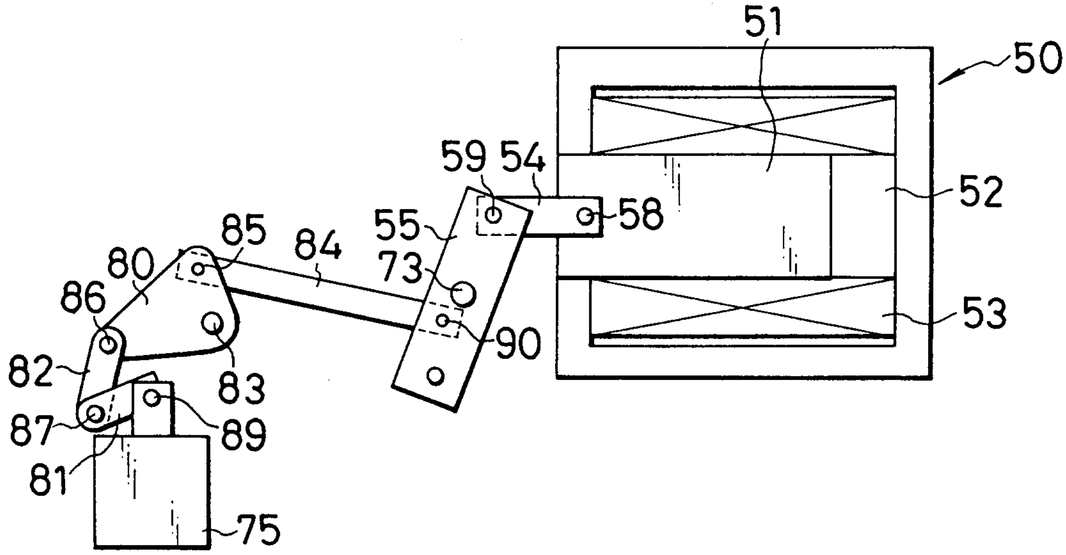
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FIG. 6

