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(54) Auxiliary device

(57) An auxiliary device for opening the contacts of a circuit breaker associated therewith following a command electric signal, comprising an insulating case (1) which contains:

- connection terminals (10);
- an actuating device (100) which is activated by said command electric signal;
- a kinematic mechanism (200) for opening/closing said contacts;
  characterized in that said kinematic mechanism (200) comprises:
- coupling means operatively associated to said actuating device and to said circuit breaker;
- release means operatively associated to said coupling means;
  and in that said actuating device (100) is a piezoelectric actuating device.

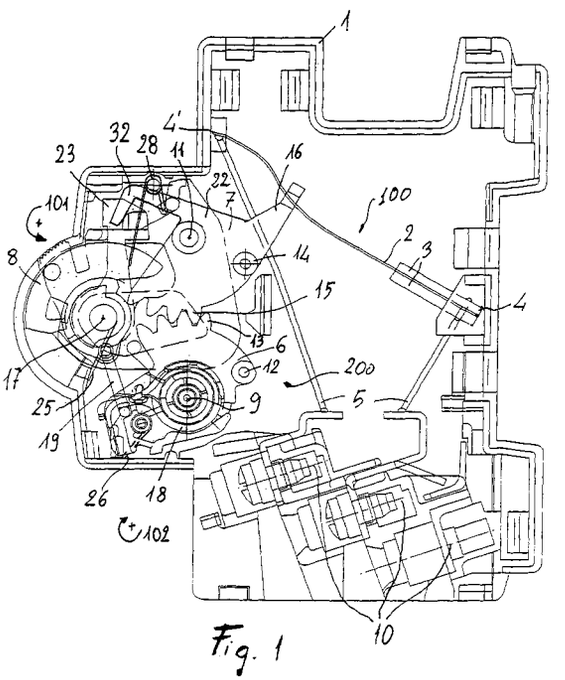

Fig. 1

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Description

[0001] The present invention relates to an auxiliary device for opening the contacts of a low-voltage circuit breaker associated therewith following a command electric signal.

[0002] It is known in the art that conventional magnetothermal or residual-current circuit breakers for low-voltage electrical applications, i.e. for voltages up to 1kV, are generally coupled to suitable auxiliary devices; these devices are conceived so as to perform specific protection functions, in addition to those basically performed by the circuit breakers.

[0003] Typical examples of auxiliary devices are constituted by under-voltage relays and shunt tripping relays.

[0004] In particular, the main function of an undervoltage relays is to protect loads which are connected to a power supply line, for example electric motors, against supplying conditions which are not optimum for their operation. Undervoltage relays are 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; in this way, malfunctions and even damages to the load are conveniently prevented.

[0005] In turn, shunt tripping relays are coupled to circuit breakers so as to perform opening of the contacts and interruption of the current flow, following a remote opening command, issued for example for security reasons, by an operator which acts on push-button or on a control panel.

[0006] According to a solution widely used in the art, the constructive embodiment of such auxiliary devices foresees in both cases, the use of a mechanical part constituted by a kinematic mechanism, operatively coupled to the kinematism of the associated circuit breaker, and of an electromagnetic part which acts as an actuating device for the kinematic mechanism.

[0007] The electromagnetic part is basically formed by a fixed magnet, on which a coil is wound, and by a moving magnet which can electromagnetically couple/uncouple to/from it.

[0008] In particular, in the case of a shunt tripping relay, in normal operating conditions the coil is not supplied with electric power and the moving magnet is uncoupled from the fixed one; when a remote command for opening the contacts is issued, the coil is excited by current pulses which cause the generation of a magnetic field by means of which the moving magnet is attracted by the fixed magnet. During this movement, the moving magnet actuates the kinematic mechanism which in turn transmits motion to the associated circuit breaker, thus causing the opening of the contacts.

[0009] In the case of an under-voltage relay, in normal operating conditions, the coil is supplied with electric power so as to generate a magnetic field whose intensity allows to keep the moving magnet coupled electromagnetically to the fixed magnet. If the line supply voltage drops below a preset threshold, the intensity of the magnetic field generated by the coil is no longer sufficient to retain the moving magnet and contrast the force applied for example by a spring which pulls the moving magnet and causes its uncoupling from the fixed magnet. As previously described, also in this case the movement of the moving magnet causes actuation of the kinematic mechanism and the opening of the contacts.

