(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 3 855 468 A1

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.07.2021 Bulletin 2021/30

(51) Int Cl.:
H01H 33/90 (2006.01)

(21) Application number: 20153684.4

(22) Date of filing: 24.01.2020

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

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(54) CIRCUIT BREAKER, VALVE ASSEMBLY AND OPERATING METHOD THEREOF

(57) A circuit breaker, a valve assembly and an operating method thereof are provided. The circuit breaker comprises a compression volume surrounding at least a portion of a space between first and second electric contacts, and a low-pressure volume, filled with insulating gas, disposed adjacent to the compression volume. The circuit breaker further comprises a valve assembly interconnecting the compression volume and the low-pressure volume, and configured to allow threshold-based flow of the insulating gas. The valve assembly comprises a valve body. The valve assembly also comprises a first valve plate movably mounted in the valve body and a second valve plate movably seated on the first valve plate. The valve assembly further comprises a torsion spring arranged in the valve body and coupled to the first valve plate, the torsion spring configured to constrain the movement of the first valve plate in the valve body.

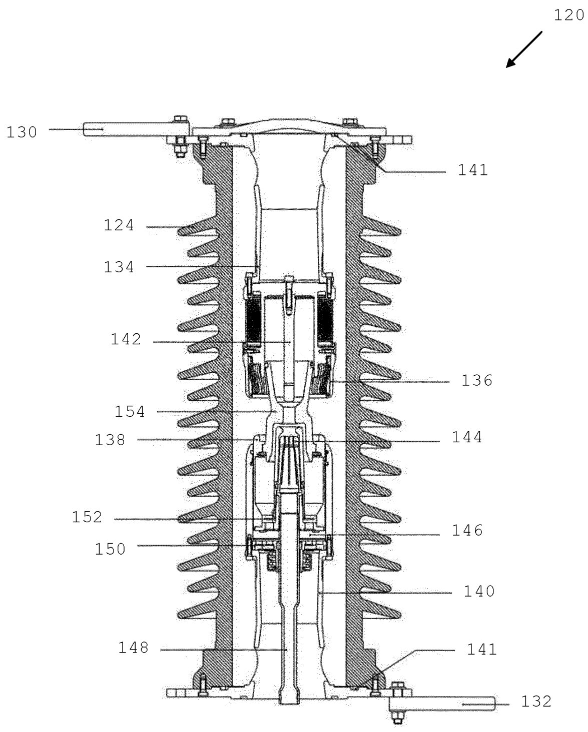

FIG 3

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Description

[0001] The present invention relates generally to arc chambers for extinguishing arcs, such as in circuit breakers, and more particularly relates to a valve assembly for regulating flow of insulating gas in a circuit breaker.

[0002] In general, a circuit breaker operates to engage and disengage a selected electrical circuit from an electrical power supply. The circuit breaker ensures current interruption thereby providing protection to the electrical circuit from continuous over current conditions and high current transients due to, for example, electrical short circuits. Such circuit breakers operate by separating a pair of internal electrical contacts contained within a housing (e.g., molded case) of the circuit breaker. Typically, one electrical contact is stationary while the other is movable (e.g., typically mounted on a pivotable contact arm).

[0003] The contact separation may occur manually, such as when a person throws an operating handle of the circuit breaker. This may engage an operating mechanism, which may be coupled to the contact arm and moveable electrical contact. Otherwise, the electrical contacts may be separated automatically when an over current, short circuit, or fault condition is encountered. Automatic tripping may be accomplished by an operating mechanism actuated via a thermal overload element (e.g., a bimetal element) or by a magnetic element, or even by an actuator (e.g., a solenoid).

[0004] Upon separation of the electrical contacts by tripping, an intense electrical arc may be formed in an arc chamber containing the electrical contacts. This separation may occur due to heat and/or high current through the circuit breaker or due to sensing a ground or other arc fault. It is desirable to extinguish the arc as quickly as possible to avoid damaging internal components of the circuit breaker.

[0005] In power distribution networks, a circuit breaker of type, called a gas-insulated circuit breaker is commonly used. Such gas-insulated circuit breaker is designed in such a way that in the event of a separating of the contacts, or in the case of a short circuit, the arc is blasted with gas and consequently quenched as quickly as possible. The gas which is used most for this purpose is SF6 (Sulphur Hexafluoride).

[0006] In the case of such circuit breaker, a pressure chamber, in which the arc is created, is connected in a valve-controlled manner to a compression chamber. The compression chamber is connected to a low-pressure chamber via a valve arrangement. The valve arrangement, on the low-pressure chamber side, is pressed by a spring against a valve holder in the direction of the compression volume. Gas can therefore flow from the compression volume into the low-pressure chamber only when its pressure is higher than the spring force.

[0007] In a high voltage circuit breaker, a valve is typically implemented to regulate the flow of gas towards arcing contact. Such a valve allows the free flow of gas in one direction while gas flow in other direction is depending on the pressure built in compression volume. It is required that the valve should allow gas flow towards arcing contacts during gas filling. Further, during opening of the circuit breaker, the valve has to be closed such that pressure in the compression volume increases up to specified limit. Also, it is required that once the pressure in compression volume increases beyond specified limit, valve should open.

[0008] European Patent Application Number 3419039A1 ('039 application) relates to an electric high-voltage circuit breaker comprising a primary chamber and a compression chamber, wherein said circuit breaker further comprises a valve configured to control a fluid flow between said primary chamber and said compression chamber. The electric high-voltage circuit breaker of the '039 application discloses that said valve comprises a valve body, a first valve plate that is arranged axially movable with respect to said valve body, and a second valve plate that is arranged between and movable, preferably at least axially movable, with respect to said valve body and said first valve plate, wherein said first valve plate comprises at least one opening enabling a fluid flow through said first valve plate, wherein a first surface of said valve body forms a valve seat for said first valve plate, and wherein a first surface of said first valve plate forms a valve seat for said second valve plate.

[0009] In the circuit breaker of the '039 application, one or more guide pins may be provided for guiding an axial movement of both said first valve plate and said second valve plate. Further, a first spring force mechanism is provided to press said first valve plate to said valve seat of the valve body, and a second spring force mechanism is provided to press said second valve plate to said valve seat of the first valve plate. Each of the spring force mechanisms may comprise one or more springs (for example, helical springs) arranged at said guide pins.

[0010] The type of construction implemented for the valve in the circuit breaker, as disclosed in the '039 application, is relatively complicated and requires a large number of components. The use of that many number of components may result in hindrance to the path of flow of gas which is undesirable. It may be appreciated that pressure opening from compression volume is only possible from one side in such configuration. Further, in such configuration of the valve arrangement, typically, a pneumatic press is required to mount the spring on the valve which is an added expense. Also, the load value needs to be set for each of the springs to get desired pressure release output, which may be time-consuming and cumbersome.

[0011] In light of the above, there is a need of a circuit breaker with a valve assembly to regulate the flow of gas towards arcing contact, which is simple in construction, is economical to manufacture and is efficient to operate.

