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(54) VACUUM INTERRUPTER POLE AND ITS ASSOCIATED ELECTRICAL DEVICE

(57) The present disclosure provides a vacuum interrupter pole for a circuit breaker and its associated electrical device. The vacuum interrupter pole comprises: a vacuum interrupter; an insulation supporting shell for accommodating and supporting the vacuum interrupter and having a top wall and side walls defining a U shape, where the vacuum interrupter is adapted to be placed within an interior space limited by the side walls via an opening side of the U shape; and a conductive connector with a first end and a second end, wherein the first end is fastened between the top wall and the vacuum interrupter and electrically connected to the vacuum interrupter, and the second end is adapted to act as a supporting point for a moving knife component of an isolation switch that is electrically connected with the circuit breakers.

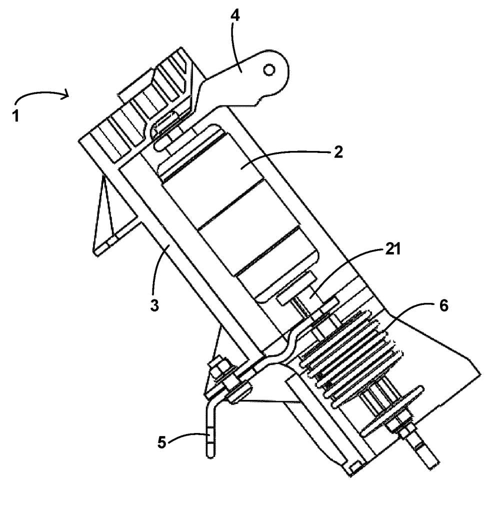

Fig. 1

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Description

FIELD

[0001] The present disclosure relates to the electrical field, and more specifically to a vacuum interrupter pole for a circuit breaker and its associated electrical device.

BACKGROUND

[0002] Circuit breaker (known as CB) is an electrical safety device for protecting the circuit from damage caused by overcurrent or short circuit. In addition to closing, bearing and cutting off current under normal loop conditions, the circuit breaker also can close, bear and cut off current under abnormal loop conditions within specified time.

[0003] A classic example of the circuit breaker is vacuum circuit breaker, which is known for its arc-extinguishing medium and insulation medium in the gap between contacts after an arc extinguishing operation being both high vacuum. The vacuum circuit breaker is small and light weight and further adapted for frequent operations. Meanwhile, maintenance is not required for arc extinguishing. On account of the above advantages, the vacuum circuit breaker is extensively applied in the power distribution networks.

SUMMARY

[0004] One of the objects of the present disclosure is to provide an improved vacuum interrupter pole and its associated electrical device, to at least solve the technical problems of the structure of existing circuit breakers including poor heat dissipation performance, environmental unfriendliness and/or low integration level.

[0005] According to a first aspect of the present disclosure, there is provided a vacuum interrupter pole for a circuit breaker. The vacuum interrupter pole comprises: a vacuum interrupter; an insulation supporting shell for accommodating and supporting the vacuum interrupter and having a top wall and side walls defining a U shape, wherein the vacuum interrupter is adapted to be placed within an interior space limited by the side walls via an opening side of the U shape; and a conductive connector with a first end and a second end, wherein the first end is fastened between the top wall and the vacuum interrupter and electrically connected to the vacuum interrupter, and the second end is adapted to act as a supporting point for a moving knife component of an isolation switch that is electrically connected with the circuit breakers. It is easily understood that with the aid of the vacuum interrupter pole of the present disclosure, it may be conveniently integrated with the moving knife component of the isolation switch. Meanwhile, the vacuum interrupter pole according to the present disclosure is no longer covered with traditional thermosetting material (e.g., epoxy resin) and thus overcomes the disadvantages including large size, heavy weight, poor heat dissipation performance and environmental unfriendliness.

[0006] In some embodiments, the top wall has a honeycomb structure. It is to be easily appreciated that the honeycomb structure has a relatively high impact resistance strength which can withstand the impact generated during the breaking or closing of the vacuum interrupter.

[0007] In some embodiments, most of the honeycomb structure is formed by structural units with a pentagonal or hexagonal shape. In this way, the honeycomb structure may have a more satisfactory impact resistance strength.

[0008] In some embodiments, the insulation supporting shell further comprises a mounting base disposed opposing to the top wall, and the side walls include a first side wall and a second side wall opposing to each other for defining the opening of the U shape, wherein a distance between the first side wall and the second side wall at a side proximate to the mounting base is smaller than a corresponding distance at a side proximate to the top wall . In this way, the insulation supporting shell defines a necking-in structure proximate to the mounting base side, which is helpful to provide a sufficient mounting space and more easily meet the insulation requirement for the mounting bases of vacuum interrupter poles in a potential scenario that three vacuum interrupter poles for three phases are disposed in parallel.

[0009] In some embodiments, the top wall has a thickness ranging from 20mm to 50mm and the side walls have a thickness smaller than 10mm. With the above design of thickness, the requirement for impact resistance strength by the insulation supporting shell can be sufficiently met.

[0010] In some embodiments, the conductive connector includes a first plane and a second plane perpendicular to each other; the first plane is formed by the first end and the second plane is formed by the second end. With such a design of the conductive connector, the requirement for fastening the insulation supporting shell with the vacuum interrupter may be satisfied at one end, while the other end is adapted to serve as a supporting point for the moving knife component of the isolation switch.

[0011] In some embodiments, the conductive connector further includes a bending engagement surface serving as a transition between the first plane and the second plane. With such a design, the requirement for the density of the current flowing from the vacuum interrupter to the moving knife component of the isolation switch can be more easily fulfilled.

[0012] In some embodiments, the conductive connector is integrally formed.

[0013] In some embodiments, the vacuum interrupter and the conductive connector are fastened together via a first bolt, which is arranged to be mounted by passing through a first mounting hole disposed at the middle of the first plane. In some other embodiments, the conductive connector and the insulation supporting shell are fastened together via at least one second bolt, which is arranged to be mounted by passing through a top wall mounting hole of the top wall and a second mounting hole on the first plane in sequence, the second bolt being different from the first bolt. That is, in these embodiments, the vacuum interrupter, the conductive connector and the insulation supporting shell are not fastened together by a common bolt. In such a case, the stable electrical connection between the vacuum interrupter and the conductive connector can be secured even in the case of thermoplastic deformation of the insulation supporting shell.

[0014] In some embodiments, the second mounting hole is formed by a circular platform protruding from the first plane, the circular platform having a height ranging from 1mm to 3mm with respect to the first plane, wherein in a state where the conductive connector and the insulation supporting shell are fastened together, a top surface of the circular platform abuts against a surrounding plane of the top wall on which the top wall mounting hole is formed. In these embodiments, the above arrangement avoids forming a wedge-shaped gap at the top wall mounting hole and which wedge-shaped gap may unfavorably cause gap discharge.

[0015] In some embodiments, the at least one second bolt includes two second bolts, which are symmetrically arranged at both sides of the first bolt. In this way, the conductive connector and the insulation supporting shell are fastened in a much stronger manner.

[0016] In some embodiments, the vacuum interrupter pole further comprises: an insulation plug with barbs, wherein the insulation plug is adapted to be inserted into the top wall mounting hole from outside of the insulation supporting shell to prevent discharge from the second bolt to components outside of the insulation supporting shell via the top wall mounting hole.

[0017] In some embodiments, the side walls include an intermediate side wall for defining an intermediate segment of the U shape, the intermediate side wall being provided thereon with a plurality of holes; and an edge of the top wall adjacent to the opening side of the U shape is configured with a chamfer; during operation of the vacuum interrupter pole, ambient gas is adapted to enter the insulation supporting shell from the holes, then pass through a gap between the vacuum interrupter and the intermediate side wall and a gap between the vacuum interrupter and the top wall, and finally exit the insulation supporting shell from the position of the chamfer, thereby creating convection effect within the vacuum interrupter pole.

[0018] In some embodiments, the vacuum interrupter pole further comprises: an insulation push-rod component coupled to an end of a moving conductive rod of the vacuum interrupter, wherein the insulation push-rod component is also adapted to be placed within the interior space via the opening side of the U shape.

[0019] In some embodiments, the vacuum interrupter pole further comprises: a flexible connector with one end electrically connected to an end of a moving conductive rod of the vacuum interrupter and the other end passing through an intermediate side wall defining an intermediate segment of the U shape.

[0020] According to a second aspect of the present disclosure, there is provided a circuit breaker comprising the vacuum interrupter pole according to the first aspect.

[0021] According to a third aspect of the present disclosure, there is provided a switch device comprising the vacuum interrupter pole according to the first aspect.

[0022] According to a fourth aspect of the present disclosure, there is provided an electrical cabinet, comprising: a cabinet body and the vacuum interrupter pole according to the first aspect.

[0023] In some embodiments, the vacuum interrupter pole is arranged within the cabinet body in a tilted manner with respect to the cabinet body.

[0024] In some embodiments, the electrical cabinet further comprises: an auxiliary supporting beam that extends along a direction perpendicular to extension direction of the vacuum interrupter pole and supports the tilted vacuum interrupter pole.

[0025] In some embodiments, the auxiliary supporting beam is made of insulated material. In this way, the possible discharge from the vacuum interrupter to the auxiliary supporting beam via the above holes is avoided.

[0026] In some embodiments, the electrical cabinet is a gas-insulated ring main unit.

[0027] It is to be understood that contents described in the Summary are not intended to restrict key or important features of the embodiments of the present disclosure, or limit the scope of the present disclosure. Other features of the embodiments of the present disclosure will be easily understood through the following description.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] Through the following detailed description with reference to the accompanying drawings, the above and other features, advantages and aspects of various embodiments of the present disclosure will become more apparent. Throughout the drawings, same or similar reference signs may represent same or similar elements, wherein:

Fig. 1 illustrates a schematic view of the overall structure of the vacuum interrupter pole for a circuit breaker according to exemplary embodiments of the present disclosure;

Fig. 2 illustrates a schematic structural view of the flexible connector according to exemplary embodiments of the present disclosure;

Fig. 3 illustrates a schematic structural view of the insulation push-rod component according to exemplary embodiments of the present disclosure;

Figs. 4a to 4c respectively illustrate a back, front and top side perspective view of the insulation supporting shell according to exemplary embodiments of the present disclosure;

Figs. 5a to 5d respectively illustrate different angular and perspective views of the conductive connector according to exemplary embodiments of the present disclosure;

Figs. 6a to 6b respectively illustrate partial and sectional views for the connection of the conductive connector with both of the vacuum interrupter and the insulation supporting shell according to exemplary embodiments of the present disclosure;

Fig. 7 illustrates a schematic structural view of the connection between the conductive connector and the moving knife of the isolation switch according to exemplary embodiments of the present disclosure;

Figs. 8a to 8d respectively illustrate different angular views of an insulation plug according to exemplary embodiments of the present disclosure;

Fig. 9 illustrates a schematic view of the convection current inside the vacuum interrupter pole according to exemplary embodiments of the present disclosure;

Figs. 10a to 10b illustrate experiment diagrams for the temperature rise and thermodynamic simulation of the vacuum interrupter pole according to exemplary embodiments of the present disclosure; and

Figs. 11a to 11d respectively illustrate a schematic structural view of the electrical cabinet including a three-phase circuit breaker.

