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(71) Applicant: **Siemens Aktiengesellschaft**
80333 München (DE)

(72) Inventors:
- **CHIKHALE, Ravindra**
  403602 GOA (IN)
- **JUNG, Wolfgang**
  60435 Frankfurt (DE)
- **SONAWANE, Mahesh**
  410210 Navimumbai, Maharashtra (IN)
- **SUNDIKAR, Sagar**
  403726 SANCOALE, GOA (IN)

(74) Representative: **Patentanwaltskanzlei WILHELM & BECK**
Prinzenstraße 13
80639 München (DE)

(54) SWITCHING DEVICE FOR ELECTRIC POWER DISTRIBUTION

(57) A switching device (100) for opening and closing a circuit is provided. The switching device comprises an enclosure (102) filled with an insulating gas. The switching device comprises a stationary contact (110) disposed in the enclosure; and a movable contact (102) arranged inside the enclosure. The switching device comprises an actuating arrangement (124) to reciprocate the movable contact to move linearly. The switching device comprises a rigid conductive member (118), having a first end (118a) and a second end (118b), fixedly connected to the movable contact at the first end thereof to reciprocate therewith. The rigid conductive member is adapted to engage in electrical connection with the stationary contact at the second end thereof when the movable contact is in a first position for closing the circuit and is out of engagement with the stationary contact when the movable contact is in a second position for opening the circuit.

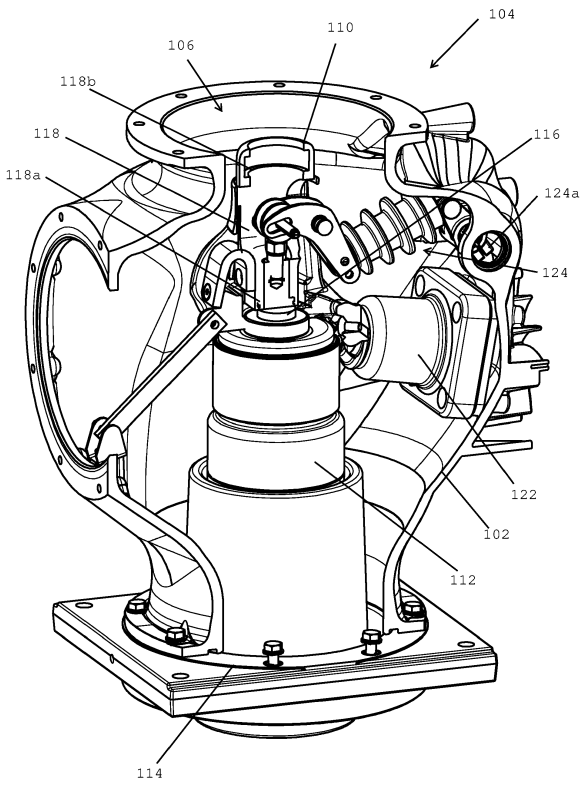

FIG 5

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Description

[0001] The present disclosure generally relates to electric power distribution, and more particularly to a switching device for opening and closing a circuit between a first electrical terminal and a second electrical terminal in electric power distribution.

[0002] A switching device (also commonly known as switchgear) is an apparatus used for controlling, regulating, switching on and off the electrical circuit in electrical power distribution. In electrical power distribution, the switching device is directly linked to the supply system. The switching device is typically placed in both the high and low voltage side of the power transformer, and is used for de-energizing the equipment for testing and maintenance and for clearing the fault. For instance, when the fault occurs in the power system, heavy current flow through equipment due to which there is a risk that the equipment may get damaged, and the service also get interrupted. Therefore, in order to protect the lines, generators, transformers and other electrical equipment from damage, automatic protective devices or switchgear devices are required.

[0003] The switching device needs to have high dielectric strength to withstand high voltages. In the case of switching device, and even other devices such as transformer (s), power line (s) (especially high-voltage electrical power transmission line (s)), busbar (s), circuit breaker, circuit breaker, switch disconnector, earthing switch, (Switching) contactor (s), waveguides, etc., and where large electrical voltages (from about 1 kV and greater) and / or strong electric fields may occur, typically a gas or gas mixture for electrical insulation of the electrical active (i.e. exposed to electrical or a strong electric field exposed) parts is utilized. Gas insulation offers significantly improved dielectric strength compared to air. In the switching device, the electrical contacts are sealed inside a tank with pressurized insulating gas. The sealed-tank design also eliminates the need for contactor maintenance. Separately installed switch disconnectors with inert gas insulation are known.

[0004] A particular type of switching device is a vacuum circuit interrupter apparatus which includes separable main contacts disposed in an insulated housing. Generally, one of the contacts is fixed relative to both the housing and to an external electrical conductor which is interconnected with the circuit to be controlled by the vacuum circuit interrupter. The other main contact is movable and usually comprises a cylindrical stem having the contact at one end thereof enclosed in a vacuum chamber and driving mechanism at the other end thereof external to the vacuum chamber. Often the electrical interconnection between the circuit to be protected by the circuit interrupter and the movable contact is made on the cylindrical stem. Conventionally, a flexible connector is used for connecting the movable contact to the fixed contact. Typically, the flexible connector is a stack of flexible sheets of a conducting material and is constructed such that it can accommodate the movement of the movable contact. For example, the flexible connector is made from multiple copper foils of 0.1mm thickness, which are brazed together to achieve the desired shape and thickness. The flexibility of the flexible connector ensures that there is always a contact between the movable contact and the stationary contact. The two ends of the flexible connector are typically bolted to the stationary contact and the movable contact using bolts.

[0005] U.S. Patent No. 6,310,310 discloses a high voltage electric switch which includes an insulated housing with an opening therethrough and an interior surface. The housing has an upper open end and a lower open end. A conductive upper terminal pad has a downwardly extending bar, wherein the upper terminal pad encloses the upper open end. A vacuum interrupter has a stationary stem that is electrically connected to the bar, and a moving stem extending in a direction opposite the stationary stem. A dielectric material is permanently bonded to at least a portion of the vacuum interrupter and substantially fills any voids between the vacuum interrupter and the interior surface. The dielectric material and the vacuum interrupter are selectively removable from the housing when the upper terminal pad is removed. A moving end assembly is connected to the moving stem and includes a highly conductive outer sleeve which receives a high strength inner sleeve having a cross-hole therethrough. A flexible shunt assembly is connected to the outer sleeve with a conductive lower terminal pad substantially enclosing the lower open end. The lower terminal pad has an opening therethrough to allow access to the flexible shunt connected to the lower terminal pad. A pull rod axially extends through the lower terminal pad opening, wherein the pull rod is connected to a pin with a cross-pin slot. The pin is connected to the inner sleeve by a cross-pin received through the cross-hole and the cross-pin slot. An over-travel spring received within the inner sleeve and biasing the slotted pin attached to the pull rod. Axial movement of the pull rod axially moves the moving stem to connect or disconnect with the stationary stem within the vacuum interrupter.

[0006] U.S. Patent No. 5,530,216 A discloses a flexible connector for a circuit breaker. The flexible connector preferably, comprises a plurality of flexible sheets arranged in a stack. The stack defines an opening having an edge including at least one tab extending inwardly from the edge of the opening. The tabs are adapted to bend so that they make a secure interference fit with a movable contact so that current can flow directly from the movable contact into the flexible connector. A circuit interrupter system is also disclosed.

[0007] The gas most commonly used as a switchgear insulating medium is Sulfur Hexafluoride (SF6). SF6 offers very good insulating properties (dielectric strength about 2.7 times better than air) as well as very good extinguishing properties (no conductive decomposition products). In addition, SF6 encapsulated systems provide a very high level of reliability, personal protection

(SF6 is chemically very stable) and lifetime (up to 30 years) and require only a very low level of maintenance. However, SF6 has a relatively high global warming potential (GWP) considered with respect to CO2. Due to its high global warming potential SF6 was included in the list of gases according to the Kyoto Protocol of 1997, whose entry into the atmosphere is to be limited. As per EU guidelines for clean air switchgear, some manufacturers have started to build a portfolio in medium voltage switchgear to shift from SF6 gas insulated switchgear to clean air solution. As there is change in insulating medium, the dielectric properties also change accordingly.

