US012387890B2

(12) **United States Patent**
Invernizzi et al.

(10) **Patent No.: US 12,387,890 B2**
(45) **Date of Patent: Aug. 12, 2025**

(54) **MEDIUM VOLTAGE SWITCHING APPARATUS**

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(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 213 days.

(21) Appl. No.: **18/317,496**

(22) Filed: **May 15, 2023**

(65) **Prior Publication Data**

US 2023/0368993 A1 Nov. 16, 2023

(30) **Foreign Application Priority Data**

May 16, 2022 (EP) 22173528

(51) **Int. Cl.**
H01H 33/02 (2006.01)
H01H 33/664 (2006.01)

(52) **U.S. Cl.**
CPC ***H01H 33/664*** (2013.01); ***H01H 33/025*** (2013.01)

(58) **Field of Classification Search**
CPC H01H 33/664; H01H 33/6661; H01H 33/666; H01H 33/025; H01H 33/122; H01H 2033/6667; H01H 31/003; H01H 31/28
USPC 218/118, 126, 140, 153, 154
See application file for complete search history.

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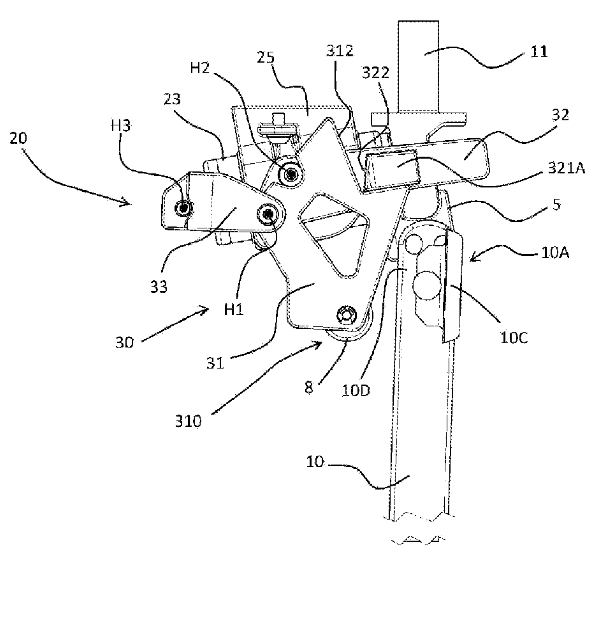
(57) **ABSTRACT**

A switching apparatus including one or more electric poles. For each electric pole, the switching apparatus includes a first pole terminal, a second pole terminal, and a ground terminal. The switching apparatus further includes a plurality of fixed contacts spaced apart one from another, a movable contact, which is reversibly movable about a corresponding rotation axis according to opposite first and second rotation directions, so that said movable contact can be coupled to or uncoupled from one or more of the above-mentioned fixed contacts, a vacuum interrupter including a vacuum chamber, in which a fixed arc contact and a movable arc contact are enclosed and can be coupled or separated, and a motion transmission mechanism operatively coupled to the movable arc contact of said vacuum interrupter.

15 Claims, 20 Drawing Sheets



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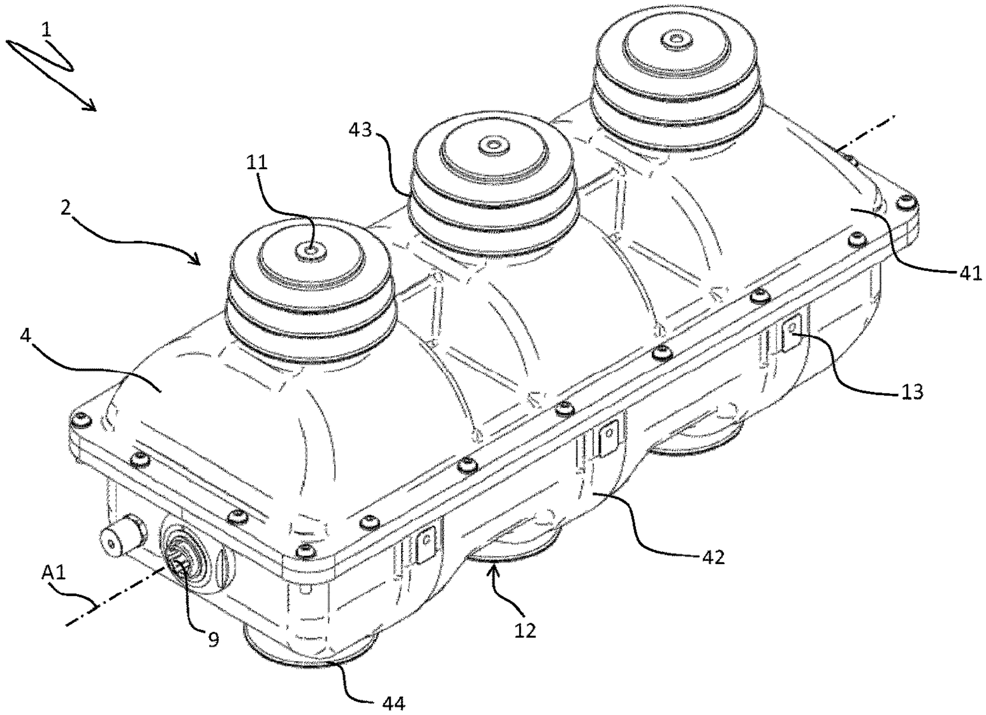
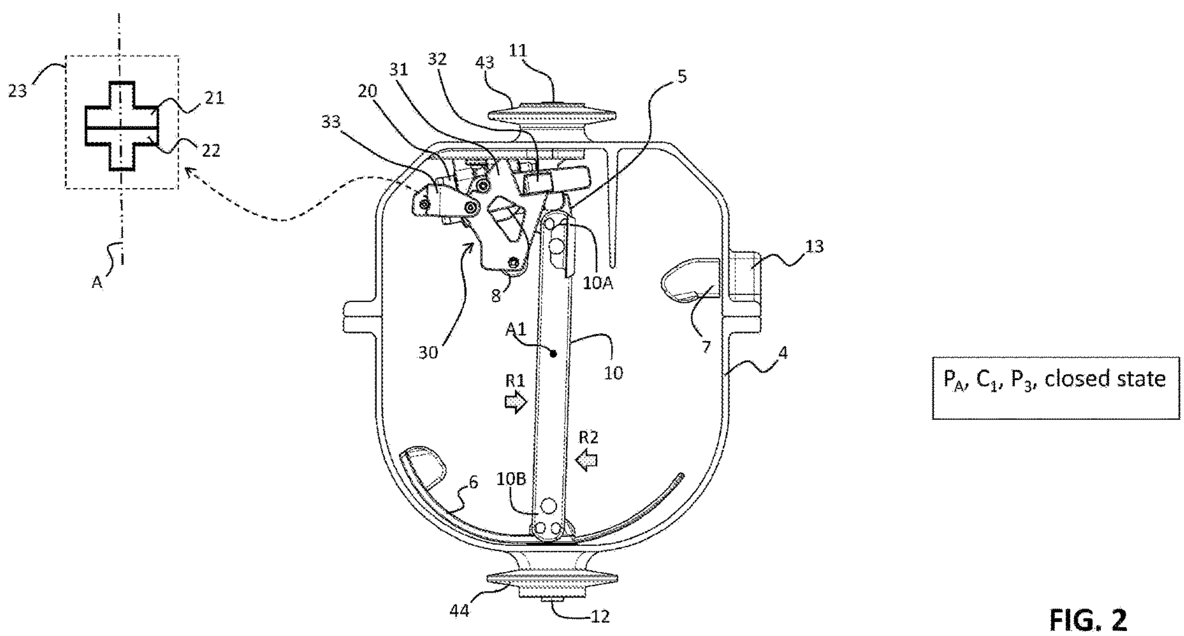


FIG. 1


23
21
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A
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32
43
11
5
13
8
10A
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A1
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7
4
R1
R2
6
10B
44
12
P_A, C_1, P_3, closed state

FIG. 2

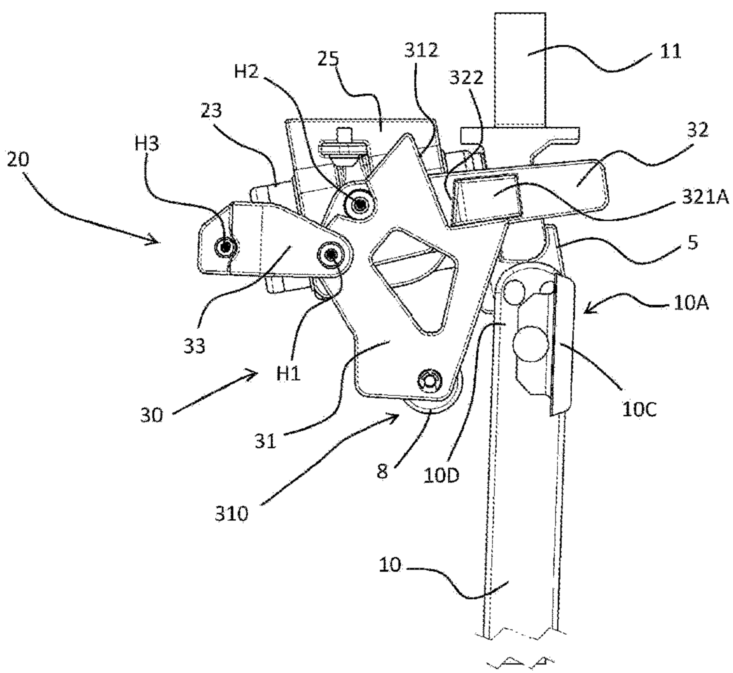


FIG. 3

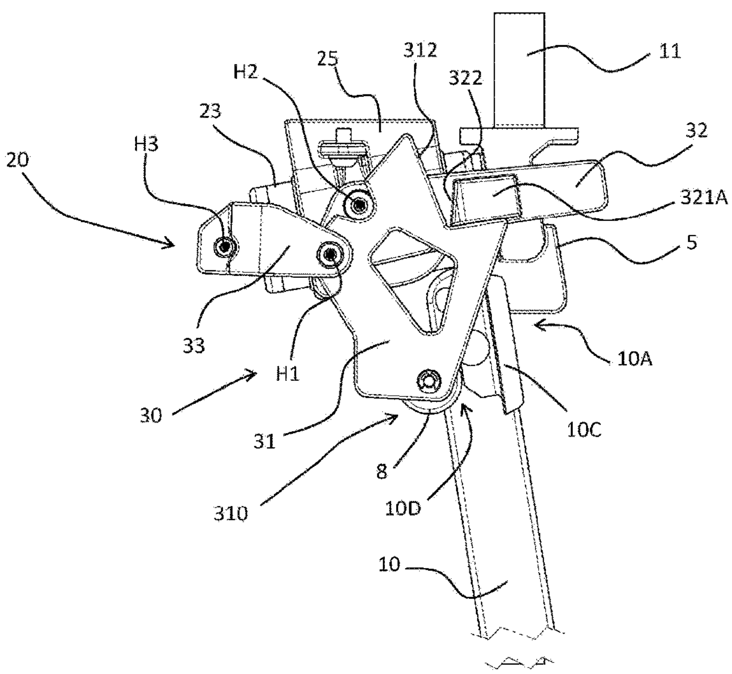
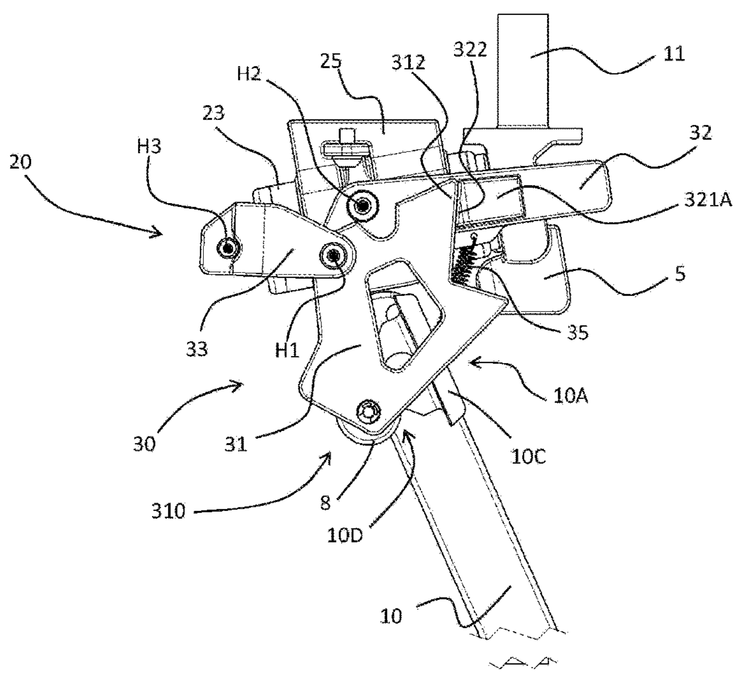


