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(54) A MEDIUM VOLTAGE SWITCHING APPARATUS

(57) A switching apparatus for medium voltage electric systems, said switching apparatus comprising one or more electric poles and, for each electric pole:
- a first pole terminal, a second pole terminal and a ground terminal, said first pole terminal being electrically couplable with a first conductor of an electric line, said second pole terminal being electrically couplable to a second conductor of said electric line and said ground terminal being electrically couplable to a grounding conductor;
- a fixed contact assembly including a plurality of fixed contact members spaced one from another;
- a movable contact assembly rotatable about a rotation axis between a first end-of-run position (P_A), which corresponds to a closed state of said switching apparatus, and a second end-of-run position (Pc), which corresponds to a earthed state of said switching apparatus, said movable contact assembly passing through an intermediate position (P_B), which corresponds to an open state of said switching apparatus, when moving between said first and second end-of-run positions.

The movable contact assembly is arranged so that, when the switching apparatus is in an open state, the electric contacts within a vacuum chamber of the movable contact assembly are mutually coupled.

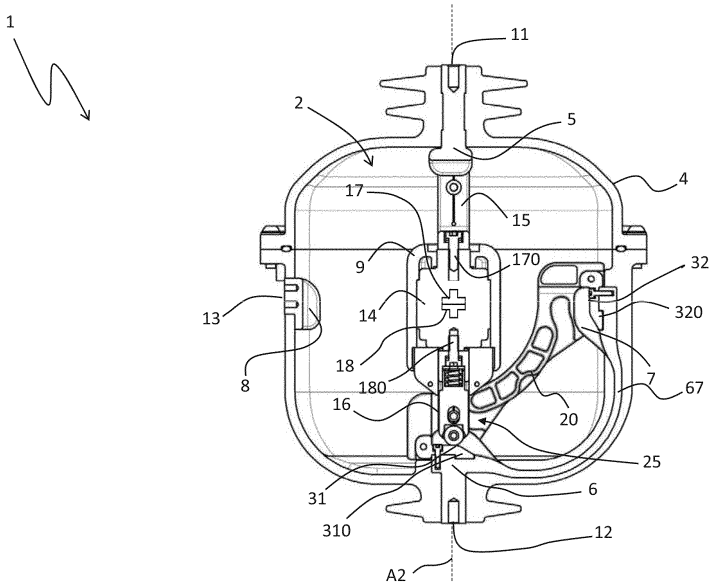

FIG. 3

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Description

[0001] The present invention relates to a switching apparatus for medium voltage electric systems, more particularly to a load-break switch for medium voltage electric systems.

[0002] Load-break switches are well known in the state of the art.

[0003] These switching apparatuses, which are generally used in secondary distribution electric grids, are capable of providing circuit-breaking functionalities (namely breaking and making a current) under specified circuit conditions (typically nominal conditions for breaking a current and nominal or fault conditions for making a current) as well as providing circuit-disconnecting functionalities (namely grounding a load-side section of an electric circuit).

[0004] Most traditional load-break switches of the state of the art have their electric poles immersed in a sulphur hexafluoride (SF_6) atmosphere as this insulating gas ensures excellent performances in terms of dielectric insulation between live parts and arc-quenching capabilities when currents are interrupted.

[0005] As is known, however, SF_6 is a powerful greenhouse gas and its usage is subject to severe restriction measurements for environmental preservation purposes. For this reason, over the years, there has been made a considerable effort to develop and design load-break switches not employing SF6 as an insulating gas.

[0006] Some load-break switches have been developed, in which electric poles are immersed in pressurized dry air or in an environment-friendly insulation gas, such as mixtures of oxygen, nitrogen, carbon dioxide and/or fluorinated gases.

[0007] Unfortunately, the experience has shown that these switching apparatuses generally do not show high levels of reliability in operation yet.

[0008] Additionally, they generally adopt complicated solutions to operate their electric contact arrangements and they still offer poor performances in terms of structural compactness and reliability in operation.

[0009] The main aim of the present invention is to provide a switching apparatus for MV electric systems that allows solving or mitigating the above-mentioned technical problems.

[0010] More particularly, it is an object of the present invention to provide a switching apparatus showing high levels of reliability in operation.

[0011] Another object of the present invention is to provide a switching apparatus ensuring high-level performances in terms of dielectric insulation and arc-quenching capabilities during the current breaking process.

[0012] Another object of the present invention is to provide a switching apparatus having electric poles with high compactness and structural simplicity.

[0013] Another object of the present invention is to provide a switching apparatus that can be easily manufactured at industrial level, at competitive costs with respect to the solutions of the state of the art.

[0014] In order to fulfill these aim and objects, the present invention provides a switching apparatus, according to the following claim 1 and the related dependent claims.

[0015] In a general definition, the switching apparatus of the invention comprises one or more electric poles.

[0016] The switching apparatus comprises, for each electric pole, a first pole terminal, a second pole terminal and a ground terminal. In operation, the first pole terminal can be electrically coupled to a first conductor of an electric line, the second pole terminal can be electrically coupled to a second conductor of said electric line and the ground terminal can be electrically coupled to a grounding conductor.

[0017] The switching apparatus comprises, for each electric pole, a fixed contact assembly including a plurality of fixed contact members spaced one from another. In particular, said fixed contact assembly comprises a first fixed contact member electrically connected to the first pole terminal, a second fixed contact member and a third fixed contact member electrically connected to the second pole terminal, and a fourth fixed contact member electrically connected to the ground terminal.

[0018] The switching apparatus comprises, for each electric pole, a movable contact assembly rotatable about a rotation axis. Said movable contact assembly comprises:

- a first main contact member couplable to the first fixed contact member or the fourth fixed contact member, upon a rotational movement of said movable contact assembly about said rotation axis;
- a second main contact member couplable to the second fixed contact member or the third fixed contact member, upon a rotational movement of said movable contact assembly about said rotation axis;
- a vacuum chamber and a pair of arc contact members that are accommodated within said vacuum chamber. Said arc contact members comprise a fixed arc contact member and a movable arc contact member. The movable arc contact member can be coupled to or decoupled from the fixed arc contact member by moving along a translation axis perpendicular to said rotation axis. Each arc contact member is electrically connected in series to a corresponding main contact member.

[0019] The movable contact assembly is reversibly movable about said rotation axis in a first end-of-run position, which corresponds to a closed state of said switching apparatus, in a second end-of-run position, which corresponds to an earthed state of said switching apparatus, and in an intermediate position, which corresponds to an open state of said switching apparatus. According to the invention, each movable contact assembly comprises a cam mechanism coupled to the movable arc contact member.

[0020] Said cam mechanism is adapted to press the movable arc contact member against the fixed arc contact member, when said movable arc contact member is coupled to said fixed arc contact member and said movable contact assembly is in said first end-of-run position or in said second end-of-run position.

[0021] Preferably, the cam mechanism comprises:

- a push member movable with respect to the movable arc contact member along said translation axis;
- a spring member arranged along said translation axis and coupled to the push member and to the movable arc contact member.

[0022] According to some embodiments of the invention, the cam mechanism comprises a slider member coupled to the push member and couplable with one or more first cam surfaces or one or more second cam surfaces, when the movable contact assembly is in said first end-of-run position or in said second end-of-run position. The slider member exerts, on the push member, an actuation force directed to cause the compression of the spring member and the consequent pressing of the movable arc contact member against the fixed arc contact member, when said slider member is coupled to said one or more first cam surfaces or said one or more second cam surfaces.

[0023] According to other embodiments of the invention, the cam mechanism comprises a lever member having a cam profile and couplable to said push member and to one or more first sliding surfaces or one or more second sliding surfaces, when the movable contact assembly is in said first end-of-run position or in said second end-of-run position.

[0024] The lever member exerts, on the push member, an actuation force directed to cause the compression of the spring member and the consequent pressing of the movable arc contact member against the fixed arc contact member, when said lever member is coupled to said one or more first sliding surfaces or said one or more second sliding surfaces.

[0025] Conveniently, when the movable contact assembly is in the first end-of-run position, the first main contact member is coupled to the first fixed contact member, the second main contact member is coupled to the second fixed contact member, and the arc contact members are coupled one to another and pressed one against the other.

[0026] Conveniently, when the movable contact assembly is in said intermediate position, the first main contact member is decoupled from the first and fourth fixed contact members, the second main contact member is decoupled from the second and third fixed contact members, and the arc contact members are coupled one to another but not pressed one against the other. Conveniently, when the movable contact assembly is in the second end-of-run position, the first main contact member is coupled to the fourth fixed contact member, the second main contact member is coupled to the third fixed contact member, and the arc contact members are coupled one to another and pressed one against the other.

[0027] According to an aspect of the invention, the switching apparatus comprises, for each electric pole, at least a track member having a track surface with a cam profile and at least a drive member solidly coupled with the movable arc contact member.

[0028] Each drive member is adapted to slide along the track surface of a corresponding track member, upon a rotational movement of said movable contact assembly about said rotation axis.

[0029] Each drive member actuates said movable arc contact member along a translation axis perpendicular to said rotation axis between a coupled position to and an uncoupled position from said fixed arc contact member, when sliding along said track surface.

[0030] When the movable contact assembly is in said first end-of run position, each drive member is in a first position along said track surface.

[0031] When the movable contact assembly is in said intermediate position, the drive member is in said second position along said track surface.

[0032] When the movable contact assembly is in said second end-of run position, the drive member is in a third position along said track surface.

[0033] Conveniently, said second position is intermediate between said first and third positions. Each drive member slides along a first track surface portion with a cam profile, when moving between said first and second positions, and it slides along a second track surface portion with a cam profile, when moving between said second and third positions.

[0034] Each drive member actuates the movable arc contact member to a coupled position with said fixed arc contact member, when said drive member is in said first position or in said second position or in said third position along said track surface.

[0035] Each drive member actuates the movable arc contact member along said translation axis between a coupled position to and an uncoupled position from said fixed arc contact member, when sliding along said first track surface portion or said second track surface portion.

Further characteristics and advantages of the invention will emerge from the description of preferred, but not exclusive embodiments of the switching apparatus, according to the invention, non-limiting examples of which are provided in the attached drawings, wherein:

- Figures 1 is a schematic view of the switching apparatus, according to the invention;
- Figures 2-4, 4A, 4B are schematic views partially showing an embodiment of the switching apparatus, according to the invention;
- Figures 5-7, 7A, 7B are schematic views partially showing another embodiment of the switching apparatus, according to the invention;
- Figures 8-16 are schematic views illustrating oper-

ation of the switching apparatus of Figs. 5-7.

[0036] With reference to the figures, the present invention relates to a switching apparatus 1 for medium voltage electric systems.

[0037] For the purpose of the present application, the term "medium voltage" (MV) relates to operating voltages at electric power distribution level, which are higher than 1 kV AC and 1.5 kV DC up to some tens of kV, e.g. up to 72 kV AC and 100 kV DC.

[0038] The switching apparatus 1 is particularly adapted to operate as a load-break switch. It is therefore designed for providing circuit-breaking functionalities under specified circuit conditions (nominal conditions for breaking a current and nominal or fault conditions for making a current) as well as circuit-disconnecting functionalities, in particular grounding a load-side section of an electric circuit.

[0039] The switching apparatus 1 comprises one or more electric poles 2.

[0040] Preferably, the switching apparatus 1 is of the multi-phase (e.g. three-phase) type and it comprises a plurality (e.g. three) of electric poles 2.

[0041] Preferably, the switching apparatus 1 comprises an insulating housing 4, which conveniently defines an internal volume where the electric poles 2 are accommodated.

[0042] Preferably, the insulating housing 4 has an elongated shape (e.g. substantially cylindrical or parallelepiped-like) developing along a a main longitudinal axis A1 (figure 1). The electric poles 2 are arranged side by side along the longitudinal axis A1 at corresponding transversal planes perpendicular the said longitudinal axis.

[0043] In general, the insulating housing 4 of the switching apparatus may be realized according to solutions of known type. Therefore, in the following, it will be described only in relation to the aspects of interest of the invention, for the sake of brevity.

[0044] Conveniently, the internal volume of the switching apparatus 1 is filled with pressurized dry air or another insulating gas having a low environmental impact, such as mixtures of oxygen, nitrogen, carbon dioxide and/or fluorinated gases.

[0045] For each electric pole 2, the switching apparatus 1 comprises a first pole terminal 11, a second pole terminal 12 and a ground terminal 13.

[0046] The first pole terminal 11 is adapted to be electrically coupled to a first conductor of an electric line (e.g. a phase conductor electrically connected to an equivalent electric power source), the second pole terminal 12 is adapted to be electrically connected to a second conductor of an electric line (e.g. a phase conductor electrically connected to an equivalent electric load) while the ground pole terminal 13 is adapted to be electrically connected to a grounding conductor. In general, the terminals 11, 12, 13 of each electric pole 2 of the switching apparatus may be realized according to solutions of known type. Therefore, in the following, they will be described only in relation to the aspects of interest of the invention, for the sake of brevity. According to the invention, for each electric pole 2, the switching apparatus 1 comprises a fixed contact assembly including a plurality of fixed contact members 5, 6, 7, 8 spaced one from another.

[0047] The above-mentioned fixed contact assembly comprises a first fixed contact member 5, a second fixed contact member 6, a third fixed contact member 7 and a fourth fixed contact member 8, which are circumferentially spaced around the longitudinal axis A1.

[0048] Each fixed contact member 5, 6, 7, 8 is at least partially made of an electrically conductive material.

[0049] As shown in cited figures (figures 2 and 5), each fixed contact member 5, 6, 7, 8 is preferably formed by a shaped piece of conductive material provided with a pair of parallel blades including suitable free contact surfaces with other electric contacts.

[0050] In principle, however, each fixed contact member 5, 6, 7, 8 may be realized according to other solutions of known type (e.g. according to a single-blade configuration), which are here not described in details for the sake of brevity.

[0051] For each electric pole 2, the first fixed contact member 5 and the second fixed contact member 6 are accommodated in the internal volume of the switching apparatus at opposite sides of the insulating housing 4 with respect to the longitudinal axis A1, in particular at lower and upper walls of the insulating housing 4 (reference is made to a normal installation position of the switching apparatus, as shown in figure 1).

[0052] Preferably, the fixed contact members 5, 6 are aligned along a first reference plane perpendicular to said upper and lower walls of the insulating housing 4 and passing through the longitudinal axis A1.

[0053] The first fixed contact member 5 is electrically connected to the first pole terminal 11 while the second fixed contact member 6 is electrically connected to the second pole terminal 12. To this aim, the fixed contact members 5, 6 include suitable connecting portions for electrical connection with the corresponding pole terminals 11, 12.

[0054] For each electric pole 2, the third fixed contact member 7 and the fourth fixed contact member 8 are accommodated in the internal volume of the switching apparatus at further opposite sides of the insulating housing 4 with respect to the longitudinal axis A1, in particular at opposite lateral walls of the insulating housing (reference is made to a normal installation position of the switching apparatus, as shown in figure 1).

[0055] Preferably, the fixed contact members 7, 8 are aligned along a second reference plane perpendicular to said lateral walls of the insulating housing 4 and passing through the longitudinal axis A1.

[0056] The third fixed contact member 7 is electrically connected to the second fixed contact member 6 (and, therefore, to the second pole terminal 12) through a suitable conductive member 67 formed, for example, by a shaped piece of electrically conductive material (as

shown in the cited figures) or by an electric cable.

[0057] The fourth fixed contact member 8 is electrically connected to the ground terminal 13. To this aim, the fixed contact member 8 includes a suitable connecting portion for electrical connection with said ground terminal.

[0058] According to the invention, for each electric pole 2, the switching apparatus 1 comprises a movable contact assembly 10 including a plurality of contact members 15, 16, 17, 18.

[0059] The movable contact assembly 10 rotates as a whole about a suitable rotation axis A1 (which is preferably the main longitudinal axis of the switching apparatus) along a given plane of rotation perpendicular to said rotation axis.

[0060] The movable contact assembly 10 can rotate according to a first rotation direction R1 or according to a second rotation direction R2, which is opposite to the first rotation direction R1. With reference to an observation plane of figures 8-16, the above-mentioned first rotation direction R1 is oriented counter-clockwise while the above-mentioned second rotation direction R2 is oriented clockwise.

[0061] As it will better illustrated in the following, the movable contact assembly 10 moves according to the first rotation direction R1 during an opening manoeuvre or a disconnecting manoeuvre of the switching apparatus and it moves according to the second rotation direction R2 during a closing manoeuvre or a reconnecting manoeuvre of the switching apparatus.

[0062] Preferably, the switching apparatus 1 comprises a motion transmission shaft 3 made of electrically insulating material, which can rotate about the rotation axis A1.

[0063] Preferably, the switching apparatus 1 comprises an actuation assembly 30 providing suitable actuation forces to actuate the movable components of the switching apparatus.

[0064] The motion transmission shaft 3 is conveniently coupled to the movable actuation assembly 30 and to the movable contact assembly 10 of each electric pole.

[0065] The motion transmission shaft 3 thus transmits rotational mechanical forces to move the movable contact assembly 10 of each electric pole about the rotation axis A1 during the manoeuvres of the switching apparatus.

[0066] Preferably, the actuation assembly 30 comprises an actuator 30A coupled to the transmission shaft 3 through a suitable kinematic chain 30B. The actuator 30A may be, for example, a mechanical actuator, an electric motor or an electromagnetic actuator.

