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(54) SWITCHING DEVICE FOR ELECTRIC POWER DISTRIBUTION

(57) A switching device (100) for opening and closing a circuit is provided. The switching device comprises a vacuum interrupter unit (124) with a first stem (126) and a second stem (128). The switching device further comprises a rigid contact member (140) having a slot (142) and a contact arm (144). The switching device further comprises a compressible contact member (150) positioned inside the slot of the rigid contact member. In the switching device, the second stem is configured to move linearly; such that in a first position, the second stem is in electrical engagement with the compressible contact member thereby closing the circuit, and in the second position, the second stem is out of electrical engagement with the compressible contact member thereby opening the circuit.

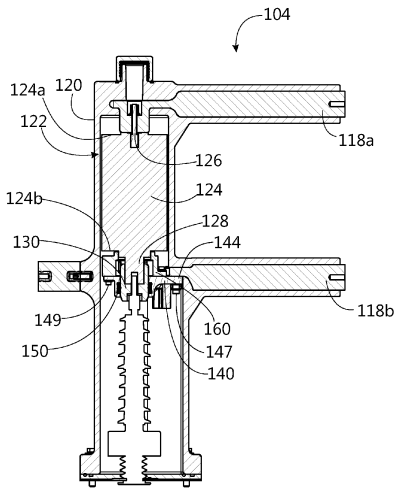

FIG 4

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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 connection arm and a second connection arm in electric power distribution.

[0002] A switching device (also commonly known as switchgear) is an apparatus used for controlling, regulating, and switching on and off the electrical circuit in electrical power distribution. The switching device is typically placed in both high and low voltage side of a 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 electrical power distribution, heavy current flows through equipment due to which there is a risk that the equipment may get damaged, and the service also may get interrupted. Therefore, in order to protect the lines, generators, transformers and other electrical equipment from damage, automatic protective devices, such as the switchgear devices, are utilized.

[0003] A particular type of switching device is a vacuum circuit interrupter apparatus which includes separable main contacts disposed in an insulated housing. Herein, the switchgear, typically, includes a bus-bar compartment, a circuit-breaker compartment, a transformer compartment and a cable bushing compartment which together forms a single-phase pole assembly. Such similar pole assemblies mounted together in adjacent layer will form the entire switchgear. The circuit-breaker compartment consists of a vacuum interrupter which is used to connect and disconnect the circuit which is operated by means of spring-operated drive.

[0004] Conventionally, 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 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 a 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.

[0005] Further, a flexible connector is used for connecting the movable contact to the fixed contact. Typically, the flexible connector is made of 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 0.1 millimeters 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. Herein, the flexible connector connects electrical current carrying connection between the circuit-breaker compartment and the bus-bar compartment. In particular, the flexible connector is mechanically bolted at both ends by nut and bolts which forms rigid connection to bushing between the circuit-breaker compartment and the bus-bar compartment.

[0006] FIG 1A illustrates a partial diagrammatic cross-section representation of a switchgear device 10 implementing a vacuum interrupter based circuit breaker 20, in accordance with prior-art. As shown, the switchgear device 10 has a top contact arm 14 and a bottom contact arm 16 embedded in a housing 12. The circuit breaker 20 has a vacuum interrupter (VI) fixed stem 22 rigidly fixed with the top contact arm 14. A flexible connection 26 is used to join a vacuum interrupter (VI) moving stem 24 to the bottom contact arm 16 of switchgear device 10. The VI moving stem 24 has linear movement for switching the circuit breaker 20 in ON and OFF configurations using the circuit breaker kinematics (not shown). The flexibility of the flexible connection 26 ensures that there is always a contact between the VI moving stem 24 and the bottom contact arm 16. FIG 1B illustrates a diagrammatic representation of the flexible connection 26, in accordance with prior-art. The flexible connection 26, as known in the prior-art, is made from multiple copper foils typically of 0.1 mm thickness which are brazed together to achieve the desired shape and thickness as per cross section required for carry rated current.

[0007] Such flexible connection 26 need to move along with the VI moving stem 26 during ON and OFF operation. Since the flexible connection 26 is part of the main current path, it is critical for temperature rise when continuous current rated current flows through the switchgear device 10.

[0008] Also because of the flexible connection 26, assembly of components becomes bigger and critical for dielectric requirements for the switchgear device 10. Further, the flexible connection 26 typically has sharp edges, thus there is a possibility of dielectric flashovers. Furthermore, the need to bolt the flexible connection 26, especially at the top end requires access space which needs to be incorporated into the design of the switchgear device 10.

[0009] One object of the present disclosure is to provide a switching device for electric power distribution which replaces the flexible connection with a novel contact arrangement which solves critical issues like temperature rise, dielectric requirements, and bigger assembly by carrying out the excess heat and making it dielectrically more stable at the moving stem of the vacuum interrupter with compact and simplified assembly.

[0010] The object of the present disclosure is achieved by a switching device for opening and closing a circuit between a first connection arm and a second connection arm. The switching device comprises an insulated chamber. The switching device further comprises a vacuum interrupter unit arranged inside the insulated chamber and having a first end and a second end. The vacuum interrupter unit provides a first stem located at the first end thereof and a second stem located at the second end thereof. The first stem is disposed in fixed electrical contact with the first connection arm. The switching

device further comprises a rigid contact member having a first end and a second end. The rigid contact member has a slot defined at the first end thereof and a contact arm defined at the second end thereof. The contact arm is disposed in fixed electrical contact with the second connection arm. The switching device further comprises a compressible contact member having a hollow profile adapting to an internal profile of the slot of the rigid contact member. The compressible contact member is positioned inside the slot of the rigid contact member. In the switching device, the second stem of the vacuum interrupter unit is configured to move linearly in the insulated chamber between a first position and a second position. In the first position, the second stem is in electrical engagement with the compressible contact member thereby closing the circuit between the first connection arm and the second connection arm. In the second position, the second stem is out of electrical engagement with the compressible contact member thereby opening the circuit between the first connection arm and the second connection arm.

[0011] In an embodiment, the switching device further comprises a movable contact member fixed to the second stem at the second end of the vacuum interrupter unit. The movable contact member has a profile adapted to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0012] In an embodiment, the compressible contact member is formed of multiple strips of a conducting material joined together to impart radial flexibility thereto, and ensuring physical connection with the movable contact member when received inside the hollow profile thereof.

[0013] In an embodiment, the switching device further comprises a heat sink having a body with a complementary slot to the slot of the rigid contact member. The heat sink is associated with the rigid contact member such that the complementary slot thereof is aligned with the slot of the rigid contact member, and thereby guide the movable contact member to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0014] In an embodiment, the heat sink comprises a plurality of fins extending radially outwardly from the body thereof.

[0015] In an embodiment, the insulated chamber is made of epoxy resin material.

[0016] In another aspect, a vacuum interrupter assembly for a switching device is provided. The vacuum interrupter assembly comprises a vacuum interrupter unit having a first end and a second end. The vacuum interrupter unit provides a first stem located at the first end thereof and a second stem located at the second end thereof. The vacuum interrupter assembly further comprises a rigid contact member having a first end and a second end. The rigid contact member has a slot defined at the first end thereof and a contact arm defined at the second end thereof. The vacuum interrupter assembly further comprises a compressible contact member having a hollow profile adapting to an internal profile of the slot of the rigid contact member. The compressible contact member is positioned inside the slot of the rigid contact member. Herein, the second stem of the vacuum interrupter unit is configured to move linearly between a first position and a second position, wherein in the first position, the second stem is in electrical engagement with the compressible contact member, and wherein in the second position, the second stem is out of electrical engagement with the compressible contact member.

[0017] In an embodiment, the vacuum interrupter assembly further comprises a movable contact member fixed to the second stem at the second end of the vacuum interrupter unit. The movable contact member has a profile adapted to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0018] In an embodiment, the compressible contact member is formed of multiple strips of a conducting material joined together to impart radial flexibility thereto, and ensuring physical connection with the movable contact member when received inside the hollow profile thereof

[0019] In an embodiment, the vacuum interrupter assembly further comprises a heat sink having a body with a complementary slot to the slot of the rigid contact member. The heat sink is associated with the rigid contact member such that the complementary slot thereof is aligned with the slot of the rigid contact member, and thereby guide the movable contact member to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0020] In an embodiment, the heat sink comprises a plurality of fins extending radially outwardly from the body thereof.

[0021] In an embodiment, the movable contact member has a hollow cylindrical profile adapted to be received inside a hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0022] In yet another aspect, a method of operating a switching device for opening and closing a circuit between a first connection arm and a second connection arm is provided. The method comprises providing an insulated chamber. The method further comprises arranging a vacuum interrupter unit inside the insulated chamber, with the vacuum interrupter unit having a first end and a second end, and the vacuum interrupter unit providing a first stem located at the first end thereof and a second stem located at the second end thereof. The method further comprises disposing the first stem in fixed electrical contact with the first connection arm. The method further comprises providing a rigid contact member, with the rigid contact member having a first end and a second end, and a slot defined at the first end thereof and a contact arm defined at the second end thereof. The method further comprises disposing the contact arm in fixed electrical contact with the second connection arm. The method further comprises positioning a compressible contact

member, having a hollow profile, adapting to an internal profile of the slot of the rigid contact member, inside the slot of the rigid contact member. The method further comprises reciprocating the second stem of the vacuum interrupter unit to move linearly in the insulated chamber between a first position and a second position. In the first position, the second stem is in electrical engagement with the compressible contact member thereby closing the circuit between the first connection arm and the second connection arm. In the second position, the second stem is out of electrical engagement with the compressible contact member thereby opening the circuit between the first connection arm and the second connection arm.