FIG. 4


11
322
312
25
H2
23
32
H3
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321A
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33
H1
35
10A
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31
10C
310
8
10D
10

FIG. 5

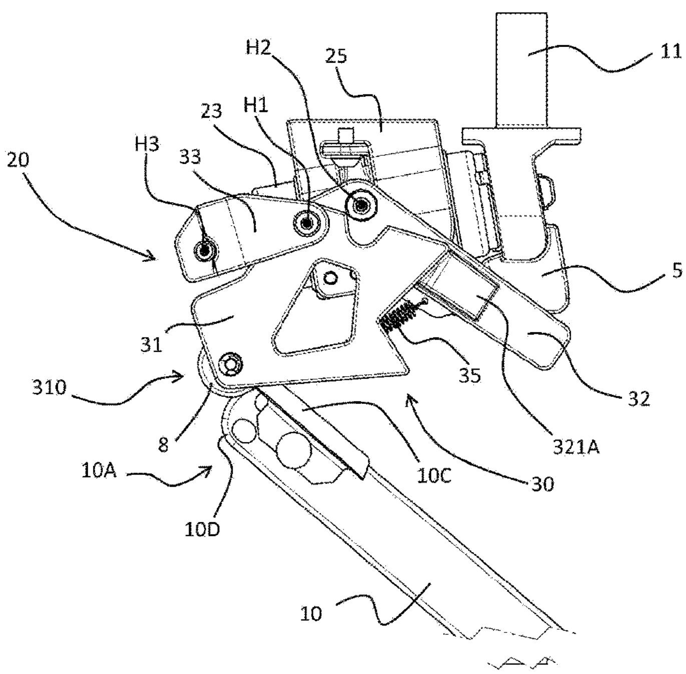


FIG. 6

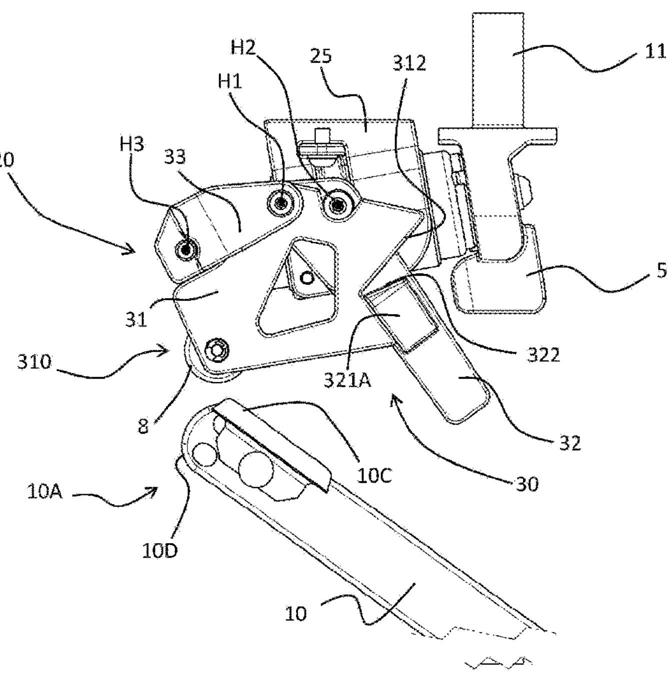
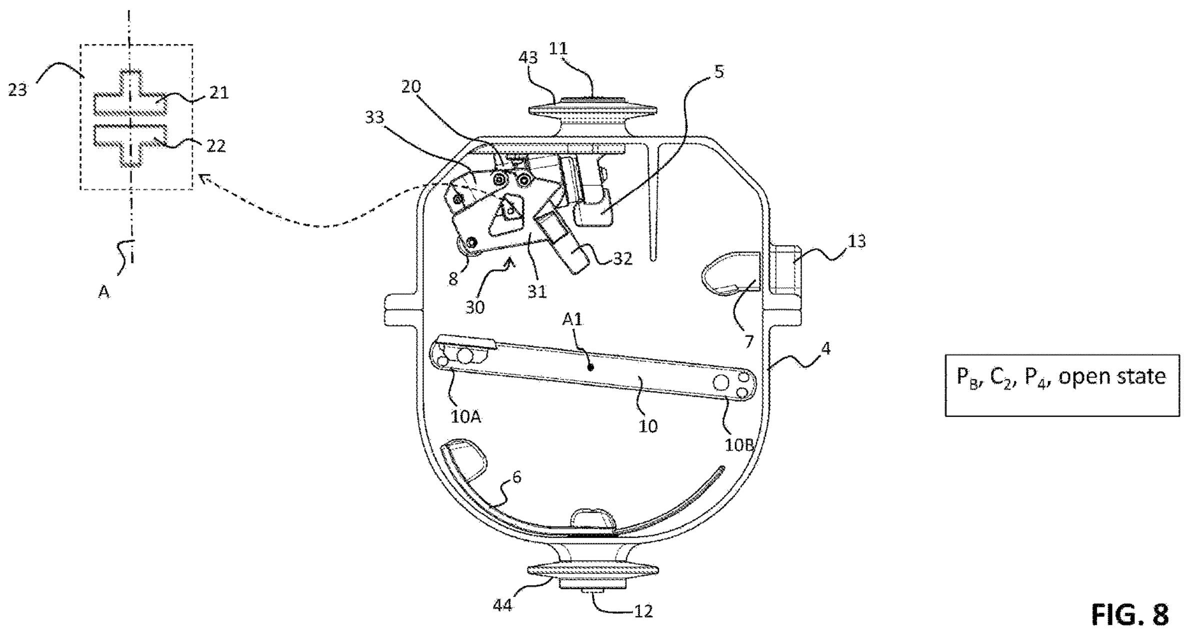


FIG. 7


23
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22
A
33
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43
11
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31
32
13
7
A1
4
10A
10
10B
6
44
12
P_B, C_2, P_4, open state

