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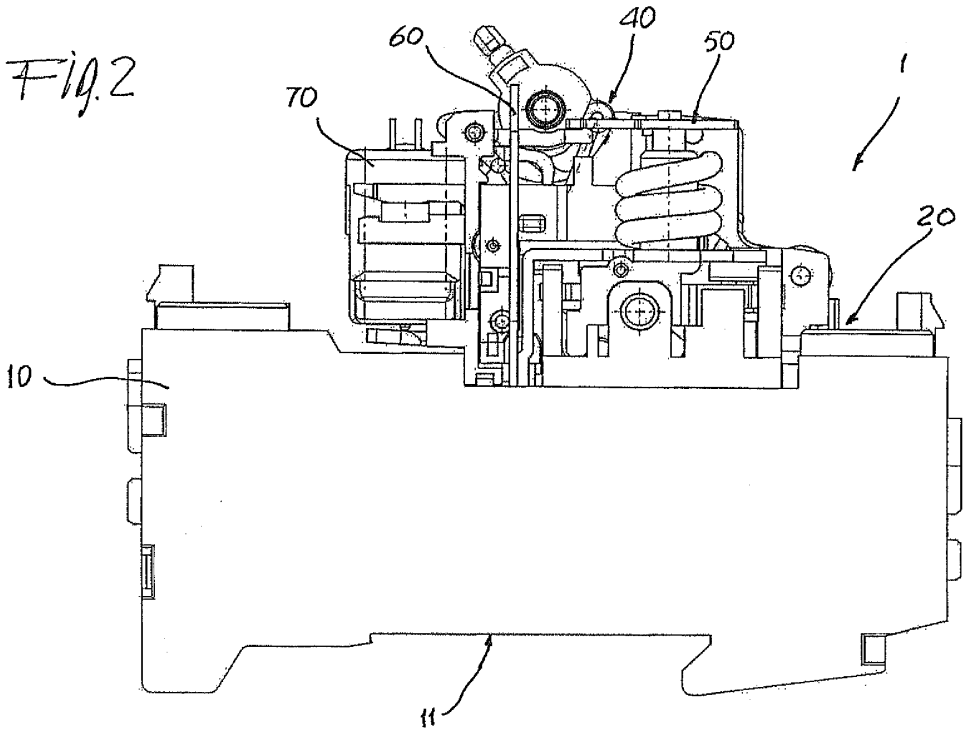
(54) Bipolar automatic circuit breaker for low-voltage applications

(57) A low-voltage bipolar automatic circuit breaker comprising a couple of electrical poles each of which has a device for protection against short-circuits. The circuit breaker further comprises a differential protection device associated with both poles and a single overload protection device associated with one of the two poles which causes the tripping of a closing/opening kinematic mechanism and the consequent opening of the contacts of the two poles upon detection of an overload fault condition.

Fig. 2



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Description

[0001] The present invention relates to a low-voltage bipolar automatic circuit breaker, and in particular to a bipolar automatic circuit-breaker having both poles protected from faults (that is, there is no neutral pole or phase) and which exhibits a plurality of functionalities, while having a compact structure and reduced components.

[0002] Low-voltage automatic circuit breakers are electrical devices of a known type. They are usually employed in electrical systems (for example, residential, industrial or commercial) in order to ensure the protection of the electrical systems and the safety of the users via the automatic opening of the circuit breaker itself, with consequent interruption of the power supply in response to failure situations.

[0003] Typically, these faulty situations are short-circuits, overloads and earth leakages. In order to guarantee protection against these failures, one or more protection devices capable of discriminating between normal operational situations and failure situations are usually associated with the circuit breaker. Such devices usually comprise an actuator which, following a determined fault situation, intervenes on the kinematic mechanism of the circuit breaker, causing its automatic tripping and the opening of the contacts.

[0004] Protection devices of the most common known type are the magnetothermic devices, which realize the protection from short-circuits and from overloads, and differential devices, which realize the earth leakage current protection.

[0005] One of the disadvantages that sometimes are found results from the fact that the protection devices consist, in some applications, of additional modules to be associated with the circuit breaker in order to realize a specific protection function. In practice, the circuit breaker and the protection devices are positioned within separate cases having a prearranged width of the modular type (one DIN module being equal to 17.5 mm). The cases are then associated and connected so as to obtain the required type of protection.

[0006] This brings about an increase in costs because it is necessary to predispose a plurality of cases suitable for housing the various devices, as well as connection and interface means for realizing the operative connection with the circuit breaker, with consequent labor requirement during the installation phase.

[0007] Furthermore, even where the protection devices and the breaking part are contained within the same case, the latter usually has relatively bulky dimensions (for example, a width greater than two standard modules) in particular when both poles are protected and there is therefore no a neutral pole. It also needs to be emphasized that the protection devices of the known type nevertheless require ad hoc components for their realization and dedicated mechanism for their coupling with the releasing kinematic mechanism, with consequent complications during the designing and realization phases of the circuit breaker and of the devices associated therewith.

[0008] As it can be seen from the above, automatic circuit breakers of the known type exhibit a series of drawbacks that it was attempted to solve, but not in an entirely satisfying way.

[0009] Based on these considerations, the main task of the present invention is to provide a low-voltage bipolar automatic circuit breaker that allows to overcome the described drawbacks.

[0010] This task is achieved via a low-voltage bipolar automatic circuit breaker, which comprises a case made of insulating material that contains:

- a first pole comprising a first contact and a second contact that are couplable/decouplable to each other and a first device for protection against short-circuits;
- a second pole comprising a third contact and a fourth contact that are couplable/decouplable to each other and a second device for protection against short-circuits;
- a differential protection device operatively associated with both first and second poles and suitable for detecting a differential current between said first and second poles;
- a closing/opening kinematic mechanism operatively coupled to said first and second poles in order to carry out the coupling/decoupling of said first and second contacts and said third and fourth contacts;
- a single overload protection device operatively associated with said first pole and suitable for causing the tripping of said kinematic mechanism and the decoupling of said first and third contacts from said second and fourth contacts, respectively, upon detection of an overload fault condition.

[0011] Further characteristics and advantages will become more apparent from the description of some preferred but not exclusive embodiments of a circuit breaker, according to the present invention, illustrated by way of examples in the accompanying drawings; wherein:

- figure 1 is a first perspective view of a bipolar automatic circuit breaker according to the present invention;
- figure 2 is a side view of the circuit breaker of figure 1;
- figure 3 is a functional schematic representation of the circuit breaker of figure 1;
- figure 4 is a first side view of some parts of the circuit breaker of figure 1;
- figure 5 is a second side view of some parts of the circuit breaker of figure 1;
- figures 6, 7 and 8 are detailed views that illustrate a first operating sequence of a bipolar automatic circuit breaker according to the present invention;
- figures 9 and 10 are detailed views that illustrate a second operating sequence of a bipolar automatic

circuit breaker according to the present invention;

- figure 11 is a further perspective view of a part of the circuit breaker of figure 1.

[0012] With reference to the appended figures, a low-voltage bipolar automatic circuit breaker 1 according to the present invention comprises a case 10 made of an electrically insulating material, which contains a first pole 20 and a second pole 30, both of which are protected from fault conditions according to what will result from the description below. The rear part 11 of case 10 is suitably shaped and exhibits means for hooking to a DIN guide.

[0013] The case 10 is arranged to allow cabling via the insertion of suitable cables or rods in suitable terminals. In addition, the front part of case 10 is suitable for being coupled to a cover, which is not illustrated in the figure, for the complete enclosure of the circuit breaker itself.

[0014] The first pole 20 comprises a first contact 21 and a second contact 22 that are couplable/decouplable to each other, while the second pole 30 comprises a third contact 31 and a fourth contact (not illustrated in the figure, but equivalent overall with the second stationary contact 22) that are couplable/decouplable to each other. The second 22 and fourth contacts are stationary while contacts 21 and 31 are movable between an opening position, in which they are decoupled from the corresponding stationary contacts, and a closing position in which they are coupled with said stationary contacts.