DETAILED DESCRIPTION OF EMBODIMENTS

[0029] Embodiments of the present disclosure will be described in more details below with reference to the drawings. Although the drawings illustrate some embodiments of the present disclosure, it should be appreciated that the present disclosure can be implemented in various manners and should not be limited to the embodiments explained herein. On the contrary, the embodiments are provided to understand the present disclosure more thoroughly and completely. It is to be understood that the drawings and the embodiments of the present disclosure are provided only as examples, rather than limiting the protection scope of the present disclosure.

[0030] As stated above, vacuum circuit breakers are extensively used in power distribution networks. However, inventors have noticed that the vacuum interrupter pole for an existing circuit breaker is often fabricated by covering the vacuum interrupter with thermosetting material (such as epoxy resin). In such case, the circuit breaker is normally large, heavy and not environmental friendly and also underperform in heat dissipation. Besides, the vacuum interrupter pole of the existing circuit breaker could not be effectively integrated with a three-position switch at the bus side. As a result, the overall height of the electrical cabinet, such as the ring main unit, is relatively high.

[0031] The idea of the present disclosure is to provide an improved vacuum interrupter pole for a circuit breaker. The vacuum interrupter pole includes a vacuum interrupter; an insulation supporting shell for accommodating and supporting the vacuum interrupter and having a top wall and side walls defining a U shape, wherein the vacuum interrupter is adapted to be placed within an interior space limited by the side walls via an opening side of the U shape; and a conductive connector with a first end and a second end, wherein the first end is fastened between the top wall and the vacuum interrupter and electrically connected to the vacuum interrupter, and the second end is adapted to act as a supporting point for a moving knife component of an isolation switch that is electrically connected with the circuit breakers. It is easily understood that the above improved vacuum interrupter pole can be effectively integrated with the three-position switch at the bus side. Besides, the heat dissipation performance of the vacuum interrupter pole may be improved by means of the above insulation supporting shell. Moreover, since the insulation supporting shell may be made of environmental-friendly material, the disadvantage of the environmental unfriendliness can be avoided.

[0032] To better understand the idea of the present disclosure, embodiments of the vacuum interrupter poles according to the present disclosure are to be described in more detail below mainly with reference to Figs. 1-10.

[0033] Fig. 1 illustrates a schematic view of the overall structure of the vacuum interrupter pole for a circuit breaker according to exemplary embodiments of the present disclosure.

[0034] As shown in Fig. 1, the vacuum interrupter pole 1 mainly includes a vacuum interrupter 2, an insulation supporting shell 3, a conductive connector 4, a flexible connector 5 and an insulation push-rod component 6.

[0035] The vacuum interrupter 2 includes moving and static contacts (or moving and static electrodes) and is provided to rapidly extinguish arcs and suppress current by virtue of excellent vacuum insulation within its tube when the moving and static contacts are separated. Usually, the movement of the moving conductive rod 21 of the vacuum interrupter 2 coupled to the end of the moving contact is controlled by the operating mechanism of the circuit breaker, such that the moving and static contacts can be separated or engaged, thereby realizing the breaking or closing of the circuit breaker.

[0036] The conductive connector 4 is connected to the end of the vacuum interrupter 2 provided with the static contact, while the flexible connector 5 is connected to the moving conductive rod 21 of the vacuum interrupter

2 extending from the moving contact. In such a manner, the upper and lower ends of the vacuum interrupter pole 1 may be electrically connected.

[0037] For the insulation push-rod component 6, one of its ends is also connected to the moving conductive rod 21 and the other end is connected to a transmission chain mechanism of the above operating mechanism. It can be easily understood that the acting force by the closing and opening operations of the operating mechanism may be transmitted to the insulation push-rod component 6 via the transmission chain mechanism. Further, by means of pulling up or down the insulation push-rod component 6, the moving and static contacts can be separated or engaged.

[0038] Figs. 2 and 3 respectively illustrate the structural views of the flexible connector 5 and the insulation push-rod component 6. It is to be noted that structures of the vacuum interrupter 2, the flexible connector 5 and the insulation push-rod component 6 are known in the art and will not be detailed herein. The description below will be focused on the structure and operating principle of the insulation supporting shell 3 and the conductive connector 4.

[0039] Figs. 4a to 4c respectively illustrate a back, front and top side perspective view of the insulation supporting shell according to exemplary embodiments of the present disclosure.

[0040] As shown in Figs. 4a to 4c, the insulation supporting shell 3 has a roughly cylindrical hollow shell structure. In particular, the insulation supporting shell 3 may have side walls 30 and a top wall 34, wherein the side walls 30 may be constructed in a U shape and the top wall 34 may be positioned at one end of the side walls 30 and is basically vertical to the side walls 30. As a simple constructional example, the side walls 30, for example, may include a first side wall 31 and a second side wall 33 opposing to each other, and an intermediate side wall 32 connecting the first side wall 31 with the second side wall 33, for defining an opening of the U shape. It is easily understood that with such a U-shaped opening, the vacuum interrupter 2 may be conveniently arranged within the interior space defined by the side walls 30 through the opening side of the U shape and then supported by the insulation supporting shell 3.

[0041] In some embodiments, the insulation supporting shell 3 may further have a mounting base 37 at a side opposite to the top wall 34. Accordingly, the insulation supporting shell 3 may be secured, via the mounting base 37, to a beam 120 (shown in the subsequent Figs. 11a to 11d) within a cabinet body of a gas-insulated ring main unit, for example. As an example, the mounting base 37 may be designed to have four mounting holes.

[0042] Further, in general, three vacuum interrupter poles 1 for three phases may be mounted in parallel inside the cabinet body 110. To ensure sufficient mounting space for the mounting bases 37 and the insulation requirements for the three adjacent vacuum interrupter poles 1, one side of the above U shape proximate to the mounting base 37 may be designed as a narrow necking-in structure (as shown in Fig. 4b). That is, between the first side wall 31 and the second side wall 33, a distance at a side proximate to the mounting base 37 is smaller than a distance at a side proximate to the top wall 34.

[0043] As a component for accommodating and supporting the vacuum interrupter 2, it is required that the insulation supporting shell 3 has certain impact resistance strength to withstand the impact force generated during the breaking and closing of the vacuum interrupter 2. For this purpose, in some embodiments, the top wall 34 and the side wall 30 may be provided with reinforcing ribs. Further, it is easily understood that the top wall 34 withstands most of the impact as it is arranged in the axial direction of the vacuum interrupter 2. As such, in some embodiments, the top wall 34 may be further designed to have a honeycomb structure. Particularly, most of the honeycomb structure may be formed by structural units with regular (e.g., pentagon, hexagon or other polygons with more sides) or irregular shapes. It is to be easily understood that this honeycomb structure can more effectively enhance the impact resistance strength of the top wall 34. In some other embodiments, the top wall 34 may be designed to have a thickness greater than the thickness of the side wall 30. For example, the thickness of the top wall may be in a range from 20mm to 50mm, while the side wall may have a thickness smaller than 10mm, such as around 5mm.

[0044] As an example for implementing the insulation supporting shell 3, the insulation supporting shell 3 for example may be made of thermoplastic material. It is easily understood that the thermoplastic material is environmentally friendly, has excellent mechanical strength and can be easily shaped. In such a case, the insulation supporting shell 3 can be easily fabricated and may be recycled and reused.

[0045] Besides, to facilitate heat dissipation of the vacuum interrupter 2, a plurality of holes may be further disposed in a direction of the intermediate side wall 32 of the insulation supporting shell 3 away from the top wall 34. Meanwhile, a chamfer 35 may be arranged at an edge of the top wall 34 adjacent to the opening side of the U shape. As further explained below, by means of the arrangement of the above holes 36 and the chamfer 35, a convection path may be easily created around the vacuum interrupter 2 within the insulation supporting shell 3. With such a gas convection manner, the heat of the vacuum interrupter 2 may be effectively dissipated.

[0046] Moreover, with reference to Fig. 1, the intermediate side wall 34 of the insulation supporting shell 3 is further provided with a hole through which the flexible connector 4 is allowed to pass. With this arrangement, one end of the flexible connector 4 may be electrically connected to the moving conductive rod 21 of the vacuum interrupter, and the other end may pass through the hole disposed on the intermediate side wall 34. Besides, in some embodiments, the other end of the flexible connector 4 may be further fixed on a protrusion 39 provided on the intermediate side wall 34. In this way, a stable electrical connection may be established between the flexible connector 4 and the moving conductive rod 21 of the vacuum interrupter.

[0047] It is to be further explained herein that in order to ensure the insulation requirements for adjacent vacuum interrupter poles 1 of different phases, no holes are provided on the first side wall 31 and the second side wall 33 of the insulation supporting shell 3.

[0048] Figs. 5a to 5d respectively illustrate different angular and perspective views of the conductive connector according to exemplary embodiments of the present disclosure; Figs. 6a to 6b respectively illustrate partial and sectional views for the connection of the conductive connector with both of the vacuum interrupter and the insulation supporting shell according to exemplary embodiments of the present disclosure; Fig. 7 illustrates a schematic structural view of the connection between the conductive connector and the moving knife of the isolation switch according to exemplary embodiments of the present disclosure; and Figs. 8a to 8d respectively illustrate different angular views of an insulation plug according to exemplary embodiments of the present disclosure.