FIG. 8

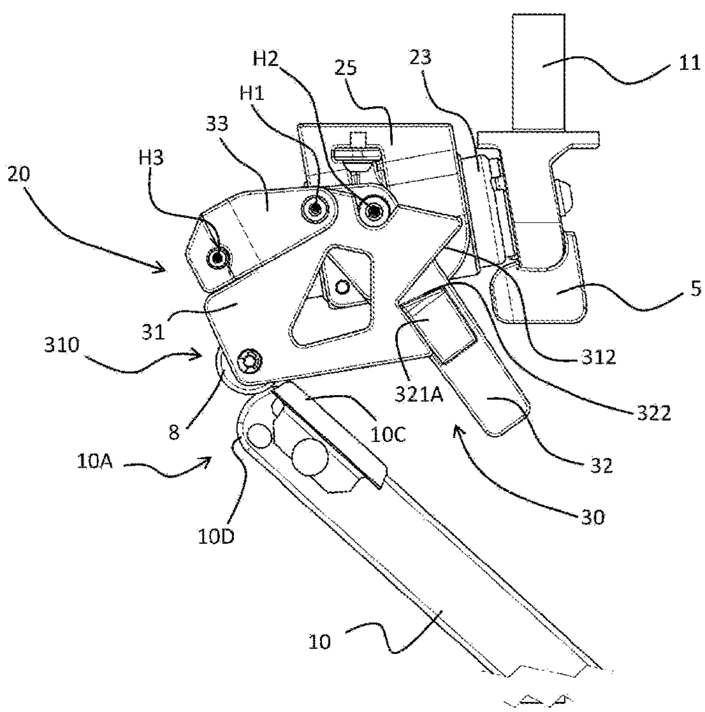


FIG. 9

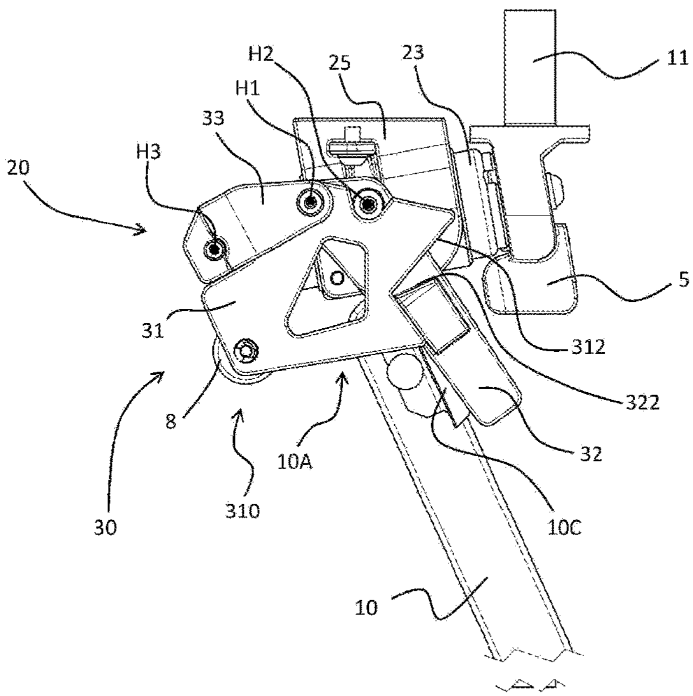


FIG. 10

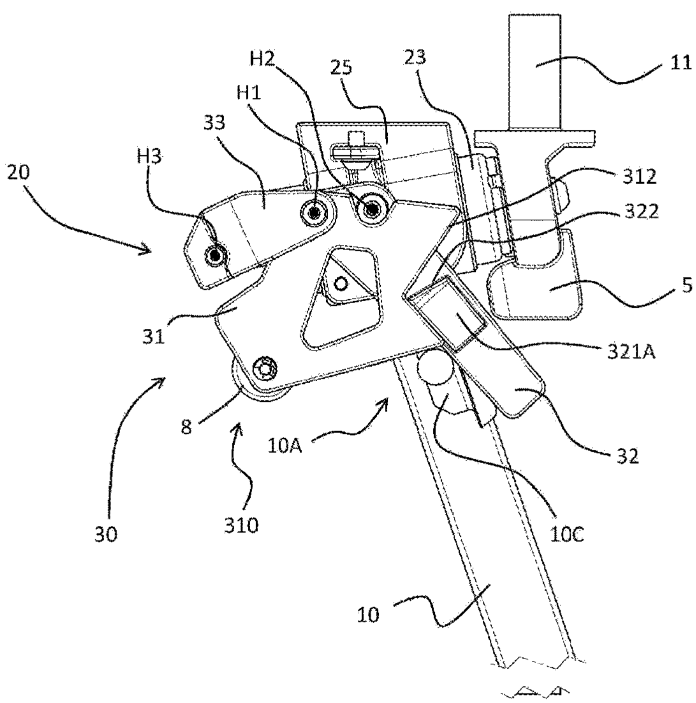


FIG. 11

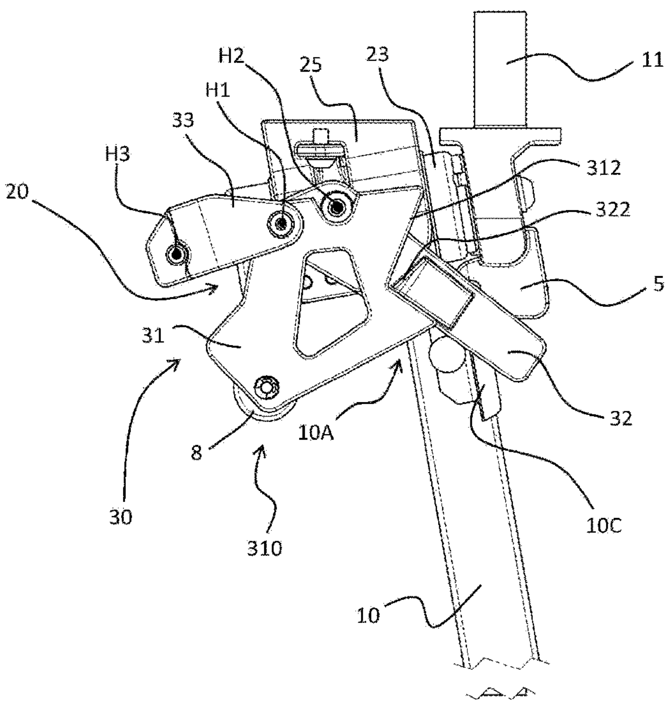


FIG. 12

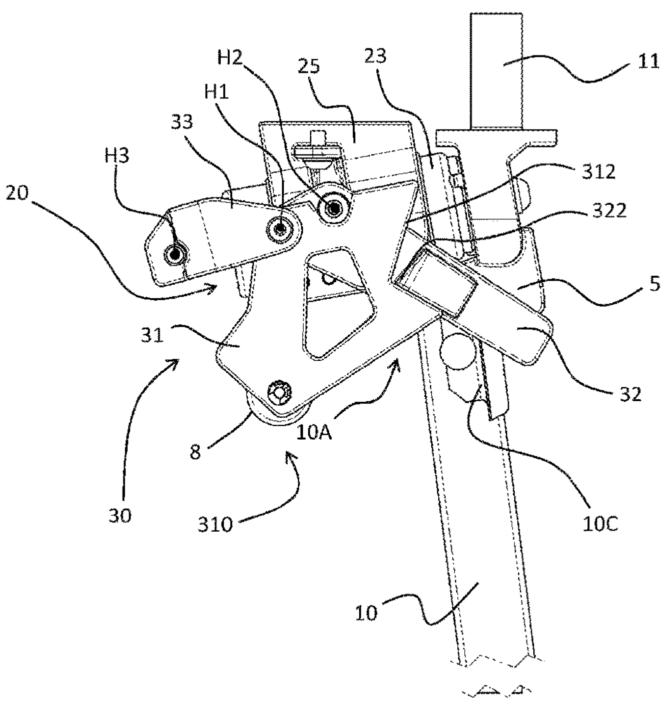


FIG. 13

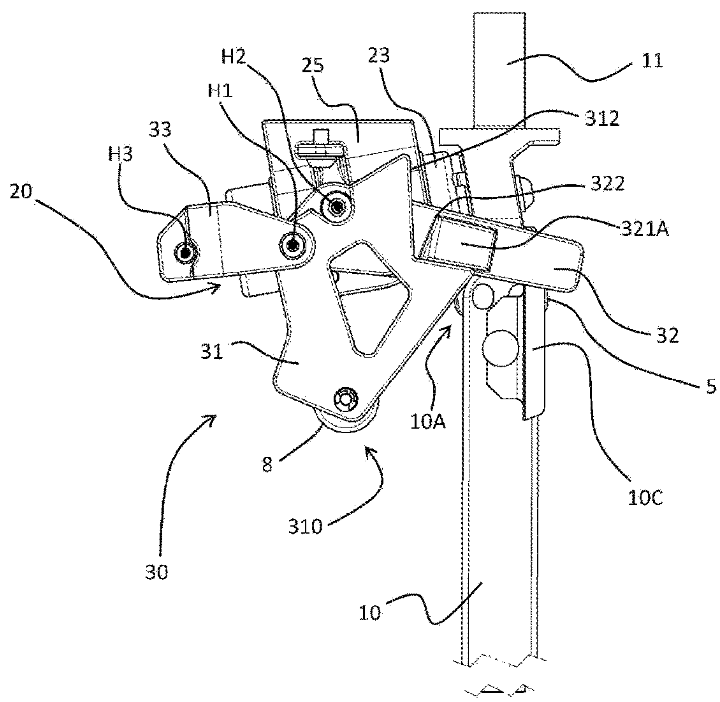
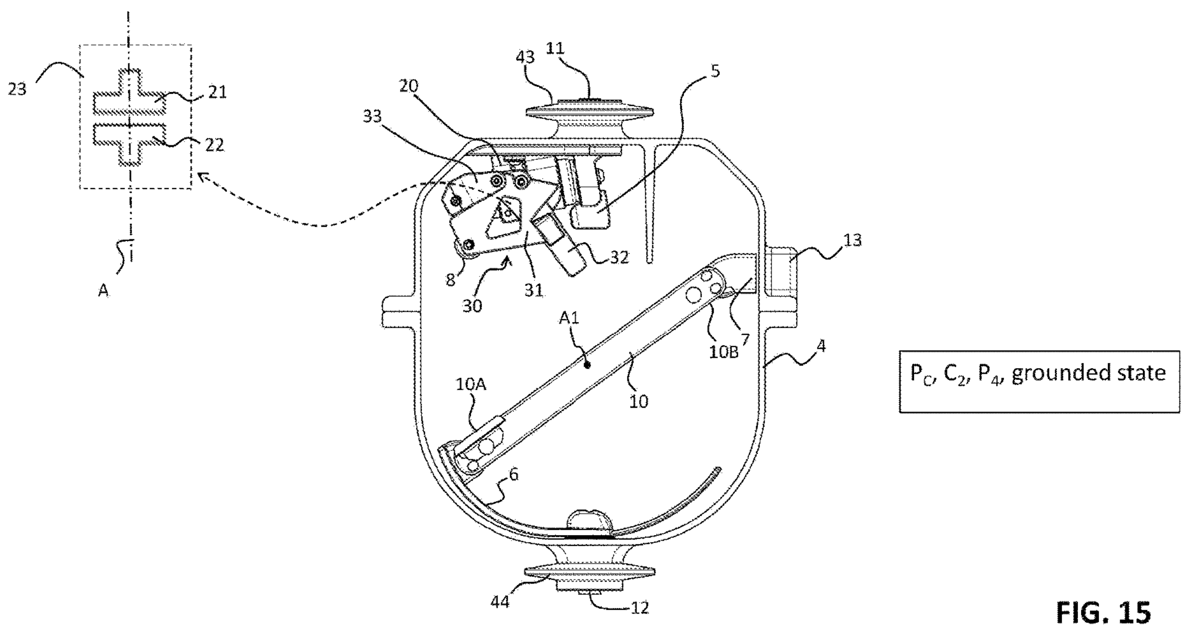


FIG. 14


23
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A1
10B
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4
10A
10
6
44
12
P_C, C_2, P_4, grounded state