[0067] In general, the actuation assembly 30 of the switching apparatus may be realized according to solutions of known type. Therefore, in the following, it will be described only in relation to the aspects of interest of the invention, for the sake of brevity.

[0068] Preferably, the movable contact assembly 10 of each electric pole comprises a main support enclosure 9, which is preferably arranged centrally at the rotation axis A1.

[0069] Preferably, the support enclosure 9 is conveniently made of an electrically insulating material. Preferably, the support enclosure 9 has an elongated shape (e.g. substantially cylindrical or parallelepiped-like) extending along a corresponding longitudinal axis A2, which is perpendicular to the rotation axis A1.

[0070] Preferably, the support enclosure 9 is solidly coupled to the motion transmission shaft 3 in such a way to rotate together with this latter about the rotation axis A1.

[0071] More preferably, as shown in the cited figures (figures 2 and 5), the support enclosure 9 is made in one piece with the motion transmission shaft 3.

[0072] According to the invention, the movable contact assembly 10 of each electric pole comprises first and second main contact members 15, 16 adapted to rotate about the rotation axis A1.

[0073] Preferably, the first and second main contact members 15 protrude from opposite sides of the support enclosure 9, which face the opposite walls of the insulating housing 4 where the first and fourth fixed contact members 5, 8 and the second and third fixed contact members 6, 7 are located, respectively.

[0074] Preferably, the main contact members 15, 16 are aligned along the longitudinal axis A2.

[0075] The main contact members 15, 16 are solidly coupled to the support enclosure 9 so as to rotate about the rotation axis A1 together with this latter.

[0076] Each main contact member 15, 16 of the movable contact assembly 10 is at least partially made of an electrically conductive material.

[0077] As shown in cited figures (figures 2 and 5), each main contact member 15, 16 is preferably formed by a shaped piece of conductive material including a pair of parallel blades having suitable free contact surfaces with other electric contacts.

[0078] In principle, however, each main contact member 15, 16 may be realized according to other solutions of known type (e.g. according to a single-blade configuration), which are here not described in details for the sake of brevity.

[0079] In operation, upon a rotational movement of the movable contact assembly 10 about the rotation axis A1, the first main contact member 15 can be coupled to or decoupled from the first fixed contact member 5 or it can be coupled to or decoupled from the fourth fixed contact member 8 while the second main contact member 16 can be coupled to or decoupled from the second fixed contact member 6 or it can be coupled to or decoupled from the third fixed contact member 7. According to the invention, the movable contact assembly 10 of each electric pole comprises a vacuum chamber 14 and a pair of arc contact members that are accommodated in said vacuum chamber and that can be coupled to or decoupled from one to another.

[0080] In particular, such arc contact members com-

prise a fixed arc contact member 17 and a movable arc contact member 18.

[0081] According to the embodiments shown in the cited figures, the fixed arc contact member 17 is electrically connected to the first main contact member 15 while the movable arc contact member 18 is electrically connected to the second main contact member 16.

[0082] Preferably, the fixed arc contact member 17 is solidly coupled to the support enclosure 9 so as to rotate together with this latter about the rotation axis A1.

[0083] The fixed arc contact member 17 is at least partially made of an electrically conductive material. As shown in cited figures (figures 3 and 6), the fixed arc contact member 17 is preferably formed by an elongated piece of conductive material having one end coupled to a first connecting member 170 (e.g. formed by a bolt), which is in turn coupled to the first main contact member 15, and an opposite free end (e.g. T-shaped) including a suitable contact surface with the movable arc contact member 18.

[0084] In principle, however, the fixed arc contact member 17 may be realized according to other solutions of known type (e.g. with a blade configuration), which are here not described in details for the sake of brevity.

[0085] The movable arc contact member 18 is coupled to the support enclosure 9 so as to rotate together with this latter about the rotation axis A1. However, the movable arc contact member 18 is movable with respect to the enclosure 9 and the fixed arc contact member 17 along a translation axis (which is preferably the longitudinal axis A2) perpendicular to the rotation axis A1 of the movable contact assembly 10.

[0086] In operation, the arc contact member 18 can be coupled to or uncoupled from the arc fixed contact member 17 by moving along the translation axis A2.

[0087] Preferably, the movable arc contact member 18 is slidingly coupled to the second main contact member 16.

[0088] As shown in cited figures, the movable arc contact member 18 is preferably formed by a shaped piece of conductive material having one end coupled to a second connecting member 180 and an opposite free end (e.g. T-shaped) including a suitable contact surface with the fixed arc contact member 17.

[0089] The connecting member 180 is coupled to each blade of the second main contact member 16 and a first connecting pin 220 couples the blades of the second main contact member 16. In this way, the movable arc contact member 18 can move together with each blade along the translation axis A2 while rotating together with the movable contact assembly 10 about the rotation axis A1.

[0090] As shown in cited figures, the connecting member 180 is preferably formed by a shaped piece of conductive material having a portion formed by a bolt coupled to the movable arc contact member 18 and another portion including a pair of parallel blades arranged in parallel to the blades of the second main contact member 16.

[0091] In principle, however, the movable arc contact member 18 may be realized according to other solutions of known type (e.g. according to a configuration), which are here not described in details for the sake of brevity.

[0092] As mentioned above, the movable contact assembly 10 of each electric pole comprises a vacuum chamber 14, in which a vacuum atmosphere is present.

[0093] Conveniently, the arc contact members 17, 18 are accommodated in the vacuum chamber 14, so that their contact surfaces are mutually coupled or decoupled inside said vacuum chamber, therefore being permanently immersed in a vacuum atmosphere.

[0094] The vacuum chamber 14 may be realized according to solutions of known type. Therefore, in the following, it will be described only in relation to the aspects of interest of the invention, for the sake of brevity.

[0095] In operation, the switching apparatus 1 is capable of switching in three different operating states.

[0096] In particular, the switching apparatus 1 can switch in:

- a closed state, in which each electric pole 2 has the first and second pole terminals 11, 12 electrically connected one to another and electrically disconnected from the ground terminal 13. When the switching apparatus is in a closed state, a line current or a fault current can flow along each electric pole 2 between the corresponding first and second pole terminals 11, 12; or
- an open state, in which each electric pole 2 has the first and second pole terminals 11, 12 and the ground terminal 13 electrically disconnected one from another. When the switching apparatus is in an open state, no currents can flow along the electric poles 2; or
- an earthed state, in which each electric pole 2 has the first and second pole terminals 11, 12 electrically disconnected one from another and the second pole terminal 12 and the ground terminal 13 electrically connected one to another. When the switching apparatus is in an earthed state, no line currents can flow along the electric poles 2. However, the second pole terminal 12 of each electric pole (and therefore the second line conductor connected thereto) is put at a ground voltage.

[0097] In operation, the switching apparatus 1 is capable of carrying out different types of manoeuvres, each corresponding to a given transition among the above-mentioned operating states.

[0098] In particular, the switching apparatus 1 is capable of carrying out:

- an opening manoeuvre when it switches from a closed state to an open state; or
- a closing manoeuvre when it switches from an open state to a closed state; or
- a disconnecting manoeuvre when it switches from

an open state to an earthed state; or

- a reconnecting manoeuvre when it switches from an earthed state to an open state. Obviously, the switching apparatus 1 can switch from a closed state to an earthed state by carrying out an opening manoeuvre and subsequently a disconnecting manoeuvre.

[0099] Similarly, the switching apparatus 1 can switch from an earthed state to a closed state by carrying out a reconnecting manoeuvre and subsequently a closing opening manoeuvre.

[0100] In order to carry out the above-mentioned manoeuvres of the switching apparatus, the above-mentioned motion transmission shaft 3 suitably drives the movable contact assembly 10 of each electric pole according to the above-mentioned first rotation direction R1 or second rotation direction R2.

[0101] In general, upon actuation by the motion transmission shaft 3, the movable contact assembly 10 of each electric pole is reversibly movable between a first end-of-run position P_A, which corresponds to a closed state of the switching apparatus, and a second end-of-run position Pc, which corresponds to an earthed state of the switching apparatus.

[0102] Conveniently, the movable contact assembly 10 passes through an intermediate position P_B, which corresponds to an open state of the switching apparatus, when it moves between the first and second end-of-run positions P_A, P_C (figures 8-16).

[0103] When the movable contact assembly 10 is in the first end-of-run position P_A, and the switching apparatus is in a closed state, the first main contact member 15 is coupled to the first fixed contact member 5 and decoupled from the fourth fixed contact member 8, the second main contact member 16 is coupled to the second fixed contact member 6 and decoupled from the third fixed contact member 7, and the movable arc contact member 18 is coupled to the fixed arc contact member 17.

[0104] When the movable contact assembly 10 is in the intermediate position P_B and the switching apparatus is in an open state, the first main contact member 15 is decoupled from both the first and third fixed contact members 5, 8 and the second main contact member 16 is decoupled from both the second and third fixed contact members 6, 7. Preferably, when the movable contact assembly 10 is in the intermediate position P_B, the movable arc contact member 18 is coupled to the fixed arc contact member 17.

[0105] When the movable contact assembly 10 is in the second end-of-run position P_C, and the switching apparatus is in an earthed state, the first main contact member 15 is decoupled from the first fixed contact member 5 and coupled to the fourth fixed contact member 8, the second main contact member 16 is decoupled from the second fixed contact member 6 and coupled to the third fixed contact member 7, and the movable arc contact member 18 is coupled to the fixed arc contact member 17.

[0106] According to an aspect of the invention, each electric pole 2 comprises at least a track member 20 made of electrically insulating material and having a track surface 21 with a cam profile and at least a drive member 22 solidly coupled with the movable arc contact member 18 and slidingly coupled to the track surface 21 of a corresponding track member 20.

[0107] Preferably, each electric pole 2 comprises a track member 20 and a corresponding drive member 22 for each blade of the second main contact member 16 (figures 2 and 5).

[0108] In the embodiments shown in the cited figures, each electric pole 2 comprises a pair of track members 20 and a corresponding pair of drive members 22, each slidingly coupled to the track surface 21 of a corresponding track member 20.

[0109] Each track member 20 may be fixed to the insulating housing 4 or be integral part of this latter. In the embodiments shown in the cited figures, each track member 20 extends between the second fixed contact member 6 and the third fixed contact member 7, conveniently with a curved shape.

[0110] Preferably, the track surface 21 of each track member 20 is arranged at an outer edge of this latter, which faces the walls of the insulating housing 4 where the second and third fixed contact members 6, 7 are located.

[0111] Preferably, each drive member 22 is formed by a roller arranged in such a way to run along the track surface 21 of a corresponding track member 20.

[0112] In the embodiments shown in the cited figures, each drive member 22 is slidingly coupled to the second main contact member 16.

[0113] Preferably, each drive member 22 is arranged externally to a corresponding blade of the second main contact member 16 and it is coupled to the movable arc contact member 18 by means of the above-mentioned connecting pin 220 and connecting member 180.

[0114] In the embodiments shown in the cited figures, the permanent contact of each drive member 22 with a corresponding track surface 21 of the track member 20 is ensured by a coupling force generated by the negative pressure constantly exerted on the movable arc contact member 18 (and directed to move this latter towards the fixed arc contact member 17) as the movable arc contact member 18 is accommodated in the vacuum chamber 14.

[0115] According to other embodiments of the invention, however, the permanent contact of the drive member 22 with the track surface 21 may be ensured also in different additional ways, for example by suitably arranging a confined tracking slot in which the drive member 22 can slide. Conveniently, each drive member 22 slides along the track surface 21 of a corresponding track member 20, upon a rotational movement of the movable contact assembly 10 (and consequently of the movable arc contact 18) about the rotation axis A1.

[0116] In this way, when the movable contact assembly 10 is in the first end-of run position P_A, the drive member 22 is in a first position T_A along the track surface 21 (figure

8), when the movable contact assembly 10 is in the intermediate position P_B, the drive member 22 is in a second position T_B along the track surface 21 (figure 12), and when the movable contact assembly 10 is in the second end-of run position P_C, the drive member 22 is in a third position Tc along the track surface 21 (figure 16).

[0117] The second position T_B is obviously intermediate between the first and third positions T_A, T_C. In the embodiments shown in the cited figures, the first position T_A is conveniently located at the second fixed contact member 6, the third position T_C is located at the third fixed contact member 7 and the second position T_B is substantially equally spaced from the first and third positions T_A, T_C.

[0118] When it slides along a corresponding track surface 21 (following a curved trajectory), each drive member 22 actuates the movable arc contact member 18 along the translation axis A2 between a coupled position to fixed arc contact member 17 and an uncoupled position from said fixed arc contact member, as said track surface has a cam profile.

[0119] Preferably, the track surface 21 is shaped so that the movable arc contact member 18 is actuated in a coupled position to the fixed arc contact member 17, when the drive member 22 is in the first position T_A or in the second position T_B or in the third position Tc along the track surface 21.

[0120] Preferably, each drive member 22 slides along a first track surface portion 21A with a cam profile when it slides between the first and second positions T_A, T_B.

[0121] When sliding along the first track surface portion 21A, each drive member 22 actuates the movable arc contact member 18 along the longitudinal axis A2 between a coupled position to and an uncoupled position from the fixed arc contact member 17.

[0122] In particular, the first track surface portion 21A is shaped so that the movable arc contact member 18 is decoupled from the fixed arc contact member 17 and it is subsequently coupled again with the fixed arc contact member 17, when the drive member 22 slides along said first track surface portion.

[0123] To this aim, referring to the observation plane of figures 8-16, the first track surface portion 21A conveniently includes first and second surface segments curved towards the fixed arc contact member 17 respectively in proximity of the first and second positions T_A, T_B and a second surface segment curved away from the fixed arc contact member 17 between said first and second surface segments.

[0124] Preferably, each drive member 22 slides along a second track surface portion 21B with a cam profile when it slides between the second and third positions T_B, T_C.

[0125] When sliding along the second track surface portion 21B, each drive member 22 actuates the movable arc contact member 18 along the longitudinal axis A2 between a coupled position to and an uncoupled position from the fixed arc contact member 17.

[0126] In particular, the second track surface portion 21B is shaped so that the movable arc contact member 18 is decoupled from the fixed arc contact member 17 and it is subsequently coupled again with the fixed arc contact member 17, when the drive member 22 slides along said second track surface portion.

[0127] To this aim, referring to the observation plane of figures 8-16, the second track surface portion 21B includes fourth and fifth surface segments curved towards the fixed arc contact member 17 respectively in proximity of the second and third positions T_B, Tc and a sixth surface segment curved away from the fixed arc contact member 17 between said fourth and fifth surface segments.

[0128] According to the invention, the movable contact assembly 10 of each electric pole 2 comprises a cam mechanism 25 coupled to the movable arc contact member 18.

[0129] The cam mechanism 25 is adapted to press the movable arc contact member 18 against the fixed arc contact member 17, when the movable arc contact member 18 is coupled to the fixed arc contact member 17 and the movable contact assembly 10 is in the first end-of-run position P_A or in the second end-of-run position P_C.

[0130] Preferably, the cam mechanism 25 comprises a push member 26, which is movable with respect to the movable contact member 18 along the translation axis A2 and a spring member 27 coupled to the push member 26 and to the movable arc contact member 18, more particularly to the above-mentioned connecting member 180.

[0131] Preferably, the push member 26 is formed by a sleeve arranged coaxially with the connecting member 180 along the longitudinal axis A2.

[0132] Preferably, the spring member 27 is preferably formed by a compression spring arranged along the longitudinal axis A2 and having an end coupled to a coupling surface of the connecting member 180 and the opposite end coupled to a coupling surface of the push member 26. According to some embodiments of the invention (figures 2-4), the cam mechanism 25 comprises a slider member 28 coupled to the push member 26.

[0133] The slider member 28 is couplable with one or more first cam surfaces 31 or with one or more second cam surfaces 32 when the movable contact assembly 10 is in the first end-of-run position P_A or in the second end-of-run position Pc, respectively.

[0134] When it is coupled to the one or more first cam surfaces 31 or the one or more second cam surfaces 32, the slider member 28 exerts on the push member 26 an actuation force, which is directed to cause the compression of the spring member 27 and the consequent pressing of the movable arc contact member 18 against the fixed arc contact member 17.

[0135] Preferably, the slider member 28 is formed by a roller rotatably coupled to a second connecting pin 280, which is, in turn, solidly coupled to the push member 26 (figure 4).

[0136] In the embodiment shown in 2-4, the slider member 28 is conveniently positioned in the gap between the parallel blades of the second main contact member 6 and it can move with respect to these latter along the translation axis A2.

[0137] Preferably, a first jig member 310 may be fixed to the second fixed contact member 6, conveniently between the parallel blades of this latter. As an alternative, the first jig member 310 may be realized in one piece with the second fixed contact member 6.

[0138] The first jig member 310 includes the one or more first cam surfaces 31 (figures 3 and 4). Similarly (figure 3), a second jig member 320 may be fixed to the third fixed contact member 7, conveniently between the parallel blades of this latter. Alternatively, the second jig member 320 may be realized in one piece with the third fixed contact member 7. The second jig member 320 includes the one or more second cam surfaces 32.

[0139] According to possible variants, the first and second cam surfaces 31, 32 may be part of jig members solidly coupled to or integrally made with the insulating housing 4.