[0015] The circuit breaker further comprises a closing/opening kinematic mechanism 40, which is operatively coupled to said first and second poles 20, 30 in order to carry out the coupling/decoupling of said first and second contacts 21, 22 and of said third 31 and fourth contacts. In practice, the closing/opening kinematic mechanism 40 comprises levers that transmit the movement of the knob 42 operated by a user to the contacts for carrying out the opening or closing maneuver of the circuit breaker; furthermore, said levers realize the opening of the contacts in case of a failure situation in the electrical system associated with the circuit breaker 1. To this end, the closing/opening kinematic mechanism 40 preferably comprises means for holding the mobile contact in the closed position and means for releasing the kinematic mechanism, allowing the automatic opening of the circuit breaker 1. According to one embodiment, the closing/opening kinematic mechanism 40 comprises at least one pair of levers, for example, the hooking lever 43 and the tripping lever 41, which, when engaged to each other, hold the contacts in the closed position. In a failure case, the tripping lever 41 is disengaged from the hooking lever 43 via rotation around the center 418, releasing the kinematic mechanism and permitting the automatic opening operation according to a mechanism, which will be described in detail below.

[0016] The circuit breaker according to the invention is in fact suitable for ensuring the protection of the electrical systems (for example, residential, industrial or commercial) and the safety of the users through the automatic opening of the circuit breaker itself, with consequent interruption of the power supply in response to a first, second or third failure situation. Typically, these faulty situations are short-circuits, overloads and earth leakages, respectively.

[0017] To this end, both the first pole 20 and the second pole 30 of the circuit breaker 1 respectively comprise a first short-circuit protection device 50 and a second short-circuit protection device 55.

[0018] Such short-circuit protection devices 50 and 55 are of the well known type and typically comprise a magnetic actuator constituted by a coil, a movable core, a stationary core, a blade or more generally, a pin and a spring, which realize the protection against short-circuits.

[0019] The circuit breaker 1 further comprises a differential protection device 70, which is operatively associated with both poles 20 and 30; the protection device 70, which is also of a well known type and therefore not described in detail, is usually a differential actuator that realizes the protection from earth leakage currents and is typically constituted by a relay and by a toroidal core. The differential protection 70 detects the earth leakage current as an unbalance between the currents of the two poles or phases 20 and 30. In practice, when the difference in absolute value between the currents circulating in said first and second poles 20 and 30 exceeds a predefined threshold, device 70 triggers the release of the kinematic mechanism 40 and therefore the decoupling of the mobile contacts from the corresponding stationary contacts.

[0020] Advantageously, the bipolar circuit breaker 1 comprises a single, unique overload protection device 60 that is operatively associated with the first pole 20 and is suitable for causing the tripping of the kinematic mechanism 40 and the decoupling of said first and third contacts 21, 31 from said second 22 and fourth contacts, respectively, upon detection of an overload fault condition.

[0021] In turn, the protection devices 50 and 55 are suitable for causing the release of said kinematic mechanism 40 and the opening of said first and second contacts 21, 22 and of said third 31 and fourth contacts following a fault condition due to a short-circuit in the electrical system associated with the circuit breaker 1.

[0022] Preferably, the overload protection device 60 is constituted by a thermal actuator that comprises a bimetal. The first short-circuit protection device 50 and the overload protection device 60 are usually consolidated to each other and constitute a magnetothermic device. Furthermore, it needs to be specified that, while the protection device 60 is calibrated for intervening when there are overloads of an intensity that is not particularly high, which are present for long times, the devices 50 and 55, in addition to intervening for short-circuit failures, can also intervene in the presence of overloads of higher intensity that appear in very short times.

[0023] Furthermore, the automatic circuit breaker 1 ac-

cording to the invention comprises coupling means that operatively connect the closing/opening kinematic mechanism 40 to the various protection devices 50, 55, 60 and 70. In substance, and unlike the circuit breakers of the known type, in the circuit breaker according to the invention, the mechanical pulses of the various protection devices 50, 55, 60 and 70 are transferred to the releasing kinematic mechanism via a single mechanism, simplifying the structure of the circuit breaker compared to the conventional solutions that need dedicated mechanisms for every protection device.

[0024] With reference to figures 6-10, some configurations for realizing the automatic opening operation in a circuit breaker, according to the invention, will be described now.

[0025] As previously mentioned, an embodiment of the closing/opening kinematic mechanism 40 conveniently comprises a first tripping lever 41 suitable for releasing the same kinematic mechanism 40 by disengaging a third hooking lever 43, allowing the automatic opening of the contacts of the two poles 20 and 30. The coupling means comprise, for example, a first tripping shaft 81 which operatively connects said closing/opening kinematic mechanism 40 to said first and second short-circuit protection devices 50 and 55, to the overload protection device 60 and to the differential protection device 70. According to this embodiment, the coupling means further comprise a second intervention lever 82 that operatively connects the closing/opening kinematic mechanism 40 to the protection device 70. The first tripping shaft 81 and the second intervention lever 82 are operatively connected to said first tripping lever 41. In other words, the coupling means constitute the single mechanical interface, for example, via the first tripping shaft 81 and the second intervention lever 82, through which the mechanical pulse, generated by the various protection devices 50, 55, 60, 70 in the presence of a corresponding failure situation, is transmitted to the closing/opening kinematic mechanism 40, acting, for example, on the tripping lever 41.

[0026] With reference to figures 6 and 9, in a closed circuit-breaker situation and in the absence of failures, the closing/opening kinematic mechanism 40 is kept blocked in the closed position for the interaction of the third hooking lever 43 with the first tripping lever 41. In particular, according to this embodiment, one end of the lever 43 is engaged by a suitable projection into the body of the lever 41 as a result of which the counterclockwise rotation of the lever 43 (and the resulting release of the circuit breaker) is impeded.

[0027] The operation of automatic opening in the case of failure due to short-circuit is illustrated with reference to the figures 6 and 7. The first protection device 50 and the second protection device 55 each comprise a blade 501 tied to the movable core. A portion of the blade 501 is positioned, under normal conditions (see figure 6), in proximity to a first extension 810 of the first tripping shaft 81.

[0028] In case of failure due to a short-circuit, the protection device 50 or 55, intervenes, dragging inside the mobile core and consequently moving the blade 501 associated therewith (see fig. 7, which shows the movement of the blade 501 to the right). Due to this movement, the blade 501 acts on the first extension 810 of the shaft 81, which rotates clockwise around its own pivot point 815. The shaft 81 exhibits a second extension 811 integral with it and suitably shaped. Due to the rotation of shaft 81, the second extension 811 interacts with the first tripping lever 41, causing the counterclockwise rotation around its own center of rotation 418. As a consequence, the tripping lever 41 disengages from the third hooking lever 43 allowing the movement and unblocking the closing/opening kinematic mechanism 40, which snaps into the open position, separating the mobile contacts 21 and 31 from the corresponding stationary contacts.

[0029] With reference to figures 6 and 8, the automatic opening operation in the case of failure due to overcurrents is illustrated. As previously indicated, the protection device 60 comprises a bimetal lamina suitable for bending because of overcurrents in the circuit. A portion of the lamina 60 is positioned, under normal conditions (see figure 6), in proximity to a third extension 812 of the first tripping shaft 81.

[0030] In the case of fault due to overload, the protection device 60 intervenes by flexure of the bimetal lamina (see fig. 8, which shows the downward movement of the lamina 60). Because of this movement, the lamina 60 acts on the extension 812 of the shaft 81, which rotates clockwise around its own pivot point 815. As a result of this rotation, the second extension 811 of the shaft 81 interacts with the first tripping lever 41, causing the rotation and automatic opening of the contacts as previously described.