[0049] As shown in Figs. 5a to 7, the conductive connector 4 is constructed in an abnormal shape and has a first end 41 and a second end 42, wherein the first end 41 is fastened between the top wall 34 and the vacuum interrupter 2 and is electrically connected to the end of the vacuum interrupter 2 with the static contact, while the second end 42 is constructed to be adapted to act as a supporting point for the moving knife component 9 of the isolation switch (see Fig. 7). As an example, the isolation switch for example may be a three-position isolation grounding switch located upstream of the circuit breaker. The moving knife component 9 may move to the three different positions to fulfill grounding, closing and opening operations of the isolation switch.

[0050] To implement the above functions of the conductive connector 4, just as an example, the conductive connector 4 in the abnormal shape may be further constructed to include a first plane 43 and a second plane 44 perpendicular to each other as shown in Figs. 5a to 5d, wherein the first end 41 is formed by the first plane 43 and the second end 42 is formed by the second plane 44. In some embodiments, the conductive connector 4 in the abnormal shape is integrally formed, e.g., by copper-forging process.

[0051] In some embodiments, in order to ensure the requirement for the density of the current flowing from the vacuum interrupter 2 to the moving knife component 9 of the isolation switch, an engagement surface between the first plane 43 and the second plane 44 may be designed as required. As an example, a bending surface 49 acting as a transition between the first plane 43 and the second plane 44 may be used as the above engagement surface. Moreover, in some embodiments, the edge of the second end 42 may be designed as a rounded corner to lower the intensity of the surrounding electrical field and further meet the requirement for insulation performance.

[0052] Further, a first mounting hole 46 may be formed at the first end 41 of the conductive connector 14. In particular, the first mounting hole 46 may be located in an intermediate region of the first end. As shown in Fig. 6a, the conductive connector 4 may be fastened, via a first bolt 61, to the end of the vacuum interrupter 2 with the static contact, wherein the first bolt 61 is mounted by passing through the above first mounting hole 46. It is easily understood that the conductive connector 4 may be fastened with the vacuum interrupter 2 by the above manner, so as to provide stable electrical connection with the end of the vacuum interrupter 2 with the static contact.

[0053] The conductive connector 4 may also be provided with at least one second mounting hole 47 at the first end 41. Particularly, the at least one second mounting hole 47 may include two second mounting holes 47, which may be symmetrically arranged at both sides of the first mounting hole 46 on the first plane 43. As illustrated in Fig. 6a, the conductive connector 4 may be fastened to the top wall 34 via a second bolt 62, wherein the top wall 34 is correspondingly configured with a top wall mounting hole 341, and at least one second bolt 62 is arranged such that it is mounted by passing through the top wall mounting hole 341 on the top wall 34 and the second mounting hole 47 on the first plane in sequence. The number of the above at least one second bolt 62 corresponds to the number of the top wall mounting hole 341, and also corresponds to the number of the at least one second mounting hole 47. In an embodiment where two second mounting holes 47 are symmetrically arranged at both sides of the first mounting hole 46, two corresponding second bolts 67 are symmetrically configured at both sides of the first bolt 61.

[0054] In some embodiments, as shown in Figs. 5a to 6b, the above second mounting hole 47 may be formed within a circular platform 48 protruding from the first plane 43 and the second mounting hole 47 may be positioned at the middle of the circular platform 58. As an example, the relative height of the circular platform 48 with respect to the first plane 43 may range from 1mm to 3mm. When the conductive connector 4 and the insulation supporting shell 3 are fastened with each other, a top face of the above circular platform 48 would abut against a surrounding plane of the top wall 34 on which the top wall mounting hole 341 is formed. The number of the above circular platform 48 may correspond to the number of the second mounting hole 47, e.g., two. It is easily appreciated that the above manner may avoid forming a wedge-shaped gap between a conductive face of the conductive connector 4 and the abutting plane of the above insulation supporting shell 3, and which wedge-shaped gap may unfavorably cause gap discharge.

[0055] It is observed from the above description that the vacuum interrupter 2, the conductive connector 4 and the insulation supporting shell 3 are not fastened together by common bolts. In fact, the vacuum interrupter 2 is connected with the conductive connector 4 via the first bolt 61 and the conductive connector 4 is connected with the insulation supporting shell 3 via the second bolt 62 different from the first bolt 61. It is easily understood that the above manner secures a stable electrical connection between the vacuum interrupter 2 and the conductive connector 4 even in case of thermoplastic deformation of the insulation supporting shell 3.

[0056] According to Fig. 6a, in an embodiment where the top wall mounting hole 341 is provided, the head of the first bolt 62 would expose from the top wall mounting hole 341. To avoid discharge from the first bolt 62 to components external to the insulation supporting shell 3 (e.g., cabinet body of the electrical cabinet to be described below), the vacuum interrupter pole 1, in some embodiments, may further include an insulation plug 8 as shown in Fig. 8a, which for example is made of silicone and adapted to be inserted into the top wall mounting hole 341 from the outside of the insulation supporting shell.

[0057] As an example, the insulation plug 8 may consist of a plug cap 81 and a plug column 82 as shown in Figs. 8b to 8d, wherein the plug column 82 is adapted to be inserted into the top wall mounting hole 341 while the plug cap 81 is configured to engage with the edge of the top wall mounting hole 341, to avoid excessive insertion of the insulation plug 8. Moreover, to facilitate the mounting of the insulation plug, the edge of the plug cap 81 is foldable as shown in Figs. 8c and 8d. Further, to ensure tight insertion of the insulation plug, the plug column 82 may have a barbed or inverted triangle structure, which may facilitate the insertion of the insulation plug 8 and also prevent back-off under impact.

[0058] As stated above, the insulation supporting shell 3 of the present disclosure may be provided with the holes 36 and the chamfer 35, which may facilitate a good heat dissipation for the vacuum interrupter pole 1. Fig. 9 illustrates a schematic view of the convection current inside the vacuum interrupter pole 1 according to exemplary embodiments of the present disclosure, and Figs. 10a to 10b illustrate experiment diagrams for the temperature rise and thermodynamic simulation of the vacuum interrupter pole according to exemplary embodiments of the present disclosure.

[0059] According to Fig. 9, during the operation of the vacuum interrupter, the ambient gas is adapted to enter the insulation supporting shell 3 from the holes 36, then pass through the gap between the vacuum interrupter 2 and the intermediate side wall 32 and the gap between the vacuum interrupter 2 and the top wall 34, and finally exit the insulation supporting shell 3 from the position of the chamfer 35, thereby creating a similar convection path in the vacuum interrupter pole as well as a convection effect analogous to a chimney effect. It is also confirmed in the experiment diagrams shown in Figs. 10a to 10b that the design of the insulation supporting shell 3 of the present disclosure achieves a good convection and associated heat dissipation effect.

[0060] Structures and implementations of various components of the vacuum interrupter pole 1 have been described above in detail. It is easily understood that the circuit breaker may be correspondingly provided with one or more of the above vacuum interrupter poles, so as to take advantage of the vacuum interrupter pole 1 according to the present disclosure. As an example, the circuit breaker may be configured as a single-phase circuit breaker or a multi-phase circuit breaker. Additionally, in some embodiments, the vacuum interrupter pole 1 may also be a part of a switching device or an electrical cabinet including the circuit breaker.

[0061] Just as an example, Figs. 11a to 11d respectively illustrate a schematic structural view of the electrical cabinet including a three-phase circuit breaker, wherein the electrical cabinet, for example, may be gas-insulated ring main unit.

[0062] As shown in Figs. 11a to 11d, the electrical cabinet 100 may include a cabinet body 110. In the embodiment where the electrical cabinet is e.g., a gas-insulated cabinet, the cabinet 110 may, for example, be filled with insulated gas such as sulfur hexafluoride, dry air or nitrogen.

[0063] In some embodiments, three vacuum interrupter poles 1 for three phases may be disposed in parallel inside the cabinet body 110. Particularly, in some practical application scenarios, the height of the cabinet body 110 may be restricted. Therefore, the vacuum interrupter poles 1 may be mounted inside the cabinet body 110 in a tilted manner as shown in the drawings. In this way, the overall height of the cabinet body 110 may be effectively controlled. During the specific mounting process, the lower end of the vacuum interrupter poles 1 for three phases, for example, may be secured to a beam 120 (e.g., a U-shaped beam) of the cabinet body 110 via the bottom of the insulation supporting shells 3, while the transmission chain mechanism (not shown) of the circuit breaker may be disposed below the beam 120. One end of the transmission chain mechanism may be connected to the operating mechanism of the circuit breaker, while the other end may be connected to the moving conductive rods 21 of the vacuum interrupter poles 1 for three phases, thereby realizing the closing and opening operations of the circuit breaker.

[0064] In the above embodiment where the vacuum interrupter pole 1 is arranged in tilted manner, the insulation supporting shell 3 may further include a protrusion 38 extending outward from the intermediate side wall 34. The cabinet body 110 may further consist of an auxiliary supporting beam 130 (e.g., an L-shaped beam) that extends along a direction perpendicular to the extension direction of the vacuum interrupter pole 1. The above protrusion 38 may be such arranged to allow the auxiliary supporting beam 130 to abut below the protrusion 38, to provide auxiliary support for the vacuum interrupter pole 1. Moreover, the auxiliary supporting beam 130 may be fastened together by means of a bolt and the protrusion 38. As an example, the auxiliary supporting beam 130 may be made of insulation material, to prevent discharge from the vacuum interrupter pole 1 to the auxiliary supporting beam 130 via the above holes 36.

[0065] Various embodiments of the vacuum interrupter pole 1 and relevant electrical device according to the present disclosure have been described in detail. It is easily appreciated that the vacuum interrupter pole of the present disclosure has a simple structure and a small size. In addition, the vacuum interrupter pole is stable and environmentally friendly, and has an enhanced mechanical strength and a good heat dissipation performance. Moreover, the unique conductive connector according to the present disclosure may effectively form an electrical connection loop and also support the moving knife component of the upstream three-position isolation grounding switch. Thus, the vacuum interrupter pole 1 of the present disclosure can more easily meet the requirement for arranging a three-position switch at the bus side, thereby improving the integration level of the entire electrical cabinet, such as a main ring unit.

[0066] While the present invention has been illustrated and described in detail in the accompanying drawings and the foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the present invention is not limited to the disclosed embodiments. Other variations to the disclosed embodiments may be understood and practiced by those skilled in the art by studying the drawings, disclosure and the appended claims upon practicing the claimed invention.