[0140] The operation of the cam mechanism 25 included in a generic electric pole 2, when designed according to the embodiment described above, is briefly illustrated with reference to figures 4, 4A, 4B.

[0141] The movable contact assembly 10 is supposed to move in proximity of the above-mentioned first end-of-run position P_A as it occurs during an opening manoeuvre or a closing manoeuvre of the switching apparatus.

[0142] Figure 4 illustrates the cam mechanism 25 when the movable contact assembly 10 is in the first end-of-run position P_A and the switching apparatus is in a closed state.

[0143] When the movable contact assembly 10 is in the first end-of-run position P_A, the second main contact member 16 is coupled to the second fixed contact member 6 and the movable arc contact member 18 is coupled to the fixed arc contact member 17. In this situation, the slider member 28 is fully coupled with the first cam surfaces 31 and it exerts the maximum actuation force on the push member 26. This latter compresses the spring member 27, which, in turn, presses of the movable arc contact member 18 against the fixed arc contact member 17.

[0144] During an opening manoeuvre of the switching apparatus, the movable contact assembly 10 moves away from the first end-of-run position P_A (direction R1). The second main contact member 16 therefore moves away from the second fixed contact member 6.

[0145] When the second main contact member 16 starts moving, the slider member 28 slides along the first cam surfaces 31 and it progressively decouples from these latter. In this way, the spring member 27 is progressively released and the movable arc contact member 18 is no more pressed against the fixed contact member 17 (figure 4A).

[0146] Upon a further movement of the movable contact assembly 10, the slider member 28 keeps on sliding along the first cam surfaces 31 until it decouples from these latter (figure 4B). The spring member 27 is released and the cam mechanism 25 does not operate anymore.

[0147] During a closing manoeuvre of the switching apparatus, the movable contact assembly 10 moves towards the first end-of-run position P_A (direction R2). The second main contact member 16 therefore moves towards the second fixed contact member 6.

[0148] While the second main contact member 16 is travelling towards the second fixed contact member 6, the slider member 28 touches the first cam surfaces 31 (figure 4B) in proximity of the second fixed contact member 6.

[0149] Upon a further movement of the movable contact assembly 10, the slider member 28 keeps on sliding along the first cam surfaces 31 and it exerts an increasing actuation force on the push member 26 (figure 4A). As a consequence, the spring member 27 is progressively compressed. When the movable contact assembly 10 reaches the first end-of-run position P_A, the spring member 27 reaches the maximum compression. The movable arc contact member 18 is thus pressed against the fixed arc contact member 17.

[0150] The cam mechanism 25 operates in the same way when the movable contact assembly 10 moves in proximity of the above-mentioned second end-of-run position Pc as it occurs during a disconnecting manoeuvre or a reconnecting manoeuvre of the switching apparatus. In this case, the slider member 28 interacts with the second cam surfaces 32 arranged in proximity of the second third fixed contact member 7.

[0151] When the arc contact members 17, 18 are decoupled one from another during the various manoeuvres of the switching apparatus or when the movable contact assembly 10 moves in proximity of the above-mentioned intermediate position P_B, the cam mechanism 25 does not operate at all. In these cases, in fact, the slider member 28 cannot interact with any cam surface. As a consequence, the spring member 27 always remains released.

[0152] According to other embodiments of the invention (figures 5-7), the cam mechanism 25 comprises a lever member 29, which comprises one or more first lever surfaces 291 coupled with the push member 26 and one or more second lever surfaces 292 couplable with one or more first sliding surfaces 33 or with one or more second sliding surfaces 34, when the movable contact assembly 10 is in the first end-of-run position P_A or in the second end-of-run position P_C.

[0153] When it is coupled to the one or more first sliding surfaces 33 or the one or more second sliding surfaces 34, the lever member 29 exerts on the push member 26 an actuation force, which is directed to cause the compression of the spring member 27 and the consequent pressing of the movable arc contact member 18 against the fixed arc contact member 17.

[0154] The lever member 29 is preferably solidly cou-

pled to the movable arc contact member 18 (more particularly to the second connecting member 180).

[0155] In the embodiments shown in figures 5-7, the lever member 29 is a cam lever rotatably coupled to the first connecting pin 220 and positioned between the parallel blades of the second main contact member 6.

[0156] Preferably, a third jig member 331, which supports first rollers 332, is fixed to the second fixed contact member 6 between the parallel blades of this latter. The first rollers 332 include the one or more first sliding surfaces 33 for the lever member 29 (figures 6 and 7).

[0157] Similarly (figure 6), a fourth jig member 334, which supports second rollers 342, is fixed to the third fixed contact member 7 between the parallel blades of this latter. The second rollers 334 include the one or more second sliding surfaces 34 for the lever member 29.

[0158] According to possible variants, the first and second cam surfaces 31, 32 may be provided by rollers suitably coupled to jig members solidly coupled to or integrally made with the insulating housing 4.

[0159] The operation of the cam mechanism 25 included in a generic electric pole 2, when designed according to the embodiment described above, is briefly illustrated with reference to figures 7, 7A, 7B.

[0160] The movable contact assembly 10 is supposed to move in proximity of the above-mentioned first end-of-run position P_A as it occurs during an opening manoeuvre or a closing manoeuvre of the switching apparatus.

[0161] Figure 7 illustrates the cam mechanism 25 when the movable contact assembly 10 is in the first end-of-run position P_A and the switching apparatus is in a closed state.

[0162] When the movable contact assembly 10 is in the first end-of-run position P_A, the second main contact member 16 is coupled to the second fixed contact member 6 and the movable arc contact member 18 is coupled to the fixed arc contact member 17 and pressed against this latter. In this situation, the lever member 29 has the second lever surfaces 292 coupled to the first sliding surfaces 33 and it exerts an actuation force on the push member 26. This latter compresses the spring member 27, which, in turn, presses of the movable arc contact member 18 against the fixed arc contact member 17.

[0163] During an opening manoeuvre of the switching apparatus, the movable contact assembly 10 moves away from the first end-of-run position P_A (direction R1). The second main contact member 16 therefore moves away from the second fixed contact member 6.

[0164] When the second main contact member 16 starts moving, the second lever surfaces 292 of the lever member 29 slides along the first sliding surfaces 33 and they progressively decouple from these latter. In this way, the spring member 27 is progressively released and the movable arc contact member 18 is no more pressed against the fixed contact member 17 (figure 7A). Upon a further movement of the movable contact assembly 10, the second lever surfaces 292 of the lever member 29 keep on sliding along the first sliding surfaces 33 until they decouple from these latter (figure 7B). The spring member 27 is released and the cam mechanism 25 does not operate anymore.

[0165] During a closing manoeuvre of the switching apparatus, the movable contact assembly 10 moves towards the first end-of-run position P_A (direction R2). The second main contact member 16 therefore moves towards the second fixed contact member 6.

[0166] While the second main contact member 16 is travelling towards the second fixed contact member 6, the second lever surfaces 292 of the lever member 29 touch the first cam surfaces 31 (figure 7B).

[0167] Upon a further movement of the movable contact assembly 10, the second lever surfaces 292 of the lever member 29 keep on sliding along the first sliding surfaces 33 and the lever member 29 exerts an increasing actuation force on the push member 26 (figure 4A). As a consequence, the spring member 27 is progressively compressed.

[0168] When the movable contact assembly 10 reaches the first end-of-run position P_A, the spring member 27 reaches the maximum compression. The movable arc contact member 18 is thus pressed against the fixed arc contact member 17.

[0169] The cam mechanism 25 operates in the same way when the movable contact assembly 10 moves in proximity of the above-mentioned second end-of-run position P_C as it occurs during a disconnecting manoeuvre or a reconnecting manoeuvre of the switching apparatus. In this case, the first lever surfaces 291 of the lever member 29 interact with the above-mentioned second sliding surfaces 34 arranged in proximity of the second third fixed contact member 7.

[0170] Also in this case, when the arc contact members 17, 18 are decoupled one from another during the various manoeuvres of the switching apparatus or when the movable contact assembly 10 moves in proximity of the above-mentioned intermediate position P_B, the cam mechanism 25 does not operate at all. In these cases, in fact, the lever surfaces 291, 292 of the lever member 29 cannot interact with any cam surface. As a consequence, the spring member 27 always remains released.

[0171] The operation of the switching apparatus 1 for each electric pole 2 is now described in more details with particular reference to the embodiment of the invention of figures 5-7. The switching apparatus 1 operates similarly in the embodiment of figure 2-4.

Closed state of the switching apparatus

[0172] When the switching apparatus is in a closed state, each electric pole 2 is in the operating condition illustrated in figure 8.

[0173] In this situation, in each electric pole 2:

- the movable contact assembly 10 is in the first end-of-run position P_A;
- the first main contact member 15 is coupled to the

first fixed contact member 5;
- the second main contact member 16 is coupled to the second fixed contact member 6;
- the movable arc contact member 18 is coupled to the fixed arc contact member 17;
- the cam mechanism 25 presses the movable arc contact member 18 against the fixed arc contact member 17;
- each guiding member 22 is in the first position T_A along the track surface 21 of the corresponding track element 20.

[0174] When an electric pole 2 is in this operating condition, a line current can flow between the first and second pole terminals 11, 12, the first and second fixed contact members 5, 6, the first and second main contact members 15, 16 and the first and second arc contact members 17, 18, which are all electrically connected in series.

Open state of the switching apparatus

[0175] When the switching apparatus is in an open state, each electric pole 2 is in the operating condition illustrated in figure 12.

[0176] In this situation, in each electric pole 2:

- the movable contact assembly 10 is in the intermediate position P_B;
- the first main contact member 15 is decoupled from the first fixed contact member 5 and the fourth fixed contact member 8;
- the second main contact member 16 is decoupled from the second fixed contact member 6 and the third fixed contact member 7;
- the movable arc contact member 18 is coupled to the fixed arc contact member 17;
- the cam mechanism 25 does not operate;
- each guiding member 22 is in the second position T_B along the track surface 21 of the corresponding track element 20.

[0177] When an electric pole 2 is in this operating condition, no current flows between the first and second pole terminals 11, 12.

Earthed state of the switching apparatus

[0178] When the switching apparatus is in an earthed state, each electric pole 2 is in the operating condition illustrated in figure 16.

[0179] In this situation, in each electric pole 2:

- the movable contact assembly 10 is in the second end-of-run position P_C;
- the first main contact member 15 is coupled to the fourth fixed contact member 8;
- the second main contact member 16 is coupled to the third fixed contact member 7;
- the movable arc contact member 18 is coupled to the fixed arc contact member 17;
- the cam mechanism 25 presses the movable arc contact member 18 on the fixed arc contact member 17;
- each guiding member 22 is in the third position T_C along the track surface 21 of the corresponding track element 20.

[0180] When an electric pole 2 is in this operating condition, no line current flows between the first and second pole terminals 11, 12 and the second pole terminal 12 is put at a ground voltage.

Opening manoeuvre

[0181] The switching apparatus 1 carries out an opening manoeuvre, when it switches from the closed state to the open state.

[0182] Initially, each electric pole 2 is therefore in the operating condition of figure 8.

[0183] During an opening manoeuvre of the switching apparatus, each movable contact assembly 10 moves, according to the first rotation direction R1, between the first end-of-run position P_A and the intermediate position P_B.

[0184] The first main contact member 15 moves away from the first fixed contact member 5 while the second main contact member 16 moves away from the second fixed contact member 6.

[0185] When the second main contact member 16 starts moving according to the first rotation direction R1, the lever member 29 progressively decouples from the first sliding surfaces 33 (figures 5-7). Similarly, in the embodiments of figures 2-4, the slider member 28 progressively decouples from the first cam surfaces 31.

[0186] In both cases, as a consequence, the spring member 27 is progressively released and the movable arc contact member 18 is no more pressed against the fixed contact member 17.

[0187] In the meanwhile, the guiding member 22 starts moving away from the first position T_A towards the second position T_B by sliding along the first track surface portion 21A portion. However, this latter is shaped so that the movable arc contact member 18 remains coupled to the fixed arc contact member 17 until the spring member 27 is released.

[0188] At this stage of the opening manoeuvre (figure 9), the first and second main contact members 15, 16 are still coupled respectively to the first and second fixed contact members 5, 6 and no arcing phenomena arise between the electric contacts under separation yet.

[0189] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the first segment of this latter) thereby moving towards the second position T_B (figure 10). The movable arc contact member 18 progressively decouples from the

fixed arc contact member 17. The first track surface portion 21A is conveniently shaped so that the movable arc contact member 18 decouples from the fixed arc contact member 17 while the first and second main contact members 15 are still coupled to the first and second fixed contact members 5, 6. In this way, possible arcing phenomena caused by the progressive interruption of the current flowing along the electric pole arise only internally to the vacuum chamber 14. At this stage of the opening manoeuvre, the lever member 29 is decoupled from the first sliding surfaces 33. The cam mechanism 25 does not operate anymore and the spring member 27 is released.

[0190] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the third segment of this latter) thereby moving towards the second position T_B (figure 11).

[0191] The movable arc contact member 18 is decoupled from the fixed arc contact member 17 and the first and second main contact members 15, 16 are decoupled from the first and second fixed contact members 5, 6. No arcing phenomena are normally present between the electric contacts under separation at this stage of the opening manoeuvre as the interruption of the current flowing along the electric pole 2 is already completed.

[0192] At this stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released.

[0193] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the second segment of this latter) and it reaches the second position T_B, when the movable contact assembly 10 reaches the intermediate position P_B (figure 12).

[0194] The movable arc contact member 18 couples again to the fixed arc contact member 17 while the first and second main contact members 15, 16 remain decoupled from the first and second fixed contact members 5, 6.

[0195] At this final stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released.

[0196] The switching apparatus 1 is in now in an open state.

Closing manoeuvre

[0197] The switching apparatus 1 carries out a closing manoeuvre, when it switches from the open state to the closed state.

[0198] Initially, each electric pole 2 is therefore in the operating condition of figure 12.

[0199] During a closing manoeuvre of the switching apparatus, each movable contact assembly 10 moves, according to the second rotation direction R2, between the intermediate position P_B and the first end-of-run position P_A.

[0200] The first main contact member 15 moves towards the first fixed contact member 5 while the second main contact member 16 moves towards the second fixed contact member 6.

[0201] When the second main contact member 16 starts moving according to the second rotation direction R2, the guiding member 22 moves away from the second position T_B towards the first position T_A by sliding along the first track surface portion 21A (in particular along the second segment of this latter). The movable arc contact member 18 thus progressively decouples from the fixed arc contact member 17 (figure 11).

[0202] At this stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released.

[0203] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the third segment of this latter) thereby moving towards the first position T_A (figure 10).

[0204] The movable arc contact member 18 is still decoupled from the fixed arc contact member 17 while the first and second main contact members 15, 16 progressively couple with the first and second fixed contact members 5, 6, respectively.

[0205] At this stage of the closing manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is still released.

[0206] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the third and first segments of this latter) thereby moving towards the first position T_A (figure 9).

[0207] The movable arc contact member 18 progressively couples to the fixed arc contact member 17 while the first and second main contact members 15, 16 are already coupled to the first and second fixed contact members 5, 6.

[0208] In the meanwhile, the lever member 29 touches the first sliding surfaces 33 and starts exerting an increasing actuation force on the push member 26 (figures 5-7).

[0209] Similarly, in the embodiments of figures 2-4, the slider member 28 touches the first cam surfaces 31 and starts exerting an increasing actuation force on the push member 26.

[0210] In both cases, as a consequence, the spring member 27 is progressively compressed.

[0211] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the first track surface portion 21A (in particular along the first segment of this latter) and it reaches the first position T_A, when the movable contact assembly 10 reaches the closed position P_A (figure 8).

[0212] The movable arc contact member 18 is coupled to the fixed arc contact member 17 and the first and second main contact members 15, 16 are coupled from the first and second fixed contact members 5, 6.

[0213] The lever member 29 is fully coupled to the sliding surfaces 33. Similarly, in the embodiments of figures 2-4, the slider member 28 is fully coupled to the cam surfaces 31.

[0214] In both cases, as a consequence, the spring member 27 reaches its maximum compression and the movable arc contact member 18 is pressed against the fixed arc contact member 17.

[0215] The switching apparatus 1 is now in a closed state.

Disconnecting manoeuvre

[0216] The switching apparatus 1 carries out a disconnecting manoeuvre, when it switches from an open state to an earthed state.

[0217] Obviously, before carrying out a disconnecting manoeuvre, the switching apparatus has to carry out an opening manoeuvre as described above in order to switch in an open state.

[0218] Initially, each electric pole 2 is therefore in the operating condition of figure 12.

[0219] During a disconnecting manoeuvre of the switching apparatus, each movable contact assembly 10 moves, according to the first rotation direction R1, between the intermediate position P_B and the second end-of-run position Pc.

[0220] The first main contact member 15 moves towards the fourth fixed contact member 8 while the second main contact member 16 moves towards the third fixed contact member 7.

[0221] When the second main contact member 16 starts moving according to the first rotation direction R1, the guiding member 22 moves away from the second position T_B towards the third position Tc by sliding along the second track surface portion 21B (in particular along the fourth segment of this latter). The movable arc contact member 18 progressively decouples from the fixed arc contact member 17 (figure 13).

[0222] At this stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released.

[0223] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the sixth segment of this latter) thereby moving towards the third position Tc (figure 14).