[0031] With reference to figures 9 and 10, the automatic opening operation in the case of fault due to earth leakage is illustrated. The third protection device 70 comprises a piston 701 suitable for sliding because of an earth leakage of current and therefore of an unbalance of the current between the conductors associated with the two poles or phases 20 and 30. One end of the piston 701 is positioned, under normal conditions (see figure 9), in proximity to an arm 822 of a second intervention lever 82. The intervention lever 82 is suitably pivoted at point 820, can rotate with respect to it and it is kept in an idle position by suitable springs. The second intervention lever 82 further exhibits coupling means 821 with the first tripping lever 41. In the case illustrated in the appended figures, the means of intervention are constituted by a protuberance 821 suitable for interacting with a portion 410 of the tripping lever 41.

[0032] In the case of fault due to earth leakage, that is, when the difference in absolute value between the currents circulating in the two poles is greater than a predetermined threshold, the protection device 70 intervenes, causing the movement of piston 701 toward the outside of the relay (see fig. 10, which shows the movement of the piston 701 to the right). Because of this move-

ment, the piston 701 acts on the arm 822 of the lever 82, which rotates counterclockwise around its own pivot point 820. As a result of this rotation, the protuberance 821 of the intervention lever 82 interacts with the portion 410 of the first tripping lever 41, causing the counterclockwise rotation and automatic opening of the contacts as previously described.

[0033] In addition to the considerable simplifications from the mechanical standpoint, the circuit breaker according to the invention can be realized in an extremely compact manner, by suitably positioning the various components within the case 10.

[0034] For example, as schematically illustrated in figure 3 and visible in figure 11, the first pole 20 and the second pole 30 are conveniently positioned in a symmetric manner to the left and to the right of the longitudinal axis 100 of the circuit breaker 1, with respect to a front view of the same. The closing/opening kinematic mechanism 40 can therefore be advantageously centered with respect to said first and second poles 20, 30.

[0035] In particular, in the first pole 20, the protection device 50 and the protection device 60 are overlapped and placed alongside the closing/opening kinematic mechanism 40. In more detail, devices 50 and 60 for magnetothermic protection are usually grouped in a single body (and for this reason illustrated with a single functional block in figure 3) and positioned at the pole 20, in the front with respect to a front view of the circuit breaker 1. The protection device 55, in turn, is placed alongside the closing/opening kinematic mechanism 40 on the side opposite to the protection device 50. The protection device 70 is positioned transversally with regard to said longitudinal axis 100 and contiguous to said closing/opening kinematic mechanism 40, thus, being located, with respect to a front view of the circuit breaker, lower than the protection devices 50, 55, 60 and the kinematic mechanism 40.

[0036] The resulting structure is exceedingly rational and compact. The arrangement of the components within case 10 is in fact substantially symmetric and allows to optimize the occupation of the spaces inside the case itself. Consequently, the dimensions of the circuit breaker can be held down; in particular, the width turns out to be equal to two DIN standard modules (35 mm), with substantial advantages from the modularity standpoint.

[0037] Based on what was described above, it can be seen that the circuit breaker 1 accomplishes its predefined task, allowing to realize a high number of functions with a reduced number of components and with reduced costs.

[0038] In fact, the bipolar circuit breaker 1 exhibits both the poles 20 and 30 protected from failures and in which the protection from overloads is obtained by utilizing a single bimetal, unlike what is known in the art in which each pole, where protected (and which, therefore, is not a neutral pole), provides the ad hoc use of a bimetal. Furthermore, the circuit breaker 1, thanks to its structure and functionality, allows to substantially simplify the realization of the mechanisms and of the couplings between the various components of the same. In other words, unlike the known type of circuit breakers, the coupling means, via a single mechanism, allow to couple the protection devices with the releasing kinematic mechanism of the circuit breaker, further reducing the number of mechanical components, optimizing the space filled up within the case and at the same time having the complete range of protection (magnetic, thermic and differential) on both poles.

[0039] Furthermore, the use of a single coupling mechanism between protection devices and opening/closing mechanism allows to reduce the costs of production.

[0040] It should also be noted that in the device according to the invention, it is possible to consolidate a high number of functionalities in a single case, with resulting savings in terms of implementation and installation costs. Furthermore, the dimensions of the case, thanks to the extremely compact and rational arrangement of the components within it, are held down. In particular, it is possible to realize a circuit breaker of a width equal to two DIN standard modules and with both the poles protected, with substantial advantages in terms of modularity and rationality of installation.

[0041] Based on the given description, other characteristics, modifications or improvements are possible and evident to the average skilled person. Such characteristics, modifications and improvements should therefore be considered as a part of the present invention. In practice, the materials employed, as well as the dimensions and the contingent forms, can vary according to the requirements and the state of the art.

Claims

1. A low-voltage bipolar automatic circuit breaker (1), **characterized in that** it comprises a case (10) made of insulating material containing:

   - a first pole (20) comprising a first contact (21) and a second contact (22) that are couplable/decouplable to each other and a first device for protection against short-circuits (50);
   - a second pole (30) comprising a third contact (31) and a fourth contact that are couplable/decouplable to each other and a second device for protection against short-circuits (55);
   - a differential protection device (70) operatively associated with both said first and second poles (20,30) and suitable for detecting a differential current between said first (20) and second (30) poles;
   - a closing/opening kinematic mechanism (40) operatively coupled to said first and second poles (20, 30) in order to carry out the coupling/decoupling of said first and second contacts (21, 22) and of said third (31) and fourth contacts;

- a single overload protection device (60) operatively associated with said first pole (20) and suitable for causing the tripping of said kinematic mechanism (40) and the decoupling of said first and third contacts (21, 31) from said second (22) and fourth contacts, respectively, upon detection of an overload fault condition.

2. A bipolar automatic circuit breaker (1) according to claim 1, **characterized in that** said single overload protection device (60) comprises a bimetal.

3. A bipolar automatic circuit breaker (1) according to claim 1 or 2 **characterized in that** it comprises coupling means that operatively connect said closing/opening kinematic mechanism (40) to said first (50) and second (55) short-circuit protection devices, to said single overload protection device (60) and to said differential protection device (70).

4. A bipolar automatic circuit breaker (1) according to one or more of the preceding claims, **characterized in that** said closing/opening kinematic mechanism (40) comprises a first tripping lever (41) suitable for releasing said kinematic mechanism (40) allowing the automatic opening of said first and second contacts (21, 22) and of said third (31) and fourth contacts.

5. A bipolar automatic circuit breaker (1) according to one or more of the preceding claims, **characterized in that** said coupling means comprise a first tripping shaft (81) which operatively connects said closing/opening kinematic mechanism (40) to said first and second short-circuit protection devices (50,55) and to said overload protection device (60), and a second intervention lever (82) which operatively connects said closing/opening kinematic mechanism (40) to said differential protection device (70).

6. A bipolar automatic circuit breaker (1) according to claims 4 and 5, **characterized in that** said first tripping shaft (81) and said second intervention lever (82) are operatively connected to said first tripping lever (41).

7. A bipolar automatic circuit breaker (1) according to one or more of the preceding claims, **characterized in that**, with respect to a front view of said circuit breaker (1), said first (20) and second (30) poles are symmetrically arranged to the left and to the right of the longitudinal axis (100) of the circuit breaker (1), said closing/opening kinematic mechanism (40) being positioned centrally with respect to said first and second poles (20, 30).

8. A bipolar automatic circuit breaker (1) according to claim 9, **characterized in that** said differential protection device (70) is positioned transversally with regard to said longitudinal axis (100) and contiguous to said closing/opening kinematic mechanism (40).

9. A bipolar automatic circuit breaker (1) according to one or more of the preceding claims, **characterized in that** it has a width equal to two standard DIN modules.