[0008] Conventionally, the flexible connection used for connecting the movable contact to the stationary contact includes multiple copper strips, and is bolted at both their ends. Such flexible connection typically has sharp edges, thus there is a possibility of dielectric flashovers due to change in insulating medium. Moreover, the need to bolt the flexible connection, especially at the top end requires access space which needs to be incorporated into the design of the switching device.

[0009] Hence, there is a need to develop an improved arrangement for switching device which can safely work within the limitations of dielectric strength of new type of insulating gases being employed, and can be easily assembled therefor.

[0010] One object of the invention is to provide a switching device for electric power distribution which can work with clean air insulating medium, such as SF_6 free gases, like mixture of carbon dioxide gas and nitrogen gas.

[0011] The object of the present disclosure is achieved by a switching device for opening and closing a circuit between a first electrical terminal and a second electrical terminal. The switching device comprises an enclosure filled with an insulating gas. The switching device comprises a stationary contact disposed in the enclosure, in electrical connection with the first electrical terminal; and a movable contact arranged inside the enclosure, in electrical connection with the second electrical terminal. The switching device also comprises an actuating arrangement configured to reciprocate the movable contact to move linearly inside the enclosure to be disposed between a first position and a second position. The switching device further comprises a rigid conductive member having a first end and a second end. Herein, the rigid conductive member is fixedly connected to the movable contact at the first end thereof to reciprocate therewith. Further, herein, the rigid conductive member is adapted to engage in electrical connection with the stationary contact at the second end thereof when the movable contact is in the first position to dispose the switching device in a closed circuit configuration and is out of engagement with the stationary contact when the movable contact is in the second position to dispose the switching device in an open circuit configuration.

[0012] In an embodiment, the rigid conductive member has one or more multi-laminated contacts arranged proximal to the second end thereof. The stationary contact is in electrical connection for current transfer with the one or more multi-laminated contacts when the movable contact is in the first position. In one example, the rigid conductive member has two number of multi-laminated contacts. The one or more multi-laminated contacts ensures proper contact between the rigid conductive member and the stationary contact for current transfer.

[0013] In an embodiment, the rigid conductive member has one or more grooves formed therein, to support the one or more multi-laminated contacts therein. The one or more grooves are dimensioned to provide a space to accommodate the one or more multi-laminated contacts while keeping a corresponding wall or surface smooth for proper reciprocating movement thereof.

[0014] In an embodiment, the rigid conductive member is fixed to the movable contact proximal to the first end thereof by means of fasteners. Such arrangement allows for an easy assembly to provide that the rigid conductive member can reciprocate along with the movable contact to engage and disengage in electrical connection with the stationary contact.

[0015] In an embodiment, the movable contact is a vacuum interrupter unit. The rigid conductive member is fixed to a stem of the vacuum interrupter unit. The rigid conductive member effectively replaces the flexible connector of the prior-art design, and is constructed such that it can accommodate the reciprocating movement of the movable contact.

[0016] In an embodiment, the stem of the vacuum interrupter unit and the rigid conductive member are enclosed in a casing. The casing is provided with a slot to accommodate a protrusion from the stem of the vacuum interrupter unit and thereby restrict reciprocating movement thereof. Such arrangement ensures that the movement of the rigid conductive member is restricted up to the stationary contact within the enclosure.

[0017] In an embodiment, the rigid conductive member has a hollow cylindrical shape. The hollow cylindrical shape makes the rigid conductive member light in weight and allows for sliding of the rigid conductive member over the stem of the vacuum interrupter unit and bolted thereto with ease, thus also making it possible to automate the assembly process for the switching device.

[0018] In an embodiment, the rigid conductive member is formed of a material comprising at least copper. The use of copper material for the rigid conductive member provides sufficient conductivity required for current transfer between the movable contact and the stationary contact.

[0019] In an embodiment, the actuating arrangement comprises a rotary to linear conversion mechanism. In particular, the actuating arrangement comprises a slider-crank mechanism. Herein, the actuating arrangement is connected to a rotating shaft extending from outside into the enclosure to provide input rotations to be converted into reciprocating linear movement of the movable contact inside the enclosure.

[0020] In an embodiment, the insulating gas is Sulfur hexafluoride (SF_6) free gas.SF6 having a relatively high global warming potential, thus the SF6 free gas would help reducing global warming effect of present switching device.

[0021] In an embodiment, the insulating gas comprises carbon dioxide gas and nitrogen gas. That is, the insulating gas is a mixture of carbon dioxide gas and nitrogen gas. Such insulating gas has good dielectric properties, and while being SF6 free gas have low global warming potential.

[0022] Other aspects, features, and advantages of the invention are readily apparent from the following detailed description, simply by illustrating a number of particular embodiments and implementations, including the best mode contemplated for carrying out the invention. The invention is also capable of other and different embodiments, and its several details can be modified in various obvious respects, all without departing from the scope of the invention. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

[0023] A more complete appreciation of the present disclosure and many of the attendant aspects thereof will be readily obtained as the same becomes better understood by reference to the following description when considered in connection with the accompanying drawings:

FIG 1 is a diagrammatic planar front view representation of a switching device, in accordance with an embodiment of the present invention;

FIG 2 is a diagrammatic planar front view representation of a circuit breaker compartment of the switching device of FIG 1, in accordance with an embodiment of the present invention;

FIG 3 is a diagrammatic planar top view representation of the circuit breaker compartment, in accordance with an embodiment of the present invention;

FIG 4 is a diagrammatic planar side view representation of the circuit breaker compartment, in accordance with an embodiment of the present invention;

FIG 5 is a diagrammatic perspective representation of the circuit breaker compartment with a section of an enclosure thereof removed for depicting components arranged therein, in accordance with an embodiment of the present invention;

FIG 6 is a diagrammatic perspective representation of a vacuum interrupter unit of the switching device along with a rigid conductive member fixed therewith, in accordance with an embodiment of the present invention;

FIG 7 is a diagrammatic exploded representation depicting the assembly of the vacuum interrupter unit with the rigid conductive member of the switching device, in accordance with an embodiment of the present invention; and

FIG 8 is a diagrammatic perspective representation of the rigid conductive member, in accordance with an embodiment of the present invention.

[0024] Various embodiments are described with reference to the drawings, wherein like reference numerals are used to refer the drawings, wherein like reference numerals are used to refer to like elements throughout. In the following description, for the purpose of explanation, numerous specific details are set forth in order to provide thorough understanding of one or more embodiments. It may be evident that such embodiments may be practiced without these specific details.

[0025] In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the embodiments of the invention. It is apparent, however, to one skilled in the art that the embodiments of the invention may be practiced without these specific details or with an equivalent arrangement. In other instances, well-known structures and devices are shown in block diagram form in order to avoid unnecessarily obscuring the embodiments of the invention.

[0026] Example embodiments of a switching device described herein is a vacuum switch which may be included in a medium voltage switchgear unit. Such vacuum switch can be used in several different applications. The switching device may be used for capacitor switching or for sectionalizing a line or system of switches. The switching device may also be molded into a "load break" elbow connector to interrupt currents of medium voltage distribution systems. Examples of the switching device as per the embodiments of the present disclosure has been fully described with reference to FIG 1 through FIG 8 herein.

[0027] FIG 1 is a diagrammatic representations of an exemplary switching device 100, in accordance with one or more embodiments of the present disclosure. In the present illustration, the depicted switching device 100 is a medium voltage switchgear; however, for the purposes of the present disclosure, the switching device 100 may be any type of switchgear as known in the art. In the present embodiments, the switching device 100 may be implemented as a gas-insulated switchgear, a vacuum interrupter or an air-break disconnector. The switching device 100 may be connected to a generator or to a consumer line, in which the generator or the consumer line is disconnectable from or connectable to the energy line by means of the switching device 100, as per the embodiments of the present disclosure.

[0028] As illustrated, the switching device 100 includes an enclosure 102. The enclosure 102 is generally hollow and may have any suitable shape based on the design and configuration of the switching device. Herein, the enclosure 102 is typically grounded during operation, i.e. electrically connected to earth. Advantageously, the enclosure 102 is made of a suitable electrically conductive material, e.g. aluminum, such as cast aluminum. Casting, or molding, an aluminum enclosure is a non-expensive procedure. However, the enclosure 102 can also be made of copper, zinc or any other suitable electrically conductive material. Advantageously, the enclosure 102 may be strategically plated with nickel or silver at certain locations, e.g. at electric connection areas.