[0224] The movable arc contact member 18 is decoupled from the fixed arc contact member 17 while the first and second main contact members 15, 16 progressively couple to the fourth and third fixed contact members 8, 7, respectively.

[0225] At this stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is still released.

[0226] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the fifth segment of this latter), thereby moving towards the third position Tc (figure 15).

[0227] The movable arc contact member 18 progressively couples to the fixed arc contact member 17 while the first and second main contact members 15, 16 are already coupled to the fourth and third fixed contact members 8, 7, respectively.

[0228] In the meanwhile, the lever member 29 touches the second sliding surfaces 34 and starts exerting an increasing actuation force on the push member 26 (figures 5-7).

[0229] Similarly, in the embodiments of figures 2-4, the slider member 28 touches the second cam surfaces 32 and starts exerting an increasing actuation force on the push member 26.

[0230] In both cases, as a consequence, the spring member 27 is progressively compressed.

[0231] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the fifth segment of this latter) and reaches the third position Tc, when the movable contact assembly 10 reaches the second end-of-run position Pc (figure 16).

[0232] The movable arc contact member 18 is coupled to the fixed arc contact member 17 and the first and second main contact members 15, 16 are coupled to the fourth and third fixed contact members 8, 7, respectively.

[0233] The lever member 29 is fully coupled to the second sliding surfaces 34.

[0234] Similarly, in the embodiments of figures 2-4, the slider member 28 is fully coupled to the second cam surfaces 32.

[0235] In both cases, as a consequence, the spring member 27 reaches its maximum compression and the movable arc contact member 18 is pressed against the fixed arc contact member 17.

[0236] The switching apparatus 1 is now in an earthed state.

Reconnecting manoeuvre

[0237] The switching apparatus 1 carries out a reconnecting manoeuvre, when it switches from an earthed state to an open state.

[0238] Initially, each electric pole 2 is therefore in the operating condition of figure 16.

[0239] During a reconnecting manoeuvre of the switching apparatus, each movable contact assembly 10 moves, according to the second rotation direction R2, between the second end-of-run position Pc and the intermediate position P_B.

[0240] The first main contact member 15 moves away from the fourth fixed contact member 8 while the second main contact member 16 moves away from the third fixed contact member 7. When the second main contact member 16 starts moving according to the second rotation direction R2, the lever member 29 progressively decouples from the second sliding surfaces 34 (figures 5-7).

[0241] Similarly, in the embodiments of figures 2-4, the slider member 28 progressively decouples from the second cam surfaces 32 (figure 15).

[0242] In both cases, as a consequence, the spring member 27 is progressively released and the movable arc contact member 18 is no more pressed against the fixed contact member 17.

[0243] In the meanwhile, the guiding member 22 starts moving away from the third position Tc towards the second position T_B by sliding along the second track surface portion 21B.

[0244] Upon a further movement of the movable contact assembly 10 towards the intermediate position P_B, according to the second rotation direction R2, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the fifth and sixth segments of this latter) thereby moving towards the second position T_B (figure 14). The movable arc contact member 18 progressively decouples from the fixed arc contact member 17.

[0245] At this stage of the opening manoeuvre, the cam lever 29 (or the slider member 28) is decoupled from the second sliding surfaces 34 (or the second cam surfaces 32). The cam mechanism 25 does not operate anymore and the spring member 27 is released.

[0246] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the fifth segment of this latter) thereby moving towards the second position T_B (figure 13).

[0247] The movable arc contact member 18 is decoupled from the fixed arc contact member 17 and the first and second main contact members 15, 16 are decoupled from the first and second fixed contact members 5, 6.

[0248] At this stage of the opening manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released.

[0249] Upon a further movement of the movable contact assembly 10, the guiding member 22 keeps on sliding along the second track surface portion 21B (in particular along the fourth segment of this latter). The guiding member 22 reaches the second position T_B when the movable contact assembly 10 reaches the intermediate position P_B (figure 12).

[0250] The movable arc contact member 18 couples again to the fixed arc contact member 17 while the first and second main contact members 15, 16 remain decoupled from the first and second fixed contact members 5, 6.

[0251] At this final stage of the reconnecting manoeuvre, the cam mechanism 25 does not operate and the spring member 27 is released. The switching apparatus 1 is now in an open state.

[0252] The switching apparatus, according to the invention, may be subject to variants and modifications, which still fall within the scope of the invention.

[0253] According to some embodiments of the invention (not shown), for example, for each electric pole 2, the position of the fixed and movable arc contact members 17, 18 may be inverted. In this case, the fixed arc contact member 17 will be electrically connected to the second main contact member 16 while the movable arc contact member 18 will be electrically connected to the first main contact member 15. Each guiding member 22 and the cam mechanism 25 will be operatively associated to the first main contact member 15 while each track element 20 will be arranged between first fixed contact member 5 and the fourth contact member 8, in a symmetrical position with respect to that shown in the cited figures.

[0254] As a further example, according to other embodiments of the invention (not shown), both the arc contact members may be movable. In this case, one or more further guiding members and a further cam mechanism will be operatively associated to the first main contact member 15 while one or more further track elements will be arranged between first fixed contact member 5 and the fourth contact member 8.

[0255] The switching apparatus, according to the invention, provides remarkable advantages with respect to the known apparatuses of the state of the art.

[0256] In the switching apparatus of the invention, each electric pole 2 is provided with a cam mechanism 25 integrated with a main contact member of the movable contact assembly 10 and operatively coupled with a movable contact member 18 accommodated in the vacuum chamber. The cam mechanism 25 allows pressing the arc contact members 17, 18 accommodated in the vacuum chamber when the switching apparatus is in a closed state or earthed state. This improves the behaviour of the switching apparatus if high currents flow along the electric poles for any reason, e.g. due to a fault.

[0257] The switching apparatus of the invention has electric poles with a very compact, simple and robust structure with relevant benefits in terms of size optimization. At the same time, the switching apparatus of the invention is characterised by high levels of reliability for the intended applications.

[0258] In the switching apparatus of the invention, the electric contacts 17, 18 are accommodated within the vacuum chamber 14 of each electric pole are transitionally decoupled during the manoeuvres of the switching apparatus but remain mutually coupled when the switching apparatus is in a closed state, an open state or an earthed state. This allows improving the dielectric behaviour of the internal components of the switching apparatus, in particular when this latter is in an open state.

[0259] In the switching apparatus of the invention, the separation between the electric contacts 17, 18 in the vacuum chamber 14 is driven depending on the position reached by the main contact members 15, 16 during an opening manoeuvre of the switching apparatus. The breaking process of the current flowing along each electric pole is thus made to occur at level of the electric contacts 17, 18. Possible electric arcs deriving from the interruption of a current flowing along each electric pole

therefore form in a vacuum atmosphere only, which allows improving their quenching.

[0260] The switching apparatus, according to the invention, ensures high-level performances in terms of dielectric insulation and arc-quenching capabilities during the current breaking process. The switching apparatus, according to the invention, is of relatively easy and cheap industrial production and installation on the field.

Claims

1. A switching apparatus (1) for medium voltage electric systems, said switching apparatus comprising one or more electric poles (2),
wherein, for each electric pole, said switching apparatus comprises:

- a first pole terminal (11), a second pole terminal (12) and a ground terminal (13), wherein said first pole terminal (11) is electrically couplable with a first conductor of an electric line, said second pole terminal (12) is electrically couplable to a second conductor of said electric line and said ground terminal (13) is electrically couplable to a grounding conductor;
- a fixed contact assembly including a plurality of fixed contact members spaced one from another,
wherein said fixed contact assembly comprises a first fixed contact member (5) electrically connected to said first pole terminal (11), a second fixed contact member (6) and a third fixed contact member (6, 7) electrically connected to said second pole terminal (12), and a fourth fixed contact member (8) electrically connected to said ground terminal (13);
- a movable contact assembly (10) rotatable about a rotation axis (A1) and comprising:

- a first main contact member (15) couplable to said first fixed contact member (5) or said fourth fixed contact member (8), upon a rotational movement of said movable contact assembly about said rotation axis (A1);
- a second main contact member (16) couplable to said second fixed contact member (6) or said third fixed contact member (7), upon a rotational movement of said movable contact assembly about said rotation axis (A1);
- a vacuum chamber (14), a fixed arc contact member (17) and a movable arc contact member (18),

wherein said movable arc contact member (18) can be coupled to or decoupled from said fixed arc contact member (17) by moving along a translation axis (A2) perpendicular to said rotation axis (A1),
wherein said arc contact members (17, 18) are accommodated within said vacuum chamber,
wherein said movable arc contact member (18) can be coupled to or decoupled from said fixed arc contact member (17),
wherein each arc contact member (17, 18) is electrically connected in series to a corresponding main contact member (15, 16);
wherein said movable contact assembly is reversibly movable about said rotation axis (A1) in a first end-of-run position (P_A), which corresponds to a closed state of said switching apparatus, in a second end-of-run position (P_C), which corresponds to a earthed state of said switching apparatus, and in an intermediate position (P_B), which corresponds to an open state of said switching apparatus;
characterised in that said movable contact assembly (10) comprises a cam mechanism (25) coupled to said movable arc contact member (18),
wherein said cam mechanism is adapted to press said movable arc contact member (18) against said fixed arc contact member (17), when said movable arc contact member is coupled to said fixed arc contact member (17) and said movable contact assembly (10) is in said first end-of-run position (P_A) or in said second end-of-run position (P_B).

2. Switching apparatus, according to claim 1, **characterised in that** said cam mechanism (25) comprises:

- a push member (26) movable with respect to said movable arc contact member (18) along said translation axis (A2);
- a spring member (27) arranged along said translation axis (A2) and coupled to said push member (26) and to said movable arc contact member (18).

3. Switching apparatus, according to claim 2, **characterised in that** said cam mechanism (25) comprises a slider member (28) coupled to said push member (26) and couplable with one or more first cam surfaces (31) or one or more second cam surfaces (32), when said movable contact assembly (10) is in said first end-of-run position (P_A) or in said second end-of-run position (P_C),
wherein said slider member (28) exerts, on said push member (26), an actuation force directed to cause the compression of said spring member (27) and the consequent pressing of said movable arc contact member (18) against said fixed arc contact member (17), when coupled to said one or more first cam surfaces (31) or said one or more second cam surfaces (32).

4. Switching apparatus, according to claim 2, **characterised in that** said cam mechanism (25) comprises

a lever member (29) having a cam profile and couplable to said push member (26) and one or more first sliding surfaces (33) or one or more second sliding surfaces (34), when said movable contact assembly (10) is in said first end-of-run position (P_A) or in said second end-of-run position (P_C),
wherein said lever member (29) exerts, on said push member (26), an actuation force directed to cause the compression of said spring member (27) and the consequent pressing of said movable arc contact member (18) against said fixed arc contact member (17), when coupled to said one or more first sliding surfaces (33) or said one or more second sliding surfaces (32).

5. Switching apparatus, according to anyone of the previous claims, **characterised in that**, when said movable contact assembly (10) is in said first end-of-run position (P_A), said first main contact member (15) is coupled to said first fixed contact member (5), said second main contact member (16) is coupled to said second fixed contact member (6), and said arc contact members (17, 18) are coupled one to another.

6. Switching apparatus, according to anyone of the previous claims, **characterised in that**, when said movable contact assembly (10) is in said intermediate position (P_B), said first main contact member (15) is decoupled from said first and fourth fixed contact members (5, 8), said second main contact member (16) is decoupled from said second and third fixed contact members (6, 7), and said arc contact members (17, 18) are coupled one to another.

7. Switching apparatus, according to anyone of the previous claims, **characterised in that**, when said movable contact assembly (10) is in said second end-of-run position (Pc), said first main contact member (15) is coupled to said fourth fixed contact member (8), said second main contact member (16) is coupled to said third fixed contact member (7), and said arc contact members (17, 18) are coupled one to another.

8. Switching apparatus, according to anyone of the previous claims, **characterised in that** it comprises, for each electric pole, at least a track member (20) having a track surface (21) with a cam profile and at least a drive member (22) solidly coupled with said movable arc contact member (18),
wherein each drive member (22) is adapted to slide along the track surface (21) of a corresponding track member (20), upon a rotational movement of said movable contact assembly (10) about said rotation axis (A1),
wherein said drive member (22) actuates said movable arc contact member (18) along said translation axis (A2) between a coupled position to and an uncoupled position from said fixed arc contact member (17), when sliding along said track surface (21).

9. Switching apparatus, according to claim 8, **characterised in that**:

- when said movable contact assembly (10) is in said first end-of run position (P_A), said drive member (22) is in a first position (T_A) along said track surface (21);
- when said movable contact assembly (10) is in said intermediate position (P_B), said drive member (22) is in a second position (T_B) along said track surface (21);
- when said movable contact assembly (10) is in said second end-of run position (P_C), said drive member (22) is in a third position (T_C) along said track surface (21);

wherein said second position (T_B) is intermediate between said first and third positions.

10. Switching apparatus, according to claim 9, **characterised in that** said drive member (22) slides along a first track surface portion (21A) with a cam profile, when moving between said first and second positions (T_A, T_B), and slides along a second track surface portion (21B) with a cam profile, when moving between said second and third positions (T_B, T_C).

11. Switching apparatus, according to anyone of the claims from 9 to 10, **characterised in that** said drive member (22) actuates said movable arc contact member (18) to a coupled position to said fixed arc contact member (17), when said drive member (22) is in said first position (T_A) or in said second position (T_B) or in said third position (T_C) along said track surface (21),
wherein said drive member (22) actuates said movable arc contact member (18) along said translation axis (A2) between a coupled position to and an uncoupled position from said fixed arc contact member (17), when sliding along said first track surface portion (21A) or said second track surface portion (21B).

12. Switching apparatus, according to one of the previous claims, **characterised in that** it is a load-break switch for medium voltage electric systems.