[0010] At the present state of the art, this constructive solution, although it allows to correctly and effectively perform the functions required, still presents some drawbacks.

[0011] More specifically, the presence of the electromagnetic part contributes significantly to make the whole device quite cumbersome and heavy, and negatively effects the complexity of the design; further, the use of the coil and of the magnets increases the production and assembling costs.

[0012] Finally, also the kinematic mechanism, due to the high number of levers generally used, negatively influences the design and the production costs.

[0013] The aim of the present invention is to overcome the drawbacks of the prior art and in particular to provide an auxiliary device for opening the contacts of a circuit breaker associated therewith, which has a simplified structure with respect to known auxiliary devices.

[0014] Within the scope of this aim, an object of the present invention is to provide an auxiliary device for opening the contacts of a circuit breaker associated therewith which allows to ease the design phase.

[0015] Another object of the present invention is to provide an auxiliary device for opening the contacts of a circuit breaker associated therewith which is less cumbersome and heavy with respect to known devices.

[0016] Another object of the present invention is to provide an auxiliary device for opening the contacts of a circuit breaker associated therewith which allows to reduce the production costs and to facilitate assembling.

[0017] Another object of the present invention is to provide an auxiliary device for opening the contacts of a circuit breaker associated therewith which is highly reliable, relatively easy to manufacture and at competitive costs.

[0018] Thus, the present invention relates to an auxiliary device for opening the contacts of a circuit breaker associated therewith following a command electric signal, comprising an insulating case which contains:

- connection terminals;
- an actuating device which is activated by said command electric signal;
- a kinematic mechanism for opening/closing said contacts.

[0019] The auxiliary device according to the invention

is characterized in that said kinematic mechanism comprises:

- coupling means operatively associated to said actuating device and to said circuit breaker;
- release means operatively associated to said coupling means; and in that said actuating device is a piezoelectric actuating device.

[0020] The device thus conceived has a structure which is significantly simplified with respect to the prior art auxiliary devices, allowing at the same time to ease the design and to facilitate assembling, as well as to reduce the costs, without affecting in any way the performances required.

[0021] 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 invention, illustrated only by way of non-limitative example in the accompanying drawings, wherein:

Figure 1 is a schematic side view illustrating a first embodiment of the auxiliary device according to the present invention;
Figure 2 is a schematic side view illustrating a second embodiment of the auxiliary device according to the present invention;
Figure 3 is a perspective view of a release lever used in the device according to the present invention;
Figure 4 is a perspective view of a reset and indication lever used in the device according to the present invention;
Figure 5 is a perspective view of an engagement lever used in the device according to the present invention.

[0022] In the following description, the auxiliary device according to the invention will be described with particular reference to its use as a shunt tripping relay or as an under-voltage relay, without intending in any way to limit its possible applications.

[0023] With reference to figures 1 and 2, the auxiliary device according to the invention comprises an insulating case 1 which contains an actuating device 100, a kinematic mechanism, generally indicated by the reference numeral 200, for opening/closing the contacts of a circuit breaker associated with the device itself, and connection terminals 10 for connection with an electric line, not illustrated; in particular there are four terminals 10, three of which are illustrated in figures 1 and 2.

[0024] Advantageously, in the present invention the actuating device 100 is a piezoelectric actuating device, preferably a bistable piezoelectric device.

[0025] With the term "piezoelectric actuating device" is meant a device which uses a piezoelectric element, a system for electrically exciting it so in order to determine its deformation, and means for exploiting the deformation of the piezoelectric element so as to produce a movemevent, which can be transmitted to further components.

[0026] As shown in figures 1 and 2, the piezoelectric actuating device 100 comprises a structural element 2 and at least one layer of piezoelectric material 3 operatively coupled therewith. In particular, the structural element 2 is preferably constituted by a thin, bistable, and substantially rectangular lamina, for example metallic, while the layer of piezoelectric material 3 may comprise a ceramic piezoelectric material, or an inorganic crystal piezoelectric material, or an organic polymer piezoelectric material.

