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(54) **Auxiliary device for circuit breakers**

(57) An auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold, comprising an insulating enclosure which contains a fixed magnet on which a coil is wound, a moving magnet and connecting terminals, further comprising:

- actuation means which are operatively connected to and actuated by the moving magnet;

- a kinematic chain operatively connected to said actuation means;
- means for coupling to the circuit breaker which are operatively connected to the kinematic chain;
- means for the local visual indication of the open state of the circuit breaker due to a condition of supply voltage lower than a threshold, actuated by said actuation means.

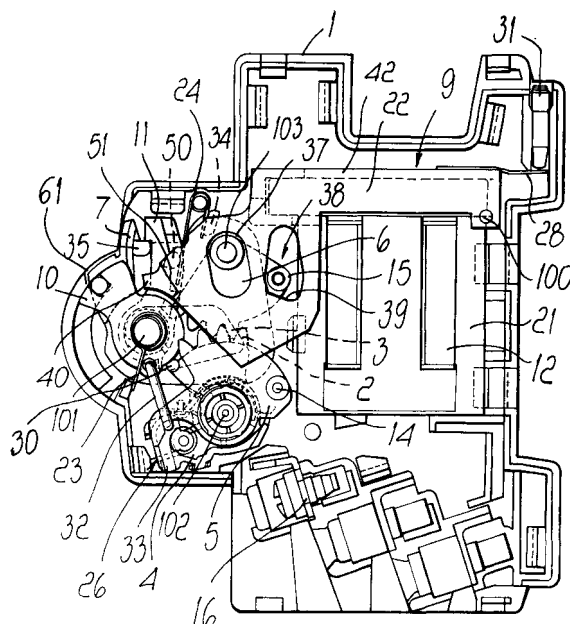


Fig. 1

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Description

[0001] The present invention relates to an auxiliary actuation device for opening a circuit breaker associated therewith if the supply voltage drops below a preset threshold. More particularly, the present invention relates to an auxiliary device, known in the art as undervoltage relay, which has improved shape and characteristics.

[0002] It is known that magnetothermal or residual-current circuit breakers for low-voltage electrical applications are generally coupled to suitable auxiliary devices. These devices are conventionally of two kinds, respectively an actuating type and an actuated type, depending on whether they act on the circuit breaker and actuate an action thereof or perform an action as a consequence of an actuation received from said circuit breaker.

[0003] A typical example of an actuating auxiliary device is constituted by an undervoltage relay, whose main function is to allow to protect loads which are connected to a power supply line, such as for example electric motors, against supply conditions which are not optimum for their operation. The undervoltage relay is in fact supplied by a voltage which is correlated to the voltage of the line to which the load to be protected is connected. If the value of the line supply voltage drops below a threshold, the relay trips, causing the circuit breaker associated therewith to open and therefore interrupting the supply of power to the load. If this did not occur, the load would operate in non-optimum conditions which might cause malfunctions and even damage to said load.

[0004] As a consequence of the opening determined by the relay, the circuit breaker actuates, by means of appropriate lever systems, a kinematic mechanism inside a device for signaling the state of the circuit breaker associated therewith, which accordingly constitutes an actuated device. In turn, the actuated device provides operators with a signal which corresponds to the current state of the circuit breaker.

[0005] As regards the coupling between the circuit breaker and the auxiliary devices, one of the solutions generally used entails placing all the auxiliary devices on a same side of the circuit breaker relative to a front view of said circuit breaker. In this case, the mechanical connection between the circuit breaker and the auxiliary devices is achieved by using a shaft which is shaped so as to have multiple protrusions and transmits the movements among the various components, according to a solution which is particularly disadvantageous from the point of view of production as well as from the point of view of functionality. The shaft that is used in fact requires accurate machining in order to form the protrusions and the dimensions required to take into account the different stress levels and the considerable clearances involved. This leads to an increase in production costs and possibly to a reduction in the precision and overall reliability of the assembly constituted by the cir-

cuit breakers and the auxiliary devices.

[0006] Another solution that is used for coupling the circuit breaker and the auxiliary devices is to distribute the devices on both sides of the circuit breaker; in particular, relative to a front view of the circuit breaker, the actuating auxiliary devices according to the present invention are always fitted on the same side of the circuit breaker, for example on the left, while the actuated ones are fitted on the other side, on the right.