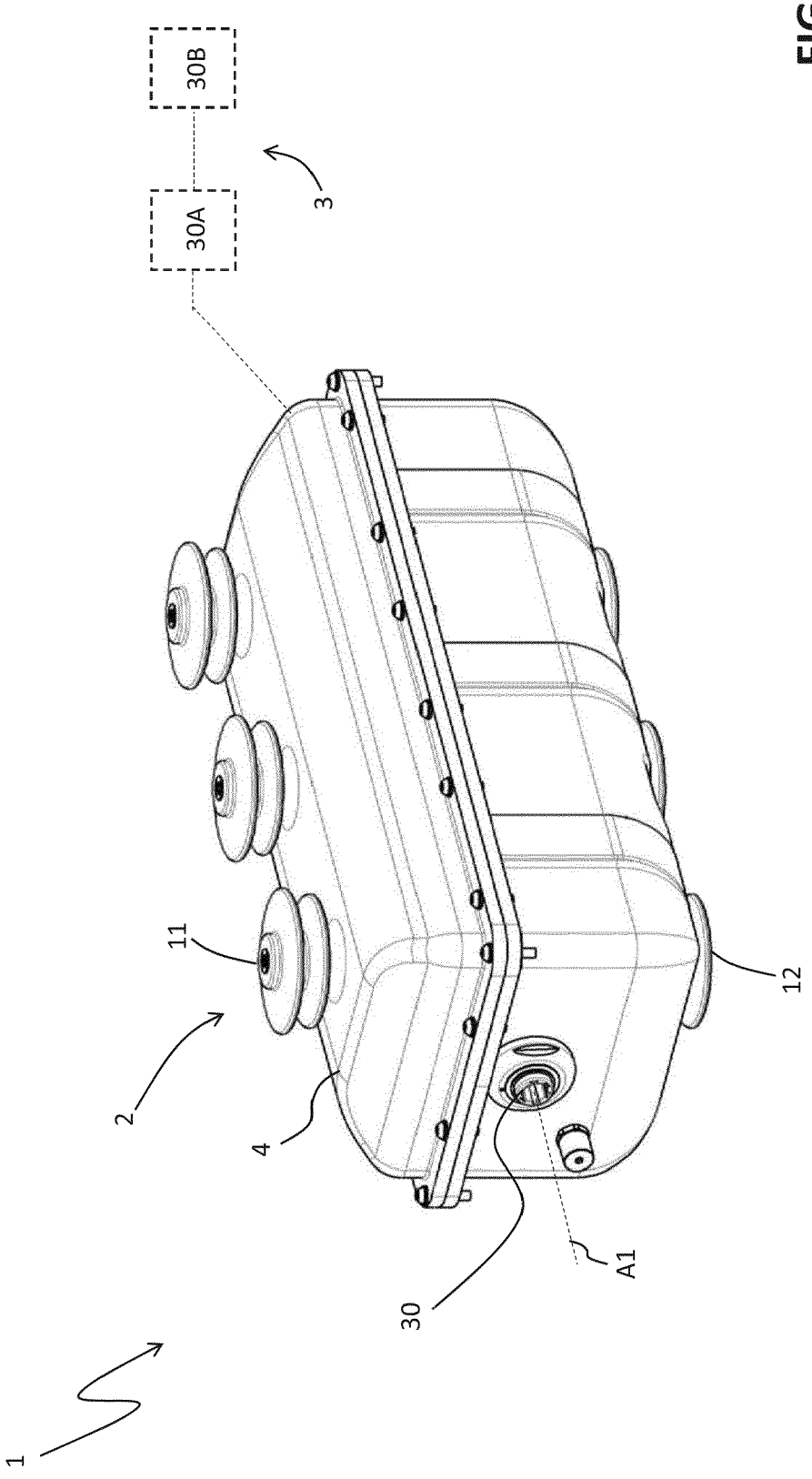


FIG. 1

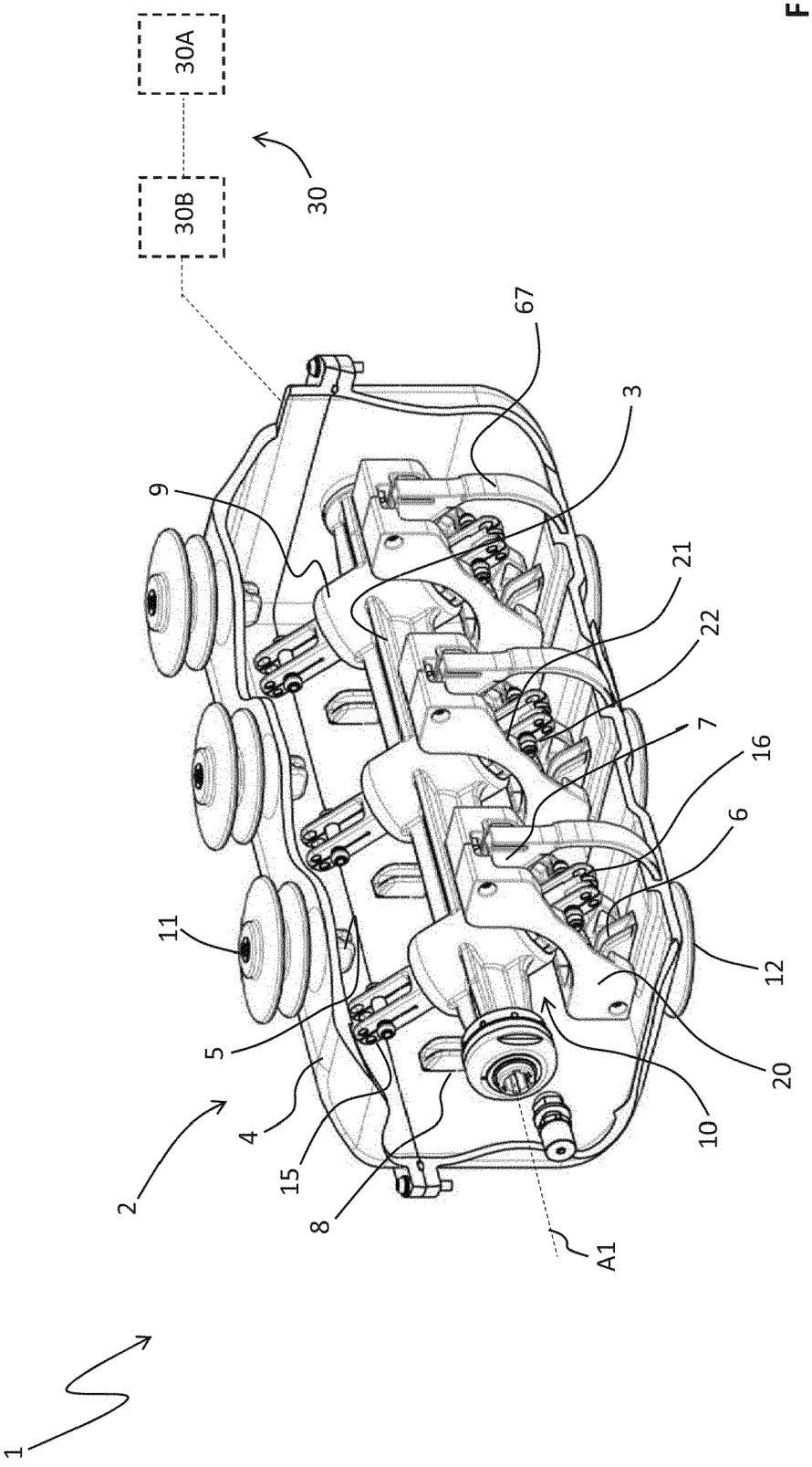


FIG. 2

FIG. 3

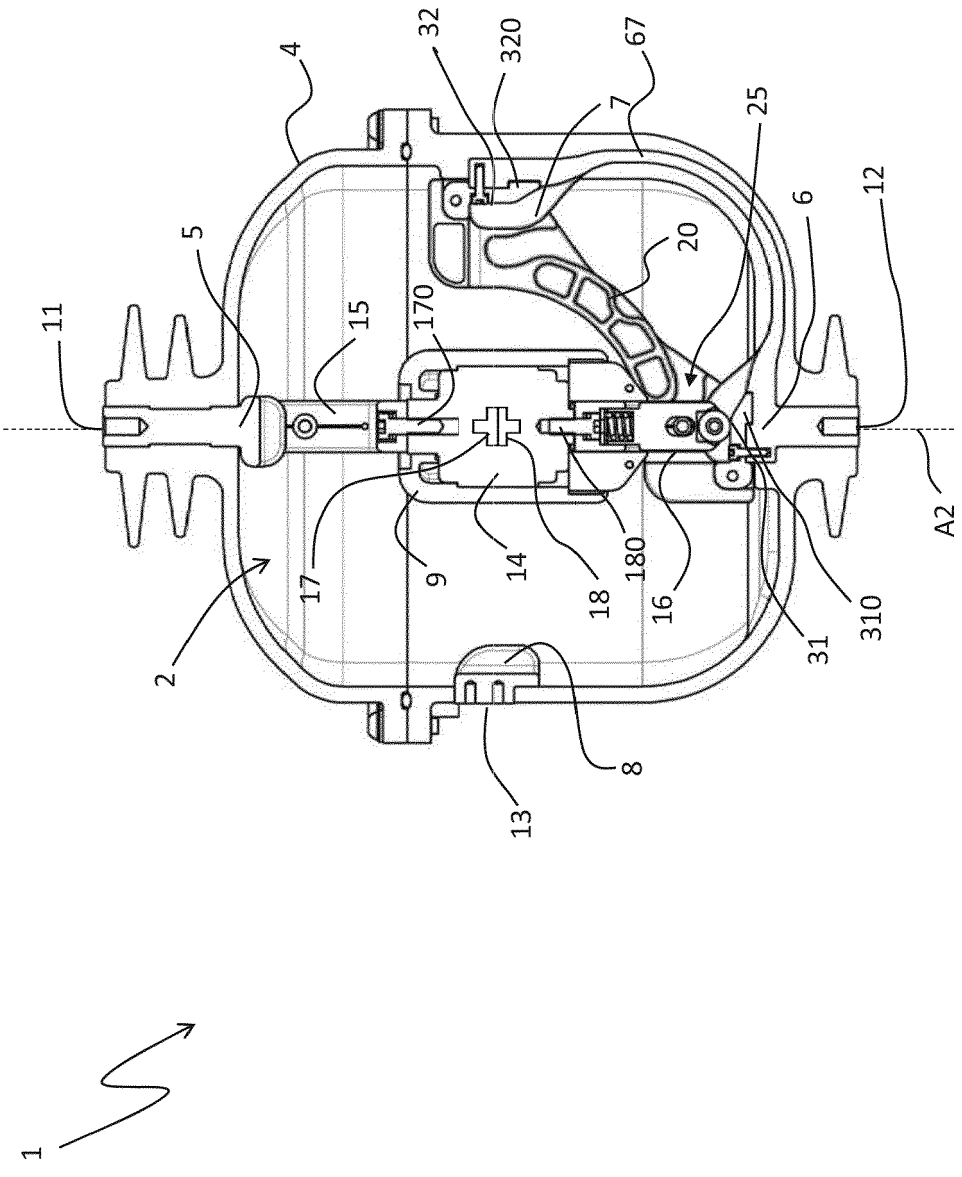


FIG. 4

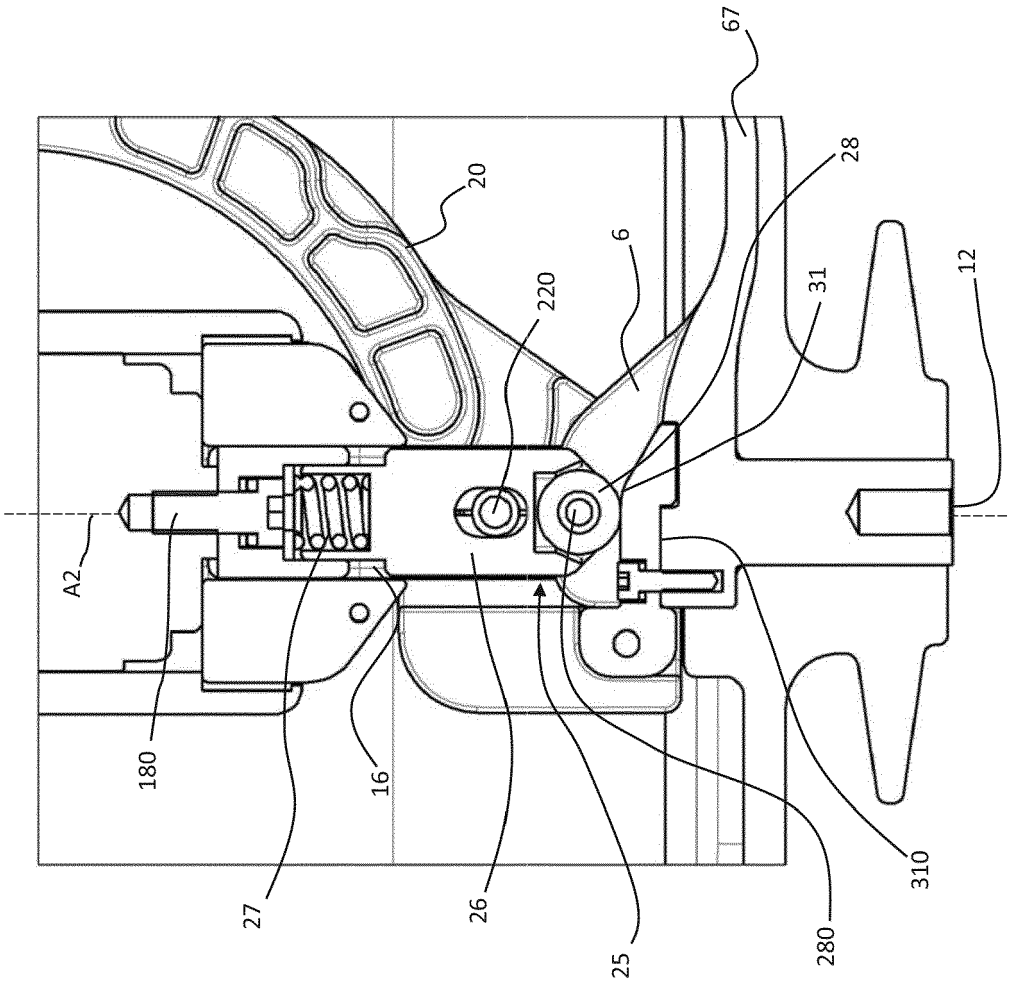
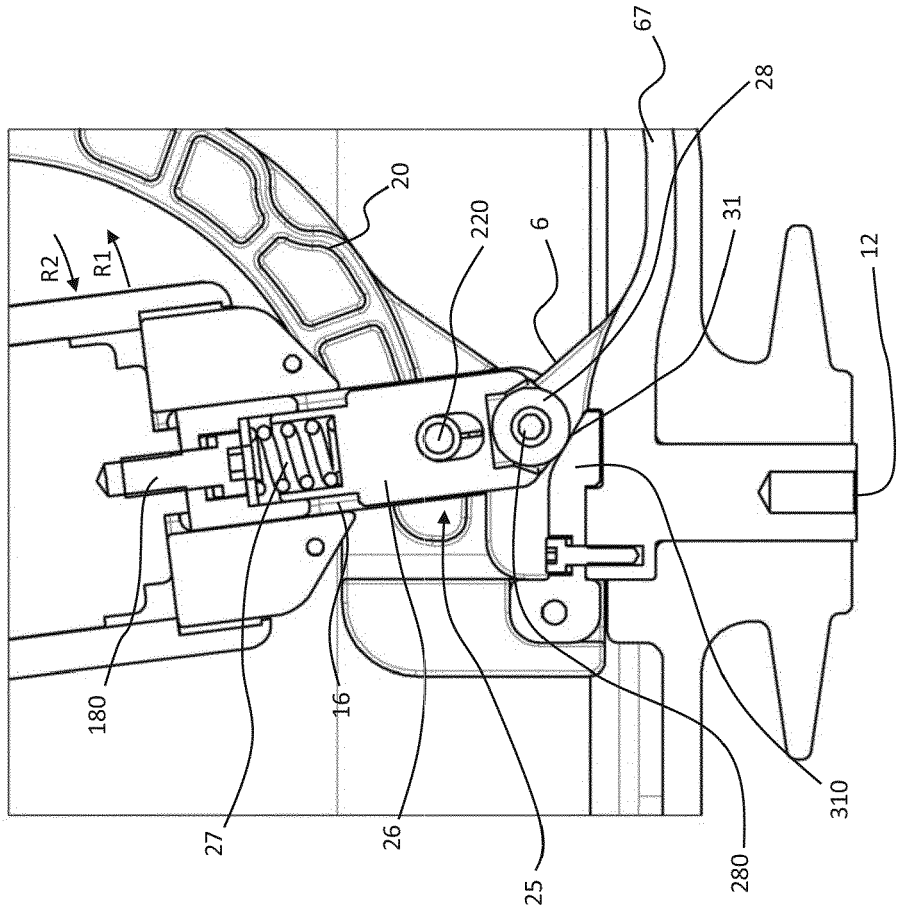


