(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
28 June 2018 (28.06.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/115151 A1

(51) International Patent Classification:
H01H 71/52 (2006.01) *H01H 71/58* (2006.01)

(21) International Application Number:
PCT/EP2017/083869

(22) International Filing Date:
20 December 2017 (20.12.2017)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
201611044086 23 December 2016 (23.12.2016) IN

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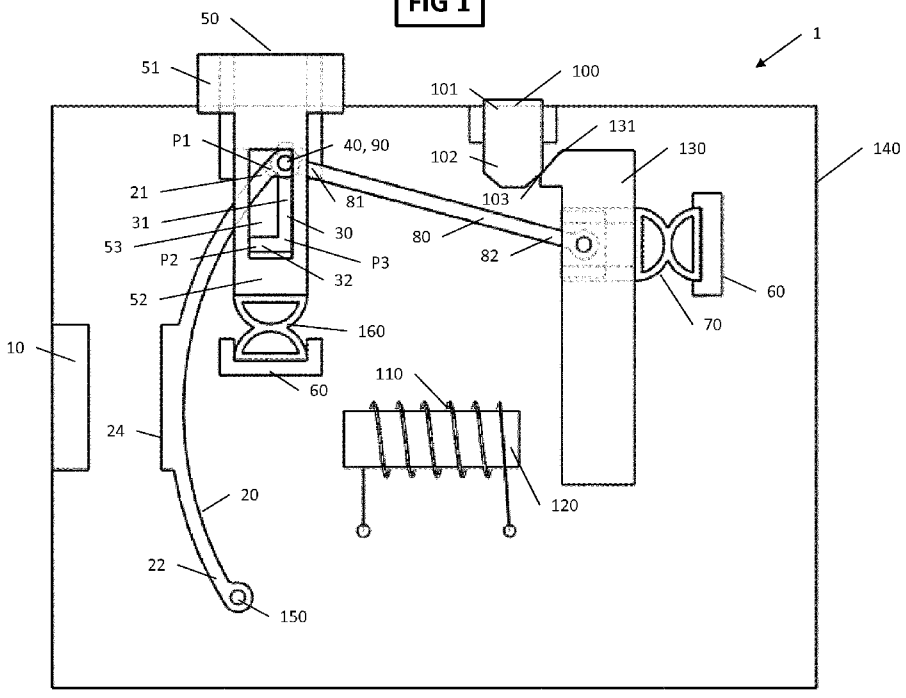
(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH,

(54) Title: CIRCUIT BREAKER WITH MANUALLY CLOSING AND OPENING FUNCTIONALITY AND TRIPPING FUNCTIONALITY

FIG 1



(57) Abstract: A circuit breaker comprises a fixed contact (10) and a compliant element (20) comprising a movable contact (24). A guiding element (40) is coupled to the compliant element (20). The compliant element (20) has a first bending state in which the movable contact (24) is in the open state, when the guiding element (40) is arranged at a first position (P1) of a guiding slot (30). The compliant element (20) has a second bending state in which the movable contact (24) is in the closed state, when the guiding element (40) is arranged at a second position (P2) of the guiding slot (30) being different from the first position (P1) of the guiding slot (30).

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GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

Description

CIRCUIT BREAKER WITH MANUALLY CLOSING AND OPENING FUNCTIONALITY AND TRIPPING FUNCTIONALITY

Technical Field

The disclosure relates to a circuit breaker for manually closing and opening a current path by means of an actuation element and having a tripping functionality that allows to operate the circuit breaker in a tripped operation state in which a movable contact is moved in an open state without operating the actuation element.

Background

A circuit breaker is an automatically operated electrical switch that is used to protect an electrical circuit from damage caused by the occurrence of a short-circuit or by a large current that is lower than the current in the case of the short-circuit but large enough to damage the electrical circuit. One requirement to the functionality of a circuit breaker is to operate the circuit breaker in a manually operating state that allows to move a movable contact between a closed and an open state. The circuit breaker may comprise an actuation element for example a rotatable knob that allows to switch the circuit breaker between the open and closed state by hand.

In the closed state, the movable contact is in electrical contact with a fixed contact of the circuit breaker so that a current path is closed and a current can flow from an input terminal to an output terminal of the circuit breaker. In an open state of the circuit breaker, the movable contact is separated from the fixed contact so that the flow of current

between the input and output terminal of the circuit breaker is interrupted.

In the case of a short-circuit in the electrical circuit connected to the circuit breaker, the circuit breaker has to be autonomously switched in a tripped operation state in which the moving contact is electrically isolated from the fixed contact so that the current path between the input and output terminal of the circuit breaker is interrupted. In the tripped operation state of the circuit breaker, it is required that the moving contact is separated from the fixed contact without moving the actuation element.

For this purpose, the circuit breaker usually comprises a solenoid and a solenoid tripping actuator. The solenoid tripping actuator may be configured as an anchor being arranged in the solenoid. A high current flowing through the solenoid excites a magnetic field by which the solenoid tripping actuator is moved out of the solenoid and hits against the moving contact to separate the moving contact from the fixed contact.

It is desirable to provide a circuit breaker with a manually closing and opening functionality and with a tripping functionality, wherein the circuit breaker allows to be switched from the manually operated state to the tripped operation state in an easy and reliable manner and the circuit breaker only comprises a low number of components.

Summary

This object is achieved by a circuit breaker as specified in claims 1 and 14.

According to the embodiment of the circuit breaker defined in claim 1, the circuit breaker comprises a fixed contact, a compliant element comprising a movable contact, a guiding slot and a guiding element being slidably arranged in the guiding slot. The compliant element is configured to move the movable contact between an open and closed state, wherein, in the open state, the movable contact is isolated from the fixed contact, and, in the closed state, the movable contact is electrically connected to the fixed contact. The guiding element is coupled to the compliant element. The compliant element has a first bending state in which the movable contact is in the open state, when the guiding element is arranged at a first position of the guiding slot. The compliant element has a second bending state in which the movable contact is in the closed state, when the guiding element is arranged at a second position of the guiding slot being different from the first position of the guiding slot.

According to a possible embodiment of the circuit breaker, the guiding slot may be formed within a casing of the circuit breaker. The first end portion of the compliant element is movably arranged within the guiding slot by means of the guiding element that is coupled to a first end portion of the compliant element. The guiding element is slidably arranged within the guiding slot. The compliant element may be configured as a compliant bow that is bent, when the guiding element slides in the guiding slot from the first position to the second position. The second end portion of the compliant element is coupled to a revolute joint.

The circuit breaker comprises a first actuation element that is configured to manually move the movable contact between the open and the closed state. The first actuation element is configured as a closing switch to move the movable contact from the open to the closed state. The first actuation

element is coupled to the guiding element and thus to the first end portion of the compliant element. In particular, the first actuation element is configured to move the guiding element/the first end portion of the compliant element from the first position of the guiding slot, at which the movable contact is separated from the fixed contact, to the second position of the guiding slot, at which the movable contact is electrically connected to the fixed contact.

The first position of the guiding slot may be located at the upper end of a vertical section of the guiding slot. The second position may be located at an end of a horizontal section of the guiding slot. In this configuration, the guiding slot may be configured as an L-shaped slot within the material of the casing of the circuit breaker.

When the first actuator is pressed downwards, it exerts a force to the guiding element. As a result, the first end portion of the compliant element and the guiding element is moved downwards in the vertical section to a third position at which the vertical and the horizontal section of the guiding slot intersect. The guiding element is then moved in the vertical section of the guiding slot towards the third position.

The circuit breaker comprises a second actuation element being configured as an opening switch to move the movable contact from the closed to the open state. The second actuation element is coupled to a supporting element. The supporting element is arranged at an end of a coupling element that couples the supporting element with the first end portion of the compliant element and the guiding element. The supporting element bears on a spring element.

When the second actuation element is moved from a first actuation state to a second actuation state, for example is pressed downwards in the casing, the second actuation elements comes in contact with the supporting element and moves the supporting element. The supporting element moves the coupling element and thus the first end section of the compliant element and the guiding pin in the guiding slot from the second position in the vertical section of the guiding slot to the third position at the interconnection of the vertical and the horizontal section of the guiding slot and from the third position to the first position of the guiding slot at which the movable contact is again electrically separated from the fixed contact.

In order to realize a tripping functionality of the circuit breaker, a solenoid pin may exert a force on the supporting element in the case of a short circuit so that the first end portion of the compliant element and the guiding pin is moved from the second position of the guiding slot to the third position of the guiding slot at which the movable contact is electrically isolated from the fixed contact.

According to another possible embodiment, the circuit breaker may comprise a rotatable element that is rotatably arranged at the casing of the circuit breaker. The guiding slot may be arranged at the rotatable element. The circuit breaker may comprise a latching element to lock the rotatable element in a first rotatable state. In the first rotatable state of the rotatable element the movable contact may be moved between the open and the closed position by an actuation element of the circuit breaker.