[0067] In the claims, the word "comprise" does not exclude other elements, and indefinite articles "a" and "an" do not exclude a plurality. A single element or other unit may fulfill the functions of several items recited in the claims. The mere fact that certain features are recited in mutually different dependent claims or described in different embodiments does not indicate that a combination of these features cannot be used to advantage. The protection scope of the present application covers any possible combination of various features recited in the embodiments or dependent claims without departing from the spirit and scope of the present application.

[0068] In addition, any reference signs in the claims should not be construed as limiting the scope of the invention.

Claims

1. A vacuum interrupter pole (1) for a circuit breaker, comprising:

   a vacuum interrupter (2);
   an insulation supporting shell (3) for accommodating and supporting the vacuum interrupter (2) and having a top wall (34) and side walls (30) defining a U shape, wherein the vacuum interrupter (2) is adapted to be placed within an interior space limited by the side walls (30) via an opening side of the U shape; and
   a conductive connector (4) with a first end (41) and a second end (42), wherein the first end (41) is fastened between the top wall (34) and the vacuum interrupter (2) and electrically connected to the vacuum interrupter (2), and the second end (42) is adapted to act as a supporting point for a moving knife component (9) of an isolation switch that is electrically connected with the circuit breaker.

2. The vacuum interrupter pole (1) according to claim 1, wherein the top wall (34) has a honeycomb structure wherein particularly most of the honeycomb structure is formed by structural units with a pentagonal or hexagonal shape.

3. The vacuum interrupter pole (1) according to any of claims 1 or 2, wherein the insulation supporting shell (3) further comprises a mounting base (37) disposed opposing to the top wall (34), the side walls (30) include a first side wall (31) and a second side wall (33) opposing to each other for defining an opening of the U shape, wherein a distance between the first side wall (31) and the second side wall (33) at a side proximate to the mounting base (37) is smaller than a corresponding distance at a side proximate to the top wall (34); or
   wherein the top wall (34) has a thickness in the range from 20mm to 50mm and the side walls (30) have a thickness smaller than 10mm.

4. The vacuum interrupter pole (1) according to claim 1, wherein the conductive connector (4) include a first plane (43) and a second plane (44) perpendicular to each other; the first plane (43) being formed by the first end (41) and the second plane (44) being formed by the second end (42).

5. The vacuum interrupter pole (1) according to claim 4, wherein the conductive connector (4) further comprises a bending engagement surface (49) serving as a transition between the first plane (43) and the second plane (44); or wherein the conductive connector (4) is integrally formed.

6. The vacuum interrupter pole (1) according to claim 4, wherein the vacuum interrupter (2) and the conductive connector (4) are fastened together via a first bolt (61), which is arranged to be mounted by passing through a first mounting hole (46) disposed at the middle of the first plane (43).

7. The vacuum interrupter pole (1) according to claim 6, wherein the conductive connector (4) and the insulation supporting shell (3) are fastened together via at least one second bolt (62), which is arranged

to be mounted by passing through a top wall mounting hole (341) of the top wall (34) and a second mounting hole (47) on the first plane (43) in sequence, the second bolt (62) being different from the first bolt (61).

8. The vacuum interrupter pole (1) according to claim 7, wherein the second mounting hole (47) is formed by a circular platform (48) protruding from the first plane (43), the circular platform (48) having a height ranging from 1mm to 3mm with respect to the first plane (43), wherein in a state where the conductive connector (4) and the insulation supporting shell (3) are fastened together, a top surface of the circular platform (4) abuts against a surrounding plane of the top wall (34) on which the top wall mounting hole (341) is formed; or

wherein the at least one second bolt (62) includes two second bolts (62) which are symmetrically arranged at both sides of the first bolt (61); or
further comprising: an insulation plug (8) with barbs, wherein the insulation plug is adapted to be inserted into the top wall mounting hole (341) from outside of the insulation supporting shell (3) to prevent discharge from the second bolt (62) to components outside of the insulation supporting shell (3) via the top wall mounting hole (341).

9. The vacuum interrupter pole (1) according to any of claims 1, 2 and 4-8, wherein the side walls (30) include an intermediate side wall (32) for defining an intermediate segment of the U shape, the intermediate side wall (32) being provided thereon with a plurality of holes (36); and an edge of the top wall (34) adjacent to the opening side of the U shape is configured with a chamfer (35);
during operation of the vacuum interrupter pole (1), ambient gas is adapted to enter the insulation supporting shell (3) from the holes (36), then pass through a gap between the vacuum interrupter (2) and the intermediate side wall (32) and a gap between the vacuum interrupter (2) and the top wall (34), and finally exit the insulation supporting shell (3) from the position of the chamfer (35), thereby creating convection effect within the vacuum interrupter pole (1).

10. The vacuum interrupter pole (1) according to any of claims 1, 2 and 4-8, further comprising: an insulation push-rod component (6) coupled to an end of a moving conductive rod (21) of the vacuum interrupter (2), wherein the insulation push-rod component (6) is also adapted to be placed within the interior space via the opening side of the U shape; or further comprising:

a flexible connector (5) with one end electrically connected to an end of a moving conductive rod (21) of the vacuum interrupter (2) and the other end passing through an intermediate side wall (32) defining an intermediate segment of the U shape.

11. A circuit breaker comprising the vacuum interrupter pole (1) according to any of claims 1-10.

12. A switching device comprising the vacuum interrupter pole (1) according to any of claims 1-10.

13. An electrical cabinet (100), comprising:

a cabinet body (100);
the vacuum interrupter pole (1) according to any of claims 1-10.

14. The electrical cabinet (100) according to claim 13, wherein the vacuum interrupter pole (1) is arranged within the cabinet body in a tilted manner with respect to the cabinet body (110), particularly

further comprising: an auxiliary supporting beam (130) that extends along a direction perpendicular to extension direction of the vacuum interrupter pole (1) and supports the tilted vacuum interrupter pole (1), more particularly
wherein the auxiliary supporting beam (130) is made of insulation material.

15. The electrical cabinet (100) according to claims 13 or 14, wherein the electrical cabinet (100) is a gas-insulated ring main unit.