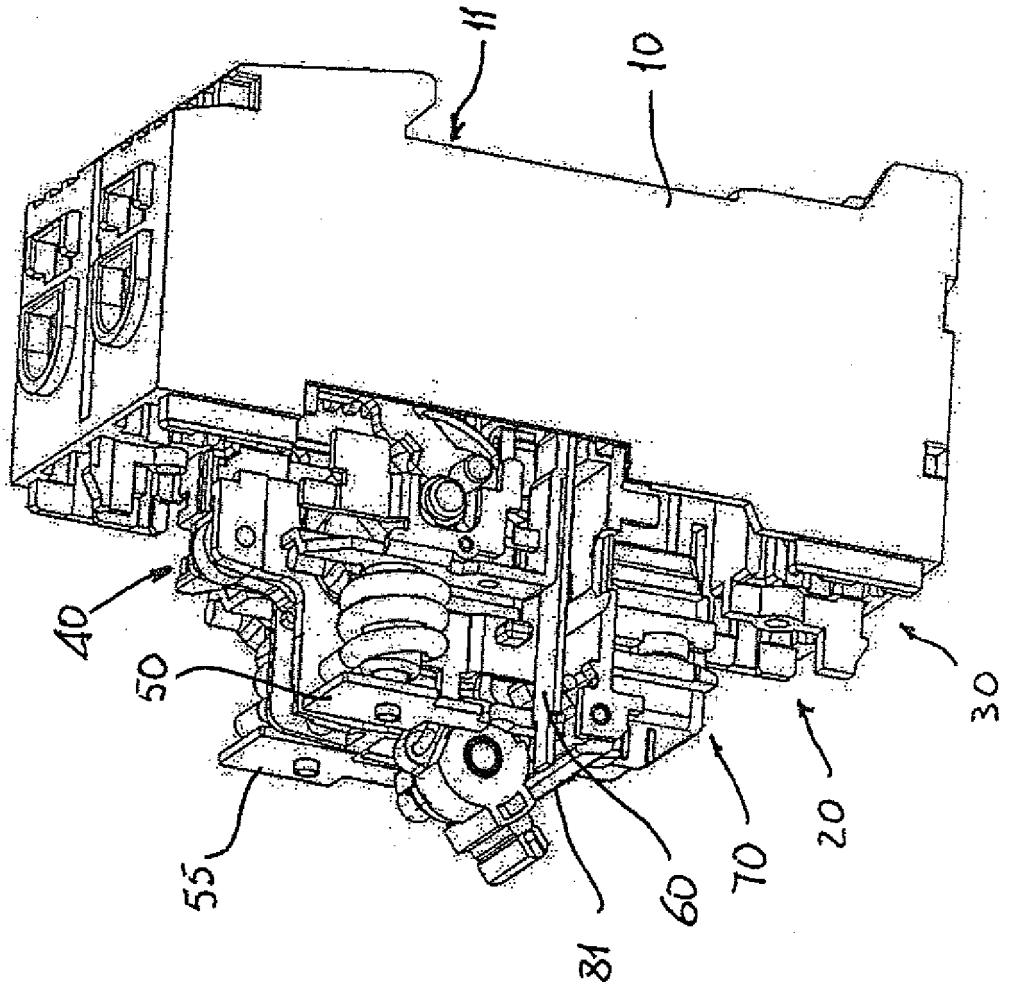

Fig.1

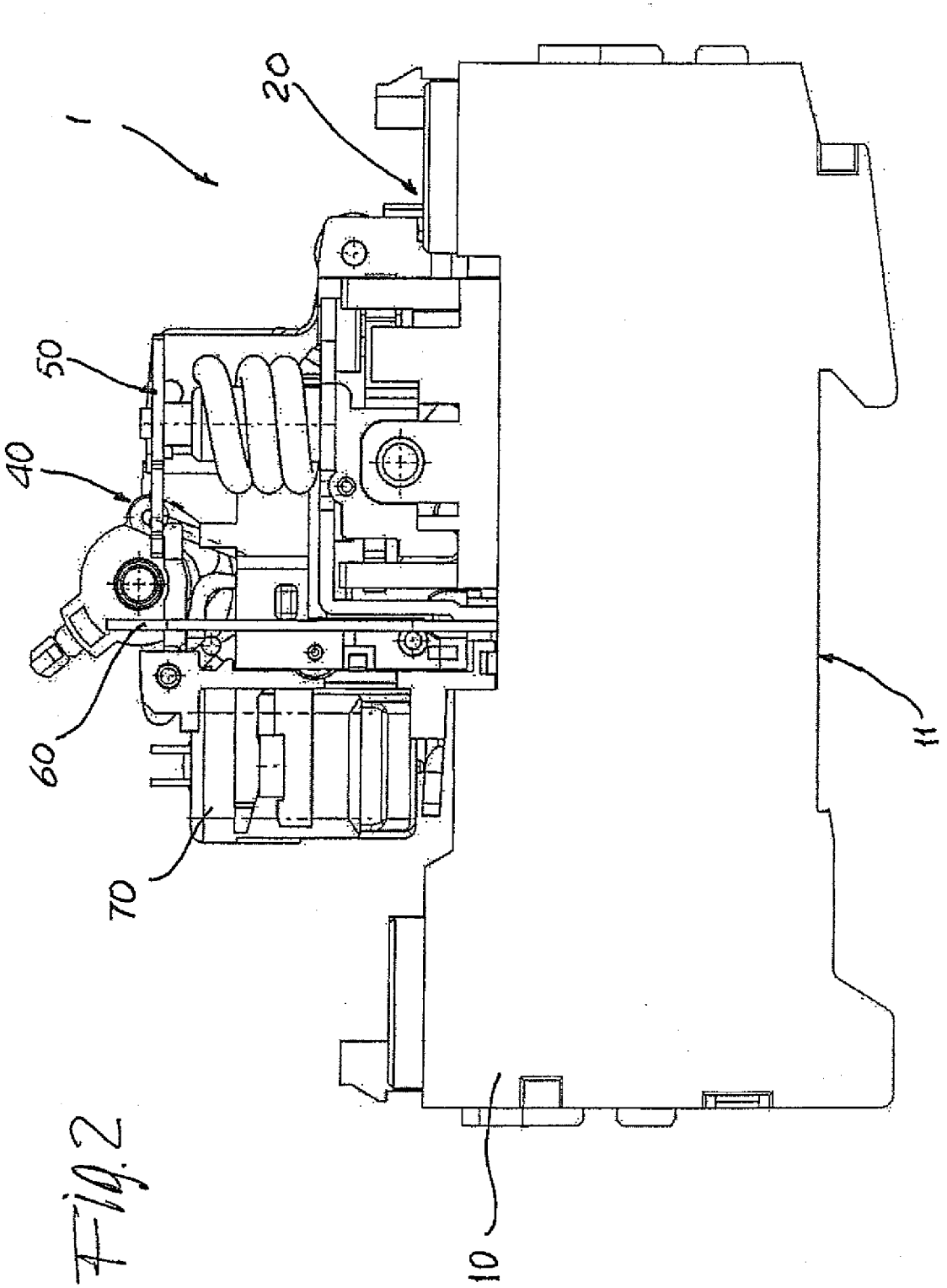

Fig. 2