In order to operate the circuit breaker in a tripped operation state the latching element may be actuated by a solenoid pin to unlock the rotatable element so that the

rotatable element is freely movable. In the unlocked state of the rotatable element the bending force stored in the compliant element releases so that the guiding element and thus the first end portion of the compliant element is moved in the guiding slot from the second position at which the movable contact is in a closed state to a position of the guiding slot at which the movable contact is electrically separated from the fixed contact.

According to an embodiment of the circuit breaker specified in claim 14, the circuit breaker comprises a fixed contact, and a compliant element comprising a movable contact. The compliant element is configured to move the movable contact between an open and closed state. In the open state, the movable contact is isolated from the fixed contact, and, in the closed state, the movable contact is electrically connected to the fixed contact. The circuit breaker comprises a rotatable actuation element to move the movable contact from the open state to the closed state. The compliant element has a first end being coupled to the rotatable actuation element and a second end coupled to a revolute joint. In a first rotatable state of the rotatable actuation element, the compliant element has a first bending state, in which the movable contact is in the open state. In a second rotatable state of the rotatable actuation element, the compliant element has a second bending state, in which the movable contact is in the closed state.

The circuit breaker may comprise a latching element to lock the rotatable actuation element at the second rotatable state so that the movable contact is secured in the closed state of the circuit breaker. In the case of the occurrence of a short circuit a solenoid pin may exert a force on the latching element so that the rotatable actuation element is unlocked

and the movable contact snaps back by a release of the compliant element to the open state.

The accompanying drawings are included to provide a further understanding and are incorporated in and constitute a part of this specification. The drawings illustrate several embodiments of the circuit breaker, and together with the description serve to explain principles and the operation of the various embodiments.

Brief Description of the Drawings

Figure 1 shows a first embodiment of a circuit breaker in a manually operation state with a movable contact in an open position;

Figure 2 shows the first embodiment of the circuit breaker in a manually operation state with a movable contact in the closed position;

Figure 3 shows the first embodiment of the circuit breaker in a tripped operation state with a movable contact in an open position;

Figure 4 shows a second embodiment of a circuit breaker in a manually operation state with a movable contact in an open position;

Figure 5 shows the second embodiment of the circuit breaker in a manually operation state with a movable contact in a closed position;

Figure 6 shows the second embodiment of the circuit breaker in a tripped operation state with a movable contact in an open position;

Figure 7 shows a third embodiment of a circuit breaker in an open state; and

Figure 8 shows the third embodiment of the circuit breaker in a closed state.

Detailed Description

Figures 1 to 3 illustrate a first embodiment of a circuit breaker 1 to realize the manually opening and closing functionality as well as the tripping functionality of the circuit breaker. Figures 1 and 2 illustrate the functionality of the first embodiment of the circuit breaker in the manual operation state in which the circuit breaker may be switched by hand between the open and closed state. Figure 3 illustrates the tripping state of the circuit breaker of the first embodiment in which the circuit breaker is switched in the open state in the case of the occurrence of a short circuit.

The circuit breaker 1 comprises a fixed contact 10 and a compliant element 20 comprising a movable contact 24. The circuit breaker further comprises a guiding slot 30 and a guiding element 40 that is slidably arranged in the guiding slot 30. According to the first embodiment of the circuit breaker shown in Figures 1 to 3, the guiding slot 30 is arranged in a casing 140 of the circuit breaker, for example the guiding slot 30 is provided in a wall of the casing 140. The guiding element 40 is coupled to the compliant element 20. In particular, the guiding element 40 is coupled to a first end portion 21 of the compliant element 20. The guiding element 40 may be configured as a guiding pin that is slidably/movably arranged within the guiding slot 30. A second end portion 22 of the compliant element 20 may be

supported at an abutment element 150. The abutment element 150 may be configured as a revolute joint.

The compliant element 20 is configured to move the movable contact 24 between an open and closed state. In the open state shown in Figure 1, the movable contact 24 is isolated from the fixed contact 10. In the closed state shown in Figure 2, the movable contact 24 is electrically connected to the fixed contact 10.

The compliant element 20 has a first bending state shown in Figure 1 in which the movable contact 24 is in an open state, when the guiding element 40 is arranged at a first position P1 of the guiding slot 30. Referring to Figure 2, the compliant element 20 is shown in a second bending state in which the movable contact 24 is in the closed state, when the guiding element 40 is arranged at a second position P2 of the guiding slot 30 being different from the first position P1 of the guiding slot 30.

The guiding slot 30 has a first section 31 and a second section 32 that are directed in different directions. The first section 31 of the guiding slot 30 extends from the first position P1 of the guiding slot to a third position P3 of the guiding slot. The second section 32 of the guiding slot extends from the third position P3 to the second position P2.

According to the first embodiment of the circuit breaker the first section 31 of the guiding slot may be configured as a vertical section, and the second section 32 of the guiding slot may be configured as a horizontal section. In particular, the guiding slot may be L-shaped, as shown in Figures 1 to 3.

In order to manually move the movable contact 24 from the open to the closed state when the circuit breaker is operated in the manual operation state, the circuit breaker 1 comprises a first actuation element 50 that is configured as a closing switch. The first actuation element 50 protrudes out of the casing 140 and is coupled to the compliant element 20 to bend the compliant element from the first bending state (Figure 1) to the second bending state (Figure 2). In particular the first actuation element 50 is coupled to the guiding element 40 to move the guiding element 40 in the guiding slot 30 from the first position P1 to the second position P2. As a consequence, the compliant element 20 and thus the movable contact 24 is bent towards the fixed contact 10.

The first actuation element 50 may comprise a first portion 51 that may be configured as a knob to be manually pushed by an operator from a first actuation state to a second actuation state. In the first actuation state of the first actuation element 50, the movable contact 24 is in the open state. In the second actuation state of the first actuation element 50 the movable contact 24 is in the closed state.

The first actuation element 50 comprises a second portion 52, wherein an end section of the second portion 52 of the first actuation element 50 is supported at a spring element 160. The spring element 160 bears on an abutment element 60. The second portion 52 of the first actuation element 50 has a cavity 53. The first actuation element 50 is arranged such that in the first actuation state of the first actuation element 50 in which the movable contact is in the open state, the second portion 52 and, in particular, the cavity 53 extends along the guiding slot 30, as illustrated in Figures 1 and 2. In the first actuation state of the first actuation element 50, the second portion 52 and, in particular, the

cavity 53 of the first actuation element 50 is arranged above the guiding slot 30.

The first section 31 of the guiding slot 30 is directed so that the guiding element 40 is vertically moved in the guiding slot 30 from the first position P1 to the third position P3 of the guiding slot, when the first actuation element 50 is pressed downwards from the first actuation state to the second actuation state. The second section 32 of the guiding slot 30 is directed so that the guiding element 40 is horizontally moved in the second portion 32 of the guiding slot 30 from the third position P3 of the guiding slot 30 to the second position P2 of the guiding slot, when the guiding element 40 is moved prior to that in the first section 31 from the first position P1 to the third position P3.

The guiding slot 30 may be formed such that the guiding element 40 is locked at the second position P2 of the guiding slot 30 so that the compliant element 20 is locked in the second bending state of the compliant element 20 and the movable contact 24 is locked in the closed state.

The circuit breaker 1 further comprises a spring element 70 and a coupling element 80. The spring element 70 bears on an abutment element 60. The coupling element 80 has a first end section 81 coupled to the compliant element 20 by a joint 90. The compliant element 80 further has a second end section 82 coupled to the spring element 70. The spring element 70 is configured to exert a force on the compliant element 20 by means of the coupling element 80 so that the guiding element 40 is moved in the second section 32 of the guiding slot 30 from the third position P3 of the guiding slot 30 to the second position P2 of the guiding slot, when the guiding element 40 is moved prior to that by the first actuation

element 50 from the first position P1 of the guiding slot 30 to the third position P3 of the guiding slot.

In order to move the movable contact 24 from the closed state shown in Figure 2 to the open state shown in Figure 1, the circuit breaker comprises a second actuation element 100 that is configured as an opening switch. The second actuation element 100 is coupled to the coupling element 80 to move the coupling element 80 in a direction so that the guiding element 40 is moved in the second section 32 of the guiding slot 30 from the second position P2 to the third position P3. In order to open the movable contact 24, the second actuation element 100 is moved from a first actuation state to a second actuation state by pressing the second actuation element 100 downwards. As a consequence, the second actuation element 100 moves/pulls the coupling element 80 towards the spring element 70.

The circuit breaker 1 may comprise a supporting element 130 that is coupled to the coupling element 80 and is arranged between the second end section 82 of the coupling element 80 and the spring element 70. The second end section 82 of the compliant element 80 is coupled to the spring element 70 by the supporting element 130. When the second actuation element 100 is moved from the first actuation state to the second actuation state to open the movable contact 20, the second actuation element 100 exerts a force on the supporting element 130. As a consequence, the coupling element 80 is moved by the supporting element 130 towards the spring element 70, and the guiding element 40 is moved in the second section 32 of the guiding slot 30 from the second position P2 to the third position P3.