[0012] The object of the present disclosure is achieved by a circuit breaker comprising first and second electrical contacts, the electrical contacts configured to generate an electrical arc upon being separated during operation of the circuit breaker. The circuit breaker comprises a first chamber at least partially surrounding the first and second electric contacts, and a second chamber filled with insulating gas. The circuit breaker further comprises a valve assembly interconnecting the first chamber and the second chamber. The valve assembly is configured to allow threshold-based flow of the insulating gas into and out of the first chamber. The valve assembly comprises a valve body. The valve assembly also comprises a first valve plate movably mounted in the valve body and a second valve plate arranged in the valve body so as to move between a first position and a second position, wherein in the first position, the second valve plate lifts above the first valve plate and in the second position, the second valve plate seats upon the first valve plate. The valve assembly further comprises a torsion spring arranged in the valve body and coupled to the first valve plate. The torsion spring is configured to constrain the movement of the first valve plate in the valve body.

[0013] In an embodiment, the second valve plate assumes first position during filling of the insulating gas into the second chamber thereby, allowing passage to the insulated gas into the first chamber which is at a lower pressure than the second chamber, and wherein the second valve plate assumes second position upon completion of the filling of the insulating gas when the pressure in the first chamber is higher than in the second chamber.

[0014] In an embodiment, the second valve plate assumes first position upon generation of the electrical arc by overcoming constrain of the torsion spring due to additional pressure built in the first chamber.

[0015] In an embodiment, the torsion spring is tensioned to define the constrain on the movement of the first valve plate in the valve body based on desired threshold pressure of the insulating gas in the first chamber.

[0016] In an embodiment, the torsion spring is arranged at an angle of disposition with respect to the first valve plate in the valve body to define the constrain on the movement of the first valve plate in the valve body.

[0017] In an embodiment, the torsion spring is arranged proximal to a central opening in the valve body.

[0018] In an embodiment, the torsion spring is arranged proximal to an outer wall of the valve body.

[0019] In an embodiment, the valve body has a substantially cylindrical shape.

[0020] In an embodiment, the first valve plate has one or more openings formed therein, and wherein the second valve plate is seated on the first valve plate in a manner so as to seal the one or more openings thereof.

[0021] The object of the present disclosure is also achieved by a valve assembly for a circuit breaker having a first chamber and a second chamber filled with insulating gas, the valve assembly being of the configuration as discussed in preceding paragraph.

[0022] The object of the present disclosure is further achieved by an arc pressure control arrangement, which may be implemented, for example, in a circuit breaker. Herein, the arc pressure control arrangement comprises a first chamber containing first and second electrical contacts, the electrical contacts configured to generate an electrical arc upon being separated during operation of the circuit breaker. The arc pressure control arrangement further comprises a second chamber filled with insulating gas. The arc pressure control arrangement further comprises a valve assembly interconnecting the first chamber and the second chamber, the valve assembly being of the configuration as discussed in preceding paragraphs.

[0023] The object of the present disclosure is further achieved by a method of operating a circuit breaker. The method comprises separating a first electrical contact from a second electrical contact in a first chamber of the circuit breaker to generate an electrical arc. The method further comprises filling a second chamber, disposed adjacent to the first chamber in the circuit breaker, with insulating gas. The method further comprises providing a valve assembly with a first valve plate and a second valve plate movably seated on the first valve plate such that during filling operation, the second valve plate gets lifted from the first valve plate due to pressure of the insulating gas in the second chamber to provide a flow path for the insulating gas to flow from the second chamber into the first chamber, and subsequently the second valve plate gets seated back onto the first valve plate due to the pressure build-up of the insulating gas in the first chamber. The method further comprises providing a torsion spring configured to constrain the movement of the first valve plate such that upon generation of the electrical arc, the first valve plate is separated from the second valve plate due to further pressure build-up of the insulating gas in the first chamber overcoming the constrain of the torsion spring coupled thereto to provide a flow path for the insulating gas to flow out of the first chamber to the second chamber.

[0024] Still 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.

[0025] 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 perspective representation of an exemplary circuit breaker, in accordance with an embodiment of the present invention;

FIG 2 is a diagrammatic cross-sectional representation of a pole column of the circuit breaker as shown in FIG 1, in accordance with an embodiment of the present invention;

FIG 3 is a diagrammatic cross-sectional representation of an interrupter unit of the circuit breaker, in accordance with an embodiment of the present invention;

FIGS 4A-4B are partial schematic representations of an arc pressure control arrangement 155 depicting arc quenching operation therein, in accordance with an embodiment of the present invention;

FIG 5 is a diagrammatic right-side perspective representation of a valve assembly, in accordance with an embodiment of the present invention;

FIG 6 is a diagrammatic left-side perspective representation of the valve assembly, in accordance with an embodiment of the present invention;

FIG 7 is a diagrammatic side representation of the valve assembly, in accordance with an embodiment of the present invention;

FIG 8 is a diagrammatic cross-sectional representation of the valve assembly, in accordance with an embodiment of the present invention;

FIG 9 is a diagrammatic right-side exploded representation of the valve assembly, in accordance with an embodiment of the present invention;

FIG 10 is a diagrammatic left-side exploded representation of the valve assembly, in accordance with an embodiment of the present invention;

FIG 11 is a schematic representation of the circuit breaker with the valve assembly in normal state, in accordance with an embodiment of the present invention;

FIG 12 is a diagrammatic cross-sectional representation of the valve assembly in normal state thereof, in accordance with an embodiment of the present invention;

FIG 13 is a schematic representation of the circuit breaker with the valve assembly in gas upward state, in accordance with an embodiment of the present invention;

FIG 14 is a diagrammatic cross-sectional representation of the valve assembly in gas upward state thereof, in accordance with an embodiment of the present invention;

FIG 15 is a schematic representation of the circuit breaker with the valve assembly in gas downward state, in accordance with an embodiment of the present invention;

FIG 16 is a diagrammatic cross-sectional representation of the valve assembly in gas downward state thereof, in accordance with an embodiment of the present invention;

FIG 17 is a flowchart listing steps involved in a method of operating a circuit breaker, in accordance with an embodiment of the present invention.

[0026] 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.

[0027] 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.

[0028] Example embodiments of an arc pressure control arrangement described herein may be included in a circuit breaker to prevent a re-ignition failure of the circuit breaker. In certain example embodiments, upon contact separation, an arc is formed in a compression volume of the circuit breaker. The arc, extending between the first and second electrical contacts (e.g., stationary and moveable electrical contacts), produces arcing gases and also heats up and pressurizes the insulating gas within the compression volume. This causes a flow of the heated insulating gas and arc gasses, due to the pressure change, into a low-pressure volume disposed adjacent to the compression volume, but only at certain times during the arcing event.

[0029] A valve assembly is provided between the compression volume and the low-pressure volume to allow flow into and out of the compression volume only at the certain times during the arcing event. For example, the valve assembly may allow gas flow only when an inlet threshold pressure in the compression volume is exceeded. Further, the valve assembly may allow gas flow only when a pressure in the compression volume falls below an outlet threshold pressure. Thus, gas flows into the low-pressure volume after the gas pressure in the compression volume reaches the inlet threshold pressure, is held in the low-pressure volume for part of the arc cycle, and then flows out of the low-pressure volume and back into the compression volume when the pressure in the compression volume falls below the outlet threshold pressure.