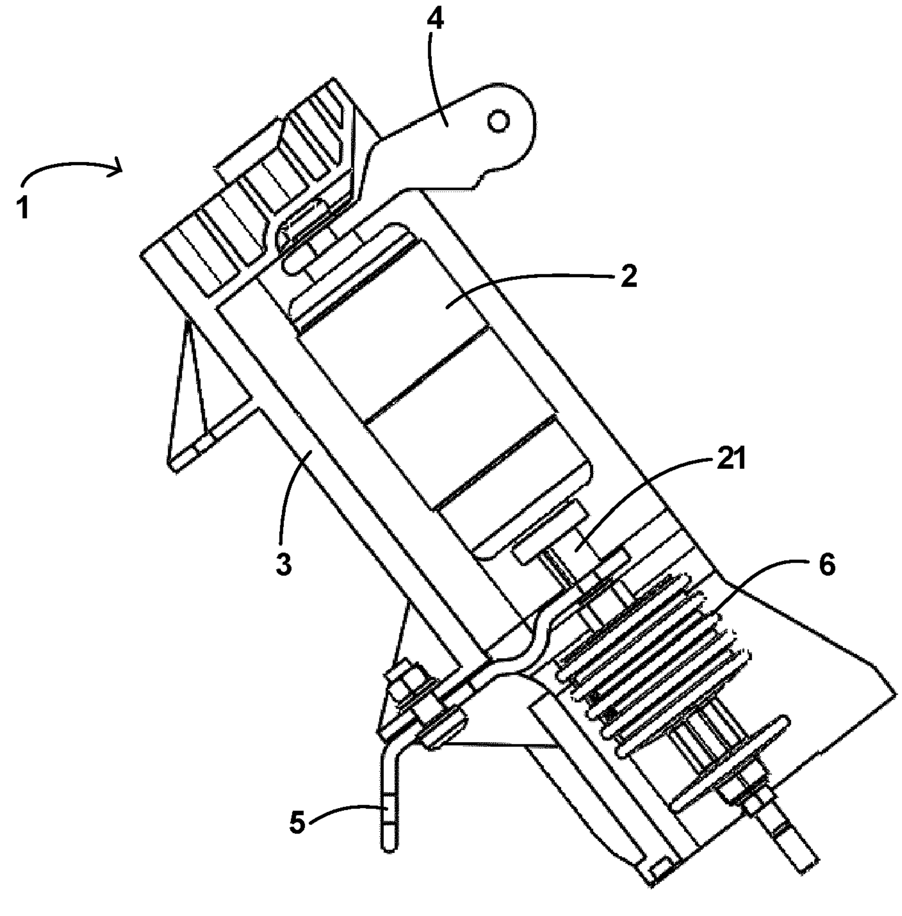

Fig. 1

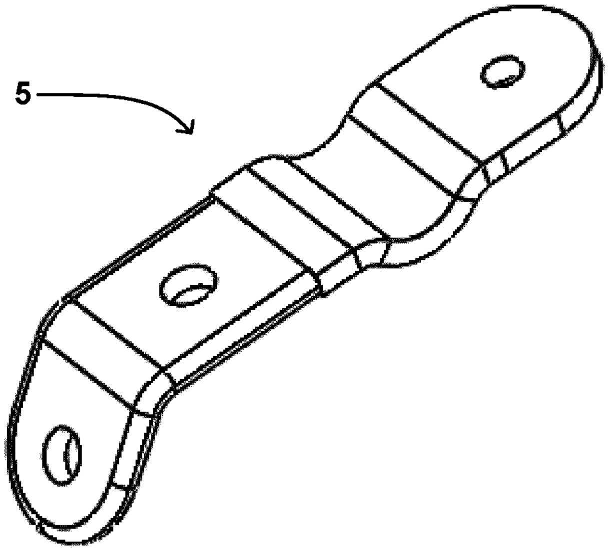

Fig. 2

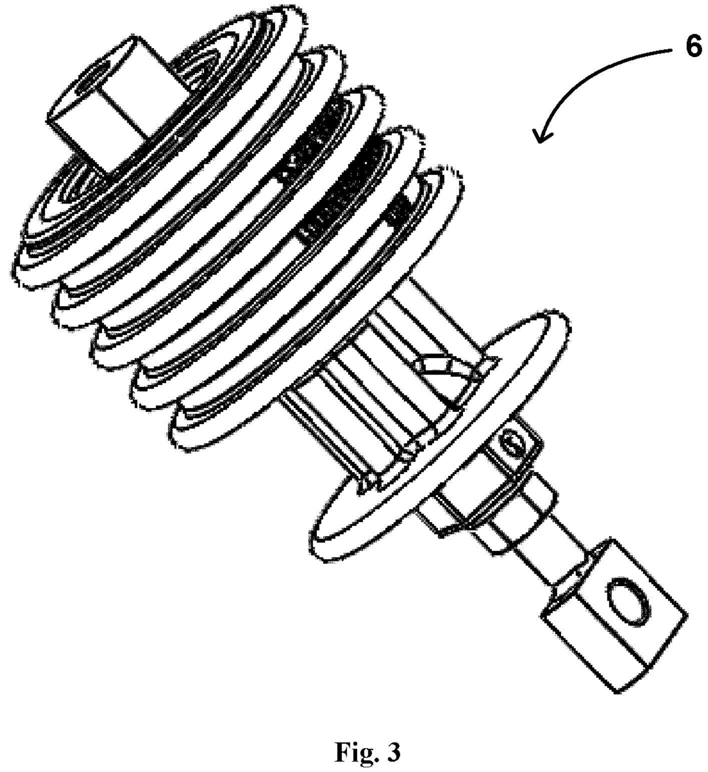

Fig. 3

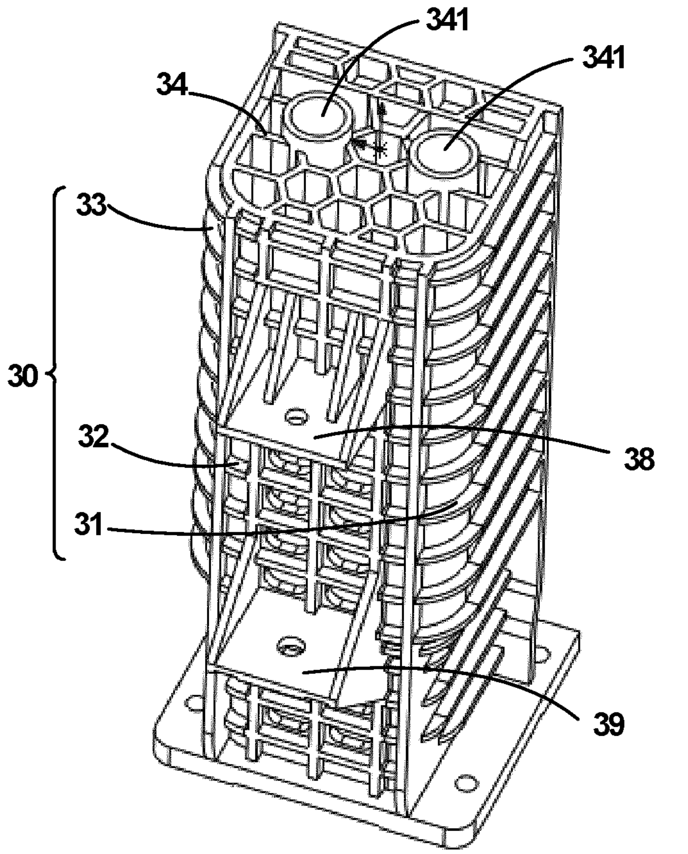

Fig. 4a

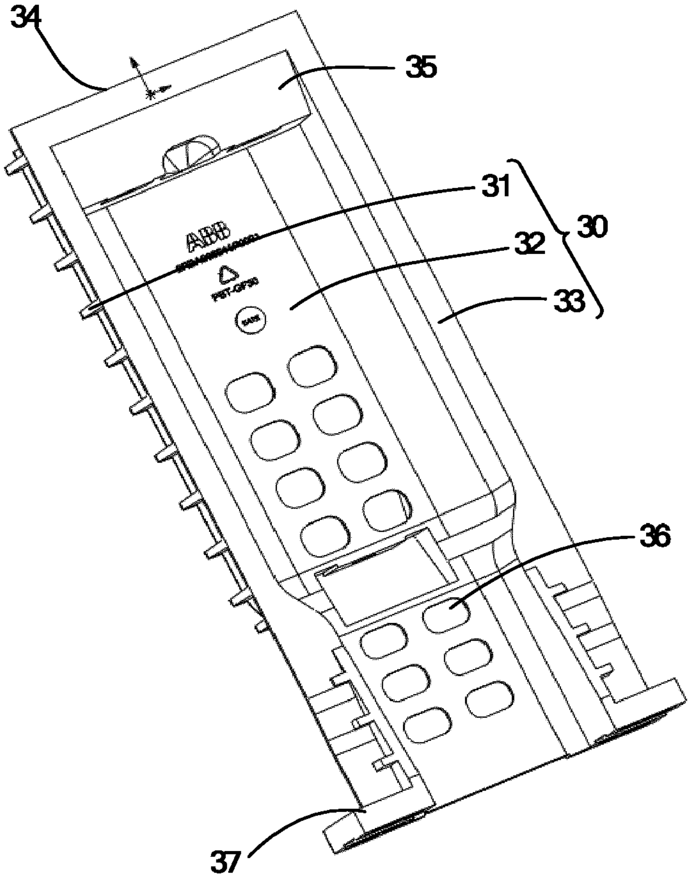

Fig. 4b

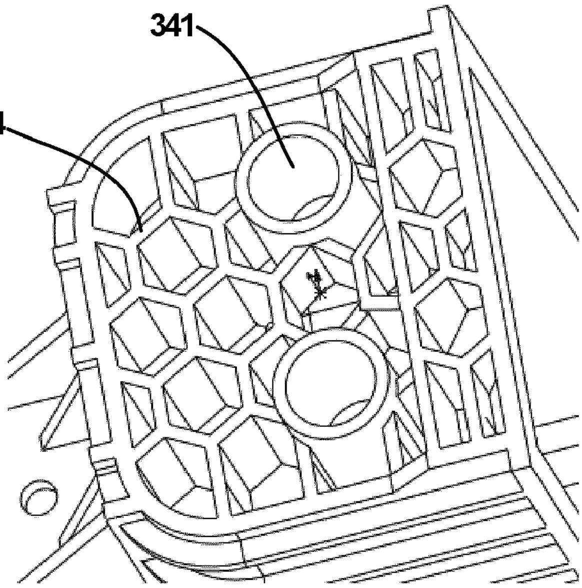

Fig. 4c

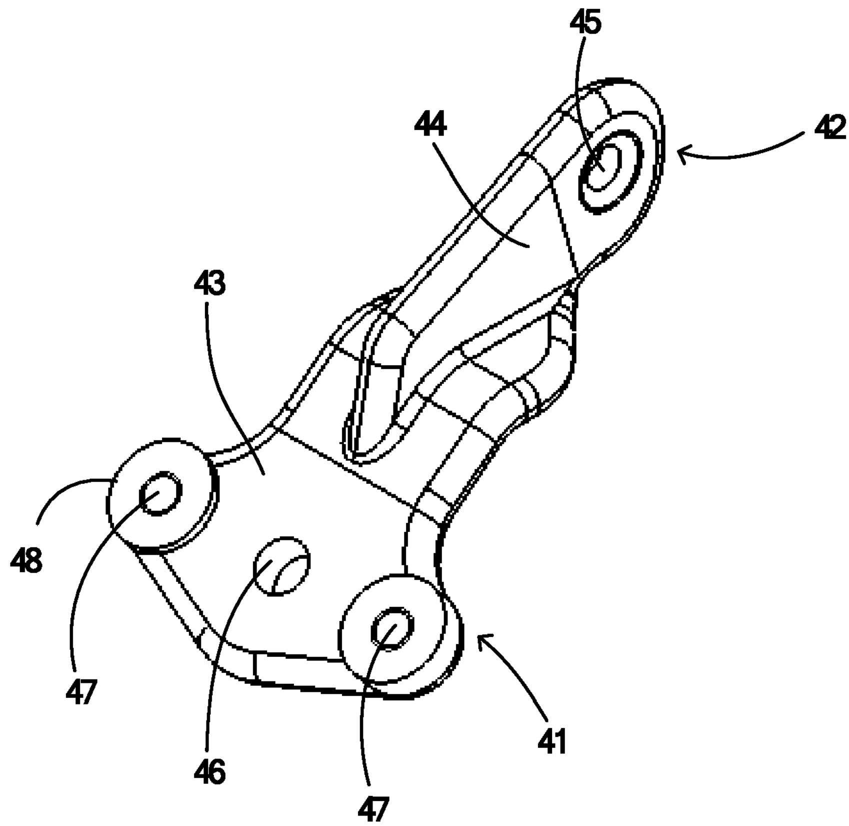

Fig. 5a

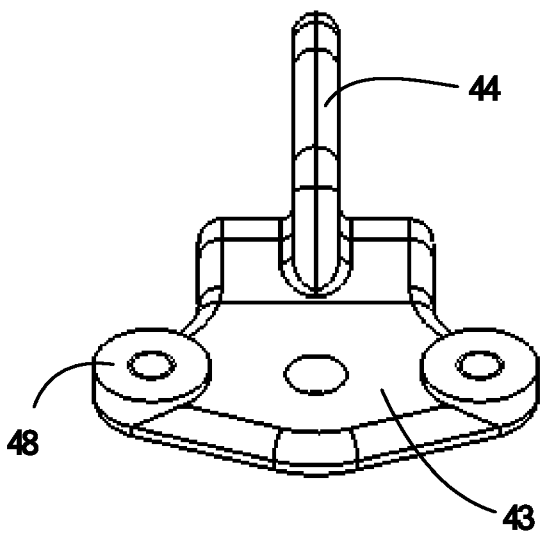

Fig. 5b