The second actuation element 100 has a first end section 101 to be pushed by an operator and a second end section 102

having a slanted surface 103. The supporting element 130 has a slanted surface 131 being in contact with the slanted surface 103 of the second actuation element 100. When the second actuation element 100 is moved from the first actuation state to the second actuation state, for example is pushed down, the slanted surface 103 of the second end section 102 of the second actuation element 100 slides on the slanted surface 131 of the supporting element 130.

As a result, the supporting element 130 pulls the coupling element 80 in a direction to the left so that the guiding element 40 is moved in the second section 32 of the guiding slot 30 from the second position P2 to the third position P3. In particular, the supporting element 130 is moved by the second actuation element 100 towards the spring element 70 and pushes the guiding element 40 in the second section 32 of the guiding slot from the second position P2 to the third position P3. As shown in Figure 2, the coupling element 80 is arranged and moved in a direction parallel to the second section 32 of the guiding slot 30.

When the guiding element 40 is moved in the guiding slot 30 from the second position P2 to the third position P3, the bending force stored in the compliant element 20 effects that the compliant element 20 releases and the guiding element 40 is moved in the first section 31 of the guiding slot 30 from the third position P3 to the first position P1 of the guiding slot 30 so that the movable contact 24 returns in the open state shown in Figure 1.

The functioning of the first embodiment of the circuit breaker 1 in the manual operation state can be summarized as follows.

In order to manually switch the circuit breaker 1 from the open to the closed state, a vertical force is applied on the first actuation element 50 against the spring element 160. The guiding element 40 is moved by the first actuation element 50 within the guiding slot 30 in the vertical downward direction. As a consequence, the compliant element 20 bends which in turn translates the movable contact 24 towards the fixed contact 10 until the contact is closed. The spring element 70 always tries to keep the joint 90/guiding element 40 within the horizontal arm 32 of the guiding slot 30 at the second position P2, i.e. in the extreme left position. This spring force along with the compliance of the mechanism provides the necessary contact force. The guiding element 40 may be held at the second position P2 by some latching mechanism. Figure 2 shows the mechanism in the closed position.

In order to manually open the movable contact 24, a vertical force is applied on the second actuation element 100 so that the guiding element 40/the joint 90 is pushed from the second position P2 to the third position P3 against the spring force of the spring element 70 until the guiding element 40 comes to the third position P3 in the extreme right position of the horizontal arm 32 of the guiding slot 30. The guiding element 40 then freely moves upwards in the vertical arm 31 of the guiding slot 30 unloading the compliant element 20, which in turn opens the movable contact 24 by a snapping action. The spring element 160 will bring back the first actuation element 50 to its original position once the contacts are open.

In order to operate the circuit breaker 1 of the first embodiment in the tripped operation state, the circuit breaker 1 comprises a solenoid 110 and a solenoid pin 120. The solenoid pin 120 is arranged so that in the case of a

short circuit, an electromagnetic field is generated in the solenoid 110 that moves the solenoid pin 120 towards the supporting element 130. As a consequence, the coupling element 80 moves in a direction that causes the guiding element 40 to be moved in the second section 32 of the guiding slot 30 from the second position P2 to the third position P3.

Figure 3 shows the circuit breaker 1 in the tripped configuration when the guiding element 40 is moved by the tripping force applied to the supporting element 30 from the second position P2 to the third position P3 in the horizontal arm 32 of the guiding slot 30. The guiding element 40 then moves freely upwards in the vertical arm 31 of the guiding slot unloading the compliant element 20 which opens the contacts by a snapping action. Thus irrespective of the first and the second actuation elements 50 and 100, the contacts 10, 24 will open when the tripping force is applied. The spring element 160 will bring back the first actuation element 50 to its original position once the contacts are open.

Figures 4 to 6 show a second embodiment of the circuit breaker 2 to realize the manual opening and closing functionality and to realize a tripping operation of the circuit breaker. The circuit breaker 2 comprises a fixed contact 10 and a compliant element 20 comprising a movable contact 24. The circuit breaker 2 further comprises a guiding slot 30 and a guiding element 40 being slidably arranged in the guiding slot 30. The compliant element 20 is configured to move the movable contact 24 between an open and closed state. The guiding element 40 is coupled to the compliant element 20 at a first end portion 21 of the compliant element 20. A second end portion 22 of the compliant element is

coupled to an abutment element 150 that may be configured as a revolute joint.

The guiding element 40 may be configured as a guiding pin that is slidably or movably arranged within the guiding slot 30. The guiding element 40 is fixed to the first end portion 21 of the compliant element 20. An opposite second end portion 22 of the compliant element 20 may be supported at an abutment element 150. The abutment element 150 may be configured as a revolute joint.

The compliant element 20 has a first bending state shown in Figure 4 in which the movable contact 24 is in the open state, when the guiding element 40 is arranged at a first position P1 of the guiding slot 30. The compliant element 20 has a second bending state shown in Figure 5 in which the movable contact 24 is in the closed state when the guiding element 40 is arranged at a second position P2 of the guiding slot 30. The compliant element 20 may be configured as a compliant bow.

The circuit breaker 2 comprises a rotatable element 170 being rotatably arranged at the casing 140. The rotatable element 170 may be configured as a rotating disk. The guiding slot 30 is arranged within the rotatable element 170. The guiding slot 30 has a first section 31 and a second section 32 that are directed in different directions. The first section 31 of the guiding slot 30 extends from the first position P1 of the guiding slot 30 to a third position P3 of the guiding slot 30. The second section 32 of the guiding slot 30 extends from the third position P3 of the guiding slot to the second position P2 of the guiding slot. The first and the second sections 31, 32 of the guiding slot may be orthogonally arranged and intersect at the third position P3. The guiding slot 30 may be formed such that the guiding element 40 is

locked at the second position P2 of the guiding slot 30 so that the compliant element 20 is locked in the second bending state of the compliant element 20 and the movable contact 24 is locked in the closed state.

The circuit breaker 2 comprises an actuation element 180 to move the movable contact 24 from the open state to the closed state. The circuit breaker 2 further comprises a coupling element 80 having a first end section 81 coupled to the compliant element 50 by a joint 90 and having a second section 82 coupled to the actuation element 180. The actuation element 180 may be configured as a push button having a first end section 181 to apply a force by an operator to the actuation element 180 to close the movable contact 24. A second end section 182 of the actuation element 180 rests on a spring element 200.

The actuation element 180 is configured to exert a force on the compliant element 20 by the coupling element 80 so that the compliant element 20 is bent from the first bending state shown in Figure 4 to the second bending state shown in Figure 5, when the actuation element 180 is moved from a first actuation state in which the movable contact 24 is in the open state to a second actuation state in which the movable contact is in the closed state. When pushing the actuation element 180 from the first actuation state to the second actuation state, the guiding element 40 is moved in the guiding slot 30 from the first position P1 (Figure 4) to the second position P2 (Figure 5).

The circuit breaker 2 comprises a latching element 190 to lock the rotatable element 170 in a first rotatable state so that the guiding slot 30 is firmly positioned. In the first rotatable state of the rotatable element 170, the actuation element 180 is configured to manually move the movable

contact 24 between the open and closed state by means of the actuation element 180. The rotatable element 170 is locked during the manual operating state of the circuit breaker when the guiding pin 40 is moved from the first position P1 to the second position P2 of the guiding slot 30.

Referring to Figure 4 showing the mechanism of the circuit breaker 2 in an open position, a force is applied in the negative “x” direction on the actuation element 180 that pushes the guiding element 40 in the guiding slot 30 from the first position P1 to the second position P2. As the guiding element 40 is moved in the guiding slot 30, the compliant element 20 gets translated in the negative “x” direction as well as getting bent. Thus, the movable contact 24 is electrically connected to the fixed contact 10. The actuation element 180 may be arrested in this position with some spring mechanism. Slot angled orientation helps in arresting the mechanism in a closed position. The latching element 190 is in the latched condition during the manual operating state of the circuit breaker. The latching element 190 along with the compliance of the mechanism provides necessary contact force in the closed state of the movable contact 24.

Figure 5 shows the mechanism in the closed state. When the actuation element 180 is released, it pulls the coupling element 80 in the positive “x” direction. This pulling force along with the compliance of the mechanism results in opening of the contacts. The angled orientation of the guiding slot 40 helps in contact opening. The latching element 190 is in the latched condition during the manual opening of the movable contact 24.

In order to realize the tripping functionality the circuit breaker 2 comprises a solenoid 110 and a solenoid pin 120. The solenoid pin 120 is arranged so that, in the case of a

short circuit, an electromagnetic field is generated in the solenoid 110 that move the solenoid pin 120 towards the latching element 190. The latching element 190 releases the rotatable element 170 so that the fixed state of the rotatable element 170 is changed in an unlocked state in which the rotatable element is freely rotatable.