[0027] According to a preferred embodiment, the actuating device 100 comprises two layers of piezoelectric ceramic material 3 in a bimorph configuration, such as a barium or a lead zirconate titanate (PZT) piezoelectric compound, which are fixed on two corresponding opposite faces of the lamina 2, at a first end thereof, with the lamina interposed therebetween. The layers 3 are electrically connected to the connection terminals 10, by means of conducting means 5, for example electrical wires; also a second end of the lamina 2, opposite to the first end, is electrically connected to the terminals 10.

[0028] Furthermore, according to a particularly preferred embodiment, the lamina 2 has the two substantially opposite ends 4 and 4' which are operatively coupled to the insulating case 1 in an offset position to each other with respect to a reference plane. In this way, and in the manner which will be described in more details hereinafter, the energy that the lamina 2 requires for shifting from a first stable equilibrium position to a second one, thereby actuating the kinematic mechanism 200, is advantageously minimized.

[0029] In turn, the kinematic mechanism 200 comprises coupling means, which are operatively associated to the actuating device 100 and to the circuit breaker, and release means which are operatively associated to the coupling means.

[0030] In particular, the coupling means comprise a triggering lever 6, a coupling lever 7, and a transmission lever 8 whose functions and connections are described hereinafter.

[0031] The tripping lever 6, which is pivoted at a point 9 of the case 1, has a pivot 12 suitable for coupling to the associated circuit breaker, and a toothed sector 13; the coupling lever 7 is pivoted at a point 11 of the case 1 and has a pivot 14 for optional coupling to the kinematic mechanism of the associated circuit breaker, and a toothed sector 15 which is operatively coupled to the toothed sector 13 of the tripping lever 6. Finally, and according to a constructive solution particularly advantageous, the coupling lever 7 comprises a first protruding arm 16 having a contoured end suitable for operatively interacting with the lamina 2, and a second arm 32 having a contoured end which is suitable for interacting with indication and reset means, for the purposes which will

be described hereinafter. In this way, the kinematic mechanism 200 has a lever which, with a single body, allows to perfom different functions, as it will appear more clearly in the following description. Alternatively it would be possible to use two or more different levers for performing the same functions.

[0032] The transmission lever 8, to which a return spring 25' is associated, is pivoted to a point 17 of the case 1 and is operatively connected to the circuit breaker and to the release means, respectively.

[0033] The release means comprise a release lever 18 which is also pivoted at the point 9 of the case 1, and a spring 26 which acts on the lever 18 itself; the release lever 18 is operatively coupled to the transmission lever 8 and to the tripping lever 6 by means of a U-shaped element 19 which can slide in a groove 20 provided on the lever 18, as illustrated in figure 3. Further, as shown in figure 3, the lever 18 is provided with a seat 21 in which a spring, not illustrated, is inserted; said spring allows to couple the movement of the levers 18-6 during opening operations, as it will be described hereinafter.

[0034] The kinematic mechanism 200 may further be provided with indication and reset means suitable for providing a local visual indication of the open state of the circuit breaker; in particular, said indication and reset means comprise a reset and indication lever 22 and an engagement lever 23, illustrated in figures 4 and 5 respectively.

[0035] As shown in Figure 4, the reset and indication lever 22, which is pivoted at the point 17 of the case 1, has a slot 31 suitable for interacting with a pivot 30 which is provided on the lever 18, a first raised portion 34, on which a first end of a spring 28 acts, and a second raised portion 35, which interacts against a shaped wall 36 of the engagement lever 23; moreover, the lever 22 has a shaped protrusion 60 which, when the circuit breaker opens due to a command electric signal, protrudes from a corresponding opening formed in the case 1 and therefore allows local visual indication of the tripping of the associated circuit breaker. Moreover, once the protrusion 60 has protruded from the case 1, it directly provides a button on which an operator can, for any requirement, act directly and restore the auxiliary device without having to act on the associated circuit breaker, which accordingly remains open.