[0029] In the switching device 100, the enclosure 102 is filled with insulating gas. In the present embodiments, the insulating gas is sulfur hexafluoride (SF_6) free gas. In a particular embodiment, the insulating gas comprises carbon dioxide gas and nitrogen gas, i.e. the insulating gas is a mixture of carbon dioxide gas and nitrogen gas. In one example, the insulating gas may have carbon dioxide gas and nitrogen gas in a ratio of 20:80. In another example, the insulating gas may have carbon dioxide gas and nitrogen gas in a ratio of 40:60. It may be appreciated that the given ratios are exemplary only and shall not be construed as limiting to the present disclosure in any manner. Alternatively, as a gaseous insulating medium, various insulating gases, in particular hydrofluoroolefins, perfluoroketones, perfluoronitriles, hydrofluoroxiranes, perfluoroxiranes, hydrofluoroethers, perfluoroether, or a mixture of said gases may be utilized. These are media which, at the operating temperature of the high or medium-voltage arrangements, are generally gaseous, or liquid and gaseous with a gaseous fraction having a high dielectric strength. It may be understood that in order to accommodate the insulating gas, the enclosure 102 is sealed and in turn may preferably be made of a material which is gas-impermeable, such as glass, polymers or resins.

[0030] In some examples, a filler material (not shown) may surround the enclosure 102 filled with the gaseous insulating medium, with the filler material having preferably a higher specific permittivity as compared to the enclosure 102 filled with the gaseous insulating medium. This relationship reduces dielectric requirements for the insulating gas, because the electric field is increased in areas of low electrical permittivity over areas of high dielectric permittivity. The filler material may be a liquid dielectric, a solid dielectric, but also supercritical fluids, suspensions, in particular colloids or other mixed-phase substances. A liquid fluid may in particular be an oil based on fluorinated hydrocarbons or a silicone oil. A solid fluid may be a polymer or a resin. In principle, the filler material may also be a gas which has a higher dielectric strength than the gaseous insulating medium in the hollow enclosure 102. In this case, it is not necessary that the filler material has a higher dielectric permittivity than the hollow spheres with the gaseous insulating medium.

[0031] In some implementations, an outer shape, or an outer geometry, of the enclosure 102 is smooth to distribute the electric field generated by the current through the switching device 100. The outer surface of the enclosure 102 is designed to be smooth to distribute the electric field generated by the current through the switching device 100. The outer surface of the enclosure 102 is smooth in that the enclosure 102 does not have an angular outer shape and is without roughness. That is, the outer surface of the enclosure 102 is smooth in that the outer surface has no roughness, sharp projections or sharp indentations.

[0032] FIGS 2-4 are diagrammatic representations of a circuit breaker compartment 104 of the switching device 100, in accordance with one or more embodiments of the present disclosure. It may be understood that the enclosure 102 is divided into multiple compartments. In particular, the enclosure 102 comprises an electrical conductor compartment, a disconnector compartment and a circuit breaker compartment (such as, the circuit breaker compartment 104). It may be appreciated that the circuit breaker compartment 104 forms a part or a section of the enclosure 102 of the switching device 100. Hereinafter, the various components and assemblies of the circuit breaker compartment 104 have been described generally being part of the switching device 100 without any limitations.

[0033] As illustrated, the switching device 100, or in particular the circuit breaker compartment 104, has a top opening 106 and a side opening 108. It may be understood by a person skilled in the art that the disconnector compartment (as may be seen from FIG 1) is mounted on top of the circuit breaker compartment 104 and is accessible via the top opening 106. The top opening 106 and the side opening 108 may have circular grooves that receive O-rings to preclude entry of moisture into the enclosure 102. Generally, the circuit breaker compartment 104 receives a first electrical terminal (not shown) and a second electrical terminal (not shown) of the switching device 100. Typically, the first electrical terminal is received generally at a top region of the circuit breaker compartment 104, i.e. near the top opening 106; and the second electrical terminal is received generally at a bottom region of the circuit breaker compartment 104. It may be appreciated that the first electrical terminal and the second electrical terminal may each include multiple electrical lines based on the design and configuration (e.g., multi-phase configuration) of the switching device 100. In some examples, the first electrical terminal and the second electrical terminal may be busbars, but can also be in the form of any other electrical conductor without any limitations. In particular, the first electrical terminal and the second electrical terminal may include a number of electrical bushings (not shown) penetrating into the circuit breaker compartment 104, one for each phase of a plural phase system. The bushings may be brazed in end covers. On the outside of the enclosure 102, the first electrical terminal and the second electrical

terminal are connected to cables (not shown) which either connect the switching device 100 to a load or to a medium or high voltage power distribution line. The first electrical terminal and the second electrical terminal may each engage a fitting (not shown) to join the power cables of the power distribution line.

[0034] Referring now to FIG 5, illustrated is a diagrammatic representation of the circuit breaker compartment 104 with a section of the enclosure 102 removed for depicting components arranged therein, in accordance with one or more embodiments of the present disclosure. In the present illustrations, the switching device 100 is depicted to be disposed in its closed circuit configuration. The circuit breaker compartment 104 encloses an arrangement for opening and closing a circuit between the first electrical terminal and the second electrical terminal of the switching device 100. The circuit breaker compartment 104 includes a stationary contact (generally referred by numeral 110) disposed in the enclosure 102. Further, the circuit breaker compartment 104 includes a movable contact (generally referred by numeral 112) arranged inside the enclosure 102. Typically, as illustrated, the stationary contact 110 is located at the top region of the circuit breaker compartment 104, and the movable contact 112 is located at the bottom region of the circuit breaker compartment 104. Specifically, the stationary contact 110 is disposed on a terminal end of the first electrical terminal and the moveable contact 112 is mounted on a contact support (generally referred by the numeral 114) associated with the second electrical terminal, of the switching device 100. In one example, the stationary contact 110 and the movable contact 112 may have contact points formed from copper-impregnated tungsten. Herein, the stationary contact 110 is disposed in electrical connection with the first electrical terminal and the movable contact 112 is disposed in electrical connection with the second electrical terminal; such that when the stationary contact 110 and the movable contact 112 are in contact with each other, the circuit between the first electrical terminal and the second electrical terminal is disposed in closed configuration, and when the stationary contact 110 and the movable contact 112 are not in contact with each other, the circuit between the first electrical terminal and the second electrical terminal is disposed in open configuration.

[0035] In the present embodiments, the movable contact 112 is a vacuum interrupter unit; the two terms being interchangeably used and the vacuum interrupter unit being also referred by the numeral 112 hereinafter. The vacuum interrupter unit 112 has a generally cylindrical shape and has ribbed sections on its outer surface. The term "generally cylindrical" is used to mean that a housing of the vacuum interrupter unit 112 is substantially cylindrical but not necessarily of circular cross-section. Other less preferred cross-sections may be employed, if desired. The vacuum interrupter unit 112 is aligned substantially coaxially to a central axis of the enclosure 102. As a result, the vacuum interrupter unit 112 and the enclosure 102 are arranged substantially coaxially with respect to one another in the circuit breaker compartment 104. As illustrated, the vacuum interrupter unit 112 includes a stem 116 of circular cross-section. The stem 116 may generally be extending in upward direction towards the stationary contact 110 disposed in the top region of the enclosure 102. Again, herein, the stem 116 has a generally cylindrical shape.

[0036] According to embodiments of the present disclosure, the switching device 100 includes a rigid conductive member 118. FIG 8 is a diagrammatic perspective representation of the rigid conductive member 118, in accordance with an embodiment of the present invention. The rigid conductive member 118 has a first end 118a and a second end 118b. As illustrated, the rigid conductive member 118 has a hollow cylindrical shape. It may be appreciated that the illustrated shape for the rigid conductive member 118 is exemplary only and shall not be construed as limiting to the present disclosure in any manner. In the present embodiments, the rigid conductive member 118 is fixedly connected to the vacuum interrupter unit 112. FIG 6 is a diagrammatic perspective representation of the vacuum interrupter unit 112 along with the rigid conductive member 118 fixed therewith, in accordance with an embodiment of the present disclosure. Further, FIG 7 is a diagrammatic exploded representation depicting the assembly of the vacuum interrupter unit 112 with the rigid conductive member 118, in accordance with an embodiment of the present invention. Referring again to FIGS 5-8 in combination, as illustrated, the rigid conductive member 118 is fixedly connected to the vacuum interrupter unit 112 at the first end 118a thereof. Generally, the cross-sectional shape of the rigid conductive member 118 is designed to be complementary to the shape of the stem 116 of the vacuum interrupter unit 112, such that the rigid conductive member 118 can slidably be received onto the stem 116 of the vacuum interrupter unit 112. Further, the rigid conductive member 118 is bolted to the stem 116 of the vacuum interrupter unit 112 by means of fasteners (such as, fasteners 120 as shown best in FIG 7).