The rotatable element 170 is configured to move in a stable rotatable state, when the rotatable element 170 is unlocked during the tripping operation. To this purpose, the rotatable element 170 may be configured as a spring loaded device. As shown in Figure 6, the rotatable element rotates in the anticlockwise direction, when the latching element 190 releases the locking element 171 of the rotatable element 170. The rotational movement of the rotatable element 170 is stopped when the locking element 171 abuts on a connecting link/abutment 210. In the stable rotatable state of the rotatable element 170, the guiding slot 30 is positioned such that the bending force stored in the compliant element 20 effects that the compliant element 20 releases and the guiding element 40 is moved in the second section 32 of the guiding slot 30 from the second position P2 to the third position P3 so that the movable contact 20 is moved in the open state, as shown in Figure 6.

During the tripped operation state, the tripping force from the solenoid pin 120 is applied on the latching element 190 which unlatches the mechanism allowing the rotatable element 170 to rotate in the anticlockwise direction. The rotatable element stops until the locking element 171 abuts on the connecting link/abutment 210. During the rotation of the rotatable element 170 the guiding element 40 moves in the guiding slot from the position P2 to the position P3 which results in span opening of the contacts. The compliant element 20 bends as the guiding element 40 moves in the

guiding slot 30, making sure that the contacts will open irrespective of the actuation state of the actuation element 180.

Figures 7 and 8 show a third embodiment of a circuit breaker 3 to realize an opening and closing functionality in a manual operation state and a tripping operation state, when a short circuit occurs. The circuit breaker 3 comprises a fixed contact 10 and a compliant element 20 comprising a movable contact 24. The compliant element 20 is configured to move the movable contact 24 between an open and closed state. In the open state, the movable contact 24 is isolated from the fixed contact 10, and in the closed state the movable contact 24 is electrically connected to the fixed contact 10.

The circuit breaker 3 further comprises a rotatable actuation element 220 to move the movable contact 24 from the open state to the closed state. The compliant element 20 has a first end 21 being coupled to the rotatable actuation element 220 and a second end 22 coupled to a revolute joint 150. The revolute joint 150 is attached to the ground/casing of the circuit breaker.

The proposed mechanism makes use of the compliant element being configured as a flexible bow-like structure to store energy as well as to transfer motion of the movable contact 24. In a first rotatable state of the rotatable actuation element 220 shown in Figure 7, the compliant element 20 has a first bending state, in which the movable contact 24 is in the open state. In a second rotatable state of the rotatable actuation element 200 shown in Figure 8, the compliant element 20 has a second bending state, in which the movable contact 24 is in the closed state. In order to move the movable contact 24 in the closed state, the actuation element

220 is rotated in the anticlockwise direction. The contact is established and also the mechanism is latched.

To realize the latching action, the circuit breaker 2 comprises a latching element 230 being configured to lock the rotatable actuation element 220, when the rotatable actuation element 220 is manually moved by means of the rotatable actuation element 220 in the second rotatable state, as shown in Figure 8.

The rotatable actuation element 220 comprises a locking element 221. The latching element 230 is configured to engage in the locking element 221 so that the rotatable actuation element 220 is locked in the second rotatable state in which the movable contact 24 is electrically connected to the fixed contact 10. The latching element 230 is configured as a spring-loaded latching element comprising a pre-loaded torsional spring 233.

In order to realize the tripping functionality, the circuit breaker 3 comprises a solenoid 110 and a solenoid tripping actuator 120. The latching element 230 has a first section 231 to engage in the locking element 221 and a second section 232. The solenoid tripping actuator 120 is arranged so that, in the case of a short circuit, an electromagnetic field is generated in the solenoid 110 that moves the solenoid tripping actuator 120 towards the second section 232 of the latching element 230. As a result, the first section 231 of the latching element 230 disengages from the locking element 221. The rotatable actuation element 220 is unlocked and the bending force stored in the compliant element 20 effects that the compliant element 20 releases and the movable contact 24 is moved in the open/tripped state.

List of Reference Signs

1, 2, 3	embodiments of a circuit breaker
10	fixed contact
20	compliant element
30	guiding slot
40	guiding element
50	first actuation element
60	abutment element
70	spring element
80	coupling element
90	joint
100	second actuation element
110	solenoid
120	solenoid tripping actuator
130	supporting element
140	casing
150	revolute joint
160	spring element
170	rotatable element
180	actuation element
190	latching element
200	spring element
210	connecting link
220	rotatable actuation element
230	latching element

Claims

1. A circuit breaker, comprising:
- a fixed contact (10),
- a compliant element (20) comprising a movable contact (24),
- a guiding slot (30),
- a guiding element (40) being slideably arranged in the guiding slot (30),
- wherein the compliant element (20) is configured to move the movable contact (24) between an open and closed state, wherein, in the open state, the movable contact (24) is isolated from the fixed contact (10), and, in the closed state, the movable contact (24) is electrically connected to the fixed contact (10),
- wherein the guiding element (40) is coupled to the compliant element (20),
- wherein the compliant element (20) has a first bending state in which the movable contact (24) is in the open state, when the guiding element (40) is arranged at a first position (P1) of the guiding slot (30), and wherein the compliant element (20) has a second bending state in which the movable contact (24) is in the closed state, when the guiding element (40) is arranged at a second position (P2) of the guiding slot (30) being different from the first position (P1) of the guiding slot (30).

2. The circuit breaker of claim 1,
wherein the guiding slot (30) is formed such that the guiding element (40) is locked at the second position (P2) of the guiding slot (30) so that the compliant element (20) is locked in the second bending state.

3. The circuit breaker of claims 1 or 2,

- wherein the guiding slot (30) has a first section (31) and a second section (32) that are directed in different directions,
- wherein the first section (31) of the guiding slot (30) extends from the first position (P1) of the guiding slot (30) to a third position (P3) of the guiding slot (30) and the second section (32) of the guiding slot (30) extends from the third position (P3) of the guiding slot (30) to the second position (P2) of the guiding slot (30).

4. The circuit breaker of claims 1 to 3, comprising:
a first actuation element (50) to move the movable contact (24) from the open state to the closed state, wherein the first actuation element (50) is coupled to the compliant element (20) to bend the compliant element from the first bending state to the second bending state.

5. The circuit breaker of claim 4, comprising:
- a spring element (70),
- a coupling element (80) having a first end section (81) coupled to the compliant element (20) by a joint (90) and having a second end section (82) coupled to the spring element (70),
- wherein the spring element (70) is configured to extert a force to the compliant element (20) by means of the coupling element (80) so that the the guiding element (40) is moved in the second section (32) of the guiding slot (30) from the third position (P3) of the guiding slot (30) to the second position (P2) of the guiding slot (30), when the guiding element (40) is moved prior to that by the first actuation element (50) from the first position (P1) of the guiding slot (40) to the third position (P3) of the guiding slot (30).

6. The circuit breaker of claims 4 or 5, comprising:

a second actuation element (100) to move the movable contact (24) from the closed state to the open state, wherein the second actuation element (100) is coupled to the coupling element (80) to move the coupling element (80) in a direction so that the guiding element (40) is moved in the second section (32) of the guiding slot (30) from the second position (P2) to the third position (P3) of the guiding slot (30).

7. The circuit breaker of claims 5 or 6, comprising:
- a solenoid (110) and a solenoid tripping actuator (120),
- a supporting element (130) coupled to the coupling element (80),
- wherein the solenoid tripping actuator (120) is arranged so that, in the case of a short circuit, an electromagnetic field is generated in the solenoid (110) that moves the solenoid tripping actuator (120) towards the supporting element (130) so that the coupling element (80) moves in a direction that causes the guiding element (40) to be moved in the second section (32) of the guiding slot (30) from the second position (P2) to the third position (P3) of the guiding slot (30).

8. The circuit breaker of claims 1 to 7, comprising:
- a casing (140),
- wherein the guiding slot (30) is arranged in the casing (140).

9. The circuit breaker of claims 1 to 4, comprising:
- a casing (140),
- a rotatable element (170) being rotatably arranged at the casing (140),
- wherein the guiding slot (30) is arranged within the rotatable element (170).

10. The circuit breaker of claim 9, comprising:
- an actuation element (180) to move the movable contact (24) from the open state to the closed state,
- a coupling element (80) having a first end section (81) coupled to the compliant element (20) by a joint (90) and having a second end section (82) coupled to the actuation element (180),
- wherein the actuation element (180) is configured to exert a force to the compliant element (20) by the coupling element (80) so that the compliant element (20) is bent from the first bending state to the second bending state, when the actuation element (180) is moved from a first actuation state in which the movable contact (24) is in the open state to a second actuation state.

11. The circuit breaker of claims 9 or 10, comprising:
- a latching element (190) to lock the rotatable element (170) in a first rotatable state so that the guiding slot (30) is firmly positioned,
- wherein, in the first rotatable state, the actuation element (180) is configured to move the movable contact (24) between the open and closed state.