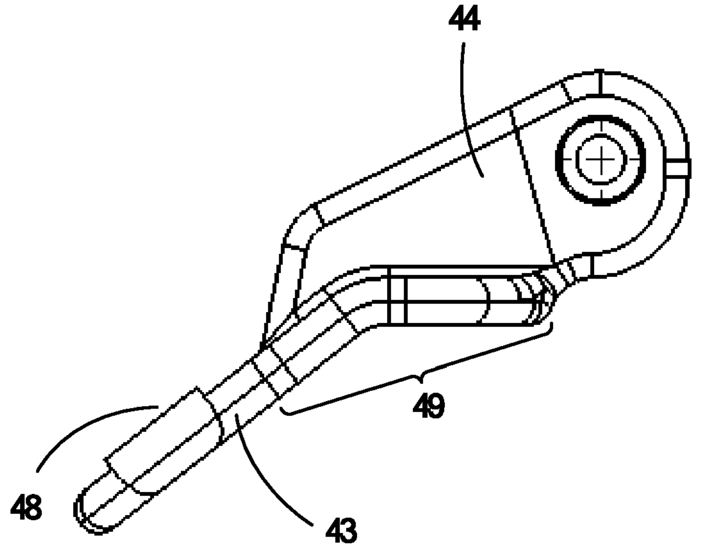

Fig. 5c

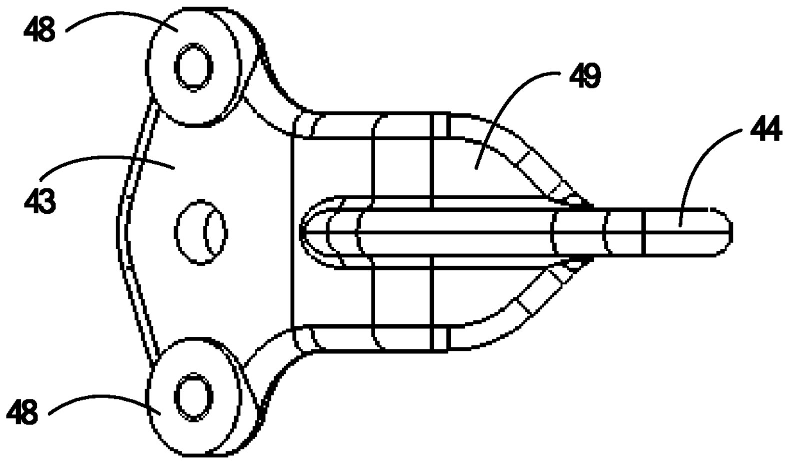

Fig. 5d

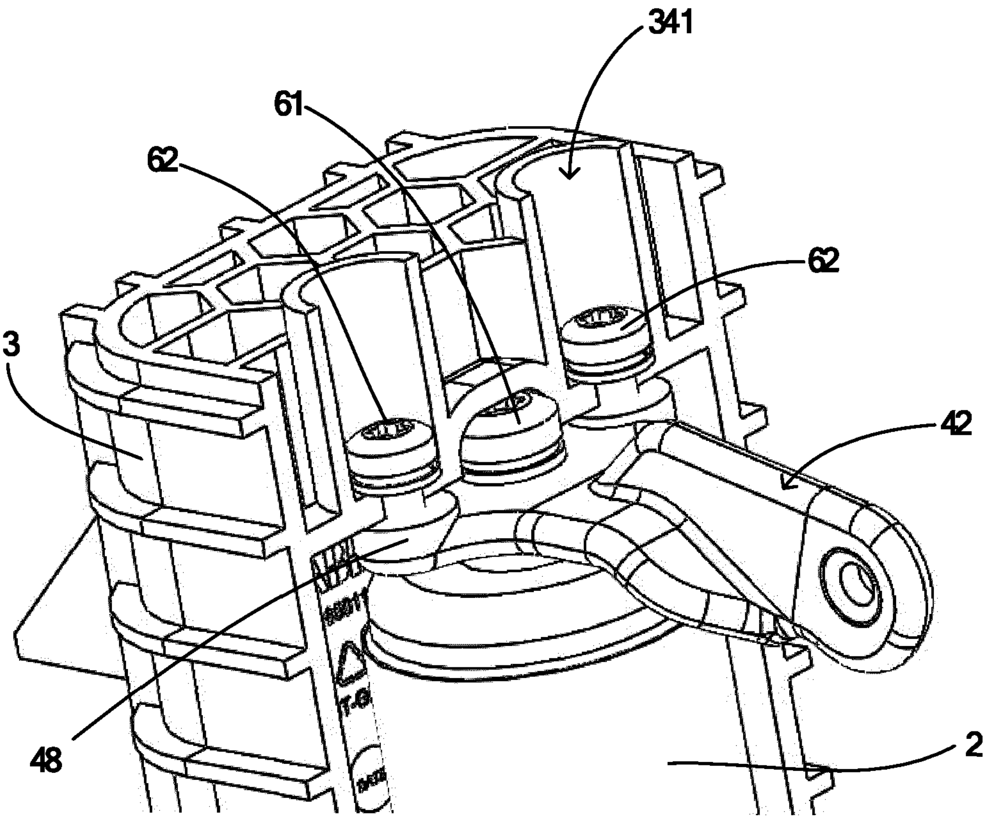

Fig. 6a

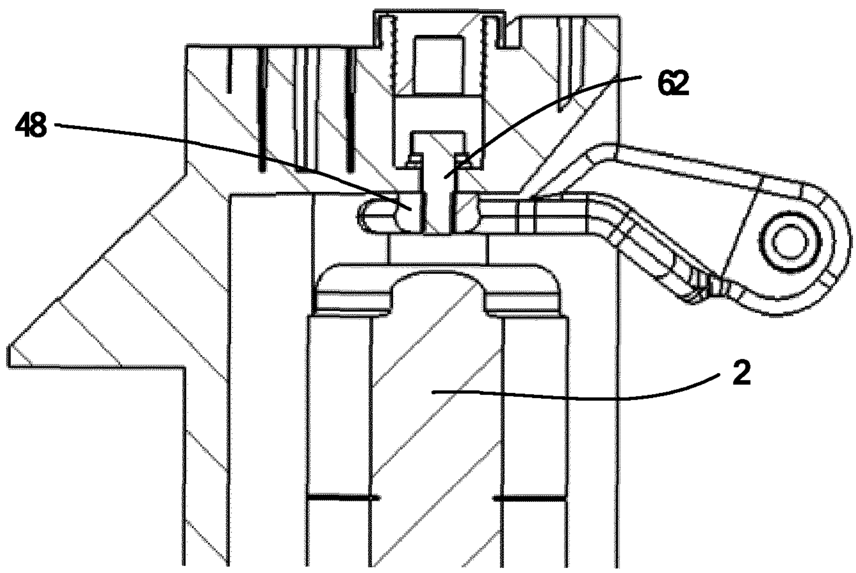

Fig. 6b

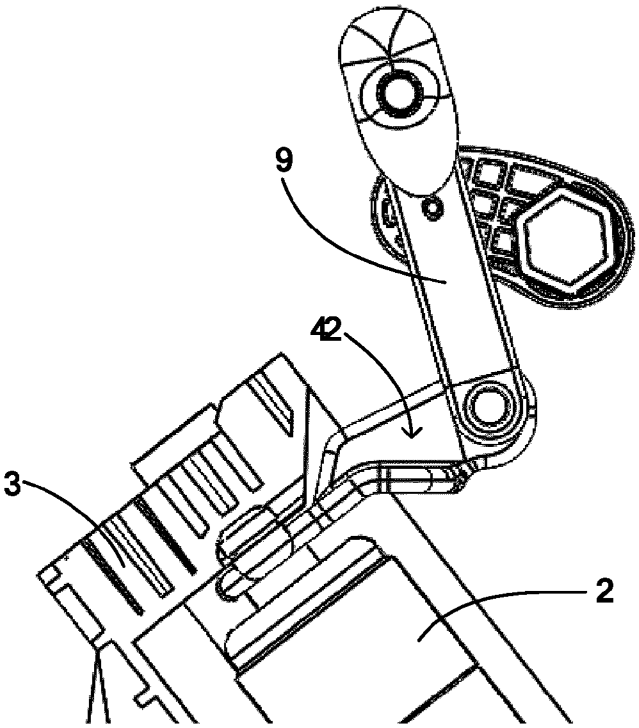

Fig. 7

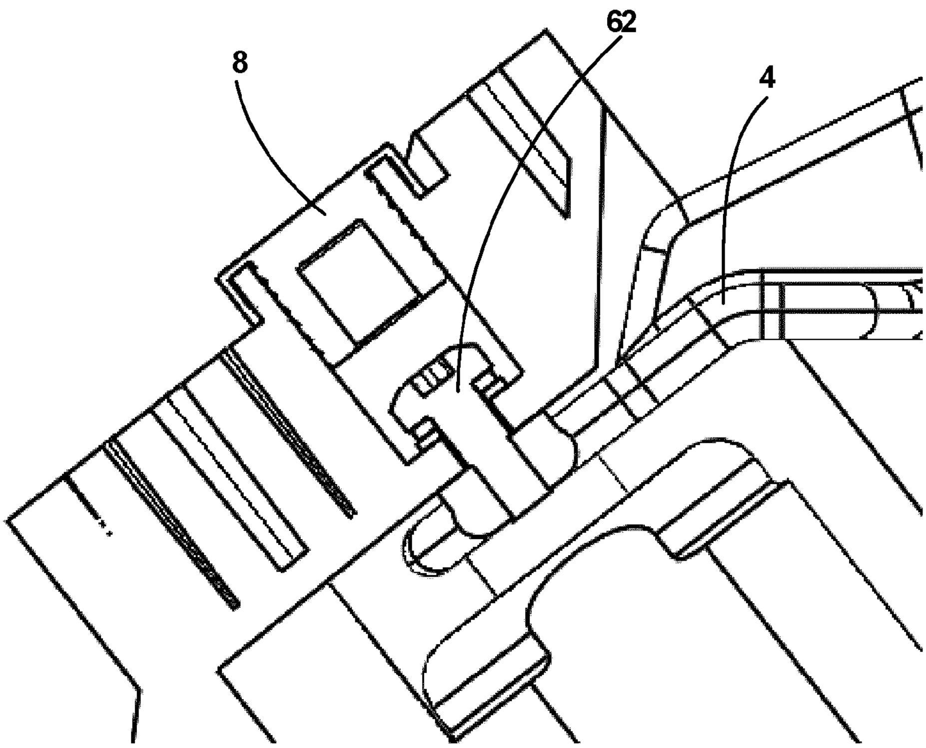

Fig. 8a

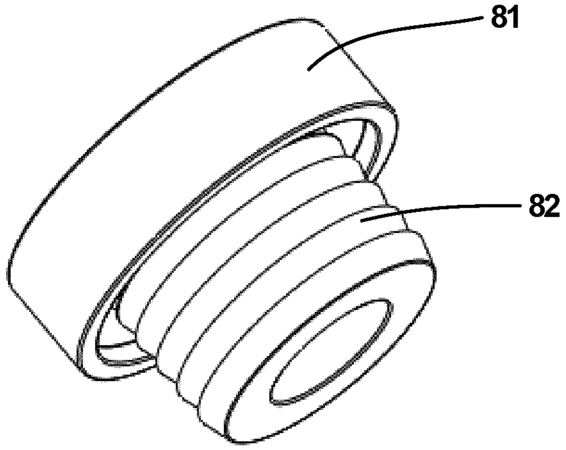

Fig. 8b

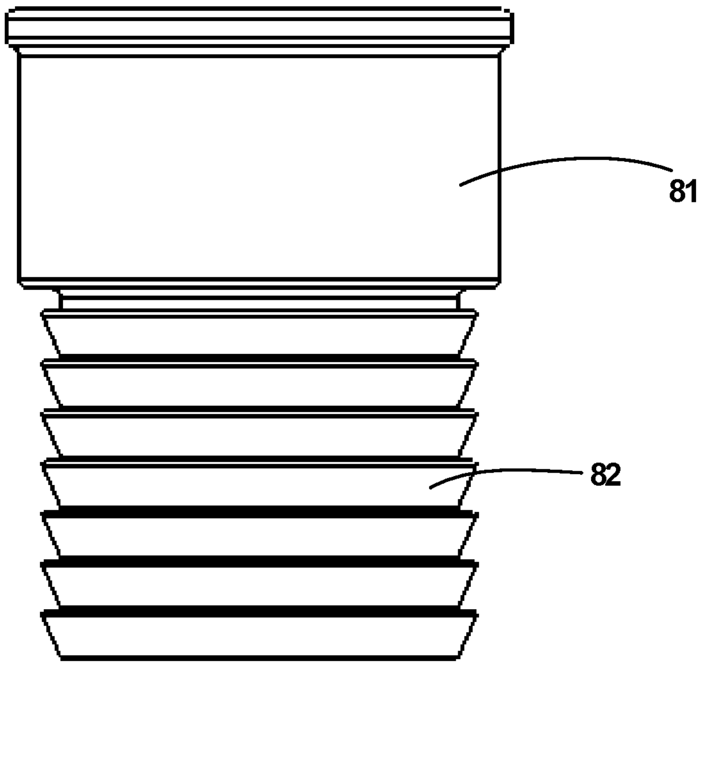

Fig. 8c