FIG. 4A



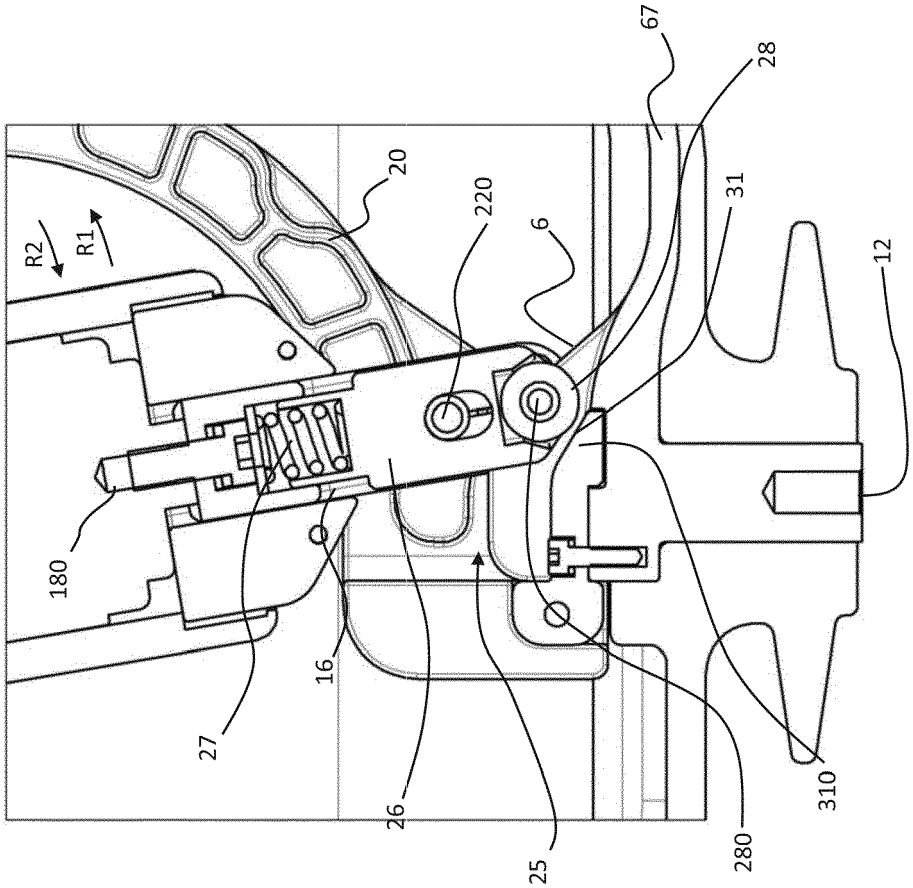


FIG. 4B

FIG. 5

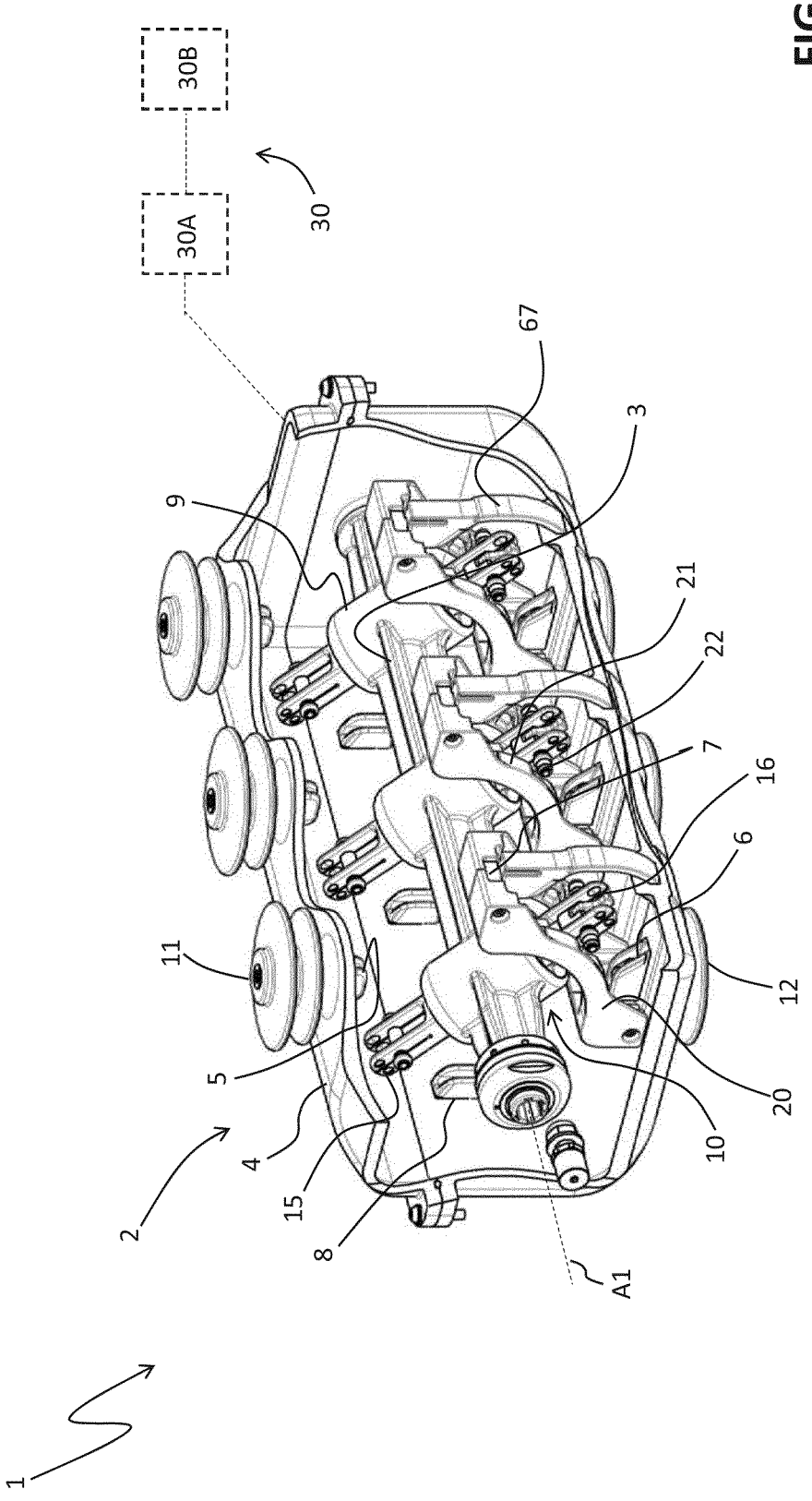
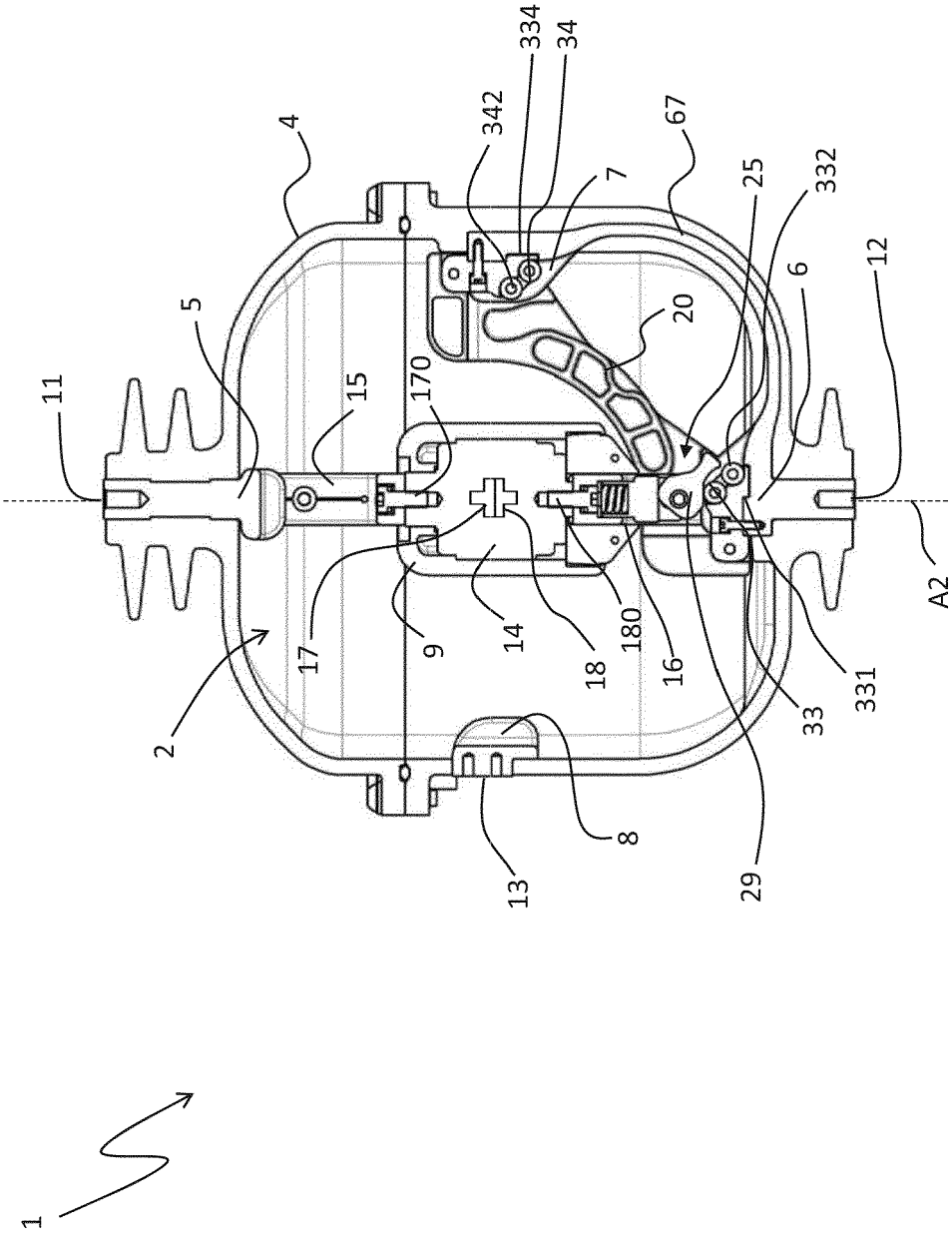


FIG. 6


1
2
4
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6
7
8
9
11
12
13
14
15
16
17
18
20
25
29
33
331
332
334
34
342
67
170
180
A2

FIG. 7

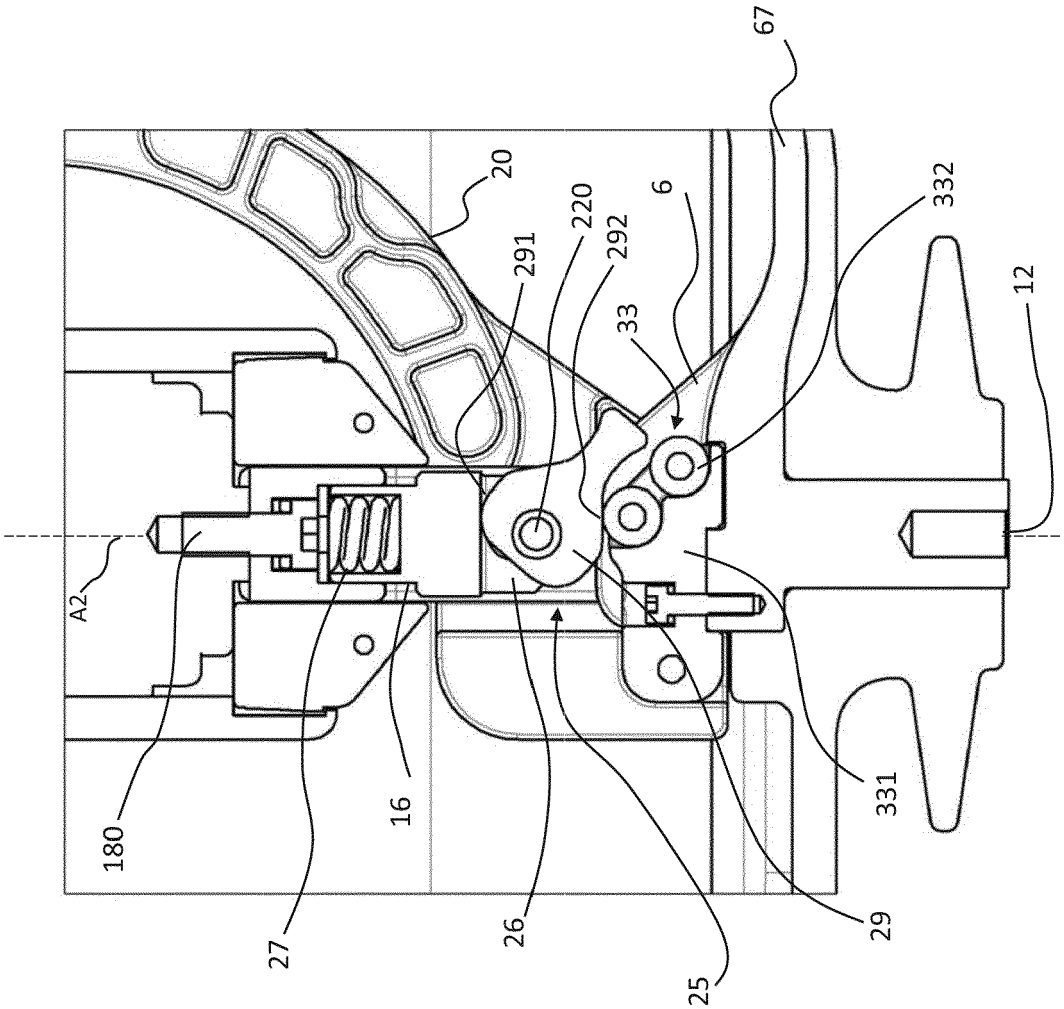
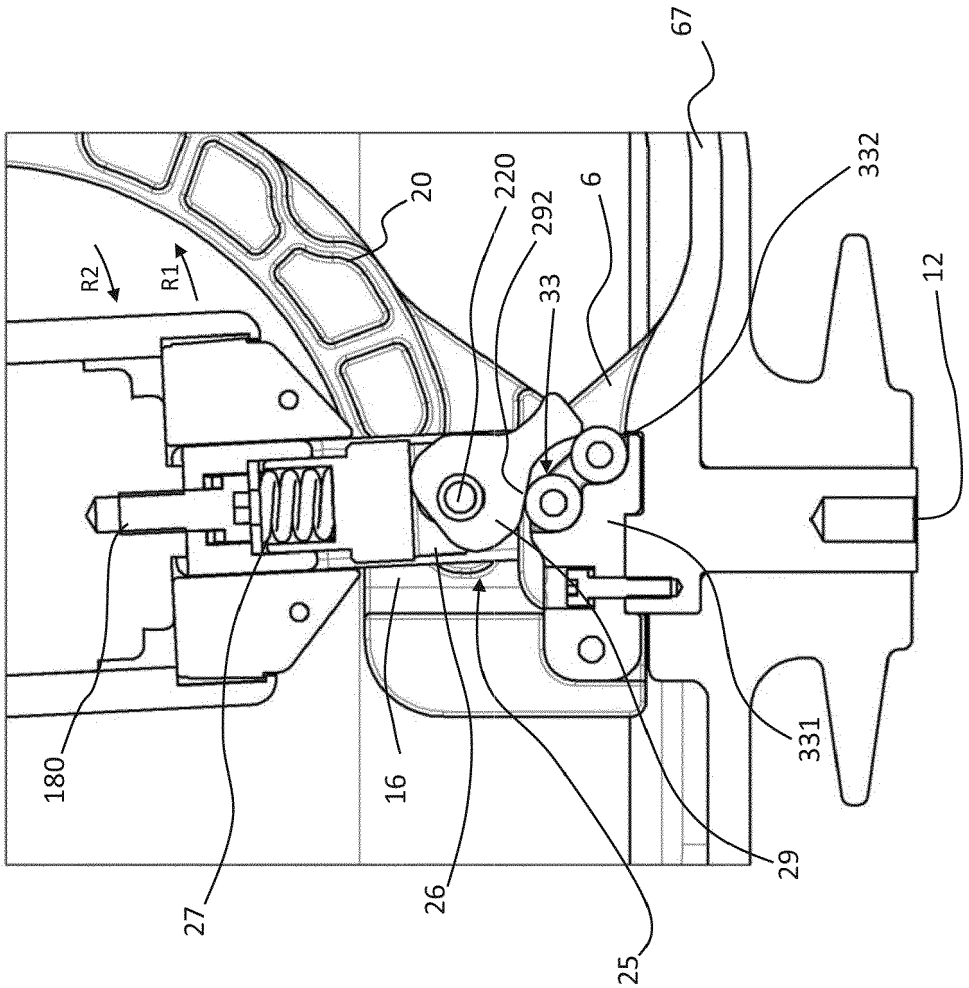