12. The circuit breaker of claim 11, comprising:
- a solenoid (110) and a solenoid tripping actuator (120),
- wherein the solenoid tripping actuator (120) is arranged so that, in the case of a short circuit, an electromagnetic field is generated in the solenoid (110) that moves the solenoid tripping actuator (120) towards the latching element (190) so that the rotatable element (170) is in an unlocked state in which the rotatable element is freely rotatable.

13. The circuit breaker of claim 12,

- wherein the rotatable element (170) is configured to move in a stable rotatable state, when the rotatable element (170) is unlocked during the tripping operation,
- wherein, in the stable rotatable state of the rotatable element (170), the guiding slot (30) is positioned such that the bending force stored in the compliant element (20) effects that the compliant element (20) releases and the guiding element (40) is moved in the guiding slot (30) from the second position (P2) to the third position (P3) of the guiding slot 30 so that the movable contact (20) is moved in the open state.

14. A circuit breaker, comprising:
- a fixed contact (10),
- a compliant element (20) comprising a movable contact (24), wherein the compliant element (20) is configured to move the movable contact (24) between an open and closed state, wherein, in the open state, the movable contact (24) is isolated from the fixed contact (10), and, in the closed state, the movable contact (24) is electrically connected to the fixed contact (10),
- a rotatable actuation element (220) to move the movable contact (24) from the open state to the closed state,
- wherein the compliant element (20) has a first end (21) being coupled to the rotatable actuation element (220) and a second end (22) coupled to a revolute joint (150),
- wherein, in a first roatable state of the rotatable actuation element (220), the compliant element (20) has a first bending state, in which the movable contact (24) is in the open state, and, in a second rotatable state of the rotatable actuation element (220), the compliant element (20) has a second bending state, in which the movable contact (24) is in the closed state.

15. The circuit breaker of claim 14, comprising:

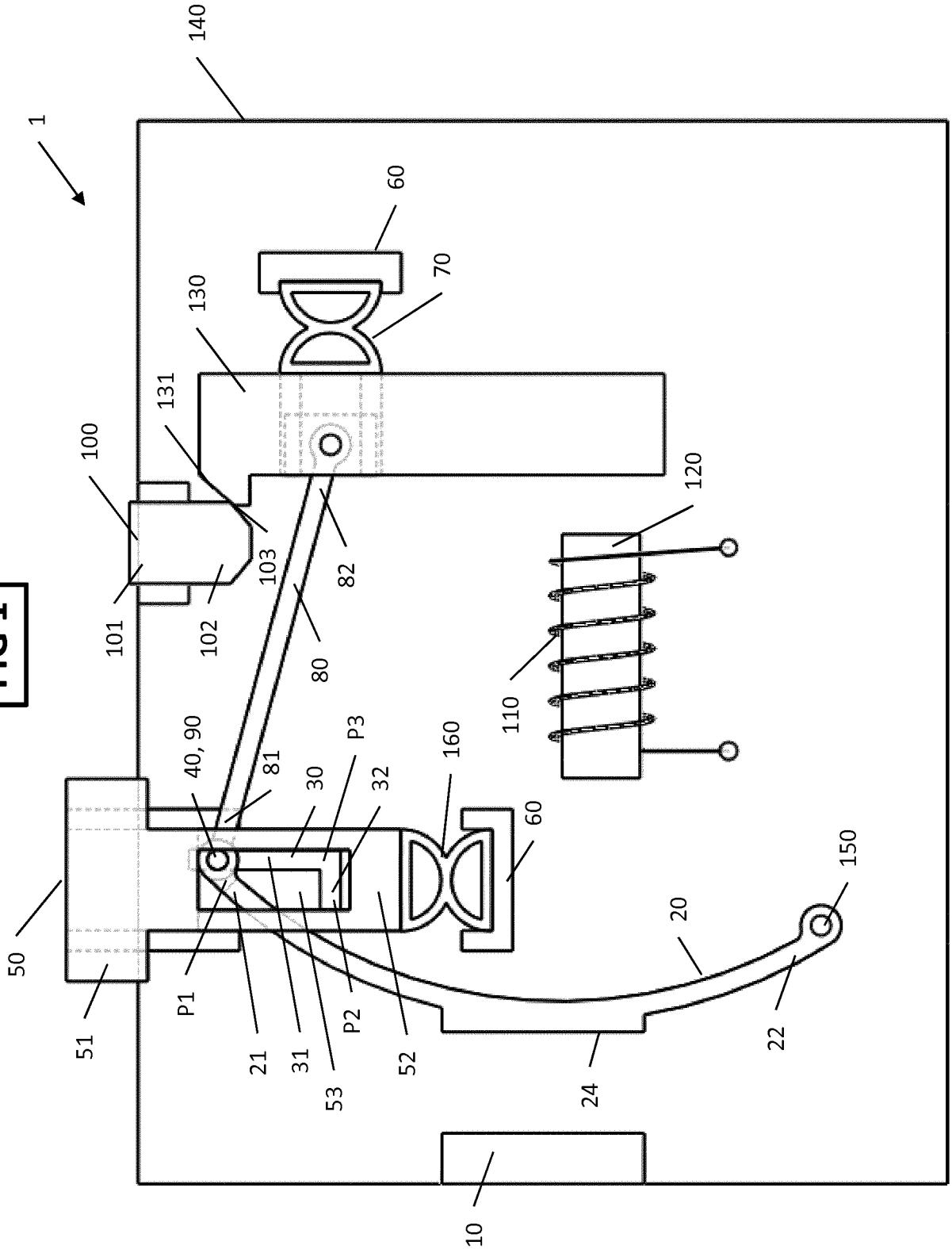
a latching element (230) being configured to lock the rotatable actuation element (220), when the rotatable actuation element (220) is moved to the second rotatable state.

16. The circuit breaker of claim 15,
- wherein the rotatable actuation element (220) comprises a locking element (221),
- wherein the latching element (230) is configured to engage in the locking element (221) so that the rotatable actuation element is locked in the second rotatable state.

17. The circuit breaker of claims 15 or 16,
wherein the latching element (230) is configured as a spring loaded latching element.

18. The circuit breaker of claims 15 to 17, comprising:
- a solenoid (110) and a solenoid tripping actuator (120),
- wherein the latching element (230) has a first section (231) to engage in the locking element (221) and a second section (232),
- wherein the solenoid tripping actuator (120) is arranged so that, in the case of a short circuit, an electromagnetic field is generated in the solenoid (110) that moves the solenoid tripping actuator (120) towards the second section (232) of the latching element (230) so that the first section (231) of the latching element (230) disengages from the locking element (221) and the rotatable actuation element (220) is unlocked and the bending force stored in the compliant element (20) effects that the compliant element (20) releases and the movable contact (24) is moved in the open state.

FIG 1


140
1
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130
131
100
120
103
82
101
102
80
110
40, 90
81
30
P3
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32
60
150
50
20
P1
P2
51
21
31
53
52
24
22
10