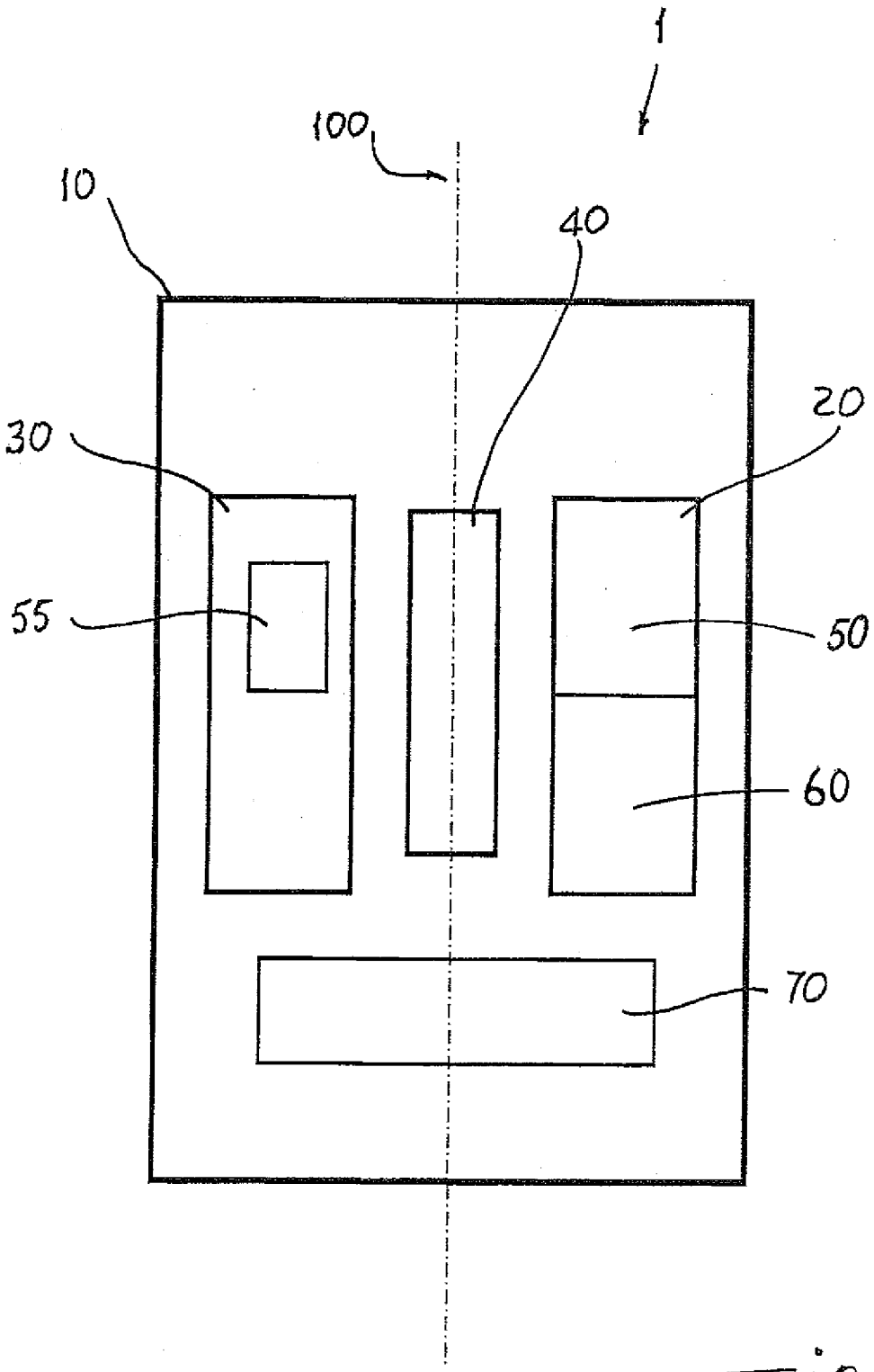

Fig. 3

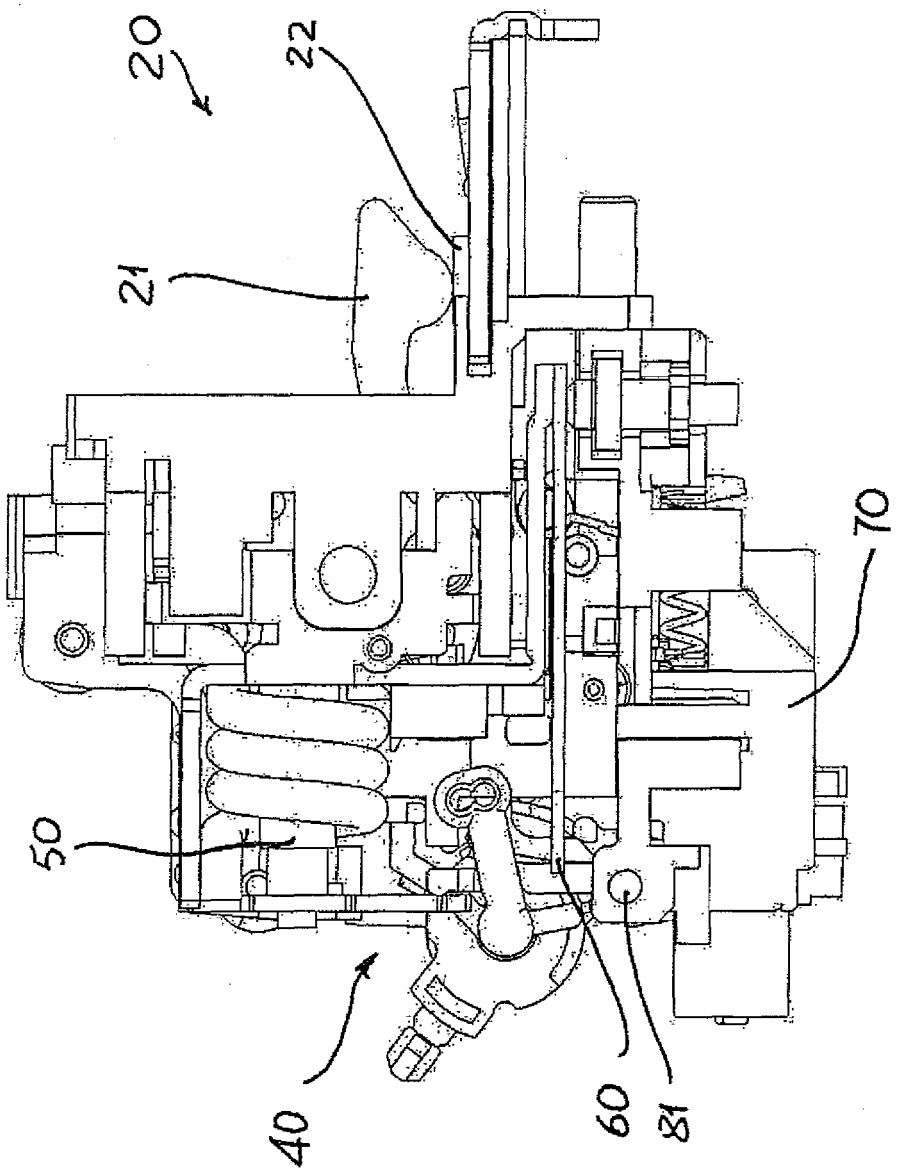

Fig. 4

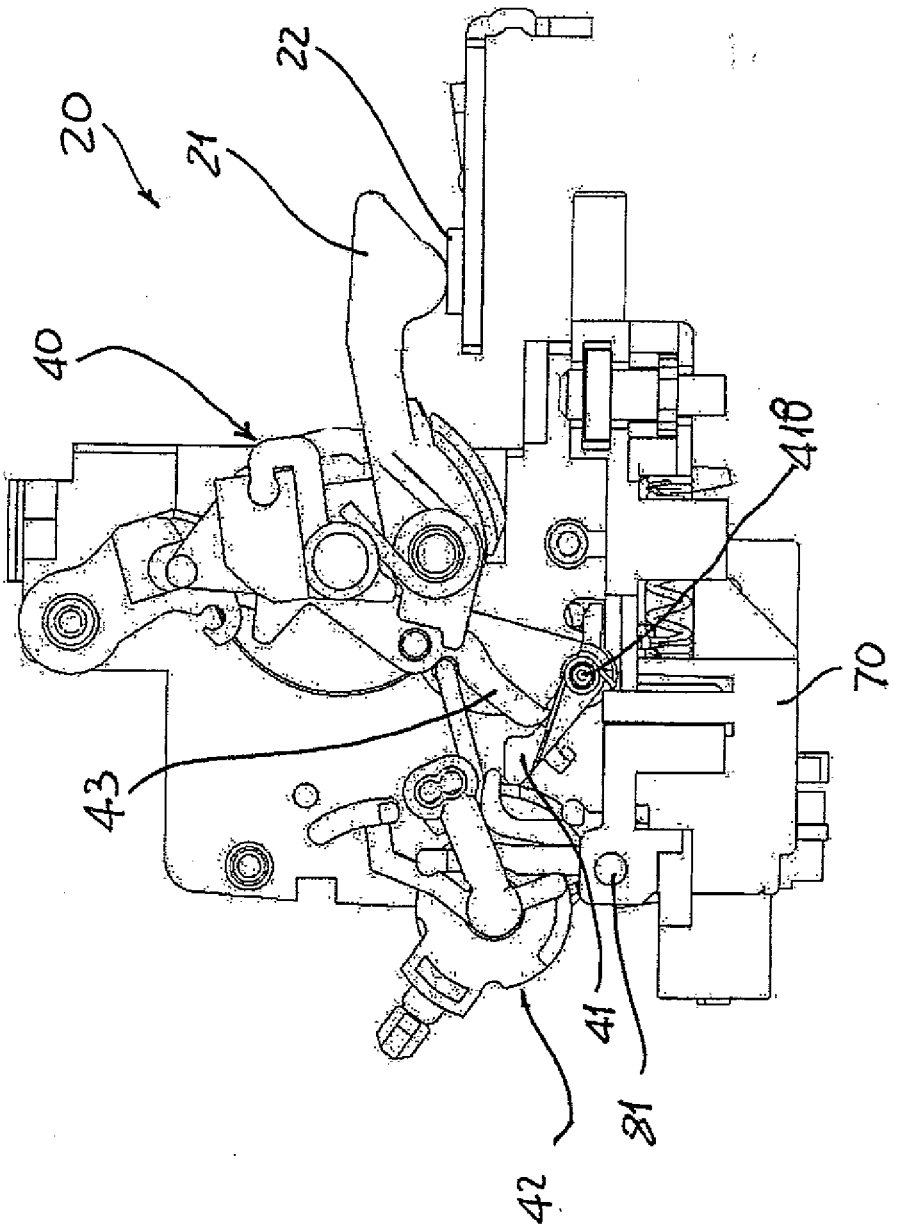