FIG. 15

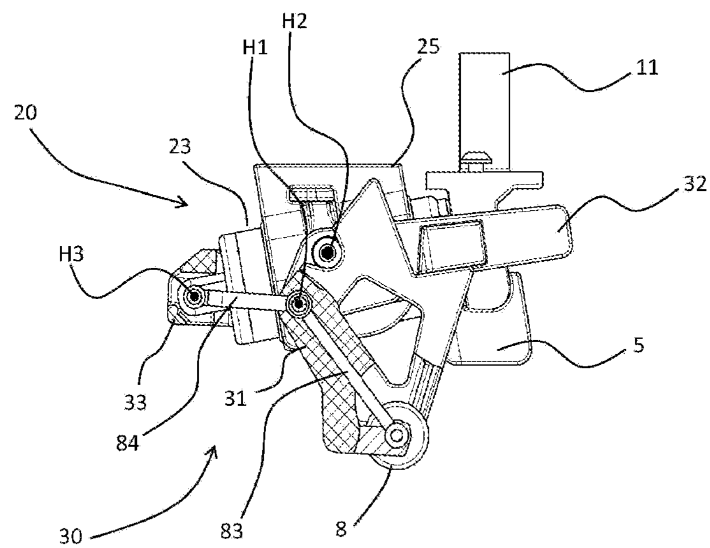

FIG. 16

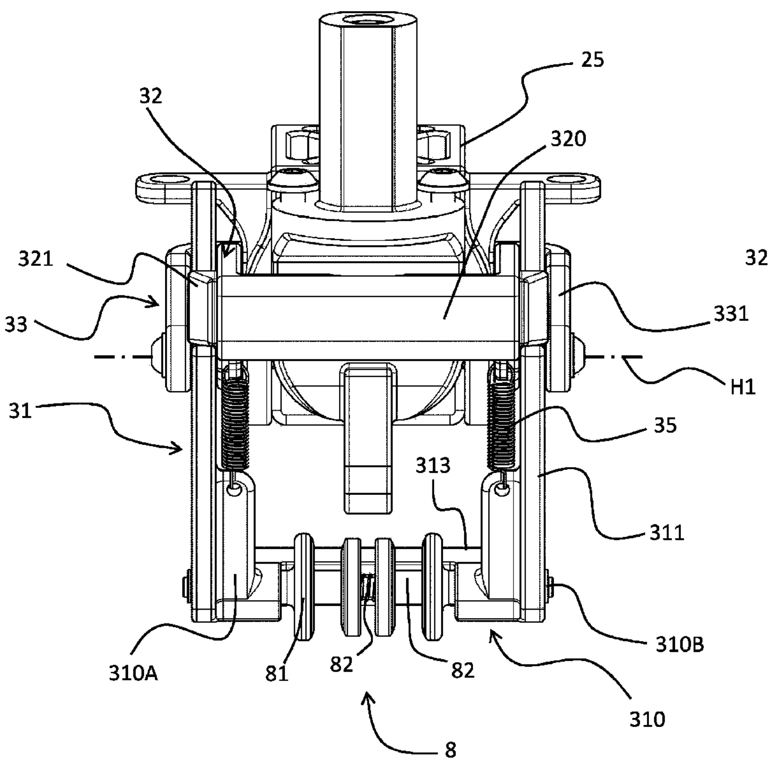

FIG. 17

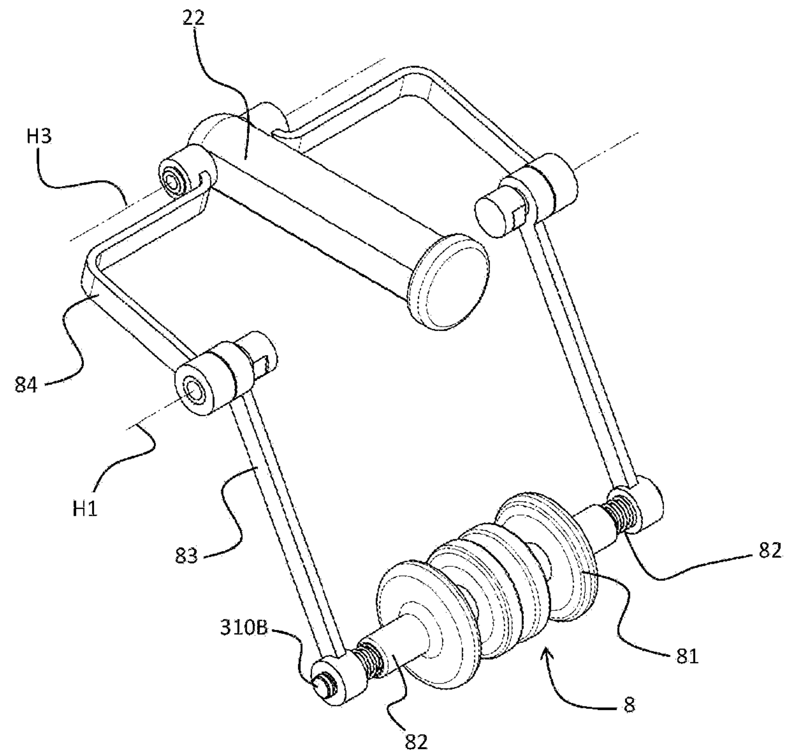

FIG. 18

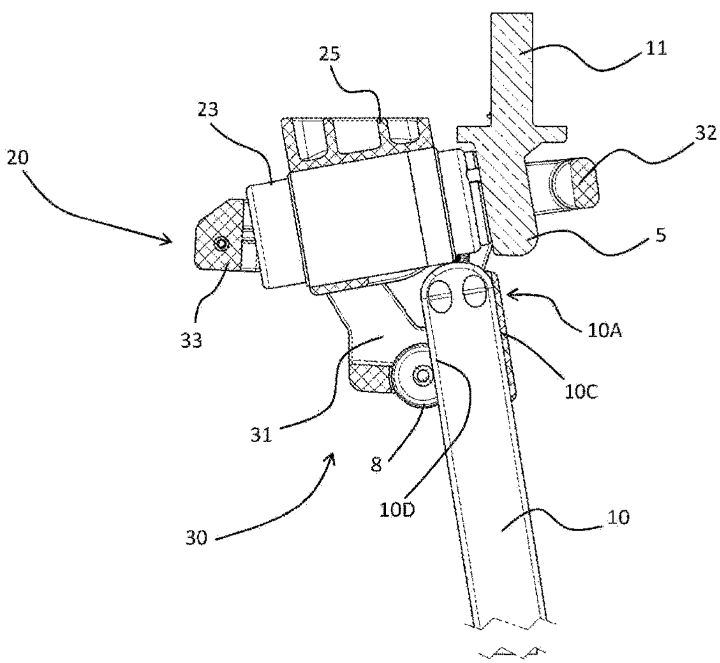

FIG. 19

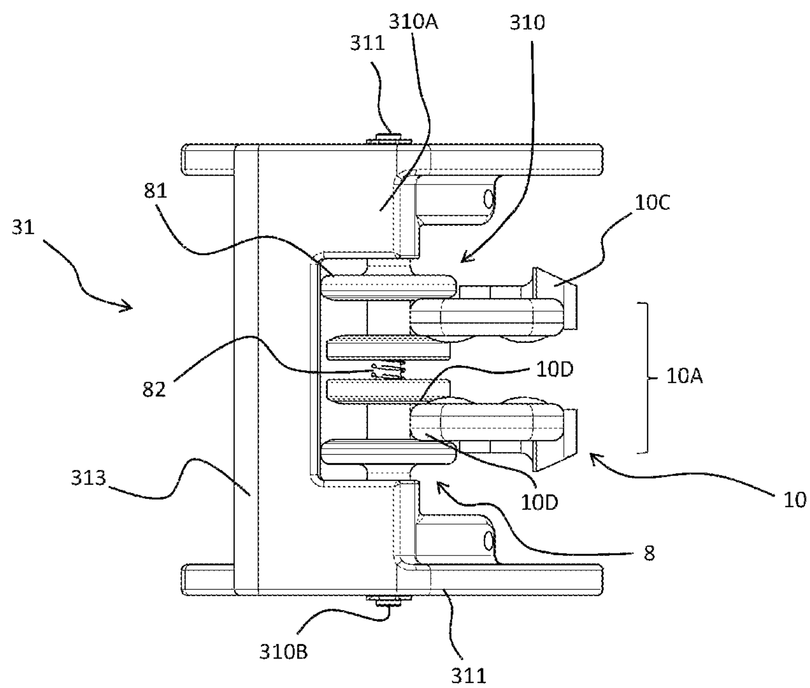

FIG. 20

MEDIUM VOLTAGE SWITCHING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

This patent application claims the benefit and priority of European Patent Application No. 22173528.5 filed on May 16, 2022, the disclosure of which is incorporated by reference herein in its entirety as part of the present application.

BACKGROUND

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

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

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 or overload conditions) as well as providing circuit-disconnecting functionalities (namely grounding a load-side section of an electric circuit).

Most traditional load-break switches of the state of the art have their electric poles immersed in a sulphur hexafluoride (SF6) atmosphere as this insulating gas ensures excellent performances in terms of dielectric insulation between live parts and arc-quenching capabilities when currents are interrupted.

As is known, however, SF6 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.

Some load-break switches have been developed, in which electric poles are immersed in pressurized dry air or other environment-friendly insulation gases, such as mixtures of oxygen, nitrogen, carbon dioxide, and/or fluorinated gases. Unfortunately, the experience has shown that these switching apparatuses generally do not show fully satisfactory performances, particularly in terms of arc-quenching capabilities.

Other currently available load-break switches employ, for each electric pole, different contact arrangements electrically connected in parallel between the pole terminals.

A contact arrangement has electric contacts operating in an atmosphere filled with an environment-friendly insulating gas or air and it is designed for carrying most of the current flowing along the electric pole as well as driving possible switching maneuvers.

Another contact arrangement, instead, has electric contacts operating in a vacuum atmosphere and it is specifically designed for quenching the electric arcs arising when the current flowing along the electric pole is interrupted.

These last switching apparatuses have proven to ensure a relatively low environmental impact while providing, at the same time, high-level performances in terms of dielectric insulation and arc-quenching capabilities. However, until now, they adopt complicated solutions to manage and coordinate the operation of the above-mentioned multiple contact arrangements. Therefore, they still offer poor performances in terms of structural compactness and reliability in operation.

BRIEF DESCRIPTION

Embodiments of the present disclosure provide a switching apparatus for MV electric systems that allows solving or mitigating the above-mentioned technical problems.

More particularly, the present disclosure provides a switching apparatus ensuring high-level performances in terms of dielectric insulation and arc-quenching capabilities during the current breaking process.

Another aspect of the present disclosure provides a switching apparatus showing high levels of reliability in operation.

Another aspect of the present disclosure provides a switching apparatus having electric poles with high compactness and structural simplicity.

Another aspect of the present disclosure provides 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.

In order to fulfill these aims and aspects, the present disclosure provides a switching apparatus, according to the following claim **1** and the related dependent claims.

In a general definition, the switching apparatus of the present disclosure includes one or more electric poles.

For each electric pole, the switching apparatus includes 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.

For each electric pole, the switching apparatus includes a plurality of fixed contacts spaced apart one from another. Such a plurality of fixed contacts include a first fixed contact electrically connected to the first pole terminal, a second fixed contact electrically connected to the second pole terminal, and a third fixed contact electrically connected to the ground terminal.

For each electric pole, the switching apparatus further includes a movable contact, which is reversibly movable about a corresponding rotation axis according to opposite first and second rotation directions, so that said movable contact can be mechanically and electrically coupled to or uncoupled from one or more of the above-mentioned fixed contacts.

For each electric pole, the switching apparatus further includes a vacuum interrupter, which includes a fixed arc contact electrically connected to the first pole terminal (e.g., through said first fixed contact) and a movable arc contact reversibly movable along a corresponding translation axis between a coupled position with the fixed arc contact and an uncoupled position from the fixed arc contact. The vacuum interrupter additionally includes a vacuum chamber, in which the fixed arc contact and the movable arc contact are enclosed and can be coupled or separated.

For each electric pole, the switching apparatus further includes a motion transmission mechanism mechanically coupled to the movable arc contact. Such a motion transmission mechanism is actuatable by said movable contact, when said movable contact moves about said rotation axis, in order to cause a movement of said movable arc contact along said translation axis.

The motion transmission mechanism includes a first lever pivoted at a first axis and configured to be actuated by said movable contact, during an opening maneuver of the switching apparatus.

The first lever includes a first coupling portion mechanically couplable to said movable contact, during an opening maneuver of the switching apparatus. At said first coupling portion, the first lever includes an auxiliary contact arrangement electrically connected to the movable arc contact and electrically couplable to said movable contact of the switching apparatus, when said movable contact mechanically couples to said first coupling portion.

The motion transmission mechanism includes a second lever pivoted on a fixed support at a second hinge axis and configured to be actuated by said movable contact, during a closing maneuver of said switching apparatus. The second lever includes a second coupling portion mechanically couplable to said movable contact, during an opening maneuver of the switching apparatus.

The motion transmission mechanism includes third lever pivoted on the first lever at said first hinge axis and pivoted on the movable arc contact of the vacuum interrupter at a third hinge axis.

According to an aspect of the present disclosure, said first lever is configured to actuate said second lever, when the first lever is actuated by said movable contact, during an opening maneuver of said switching apparatus.

The said first lever may include one or more first coupling surfaces configured to couple mechanically to one or more corresponding second coupling surfaces of said second lever, when said first lever is actuated by said movable contact, during an opening maneuver of said switching apparatus.

According to an aspect of the present disclosure, said second lever is configured to actuate said first lever, when said second lever is actuated by said movable contact, during a closing maneuver of said switching apparatus.

The said second lever may be hinged on said first lever at the first hinge axis.

The said first and second levers may be configured to be actuated by the movable contact of the switching apparatus, at different points of the motion trajectory of said movable contact.

The motion transmission mechanism may further include elastic means mechanically coupling said first and second levers.

The aforesaid auxiliary contact arrangement may include a plurality of conductive elements configured to be slidingly coupled with corresponding contact surfaces of the movable contact and holding means configured to press said electric contact elements against the contact surfaces of the movable contact.

The first lever and the third lever may include, respectively, first electrical connections and second electrical connections configured to connect electrically the auxiliary contact arrangement with the movable arc contact of the vacuum interrupter. Said first and second electrical connections are formed by conductors at least partially buried in an electrically insulating material of said first and third levers.

According to an aspect of the present disclosure, the aforesaid motion transmission mechanism is configured to take alternatively a first configuration, at which said movable arc contact is in said coupled position, and a second configuration, at which said movable arc contact is in said uncoupled position.

The said motion transmission mechanism may be configured to maintain stably said first configuration or said second configuration, if the first and second levers are not actuated by said movable contact.

The said motion transmission mechanism may be configured to change configuration, if said first lever or said second lever is actuated by said movable contact.

More particularly, said motion transmission mechanism is configured to switch from said first configuration to said second configuration upon an actuation of the first lever by said movable contact and it is configured to switch from said second configuration to said first configuration upon an actuation of the second lever by said movable contact.

A transition of said motion transmission mechanism from said first configuration to said second configuration causes a movement of said movable arc contact from said coupled position to said uncoupled position while a transition of said motion transmission mechanism from said second configuration to said first configuration causes a movement of said movable arc contact from said uncoupled position to said coupled position.

According to an aspect of the present disclosure, said movable contact may include at least a contact blade, more preferably a pair of parallel contact blades.

BRIEF DESCRIPTION OF THE DRAWINGS

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

FIG. **1** shows an outer view of the switching apparatus of the present disclosure;

FIGS. **2-15** are schematic views partially showing the structure and operation of an electric pole of the switching apparatus of the present disclosure;

FIGS. **16-20** are schematic views showing some structural details of a motion transmission mechanism of the switching apparatus, according to the present disclosure.

DETAILED DESCRIPTION

With reference to the figures, the present disclosure relates to a switching apparatus **1** for medium voltage electric systems.

For the purposes of the present disclosure, 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.

For the purposes of the present disclosure, the terms "terminal" and "contact" should be hereinafter intended, unless otherwise specified, as "electric terminal" and "electric contact", respectively, thereby referring to electrical components suitably arranged to be electrically connected or coupled to other electrical conductors.

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 or overload conditions) as well as circuit-disconnecting functionalities, in particular grounding a load-side section of an electric circuit.

In the following, the switching apparatus of the disclosure will be described with particular reference to this application for the sake of simplicity only and without intending to limit the scope of the disclosure.

The switching apparatus **1** includes one or more electric poles **2**.

The switching apparatus **1** is of the multi-phase (e.g., three-phase) type and it may include a plurality (e.g., three) of electric poles **2**.

According to the embodiments shown in the cited figures, the switching apparatus **1** may include an insulating housing **4**, which conveniently defines an internal volume where the electric poles **2** are accommodated.

The insulating housing **4** may have an elongated shape (e.g., substantially cylindrical) developing along a main longitudinal axis. The electric poles **2** are arranged side by side along corresponding transversal planes perpendicular the main longitudinal axis of the switching apparatus.

The insulating housing **4** may be formed by an upper shell **41** and a lower shell **42** that are mutually joined along suitable coupling edges.