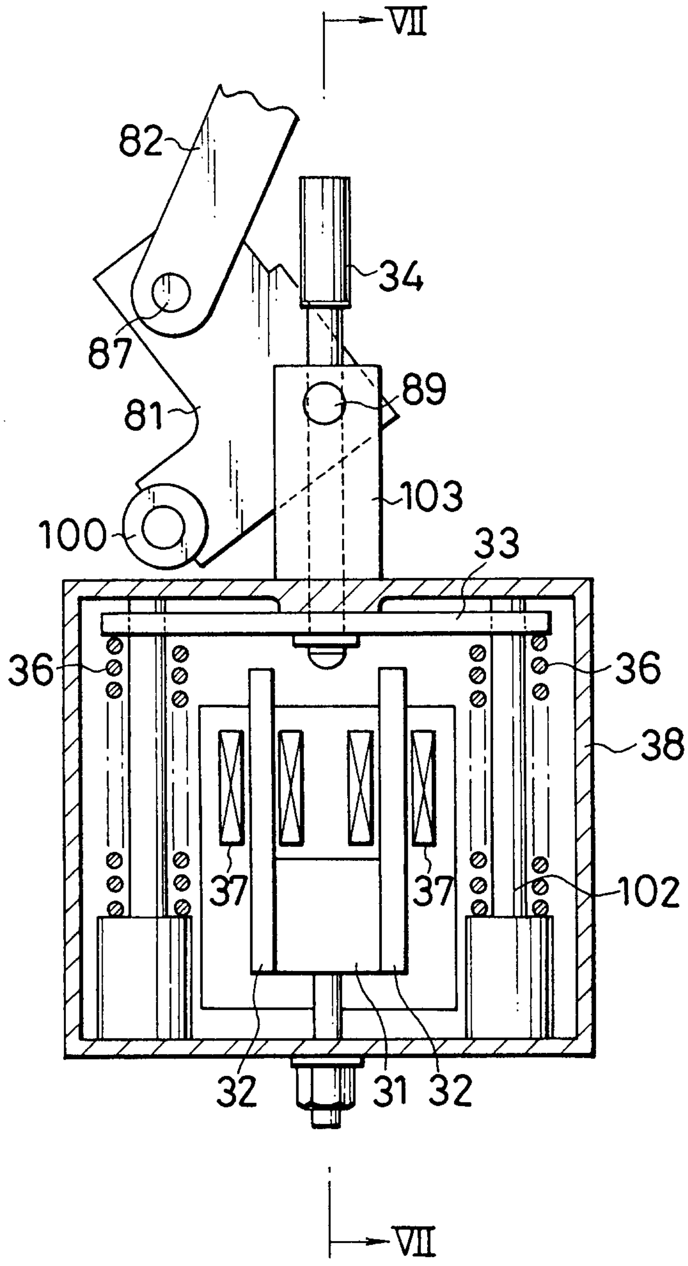
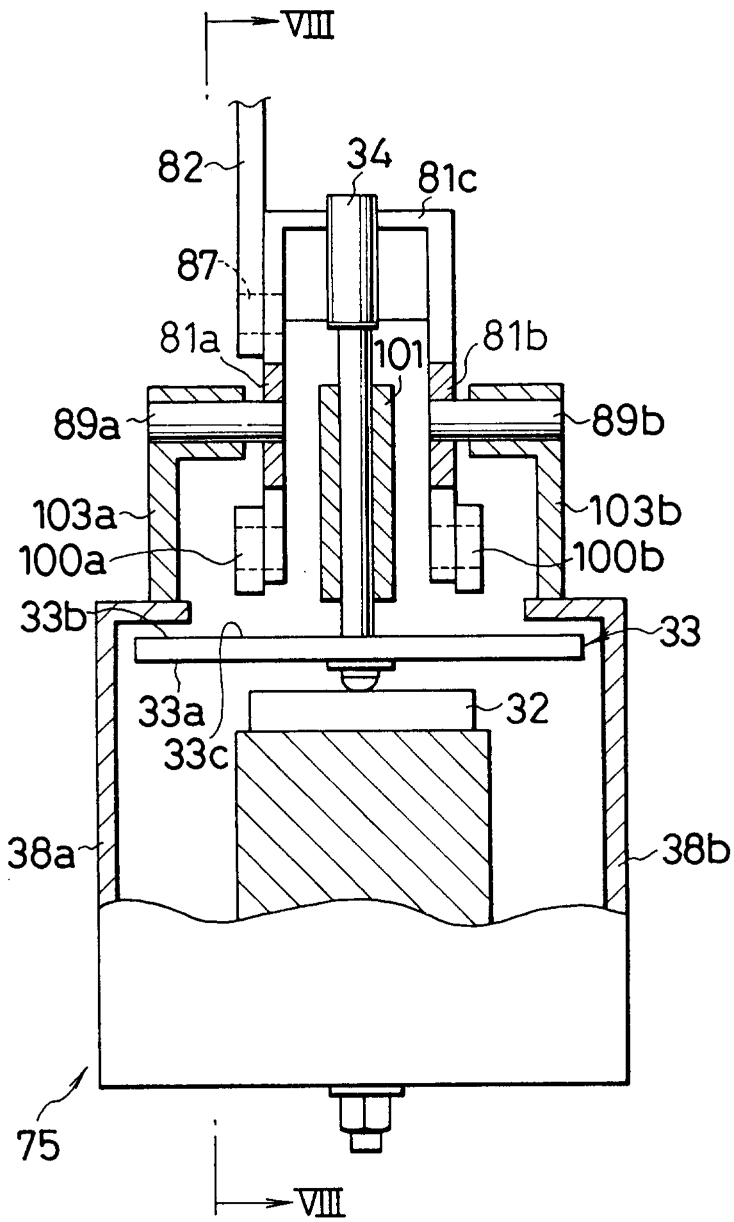