[0037] In the switching device 100, the vacuum interrupter unit 112 is adapted to move linearly inside the enclosure 102. As illustrated in FIG 5, the switching device 100 includes an actuating arrangement 124 configured to reciprocate the vacuum interrupter unit 112 to move linearly inside the enclosure 102 to be disposed between a first position and a second position. In one or more embodiments, the actuating arrangement 124 includes a rotary to linear conversion mechanism. Specifically, the actuating arrangement 124 includes a slider-crank mechanism. Herein, the actuating arrangement 124 is connected to a rotating shaft 124a extending from outside into the enclosure 102 to provide input rotations to be converted into reciprocating linear movement of the vacuum interrupter unit 112 inside the enclosure 102. Such actuating arrangement 124 may be contemplated from the associated drawings by a person skilled in the art and

thus has not been described in detail herein for the brevity of the present disclosure.

[0038] In the present embodiments, with the rigid conductive member 118 being fixed to the vacuum interrupter unit 112, the rigid conductive member 118 is adapted to move linearly inside the enclosure 102. With its linear movement, the rigid conductive member 118 is adapted to engage in electrical connection with the stationary contact 110 at the second end 118bthereof when the movable contact 112 (i.e. vacuum interrupter unit 112) is in the first position to dispose the switching device 100 in a closed circuit configuration and is out of engagement with the stationary contact 110 when the movable contact 112 (i.e. vacuum interrupter unit 112) is in the second position to dispose the switching device 100 in an open circuit configuration. It may be understood that the stationary contact 110 is also cylindrical with cross-sectional diameter being slightly smaller than an inner diameter of the hollow cylindrical rigid conductive member 118, so as to allow the rigid conductive member 118 to slide thereover and being disposed in electrical connection therewith, when the movable contact 112 (i.e. vacuum interrupter unit 112) is in the first position to dispose the switching device 100 in the closed circuit configuration.

[0039] For the purposes of the present disclosure, the rigid conductive member 118 is formed of copper material. Generally, the rigid conductive member 118 may be formed of any suitable conductive material with high current transfer characteristics known in the art without any limitations. Further, the rigid conductive member 118 has one or more multi-laminated contacts 126 (as shown in FIGS 5 and 6, not shown in FIG 8 for clarity purposes) formed proximal to the second end 118b thereof. The multi-laminated contacts 126 may include a bunch or stack of flexible connectors which may help the engagement between the rigid conductive member 118 and the stationary contact 110. Herein, the stationary contact 110 is in electrical connection for current transfer with the one or more multi-laminated contacts 126 when the movable contact 112 (i.e. vacuum interrupter unit 112) is in the first position, to dispose the switching device 100 in the closed circuit configuration. As may be seen from FIG 8, the rigid conductive member 118 has one or more grooves 128 formed therein, to support the one or more multi-laminated contacts 126 therein. It may be appreciated that the grooves 128 may be bored into inner surface of the hollow cylindrical rigid conductive member 118, and the multi-laminated contacts 126, which are generally annular in shape, are arranged or seated into the formed grooves 128. The multi-laminated contacts 126 acts as current transfer points and can withstand and transfer high currents. It can be appreciated, therefore, that significant amounts of electrical current may be channeled from the movable contact 112 to the stationary contact 110 by the rigid conductive member 118.

[0040] In the illustrated examples, the rigid conductive member 118 is shown to have two number of grooves 128 formed therein, with two number of complementary multi-laminated contacts 126. Although two number of complementary multi-laminated contacts 126 are utilized for the illustrated embodiments, it may be appreciated that more or less number of multi-laminated contacts 126 may be utilized based on the current transfer requirements, without departing from the scope and the spirit of the present disclosure. In one example, the rigid conductive member 118 is about twelve inches in length and four inches in width, so as to ensure contact thereof with (i.e. sliding thereof over) the stationary contact 110 for engagement therewith as required.

[0041] Also, as illustrated in FIG 6, the stem 116 of the vacuum interrupter unit 112 and the rigid conductive member 118 are enclosed in a casing 122. The casing 122 may help with heat conduction, to remove heat from inside of the circuit breaker compartment 104 to the ambient atmosphere. In one example, the casing 122 may be made of metal, preferably stainless steel. In other examples, the casing 122 may be made of ceramic insulators, such as ceramic insulators made of aluminum oxide (Al_2O_3). As illustrated, the casing 122 is a provided with a slot 130 to accommodate a protrusion 132 from the stem 116 of the vacuum interrupter unit 112. Such configuration restricts reciprocating movement of the vacuum interrupter unit 112, or specifically the rigid conductive member 118, and ensures that the second end 118b of the rigid conductive member 118 move linearly upward only up to required distance for establishing contact with the stationary contact 110 and not beyond thereof so as to avoid any damage thereto, in spite of any extra linear movement provided by the actuating arrangement 124, if any.

[0042] The switching device 100 of the present disclosure replaces the flexible connector as used for engagement of the movable contact with stationary contact in the prior-art with the rigid conductive member 118 as disclosed herein. The use of rigid conductive member 118 reduces the possibility of dielectric flashovers at the stationary (disconnector) contact due to change in insulating medium like the presently used mixture of carbon dioxide gas (CO2) and nitrogen gas (N2), instead of SF6, while still achieving dielectric test values similar to SF6 products for, for example, 36kv rating of the electrical switchgear. The present switching device 100 is capable of transferring high current in compact space using the same kinematics currently employed. The disclosed design of the present switching device 100 provides that the rigid conductive member 118 can be pushed to fit inside the stem 116 of the vacuum interrupter unit 112 with ease and further there is no need of bolting the rigid conductive member 118 to the stationary (disconnector) contact 110 at the second end 118b thereof. Such configuration allows to automate the process of assembly of the components inside the circuit breaker compartment 104, therefore providing a possible reduction in assembling costs and simplifying the manufacturing process. It is to be noted that with the introduction of the rigid conductive member 118, the overall dimensions of the circuit

breaker compartment 104 remain the same, thus no significant change in product footprint size and manufacturing process.

[0043] While the present disclosure has been described in detail with reference to certain embodiments, it should be appreciated that the present disclosure is not limited to those embodiments. In view of the present disclosure, many modifications and variations would be present themselves, to those skilled in the art without departing from the scope of the various embodiments of the present disclosure, as described herein. The scope of the present disclosure is, therefore, indicated by the following claims rather than by the foregoing description. All changes, modifications, and variations coming within the meaning and range of equivalency of the claims are to be considered within their scope.

Reference Numerals

switching device	100
enclosure	102
circuit breaker compartment	104
top opening	106
side opening	108
stationary contact	110
movable contact	112
contact support	114
stem	116
rigid conductive member	118
first end	118a
second end	118b
fasteners	120
casing	122
actuating arrangement	124
rotating shaft	124a
multi-laminated contacts	126
grooves	128
slot	130
protrusion	132

Claims

1. A switching device (100) for opening and closing a circuit between a first electrical terminal and a second electrical terminal, the switching device (100) comprising:

- an enclosure (102) filled with an insulating gas; and
- a stationary contact (110) disposed in the enclosure (102), in electrical connection with the first electrical terminal;
- a movable contact (112) arranged inside the enclosure (102), in electrical connection with the second electrical terminal;
- an actuating arrangement (124) configured to reciprocate the movable contact (110) to move linearly inside the enclosure (102) to be disposed between a first position and a second position; and
- a rigid conductive member (118) having a first end (118a) and a second end (118b), wherein the rigid conductive member (118) is fixedly connected to the movable contact (112) at the first end (118a) thereof to reciprocate therewith; and **characterized in that**:

the rigid conductive member (118) is adapted to engage in electrical connection with the stationary contact (110) at the second end (118b) thereof when the movable contact (112) is in the first position to dispose the switching device (100) in a closed circuit configuration, and
the rigid conductive member (118) is adapted to be out of engagement with the stationary contact (110) when the movable contact (112) is in the second position to dispose the switching device (100) in an open circuit configuration.