[0023] In an embodiment, the method also comprises providing a movable contact member fixed to the second stem at the second end of the vacuum interrupter unit, with the movable contact member having a profile adapted to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0024] In an embodiment, the method also comprises providing a heat sink having a body with a complementary slot to the slot of the rigid contact member. The method further comprises associating the heat sink with the rigid contact member such that the complementary slot thereof is aligned with the slot of the rigid contact member, and thereby guide the movable contact member to be received inside the hollow profile of the compressible contact member when the second stem is disposed in the first position thereof.

[0025] Other aspects, features, and advantages of the present disclosure 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 present disclosure. The present disclosure 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 present disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

[0026] 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 1A is a diagrammatic partial cross-sectional view of a pole assembly, in accordance with prior-art;

FIG 1B is a diagrammatic perspective view representation of a flexible connection, in accordance with prior-art;

FIG 2 is a diagrammatic perspective view of a switching device, in accordance with certain embodiments of the present disclosure;

FIG 3 is a diagrammatic perspective view of a pole assembly of the switching device, in accordance with certain embodiments of the present disclosure;

FIG 4 is a diagrammatic partial cross-sectional view of the pole assembly, in accordance with an embodiment of the present disclosure;

FIG 5 is a diagrammatic perspective view of a movable contact member, in accordance with an embodiment of the present disclosure;

FIG 6A is a diagrammatic top perspective view of a rigid contact member, in accordance with an embodiment of the present disclosure;

FIG 6B is a diagrammatic bottom perspective view of the rigid contact member, in accordance with an embodiment of the present disclosure;

FIG 7 is a diagrammatic perspective view of a compressible contact member, in accordance with an embodiment of the present disclosure;

FIG 8 is a diagrammatic perspective view of a heat sink, in accordance with an embodiment of the present disclosure;

FIG 9 is a diagrammatic perspective view of a connection support member for the heat sink, in accordance with an embodiment of the present disclosure;

FIG 10A is a diagrammatic perspective view of an assembly of the rigid contact member and the heat sink, in ac-

cordance with an embodiment of the present disclosure;

FIG 10B is a diagrammatic perspective view of an assembly of the rigid contact member and the compressible contact member, in accordance with an embodiment of the present disclosure;

FIG 11 is a diagrammatic view of a vacuum interrupter assembly, in accordance with an embodiment of the present disclosure; and

FIG 12 is a flowchart listing steps involved in a method of operating a switching device for opening and closing a circuit between a first connection arm and a second connection arm, in accordance with an embodiment of the present disclosure.

[0027] Various embodiments are described with reference to 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 is apparent, however, to one skilled in the art that the embodiments of the present disclosure 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 present disclosure.

[0028] Example embodiments of a switching device described herein is a vacuum interrupter based switchgear which may be included in a medium voltage switchgear unit. Such switching device may be used in several different applications, for instance, 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. The switching device 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, as per the embodiments of the present disclosure. In the present embodiments, the switching device may be implemented as a gas-insulated switchgear, a vacuum interrupter or an air-break disconnector.

[0029] FIG 2 is a diagrammatic perspective view of an exemplary switching device 100, in accordance with certain embodiments. In the present illustration, the switching device 100 is depicted as a three-phase medium voltage switchgear, that is to say the switching device 100 has a plurality of phase conductor sections, which are used to transmit electrical power by means of a polyphase electrical power system. In the present case, the switching device 100 and further modules of the switching device 100, and therefore the entire polyphase switching device 100, are designed for three phases; however, it may be contemplated that for the purposes of the present disclosure, the switching device 100 may be a single phase or any other type of switchgear as known in the art without any limitations.

[0030] As illustrated, the switching device 100 includes a housing 102. Also, as shown, the housing 102 supports three pole assemblies 104 therein. Herein, each pole assembly 104 (sometimes, simply referred to as a pole 104) is responsible for a single phase in the three-phase switching device 100 of the present examples. The switching device 100 may further include a control panel (generally represented by the numeral 106) which acts on a switching shaft (not shown) common to all the poles 104 of the switching device 100.

[0031] FIG 3 is a diagrammatic perspective view representation of the pole assembly 104 of the switching device 100, in accordance with certain embodiments. The pole assembly 104 includes an enclosure 108. The enclosure 108 is generally hollow and may have any suitable shape based on the design and configuration of the switching device 100. Herein, the enclosure 108 is typically grounded during operation, i.e., electrically connected to earth. Advantageously, the enclosure 108 is made of a suitable electrically conductive material, e.g., aluminum (such as, cast aluminum), mild steel, etc. Casting, or molding, an aluminum enclosure is a non-expensive procedure. However, the enclosure 108 can also be made of copper, zinc or any other suitable electrically conductive material.

[0032] In the switching device 100, the enclosure 108 is filled with an insulating gas. In an embodiment, the switching device 100 is an air-insulated switching device, i.e., the enclosure 108 is filled with air. In some embodiments, the insulating gas is sulfur hexafluoride (SF_6) free gas. It may be understood that in order to accommodate the insulating gas, the enclosure 108 is sealed and in turn may preferably be made of a material which is gas-impermeable, such as glass, polymers or resins.

[0033] In some examples, a filler material (not shown) may be provided in the housing 102 (as shown in FIG 2), surrounding the enclosure 108 filled with the insulating gas (such as, air), with the filler material having preferably a higher specific permittivity as compared to the enclosure 108 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 108. 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.

[0034] In some implementations, an outer shape, or an outer geometry, of the enclosure 108 is smooth to distribute the electric field generated by the voltage through the switching device 100. The outer surface of the enclosure 108 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 108 is smooth in that the enclosure 108 does not have an angular outer shape and is without roughness. That is, the outer surface of the enclosure 108 is smooth in that the outer surface has no roughness, sharp projections or sharp indentations.

[0035] As illustrated in FIG 3, the enclosure 108 is generally divided, such that each pole 104 of the switching device 100 includes a bus-bar enclosure 110, a circuit-breaker enclosure 112, a transformer enclosure 114 (also known as current transformer) and a cable bushing enclosure 116. It may be appreciated that each of the bus-bar enclosure 110, the circuit-breaker enclosure 112, the transformer enclosure 114 and the cable bushing enclosure 116 forms a part or a section of the enclosure 108. Hereinafter, the various components and assemblies of the bus-bar enclosure 110, the circuit-breaker enclosure 112, the transformer enclosure 114 and the cable bushing enclosure 116 have been described generally being part of the pole assembly 104 and/or the switching device 100 without any limitations. As discussed, it may be understood that the enclosure 108, with all the sections therein, is filled with the insulating gas. That is, each of the bus-bar enclosure 110, the circuit-breaker enclosure 112, the transformer enclosure 114 and the cable bushing enclosure 116 therein, is filled with the insulating gas as described above.

[0036] FIG 4 is a diagrammatic partial cross-sectional view representation of the pole assembly 104 of the switching device 100, in accordance with an embodiment of the present disclosure. In particular, FIG 4 shows details of inside of the circuit-breaker enclosure 112 in the pole assembly 104. Referring to FIGS 2-4 in combination, as illustrated, the pole assembly 104 includes a first connection arm 118a and a second connection arm 118b of the switching device 100. Typically, the first connection arm 118a is received generally in the bus-bar enclosure 110; and the second connection arm 118b is received generally in the cable bushing enclosure 116, extending into the circuit-breaker enclosure 112. It may be appreciated that the first connection arm 118a and the second connection arm 118b may each include multiple electrical lines based on the design and configuration (e.g., multi-phase configuration) of the switching device 100.

[0037] In the present examples, the first connection arm 118a and the second connection arm 118b may be busbars, but may also be in the form of any other electrical conductor without any limitations. In particular, the first connection arm 118a and the second connection arm 118b may include a number of electrical bushings (not shown) penetrating into the respective bus-bar enclosure 110 and the cable bushing enclosure 116, one for each phase of a plural phase system. The bushings may be brazed in end covers. On the outside of the enclosure 108, the first connection arm 118a and the second connection arm 118b 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. In some examples, the first connection arm 118a and the second connection arm 118b may each engage a fitting (not shown) to join the power cables of the power distribution line.

[0038] As illustrated in FIG 4, the switching device 100 includes an insulated chamber 120. It may be appreciated that the insulated chamber 120 may generally be part of the enclosure 108 (as described above). In an embodiment of the present disclosure, the insulated chamber 120 is made of epoxy resin material. Such materials provide good dielectric resistance and thus are suited to be used for manufacturing of the insulated chamber 120, as needed for the purposes of the present disclosure. It may be appreciated that, in other examples, the insulated chamber 120 may be made of other suitable material with high dielectric resistance without any limitations.

[0039] Further, as illustrated, the switching device 100 includes a vacuum interrupter assembly 122. Herein, the vacuum interrupter assembly 122 acts as the circuit-breaker for opening and closing a circuit between the first connection arm 118a and the second connection arm 118b. The vacuum interrupter assembly 122, as part of the switching device 100, includes a vacuum interrupter unit 124. As shown, the vacuum interrupter unit 124 is arranged inside the insulated chamber 120. The vacuum interrupter unit 124 has a generally cylindrical shape. The term "generally cylindrical" is used to mean that a housing of the vacuum interrupter unit 124 is substantially cylindrical but not necessarily of circular cross-section. Other less preferred cross-sections may be employed, if desired. In some examples, the vacuum interrupter unit 124 may have ribbed sections on its outer surface. The vacuum interrupter unit 124 is aligned substantially coaxially to a central axis of the insulated chamber 122.

[0040] As shown in FIG 4, the vacuum interrupter unit 124 has a first end 124a and a second end 124b. The vacuum interrupter unit 124 provides a first stem 126 located at the first end 124a thereof. Herein, the first stem 126 is disposed in fixed electrical contact with the first connection arm 118a. In one example, the first stem 126 may have contact points formed from copper-impregnated tungsten to be disposed in fixed electrical contact with the first connection arm 118a, of the switching device 100. The vacuum interrupter unit 124 further provides a second stem 128 located at the second end 124b thereof. In an example embodiment, the second stem 128 may be in the form of a cylindrical extension from the second end 124b of the vacuum interrupter unit 124.