For each electric pole, the insulating housing **4** includes a first bushing **43** protruding from a top region of the upper shell **41** and a second bushing **44** protruding from a bottom region of the second shell **42** (reference is made to a normal operating positioning of the switching apparatus as shown in FIG. **1**).

In the following, the switching apparatus of the disclosure will be described with particular reference to these embodiments for the sake of brevity only and without intending to limit the scope of the disclosure.

As a matter of fact, according to other embodiments of the disclosure (not shown), the switching apparatus of the disclosure may be installed in a cubicle together with other electric devices. In this case, the switching apparatus may not include a dedicated housing as shown in the cited figures.

The internal volume of the switching apparatus **1** may be filled with pressurized dry air or another insulating gas having a low environmental impact, such as a mixture of oxygen, nitrogen, carbon dioxide, and/or a fluorinated gas.

For each electric pole **2**, the switching apparatus **1** includes a first pole terminal **11**, a second pole terminal **12**, and a ground terminal **13**. The first pole terminal **11** is configured 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 configured 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 terminal **13** is configured to be electrically connected to a grounding conductor.

According to the embodiments shown in the cited figures, the first pole terminal **11** is at least partially accommodated in the first bushing **43** while the second pole terminal **12** is at least partially accommodated in the second bushing **44**.

For each electric pole, the first and second pole terminals **11**, **12** may be arranged at opposite sides of the switching apparatus.

For each electric pole **2**, the switching apparatus **1** includes a plurality of fixed contacts, which are spaced apart one from another around the main longitudinal axis of the switching apparatus. In particular, the switching apparatus **1** includes a first fixed contact **5**, a second fixed contact **6**, and a third fixed contact **7**.

The first fixed contact **5** is electrically connected to the first pole terminal **11**, the second fixed contact **6** is electrically connected to the second pole terminal **12** while the third fixed contact **7** is electrically connected to the ground terminal **13**.

The switching apparatus **1** includes, for each electric pole **2**, a movable contact **10** reversibly movable (along a given plane of rotation) about a corresponding rotation axis **A1**, which is substantially parallel to or coinciding with the main longitudinal axis of the switching apparatus.

The movable contact **10** can rotate according to a first rotation direction **R1**, which is conveniently oriented away from the first fixed contact **5**, or according to a second rotation direction **R2**, which is opposite to the first rotation direction **R1** and is oriented towards the first fixed contact **5** (FIG. **2**). With reference to the observation plane of FIGS. **2-15**, the above-mentioned first rotation direction **R1** is oriented counter-clockwise while the above-mentioned second rotation direction **R2** is oriented clockwise.

In operation, the switching apparatus **1** is capable of switching in three different operating states, namely:

- 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 current can flow along each electric pole **2** between the corresponding first and second pole terminals **11**, **12** (FIG. **2**);
- 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** (FIG. **8**); and
- a grounded 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 a grounded state, no 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 (FIG. **15**).

In principle, the switching apparatus **1** may be of the "single-disconnection" type (not shown) or "double-disconnection" type (as shown in the cited figures) depending on how the current path through each electric pole is interrupted, when the switching apparatus reaches an open state.

If the switching apparatus is of the "single-disconnection" type, the movable contact **10** is electrically coupled to the second fixed contact **6** and is electrically decoupled from the remaining fixed contacts **5**, **7** when the switching apparatus is in an open state. The current path through each electric pole is thus interrupted only at one end of the movable contact ("single-disconnection").

If the switching apparatus is of the "double-disconnection" type, the movable contact **10** is electrically decoupled from any fixed contact **5**, **6**, **7** when the switching apparatus is in an open state. The current path through each electric pole is thus interrupted at both ends of the movable contact ("double-disconnection").

In the following, the switching apparatus of the disclosure will be described with particular reference to the above-mentioned "double-disconnection" configuration, for the sake of brevity only and without intending to limit the scope of the disclosure.

The switching apparatus **1** is capable of carrying out different type of maneuvers, each corresponding to a transition among the above-mentioned operating states. In particular, the switching apparatus is capable of carrying out:

- an opening maneuver when it switches from a closed state to an open state;
- a closing maneuver when it switches from an open state to a closed state;

a disconnecting maneuver when it switches from an open state to a grounded state; and

a reconnecting maneuver when it switches from a grounded state to an open state.

The switching apparatus can switch from a closed state to a grounded state by carrying out an opening maneuver and subsequently a disconnecting maneuver while the switching apparatus can switch from a grounded state to a closed state by carrying out a reconnecting maneuver and subsequently a closing opening maneuver.

In order to carry out the above-mentioned maneuvers, the movable contact **10** of each electric pole is suitably driven according to the above-mentioned first rotation direction R**1** or second rotation direction R**2**.

In particular, the movable contact **10** moves according to the first rotation direction R**1** during an opening maneuver or a disconnecting maneuver of the switching apparatus and it moves according to the second rotation direction R**2** during a closing maneuver or a reconnecting maneuver of the switching apparatus.

In general, the movable contact **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 (FIG. **2**), and a second end-of-run position P_C, which corresponds to a grounded state of the switching apparatus (FIG. **15**). Conveniently, the movable contact **10** passes through an intermediate position P_B, which corresponds to an open state of the switching apparatus (FIG. **8**), when it moves between the first and second end-of-run positions P_A, P_C.

As it is reversibly movable about the rotation axis A**1**, the movable contact **10** can be mechanically and electrically coupled to or uncoupled from one or more of the fixed contacts **5**, **6**, **7** thereby being electrically connecting or electrically disconnecting these fixed contacts depending on the on-going maneuver.

When it is in the first end-of-run position P_A (closed state of the switching apparatus), the movable contact **10** is coupled to the first fixed contact **5** and to the second fixed contact **6** and it electrically connects these fixed contacts and, consequently, the first and second pole terminals **11**, **12**.

When it is in the second end-of-run position P_C (grounded state of the switching apparatus), the movable contact **10** is coupled to the second fixed contact **6** and to the third fixed contact **7** and it electrically connects these fixed contacts and, consequently, the second and third pole terminals **12**, **13**.

In the embodiment shown in the cited figures, when it is in the intermediate position P_B (open state of the switching apparatus), the movable contact **10** is coupled to no fixed contacts ("double-disconnection" type).

In the switching apparatus of the disclosure, the above-mentioned fixed contacts **5**, **6**, **7** may be formed by corresponding pieces of conductive material, which are suitably shaped according to the needs.

The first fixed contact **5** may be formed by a blade-shaped conductive body having a contoured end coupled to the first pole terminal **11** and a blade-shaped free end for coupling to the movable contact **10**.

The second fixed contact **6** may be formed by an arc-shaped conductive body extending partially around the rotation axis A**1** of the movable contact **10** and having contoured ends and protrusions for coupling to the movable contact **10**.

The third fixed contact **7** may be formed by a blade-shaped conductive body having a contoured end coupled to the third pole terminal **13** and a blade-shaped free end and a blade-shaped free end for coupling to the movable contact **10**.

In the embodiments shown in the cited figures, the movable contact **10** has a pair of movable contact regions **10**A, **10**B for coupling with the fixed contacts **5**, **6**, **7** (FIGS. **2**, **8**, **15**). Said contact regions are located at opposite positions relative to the rotation axis A**1** of the movable contact **10** and are preferably aligned one to another along a same direction.

The movable contact **10** and the fixed contacts **5**, **6**, **7** may be arranged so that, in operation:

the first movable contact region **10**A of the movable contact **10** can be coupled mechanically and electrically to or uncoupled from the first contact **5** and the second fixed contact **6**, when the movable contact **10** moves between the first and second end-of-run positions P_A, P_C; and

the second movable contact region **10**B of the movable contact **10** can be coupled mechanically and electrically to or uncoupled from the second fixed contact **6** and the third fixed contact **7**, when the movable contact **10** moves between the first and second end-of-run positions P_A, P_C.

When it is in the first end-of-run position P_A, the movable contact **10** may have the first movable contact region **10**A coupled to the first fixed contact **5** and the second movable contact region **10**B coupled to the second fixed contact **6**. As mentioned above, in this situation, the movable contact **10** electrically connects the first and second fixed contacts **5**, **6** and, consequently, the first and second pole terminals **11**, **12**.

As mentioned above, when it is in the intermediate position P_B, the movable contact **10** has no contact regions coupled to fixed contacts and it is therefore electrically disconnected from these latter.

When it is in the second end-of-run position P_C, the movable contact **10** may have the first movable contact region **10**A coupled to the second fixed contact **6** and the second movable contact region **10**B coupled to the third fixed contact **7**. As mentioned above, in this situation, the movable contact **10** electrically connects the second and third fixed contacts **6**, **7** and, consequently, the second pole terminal **12** and the ground terminal **13**.

In the switching apparatus of the disclosure, the movable contact **10** may be formed by a shaped piece of conductive material.

The movable contact **10** may be formed by an elongated conductive body centered on the rotation axis A**1** and having a first contoured end forming the first movable contact region **10**A and a second contoured end (opposite to the first end **10**A relative to the rotation axis A**1**) forming the second movable contact region **10**B.

Each movable contact region **10**A, **10**B of the movable contact **10** may include at least a contact blade, more preferably a pair of parallel contact blades (FIG. **20**).

The switching apparatus **1** may include an actuation assembly providing suitable actuation forces to actuate the movable contacts **10** of the electric poles.

Such an actuation assembly may include a motion transmission shaft **9** made of electrically insulating material, which can rotate about the rotation axis A**1** and it is coupled to the movable contacts **10** of the electric poles **2**.

The motion transmission shaft **9** thus provides rotational mechanical forces to actuate the movable contacts **10** during the maneuvers of the switching apparatus.

The above-mentioned actuation assembly may include an actuator (not shown) coupled to the transmission shaft through a suitable kinematic chain. The actuator may be, for example, a mechanical actuator, an electric motor, or an electromagnetic actuator.

In general, the actuation assembly 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 disclosure, for the sake of brevity.

According to the present disclosure, for each electric pole **2**, the switching apparatus **1** includes a vacuum interrupter **20**.

The vacuum interrupter **20** includes a fixed arc contact **21** electrically connected to the first fixed contact **5** and, consequently, to the first pole terminal **11**.

The fixed arc contact **21** may be formed by an elongated piece of conductive material having one end coupled to the first fixed contact **5** and an opposite free end intended to be coupled to or separated from another arc contact.

The vacuum interrupter **20** includes a movable arc contact **22** reversibly movable along a corresponding translation axis A, which is preferably aligned with a main longitudinal axis of the vacuum interrupter.

The movable arc contact **22** can be coupled to or uncoupled from the fixed arc contact **21**, thereby being electrically connected to or electrically disconnected from this latter.

The movable arc contact **22** may be formed by an elongated piece of conductive material having a free end intended to be coupled with or decoupled from the fixed arc contact **21**.

The vacuum interrupter **20** includes a vacuum chamber **23**, in which a vacuum atmosphere is present.

Conveniently, the fixed arc contact **21** and the movable arc contact **22** are at least partially enclosed in the vacuum chamber **23**, so that they have respective contact regions that can be mutually coupled or decoupled inside the vacuum chamber, therefore while being permanently immersed in a vacuum atmosphere.

The vacuum interrupter **20** may include a fixed support structure **25** made of electrically insulating material to hold the vacuum chamber **23** in its operating position.

For each electric pole **2**, the switching apparatus **1** includes a motion transmission mechanism **30** operatively coupled to the movable arc contact **22** and actuatable by the movable contact **10** to cause a movement of the movable arc contact **22**, when such a movable contact moves about its rotation axis A**1**.

The motion transmission mechanism **30** includes a first lever **31**, a second lever **32**, and a third lever **33**.

The first lever **31** is pivoted at a first hinge axis H**1** and is configured to be actuated by the movable contact **10**, during an opening maneuver of the switching apparatus.

The first lever **31** includes a first coupling portion **310** mechanically couplable to the movable contact **10**, during an opening maneuver of the switching apparatus (i.e., when said movable contact moves according to the first rotation direction R**1**), so that the movable contact **10** can actuate the first lever **31**.