[0007] This coupling solution is particularly advantageous with respect to the one described earlier both because it considerably facilitates users in practical applications and because it allows to use a shaft with a smaller number of protrusions, which is accordingly simpler and cheaper to machine; moreover, the mechanical stresses that occur are more balanced and clearance is reduced.

[0008] However the drawback of this solution lies in the fact that magnetothermal and residual-current low-voltage circuit breakers have moving contacts which are mechanically mutually different and can be arranged differently inside the circuit breakers according to specific applications and/or to the applicable national standards. For example, with specific reference to a magnetothermal circuit breaker of the two-pole type, the moving contacts comprise phase contacts and neutral contacts which are mechanically different from each other and can be located either on the right side or on the left side of said circuit breaker relative to a front view thereof. Accordingly, since the undervoltage relay is an actuating auxiliary device, it is generally always fitted on the same side of the circuit breaker, for example on the left; in the current state of the art, this leads to the need to produce a plurality of separate series of actuation devices according to the constructive structure of the circuit breaker to which they will be coupled, increasing constructive complexity and production costs. Further, when an actuating auxiliary device is coupled to a circuit breaker, the kinematic mechanisms for opening the contacts of the circuit breaker can be affected negatively by the corresponding kinematic systems of said auxiliary device; in particular, the opening speed of the circuit breaker might be reduced, accordingly leading to malfunctions or even to breakage of said circuit breaker.

[0009] A further drawback is the fact that if the circuit breaker opens, for example due to a drop in the supply voltage below a threshold, in the current state of the art conventional actuating auxiliary devices are not provided with means for local visual indication means which protrude outside the device and allow easy and immediate identification of the tripped circuit breaker; this furthermore prevents resetting the auxiliary device without directly acting on the open circuit breaker.

[0010] The aim of the present invention is to provide an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold in which the coupling to the residual-current or magnetothermal circuit breaker occurs fully inde-

pendently of the arrangement of the contacts inside it, with a considerable benefit from the point of view of production.

[0011] Within the scope of this aim, an object of the present invention is to provide an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold in which the coupling with the circuit breaker does not affect the kinematic mechanisms of said circuit breaker, accordingly preserving its design characteristics, particularly in terms of contact opening speed in case of triggering due to a fault. Another object of the present invention is to provide an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold in which there is a local visual indication of the open state of the circuit breaker caused by a said supply voltage being lower than a threshold.

[0012] Another object of the present invention is to provide an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold in which it is possible to reset the auxiliary device without direct intervention on the circuit breaker. Another object of the present invention is to provide an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold which is highly reliable, relatively easy to provide and at competitive costs.

[0013] This aim, these objects and others which will become apparent hereinafter are achieved by an auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold, comprising an insulating enclosure which contains a fixed magnet on which a coil is wound, a moving magnet and connecting terminals, characterized in that it comprises;

- actuation means which are operatively connected to and actuated by the moving magnet;
- a kinematic chain operatively connected to said actuation means;
- means for coupling to the circuit breaker which are operatively connected to said kinematic chain;
- means for the local visual indication of the open state of the circuit breaker due to a condition of supply voltage lower than a threshold, actuated by said actuation means.

[0014] The device thus conceived ensures a coupling with the circuit breaker associated therewith which is fully independent of the mechanical structure of the circuit breaker and of the arrangement of the contacts inside it. Furthermore, said coupling does not affect at all the performance of the circuit breaker, especially in terms of opening speed during triggering caused by a fault.

[0015] Further characteristics and advantages of the present invention will become apparent from the following detailed description of preferred but not exclusive embodiments of the auxiliary device according to the in-

vention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a schematic side view of the auxiliary device according to the invention, in a position which corresponds to the position in which the associated circuit breaker is closed;

Figure 2 is a schematic side view of the auxiliary device in a position which corresponds to the position in which the associated circuit breaker is open due to direct intervention of an operator on said circuit breaker;

Figure 3 is a schematic side view of the auxiliary device in a position which corresponds to the position in which the associated circuit breaker is open due to the supply voltage being lower than a threshold;

Figure 4 is a perspective view of a reset and indication lever used in the device according to the invention;

Figure 5 is a perspective view of an engagement lever used in the device according to the invention;

Figure 6 is a perspective view of an actuation lever used in the device according to the invention.

[0016] With reference to the above figures, the device according to the invention comprises an insulating enclosure 1 inside which there is an electromagnetic element which comprises a fixed magnet 21 whereon a coil 12 is wound and a moving magnet 22 which is pivoted in a point 100 and with which a return spring 28 is associated.