FIG 2

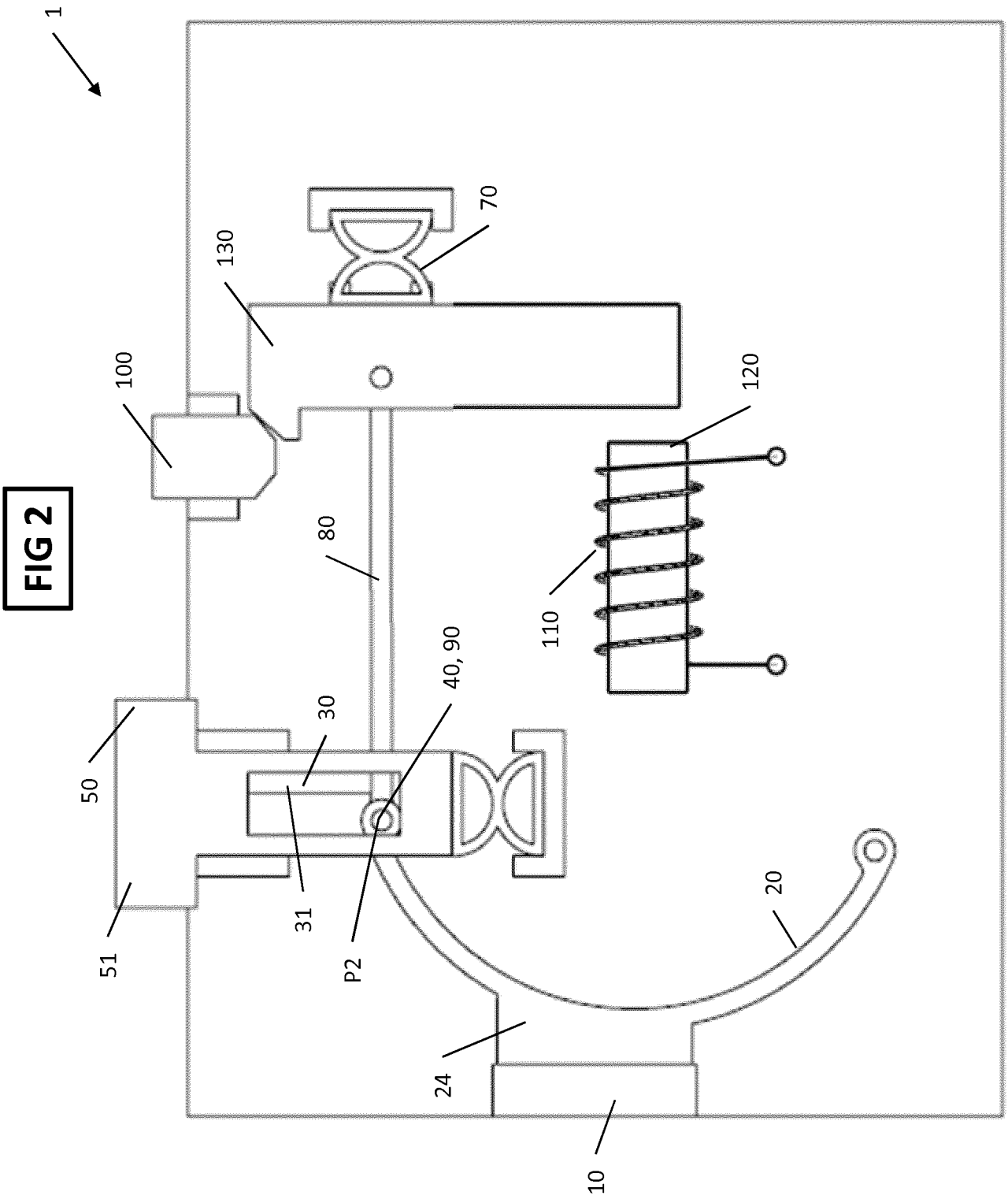


FIG 3

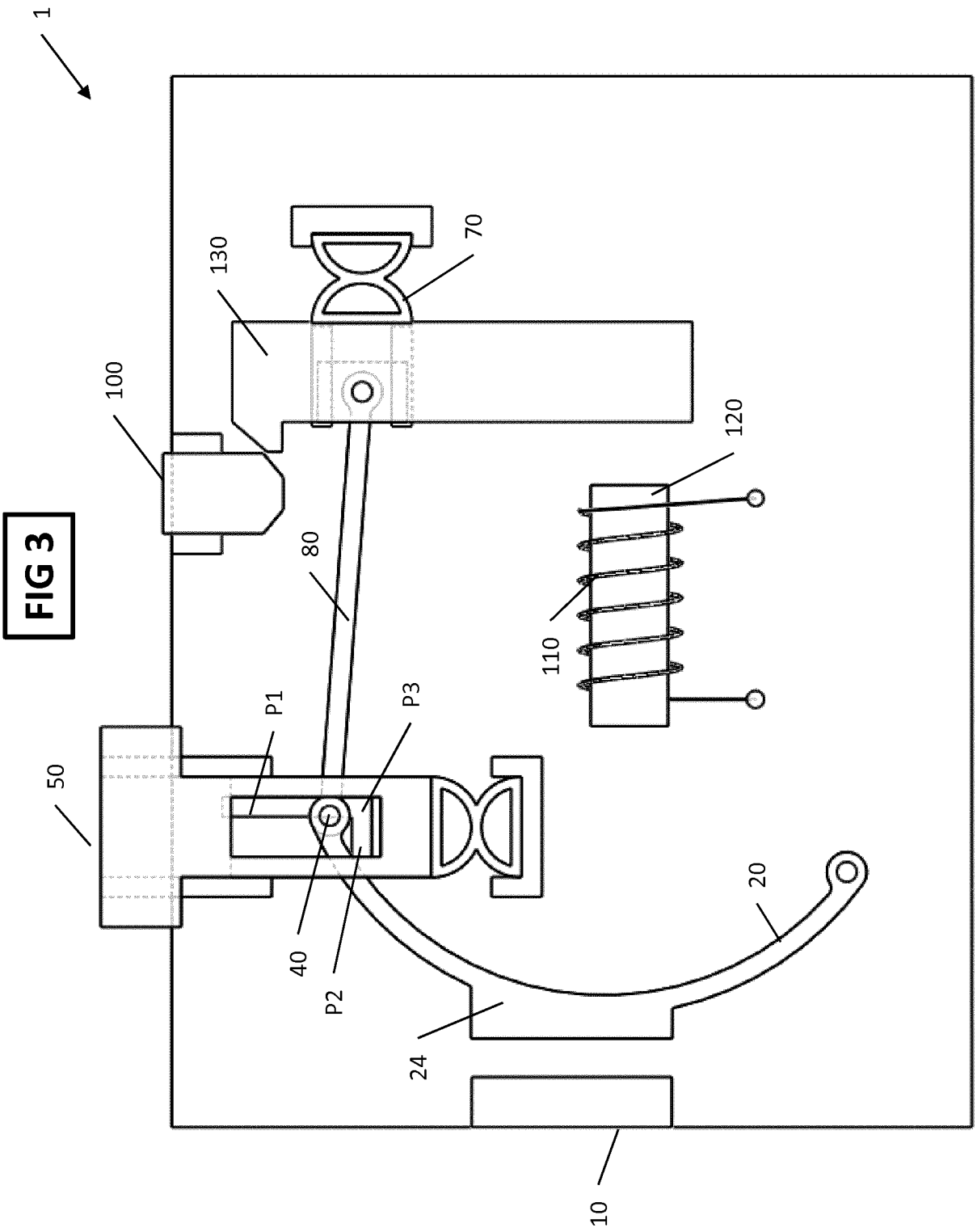
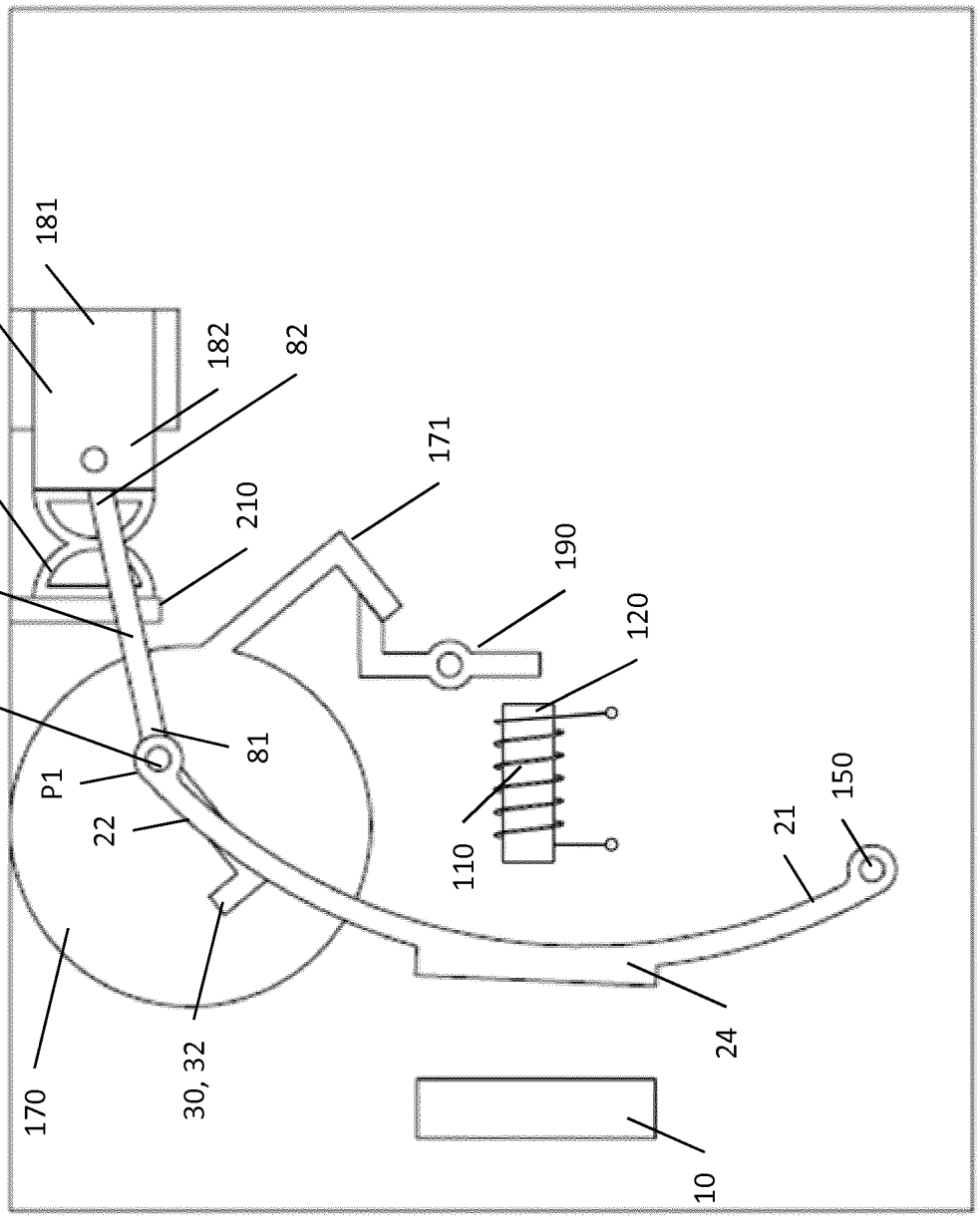