Fig. 5

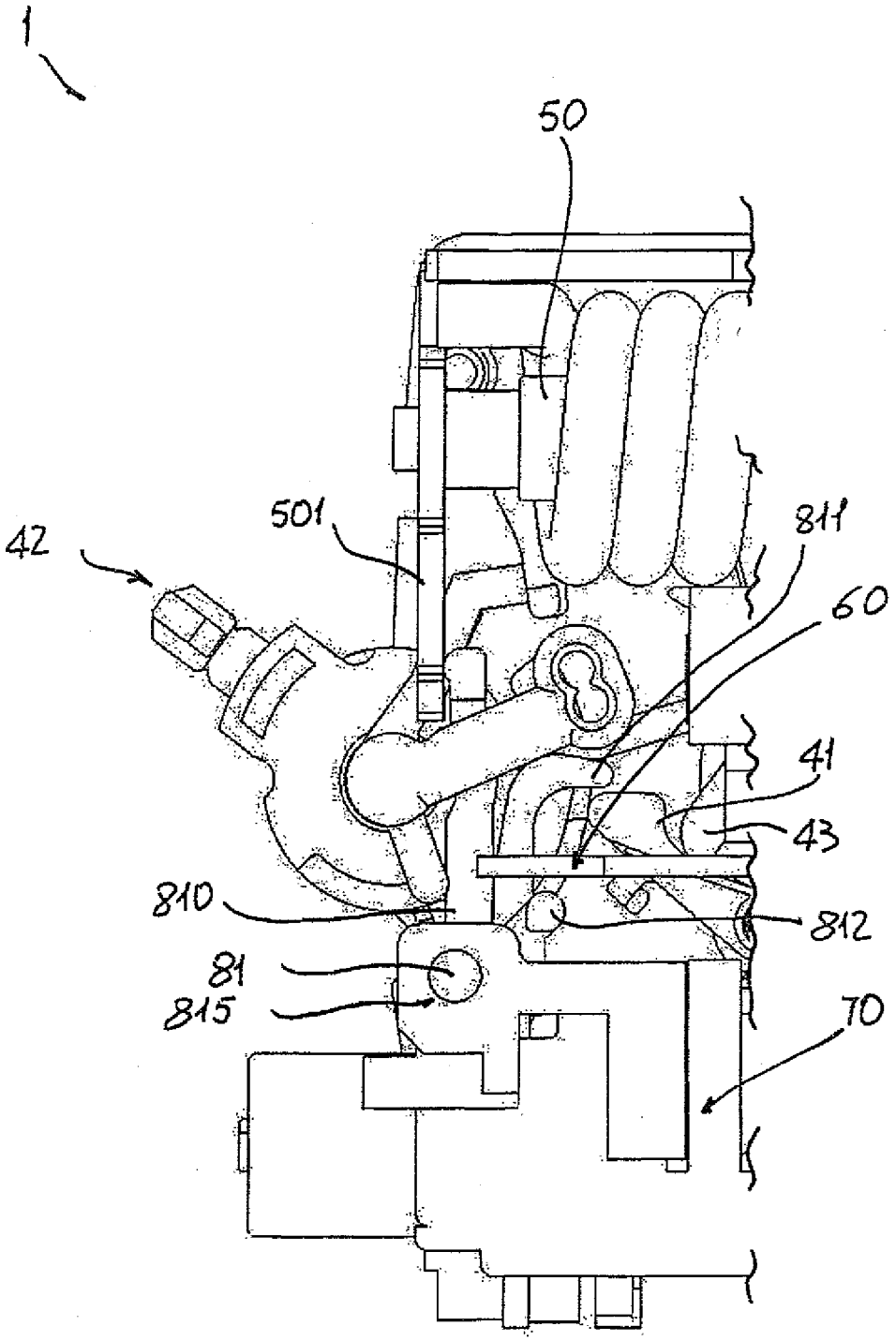

Fig. 6

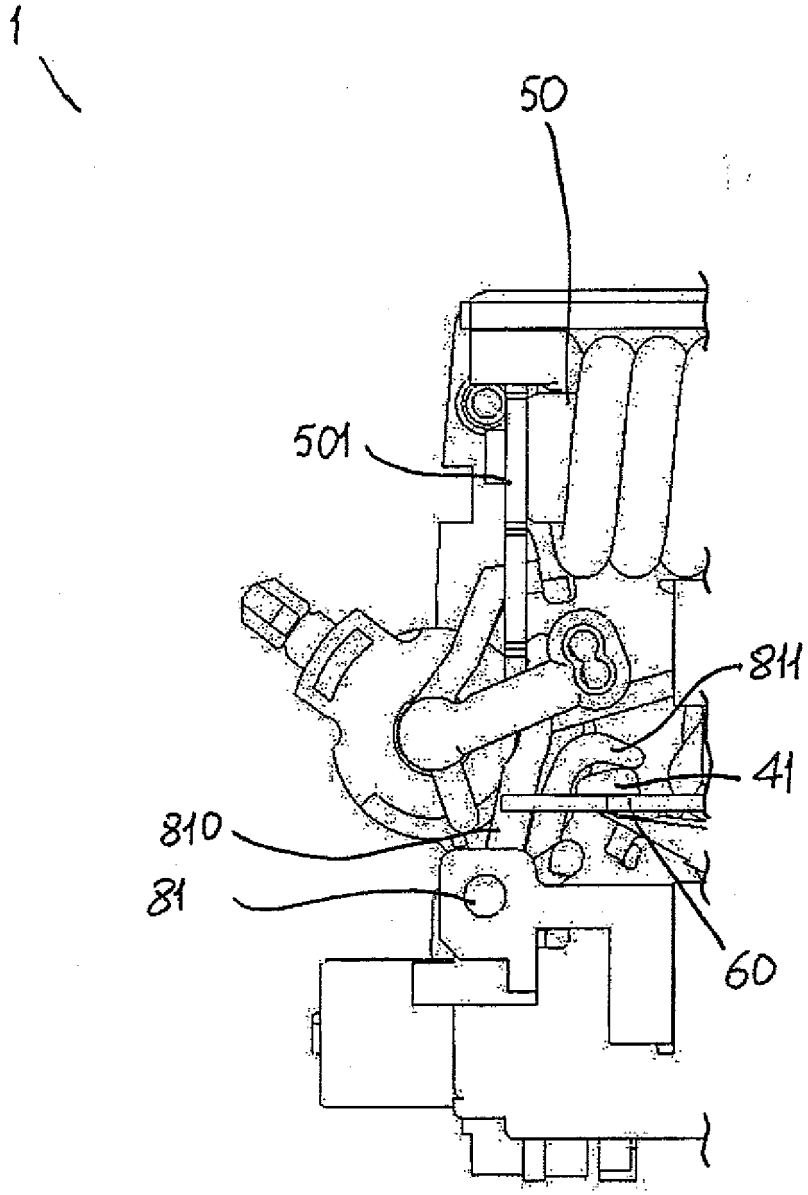