2. The switching device (100) as claimed in claim 1, **characterized in that** the rigid conductive member (118) has one or more multi-laminated contacts (126) formed proximal to the second end (118b) thereof, wherein the stationary contact (110) is in electrical connection, for current transfer, with the one or more multi-laminated contacts (126) when the movable contact (112) is in the first position.

3. The switching device (100) as claimed in claim 2, **characterized in that** the rigid conductive member (118) has one or more grooves (128) formed therein, to support the one or more multi-laminated contacts (126) therein.

4. The switching device (100) as claimed in claim 1, **characterized in that** the rigid conductive member (118) is fixed to the movable contact (112) by means of fasteners (120).

5. The switching device (100) as claimed in claim 1, **characterized in that** the movable contact (112) is a vacuum interrupter unit (112), wherein the rigid conductive member (118) is fixed to a stem (116) of the vacuum interrupter unit (112) .

6. The switching device (100) as claimed in claim 1, **characterized in that** the stem (116) of the vacuum interrupter unit (112) and the rigid conductive member (118) are enclosed in a casing (122), wherein the casing (122) is a provided with a slot (130) to accommodate a protrusion (132) from the stem (116)

of the vacuum interrupter unit (112) and thereby restrict reciprocating movement thereof.

7. The switching device (100) as claimed in claim 1, **characterized in that** the rigid conductive member (118) has a hollow cylindrical shape.

8. The switching device (100) as claimed in claim 1, **characterized in that** the rigid conductive member (118) is formed of a material comprising at least copper.

9. The switching device (100) as claimed in claim 1, **characterized in that** the actuating arrangement (124) comprises a rotary to linear conversion mechanism.

10. The switching device (100) as claimed in claim 1, **characterized in that** the actuating arrangement (124) comprises a slider-crank mechanism.

11. The switching device (100) as claimed in claim 1, **characterized in that** the insulating gas is Sulfur hexafluoride (SF_6) free gas.

12. The switching device (100) as claimed in claim 1, **characterized in that** the insulating gas comprises carbon dioxide gas and nitrogen gas.