[0030] Examples of a circuit breaker, a valve assembly for a circuit breaker, an arc pressure control arrangement, and a method of operating a circuit breaker are disclosed and fully described with reference to FIGS 1 through 17 herein.

[0031] FIG 1 is a diagrammatic perspective representation of an exemplary circuit breaker 100, in accordance with one or more embodiments of the present disclosure. In the present illustration, the depicted circuit breaker 100 is a three-pole pillar mounted circuit breaker; however, for the purposes of the present disclosure, the circuit breaker 100 may be any type of high-voltage circuit breaker as known in the art. The circuit breaker 100 includes a common breaker base 102 to which the various components are mounted. In the present three-pole circuit breaker 100, there pole columns 104, 106 and 108 are provided which are mounted on the common breaker base 102. The pole columns 104, 106 and 108 are connected by tubes to a gas compartment and are filled with insulating gas, such as, but not limited to, SF6 (Sulphur Hexafluoride) for arc-quenching and insulating purposes. The gas density is monitored by a density monitor (not shown), and the pressure can be displayed by a pressure gauge or a pressure display on the density monitor.

[0032] The circuit breaker 100 also includes an operating mechanism unit 110 fastened to the breaker base 102. A mounting plate (not shown) is integrated in the operating mechanism unit 110, which contains all equipment for control and monitoring of the circuit breaker 100 and also terminal blocks required for electrical connections. The circuit breaker 100 further includes a spring drive mechanism (not shown) located in the operating mechanism unit 110. Typically, the spring drive mechanism includes closing and opening springs, and the energy required for switching is stored in one closing spring common to all three poles and one opening spring. In the circuit breaker 100, the pole column 106 is actuated by the spring drive mechanism via a corner gear 112 (as shown in FIG. 2) and is connected with corner gears of the pole columns 104 and 108 by means of coupling rods. The circuit breaker 100 further includes a switching position indicator 114 which indicates the position and status of all switch equipment thereof.

[0033] FIG 2 is a diagrammatic cross-sectional representation of the pole column 104 of the circuit breaker 100. It may be appreciated that all of the three pole columns 104, 106 and 108 are similar in design and the present illustration can be construed to be representative of any of the three pole columns 104, 106 and 108 for the purposes of the present disclosure. As illustrated, the pole column 104 includes a post insulator 116 which provides insulation against earth. Further, the pole column 104 includes an insulated drive rod 118. The pole column 104 includes an interrupter unit 120 mounted on the post insulator 116. FIG 3 is a diagrammatic cross-sectional representation of the interrupter unit 120. Referring to FIGS 2 and 3 in combination, the interrupter unit 120 contains the filter material 122, generally in the form of filter bag. The filter material 122 is used for the absorption of decomposition products of the insulating gas (like SF6) and for keeping the gas dry. The interrupter unit 120 further includes a gas-tight jacket 124 which accommodates the breaker contacts. In the pole column 104, the switching motion is transferred from the spring drive mechanism (at earth potential) via a coupling rod 126, a shaft 128, and thereby from the insulated drive rod 118 to the interrupter unit 120 (at high voltage potential).

[0034] As illustrated, the main circuit for the interrupter unit 120 includes an upper high-voltage terminal 130, a lower high-voltage terminal 132, a diffuser socket 134, ring-placed contact laminations 136 arranged with the diffuser socket 134, a heat cylinder 138 and an operating socket 140. Herein, the contact laminations 136 are self-sprung and centrically pressed inwards, which ensures the necessary contact pressure on the heat cylinder 138 and the diffuser socket 134.Also, the upper high-voltage terminal 130 and the lower high-voltage terminal 132 are mounted using O-rings 141. Further, an arcing circuit is arranged parallel to the main circuit, which is made up of a pin 142 (also referred to as first electrical contact 142) situated in the diffuser socket 134 and a moving tube contact 144 (also referred to as second electrical contact 144) placed in the heat cylinder 138. Herein, the pin 142 and the tube contact 144 are made of materials, which produce only minimal contact erosion. Further, as illustrated, a piston 146 and a pull rod 148 are arranged in the interrupter unit 120. Herein, the tube contact 144, the piston 146 and the heat cylinder 138 are mechanically interconnected and coupled with the pull rod 148, and form the moving parts of the interrupter unit 120. In the circuit breaker 100, a valve assembly 150 is arranged in cylindrical casting 152, which together with an arc quenching nozzle 154 makes up the compression unit for arc quenching purposes.

[0035] FIGS 4A and 4B are partial schematic representations of an arc pressure control arrangement 155, implemented in the circuit breaker 100, or specifically the interrupter unit 120 of the circuit breaker 100, depicting stages of arc quenching operation therein. As illustrated, the arc pressure control arrangement 155 includes the first electrical contact 142 and the second electrical contact 144. Herein, the first electrical contact 142 and the second electrical contact 144 are configured to generate an electrical arc upon being separated during operation of the circuit breaker 100. As illustrated, the arc pressure control arrangement 155 includes a first chamber (generally represented by numeral 156) at least partially surrounding the first electric contact 142 and the second electric contact 144. Further, the arc pressure control arrangement 155 includes a second chamber (generally represented by numeral 158) disposed adjacent to the first chamber 156. Herein, the second chamber 158 is filled with insulating gas, such as, for example, SF_6. It may be understood that the first chamber 156 is a compression volume and the second chamber 158 is a low-pressure volume in the circuit breaker 100, and the said terms have been interchangeably used in the description without any limitations. In the arc pressure control arrangement 155, as illustrated, the valve assembly 150 interconnects the first chamber 156 and the second chamber 158. The valve assembly 150 regulates the flow of the insulating gas from the second chamber 158 into the first chamber 156, and vice-versa. In particular, the valve assembly 150 allows the flow of the insulating gas based on desired threshold pressure of the insulating gas in the first chamber 156. Thereby, the valve assembly 150 is configured to allow threshold-based flow of the insulating gas into and out of the first chamber 156.

[0036] In one or more embodiments, the first chamber 156 includes an internal storage volume that is greater than about 500 mm^3. For example, an internal storage volume of the first chamber 156may be greater than about 1,000 mm^3 for a 600V/250A circuit breaker, or even greater than about 1,500 mm^3 for a 600V/250A circuit breaker. In some embodiments, the internal storage volume of the second chamber 158 may be about 2,000 mm^3 or more. In some example embodiments, the second chamber 158 may be a rectangular shape and may include an internal height of about 38 mm, an internal width of about 6 mm, and an internal thickness of 6 mm. Other sizes, shapes, and storage volumes for the second chamber 158 may be used.

[0037] In an opening operation, the main contact that exists between the contact laminations 136 and the heat cylinder 138 is opened (FIG 4A). The arcing contact, consisting of the first electrical contact 142 and the second electrical contact 144 remains closed, with the result that the current commutates onto the arcing contact. During the continued course of the opening operation, the arcing contact opens creating an arc. At the same time, the heat cylinder 138 moves downward and compresses the quenching gas between the heat cylinder 138 and plate supporting the valve assembly 150. This causes the quenching gas to be forced in the direction opposite to the movement of the moving contact components, into the heat cylinder 138 and through the gap between the second electrical contact 144 and the arc-quenching nozzle, thus quenching the arc. With large short-circuit currents, the quenching gas surrounding the first electrical contact 142 in the arcing chamber is heated by the arc's energy and driven into the heat cylinder 138 at high pressure. When the current passes through zero, the gas flows back from the heat cylinder 138 into the nozzle and quenches the arc.