Fig. 7

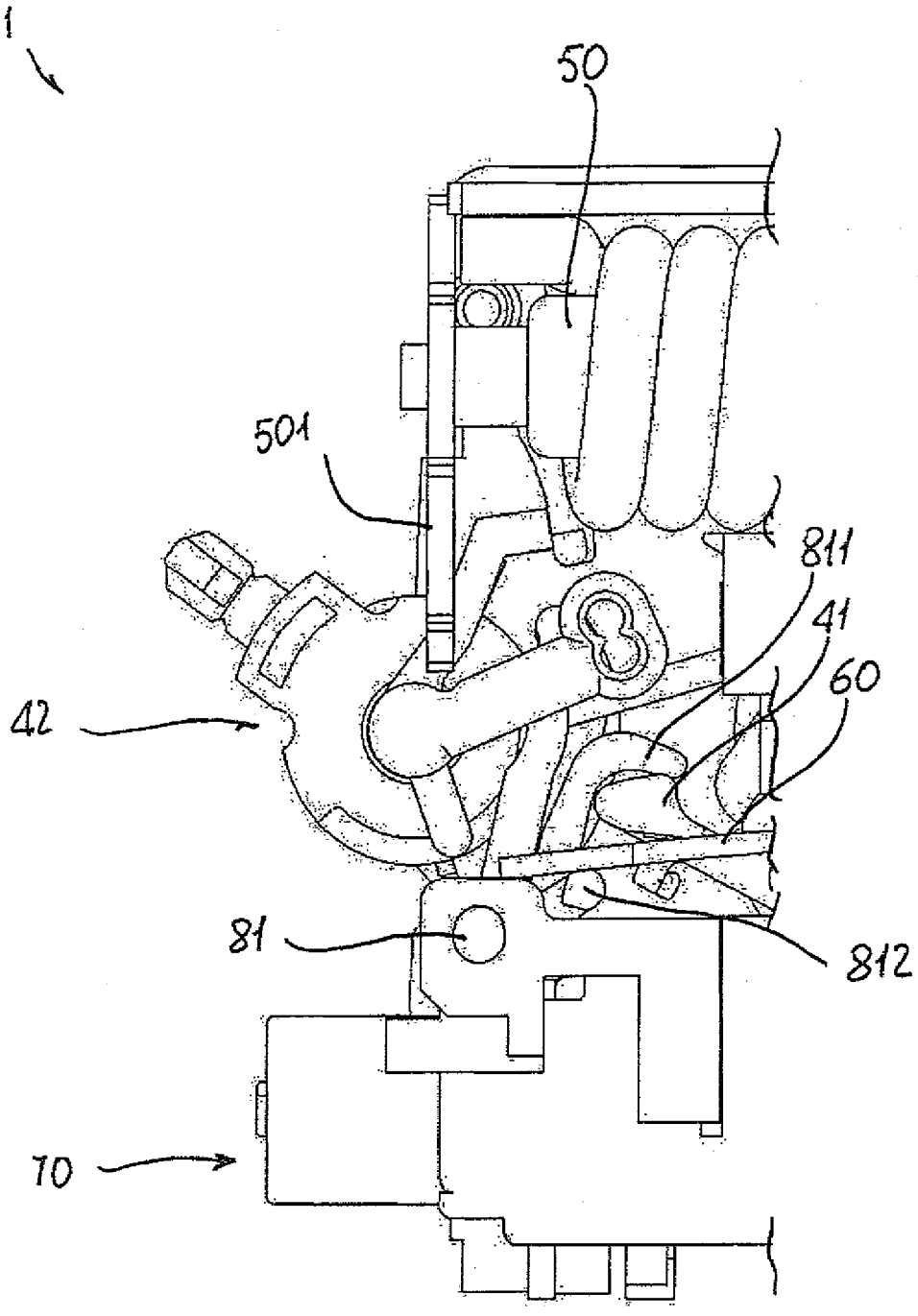

Fig. 8

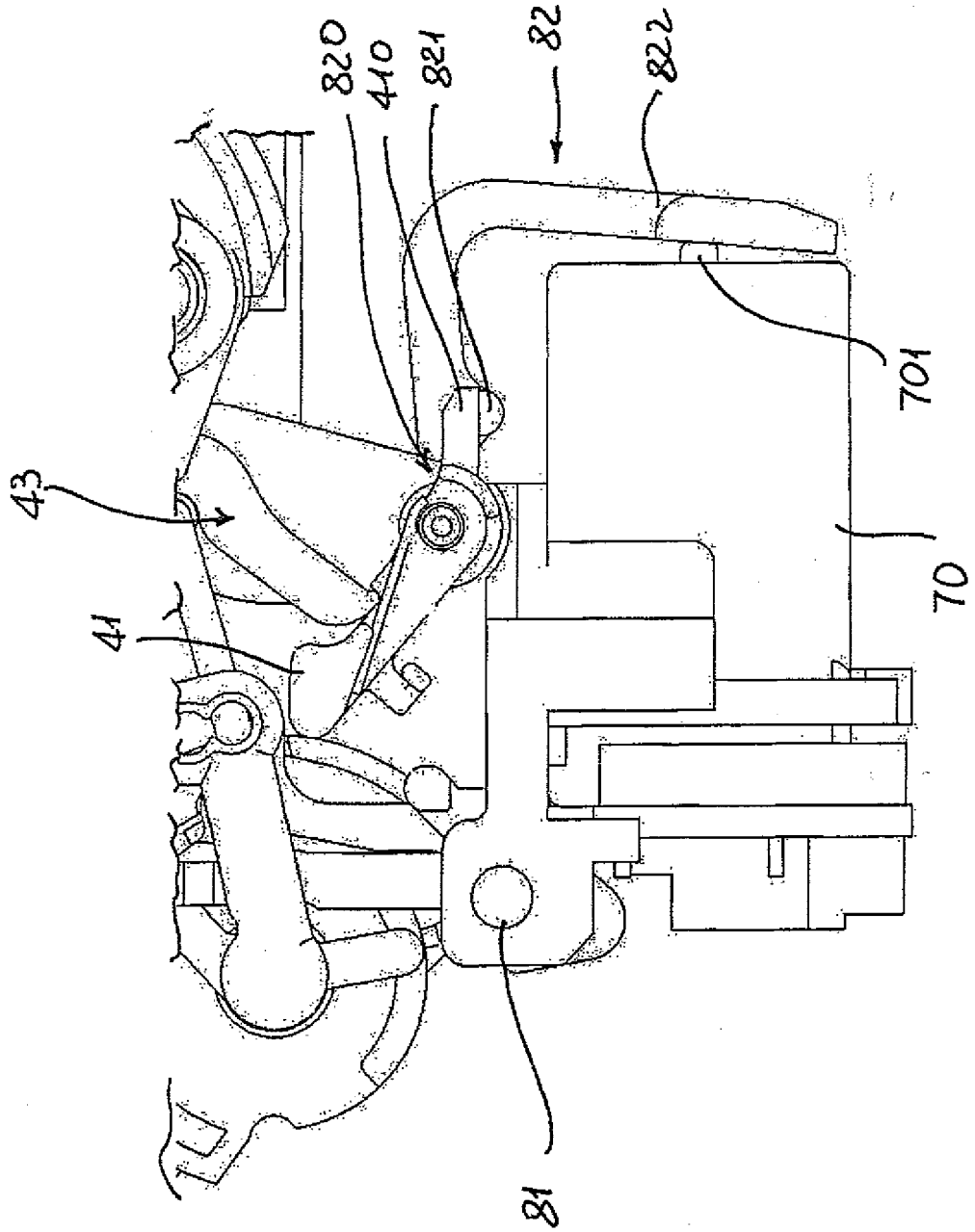