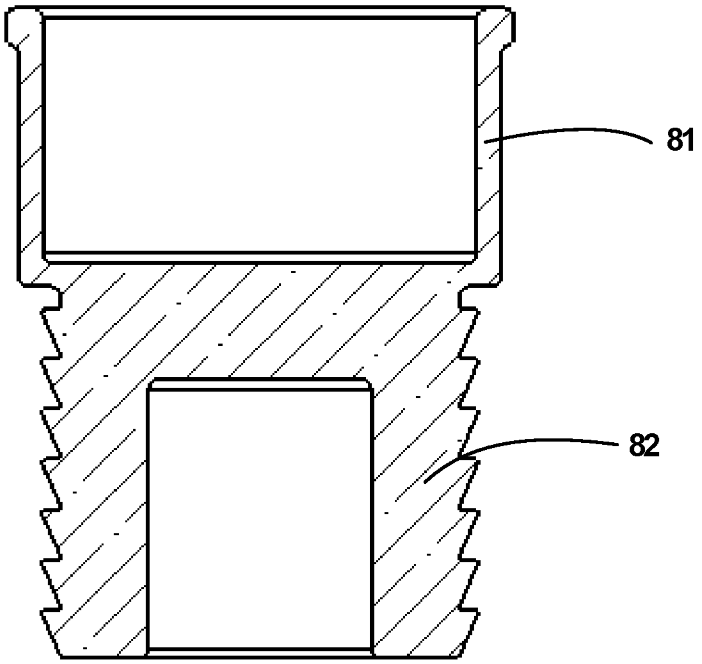

Fig. 8d

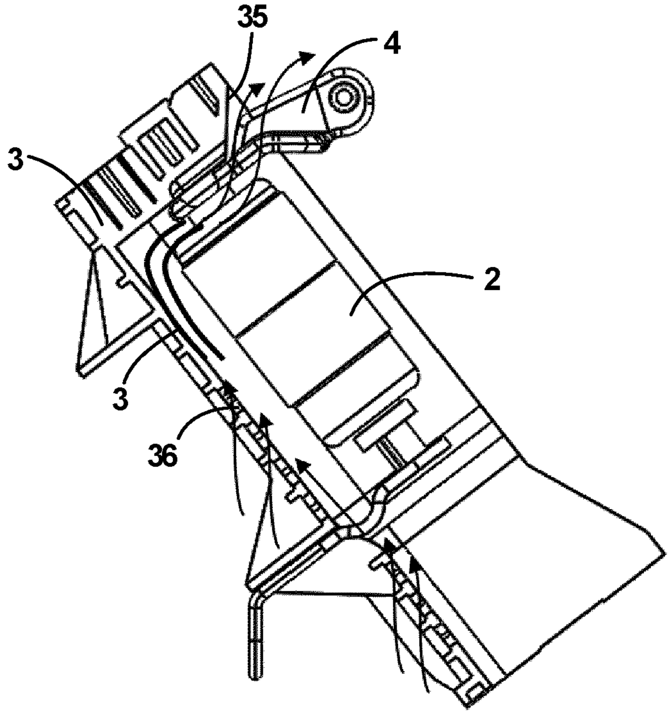

Fig. 9

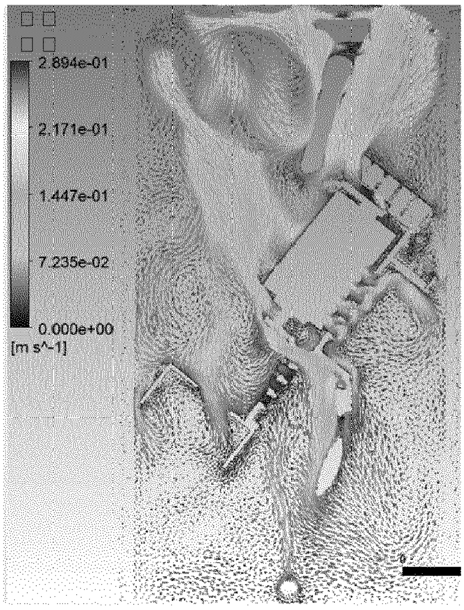

Fig. 10a

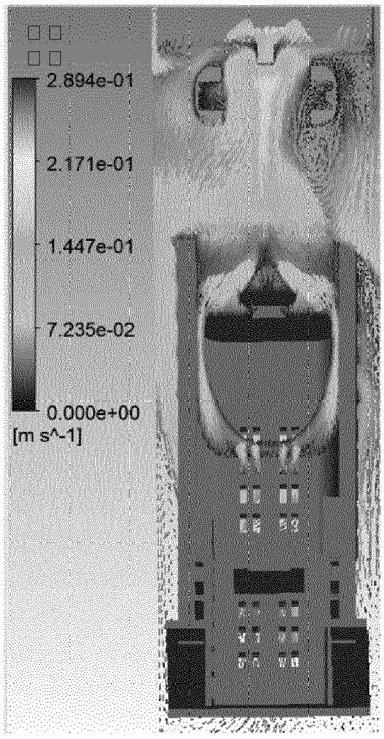

Fig. 10b

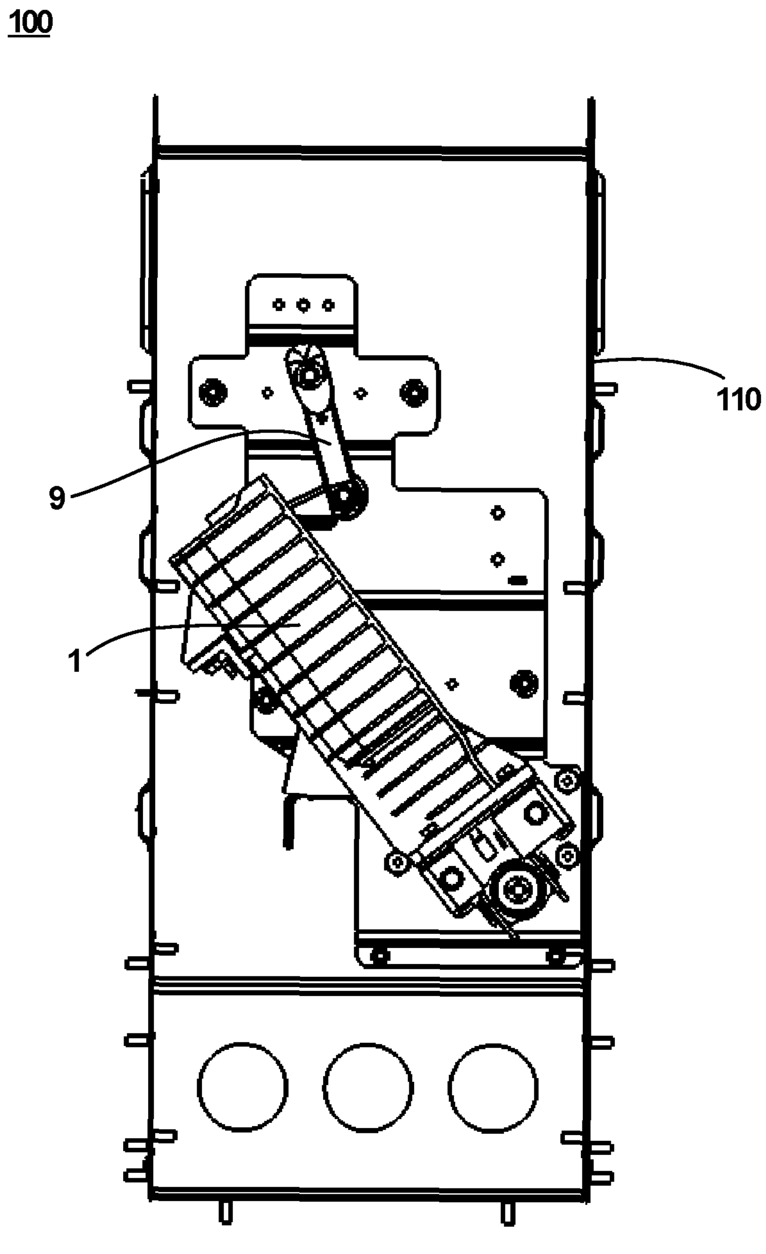

Fig. 11a

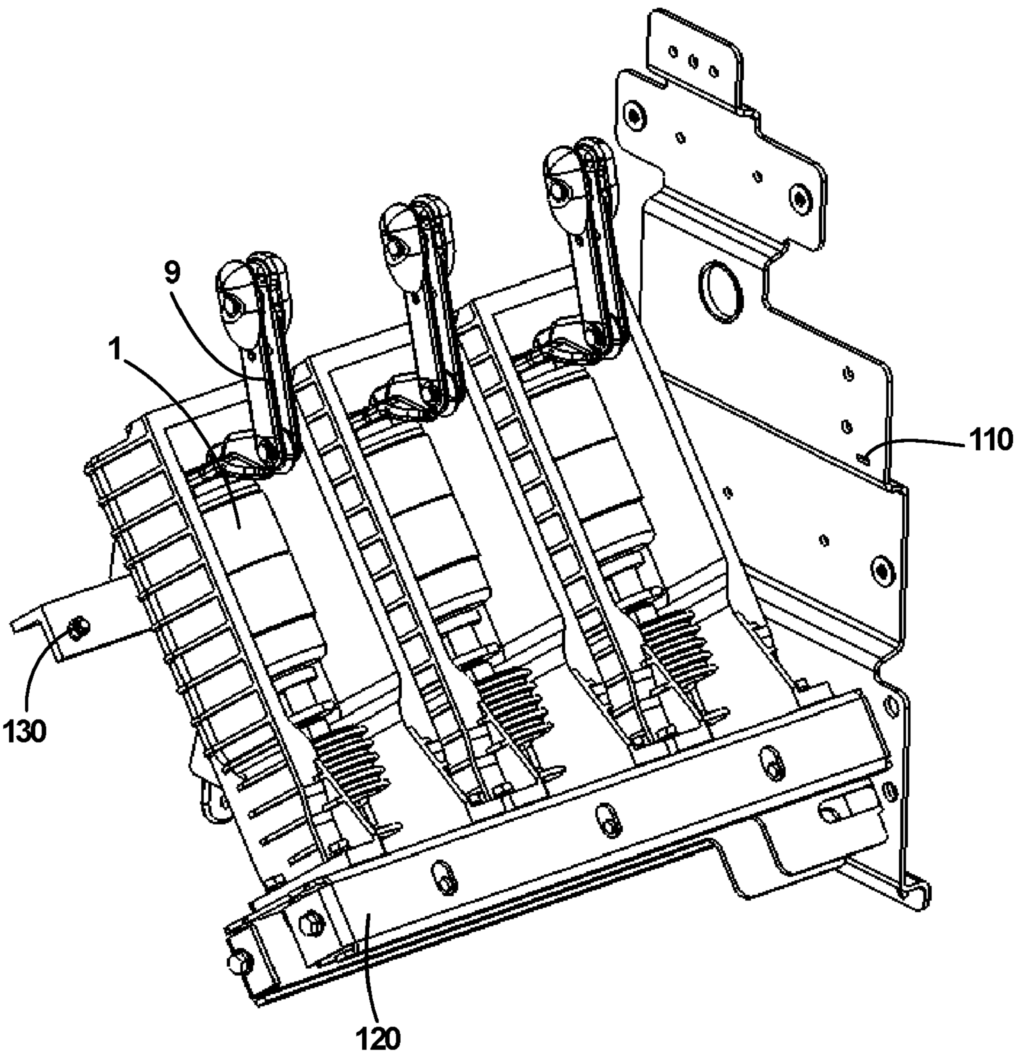

Fig. 11b

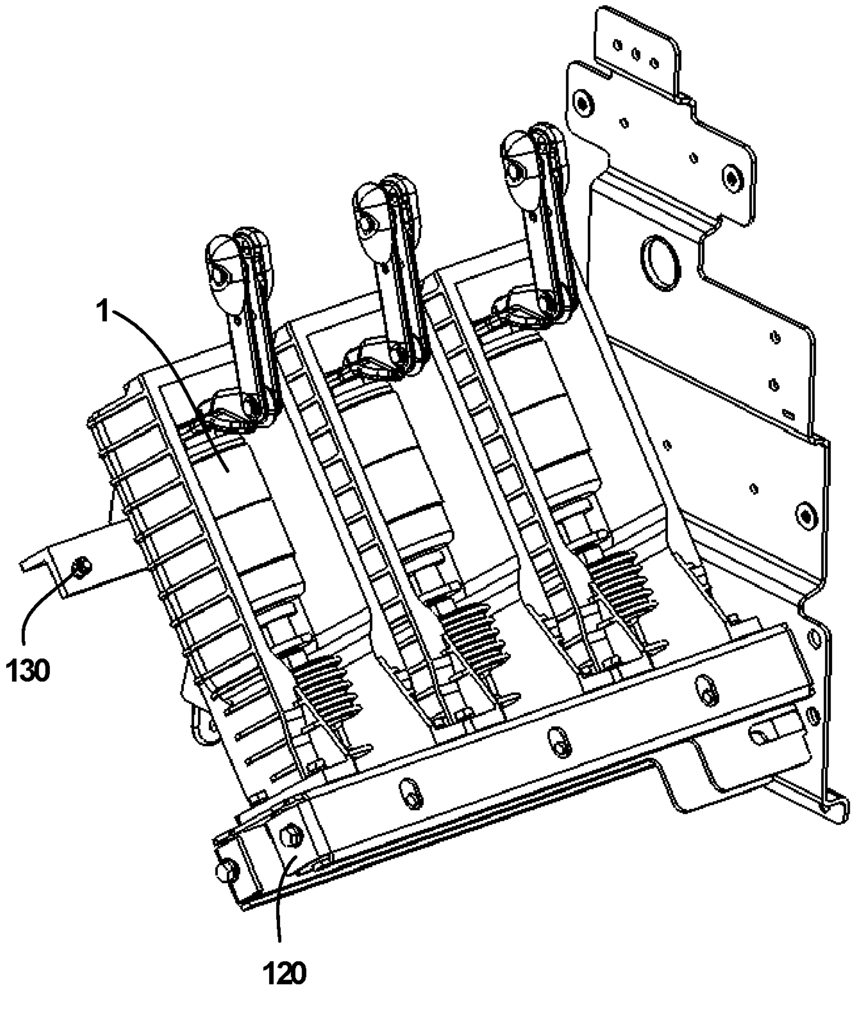

Fig. 11c

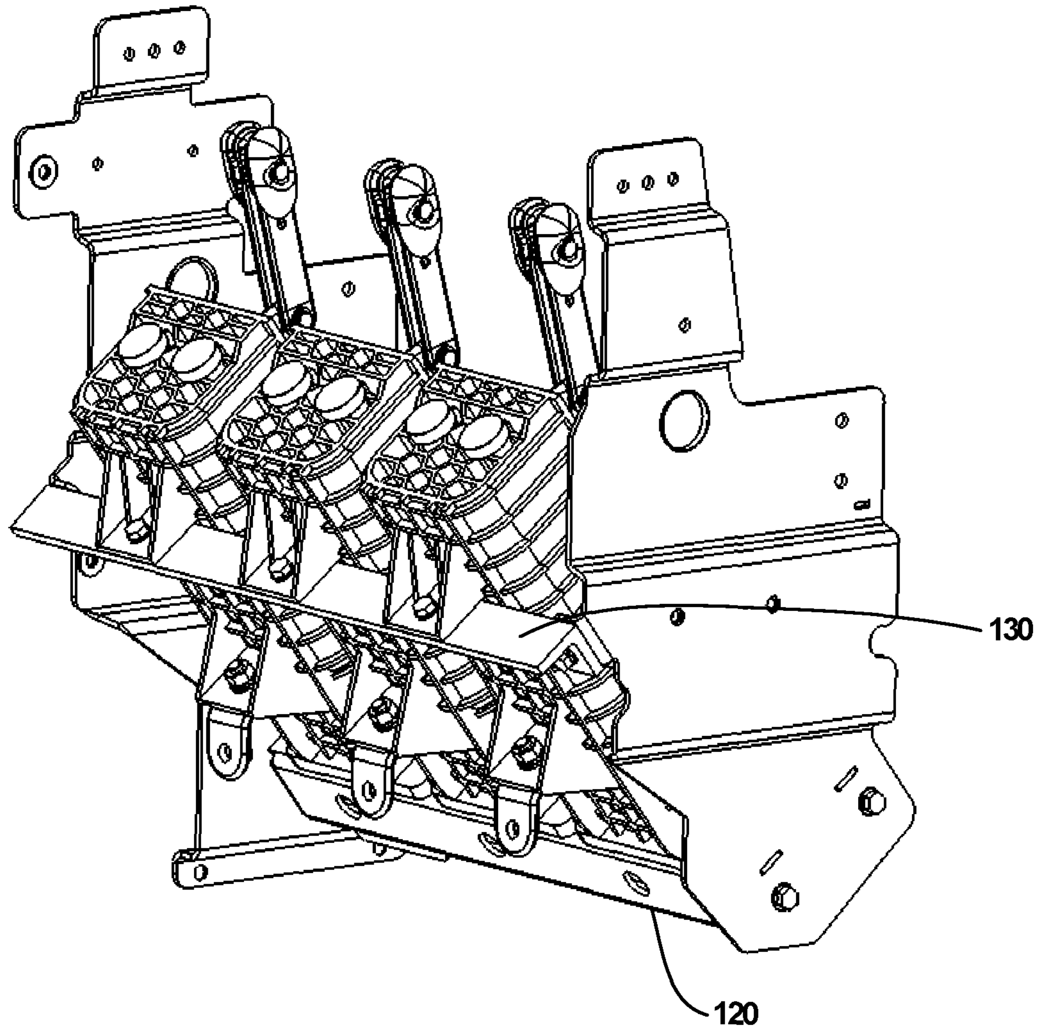

Fig. 11d

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 2729

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A	EP 3 410 455 A1 (ABB SCHWEIZ AG [CH]) 5 December 2018 (2018-12-05) * figure 1 *	1-15	TECHNICAL FIELDS SEARCHED (IPC) H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	15 November 2023	Ernst, Uwe

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 18 2729

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