[0038] FIGS 5-10 are different diagrammatic representations of the valve assembly 150. As illustrated, the valve assembly 150 includes a valve body 160. Herein, the valve body 160 has a substantially cylindrical or annular shape. As shown, the valve body 160 has a radially inner, central opening 161. The valve body 160 is guided through the wall of the first chamber 156, with a gas passage which connects the first chamber 156 and the second chamber 158.

[0039] Generally, a radially outer surface of the valve body 160 may contact a surrounding surface (not shown) of the circuit breaker 100 in a sealing (substantially gas-tight) manner. Similarly, a radially inner surface of the valve body 160 may contact a radially outer surface of the drive rod 118 (as may be seen from FIG 2) or an extension of the drive rod 118 protruding through the central opening 161 of the valve body 160 in a sealing manner. As an example, at both radially outer surface and radially inner surface, suitable sealing may be provided such as sealing rings and the like.

[0040] The valve assembly 150 further includes a first valve plate 162 movably mounted in the valve body 160. The valve assembly 150 also includes a second valve plate 164 movably seated on the first valve plate 162. Herein, the second valve plate 164 is arranged in the valve body 162 so as to move between a first position and a second position, wherein in the first position, the second valve plate 164 lifts above the first valve plate 162 and in the second position, the second valve plate 164 seats upon the first valve plate 162. In the present examples, the valve body 160, along with the first valve plate 162 and the second valve plate 164, may be formed of any suitable metallic material, such as, but not limited to, stainless steel or the like. Herein, the valve body 160 has generally larger diameter than the first valve plate 162 and the second valve plate 164, while the first valve plate 162 and the second valve plate 164 have substantially similar diameter. Generally, the first valve plate 162 and the second valve plate 164 may be pressed to the valve body 160 in a sealing manner.

[0041] In one or more examples, the first valve plate 162 may include seats defined therein onto which the second valve plate 164 is seated. As can best be seen from FIGS 9-10, the first valve plate 162 has one or more openings 166 formed therein, presently seven openings 166. The openings 166 are radially segregated on planar exposed surface of the first valve plate 162. Further, the second valve plate 164 is a substantially solid annular member seated on the first valve plate 162 in a manner so as to seal the one or more openings 166 thereof. Further, as may be seen, the valve body 160 has one or more openings 168, presently five openings 168. Similar to the openings 166, the openings 168 are radially segregated on planar exposed surface of the valve body 160. Herein, the openings 168 are generally disposed in-line with the openings 166 in the first valve plate 162, enabling a fluid flow through the first valve plate 162, for example in a basically axial direction of the circuit breaker 100. In some examples, a stop (not shown) may be integrated into the valve body 160 and limits the movement of the first valve plate 162 when the circuit breaker 100 closes.

[0042] The valve assembly 150 further includes a torsion spring 170 arranged in the valve body 160. In the present configuration, the torsion spring 170 is coupled to the first valve plate 162. As can best be seen from FIGS 9-10, the torsion spring 170 is mounted in the valve body 160 by means of fasteners 172, optionally supported by spacers 174 or the like. Such assembly may be contemplated by a person skilled in the art in light of the included drawings and thus has not been explained herein for the brevity of the present disclosure.In the present embodiments, the torsion spring 170 implemented with the valve body 160 is a double torsion spring, as known in the art; however, it may be appreciated that single torsion spring or any other type of torsion spring, or still any other type of spring with similar configuration may be implemented as the torsion spring 170 without departing from the scope and the spirit of the present disclosure. Herein, the torsion spring 170 is configured to constrain the movement of the first valve plate 162 in the valve body 160, as will be discussed in more detail in the proceeding paragraphs.

[0043] FIGS 11-16 are representations depicting various positions of the valve assembly 150 during arc quenching operation in the circuit breaker 100. As illustrated in FIGS 11-12, during normal state of the valve assembly 150, the first valve plate 162 is arranged in the valve body 160 with the second valve plate 164 in the second position thereof, i.e. seated on the first valve plate 162. Further, as illustrated in FIGS 13-14, during filling operation, the valve assembly 150 is moved to gas upward state. Herein, the second valve plate 164 assumes first position during filling of the insulating gas into the second chamber 158 thereby, allowing passage to the insulated gas into the first chamber 156 which is at a lower pressure than the second chamber 158. Further, the second valve plate 164 assumes second position upon completion of the filling of the insulating gas when the pressure in the first chamber 156 is higher than in the second chamber 158. In other words, the second valve plate 164 gets lifted from the first valve plate 162 due to pressure of the insulating gas in the second chamber 158 to provide a flow path for the insulating gas to flow from the second chamber 158 into the first chamber 156.

[0044] As discussed, upon contact separation, an arc is formed in the first chamber 156 of the circuit breaker 100. The arc, extending between the first electrical contact 142 and the second electrical contact 144 (e.g., stationary and moveable electrical contacts), produces arcing gases and also heats up and pressurizes the insulating gas within the first chamber 156. This causes a flow of the heated insulating gas and arc gasses, due to the pressure change, into the second chamber 158 disposed adjacent to the first chamber 156, but only at certain times during the arcing event. As illustrated in FIGS 15-16, upon generation of the electrical arc, the valve assembly 150 is moved to gas downward state. Herein, the second valve plate 164 assumes first position upon generation of the electrical arc by overcoming constrain of the torsion spring 170 due to additional pressure built in the first chamber 156. In other words, the first valve plate 162 is separated from the second valve plate 164 due to further pressure build-up of the insulating gas in the first chamber 156 overcoming the constrain of the torsion spring 170 coupled thereto to provide a flow path for the insulating gas to flow out of the first chamber 156 to the second chamber 158. Thus, gas flows into the second chamber 158 after the gas pressure in the first chamber 156 reaches the inlet threshold pressure, is held in the second chamber 158 for part of the arc cycle, and then flows out of the second chamber 158 and back into the first chamber 156 when the pressure in the first chamber 156 falls below the outlet threshold pressure. This gas flow may cool down the first chamber 156 and may also increase dielectric strength thereof. In one or more embodiments, the gas flow around the arc increases the arc voltage, thereby providing better current limiting performance.

[0045] In one or more embodiments of the present disclosure, the torsion spring 170 is tensioned to define the constrain on the movement of the first valve plate 162 in the valve body 160 based on desired threshold pressure of the insulating gas in the first chamber 156. It may be appreciated by a person skilled in the art that the constrain may be defined based on the voltage rating of the circuit breaker 100, in order to be able to quench the generated arc in required time to avoid any damage.

[0046] It may be contemplated by a person skilled in the art that with the use of a torsion spring, load value can be set for different pressure release value by using same spring by changing angles. In one or more embodiments of the present disclosure, the torsion spring 170 is arranged at an angle of disposition (A) (as shown in FIG. 8) with respect to the first valve plate 162 in the valve body 160. This enables to vary the constrain on the movement of the first valve plate 162 in the valve body 160, which in turn could be used to regulate the movement of the first valve plate 162 in the valve body 160 based on desired threshold pressure of the insulating gas in the first chamber 156.