Fig. 9

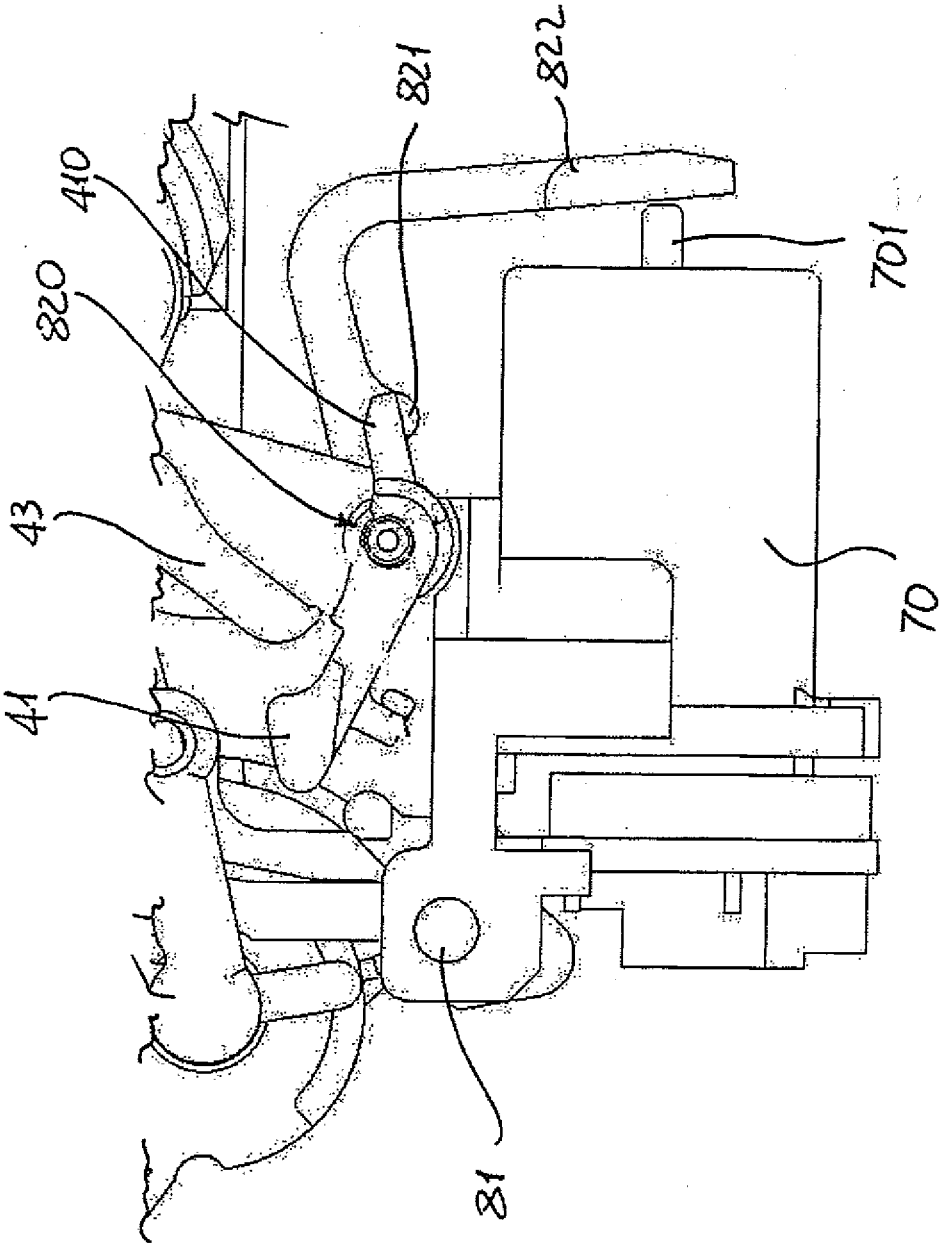

Fig. 10

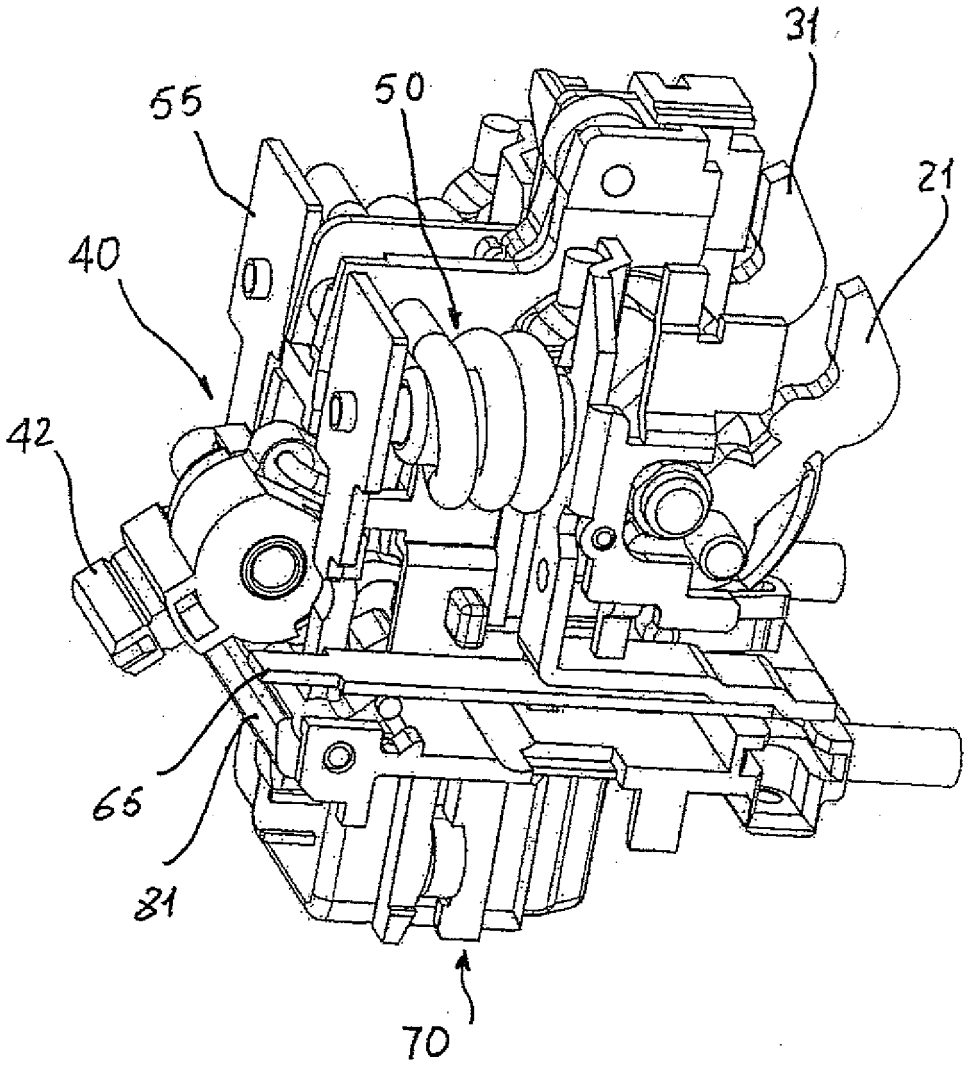

Fig. 11