[0041] In the switching device 100, the vacuum interrupter unit 124 is adapted to move linearly inside the insulated

chamber 122. The switching device 100 includes an actuating arrangement (not shown) configured to reciprocate the vacuum interrupter unit 124 to move linearly inside the insulated chamber 122 to be disposed between a first position and a second position. In particular, the actuating arrangement is configured to reciprocate the second stem 128 of the vacuum interrupter unit 124 to move linearly in the insulated chamber 122 between the first position and the second position. In one or more embodiments, the actuating arrangement may include a rotary to linear conversion mechanism. Specifically, the actuating arrangement may include a slider-crank mechanism. Herein, the actuating arrangement is connected to a rotating shaft (not shown) extending from outside into the insulated chamber 122 to provide input rotations, to be converted into reciprocating linear movement of the vacuum interrupter unit 124 inside the insulated chamber 122. Such actuating arrangement may be contemplated by a person skilled in the art and thus has not been described in detail herein for the brevity of the present disclosure.

[0042] In some embodiments, the switching device 100, or specifically the vacuum interrupter assembly 122, includes a movable contact member 130. FIG 5 illustrates a detailed view of the movable contact member 130, in accordance with an embodiment of the present disclosure. As shown, the movable contact member 130 has a generally hollow cylindrical profile. The movable contact member 130 has a body 132 which is made of conductive material, such as, but not limited to, copper. The movable contact member 130 defines a through-hole 134 in the body 132 thereof. The through-hole 134, in the body 132 of the movable contact member 130, is sized and shaped to receive and engage with the second stem 128 of the vacuum interrupter unit 124 therein. Thereby, the movable contact member 130 is fixed to the second stem 128 at the second end 124b of the vacuum interrupter unit 124. As discussed, the vacuum interrupter unit 124 has a linear movement inside the insulated chamber 122, thus the movable contact member 130, which is fixed to the second stem 128 at the second end 124b of the vacuum interrupter unit 124, may move along with the vacuum interrupter unit 124 in the insulated chamber 122.

[0043] According to embodiments of the present disclosure, the switching device 100, or specifically the vacuum interrupter assembly 122, includes a rigid contact member 140. FIGS 6A-6B illustrate detailed views of the rigid contact member 140, in accordance with an embodiment of the present disclosure. As shown, generally, the rigid contact member 140 has a hollow cylindrical shape. The rigid contact member 140 has a first end 140a and a second end 140b. The rigid contact member 140 has a slot 142 defined at the first end 140a thereof. Herein, the slot 142 may be in the form of a through-hole in the rigid contact member 140, imparting the hollow cylindrical shape thereto (as discussed).

[0044] The rigid contact member 140 further has a contact arm 144 defined at the second end 140b thereof. As may be seen, the contact arm 144 may be extending from the second end 140b of the rigid contact member 140 in a direction opposite to the first end 140a thereof. In the present embodiments, the contact arm 144 is disposed in fixed electrical contact with the second connection arm 118b. As shown, the contact arm 144 has apertures 146 defined therein. In an example, as may be seen in FIG 4, the contact arm 144 may be coupled to the second connection arm 118b using fastening members 147, such as bolts, passing through the apertures 146 in the contact arm 144 and corresponding apertures (not shown) in the second connection arm 118b, to dispose the contact arm 144 in fixed electrical contact with the second connection arm 118b, in the switching device 100.

[0045] Referring back to FIGS 6A-6B, the rigid contact member 140 further has apertures 148a proximal to the first end 140a thereof and apertures 148b proximal to the second end 140b thereof. Herein, as may be seen in FIG 4, the rigid contact member 140 may be supported directly or indirectly with the insulated chamber 122 by using fastening members 147, such as bolts, passing through the apertures 148a in the rigid contact member 140 and corresponding apertures (not shown) in the insulated chamber 122, to mount the rigid contact member 140 in the switching device 100. Further, the apertures 148b in the rigid contact member 140 may be implemented to support other components in the switching device 100 for its operation, as discussed in the proceeding paragraphs.

[0046] Again, referring to FIG 4, the switching device 100, or specifically the vacuum interrupter assembly 122, includes a compressible contact member 150. FIG 7 illustrates a detailed view of the compressible contact member 150, in accordance with an embodiment of the present disclosure. In one or more embodiments of the present disclosure, the compressible contact member 150 is formed of multiple strips 152 of a conducting material. Such multiple strips 152 are joined together such that, as shown, the compressible contact member 150 has a hollow profile 154 (as shown in FIG. 10B). In particular, the compressible contact member 150 has a hollow cylindrical profile. With the multiple strips 152 having thin sheet-like profile, the multiple strips 152 when joined together impart radial flexibility to the compressible contact member 150.

[0047] In the present embodiments, the hollow profile 154 of the compressible contact member 150 adapts (conforms) to an internal profile of the slot 142 of the rigid contact member 140. This way the compressible contact member 150 is positioned inside the slot 142 of the rigid contact member 140. That is, as may be seen from FIG 4 and may be better seen from FIG 10B (as discussed later), the compressible contact member 150 is arranged (sits) within the slot 142 (not shown in FIG 4) of the rigid contact member 140. As discussed, the movable contact member 130 linearly translates in the insulated chamber 120 along with the second stem 128 of the vacuum interrupter unit 124 between the first position and the second position. Herein, the movable contact member 130 has the hollow cylindrical profile adapted to be received inside the hollow profile 154 of the compressible contact member 150 when the second stem 128 is disposed

in the first position thereof. In the present embodiments, the compressible contact member 150 with its radial flexibility ensures physical connection with the movable contact member 130 when received inside the hollow profile 154 thereof. As may be understood, the compressible contact member 150 may generally be disposed in its relaxed state inside the slot 142 of the rigid contact member 140; and when the movable contact member 130 is received inside the hollow profile 154 thereof, the compressible contact member 150 may compress ensuring physical (and thereby electrical) connection with the movable contact member 130, and also disposing the movable contact member 130 in electrical connection with the rigid contact member 140.

[0048] Now, as may be understood, since the rigid contact member 140 is in electrical contact with the second connection arm 118b, the second stem 128 (via the movable contact member 130) may be disposed in electrical engagement with the second connection arm 118b, when the movable contact member 130 is received inside the hollow profile 154 of the compressible contact member 150. Thereby, in the switching device 100 of the present disclosure, in the first position, the second stem 128 is in electrical engagement with the compressible contact member 150 thereby closing the circuit between the first connection arm 118a and the second connection arm 118b (i.e., disposing the switching device 100 in ON configuration). Further, in the second position, the second stem 128 is out of electrical engagement with the compressible contact member 150 thereby opening the circuit between the first connection arm 118a and the second connection arm 118b (i.e., disposing the switching device 100 in OFF configuration).

[0049] In one or more embodiments, the switching device 100, or specifically the vacuum interrupter assembly 122, further includes a heat sink 160. FIG 8 illustrates a detailed view of the heat sink 160, in accordance with an embodiment of the present disclosure. As shown, the heat sink 160 has a body 162. In the illustrated example, the heat sink 160 is shown to have the body 162 with a generally hollow cylindrical profile. The body 162 of the heat sink 160 has a slot 166 in the form of a through-hole defined therein. Herein, the slot 166 is complementary to the slot 142 of the rigid contact member 140. In the present configuration, the heat sink 160 is associated with the rigid contact member 140. Specifically, as may be seen from FIG 4 and may be better seen from FIG 10A (as discussed later), the heat sink 160 is arranged with respect to the rigid contact member 140 such that the complementary slot 166 thereof is aligned with the slot 142 of the rigid contact member 140. With the heat sink 160 extending upwardly from the rigid contact member 140, the heat sink 160 is able to guide the movable contact member 130 to be received inside the hollow profile 154 of the compressible contact member 150 when the second stem 128 is disposed in the first position thereof.

[0050] Also, as illustrated in FIG 8, the heat sink 160 includes a plurality of fins 164 extending radially outwardly from the body 162 thereof. As may be understood by a person skilled in the art of thermal engineering, the body 162 and the plurality of fins 164, for the heat sink 160, may be made of a material with high thermal conductivity, so as to allow for dissipation of heat (as discussed later). In an embodiment, the heat sink 160, including the body 162 and the plurality of fins 164, may be made of, but not limited to, Aluminum.

[0051] Further, in an embodiment, as illustrated in FIG 8, the heat sink 160 has a portion 168 defined in the body 162 thereof, with no fins (such as, the fins 164) extending therefrom. The said portion 168, of the heat sink 160, has an extension with apertures 169 defined therein. Also, as illustrated in FIG 9, for the purposes of the present embodiment, the switching device 100 may also include a connection support member 170. The connection support member 170 has a body 172 which may be made of same material as the body 162 of the heat sink 160 (such as, Aluminum). Herein, the body 172 of the connection support member 170 has an arcuate profile conforming to the circular profile of the body 162 of the heat sink 160. Also, as shown, the connection support member 170 includes a plurality of fins 174 extending from the body 172 thereof. Herein, the fins 174 of the connection support member 170 may generally be similar in configuration to the fins 164 of the heat sink 160. Further, the body 172 of the connection support member 170 has apertures 176 defined therein.