The second lever **32** is pivoted on a fixed support (may be the fixed support **25** of the vacuum interrupter) at a second hinge axis H**2** and it is configured to be actuated by the movable contact **10**, during a closing maneuver of said switching apparatus.

The second lever **32** includes a second coupling portion **320** mechanically couplable to the movable contact **10**, during a closing maneuver of the switching apparatus (i.e., when said movable contact moves according to the second rotation direction R**2**), so that the movable contact **10** can actuate the second lever **32**.

The third lever **33** is pivoted on the first lever **31** at the first hinge axis H**1** and is pivoted on the movable arc contact **22** at a third hinge axis H**3**. The third lever **33** is configured to be actuated by the first lever **31**, during an opening or closing maneuver of the switching apparatus.

In particular, the third lever **33** is actuated by the first lever **31**, when said first lever is actuated by the movable contact **10**, during an opening maneuver of the switching apparatus, and when said first lever is actuated by the second lever **32**, during a closing maneuver of the switching apparatus.

The third lever **33** is configured to actuate the movable arc contact **22** in response to the actuation by the first lever **31**.

Conveniently, the above-mentioned hinge axes H**1**, H**2**, H**3** of the levers **31**, **32**, **33** are parallel to the rotation axis A**1** of the movable contact **10**.

According to an aspect of the disclosure, the first lever **31** is configured to actuate the second lever **32**, when the first lever **31** is actuated by the movable contact **10**, during an opening maneuver of said switching apparatus.

To this aim, the first lever **31** may include one or more first coupling surfaces **312** configured to couple with one or more corresponding second coupling surfaces **322** of the second lever **32**, when the first lever **31** moves (by rotating about the first hinge axis H**1**) in response to the actuation by the movable contact **10** (FIGS. **3**-**7**).

When the first and second mechanical coupling surfaces **312**, **322** are coupled, the first lever **31** actuates the second lever **32**, which can thus move together with the first lever **31** in response to the actuation by the movable contact **10**. In practice, the first and second levers **31**, **32** move as a single body actuated by the movable contact **10** as soon as the first and second mechanical coupled surfaces **312**, **322** are coupled.

The first lever **31** is configured to couple and actuate the second lever **32** only after having rotated of a given angle about the first hinge axis H**1**, upon actuation by the movable contact **10**. To this aim, before the actuation by the movable contact **10** during an opening maneuver of the switching apparatus, the first and second levers **31**, **32** are mutually positioned, so that the first and second coupling surfaces **312**, **322** of the first and second levers **31**, **32** are oriented along intersecting planes forming a certain angle (for example 30°).

According to another aspect of the present disclosure, the second lever **32** is configured to actuate the first lever **31**, when said second lever is actuated by the movable contact **10**, during a closing maneuver of said switching apparatus. To this aim, the second lever **32** is hinged on the first lever **31** at the first hinge axis H**1** (as shown in the cited figures). The first and second levers **31**, **32** thus move together, when the second lever **32** is actuated by the movable contact **10**.

As an alternative, the first and second levers **31**, **32** may be hinged at a different hinge axis provided that this latter is distinct from the second hinge axis H**2**, about which the second lever **32** rotates, when it is actuated by the movable contact **10**.

As a further alternative, the second lever **32** may include one or more third mechanical coupling surfaces (not shown) configured to couple with corresponding one or more fourth mechanical coupling surfaces (not shown) of the first lever **31**, when the second lever **32** moves (by rotating about the second hinge axis H**2**) in response to the actuation by the movable contact **10**.

According to another aspect of the present disclosure, the first and second levers **31**, **32** are configured to be alternatively actuated by the movable contact **10**, respectively during an opening maneuver and a closing maneuver of the switching apparatus, at different points of the motion trajectory of said movable contact.

In practice, the first and second levers **31**, **32** are configured so that their first and second coupling portions **310**, **320** intersect alternatively the motion trajectory of the movable contact **10** at different points of said motion trajectory, depending on the configuration taken by the motion transmission mechanism **30**, during an opening maneuver and closing maneuver of the switching apparatus.

The mechanical connections between the above-illustrated components of the motion transmission mechanism **30** may be realized according to known solutions, e.g., through pins, screws, rivets, and the like.

In general, the levers **31**, **32**, **33** are conveniently made of electrically insulating material.

In the embodiment shown in the cited figures, the first lever **31** is formed by a cradle-shaped body of electrically insulating material including a pair of first lever arms **311** (e.g., having a polygonal shape) arranged in parallel at opposite sides of the vacuum chamber **23** and joined transversally by a first reinforcement bridge **313** (FIGS. **17**, **20**).

The first lever arms **311** are hinged to the second and third levers **32**, **33** at the first hinge axis H**1**.

Each first lever arm **311** includes a side edge including an above-mentioned first coupling surface **312** of the first lever **31** (FIGS. **3**-**7**, **9**-**14**).

The above-mentioned first coupling portion **310** of the first lever **31** is arranged transversally to the first lever arms **311** at corresponding free sides of said first lever arms, may be in proximity of the first reinforcement bridge **313**.

The first coupling portion **310** includes opposite first protrusions **310**A protruding from mutually facing surfaces of the first lever arms **311** and a support pin **310**B arranged between said first lever arms, preferably in parallel to the first reinforcement bridge **313** and passing through the first protrusions **310**A (FIGS. **17**, **20**).

The support pin **310**B is configured to couple mechanically to the movable contact **10** (namely to its contact blades) and be actuated by said movable contact, during an opening maneuver of the switching apparatus.

In the embodiment shown in the cited figures, the second lever **32** is formed by a body of electrically insulating material including a pair of second lever arms **321** (e.g., having an elongated shape) arranged in parallel at opposite sides of the vacuum chamber **23**.

The second lever arms **321** are hinged to a fixed support **25** at the second hinge axis H**2** and to the first lever **31** at the first hinge axis H**1**.

Each second lever arm **321** includes a second protrusion **321**A including an above-mentioned second coupling surface **322** of the second lever **32** (FIGS. **3**-**7**, **9**-**14**).

The above-mentioned second coupling portion **320** of the second lever **32** is arranged transversally to the second lever arms **321** at corresponding free ends of said second lever arms and it is formed by a second reinforcement bridge between the parallel second lever arms **321** (FIG. **17**). The second reinforcement bridge **320** is configured to couple mechanically to the movable contact **10** (namely to the contact blades of this latter), during a closing maneuver of the switching apparatus.

In the embodiment shown in the cited figures, the third lever **33** is formed by a U-shaped body of electrically insulating material having elongated third lever arms **331** arranged in parallel at opposite sides of the vacuum chamber **23** (FIG. **17**).

The third lever arms **331** have free ends hinged to the first lever **31** at the first hinge axis H**1**.

In a distal position from said free ends, the third lever arms **331** are hinged to the movable arc contact **22** at the third hinge axis H**3** (FIGS. **3**-**7**, **16**, **19**).

An essential feature of the present disclosure consists in that the first lever **31** includes, at the first coupling portion **310**, a contact arrangement **8**, which is electrically connected to the movable arc contact **22** of the vacuum interrupter and which is electrically couplable to the movable contact **10**, when this latter mechanically couples to the first coupling portion **310**, during an opening maneuver of the switching apparatus.

In practice, the auxiliary contact arrangement **8** is configured to connect electrically the movable contact **10** to the movable arc contact **22** of the vacuum interrupter, when the first lever **31** is actuated by the movable contact **10**, during an opening maneuver of the switching apparatus.

The auxiliary contact arrangement **8** may include a plurality of conductive elements **81** configured to be slidingly coupled to corresponding contact surfaces **10**D of the movable contact **10** (may be of the contact blades of this latter) and holding means **82** configured to press the electric contact elements **81** against the contact surfaces **10**D of the movable contact **10**.

In the embodiment shown in the cited figures, the above-mentioned conductive elements **81** are formed by one or more pairs of conductive rollers mechanically coupled to the support pin **310**B of the first lever **31** and arranged coaxially to said support pin. Each pair of conductive rollers **81** is configured to couple slidingly with a contact surface **10**D of the movable contact **10** (may be a corresponding contact blade thereof), when said movable contact mechanically couples to the first lever **31**. In this way, an electric contact between the auxiliary contact arrangement **8** and the movable contact **10** is established (FIG. **20**).

The above-mentioned holding means **82** are formed by suitably spacers and springs arranged between the above-mentioned conductive rollers **81**. The spacers and the springs **82** are mechanically coupled to the support pin **310**B and arranged coaxially to this latter. The spacers and the compression springs **82** can thus exert a force on the conductive rollers **81**, which is directed in such a way to press said rollers against the corresponding contact surfaces **10**D of the contact blades of the movable contact **10** (FIG. **20**).

As mentioned above, the auxiliary contact arrangement **8** is electrically connected to the movable arc contact **22**.

The first and third levers **31**, **33** may include, respectively, first electrical connections **83** and second electrical connections **84** configured to connect electrically the auxiliary contact arrangement **8** and the movable arc contact **22**.

The above-mentioned first and second electrical connections **83**, **84** may be formed by conductors at least partially buried in the electrically insulating material of the first and third levers **31**, **33** (FIGS. **16** and **18**). This solution is particularly useful as it simplifies the arrangement of the motion transmission mechanism **30**.

In the embodiment shown in the cited figures, the first electrical connections **83** include first conductors buried in the first lever arms **311** of the first lever **31** and electrically connected to the conductive elements **81** of the auxiliary contact arrangement **8** (e.g., through the conductive support pin **310**B). The second electrical connections **84** instead include second conductors buried in the third lever arms **331** of the third lever **33** and electrically connected to the first conductors **83** (e.g., through suitable conductive pins at the first hinge axis H1) and to the movable arc contact **22** (e.g., through suitable conductive pins at the third hinge axis H3).

According to another aspect of the present disclosure, the motion transmission mechanism **30** includes elastic means **35** mechanically coupling the first and second levers **31**, **32**.

The elastic means **35** are particularly useful to damp the mechanical impact of the movable contact **10** on the first lever **31**, when said movable contact mechanically couples to the first coupling portion **310** of the first lever **31**, during an opening maneuver of the switching apparatus.

The elastic means **35** additionally favor the correct relative positioning of the first and second levers **31**, **32**, when the movable contact **10** mechanically decouples from the first coupling portion **310** of the first lever **31** and stops actuating said first lever, during an opening maneuver of the switching apparatus.

The elastic means **35** may include one or more springs arranged between the first and second levers **31**, **32**.

In the embodiment shown in the cited figures, the elastic means **35** include a pair of springs, each mechanically coupled between a corresponding first lever arm **311** of the first lever **31** and a corresponding second lever arm **321** of the second lever **32**.

As mentioned above, the second lever **32** is configured to be actuated by the movable contact **10**, during a closing operation of the switching apparatus.

The movable contact **10** may include, at the first movable contact region **10**A, one or more coupling members **10**C configured to couple mechanically to the second lever **32**, during a closing operation of the switching apparatus.

In the embodiment shown in the cited figures, each coupling member **10**C is formed by an elongated conductive pad solidly coupled of a corresponding contact blade of the movable contact **10**, at an outer surface of said contact blade (FIGS. **3**-**7**, **9**-**14**, **20**). Each conductive pad **10**C is configured to couple mechanically to a third protrusion **320**A of a correspond second lever arm **321** of the second lever **32**.

According to example embodiments of the disclosure, the motion transmission mechanism **30** is configured to take alternatively a first configuration C1 and a second configuration C2.

The first configuration C1 of the motion transmission mechanism **30** corresponds to a closed condition of the vacuum interrupter **20**, in the sense that, when the motion transmission mechanism takes this configuration, the movable arc contact **22** is in a coupled position P3 with the fixed arc contact **21**.

The second configuration C2 of the motion transmission mechanism **30** instead corresponds to an open condition of the vacuum interrupter **20**, in the sense that, when the motion transmission mechanism takes this configuration, the movable arc contact **22** is in an uncoupled position P4 from the fixed arc contact **21**.