[0047] Further, in one or more embodiments, the torsion spring 170 is arranged proximal to a central opening 161 in the valve body 160. In another embodiment, the torsion spring 170 is arranged proximal to an outer wall 165 of the valve body 160. That is, the torsion spring 170 may be arranged either on a side in the valve body 160 or around the central opening 162 thereof, thus reducing any possible hindrance to the flow path of insulating gas into and out of the first chamber 156.

[0048] FIG 17 is a flowchart 1700 listing steps involved in a method of operating a circuit breaker, such as the circuit breaker 100. At step 1702, the method includes separating a first electrical contact (such as, the first electrical contact 142) from a second electrical contact (such as, the second electrical contact 144) in a first chamber (such as, the first chamber 156) of the circuit breaker 100 to generate an electrical arc. At step 1704, the method includes filling a second chamber (such as, the second chamber 158), disposed adjacent to the first chamber 156 in the circuit breaker 100, with insulating gas (such as, SF6). At step 1706, the method includes providing a valve assembly (such as, the valve assembly 150) with a first valve plate (such as, the first valve plate 162) and a second valve plate (such as, the second valve plate 164) movably seated on the first valve plate 162 such that during filling operation, the second valve plate 164 gets lifted from the first valve plate 162 due to pressure of the insulating gas in the second chamber 158 to provide a flow path for the insulating gas to flow from the second chamber 158 into the first chamber 156, and subsequently the second valve plate 164 gets seated back onto the first valve plate 162 due to the pressure build-up of the insulating gas in the first chamber 156. At step 1708, the method includes providing a torsion spring (such as, the torsion spring 170) configured to constrain the movement of the first valve plate 162 such that upon generation of the electrical arc, the first valve plate 162 is separated from the second valve plate 164 due to further pressure build-up of the insulating gas in the first chamber 156 overcoming the constrain of the torsion spring 170 coupled thereto to provide a flow path for the insulating gas to flow out of the first chamber 156 to the second chamber 158.

[0049] In the embodiments of the present disclosure, the function of multiple linear helical springs as used with valve arrangements of prior-art is carried out by utilizing a single torsion spring 170 below the first valve plate 162 (i.e. the pressure plate) . This makes the design of the valve assembly 150 simple and easy to assemble. Use of the torsion spring 170 results in compactness of the valve assembly 150, as only one torsion spring is sufficient for executing the operation of the valve assembly 150. Further unlike valve arrangements of prior-art with linear helical springs, no guides are required to operate the torsional spring 170. Further, the valve body 160 itself act as guide for the first valve plate 162 and the second valve plate 164. All of these factors results in that the present valve assembly 150 incorporates less number of components, and thus provides an economical and cost-effective proposition to manufacture. This further results in more opening or space for the flow of the insulating gas, for flow into and out of the first chamber 156, thus increasing in efficiency and response time for the circuit breaker 100.

[0050] 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

circuit breaker	100
common breaker base	102
pole column	104
pole column	106
pole column	108
operating mechanism unit	110
corner gear	112
switching position indicator	114
post insulator	116
insulated drive rod	118
interrupter unit	120
filter material	122
gas-tight jacket	124
coupling rod	126
shaft	128
upper high-voltage terminal	130
lower high-voltage terminal	132
diffuser socket	134
ring-placed contact laminations	136
heat cylinder	138
operating socket	140
O-rings	141
first electrical contact	142
second electrical contact	144
piston	146
pull rod	148
valve assembly	150
cylindrical casting	152
arc quenching nozzle	154
arc pressure control arrangement	155
first chamber	156
second chamber	158
valve body	160
central opening	161
first valve plate	162
second valve plate	164
outer wall	165
openings	166
openings	168
torsion spring	170
fasteners	172
spacers	174

(continued)

flowchart	1700
step	1702
step	1704
step	1706
step	1708
angle of disposition	A

Claims

1. A circuit breaker (100), comprising:

   first and second electrical contacts (142, 144), the electrical contacts (142, 144) configured to generate an electrical arc upon being separated during operation of the circuit breaker (100);
   a first chamber (156) at least partially surrounding the first and second electric contacts (142, 144);
   a second chamber (158) filled with insulating gas; and
   a valve assembly (150) interconnecting the first chamber (156) and the second chamber (158), the valve assembly (150) configured to allow threshold-based flow of the insulating gas into and out of the first chamber (156), the valve assembly (150) comprising:

      a valve body (160);
      a first valve plate (162) movably mounted in the valve body (160);
      a second valve plate (164) arranged in the valve body (162) so as to move between a first position and a second position, wherein in the first position, the second valve plate (164) lifts above the first valve plate (162) and in the second position, the second valve plate (164) seats upon the first valve plate (162); and

   a torsion spring (170) arranged in the valve body (160) and coupled to the first valve plate (162), the torsion spring (170) configured to constrain the movement of the first valve plate (162) in the valve body (160).

2. The circuit breaker (100) as claimed in claim 1, wherein the second valve plate (164) assumes first position during filling of the insulating gas into the second chamber (158) thereby, allowing passage to the insulated gas into the first chamber (156) which is at a lower pressure than the second chamber (158), and wherein the second valve plate (164) assumes second position upon completion of the filling of the insulating gas when the pressure in the first chamber (156) is higher than in the second chamber (158).

3. The circuit breaker (100) as claimed in claim 1, wherein the second valve plate (164) assumes first position upon generation of the electrical arc by overcoming constrain of the torsion spring (170) due to additional pressure built in the first chamber (156).

4. The circuit breaker (100) as claimed in claim 1, wherein the torsion spring (170) is tensioned to define the constrain on the movement of the first valve plate (162) in the valve body (160) based on desired threshold pressure of the insulating gas in the first chamber (156).

5. The circuit breaker (100) as claimed in claim 1, wherein the torsion spring (170) is arranged at an angle of disposition (A) with respect to the first valve plate (162) in the valve body (160) to define the constrain on the movement of the first valve plate (162) in the valve body (160).

6. The circuit breaker (100) as claimed in claim 1, wherein the torsion spring (170) is arranged proximal to a central opening (161) in the valve body (160).

7. The circuit breaker (100) as claimed in claim 1, wherein the torsion spring (170) is arranged proximal to an outer wall (165) of the valve body (160).

8. The circuit breaker (100) as claimed in claim 1, wherein the valve body (160) has a substantially cylindrical shape.

9. The circuit breaker (100) as claimed in claim 1, wherein the first valve plate (162) has one or more openings (168) formed therein, and wherein the second valve plate (164) is seated on the first valve plate (162) in a manner so as to seal the one or more openings (168) thereof.

10. A valve assembly (150) for a circuit breaker (100) having a first chamber (156) and a second chamber (158) filled with insulating gas, the valve assembly (150) comprising:

    a valve body (160) interconnecting the first chamber (156) and the second chamber (158);
    a first valve plate movably mounted in the valve body;
    a second valve plate movably seated on the first valve plate; and
    a first valve plate (162) movably mounted in the valve body (160) ;
    a second valve plate (164) arranged in the valve body (162) so as to move between a first position and a second position, wherein in the first posi-

tion, the second valve plate (164) lifts above the first valve plate (162) and in the second position, the second valve plate (164) seats upon the first valve plate (162); and

a torsion spring (170) arranged in the valve body (160) and coupled to the first valve plate (162), the torsion spring (170) configured to constrain the movement of the first valve plate (162) in the valve body (160).