FIG. 7A



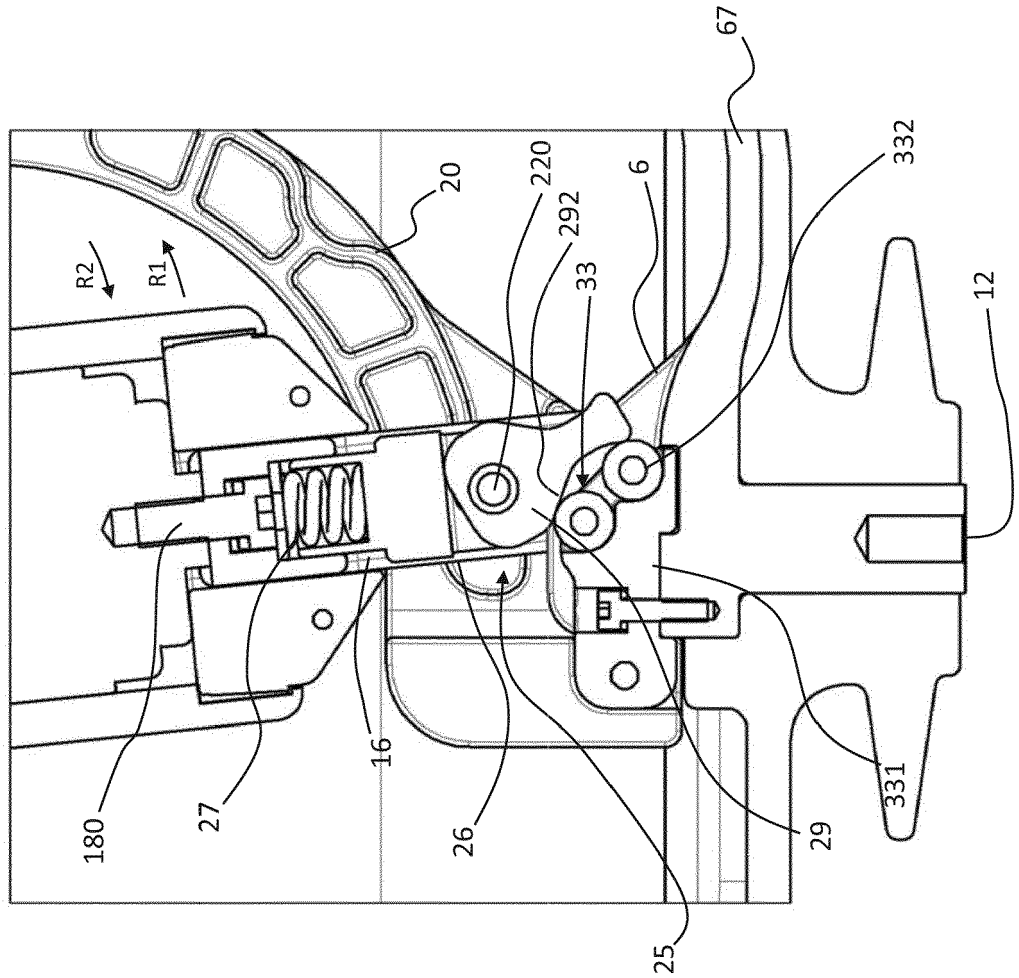


FIG. 7B

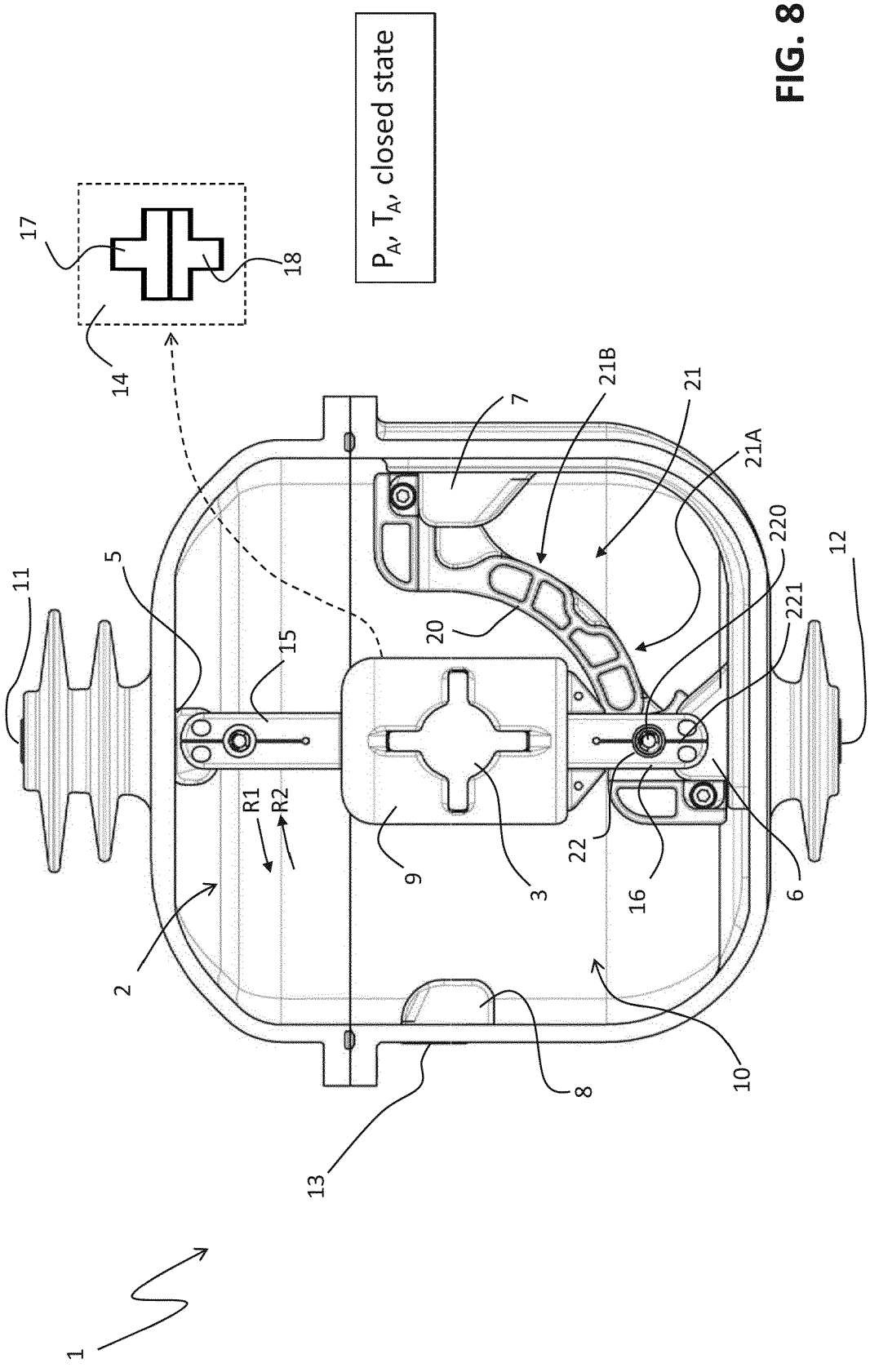

P_A, T_A, closed state
17
18
14
7
21B
21
21A
220
12
11
5
15
20
221
R1
R2
9
3
22
16
6
2
10
8
13
1

FIG. 8

FIG. 9

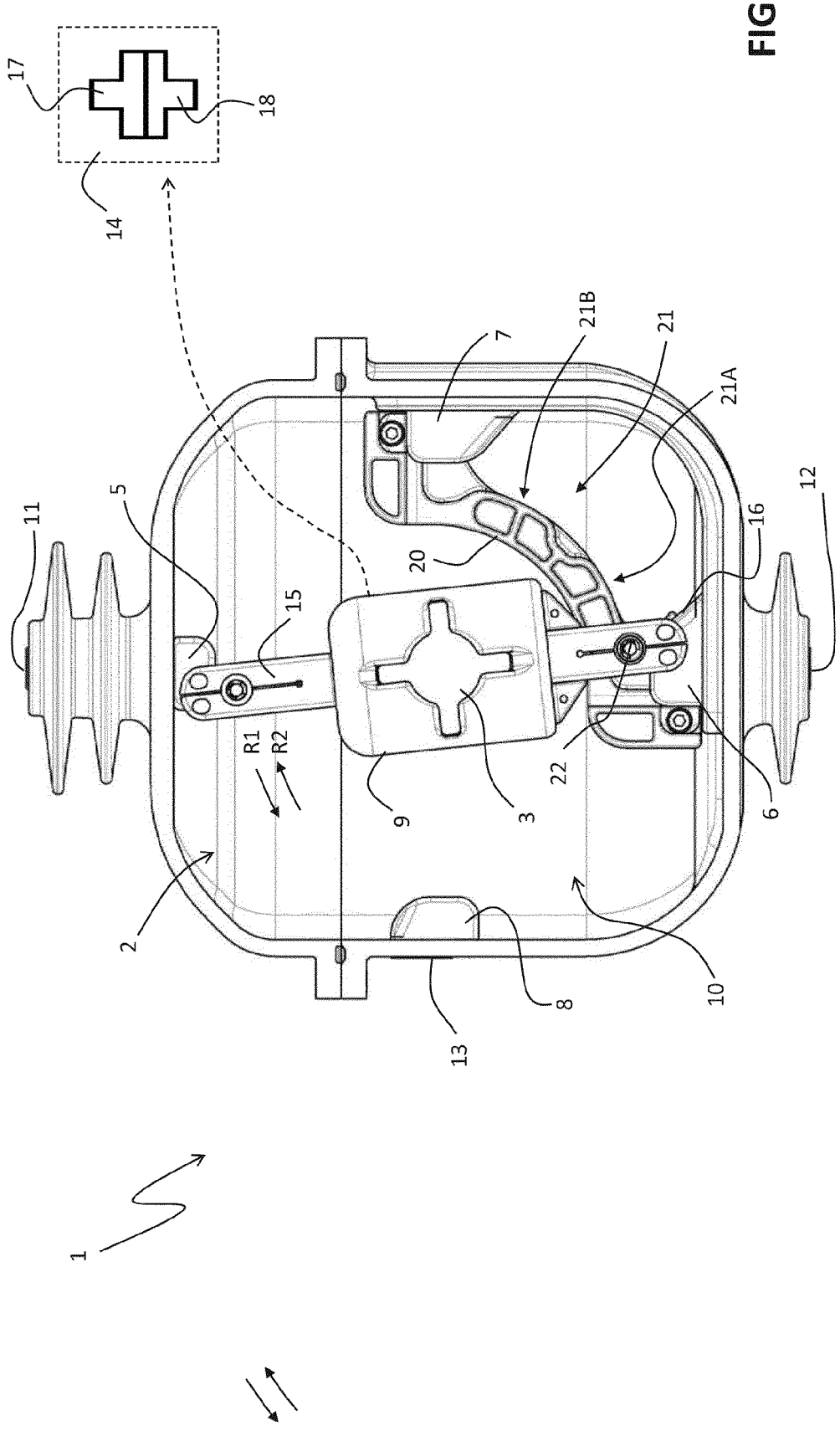


FIG. 10

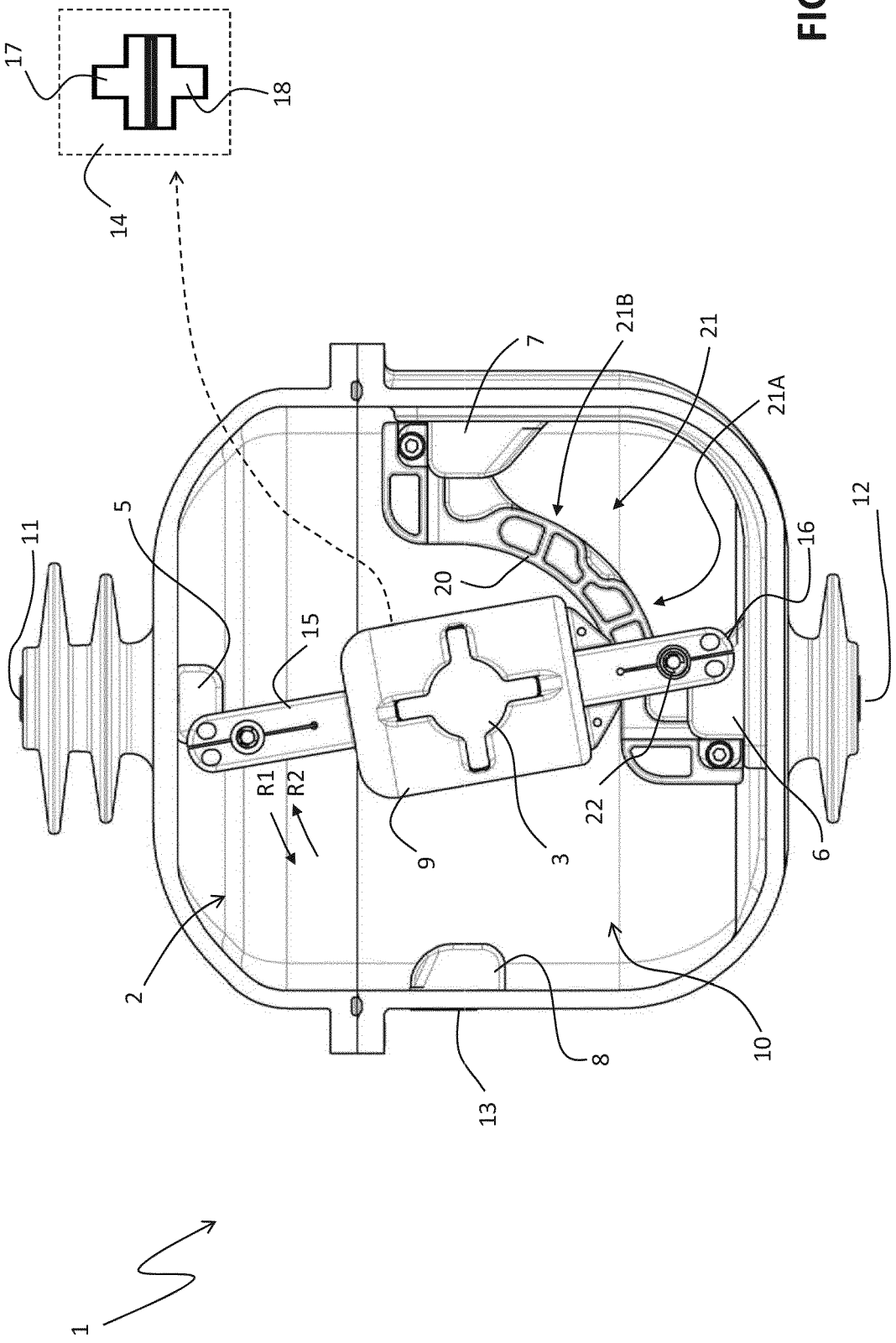
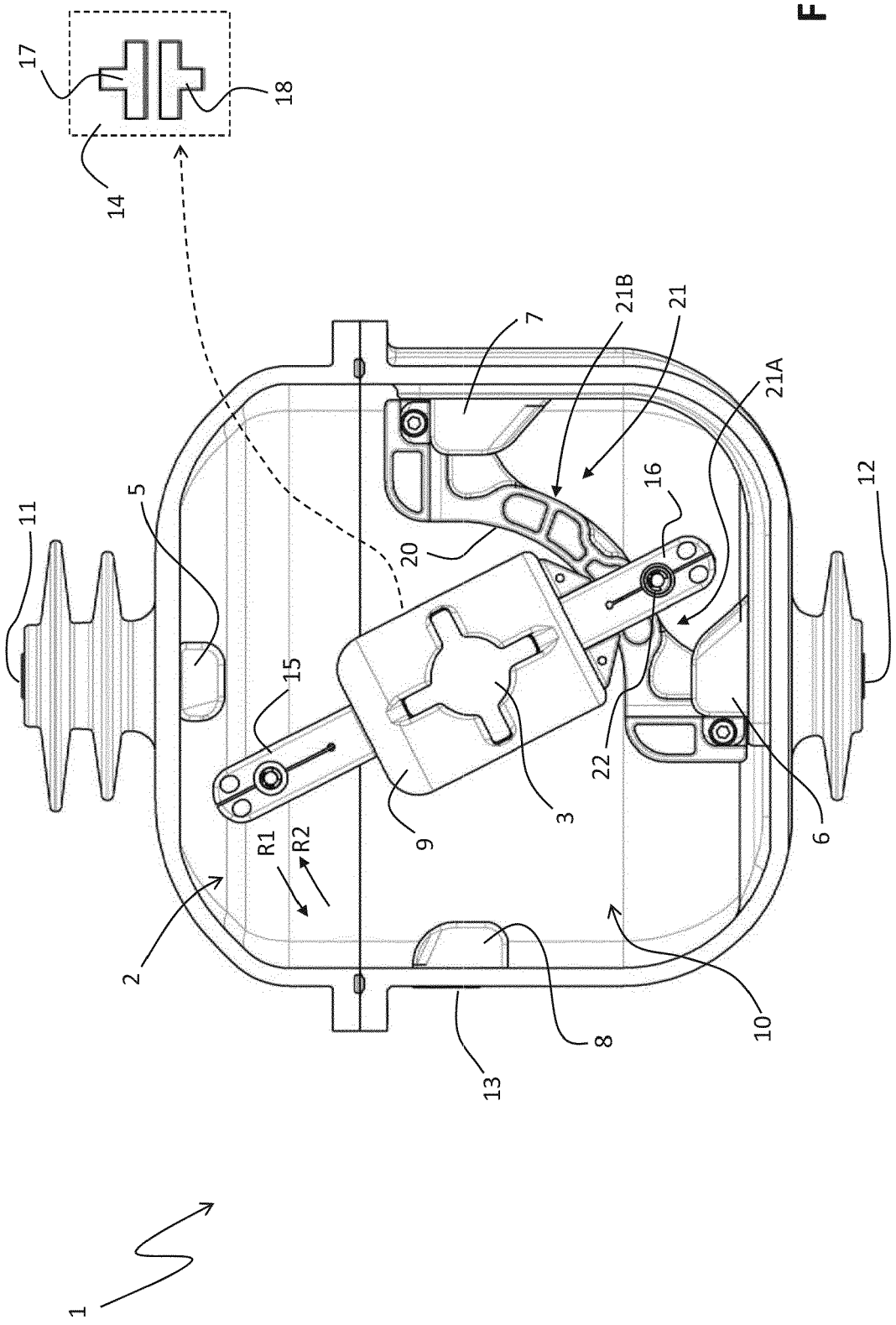


FIG. 11



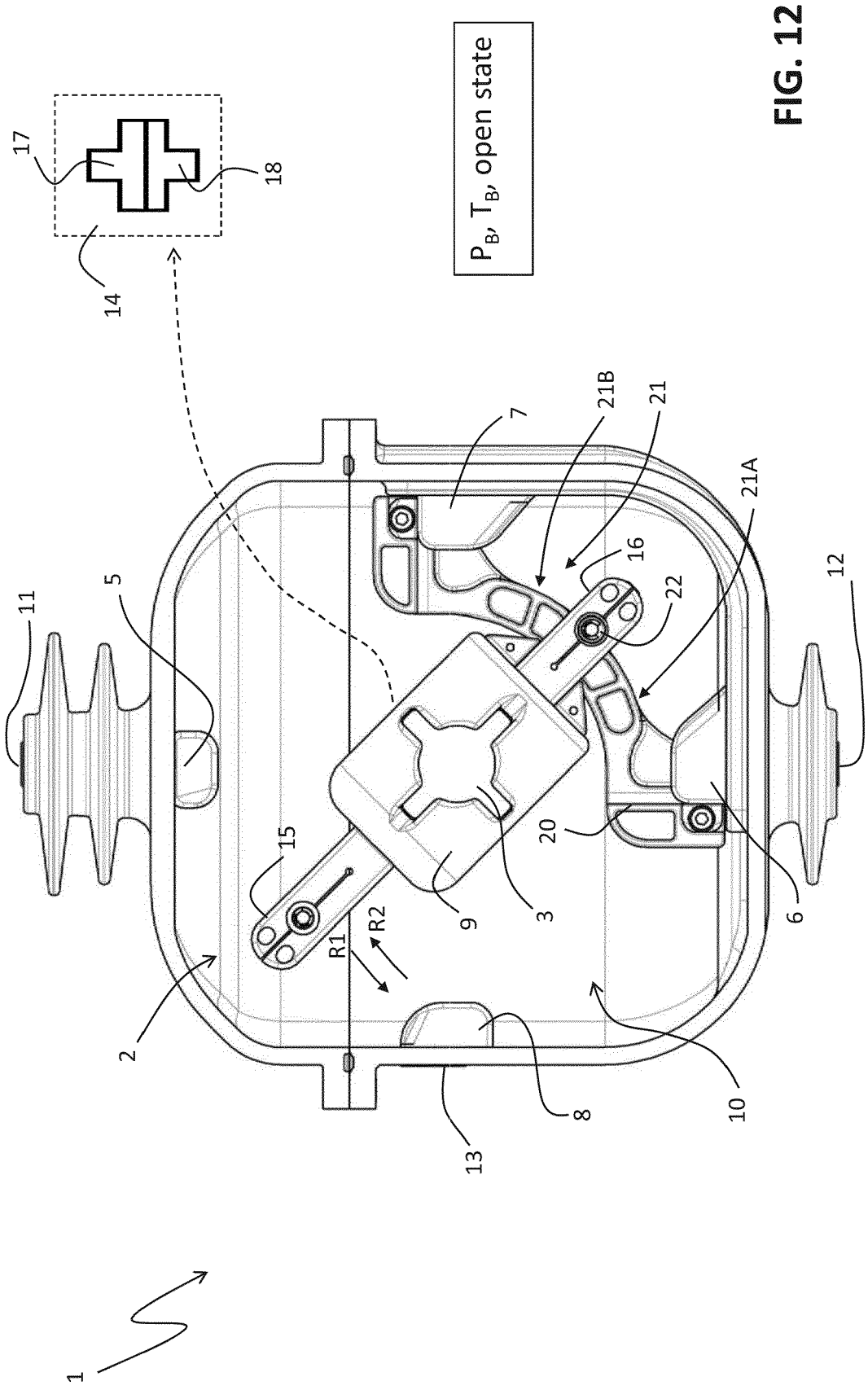

P_B, T_B, open state
17
18
14
1
2
3
5
6
7
8
9
10
11
12
13
15
16
20
21
21A
21B
22
R1
R2