[0036] The engagement lever 23, shown in detail in Figure 5, is pivoted at the point 11 of the case 1 and has also a pivot 50 on which the second end of the spring 28 acts. In practice, in the position shown in Figure 1, the spring 28 pushes on one side against the raised portion 34, forcing the lever 22 to turn clockwise, and against the pivot 50 at the other side, forcing the lever 23 to turn counterclockwise. Accordingly, the levers 22 and 23 move against each other, facilitating contact between the raised portion 35 and the shaped wall 36 and remaining engaged in the position shown in Figure 1.

[0037] Finally, if the auxiliary device is used as a shunt tripping relay, it comprises also a first fixed and a second fixed contact, both indicated by the reference numeral 24, which are electrically connected to the connection terminals 10, and a movable contact 25, for example of the laminar type suitable for coupling therewith; further, there are provided means for interacting with the moving contact 25, constituted by an interaction lever 40. The lever 40, which is freely pivoted to a point 29 of the case 1, has a first end which abuts against the lamina of the contact 25, and a second end operatively engaged with a protrusion 27 of the lever 18.

[0038] The operation of the auxiliary 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.

[0039] When the circuit breaker is opened due to manual intervention of an operator who acts directly on its actuation knob, the kinematic mechanism of the circuit breaker transmits the motion to the transmission lever 8, which rotates in the direction indicated by the arrow 101, pulling the U-shaped element 19. The release lever 18, under the action of the U-shaped element 19, rotates about its own pivoting axis 9, in the direction indicated by the arrow 102; at the same time, the levers 6 and 7 also rotate in mutually opposite directions, causing the meshing of the two toothed sectors 13 and 15.

[0040] The remaining part of the mechanism is substantially not affected by the movement.

[0041] If the device is used as a shunt tripping relay and the interaction lever 40 is present, the rotation of the release lever 18 causes the disengagement of its protrusion 27 from one end of the lever 40 itself; in this way, the lever 40 releases the lamina 25, which by means of its elastic loading facilitates the switching of the moving contact 25 from the first fixed contact 24 to the second one.

[0042] If instead the opening of the contacts of the circuit breaker is due to a command issued for example by a remote operator which acts on a pushbutton or on a control panel, or by a protection device which detects that the load supply voltage is lower than a preset threshold, a command electric signal is supplied to the layer of piezoelectric materials 3. As a consequence, the piezoelectric layers 3 deform so as to determine a shifting of the bistable lamina 2 from a first stable equilibrium position, illustrated in figure 1, to a second stable equilibrium position (not illustrated); during this transition, the lamina 2 interacts with the contoured end 16 of the coupling lever 7, thus transmitting movement to it.

[0043] In this way, the lever 7 starts rotating and its toothed sector 15 meshes with the toothed sector 13 of the coupling lever 6; thus, the two toothed sectors 13 and 15 rotate in mutually opposite directions with respect to each other and transmit movement to the kinematic mechanism of the associated circuit breaker which can be operatively coupled to the pivot 12 or to the pivot 14 according to the internal positioning of its electric poles.

[0044] If the position of the poles in the circuit breaker changes, the consequent change in the direction of rotation of its kinematic mechanism is rendered irrelevant, in terms of the functionality of the coupling between the circuit breaker and the device, by the presence of the two mutually contrarotating toothed sectors 15 and 13.

[0045] Moreover, by means of this rotation the tripping lever 6 disengages the U-shaped element 19, which becomes able to slide freely in the groove 20 of the lever 18. Advantageously, the release lever 18, no longer locked by the U-shaped element 19, rotates under the action of the spring 26 in the direction indicated by the arrow 102 and simultaneously facilitates a faster rotation of the lever 6; as previously indicated this simultaneous rotation is achieved by means of a spring, not shown, arranged in the seat 21 of the lever 18.

[0046] Therefore, in this manner 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 with opening of its contacts. This ensures the advantage of being able to further optimize the sizing of the actuating device 100, with a consequent saving in terms of materials, dimensions and costs.