[0017] In normal operating conditions, i.e., when the associated circuit breaker is closed, the coil 12, whose terminals are connected to connection terminals 16, is supplied with electric power by means of a suitable power supply circuit. In particular, the circuit provides a supply voltage which is a function of the voltage of the line in which the device and the circuit breaker associated therewith are inserted. Figures 1 and 2 illustrate a single terminal 16, but the device in actual fact comprises a second connection terminal 16 which is superimposed on the first one.

[0018] This arrangement generates a magnetic field whose intensity allows to contrast the force applied by the return spring 28 on the moving magnet 22 and to keep the latter coupled electromagnetically to the fixed magnet 21 in the position shown in Figure 1. In particular, the return force applied by the spring 28 can be adjusted appropriately by means of an adjustment screw 31 which acts directly on said spring 28. This allows to make the device easily suitable to the applicable standards and/or to specific application requirements.

[0019] If the line supply voltage drops below a preset threshold, the intensity of the magnetic field generated by the coil 12 is no longer sufficient to contrast the force applied by the spring 28, which pulls the moving magnet 22 and moves it into the position shown in Figure 3.

[0020] Advantageously, the movement of the moving magnet 22 actuates a suitable kinematic mechanism which opens the circuit breaker in a way described in detail hereinafter. The device according to the invention comprises means for coupling to the circuit breaker which comprise a tripping lever 5, a coupling lever 6 and a transmission lever 10 whose function and connections are described hereinafter.

[0021] Actuation means actuated by the moving magnet comprise an actuation lever 9. Further, there are means for the local visual indication of the open state of the circuit breaker due to the supply voltage being lower than a threshold; said means comprise a reset and indication lever 7 and an engagement lever 11.

[0022] In particular, the transmission lever 10 is pivoted in a point 101 of the enclosure 1 with which a return spring 23 is associated; the engagement lever 11 is furthermore arranged on the same pivoting point 101, whereas the reset and indication lever 7 is pivoted in a point 103. The transmission lever 10 is detachably connected, by means of a U-shaped element 32, to a kinematic chain, comprising an actuation lever 4, and to the tripping lever 5, both of which are pivoted to a point 102 of the enclosure 1; an actuation spring 26 whose function will be described in greater detail hereinafter acts on the lever 4.

[0023] As shown in Figure 6, the actuation lever 4 has a pivot 30 which can interact with the surface of a slot 31 of the lever 7 and a groove 33 in which the U-shaped element 32 can slide. The tripping lever 5 comprises a pivot 14 for coupling to the tripping mechanism of the circuit breaker and has the particularity of having a toothed sector 2 whose function will be described hereinafter.

[0024] As shown in Figure 4, the reset and indication lever 7 has, in addition to the slot 31, a first raised portion 34, on which a first end of a spring 24 acts, and a second raised portion 35, which interacts against a shaped wall 36 of the engagement lever 11. Said engagement lever 11, shown in detail in Figure 5, furthermore has a pivot 50 on which the second end of the spring 24 acts. In practice, in the position shown in Figure 1, the spring 24 pushes on one side against the raised portion 34, forcing the lever 7 to turn clockwise, and against the pivot 50 at the other side, forcing the lever 11 to turn counterclockwise. Accordingly, the levers 7 and 11 move against each other, facilitating contact between the second raised portion 35 and the shaped wall 36 and remaining engaged in the inactive position shown in Figure 1. The device according to the invention comprises the actuation lever 9 which is operatively actuated by the moving magnet; further, the lever 9 is pivoted to a point 100 of the enclosure 1 and is connected to a return spring 28. The lever 9 is composed of two parts: a first part is shaped so as to form a seat 42 for geometric coupling to the moving magnet 22 and a second part protrudes from the first one, two slots 37 and 38 being formed thereon; in particular, the slot 38 has a substantially straight

shaped portion 39 for the purpose described hereinafter. A wing 40 is further provided on the lever 9 and has a protrusion which is substantially perpendicular to the median plane of the lever 9 and is suitable to interact with the pivot 50 of the lever 11 and with the second raised portion 35.

[0025] Advantageously, the device according to the invention comprises an additional coupling lever 6, pivoted to the point 103, which has a pivot 15 for optional coupling to the kinematic mechanism of the associated circuit breaker, and a toothed sector 3 which is operatively coupled to the toothed sector 2 of the tripping lever 5. In practice, once the kinematic mechanism of the device is actuated, the two toothed sectors 2 and 3 mutually mesh, rotating with respect to each other in opposite directions.