FIG. 7


VIII
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33c
38a
38b
75
VIII

FIG. 8

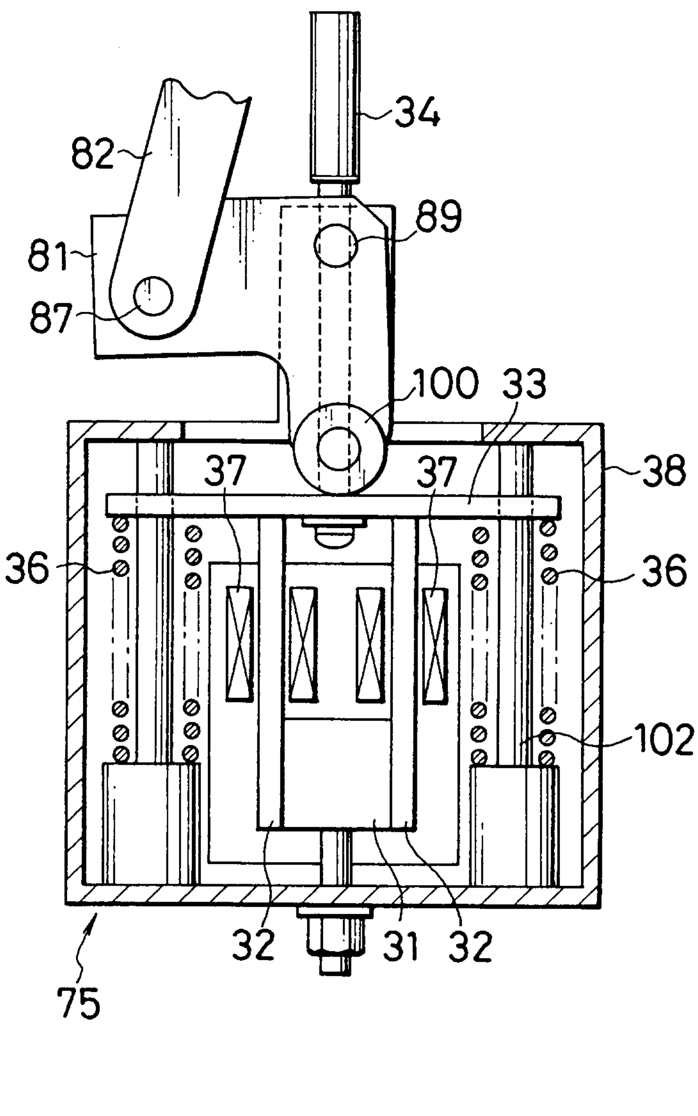


FIG. 9

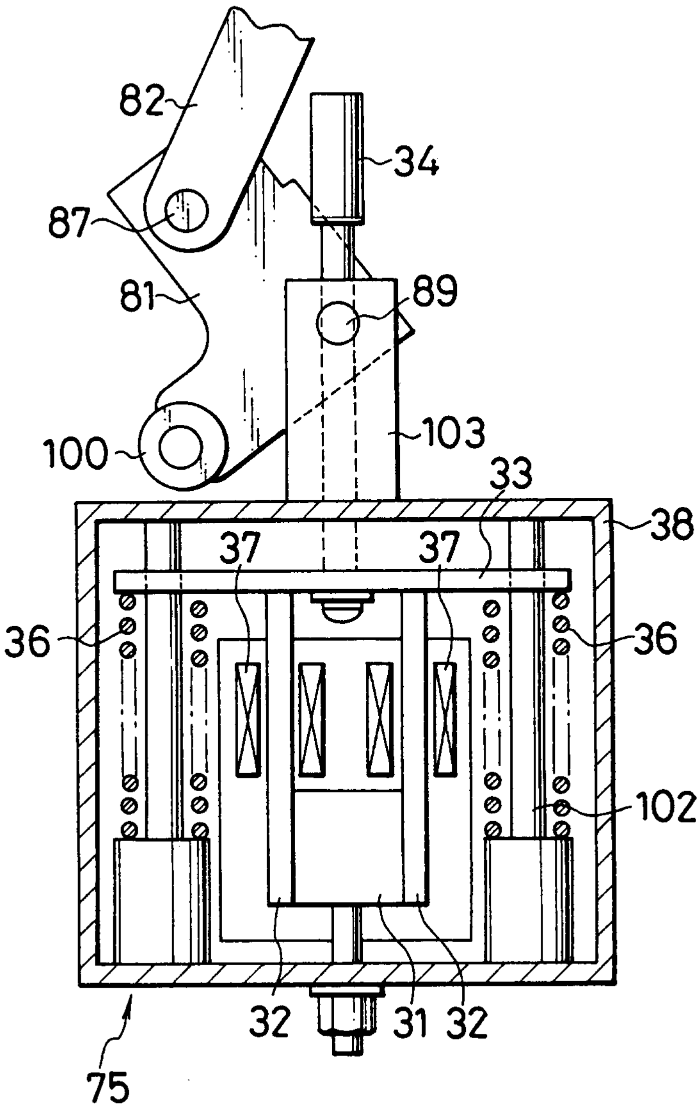


FIG.10

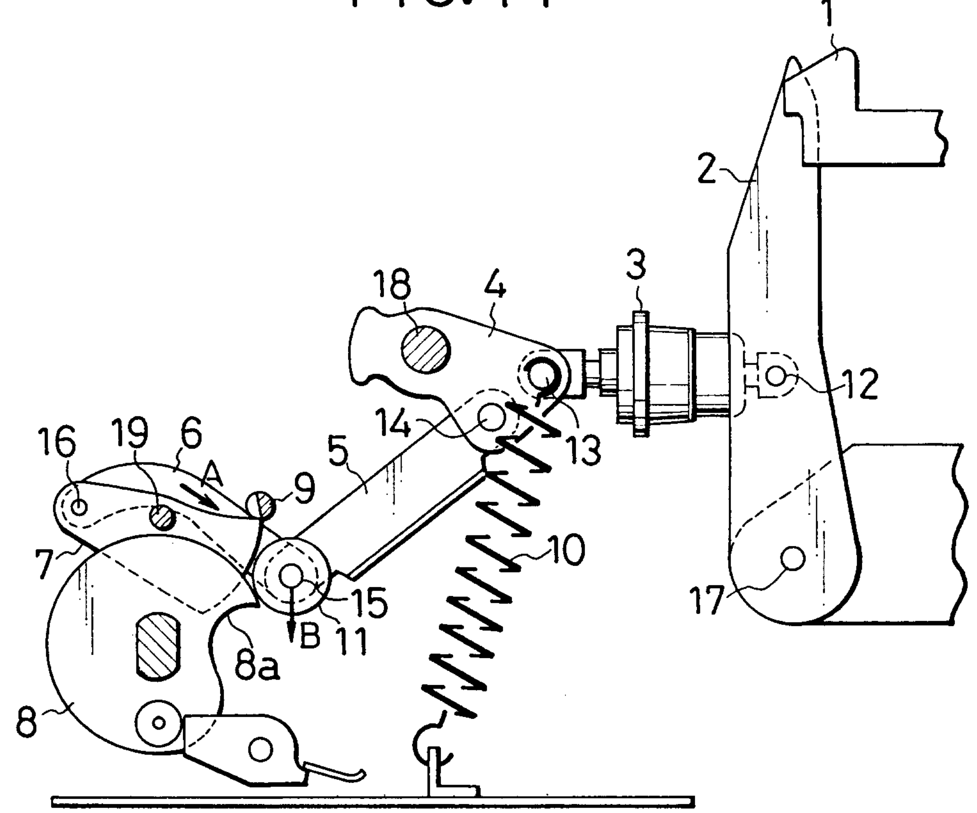
MOVABLE CONTACTOR 2	CLOSING ELECTRO-MAGNET 50	SMALL-POWER TRIPPING DEVICE 75	RESET MECHANISM
OPEN FIG. 1	SEPA-RATED FIG. 1	SEPA-RATED FIG. 6	DIS-ENGAGED FIG. 4
OPEN FIG. 2	ATTRAC-TED FIG. 2	ATTRAC-TED FIG. 8	ENGAGED FIG. 5
CLOSED FIG. 3	SEPA-RATED FIG. 3	ATTRAC-TED FIG. 9	DIS-ENGAGED FIG. 4

1st STEP OF CLOSING

2nd STEP OF CLOSING

TRIPPING

FIG. 11


1
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A
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15
B
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17
8a
8