[0052] Referring now to FIG 10A, illustrated is a diagrammatic perspective view of an assembly (represented by reference numeral 180) of the rigid contact member 140 and the heat sink 160, in accordance with an embodiment of the present disclosure. As shown, the heat sink 160 is associated with the rigid contact member 140 such that the complementary slot 166 thereof is aligned with the slot 142 (not shown in FIG 10A) of the rigid contact member 140. Further, as shown, the heat sink 160 is mounted to the rigid contact member 140 by using bolts 182 passing through the apertures 148a in the rigid contact member 140 and corresponding apertures (not shown) in the heat sink 160 from one side, and also by using bolts 184 passing through the apertures 148b in the rigid contact member 140 and the corresponding apertures 169 in the heat sink 160 as well as the apertures 176 in the connection support member 170 from other side. Also, referring to FIG 10B, illustrated is a diagrammatic perspective view of an assembly (represented by reference numeral 190) of the rigid contact member 140 and the compressible contact member 150. As shown, the compressible contact member 150 is positioned inside the slot 142 (not shown in FIG 10B) of the rigid contact member 140, to have the hollow profile 154 thereof able to receive the movable contact member 130 therein when the second stem 128 is disposed in the first position thereof.

[0053] FIG 11 illustrates a detailed view of the vacuum interrupter assembly 122. As illustrated, the vacuum interrupter assembly 122 includes the vacuum interrupter unit 124 having the first end 124a and the second end 124b. The vacuum interrupter unit 124 provides the first stem 126 located at the first end 124a thereof and the second stem 128 located at

the second end 124b thereof. The vacuum interrupter assembly 122 further includes the rigid contact member 140. The rigid contact member has the compressible contact member (such as the compressible contact member 150, not shown in FIG 11) positioned therein. Herein, the second stem 128 of the vacuum interrupter unit 124 is configured to move linearly along an axis 'A' (as shown) between the first position and the second position. In the first position, the second stem 128 is in electrical engagement with the compressible contact member 150. In the second position, the second stem 128 is out of electrical engagement with the compressible contact member 150. In an embodiment, as shown in FIG 11, the vacuum interrupter assembly 122 includes the movable contact member 130 fixed to the second stem 128 at the second end 124b of the vacuum interrupter unit 124. Herein, the movable contact member 130 is received inside the hollow profile of the compressible contact member 150 when the second stem 128 is disposed in the first position thereof. In an embodiment, the vacuum interrupter assembly 122 further includes the heat sink 160 associated with the rigid contact member 140 for dissipating heat generated dur to electrical engagement as described above.

[0054] In the switching device 100 and the vacuum interrupter assembly 122 of the present disclosure, the compressible contact member 150 acts as a multi-laminated contact and is housed inside the rigid contact member 140, which is fixed and stationary. Herein, the compressible contact member 150 provides a current transfer point, and due to its shape eliminating sharp edges (as in traditional design using flexible connection, which can potentially cause dielectric shocks) can withstand and transfer high currents. Further, the rigid contact member 140 having the round shape, particularly at the bottom side thereof, act as an electrode and helps to reduce di-electric stress. The heat sink 160 provides good contact surface area with the rigid contact member 140 to allow for sufficient heat dissipation. Further, the heat sink 160 acts as the guiding element for the movable contact member 130 to be received inside the hollow profile of the compressible contact member 150 when the second stem 128 is disposed in the first position thereof. Further, the compact insulated chamber 120 made of epoxy resin material allows to achieve a higher temperature rise rating for the switching device 100. The simplified design of the switching device 100 also helps in reducing its assembly time.

[0055] The present disclosure further provides a method of operating a switching device for opening and closing a circuit between a first connection arm and a second connection arm is provided. The present method has been described in view of the elements described in the preceding paragraphs in reference to FIG 2 through FIG 11. FIG 12 illustrates a flowchart listing steps involved in a method 1200 of operating the switching device 100 for opening and closing a circuit between the first connection arm 118a and the second connection arm 118b, in accordance with an embodiment of the present disclosure. The various teachings as described above apply *mutatis mutandis* to the present method 1200 as described hereinafter.

[0056] At step 1202, the method 1200 comprises providing the insulated chamber 120. At step 1204, the method further comprises arranging the vacuum interrupter unit 124 inside the insulated chamber 120, with the vacuum interrupter unit 124 having the first end 124a and the second end 124b, and the vacuum interrupter unit 124 providing the first stem 126 located at the first end 124a thereof and the second stem 128 located at the second end 124b thereof. At step 1206, the method 1200 further comprises disposing the first stem 126 in fixed electrical contact with the first connection arm 118. At step 1208, the method 1200 further comprises providing the rigid contact member 140, with the rigid contact member 140 having the first end 140a and the second end 140b, and a slot 142 defined at the first end 140a thereof and the contact arm 144 defined at the second end 140b thereof. At step 1210, the method 1200 further comprises disposing the contact arm 144 in fixed electrical contact with the second connection arm 118b. At step 1212, the method 1200 further comprises positioning the compressible contact member 150, having the hollow profile, adapting to the internal profile of the slot 142 of the rigid contact member 140, inside the slot 142 of the rigid contact member 140. At step 1214, the method 1200 further comprises reciprocating the second stem 128 of the vacuum interrupter unit 124 to move linearly in the insulated chamber 120 between the first position and the second position. In the first position, the second stem 128 is in electrical engagement with the compressible contact member 150 thereby closing the circuit between the first connection arm 118a and the second connection arm 118b. In the second position, the second stem 128 is out of electrical engagement with the compressible contact member 150 thereby opening the circuit between the first connection arm 118a and the second connection arm 118b.

[0057] In an embodiment, the method 1200 also comprises providing the movable contact member 130 fixed to the second stem 128 at the second end 124b of the vacuum interrupter unit 124, with the movable contact member 130 having the profile adapted to be received inside the hollow profile of the compressible contact member 150 when the second stem 128 is disposed in the first position thereof.

[0058] In an embodiment, the method 120 also comprises providing the heat sink 160 having the body 162 with the complementary slot 166 to the slot 142 of the rigid contact member 144. The method 1200 further comprises associating the heat sink 160 with the rigid contact member 140 such that the complementary slot 166 thereof is aligned with the slot 142 of the rigid contact member 140, and thereby guide the movable contact member 130 to be received inside the hollow profile of the compressible contact member 150 when the second stem 128 is disposed in the first position thereof. Due to improved dielectric strength, the switching device 100 of the present disclosure may also allow use of eco-friendly insulating gas, such as, Sulfur hexafluoride (SF6) free gas or a mixture of carbon dioxide gas and nitrogen gas (CO2N2) instead of using insulating gases with high dielectric strength but toxic to environment (such as SF6), without causing

dielectric breakdown.

[0059] 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

switchgear device		10	
housing			12
top contact arm		14	
bottom contact arm		16	
vacuum interrupter based circuit breaker	20		
vacuum interrupter fixed stem		22	
vacuum interrupter (VI) moving stem		24	
flexible connection		26	
switching device		100	
housing			102
pole assembly			104
control panel		106	
enclosure			108
bus-bar enclosure		110	
circuit-breaker enclosure		112	
transformer enclosure		114	
cable bushing enclosure		116	
first connection arm		118a	
second connection arm		118b	
insulated chamber		120	
vacuum interrupter assembly		122	
vacuum interrupter unit		124	
first end of vacuum interrupter unit		124a	
second end of vacuum interrupter unit		124b	
first stem		126	
second stem		128	
movable contact member		130	
body			132
through-hole		134	
rigid contact member		140	
first end of rigid contact member	140a		
second end of rigid contact member	140b		
slot		142	
contact arm		144	
apertures		146	
fastening members		147	
apertures		148a	
apertures		148b	
compressible contact member		150	
strips		152	
hollow profile		154	
heat sink		160	
body of heat sink		162	
fins		164	

(continued)

slot			166
portion			168
apertures			169
connection support member		170	
body of connection support member	172		
fins			174
apertures			176
assembly			180
bolts		182	
bolts		184	
assembly			190
method			1200
step			1202
step			1204
step			1206
step			1208
step	1210		
step	1212		
step	1214		

Claims

1. A switching device (100) for opening and closing a circuit between a first connection arm (118a) and a second connection arm (118b), the switching device (100) comprising:

   an insulated chamber (120); and
   a vacuum interrupter unit (124) arranged inside the insulated chamber (120) and having a first end (124a) and a second end (124b), the vacuum interrupter unit (124) providing a first stem (126) located at the first end (124a) thereof and a second stem (128) located at the second end (124b) thereof, the first stem (126) being disposed in fixed electrical contact with the first connection arm (118a);
   a rigid contact member (140) having a first end (140a) and a second end (140b), the rigid contact member (140) having a slot (142) defined at the first end (140a) thereof and a contact arm (144) defined at the second end (140b) thereof, the contact arm (144) being disposed in fixed electrical contact with the second connection arm (118b);
   a compressible contact member (150) having a hollow profile (154) adapting to an internal profile of the slot (142) of the rigid contact member (140), the compressible contact member (150) being positioned inside the slot (142) of the rigid contact member (140); and
   wherein the second stem (128) of the vacuum interrupter unit (124) is configured to move linearly in the insulated chamber (120) between a first position and a second position, wherein in the first position, the second stem (128) is in electrical engagement with the compressible contact member (150) thereby closing the circuit between the first connection arm (118a) and the second connection arm (118b), and wherein in the second position, the second stem (128) is out of electrical engagement with the compressible contact member (150) thereby opening the circuit between the first connection arm (118a) and the second connection arm (118b).

2. The switching device (100) as claimed in claim 1 further comprising a movable contact member (130) fixed to the second stem (128) at the second end (124b) of the vacuum interrupter unit (124), the movable contact member (130) having a profile adapted to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

3. The switching device (100) as claimed in claim 2, wherein the compressible contact member (150) is formed of multiple strips (152) of a conducting material joined together to impart radial flexibility thereto, and ensuring physical connection with the movable contact member (130) when received inside the hollow profile (154) thereof.