[0026] This constructive solution allows to provide a coupling of the auxiliary device to the circuit breaker which is fully independent of the arrangement of the contacts inside it. If the position of the poles in the circuit breaker changes, the coupling between the auxiliary device and the circuit breaker can in fact be provided either on the pivot 14 or on the pivot 15. Furthermore, the change in the direction of rotation of the mechanism of the circuit breaker according to the arrangement of the poles is rendered irrelevant in terms of the functionality of the coupling between the circuit breaker and the device by the presence of the two contrarotating toothed sectors 2 and 3.

[0027] The fact should be noted that with this solution the movement of the kinematic system inside the device does not affect at all the corresponding movement in the circuit breaker, since the pivot 15 can move without hindrance inside the slot 38; accordingly, if the circuit breaker trips due to a fault, the performance of the circuit breaker in terms of opening speed are not altered in any way.

[0028] A further innovative aspect of the actuation device according to the invention is provided by the fact that the lever 7 has a shaped protrusion 60 which, when the circuit breaker opens because the supply voltage is below a preset threshold, protrudes from a corresponding opening 61 formed in the enclosure 1 and therefore allows local visual indication of the tripping of the associated circuit breaker due to the supply voltage being lower than a given threshold. Furthermore, once the protrusion 60 has protruded from the enclosure, it directly provides a button on which an operator can, for any requirement, act directly to reset the auxiliary device without having to act on the associated circuit breaker, which accordingly remains open. The lever 7 therefore simultaneously provides local indication of an open circuit breaker and resetting of said auxiliary device. In further embodiments, not illustrated by figures, said protrusion might be associated with other levers of the kinematic mechanism of the device.

[0029] The operation of the device according to the invention is now described starting from the operating

condition shown in Figure 1, which corresponds to a position in which the associated circuit breaker is closed.

[0030] When the circuit breaker is opened due to manual intervention of an operator who acts directly on the actuation knob, the mechanism of the circuit breaker transmits the motion to the transmission lever 10, which turns in the direction indicated by the arrow 105, pulling the U-shaped element 32 and reaching, at the end of its motion, the position shown in Figure 2. The lever 4, under the action of the U-shaped element 32, rotates about its own pivoting axis 102, in the direction indicated by the arrow 106, and reaches the position shown in Figure 2. At the same time, the levers 5 and 6 also rotate in mutually opposite directions, facilitating the meshing of the two toothed sectors 2 and 3.

[0031] The remaining part of the mechanism is substantially not affected by the movement, since the coil 12 continues to be supplied correctly.

[0032] When the mains supply voltage drops below a preset value, the supply voltage of the coil 12 also decreases correspondingly; accordingly, when the supply voltage of the coil 12 drops below a preset threshold value, the return force of the spring 28 is no longer effectively contrasted by the magnetic field generated by the coil 12 and causes the separation of the moving magnet 22 from the fixed magnet 21. By means of this rotation, the shaped portion 39 of the slot 38 pushes against the pivot 15 of the lever 6, forcing it to rotate in the direction indicated by the arrow 107. The toothed sector 3 meshes with the toothed sector 2 of the lever 5, causing the movement of the pivot 14 in the direction indicated by the arrow 108; in this manner, the circuit breaker receives motion either directly by means of the pivot 15 or indirectly from the lever 5 by means of the pivot 14 and the meshing of the two toothed sectors 2 and 3: furthermore, by virtue of this rotation the tripping lever 5 disengages the U-shaped element 32, which becomes able to slide freely in the groove 33 of the lever 4. Advantageously, the actuation lever 4, no longer locked by the U-shaped element 32, rotates under the action of the thrust of the spring 26 in the direction indicated by the arrow 106 and simultaneously facilitates a faster rotation of the lever 5. This simultaneous rotation is achieved by means of a spring, not shown, which is interposed between the levers 4 and 5 and couples their movement; said spring is conveniently inserted in a seat 80 of the lever 4. Therefore, in this situation the potential energy accumulated earlier by the spring 26 is utilized; once said energy has been released, it provides the force required to ensure the prompt movement of the mechanism and the consequent correct intervention of the circuit breaker.