FIG. 12

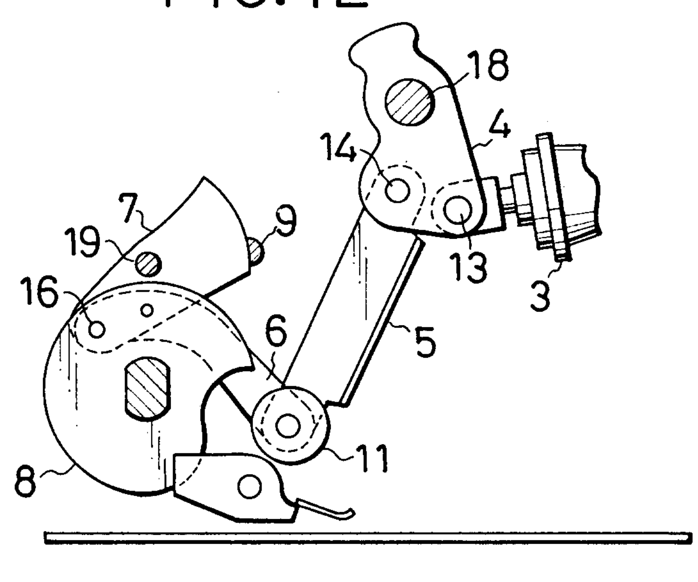
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FIG. 13