4. The switching device (100) as claimed in claim 2 further comprising a heat sink (160) having a body (162) with a complementary slot (166) to the slot (142) of the rigid contact member (140), the heat sink (160) being associated with the rigid contact member (140) such that the complementary slot (166) thereof is aligned with the slot (142) of the rigid contact member (140), and thereby guide the movable contact member (130) to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

5. The switching device (100) as claimed in claim 4, wherein the heat sink (160) comprises a plurality of fins (164) extending radially outwardly from the body (162) thereof.

6. The switching device (100) as claimed in claim 1, wherein the insulated chamber (120) is made of epoxy resin material.

7. A vacuum interrupter assembly (122) for a switching device (100), the vacuum interrupter assembly (122) comprising:
a vacuum interrupter unit (124) having a first end (124a) and a second end (124b), the vacuum interrupter unit (124) providing a first stem (126) located at the first end (124a) thereof and a second stem (128) located at the second end (124b) thereof;

a rigid contact member (140) having a first end (140a) and a second end (140b), the rigid contact member (140) having a slot defined at the first end (140a) thereof and a contact arm (144) defined at the second end (140b) thereof; and
a compressible contact member (150) having a hollow profile (154) adapting to an internal profile of the slot (142) of the rigid contact member (140), the compressible contact member (150) being positioned inside the slot (142) of the rigid contact member (140);
wherein the second stem (128) of the vacuum interrupter unit (124) is configured to move linearly between a first position and a second position, wherein in the first position, the second stem (128) is in electrical engagement with the compressible contact member (150), and wherein in the second position, the second stem (128) is out of electrical engagement with the compressible contact member (150).

8. The vacuum interrupter assembly (122) as claimed in claim 7 further comprising a movable contact member (130) fixed to the second stem (128) at the second end (124b) of the vacuum interrupter unit (124), the movable contact member (130) having a profile adapted to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

9. The vacuum interrupter assembly (122) as claimed in claim 8, wherein the compressible contact member (150) is formed of multiple strips (152) of a conducting material joined together to impart radial flexibility thereto, and ensuring physical connection with the movable contact member (130) when received inside the hollow profile (154) thereof.

10. The vacuum interrupter assembly (122) as claimed in claim 8 further comprising a heat sink (160) having a body (162) with a complementary slot (166) to the slot (142) of the rigid contact member (140), the heat sink (160) being associated with the rigid contact member (140) such that the complementary slot (166) thereof is aligned with the slot (142) of the rigid contact member (140), and thereby guide the movable contact member (130) to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

11. The vacuum interrupter assembly (122) as claimed in claim 10, wherein the heat sink (160) comprises a plurality of fins (164) extending radially outwardly from the body (162) thereof.

12. The vacuum interrupter assembly (122) as claimed in claim 8, wherein the movable contact member (130) has a hollow cylindrical profile adapted to be received inside a hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

13. A method (1200) of operating a switching device (100) for opening and closing a circuit between a first connection arm (118a) and a second connection arm (118b), the method (1200) comprising:

providing an insulated chamber (120); and
arranging a vacuum interrupter unit (124) inside the insulated chamber (120), the vacuum interrupter unit (124) having a first end (124a) and a second end (124b), the vacuum interrupter unit (124) providing a first stem (126) located at the first end (124a) thereof and a second stem (128) located at the second end (124b) thereof;

disposing the first stem (126) in fixed electrical contact with the first connection arm (118a);
providing a rigid contact member (140), the rigid contact member (140) having a first end (140a) and a second end (140b), and a slot defined at the first end (140a) thereof and a contact arm (144) defined at the second end (140b) thereof;
disposing the contact arm (144) in fixed electrical contact with the second connection arm (118b);
positioning a compressible contact member (150), having a hollow profile (154), adapting to an internal profile of the slot (142) of the rigid contact member (140), inside the slot (142) of the rigid contact member (140); and
reciprocating the second stem (128) of the vacuum interrupter unit (124) to move linearly in the insulated chamber (120) between a first position and a second position, wherein in the first position, the second stem (128) is in electrical engagement with the compressible contact member (150) thereby closing the circuit between the first connection arm (118a) and the second connection arm (118b), and wherein in the second position, the second stem (128) is out of electrical engagement with the compressible contact member (150) thereby opening the circuit between the first connection arm (118a) and the second connection arm (118b).

14. The method (1200) as claimed in claim 13 further comprising providing a movable contact member (130) fixed to the second stem (128) at the second end (124b) of the vacuum interrupter unit (124), the movable contact member (130) having a profile adapted to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

15. The method (1200) as claimed in claim 14 further comprising:

providing a heat sink (160) having a body (162) with a complementary slot (166) to the slot (142) of the rigid contact member (140);
associating the heat sink (160) with the rigid contact member (140) such that the complementary slot (166) thereof is aligned with the slot (142) of the rigid contact member (140), and thereby guide the movable contact member (130) to be received inside the hollow profile (154) of the compressible contact member (150) when the second stem (128) is disposed in the first position thereof.

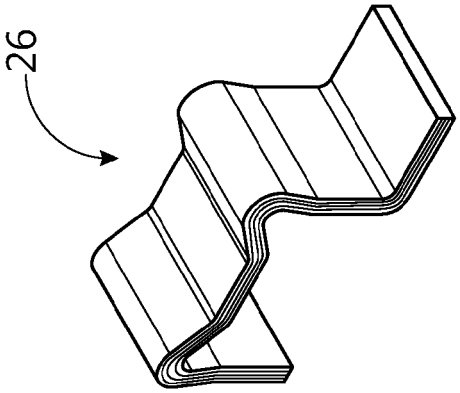

FIG 1B
(Prior-art)

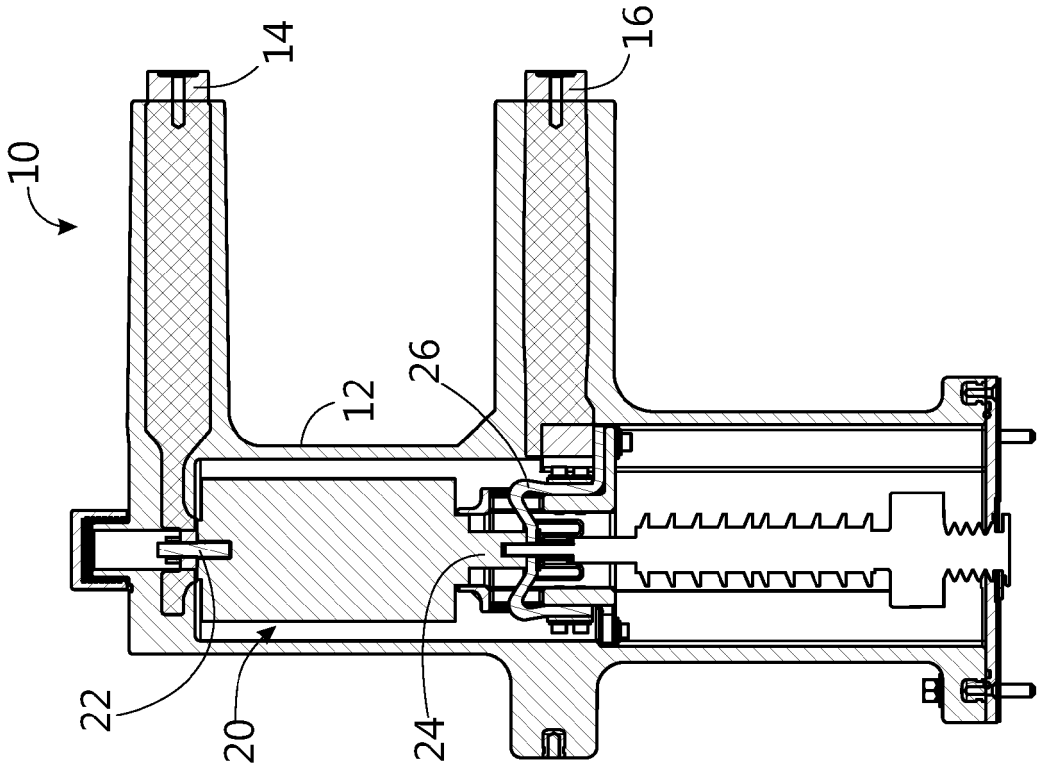

FIG 1A
(Prior-art)