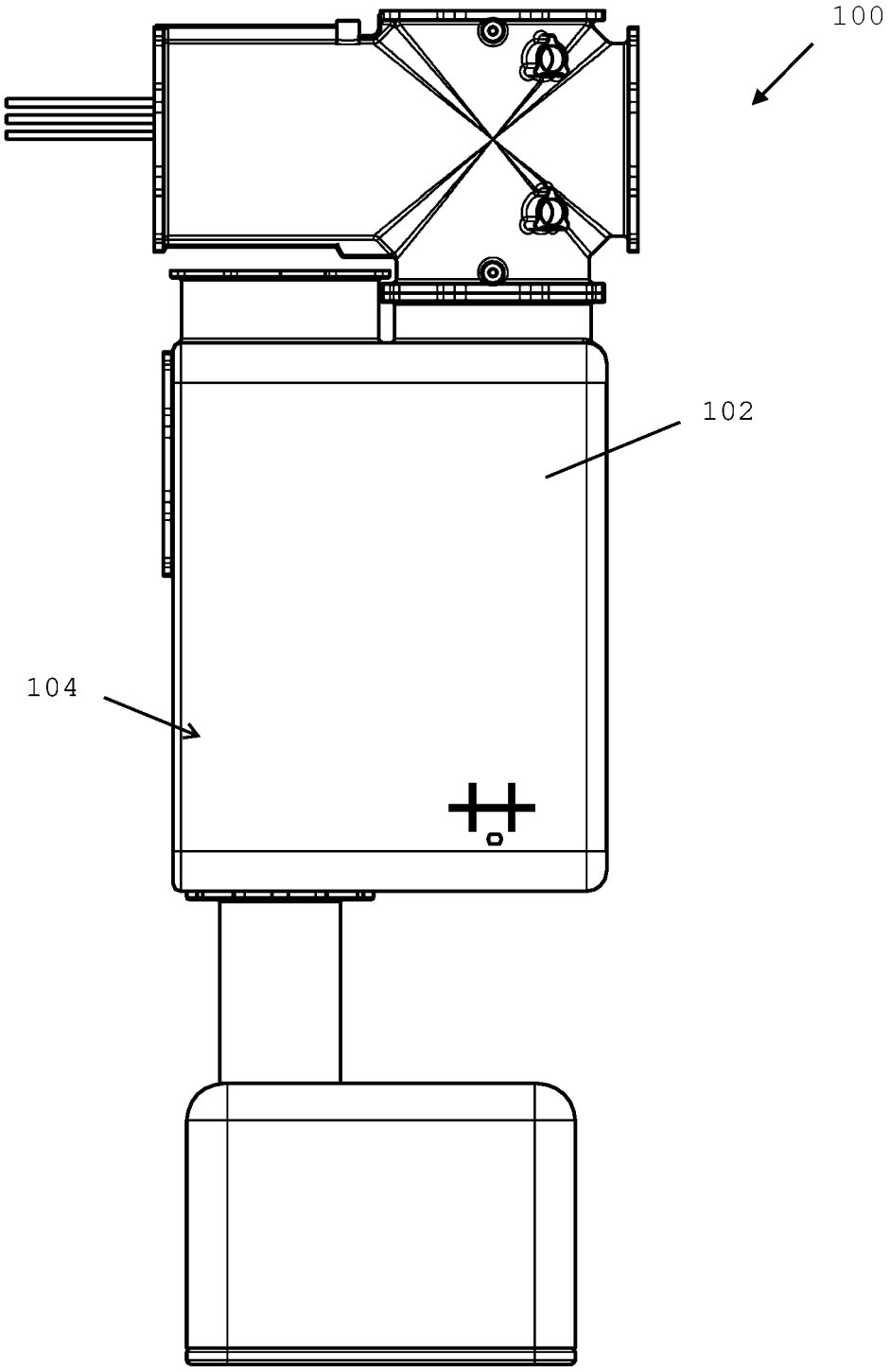

FIG 1

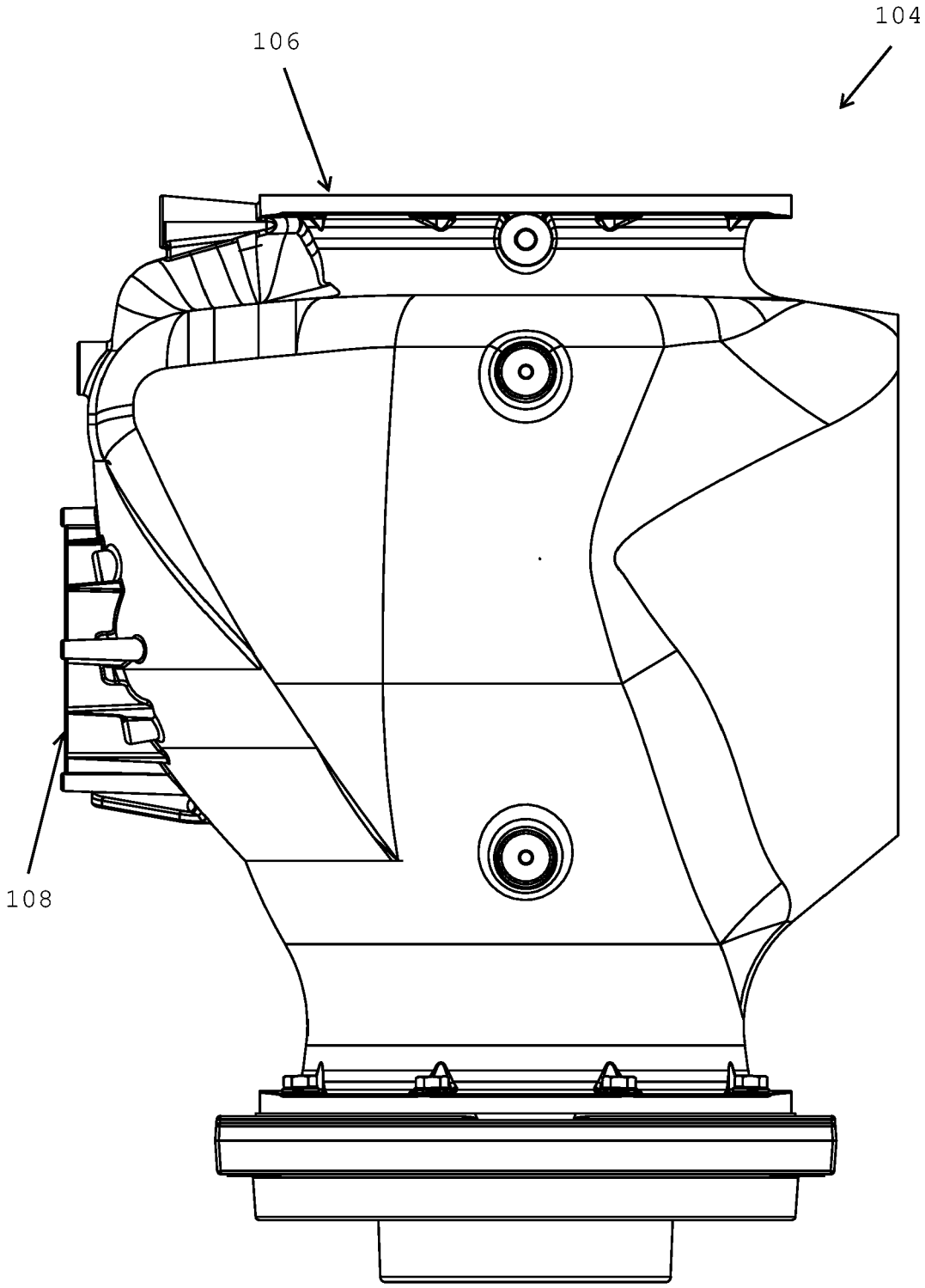

FIG 2

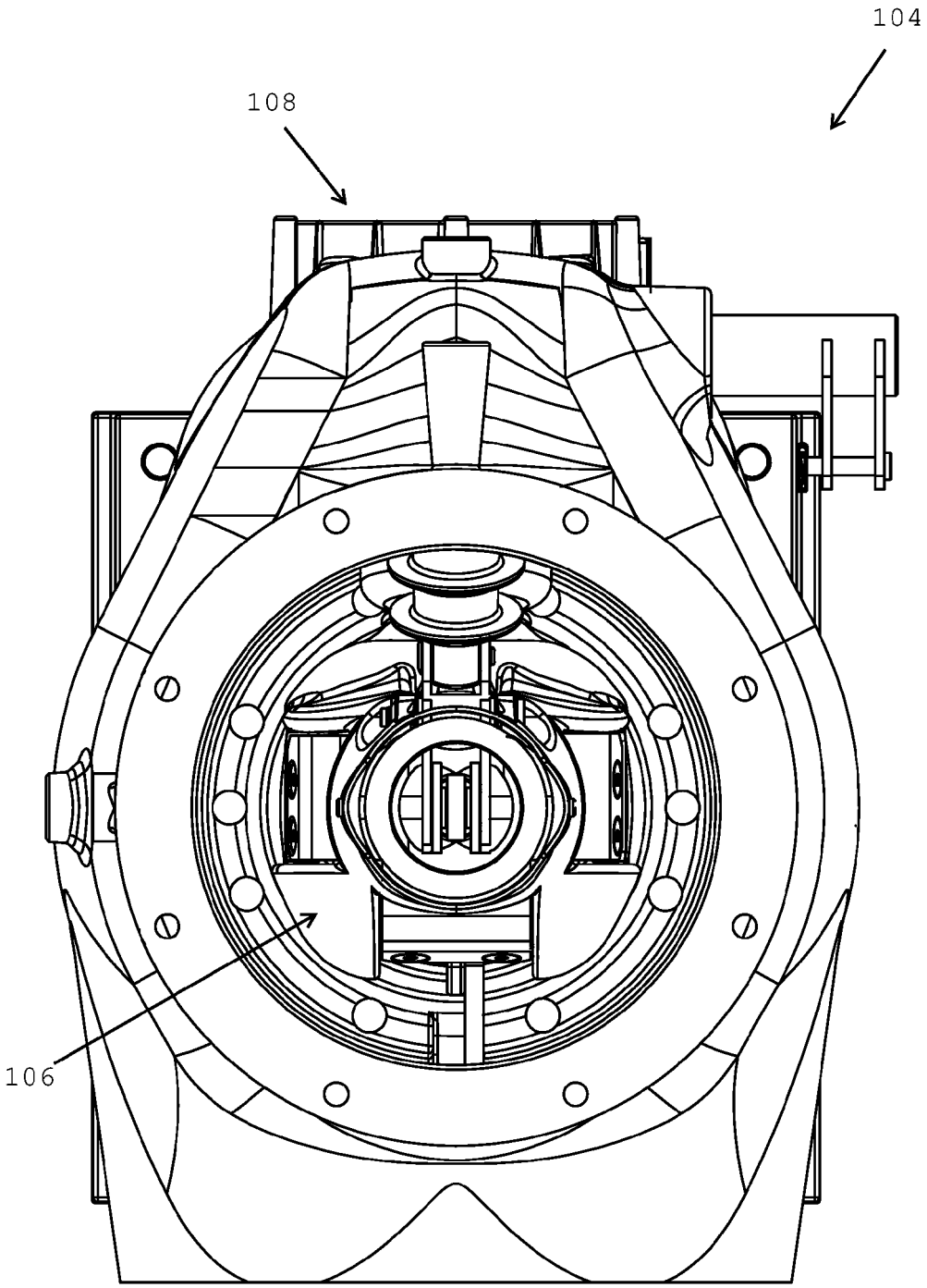

FIG 3

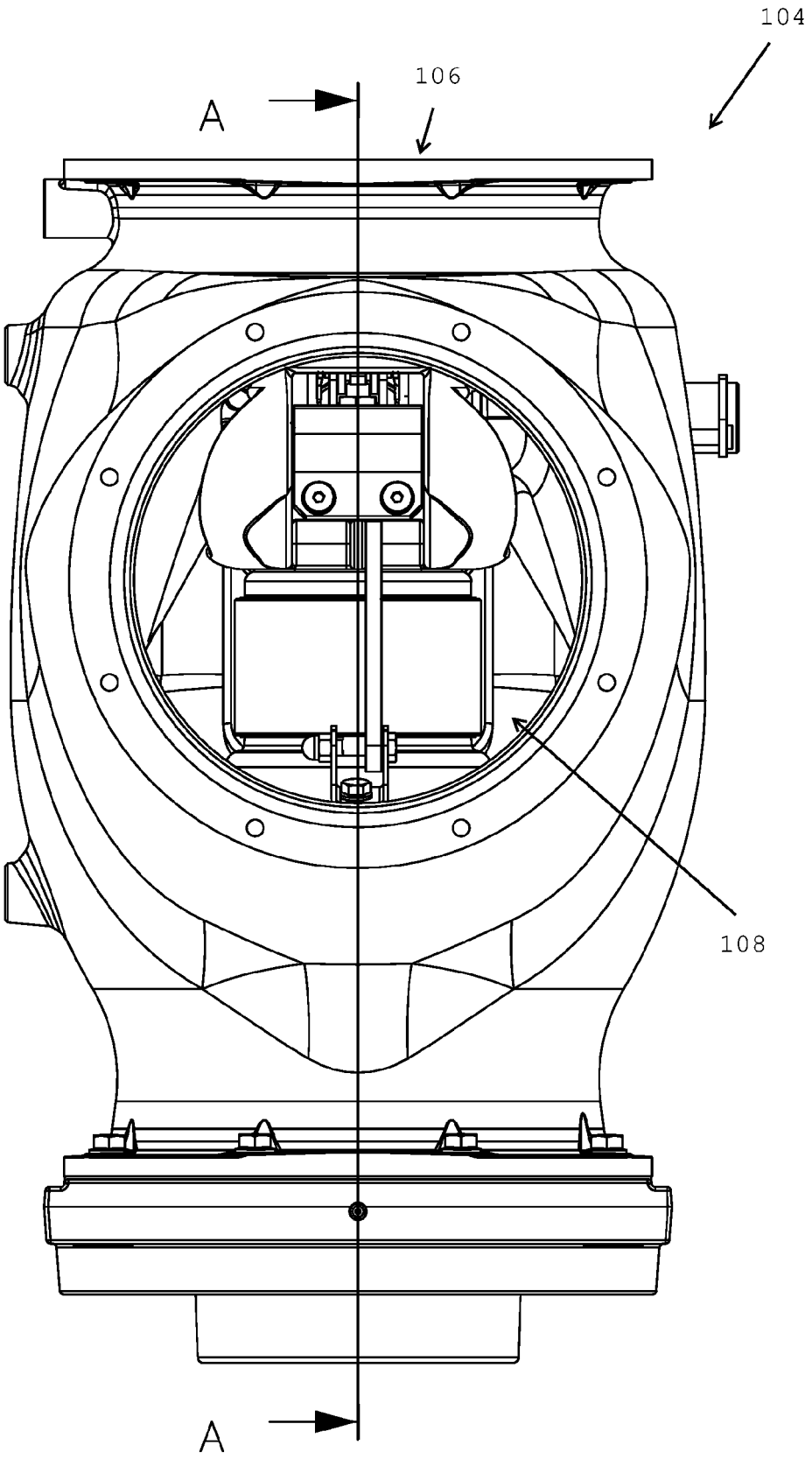

FIG 4

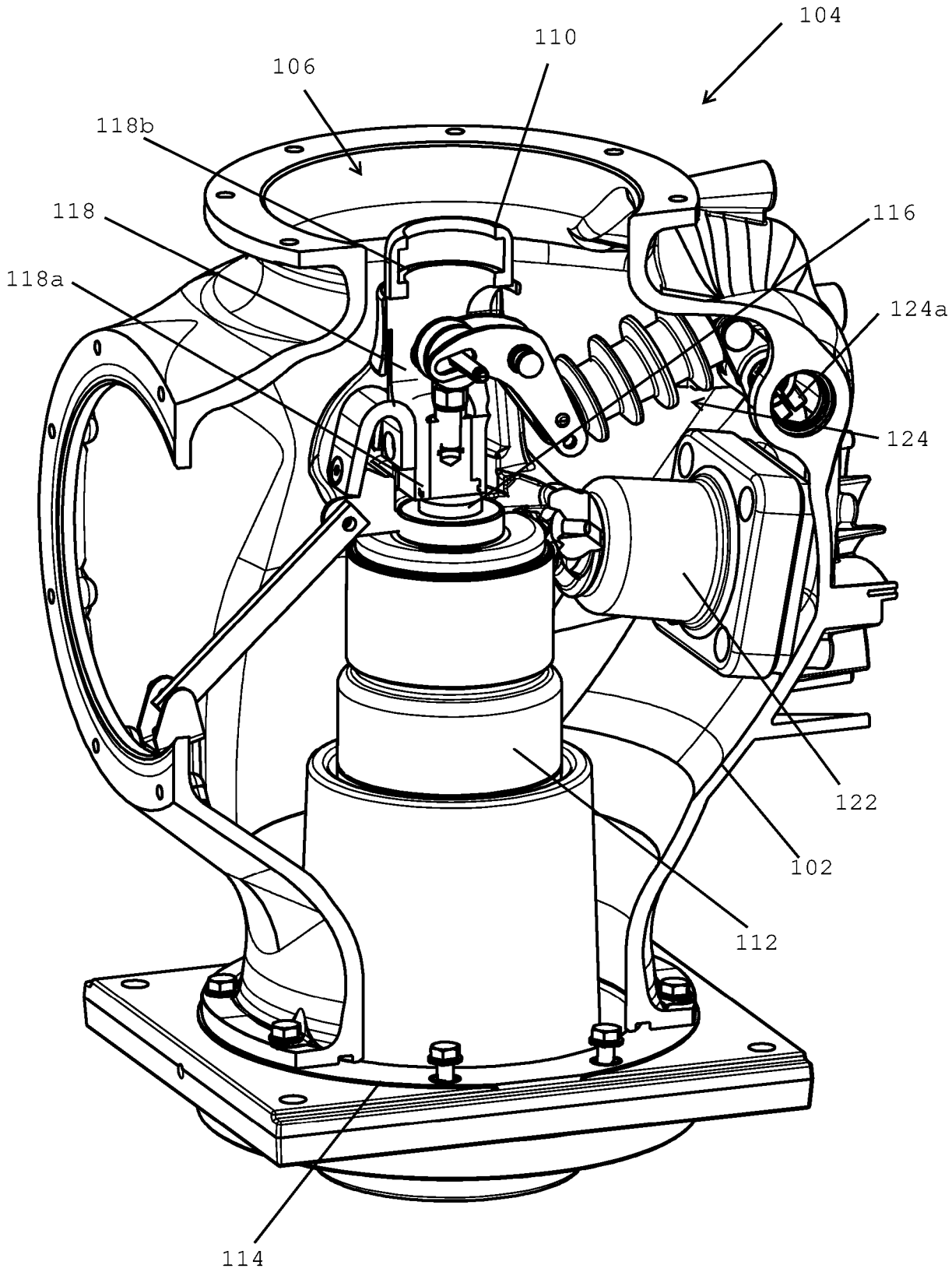

FIG 5

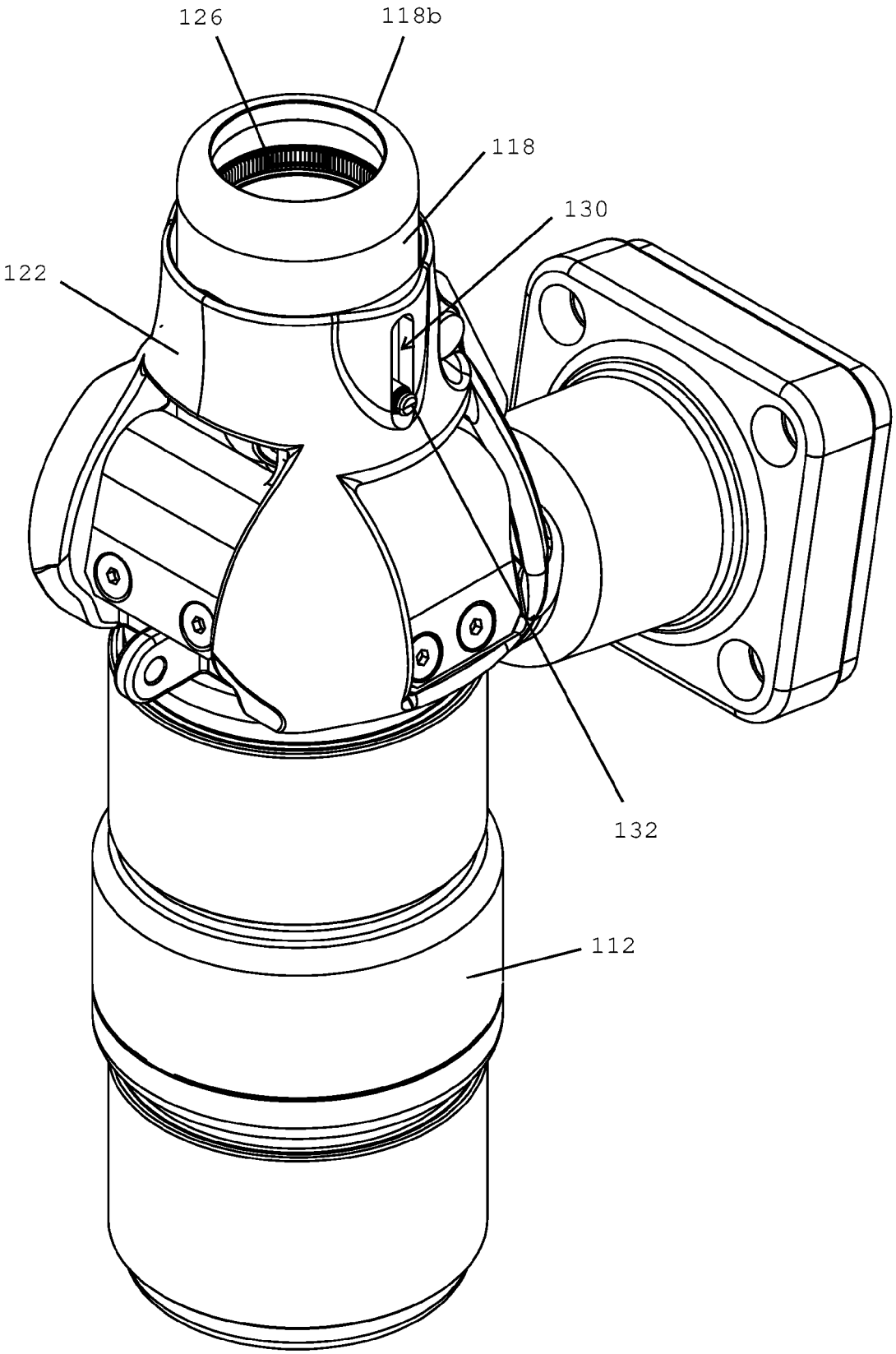

FIG 6

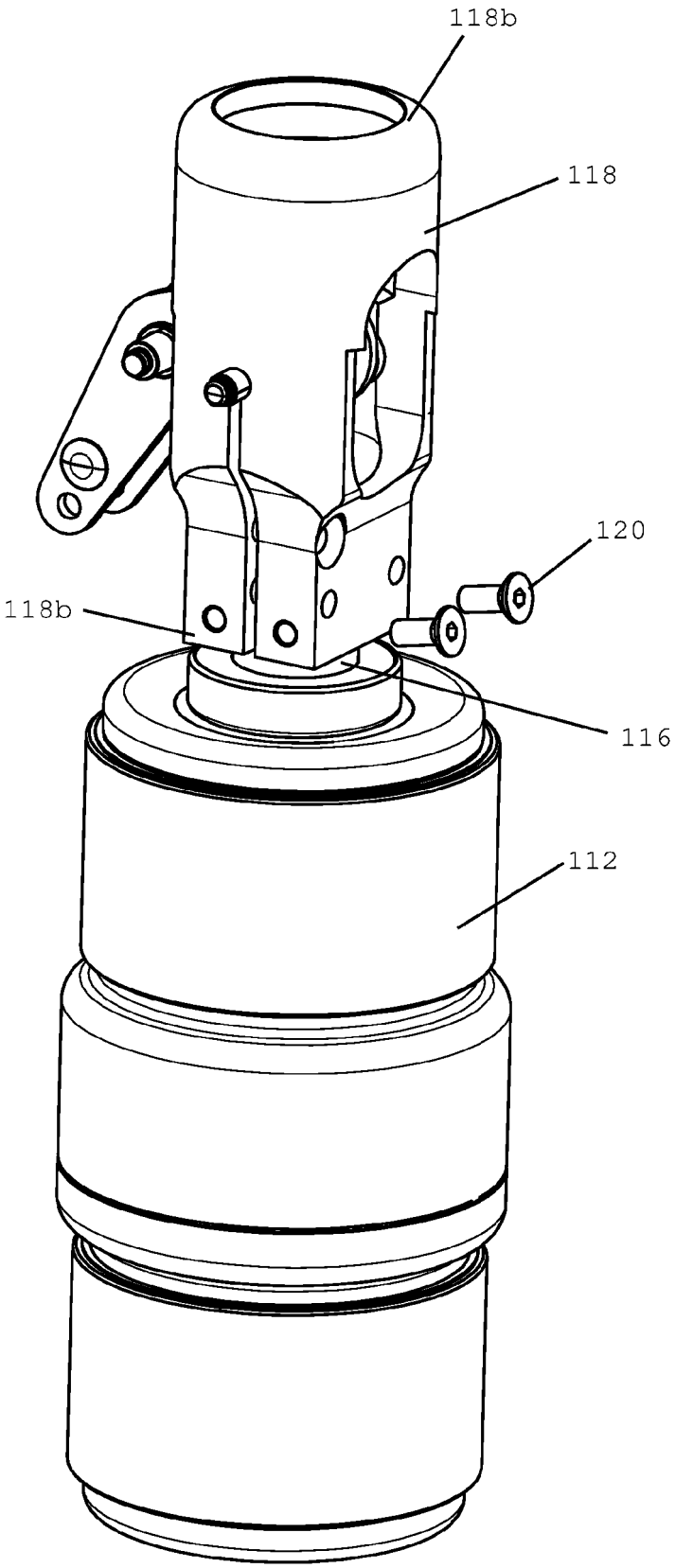