11. The valve assembly (150) as claimed in claim 10, wherein the second valve plate (164) assumes first position during filling of the insulating gas into the second chamber (158) thereby, allowing passage to the insulated gas into the first chamber (156) which is at a lower pressure than the second chamber (158), and wherein the second valve plate (164) assumes second position upon completion of the filling of the insulating gas when the pressure in the first chamber (156) is higher than in the second chamber (158).

12. The valve assembly (150) as claimed in claim 10, wherein the second valve plate (164) assumes first position upon generation of the electrical arc by overcoming constrain of the torsion spring (170) due to additional pressure built in the first chamber (156).

13. The valve assembly as claimed in claim 11, wherein the torsion spring (170) is tensioned to define the constrain on the movement of the first valve plate (162) in the valve body (160) based on desired threshold pressure of the insulating gas in the first chamber (156).

14. The valve assembly as claimed in claim 11, wherein the torsion spring (170) is arranged at an angle of disposition (A) with respect to the first valve plate (162) in the valve body (160) to define the constrain on the movement of the first valve plate (162) in the valve body (160).

15. A method of operating a circuit breaker (100), comprising:

separating a first electrical contact (142) from a second electrical contact (154) in a first chamber (156) of the circuit breaker (100) to generate an electrical arc;

filling a second chamber (158), disposed adjacent to the first chamber (156) in the circuit breaker (100), with insulating gas;

providing a valve assembly (150) with a first valve plate (162) and a second valve plate (164) movably seated on the first valve plate (162) such that during filling operation of the insulating gas, the second valve plate (164) gets lifted from the first valve plate (162) due to pressure of the insulating gas in the second chamber (158) to provide a flow path for the insulating gas to flow from the second chamber (158) into the first chamber (156), and subsequently the second valve plate (164) gets seated back onto the first valve plate (162) due to the pressure build-up of the insulating gas in the first chamber (156); and

providing a torsion spring (170) configured to constrain the movement of the first valve plate (162) such that upon generation of the electrical arc, the first valve plate (162) is separated from the second valve plate (164) due to further pressure build-up of the insulating gas in the first chamber (156) overcoming the constrain of the torsion spring (170) coupled thereto to provide a flow path for the insulating gas to flow out of the first chamber (156) to the second chamber (158).