[0033] Furthermore, during rotation the wing 40 of the lever 9 interacts with the pivot 50, pushing it toward the inside of the device and disengaging the shaped wall 36 from the engagement with the second raised portion 35. In this manner, the lever 7, pushed by the action of the spring 24 on the raised portion 34, rotates about the piv-

oting axis 103 and the shaped protrusion 60 protrudes from the enclosure 1 through an opening 61, providing a local visual indication that the circuit breaker has tripped because the voltage was lower than the preset threshold. At the end of the actuation, the transmission lever 10, following the movement of the associated circuit breaker, reaches the position shown in Figure 3, in which the U-shaped element 32 re-engages the levers 4 and 5.

[0034] In this condition, an operator can therefore reset the auxiliary device simply by acting on the protrusion 60; by pushing the protrusion 60, the second raised portion 35 in fact pushes against the wing 40 of the lever 9 until it reaches a position which is suitable for re-engagement with the shaped wall 36; this re-engagement is facilitated by the thrust applied by the spring 24, which acts on a raised portion 70 of said lever 11. The thrust applied on the wing 40 of the lever 9 furthermore facilitates the movement of the moving magnet 22 toward the fixed one 21 and therefore the reduction of the existing gap. This provides the advantage of being able to optimize the dimensions of the electromagnetic part (moving magnet 22, fixed magnet 21 and coil 12), consequently providing savings in terms of materials, dimensions and costs.

[0035] In such conditions, if the line supply voltage is still below the preset threshold, the device trips again as described above and prevents the closure of the circuit breaker and the restore of the power supply of the load that it protects.

[0036] The device can also be reset by acting on the control knob of the circuit breaker. In this case, the movement is transmitted from the circuit breaker to the transmission lever 10 which pushes the lever 4 by means of the U-shaped element 32; the pivot 30, during the movement of the lever 4, acts against the surface of the slot 31 of the lever 7 and pulls it downward, causing it to rotate. By means of this rotation, the second raised portion 35 couples to the shaped wall 36 and pushes downward the protrusion 40, as described earlier. In this case also, if the supply voltage is still below the threshold value, the device causes the circuit breaker to reopen.

[0037] In practice it has been observed that the auxiliary actuation device according to the invention fully achieves the intended aim, since it allows to provide a coupling with the circuit breaker independently of the mechanical structure of the circuit breaker and of the arrangement of the contacts inside it without affecting its performance in any way; furthermore, by means of the adoption of the particular constructive refinements described above, it is possible to locally and directly identify the opening of the circuit breaker, with consequent reset of said device. The fact should also be noted that all the innovative functions and the inventive aspects of the device can be achieved by using commonly commercially available elements and materials with extremely modest costs.

[0038] The auxiliary device thus conceived is susceptible of numerous modifications and variations, all of which are within the scope of the inventive concept; all the details may furthermore be replaced with other technically equivalent elements.

[0039] In practice, the materials used, as well as the dimensions, may be any according to the requirements and the state of the art.

Claims

1. An auxiliary device for opening a circuit breaker associated therewith if the supply voltage is lower than a threshold, comprising an insulating enclosure which contains a fixed magnet on which a coil is wound, a moving magnet and connecting terminals, characterized in that it comprises;

- actuation means which are operatively connected to and actuated by the moving magnet;
- a kinematic chain operatively connected to said actuation means;
- means for coupling to the circuit breaker which are operatively connected to said kinematic chain;
- means for the local visual indication of the open state of the circuit breaker due to a condition of supply voltage lower than a threshold, actuated by said actuation means.

2. The auxiliary device according to claim 1, characterized in that said means for coupling to the circuit breaker comprise two levers, respectively a tripping lever and a coupling lever, which are operatively connected to each other, said levers comprising a pivot for coupling to the circuit breaker.

3. The auxiliary device according to claim 2, characterized in that the coupling and tripping levers are mutually operatively connected by means of two toothed sectors which are associated with said levers and mutually mesh, rotating with respect to each other in mutually opposite directions.

4. The auxiliary device according to claim 1, characterized in that said means for coupling to the circuit breaker comprise a transmission lever which is operatively connected to the circuit breaker and with which a return spring is associated.

5. The auxiliary device according to claim 2, characterized in that said actuation means actuated by the moving magnet comprise an actuation lever with which a return spring is associated, said actuation lever having a seat for geometric coupling to the moving magnet, and a slot provided with a substantially straight portion which can interact with the piv-

ot of the coupling lever.

6. The auxiliary device according to claim 5, characterized in that it comprises an adjustment screw which is suitable to adjust the force applied by the return spring to the actuation lever.