FIG. 12

FIG. 13

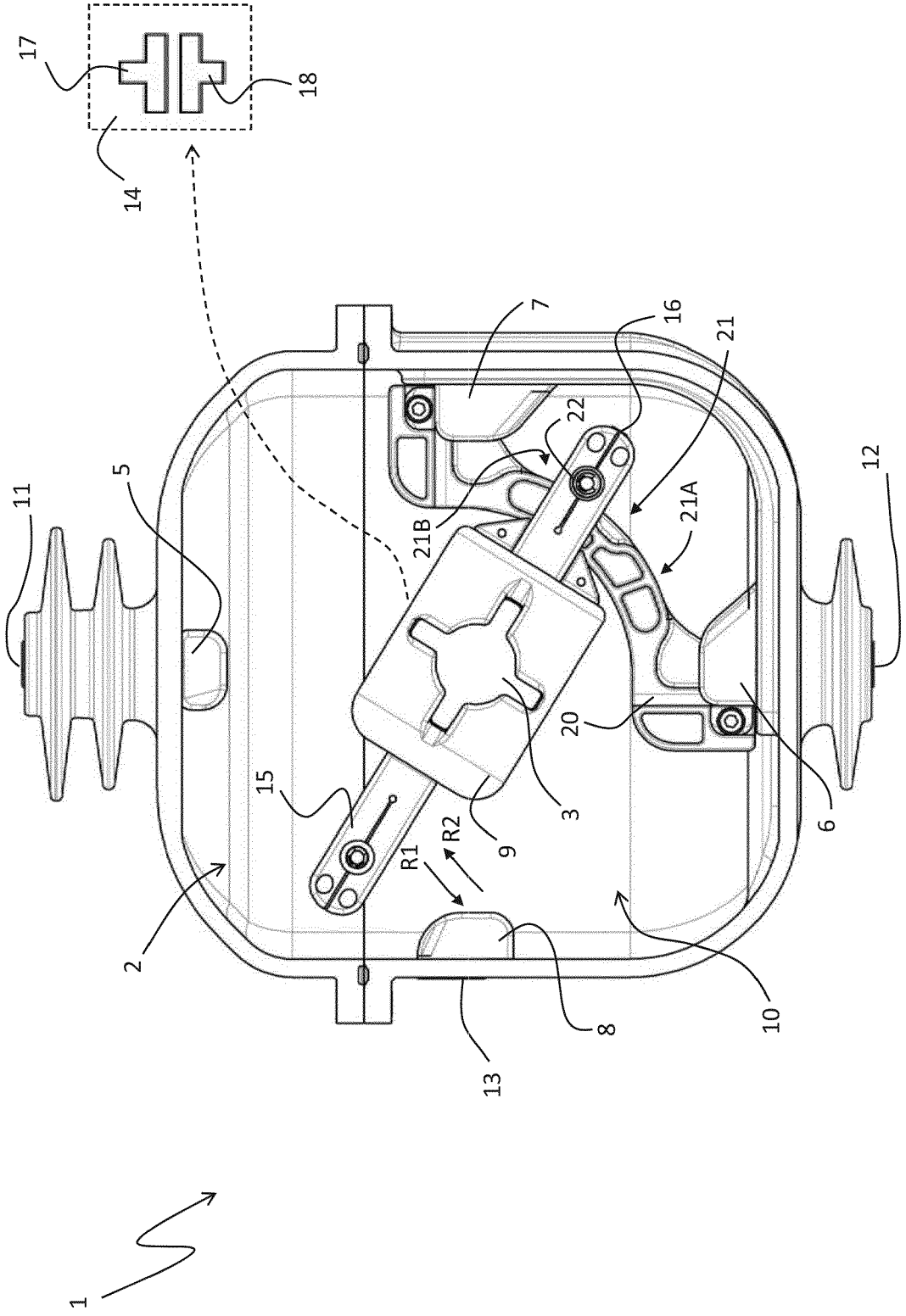


FIG. 14

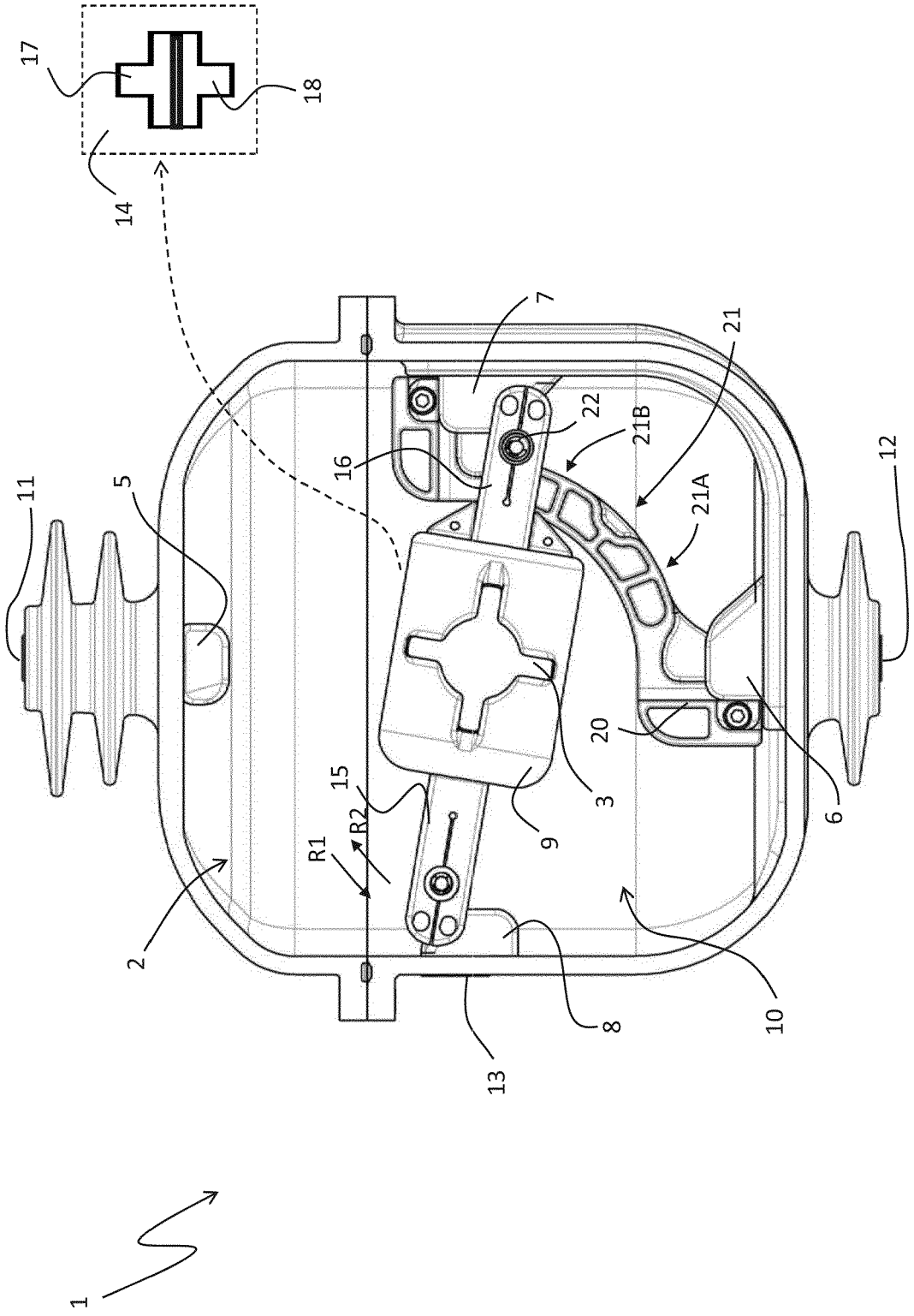
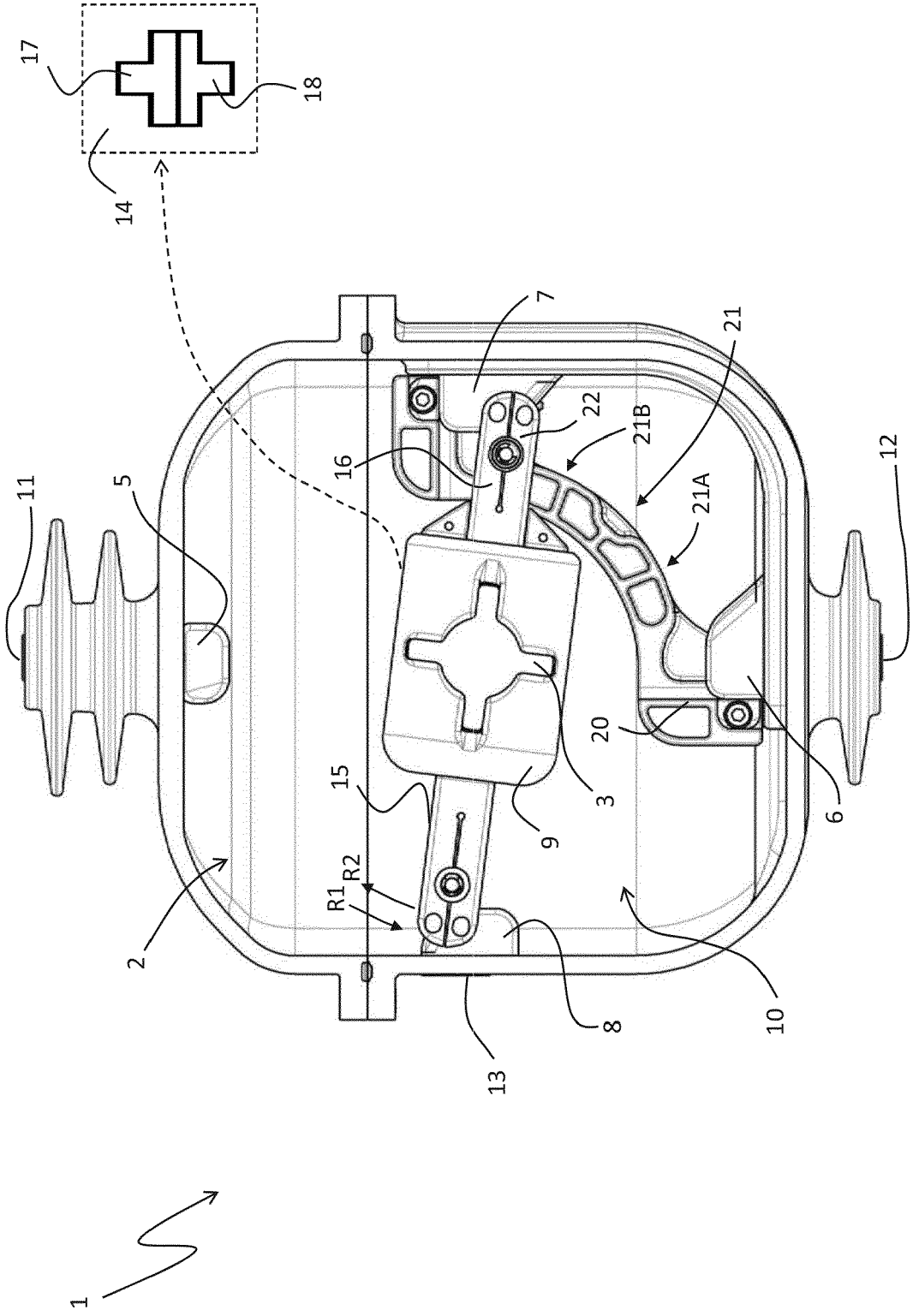


FIG. 15



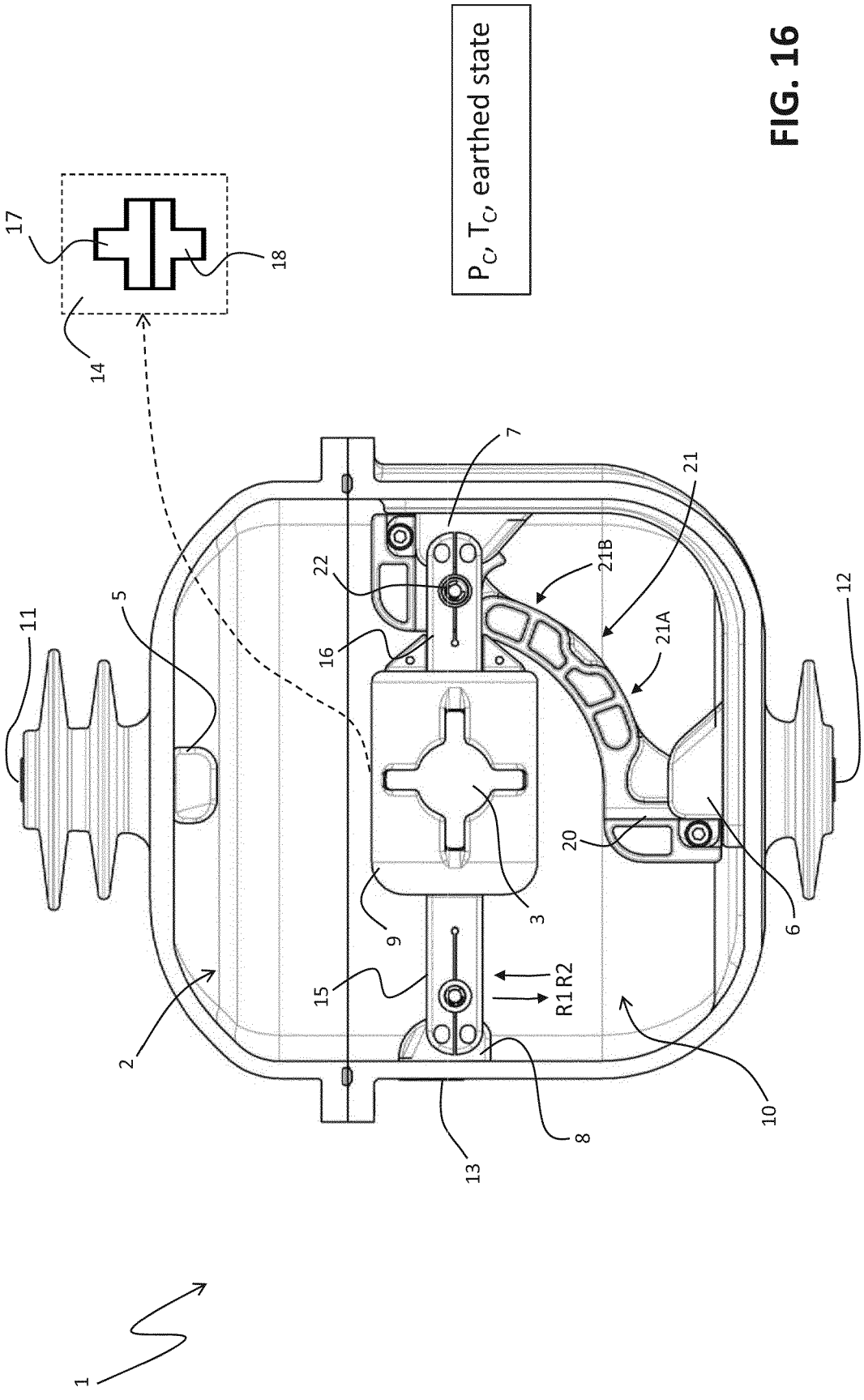

P_C, T_C, earthed state
17
18
14
7
21
22
21B
21A
16
5
11
12
20
6
3
9
15
R1R2
2
8
10
13
1

FIG. 16

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EUROPEAN SEARCH REPORT

Application Number
EP 21 17 3740

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Y	DE 10 2011 087630 A1 (SIEMENS AG [DE]) 6 June 2013 (2013-06-06) * the whole document * -----	1-12	
Y	WO 2012/031937 A1 (SIEMENS AG [DE]; BRZANK MARCEL [DE] ET AL.) 15 March 2012 (2012-03-15) * paragraph [0014] - paragraph [0019]; figures * -----	4	
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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	29 October 2021	Ramírez Fueyo, M

CATEGORY OF CITED DOCUMENTS

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EPO FORM 1503 03.82 (P04C01)

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29-10-2021

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