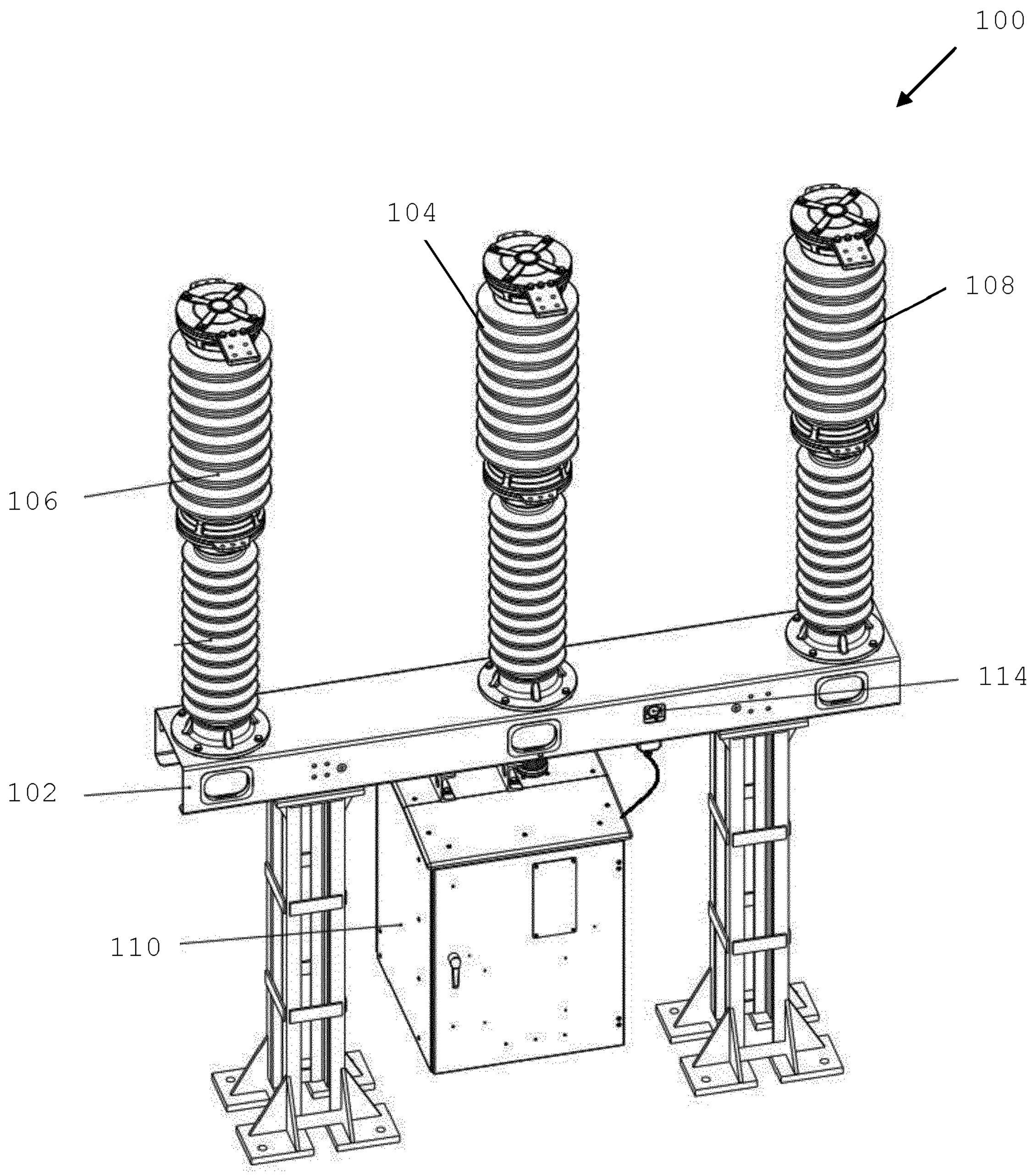

FIG 1

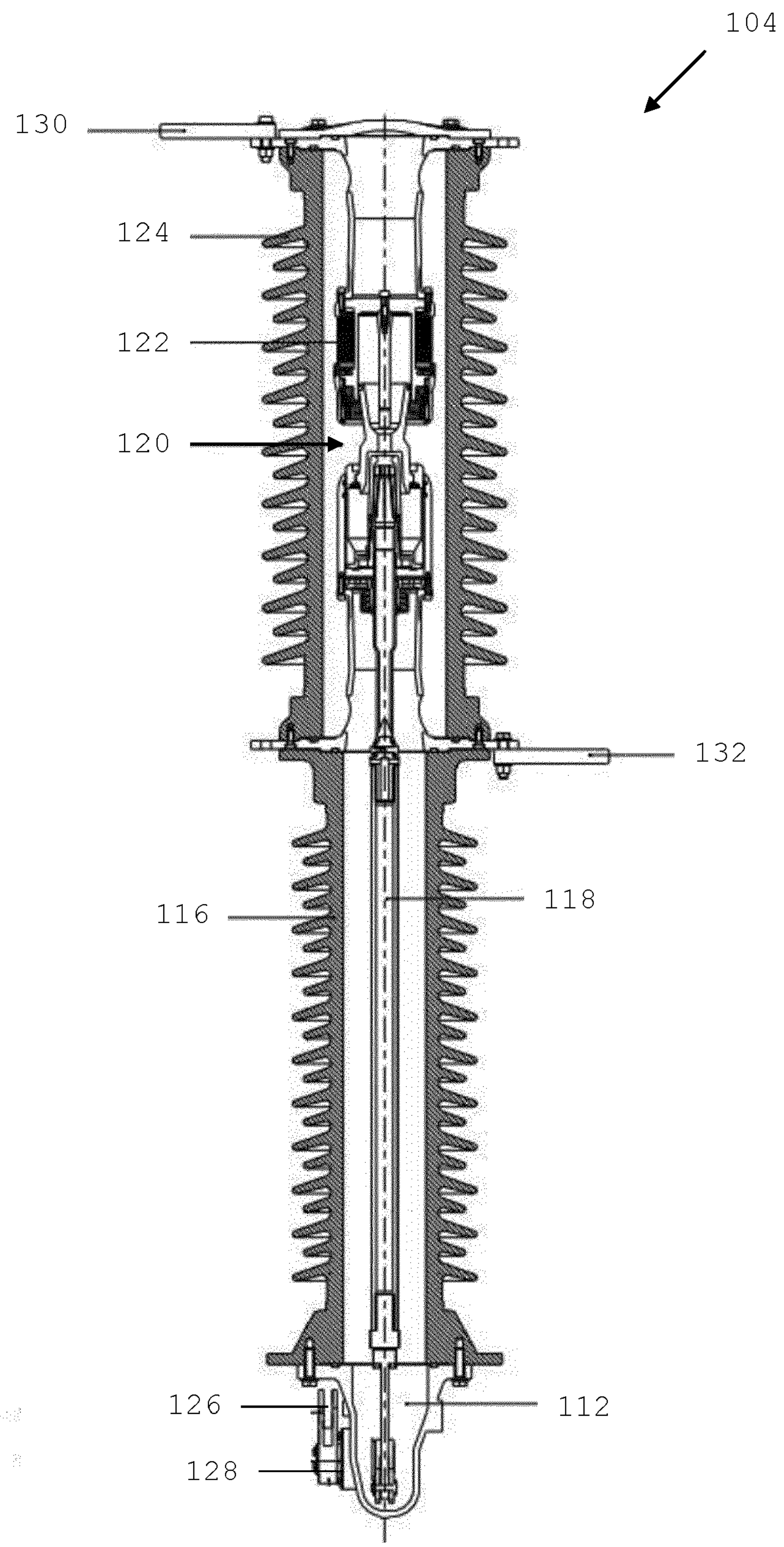

FIG 2

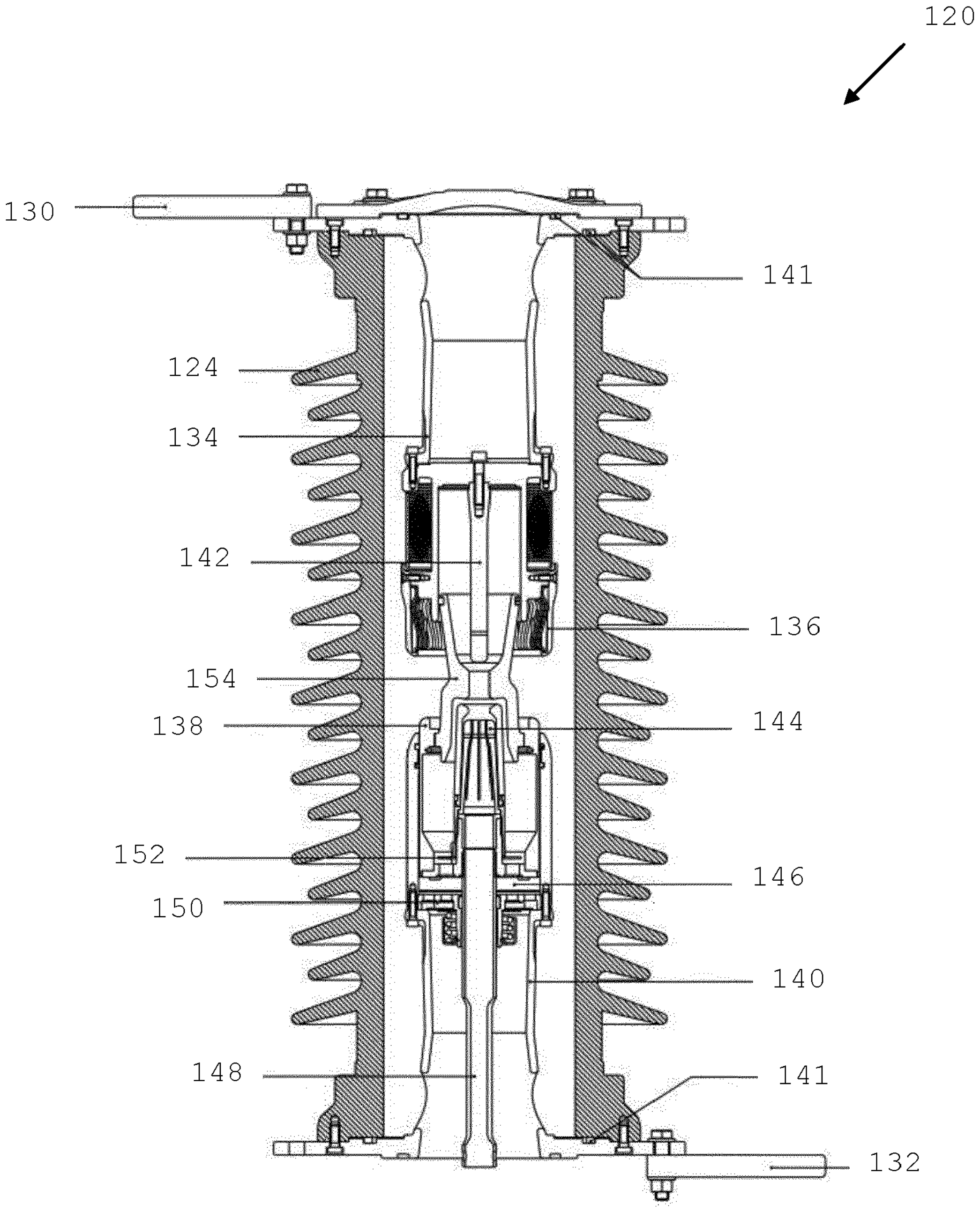
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FIG 3