FIG 4


2
180
181
182
82
200
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190
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40, 90
81
P1
22
110
150
21
170
30, 32
24
10

FIG 5

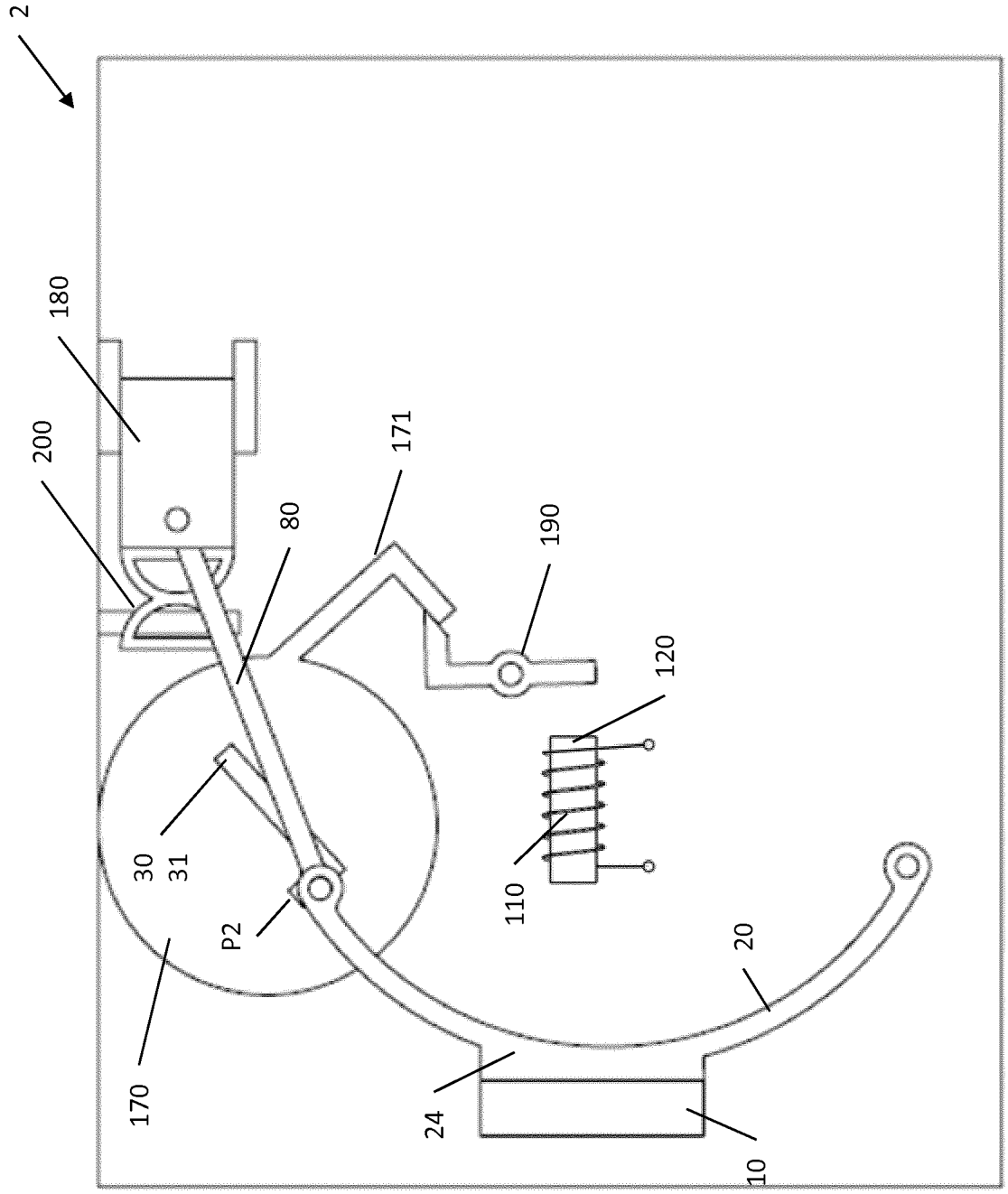


FIG 6

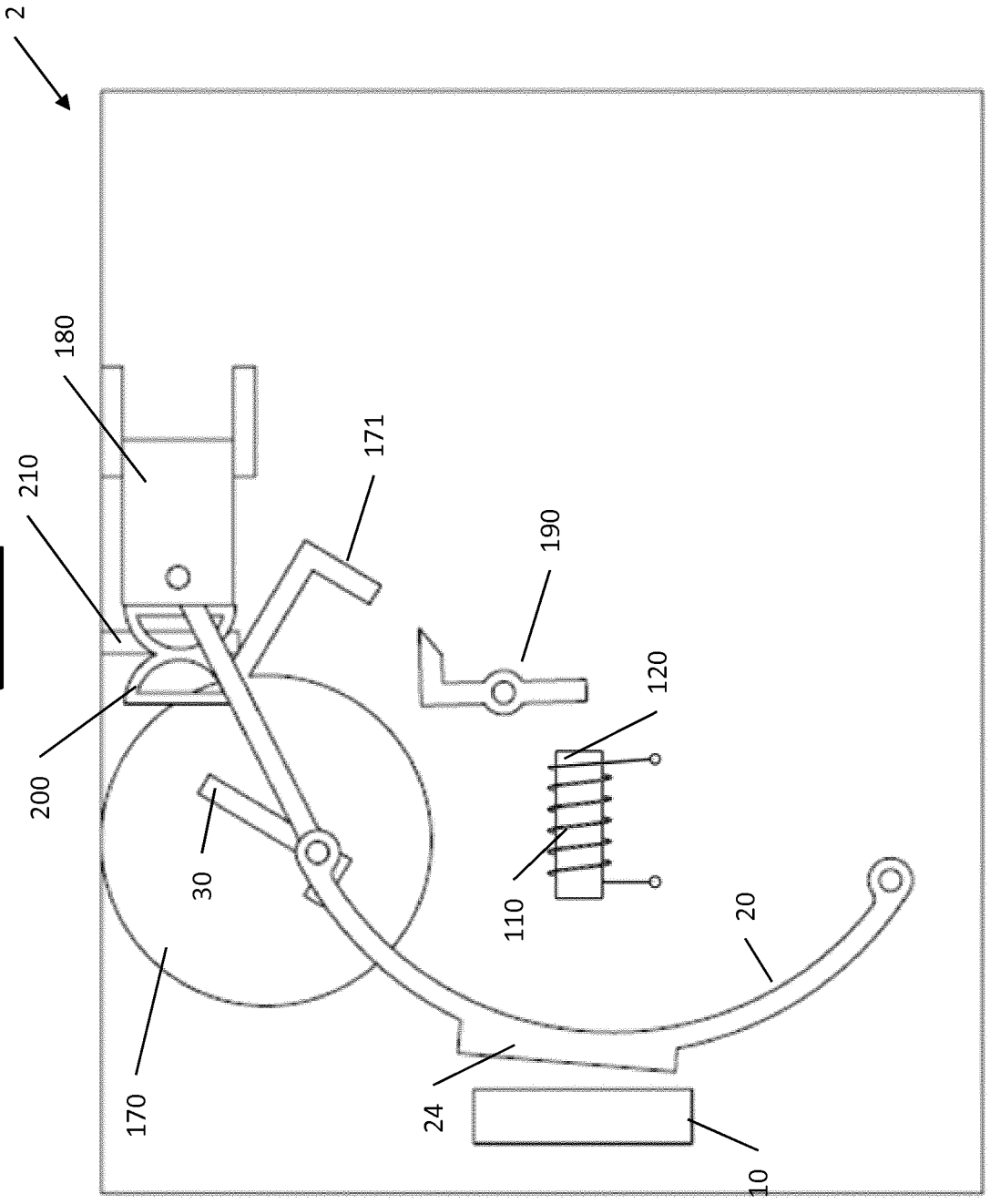


FIG 7

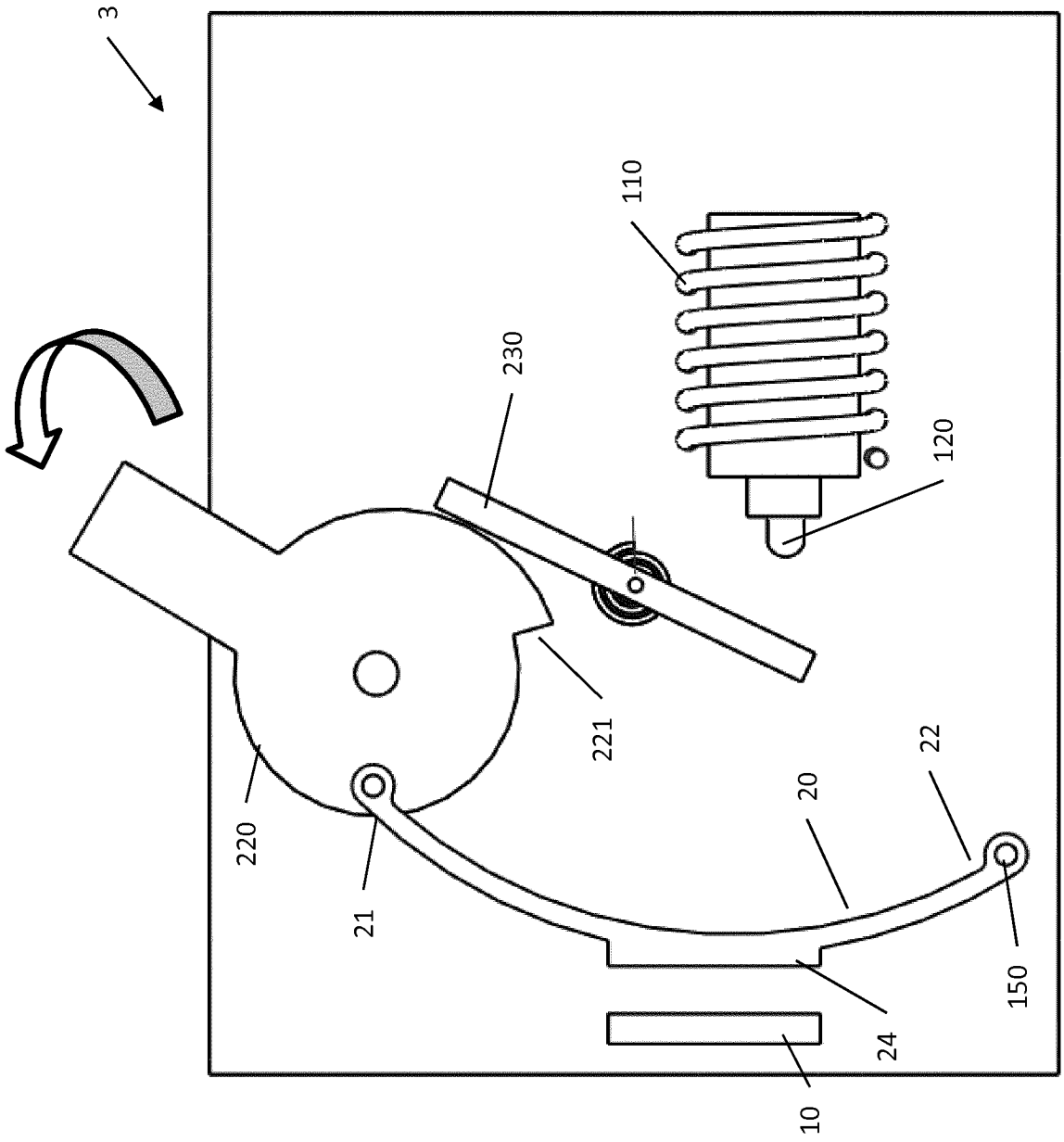
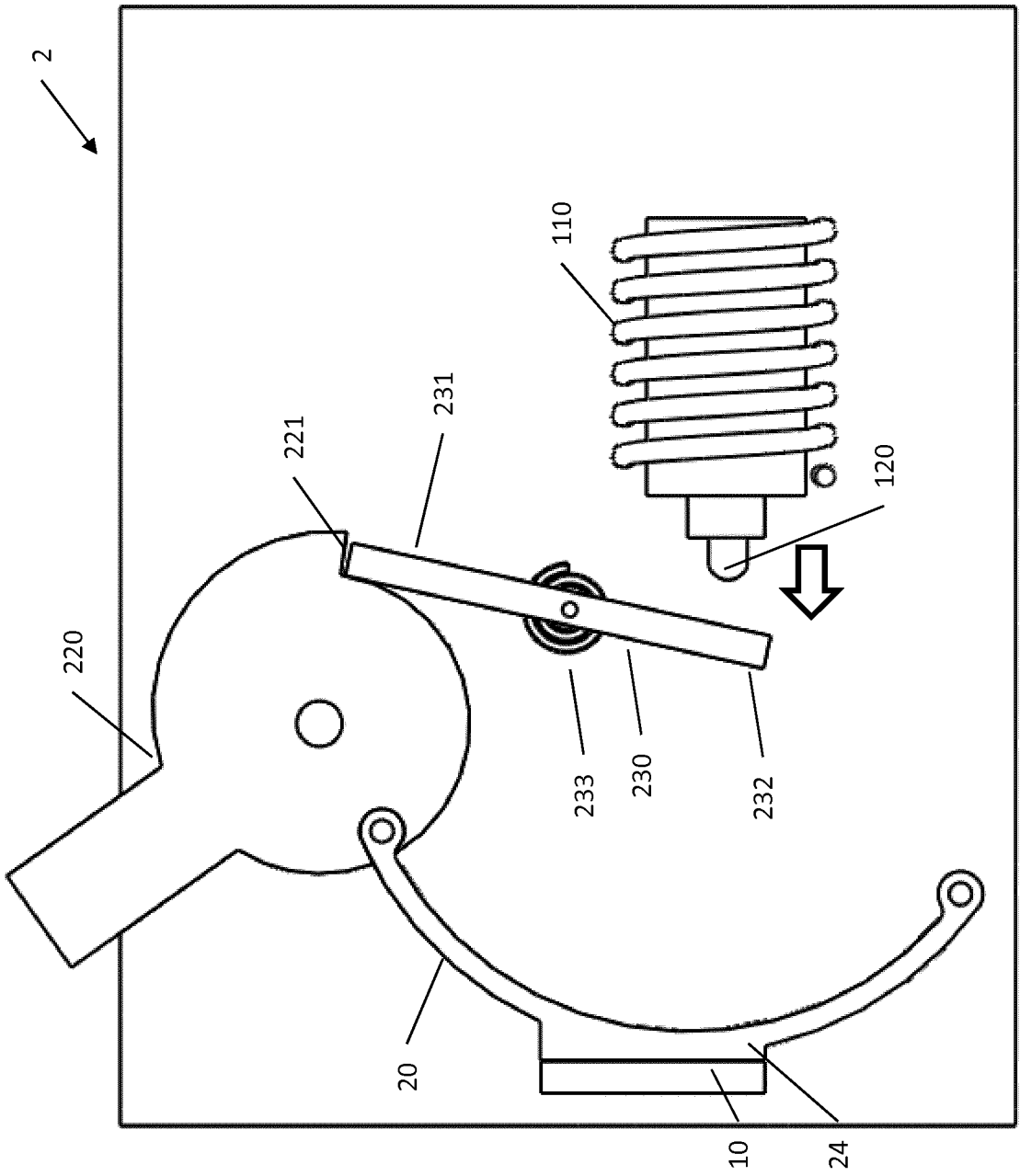


FIG 8



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/083869

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01H71/52 H01H71/58
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 6 154 116 A (SORENSON RICHARD W [US]) 28 November 2000 (2000-11-28) column 3, line 58 - column 6, line 46; figures 1-9	1,2,4,8

X	US 3 016 435 A (SCHWARTZ NORMAN J) 9 January 1962 (1962-01-09) the whole document	1,2,4,8

X	DE 467 286 C (WILHELM LEYHAUSEN) 22 October 1928 (1928-10-22)	1-4,9,10
A	page 2, lines 17-36; figures 4, 5	5-7, 11-13

X	FR 2 057 181 A5 (MERLIN GERIN) 21 May 1971 (1971-05-21) page 5, line 17 - page 6, line 32; figures 1-10	1,2,4,8

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[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 March 2018	22/05/2018

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Ramírez Fueyo, M

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2017/083869

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 2 116 791 A (JACKSON JOHN G) 10 May 1938 (1938-05-10) figures 1,2 -----	1

5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2017/083869

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-13

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-13

A circuit breaker comprising a compliant element, a guiding slot and a guiding element being slideably arranged in the guiding slot

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2. claims: 14-18

A circuit breaker, comprising a compliant element and a rotatable actuation element

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2017/083869

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 6154116 A	28-11-2000	CN 1276616 A	13-12-2000
		EP 1059654 A2	13-12-2000
		JP 2001006513 A	12-01-2001
		NO 20002822 A	11-12-2000
		TW 473756 B	21-01-2002
		US 6094126 A	25-07-2000
		US 6154116 A	28-11-2000
US 3016435 A	09-01-1962	GB 921420 A	20-03-1963
		US 3016435 A	09-01-1962
DE 467286 C	22-10-1928	NONE	
FR 2057181 A5	21-05-1971	NONE	
US 2116791 A	10-05-1938	NONE	