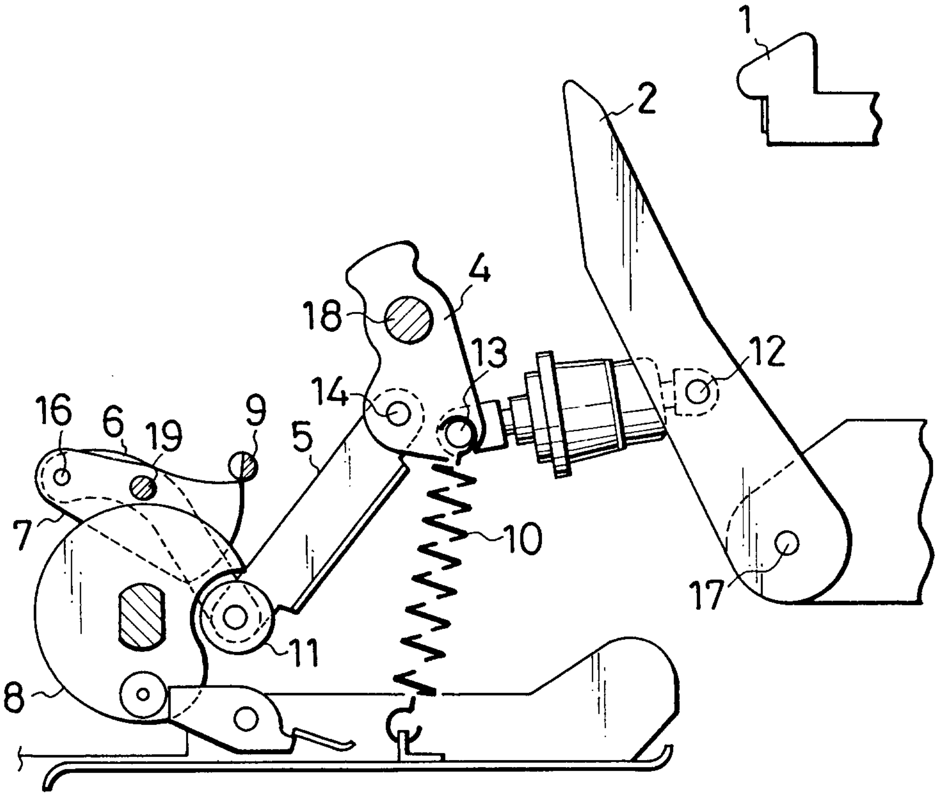


FIG.14

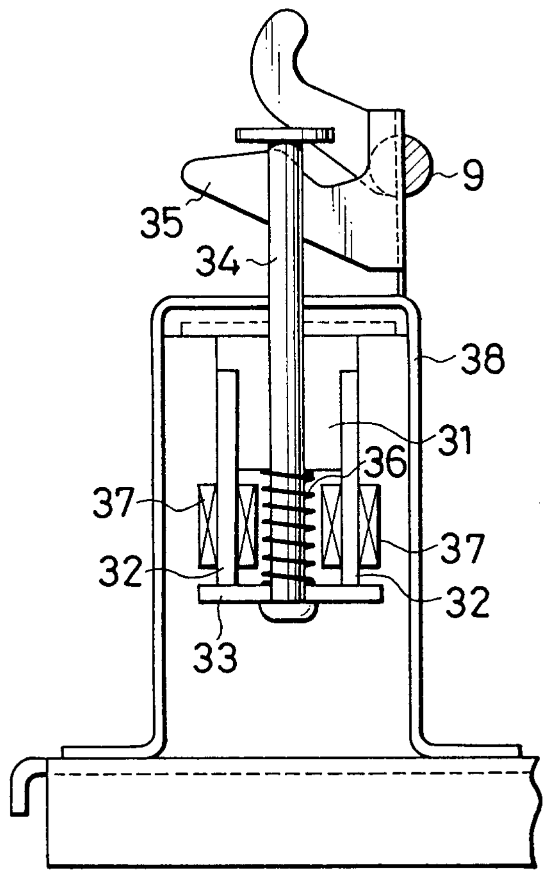


FIG.15

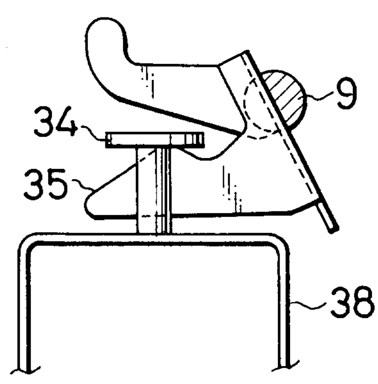
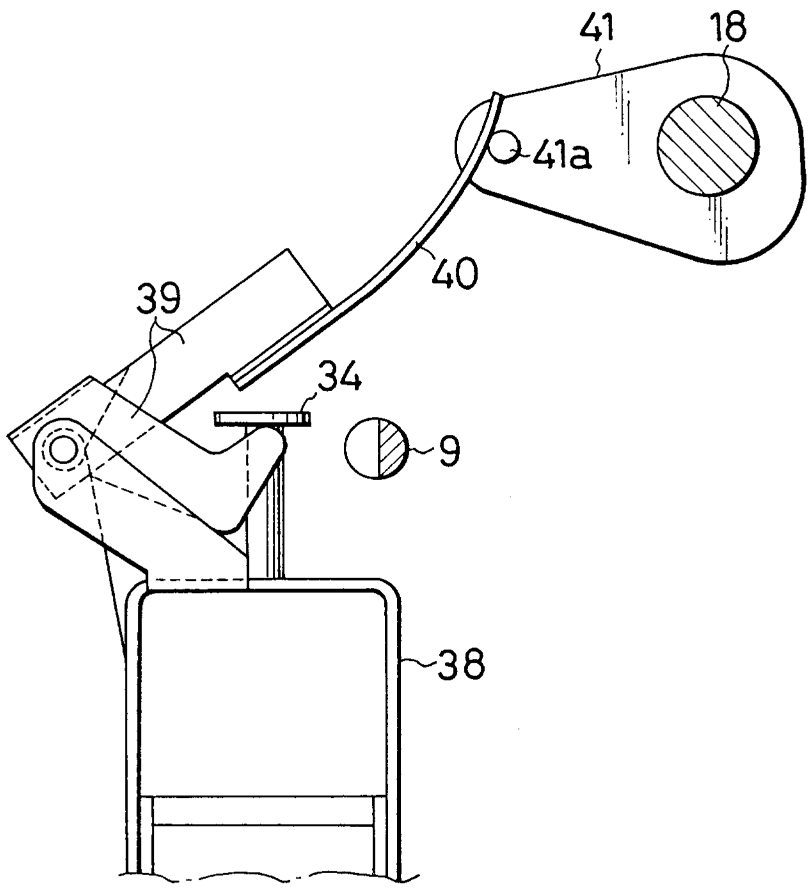


FIG.16



European Patent Office

EUROPEAN SEARCH REPORT

Application Number

EP 92 11 9381

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-3 940 723 (M. HORIKAWA) * column 3, line 7 - column 5, line 37; figures 1-3 * ---	1,2	H01H71/68
A	DE-C-1 128 009 (LICENTIA PATENT-VERWALTUNGS-GMBH) -----		
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
BERLIN	16 FEBRUARY 1993	RUPPERT W.

CATEGORY OF CITED DOCUMENTS

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