[0047] At the same time, the lever 40, if present, once its end has disengaged from the protrusion 27, releases the moving contact 25, which moves from the first fixed contact 24 to the second one; in this situation, the four-terminal configuration allows to visually indicate by means of a suitable electric circuit, to a remotely located operator the change of state of the circuit breaker; this indication can be easily achieved by means of two lamps of mutually different colors which indicate an open or closed state of the circuit breaker.

[0048] Moreover, thanks to the action of the arm 32 on the pivot 50, the lever 22 disengages from the lever 23, and under the action of the spring 28 on the raised portion 34, rotates about the pivoting axis 11, so as the shaped protrusion 60 protrudes from the case 1 through a suitable opening, providing a local visual indication that the contacts of the circuit breaker are separated. At the end of the actuation, the transmission lever 8, following the movement of the associated circuit breaker, reaches a position not shown in Figures, in which the U-shaped element 19 re-engages the levers 6 and 18.

[0049] In this condition, an operator can therefore reset the auxiliary device simply by acting on the protrusion 60, without acting on the circuit breaker, which remains open; by pushing the protrusion 60 downward, the lever 22 in fact rotates and allows reengagement between the raised portion 35 and the shaped wall 36, pushed by the spring 28, which acts on a raised portion 70 of said lever 23.

[0050] 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 8 which pushes the lever 18 by means of the U-shaped element 19; the pivot 30, during the movement of the lever 18, acts against the surface of the slot 31 of the lever 22 and pulls it downward, causing it to rotate. By virtue of this rotation, the raised portion 35 couples to the shaped wall 36, as described earlier. Moreover, the protrusion 27 engages the end of the lever 40 which, by rotating about its pivoting axis, acts on the lamina of the moving contact 25 and returns it onto the fixed contact 24.

[0051] In practice it has been found that the auxiliary device according to the invention fully achieves the intended aim and objects giving several advantages with respect to the prior art devices. In fact, the use of a piezoelectric actuating device 100 coupled with the kinematic mechanism 200 previously described, allows to simplify the structure of the whole device, which results less cumbersome and heavy. Furthermore, the design is facilitated, and thanks to the reduction of pieces used also for the kinematic mechanism, the production and assembling costs are reduced too.

[0052] 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 also be replaced with other technically equivalent elements.

[0053] In practice, the materials employed, as well as the dimensions, may be any according to requirements and to the state of the art.

Claims

1. An auxiliary device for opening the contacts of a circuit breaker associated therewith following a command electric signal, comprising an insulating case which contains:

   - connection terminals;
   - an actuating device which is activated by said command electric signal;
   - a kinematic mechanism for opening/closing said contacts;

   characterized in that said kinematic mechanism comprises:

   - coupling means operatively associated to said actuating device and to said circuit breaker;
   - release means operatively associated to said coupling means;

   and **in that** said actuating device is a piezoelectric actuating device.

2. The auxiliary device according to claim 1 **characterized in that** said actuating device is a bistable piezoelectric device.

3. The auxiliary device according to claim 2 **characterized in that** said bistable piezoelectric device comprises a structural element and at least one layer of piezoelectric material operatively coupled therewith, said layer of piezoelectric material receiving said command electric signal and deforming so as to determine a shifting of the structural element from a first stable equilibrium position to a second stable equilibrium position thereby actuating said coupling means.

4. The auxiliary device according to claim 3 **characterized in that** said at least one layer of piezoelectric material comprises a ceramic piezoelectric material, or an inorganic crystal piezoelectric material, or an organic polymer piezoelectric material.

5. The auxiliary device according to claim 3 **characterized in that** the structural element comprises a lamina on two opposite faces of which two layers of piezoelectric material are fixed with the lamina interposed therebetween.

6. The auxiliary device according to claim 5 **characterized in that** said lamina has two substantially opposite ends which are operatively coupled to the insulating case in an offset position to each other with respect to a reference plane.

7. The auxiliary device according to one or more of the preceding claims **characterized in that** said kinematic mechanism further comprises indication and reset means suitable for providing a local visual indication of the open state of the circuit breaker following said command electric signal and for resetting the kinematic mechanism, respectively, said indication and reset means being operatively associated to said coupling means.