7. The auxiliary device according to one or more of the preceding claims, characterized in that said kinematic chain comprises an actuation lever provided with a groove in which a U-shaped element slides, said U-shaped element being suitable to detachably connect said actuation lever and the tripping lever to the transmission lever.

8. The auxiliary device according to one or more of the preceding claims, characterized in that a first spring and a second spring are associated with said actuation lever, said first spring being suitable to supply an amount of energy suitable to open the circuit breaker, said second spring being inserted in a seat of the actuation lever and being suitable to operatively couple the tripping lever and said actuation lever.

9. The auxiliary device according to one or more of the preceding claims, characterized in that said means for the local visual indication of the open state of the circuit breaker due to said supply voltage being lower than a threshold comprise a reset and indication lever and an engagement lever, respectively provided with a first raised portion and with a shaped wall which can be geometrically coupled to each other, said first raised portion being able to interact with a wing formed on the surface of the actuation lever of said actuation means.

10. The auxiliary device according to claim 9, characterized in that the reset and indication lever has a protrusion which can protrude from an opening of the enclosure following the opening of the circuit breaker caused by the supply voltage being lower than a threshold.

11. The auxiliary device according to one or more of the preceding claims, characterized in that said reset and indication lever has a second raised portion, on which a first end of a spring acts, and a slot which is suitable to interact with a pivot formed on the surface of the actuation lever.

12. The auxiliary device according to one or more of the preceding claims, characterized in that the engagement lever has a pivot and a seat which are suitable to interact with the second end of said spring, said wing furthermore acting on the pivot of said engagement lever.