The motion transmission mechanism **30** is configured to maintain stably the first configuration C1 or the second configuration C2, if the lever arms **311**, **312** of each lever **31**, **32** are not actuated by the movable contact **10**.

Instead, the motion transmission mechanism **30** is configured to switch its configuration, upon an actuation of the first lever **31** or second lever **32** by the movable contact **10**.

Any transition of configuration of the motion transmission mechanism **30** causes a corresponding movement of the movable arc contact **22** and a consequent change of condition of the vacuum interrupter **20**.

The motion transmission mechanism **30** is configured to switch from the first configuration C1 to the second configuration C2 upon an actuation of the first lever **31** by the movable contact **10** at a first point of the motion trajectory of the movable contact **10**, while this latter is moving according to the first rotation direction R1, during an opening maneuver of the switching apparatus.

The transition of the motion transmission mechanism **30** from the first configuration C1 to the second configuration C2 causes a corresponding movement of the movable arc contact **22** from the coupled position P3 to the uncoupled position P4.

The motion transmission mechanism **30** is configured to switch from the second configuration C2 to the first configuration C1 upon an actuation by the movable contact **10** at a second point of the motion trajectory of the movable contact **10**, while this latter is moving according to the second rotation direction R2, during a closing maneuver of the switching apparatus.

The transition of the motion transmission mechanism **30** from the second configuration C2 to the first configuration C1 causes a corresponding movement of the movable arc contact **22** from the uncoupled position P4 to the coupled position P3.

The mechanical behavior of the motion transmission mechanism **30** and its mechanical interaction with the movable arc contact **22** is briefly described in the following with reference to FIGS. **3**-**7** and **9**-**14**.

Transition from the First Configuration C1 to the Second Configuration C2

FIGS. **3**-**4** show the motion transmission mechanism **30** in the first configuration C1.

The first and third levers **31**, **33** are relatively positioned one to another, so that the motion transmission mechanism **30** does not exert any force on the movable arc contact shaft **22**.

The first coupling surfaces **312** of the first lever **31** are decoupled from the second coupling surfaces **321** of the second lever **32**.

The first hinge axis H1 between the first and third levers **31**, **33** is in a first position, at which the movable arc contact **22** is in the coupled position P3 with the fixed arc contact **21**. The first hinge axis H1 is not aligned with the fixed hinge axes H2, H3 of the second and third levers **32**, **33**.

Upon actuation of the first lever **31** by the movable contact **10**, while said movable contact is rotating according to the first rotation direction R1, the first lever **31** rotates relative to the second lever **32** (according to a clockwise direction taking as a reference the observation plane of FIGS. **3**-**7**).

At this initial stage, the third lever **33** does not substantially move and the motion transmission mechanism **30** does not exert a force on the movable arc contact **22**, which remains in the coupled position P3 with the fixed arc contact **21** (FIGS. **3**-**4**).

The elastic means **35** between the first and second levers **31**, **32** exert a damping action of the force applied by the movable contact **10** on the first lever **31**.

As soon as the first lever **31** rotates for a given angle, the first coupling surfaces **312** of the first lever **31** couple to the second coupling surfaces **321** of the second lever **32**.

The first lever **31** actuates the second lever **32** and the first and second levers **31**, **32** start rotating together about the second hinge axis H2 (with a same clockwise direction) as they were a single body actuated by the movable contact **10**.

At the same time, the first lever **31** and the third lever **33** rotate according to opposite directions (counter-clockwise and clockwise, respectively) about the first hinge axis H**1**. The third lever **33** rotates about the third hinge axis H**3** (with clockwise direction).

The first hinge axis H**1** between the first and third levers **31**, **33** starts moving away from the above-mentioned first position and it travels towards a second position (FIG. **5**), at which the movable arc contact **22** is coupled with the fixed arc contact **21**.

The motion transmission mechanism **30** starts exerting a force on the movable arc contact **22**, which is directed to decouple this latter from the fixed arc contact **21**. The movable arc contact **22** thus starts moving away from the fixed arc contact **21** notwithstanding the vacuum attraction force generated by the vacuum atmosphere in the vacuum chamber.

While it is travelling towards the above-mentioned second position, the first hinge axis H**1** between the first and third levers **31**, **33** passes through an intermediate deadlock position, which can be defined as the position, in which the first hinge axis H**1** is aligned with the hinge axes H**2** and H**3** and the second and third levers **32**, **33** (FIGS. **5**-**6**).

Upon actuation of the first lever **31** by the movable contact **10**, the first, second and third levers **31**, **32**, **33** continue to rotate as explained above.

The movable arc contact **22** continues to move away from the fixed arc contact **21** and it reaches the maximum distance from the fixed arc contact **21**, when the first hinge axis H**1** between the second and third levers **32**, **33** reaches the intermediate deadlock position, while moving away from the above-mentioned first position (FIG. **6**).

As soon as the first hinge axis H**1** passes beyond the intermediate deadlock position, the motion transmission mechanism **30** stops exerting a force on the movable arc contact **22**.

The movable arc contact **22** slightly moves back towards the fixed arc contact **21** due to the attraction force by the vacuum atmosphere in the vacuum chamber **23**.

In the meanwhile, the movable contact **10** decouples from the first lever **31** and stops actuating this latter.

Due to the force exerted by the elastic means **35** and the vacuum attraction exerted on the third lever **33**, the first and second levers **31**, **32** rotate relatively one to another according to opposite directions. In this way, the first coupling surfaces **312** of the first lever **31** decouple from the second coupling surfaces **321** of the second lever **32**. In practice, the first and second levers **31**, **32** return in their initial relative position taken before the movable contact **10** actuated the first lever **31**.

At the end, the first hinge axis H**1** between the first and third levers **31**, **33** reaches the above-mentioned second position (FIG. **7**) and the movable arc contact **22** reaches the uncoupled position P**4** from the fixed arc contact **21**, which is stably maintained due to the force exerted on the movable arc contact **22** by the motion transmission mechanism **30**, which opposes to the vacuum attraction force.

Transition from the Second Configuration C**2** to the First Configuration C**1**

FIGS. **12**-**13** show the motion transmission mechanism **30** in the second configuration C**2**.

The first and third levers **31**, **33** are relatively positioned one to another, so that the motion transmission mechanism **30** exerts a force on the movable arc contact **22**, which is directed to maintain this latter uncoupled from the fixed arc contact **21**.

The first hinge axis H**1** between the first and third levers **31**, **33** is in the above-mentioned second position, at which the movable arc contact **22** is in the uncoupled position P**4** from the fixed arc contact **21**.

The first hinge axis H**1** is not aligned with the hinge axes H**2**, H**3**.

Upon actuation of the second lever **32** by the movable contact **10**, the second lever **32** rotates about the second hinge axis H**2** (according to a counter-clockwise direction taking as a reference the observation plane of FIGS. **8**-**14**) and actuates the first lever **31** as the first and second levers are hinged at the first hinge axis H**1**.

The first and second levers **31**, **32** start rotating together about the second hinge axis H**2** (about a same counter-clockwise direction) as they were a single body actuated by the movable contact **10**. In this case, the first and second levers **31**, **32** do not move relatively one to another.

In the meanwhile, the third lever **33** starts rotating about the third hinge axis H**3** (according to an opposite clockwise direction).

The first hinge axis H**1** between the first and third levers **31**, **33** moves away from the above-mentioned second position and it travels towards the above-mentioned first position.

The motion transmission mechanism **30** starts exerting a force on the movable arc contact **22**, which is directed to move away this latter from the fixed arc contact **21**.

The movable arc contact **22** thus initially moves away from the fixed arc contact **21** notwithstanding the vacuum attraction force generated by the vacuum atmosphere in the vacuum chamber and it reaches the maximum distance from the fixed arc contact **21**, when the first hinge axis H**1** between the first and third levers **31**, **33** reaches the intermediate deadlock position, while moving away from the above-mentioned second position.

As soon as the first hinge axis H**1** passes beyond the intermediate deadlock position, the motion transmission mechanism **30** stops exerting a force on the movable arc contact **22**.

The movable arc contact **22** starts moving towards the fixed arc contact **21** due to the vacuum attraction force.

In the meanwhile, the movable contact **10** separates from the second lever **32** and stops actuating this latter.

Due to the vacuum attraction force exerted on the third lever **33**, the first, second and third levers **31**, **32**, **33** continue their movement. At the end, the first hinge axis H**1** between the first and third levers **31**, **33** reaches the above-mentioned second position (FIG. **3**) and the movable arc contact **22** reaches the coupled position P**3** with the fixed arc contact **21**, which is stably maintained as the motion transmission mechanism **30** does not exert any force on the movable arc contact **22**.

The operation of the switching apparatus **1** (with a “double-disconnection” configuration) for each electric pole **2** is now described in more details.

Closed State of the Switching Apparatus

When the switching apparatus is in a closed state, each electric pole **2** is in the operating condition illustrated in FIG. **2**.

In this situation, each electric pole **2** has:

- the movable contact **10** in the first end-of-run position P_A;
- the movable contact **10** coupled to the first and second fixed contacts **5**, **6**;
- the first and second fixed contacts **5**, **6** electrically connected one to another and electrically disconnected from the third fixed contact **7**;
- the motion transmission mechanism **30** in the first configuration C**1**; and

the movable arc contact **22** in a coupled position P**3** with the fixed arc contact **21**.

The first lever **31** is positioned along the motion trajectory of the movable contact **10** while the second lever **32** is not positioned along the motion trajectory of the movable contact **10**.

A current can flow through the electric pole between the first and second pole terminals **11**, **12** passing through the first fixed contact **5**, the movable contact **10** and the second fixed contact **6**. No currents can flow through the vacuum interrupter **20**.

Open State of the Switching Apparatus

When the switching apparatus is in an open state, each electric pole **2** is in the condition shown in FIG. **8**.

In this situation, each electric pole **2** has:

the movable contact **10** in the intermediate position P_B;

the movable contact **10** decoupled from any fixed contact;

the first, second and third fixed contacts **5**, **6**, **7** electrically disconnected one from another;

the motion transmission mechanism in the second configuration C**2**; and

the movable arc contact **22** in an uncoupled position P**4** from the fixed arc contact **21**.

The lever **31** is not positioned along the motion trajectory of the movable contact **10** while the second lever **32** is positioned along the motion trajectory of the movable contact **10**.

No currents can flow between the first and second pole terminals **11**, **12**.

Grounded State of the Switching Apparatus

When the switching apparatus is in a grounded state, each electric pole **2** is in the condition illustrated in FIG. **15**.

In this situation, each electric pole **2** has:

the movable contact **10** in the second end-of-run position P_C;

the movable contact **10** coupled to the second and third fixed contacts **6**, **7**;

the second and third fixed contacts **6**, **7** electrically connected one to another and electrically disconnected from the first fixed contact **5**;

the motion transmission mechanism in the second configuration C**2**; and

the movable arc contact **22** in an uncoupled position P**4** from the fixed arc contact **21**.

The first lever **31** is not positioned along the motion trajectory of the movable contact **10** while the second lever **32** is positioned along the motion trajectory of the movable contact **10**.

No currents can flow between the first and second pole terminals **11**, **12** and the second pole terminal **12** is put at a ground voltage.

Opening Maneuver

The switching apparatus **1** carries out an opening maneuver, when it switches from the closed state to the open state.

During an opening maneuver of the switching apparatus, the movable contact **10** moves, according to the first rotation direction R**1**, between the first end-of-run position P_A and the intermediate position P_B. The movable contact **10** thus moves away from the corresponding first fixed contact **5**.

When moving according to the first rotation direction R**1**, at a first point of its motion trajectory, the movable contact **10** couples to the coupling portion **310** of the first lever **31** while it is still slidingly coupled to the first fixed contact **5** (FIG. **4**).

In this way, the movable contact **10** electrically couples (in a sliding manner) to the auxiliary contact arrangement **8** and it electrically connects both the first fixed contact **5** and the auxiliary contact arrangement **8** to the second fixed contact **6**. A current can flow between the first and second pole terminals **11**, **12** passing through the first fixed contact **5** and the vacuum interrupter **20** in parallel. Obviously, most of the current will flow along the first fixed contact **5** as the current path passing through this electric contact has a lower equivalent resistance with respect to the current path passing through the vacuum interrupter.