FIG 7

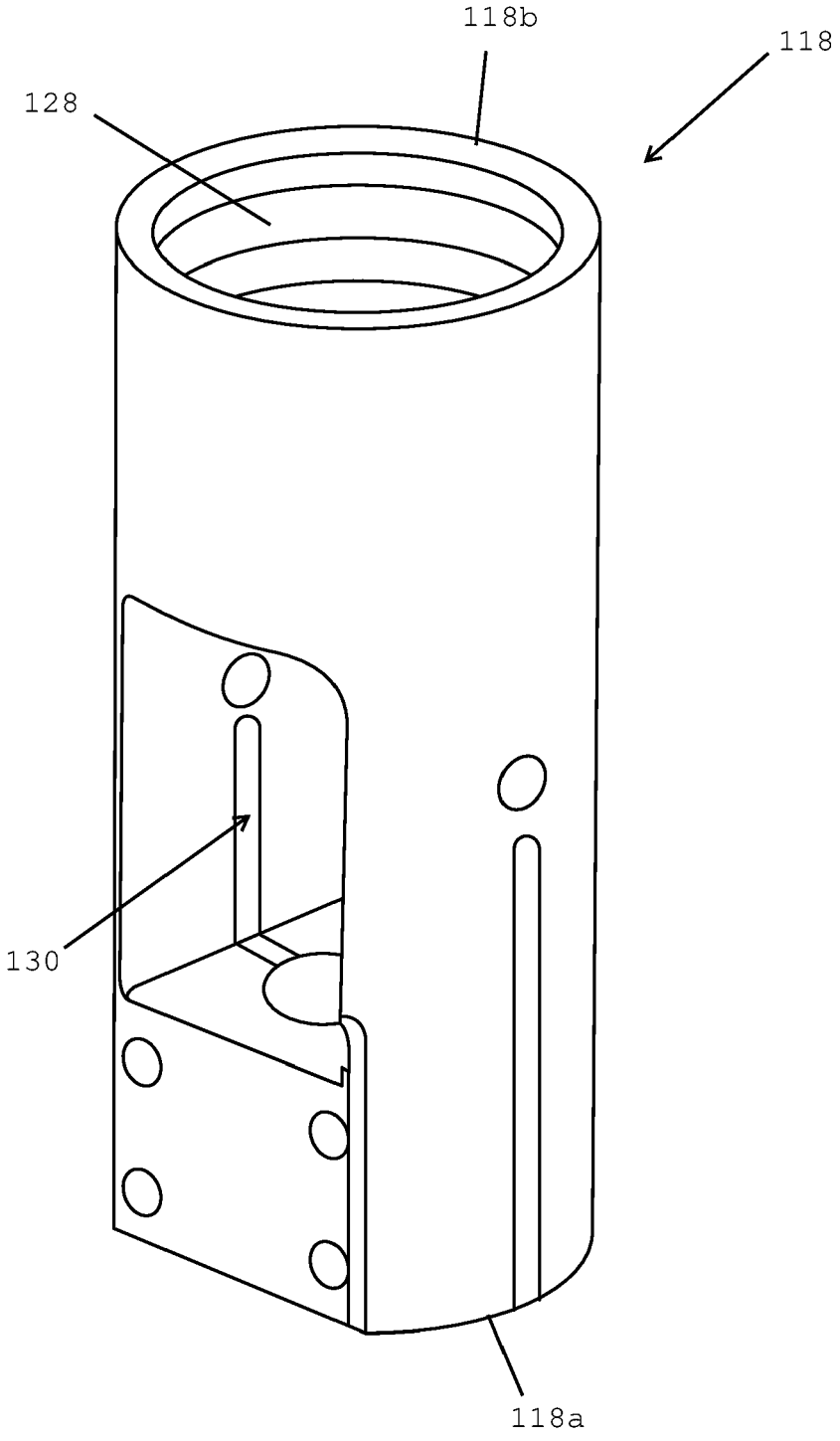

FIG 8

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EUROPEAN SEARCH REPORT

Application Number
EP 20 17 7431

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	DE 10 2007 038898 B3 (SIEMENS AG [DE]) 20 November 2008 (2008-11-20) * paragraph [0023] - paragraph [0029]; figures 1-4 *	1-12	INV. H01H33/66 H01H1/58 H01H1/38 H01H33/12
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H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 November 2020	Nieto, José Miguel

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05-11-2020

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