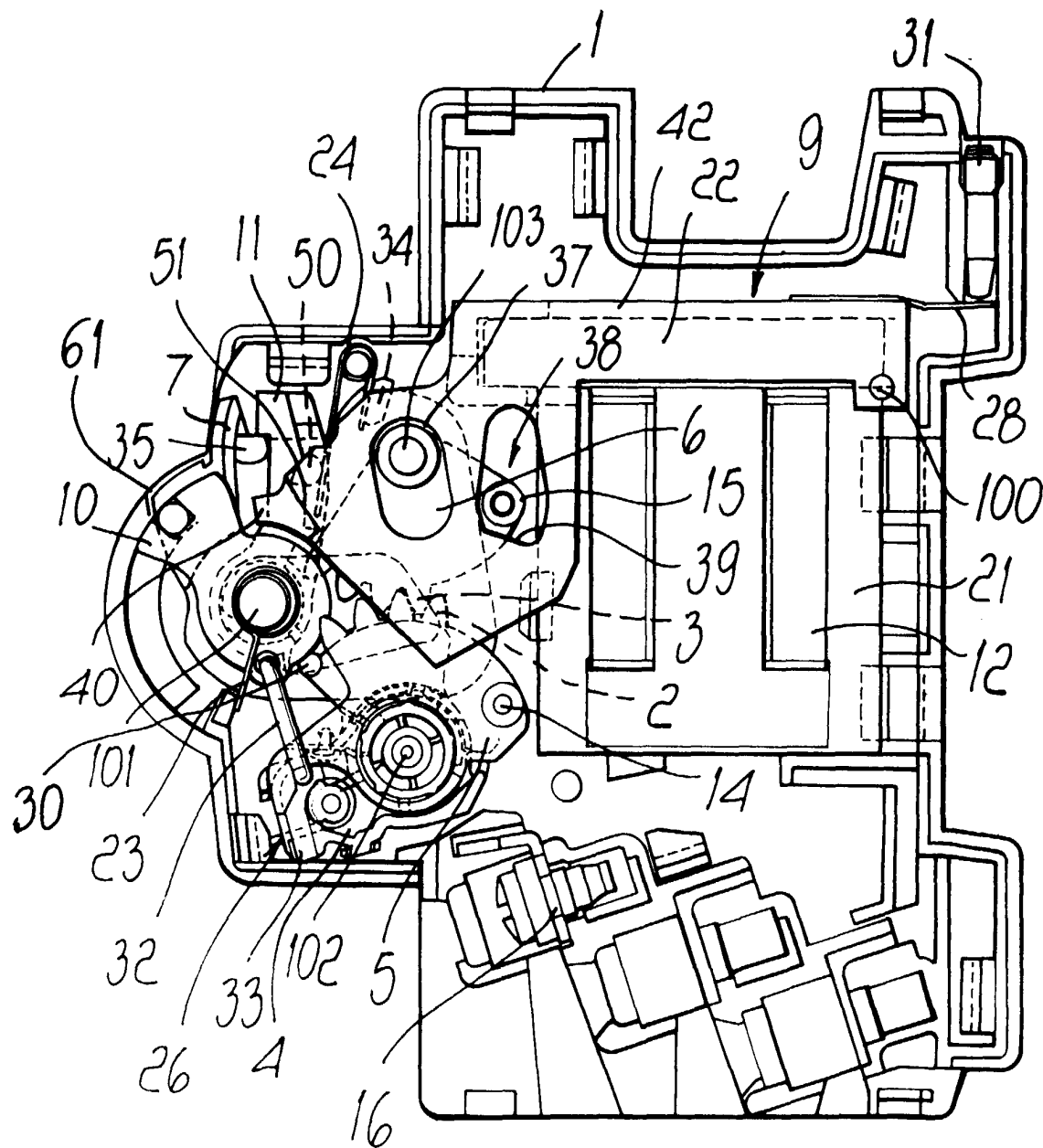


Fig. 1

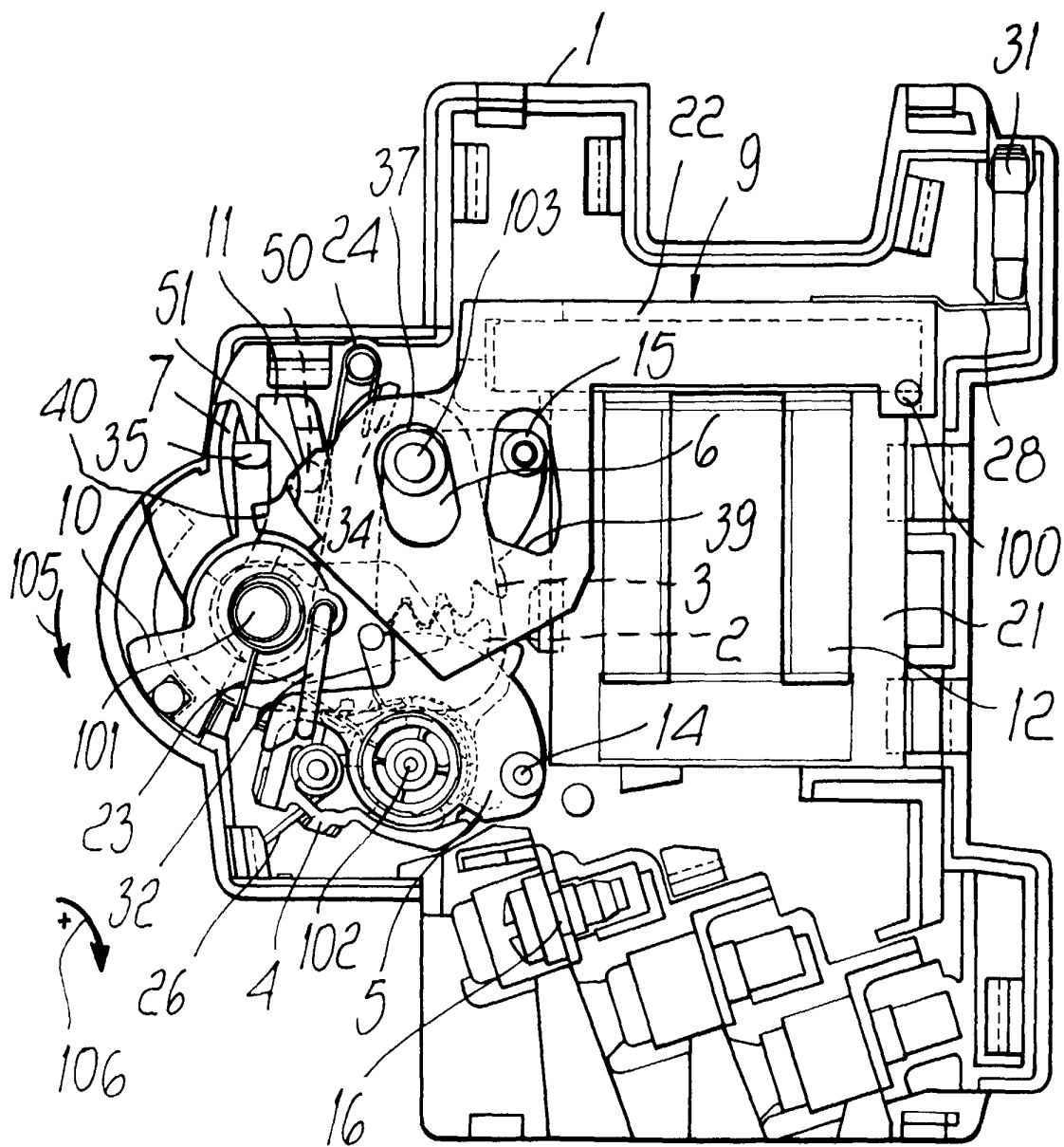