In the meanwhile, the movable contact **10** actuates the first lever **31** and, more in general, the motion transmission mechanism **30**.

Upon a further movement according to the first rotation direction R**1**, the movable contact **10** decouples from the first fixed contact **5** while remaining slidingly coupled to the auxiliary contact arrangement **8** and the second fixed contact **6** (FIG. **5**).

The movable contact **10** thus electrically disconnects the first fixed contact **5** from the second fixed contact **6** while maintaining the auxiliary contact arrangement **8** electrically connected with the second fixed contact **6**. In this situation, a current flowing along the electric pole is fully deviated through the vacuum interrupter **20** as no current can flow through the first fixed contact **5**. The formation of electric arcs at the contact region **10**A of the movable contact **10** is thus prevented.

While it is slidingly coupled to the auxiliary contact arrangement **8**, the movable contact **10** continues to actuate the first lever **31** (FIG. **5**).

The actuation of the first lever **31** by the movable contact **10** causes a transition of the motion transmission mechanism from the first configuration C**1** to the second configuration C**2** and a consequent movement of the movable arc contact **22** from the coupled position P**3** with the fixed arc contact **21** to the uncoupled position P**4** from the fixed arc contact **21**.

The separation of the electric contacts **21**, **22** causes the rising of electric arcs between said electric contacts. However, since the electric contacts **21**, **22** are immersed in a vacuum atmosphere, such electric arcs can be quenched efficiently, thereby quickly leading to the interruption of the current flowing along the electric pole.

In the meanwhile, the movable contact **10** maintains the auxiliary contact arrangement **8** electrically connected to the second fixed contact **6**, thereby preventing the formation of electric arcs at the contact regions **10**A, **10**B of the movable contact **10**.

Upon a further movement towards the intermediate position P_B, according to the first rotation direction R**1**, the movable contact **10** decouples from the first lever **31**.

The movable contact **10** thus electrically decouples from the auxiliary contact arrangement **8**, which thus results disconnected from the second fixed contact **6**.

The motion transmission mechanism **30** remains in the second configuration C**2** (FIGS. **6**-**7**).

The movable contact **10** then reaches the intermediate position P_B, which corresponds to an open state of the switching apparatus (FIG. **8**).

Closing Maneuver

The switching apparatus **1** carries out a closing maneuver, when it switches from the open state to the close state.

Before carrying out a closing maneuver, the switching apparatus may have carried out a reconnecting maneuver in order to switch in an open state.

During a closing maneuver of the switching apparatus, the movable contact **10** moves, according to the second rotation direction R**2**, between the intermediate position P_B and the first end-of-run position P_A. The movable contact **10** thus moves towards the corresponding first fixed contact **5** (FIG. **9**).

The movable contact **10** does not mechanically couple to the first lever **31** of the motion transmission mechanism **30** (FIGS. **9**-**10**). However, at a second point of its motion trajectory, the movable contact **10** mechanically couples to the coupling portion **320** of the second lever **32** and actuates this latter (FIG. **10**).

The actuation of the second lever **32** by the movable contact **10** causes a transition of the motion transmission mechanism **30** from the second configuration C**2** to the first configuration C**1** and a consequent movement of the movable arc contact **22** from the uncoupled position P4 from the fixed arc contact **21** to the coupled position P3 with the fixed arc contact **21** (FIG. **11**).

While it is actuating the second lever **32**, the movable contact **10** slidingly couples to first fixed contact **5** (FIGS. **12**-**13**), thereby electrically connecting the first and second fixed contacts **5**, **6** while the motion transmission mechanism switches from the second configuration C**2** to the first configuration C**1**.

The movable contact **10** finally reaches the first end-of-run position P_A, which corresponds to a closed state of the switching apparatus (FIG. **2**).

Disconnecting Maneuver

The switching apparatus **1** carries out a disconnecting maneuver, when it switches from an open state to a grounded state.

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

During a disconnecting maneuver of the switching apparatus, the movable contact **10** moves, according to the first rotation direction R**1**, between the intermediate position P_B and the second end-of-run position P_C.

When it reaches the second end-of-run position P_C, the movable contact **10** couples the second fixed contact **6** to the third fixed contact **7**, thereby electrically connecting the second fixed contact **6** with the third fixed contact **7** and, consequently, the second pole terminal **12** with the ground terminal **13**. The second pole terminal **12** results therefore put at a ground voltage.

The movable contact **10** does not interact with the motion transmission mechanism **30**, which remains in the second configuration C**2**, when the switching apparatus carries out a disconnecting maneuver.

Reconnecting Maneuver

The switching apparatus **1** carries out a reconnecting maneuver when it switches from a grounded state to an open state.

During a reconnecting maneuver of the switching apparatus, the movable contact **10** moves, according to the second rotation direction R**2**, between the second end-of-run position P_C and the intermediate position P_B.

In this way, the first movable contact **10** decouples from the second fixed contact **6** and from the third fixed contact **7**, thereby electrically disconnecting the movable contact from the third fixed contact **7**. As a consequence, the movable contact **10** does not electrically connect the second pole terminal **12** with the ground terminal **13** anymore. The second pole terminal **12** therefore results at a floating voltage.

The movable contact **10** does not interact with the motion transmission mechanism **30**, which remains in the second configuration C**2**, when the switching apparatus carries out a reconnecting maneuver.

As it is apparent from the above, the operation of the switching apparatus occurs according to similar operating modes, if the switching apparatus is of the "single-disconnection" type.

The switching apparatus, according to the disclosure, provides remarkable advantages with respect to the known apparatuses of the state of the art.

The switching apparatus of the disclosure includes, for each electric pole, a bistable motion transmission mechanism **30**, which allows the movable contact **10** to drive the separation of the movable arc contact **22** from the fixed arc contact **21** depending on the position reached during an opening maneuver of the switching apparatus.

As illustrated above, the levers **31**, **32** of the motion transmission mechanism **30** are actuatable at different points of the motion trajectory of the movable contact **10**. This solution improves the synchronization between the movement of the movable arc contact **22** and the movement of the movable contact **10**.

In this way, the breaking process of the current flowing along each electric pole can be easily made to occur at level of the arc contacts **21**, **22** accommodated in the vacuum chamber **23**. Possible electric arcs, which derive from the interruption of a current flowing along each electric pole, therefore form in a vacuum atmosphere only, which allows improving their quenching process.

The circumstance that the motion transmission mechanism **30** can stably take two different configurations further improves synchronization between the movements of the movable arc contact **22** and the movable contact **10**, during the opening and closing maneuvers of the switching apparatus.

The switching apparatus of the disclosure has electric poles with a very compact, simple, and robust structure with relevant benefits in terms of size optimization.

The switching apparatus, according to the present disclosure, ensures high-level performances in terms of dielectric insulation and arc-quenching capabilities during the current breaking process and, at the same time, it is characterized by high levels of reliability for the intended applications.

The switching apparatus, according to the disclosure, is of relatively easy and cheap industrial production and installation on the field.

What is claimed is:

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

a first pole terminal, a second pole terminal, and a ground terminal, wherein the first pole terminal is electrically couplable to a first conductor of an electric line, wherein the second pole terminal is electrically couplable to a second conductor of the electric line, and wherein the ground terminal is electrically couplable to a grounding conductor;

a plurality of fixed contacts spaced apart one from another, the plurality of fixed contacts comprising a first fixed contact electrically connected to the first pole terminal, a second fixed contact electrically connected to the second pole terminal, and a third fixed contact electrically connected to the ground terminal;

a movable contact reversibly movable about a corresponding rotation axis according to opposite first and second rotation directions, so that the movable contact can be coupled to or uncoupled from the fixed contacts;

a vacuum interrupter comprising a fixed arc contact electrically connected to the first pole terminal, a movable arc contact reversibly movable along a corresponding translation axis between a coupled position with the fixed arc contact and an uncoupled position from the fixed arc contact, and a vacuum chamber, in which the fixed arc contact and the movable arc contact are enclosed and can be coupled or decoupled; and

a motion transmission mechanism operatively coupled to the movable arc contact, the motion transmission mechanism actuatable by the movable contact to cause a movement of the movable arc contact along the translation axis, when the movable contact moves about the rotation axis;

wherein the motion transmission mechanism comprises:

a first lever pivoted at a first axis and configured to be actuated by the movable contact, during an opening maneuver of the switching apparatus, wherein the first lever comprises a first coupling portion mechanically couplable to the movable contact, wherein the first lever comprises, at the first coupling portion, an auxiliary contact arrangement electrically connected to the movable arc contact and electrically couplable to the movable contact, when the movable contact mechanically couples to the first coupling portion;

a second lever pivoted on a fixed support at a second hinge axis and configured to be actuated by the movable contact, during a closing maneuver of the switching apparatus, wherein the second lever comprises a second coupling portion mechanically couplable to the movable contact; and

a third lever pivoted on the first lever at the first hinge axis and pivoted on the movable arc contact at a third hinge axis.

2. The switching apparatus according to claim **1**, wherein the first lever is configured to actuate the second lever, when the first lever is actuated by the movable contact, during the opening maneuver of the switching apparatus.

3. The switching apparatus according to claim **2**, wherein the first lever comprises one or more first coupling surfaces configured to couple mechanically to one or more corresponding second coupling surfaces of the second lever, when the first lever is actuated by the movable contact, during the opening maneuver of the switching apparatus.

4. The switching apparatus according to claim **1**, wherein the second lever is configured to actuate the first lever, when the second lever is actuated by the movable contact, during the closing maneuver of the switching apparatus.

5. The switching apparatus according to claim **4**, wherein the second lever is hinged on the first lever at the first hinge axis.

6. The switching apparatus according to claim **1**, wherein the first and second levers are configured to be actuated by the movable contact, at different points of a motion trajectory of the movable contact.

7. The switching apparatus according to claim **1**, wherein the motion transmission mechanism further comprises at least one spring mechanically coupling the first and second levers.

8. The switching apparatus according to claim **1**, wherein the auxiliary contact arrangement comprises a plurality of conductive elements configured to be slidingly coupled with corresponding contact surfaces of the movable contact and spacers and springs configured to press the conductive elements against the contact surfaces of the movable contact.

9. The switching apparatus according to claim **1**, wherein the first lever and the third lever comprise, respectively, first electrical connections and second electrical connections configured to connect electrically the auxiliary contact arrangement with the movable arc contact, said first and second electrical connections formed by conductors at least partially buried in an electrically insulating material of the first and third levers.

10. The switching apparatus according to claim **1**, wherein the motion transmission mechanism is configured to take a first configuration, at which the movable arc contact is in the coupled position, and a second configuration, at which the movable arc contact is in the uncoupled position,

wherein the motion transmission mechanism is configured to maintain stably the first configuration or the second configuration, if the first and second levers are not actuated by the movable contact, and

wherein the motion transmission mechanism is configured to change configuration, if the first lever or the second lever is actuated by the movable contact.

11. The switching apparatus according to claim **10**, wherein the motion transmission mechanism is configured to switch from the first configuration to the second configuration upon an actuation of the first lever by the movable contact, a transition of the motion transmission mechanism from the first configuration to the second configuration causing a movement of the movable arc contact from the coupled position to the uncoupled position.

12. The switching apparatus according to claim **11**, wherein the motion transmission mechanism is configured to switch from the second configuration to the first configuration upon an actuation of the second lever by the movable contact, wherein a transition of the motion transmission mechanism from the second configuration to the first configuration causes a movement of the movable arc contact from the uncoupled position to the coupled position.

13. The switching apparatus according to claim **10**, wherein the motion transmission mechanism is configured to switch from the second configuration to the first configuration upon an actuation of the second lever by the movable contact, wherein a transition of the motion transmission mechanism from the second configuration to the first configuration causes a movement of the movable arc contact from the uncoupled position to the coupled position.

14. The switching apparatus according to claim **1**, wherein the movable contact comprises one or more contact blades.

15. The switching apparatus according to claim **1**, wherein the switching apparatus is a load-break switch for medium voltage electric systems.

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