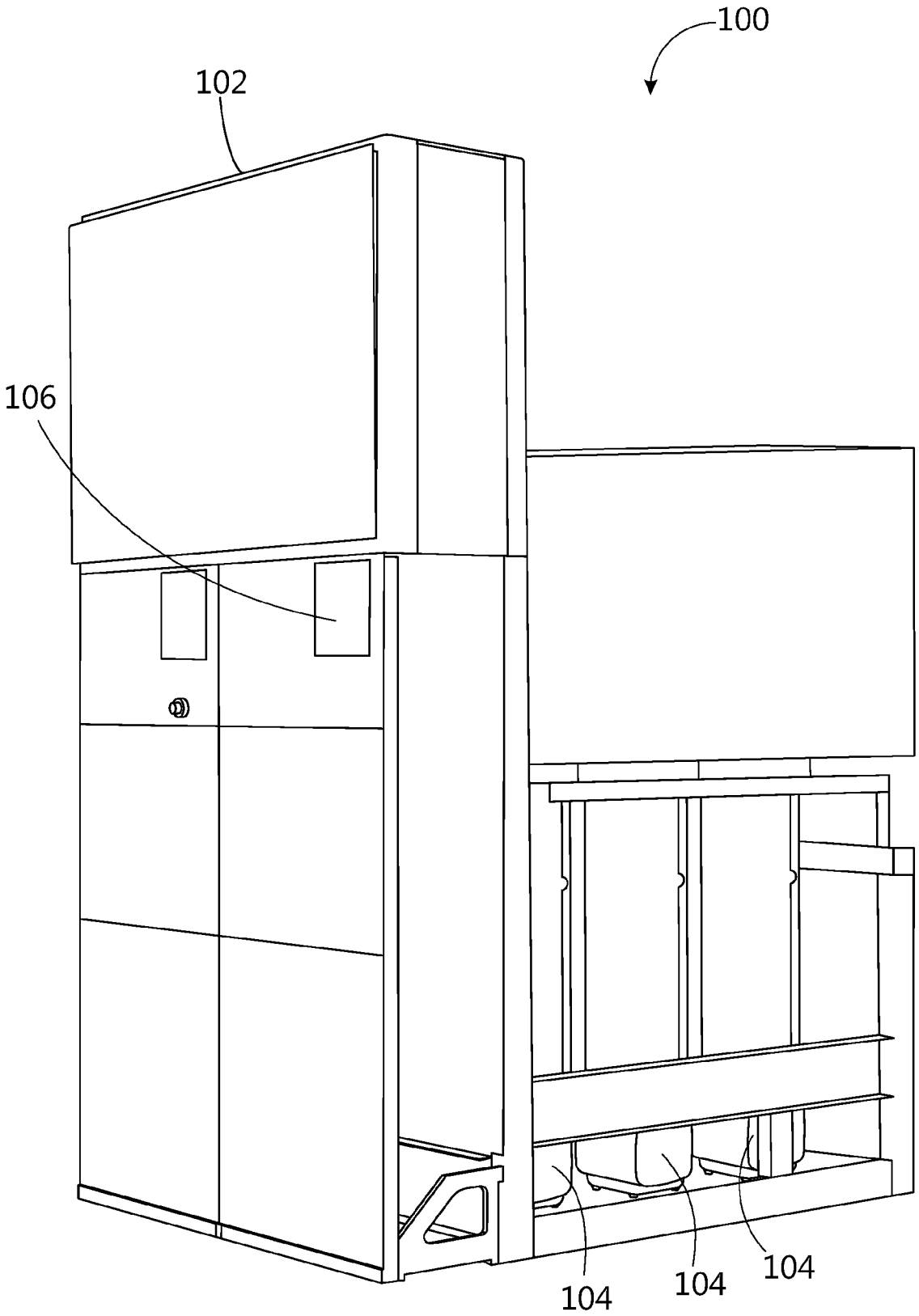

FIG 2

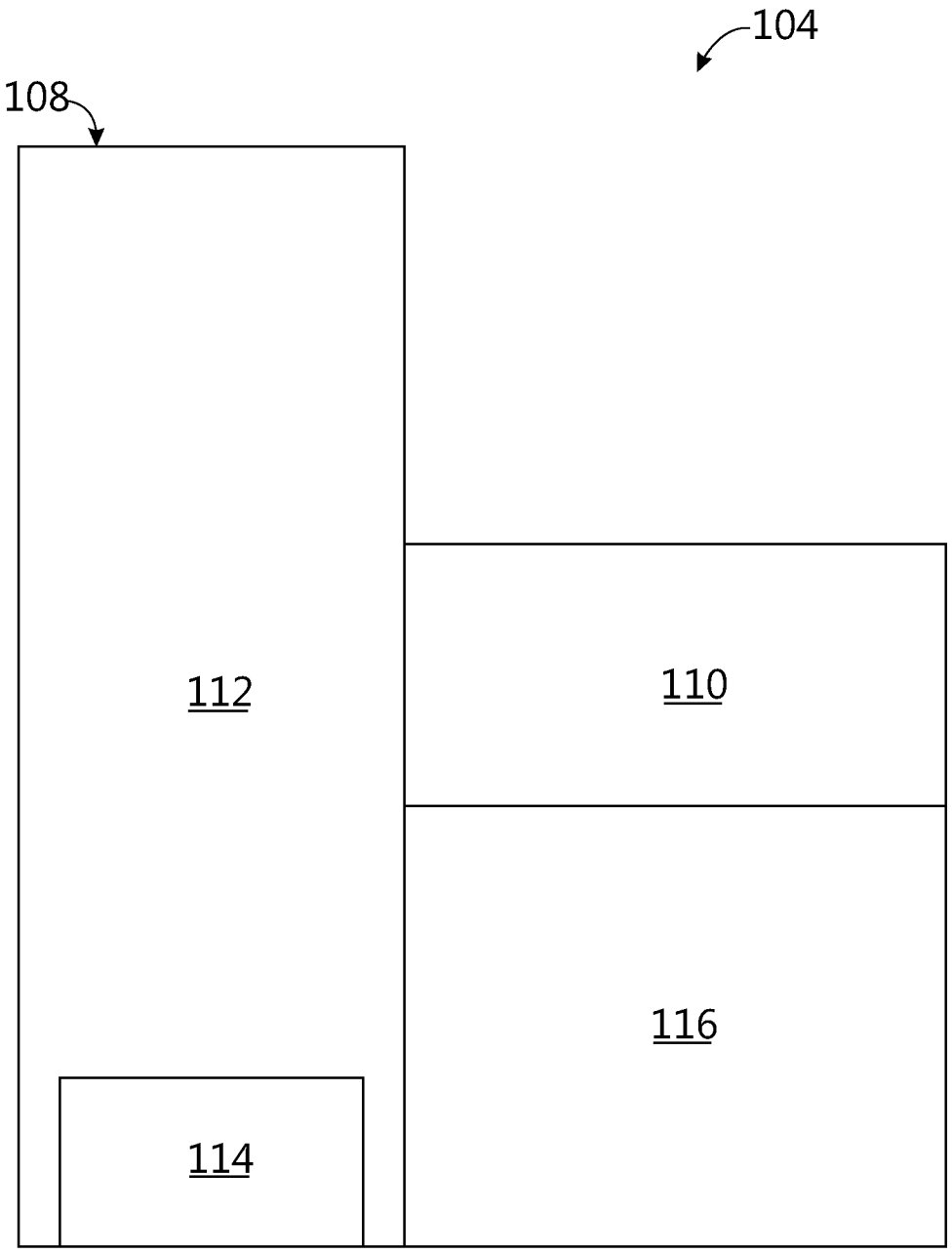

FIG 3

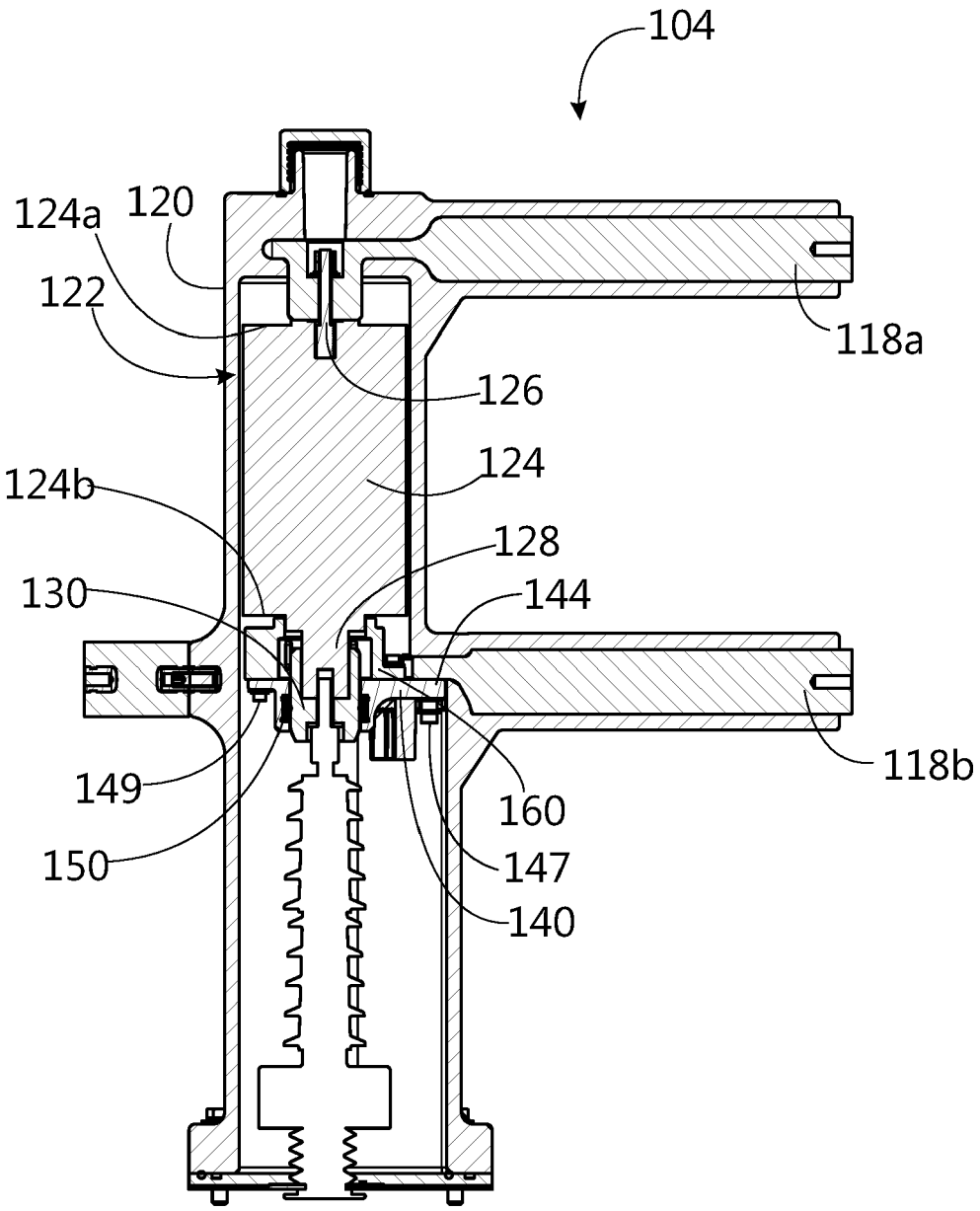
104
124a
120
122
118a
126
124
124b
128
130
144
118b
149
160
150
147
140