8. The auxiliary device according to one or more of the preceding claims **characterized in that** said coupling means comprise a coupling lever and a tripping lever, having a pivot suitable for coupling to the associated circuit breaker, and a toothed sector, the two toothed sectors mutually meshing and rotating in mutually opposite directions with respect to each other.

9. The auxiliary device according to claim 8 **characterized in that** said coupling lever comprises a first arm having a contoured end suitable for interacting with said lamina.

10. The auxiliary device according to claim 8 **characterized in that** said coupling lever comprises a second arm having a contoured end suitable for interacting with said indication and reset means.

11. The auxiliary device according to claim 8, **characterized in that** said coupling means further comprise a transmission lever which is operatively connected to the circuit breaker and with which a return spring is associated.

12. The auxiliary device according to one or more of the preceding claims, **characterized in that** said release means comprise a release lever operatively coupled to said tripping lever and to said transmission lever, and a spring which is associated with the release lever and is suitable to provide an amount of energy for the opening of the circuit breaker.

13. The auxiliary device according to one or more of the preceding claims, **characterized in that** it is an under-voltage relay.

14. The auxiliary device according to one or more of claims 1 to 12 **characterized in that** it is a shunt tripping relay.

15. The auxiliary device according to claim 14 **characterized in that** it further comprises a first fixed contact, a second fixed contact and a movable contact suitable for coupling therewith, and means for interacting with said moving contact which are operatively connected to said release means.

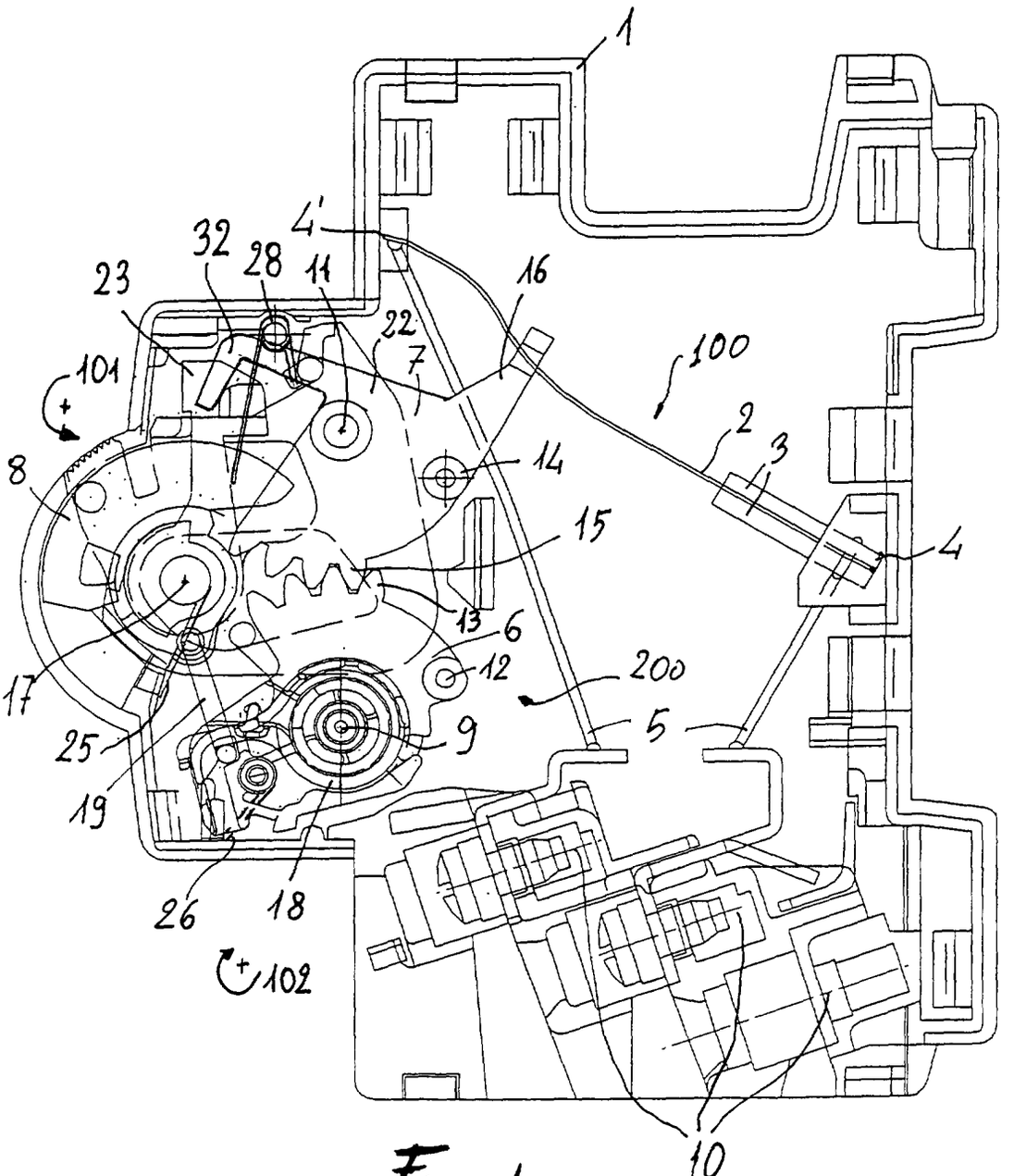
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Fig. 1