Fig. 2

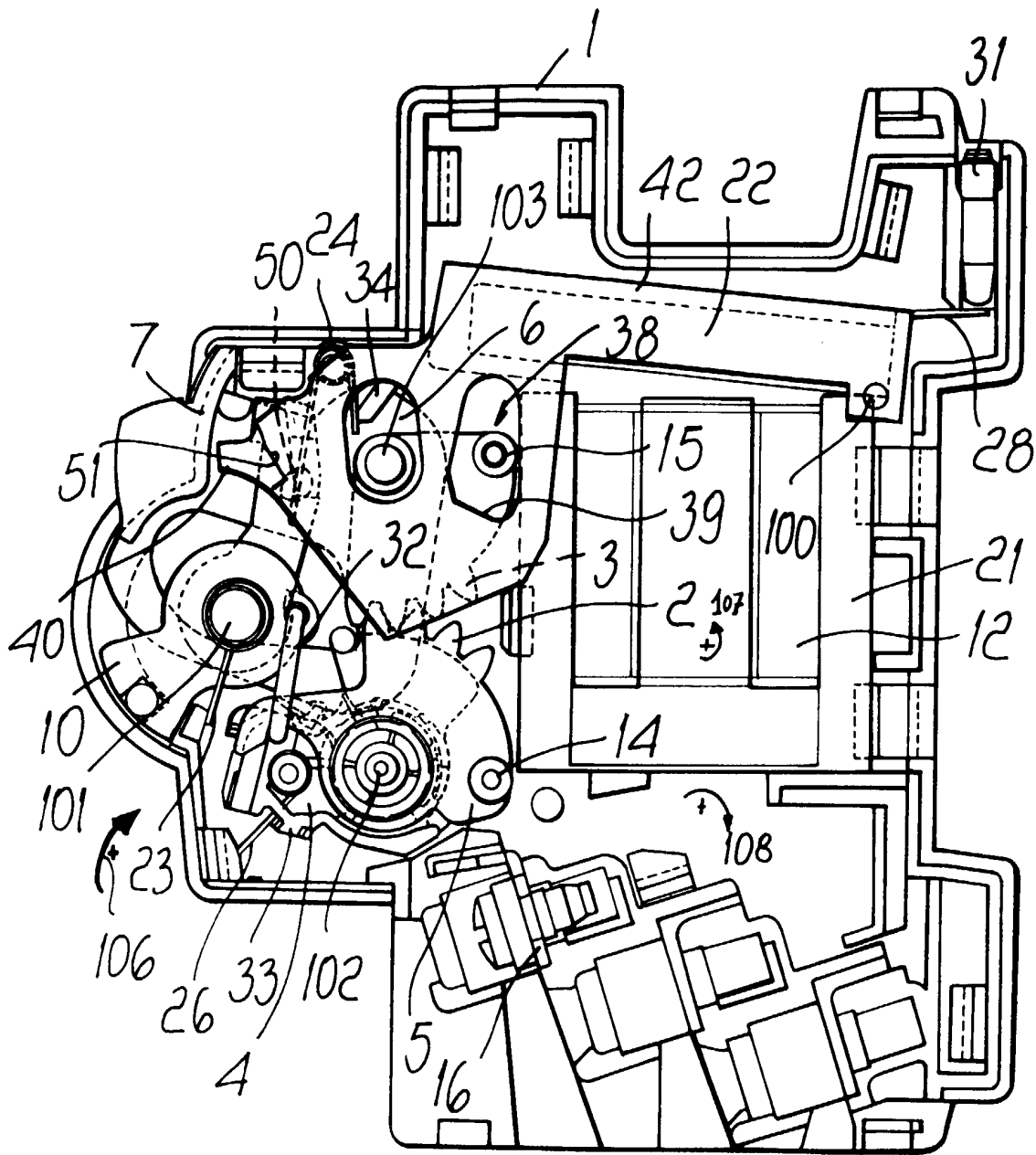


Fig. 3