FIG 4

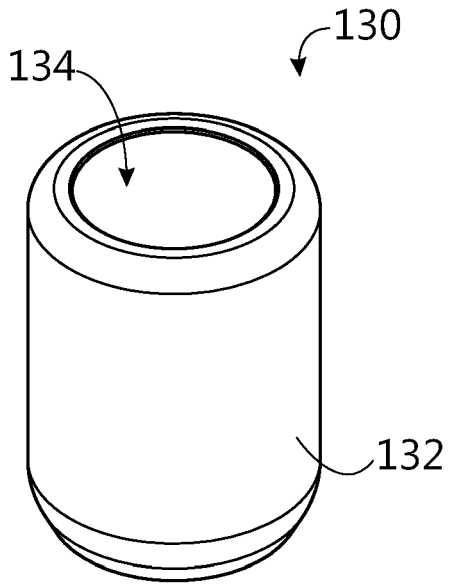

FIG 5

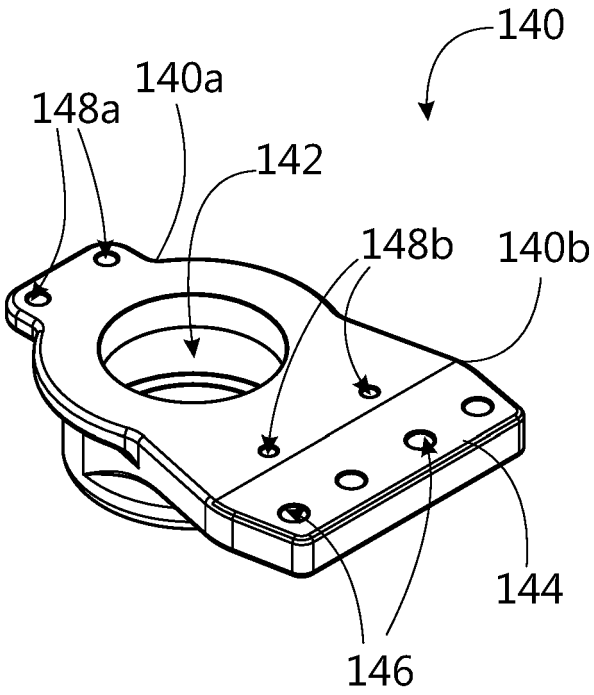

FIG 6A

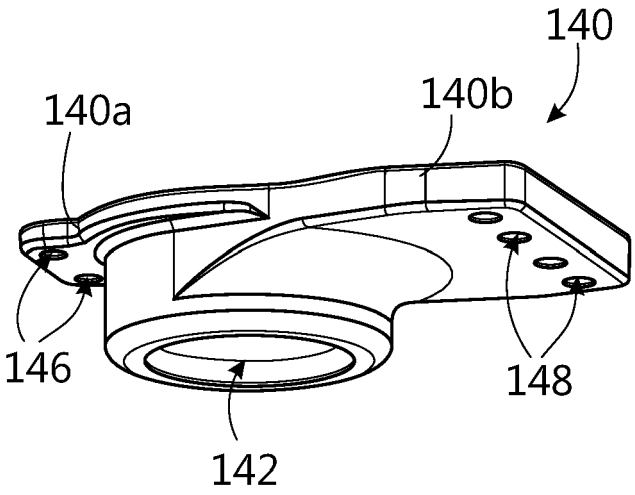

FIG 6B

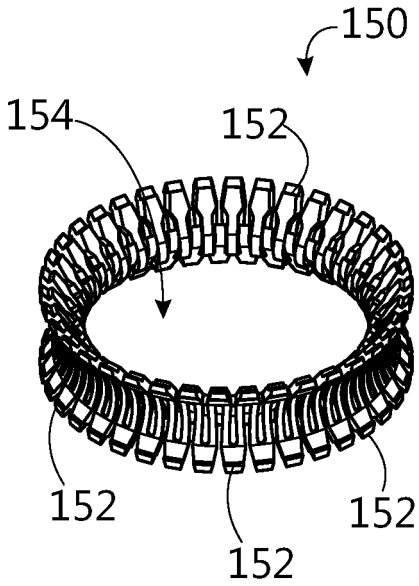

FIG 7

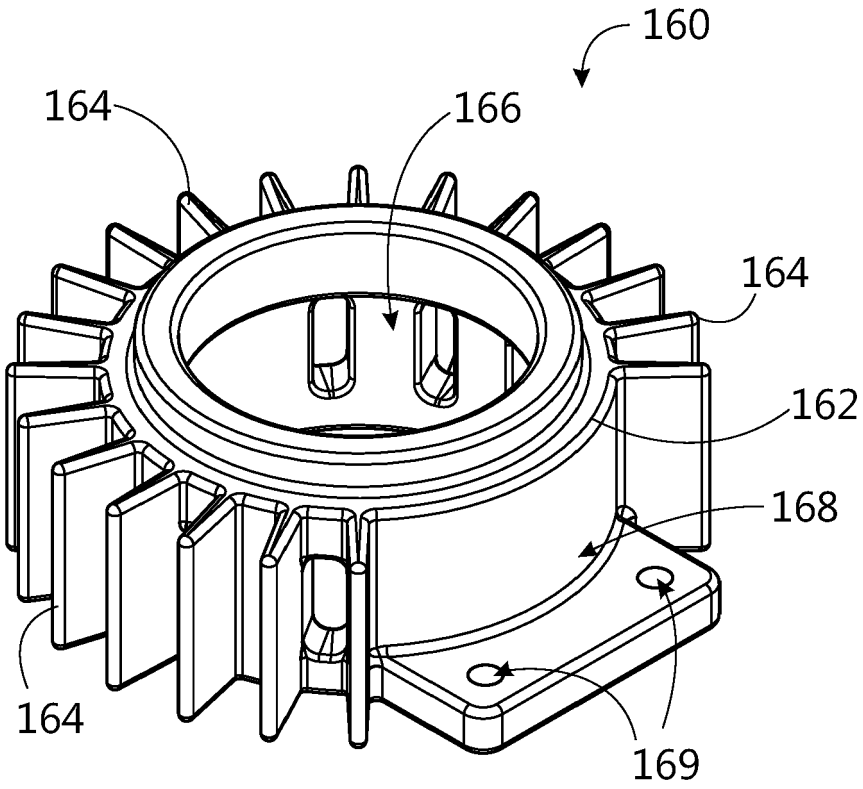

FIG 8

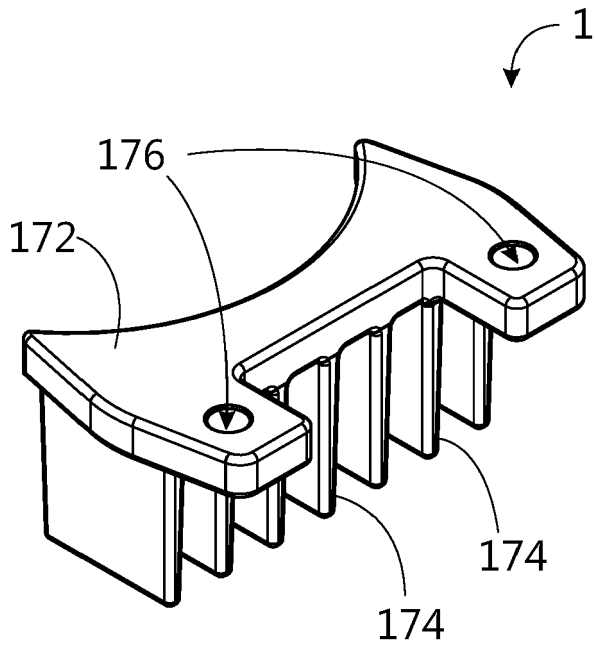

FIG 9

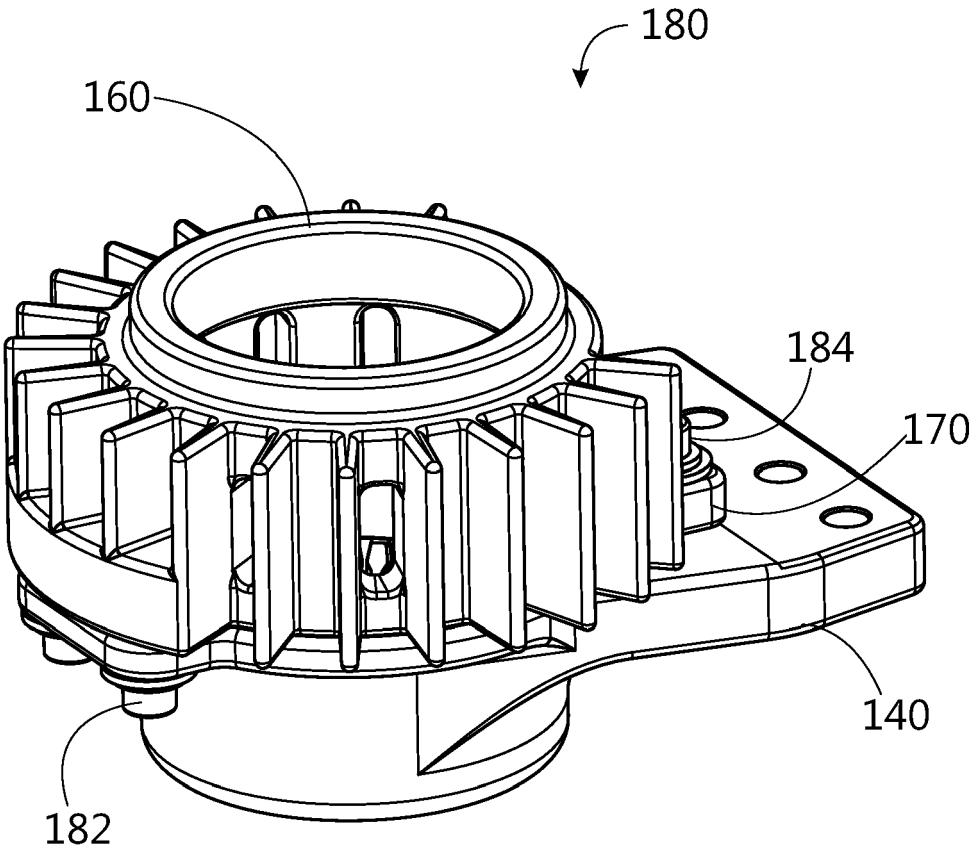

FIG 10A

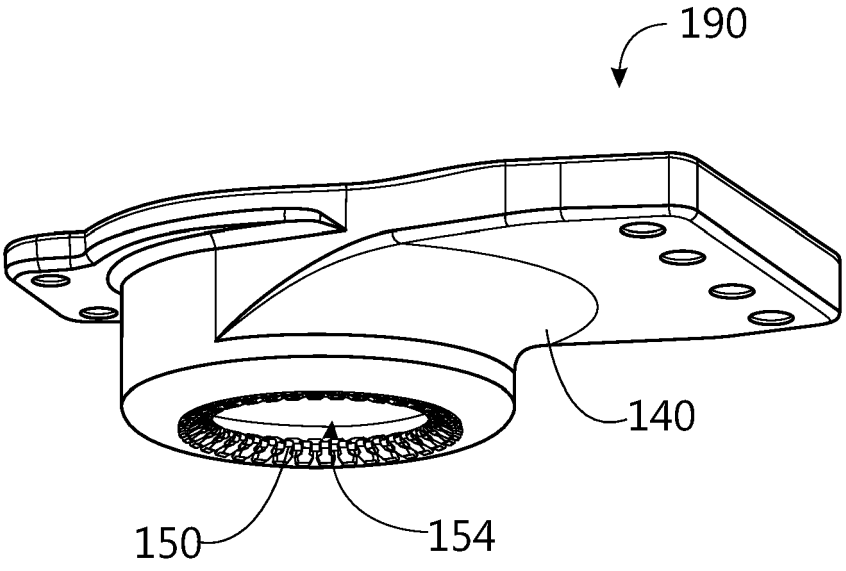

FIG 10B

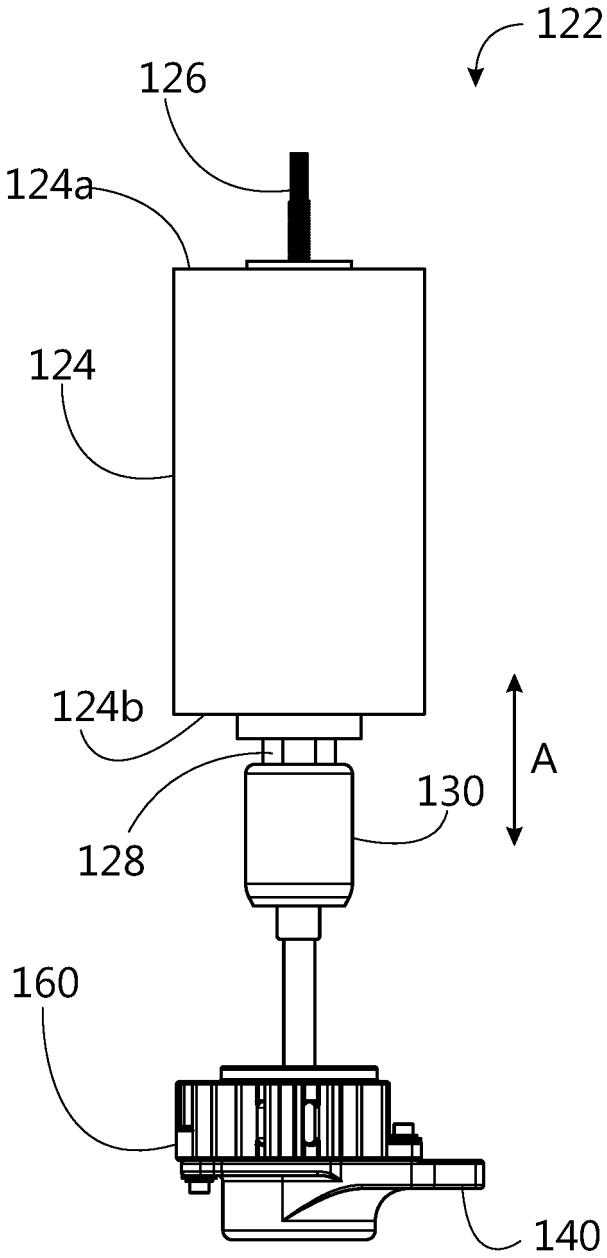

FIG 11

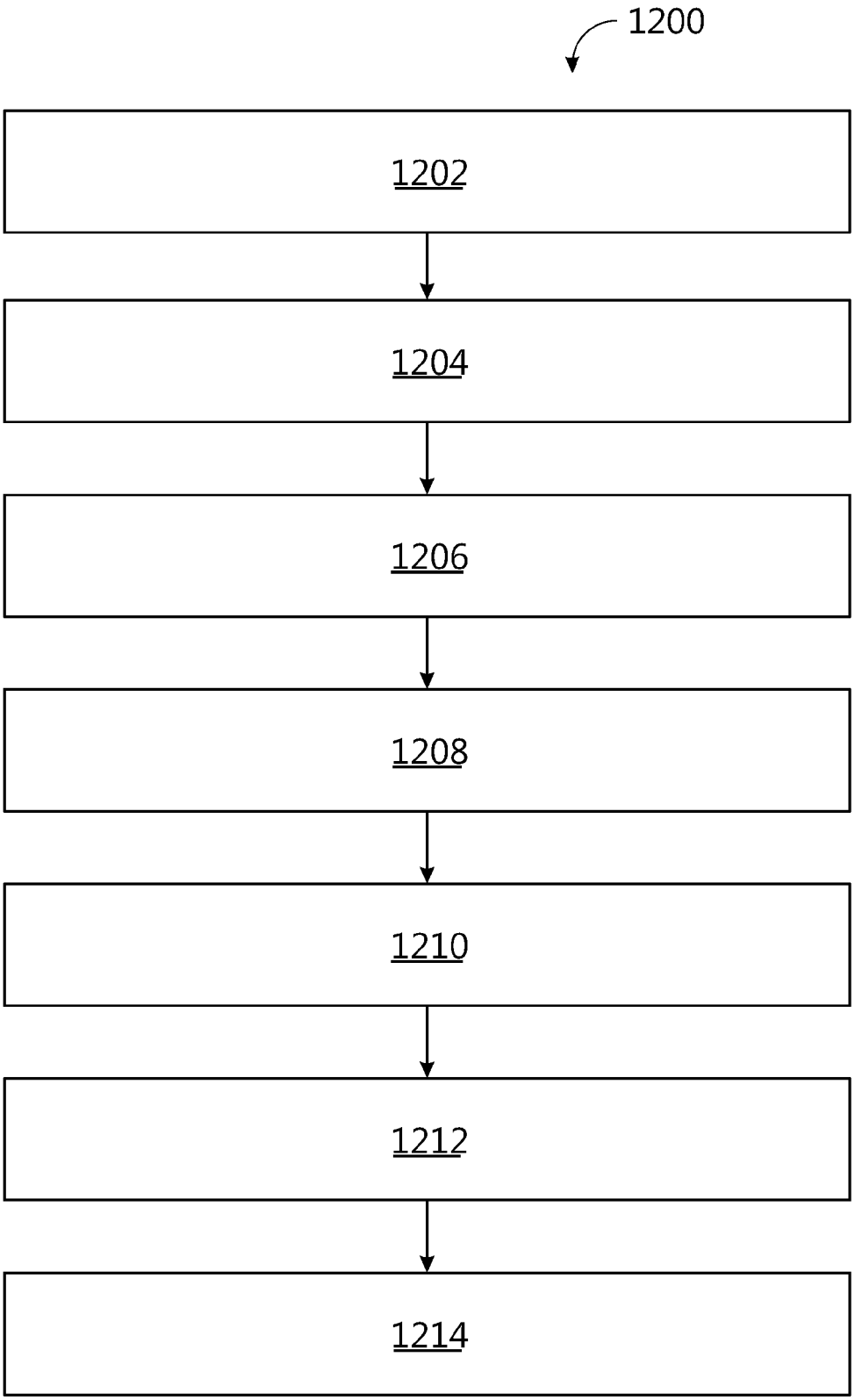

FIG 12

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 22 15 9258

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	DE 10 2007 038898 B3 (SIEMENS AG [DE]) 20 November 2008 (2008-11-20) * paragraphs [0023] - [0030]; figures *	1-3,6-9, 12-14 4,5,10, 11,15	INV. H01H1/38 H01H1/62 H01H33/666
Y	CN 112 635 205 A (TIANJIN PINGGAO INTELLIGENT ELECTRIC CO LTD ET AL.) 9 April 2021 (2021-04-09) * abstract; figures *	4,5,10, 11,15 1,7,13	
A	US 4 005 297 A (CLEAVELAND CHARLES M) 25 January 1977 (1977-01-25)	1,7,13	

TECHNICAL FIELDS SEARCHED (IPC)
H01H

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	25 August 2022	Findeli, Luc

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 22 15 9258

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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25-08-2022

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		WO 2009021882 A1	19-02-2009
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