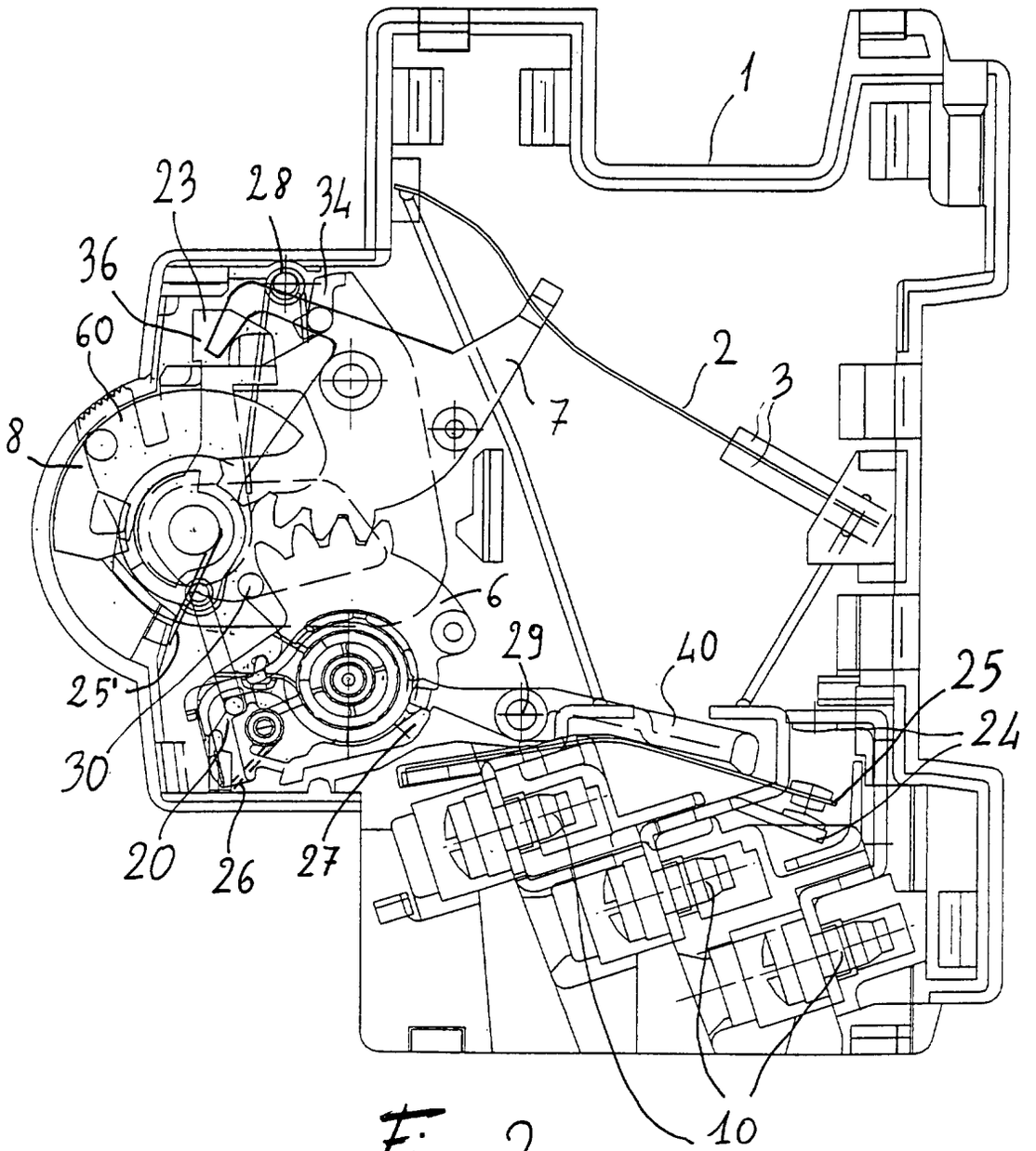

Fig. 2

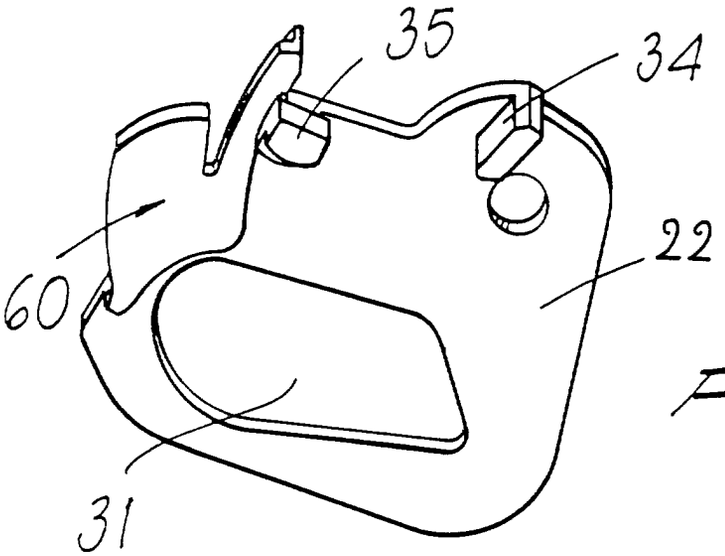

Fig. 4

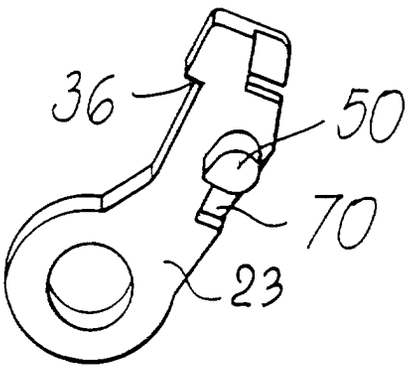

Fig. 5

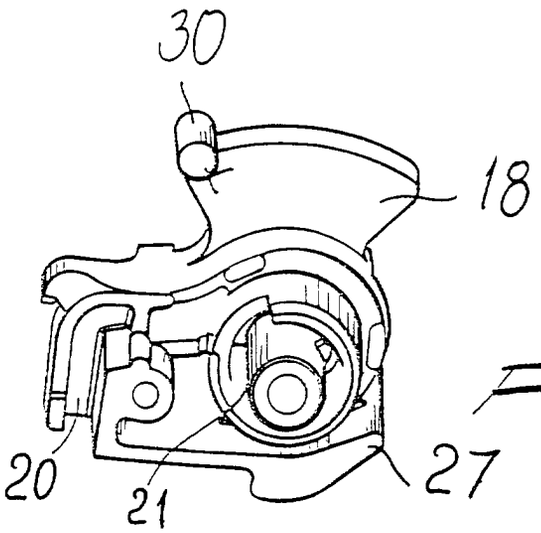

Fig. 3

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 00 20 4095

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.7)
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TECHNICAL FIELDS SEARCHED (Int.Cl.7)

H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 April 2001	Desmet, W

CATEGORY OF CITED DOCUMENTS

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