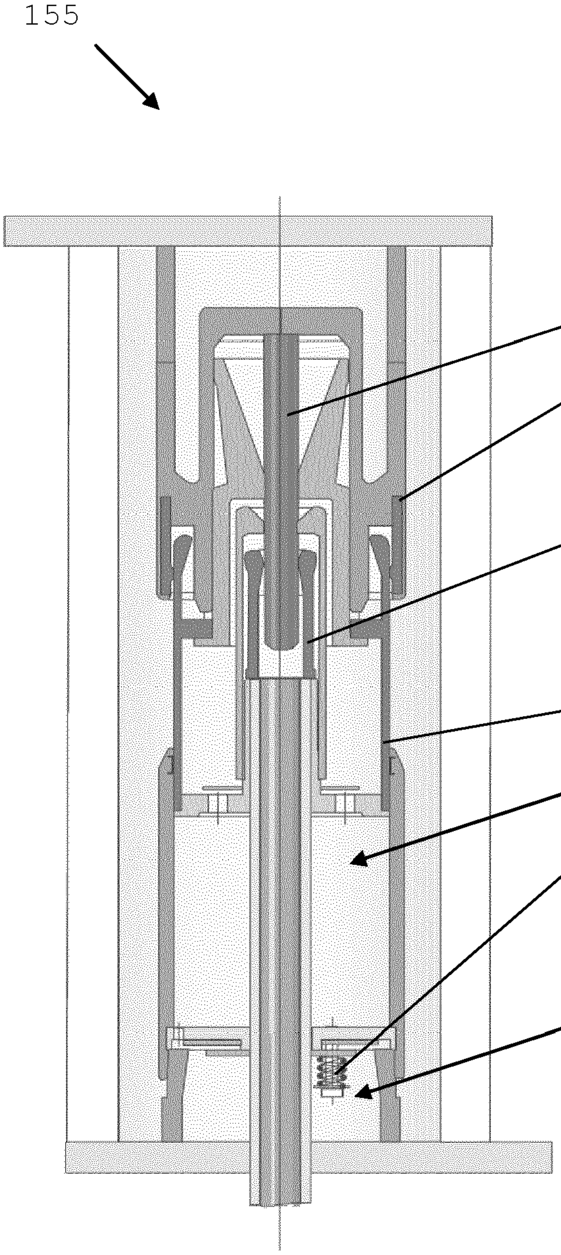

FIG 4A

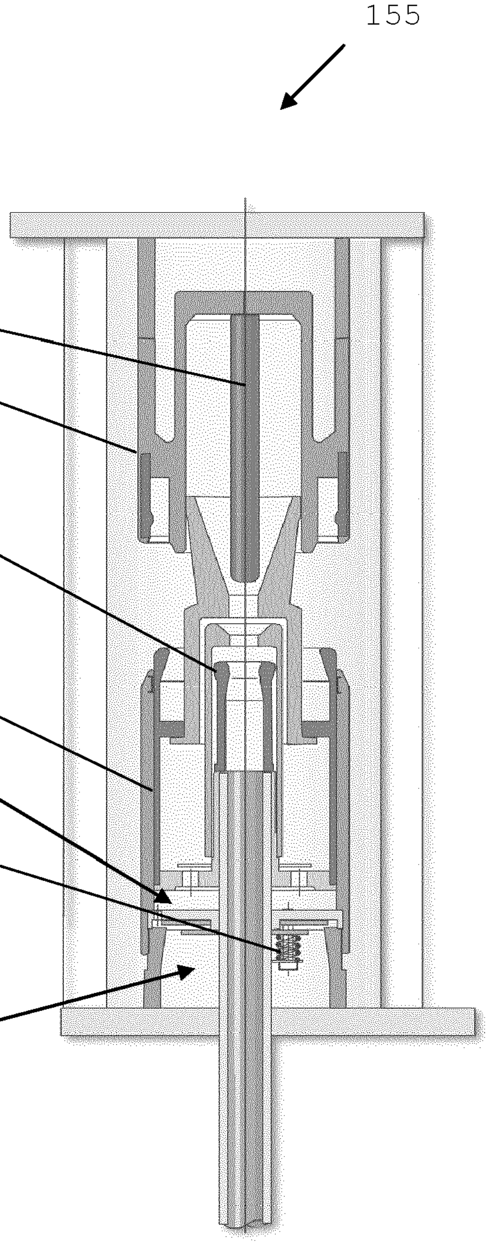

FIG 4B

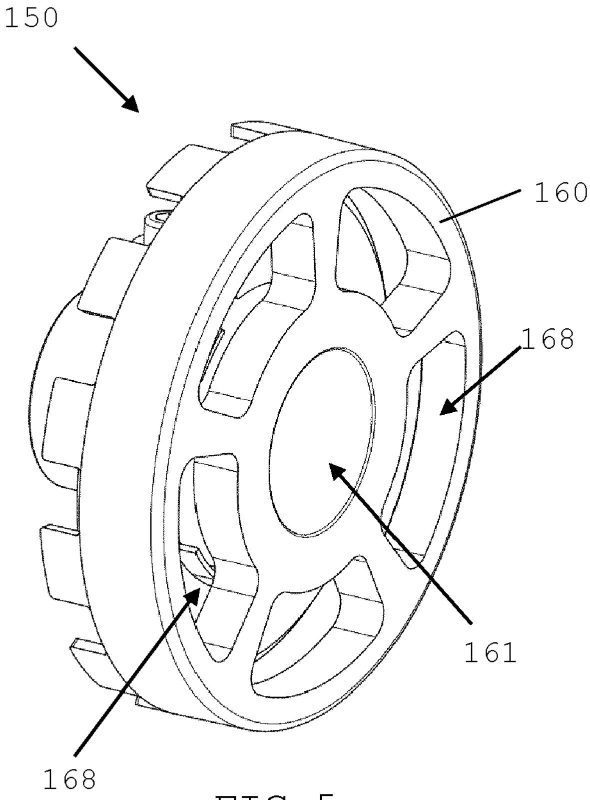

FIG 5

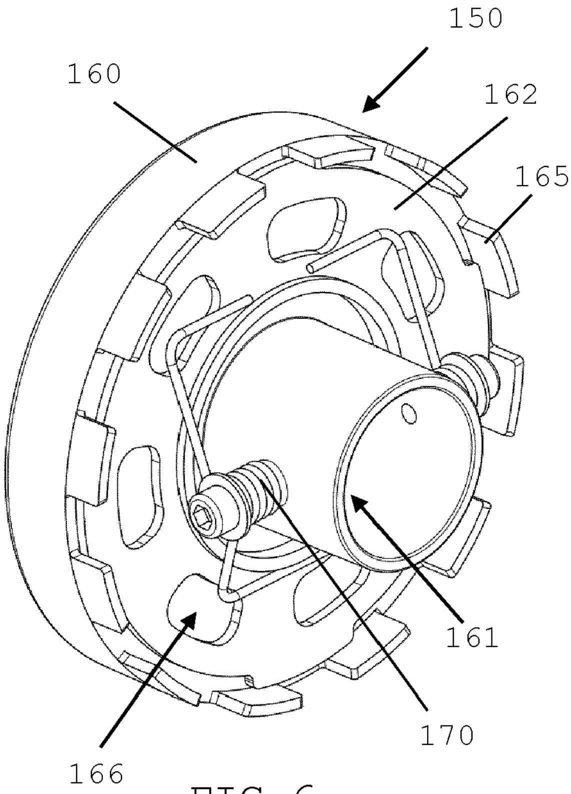

FIG 6

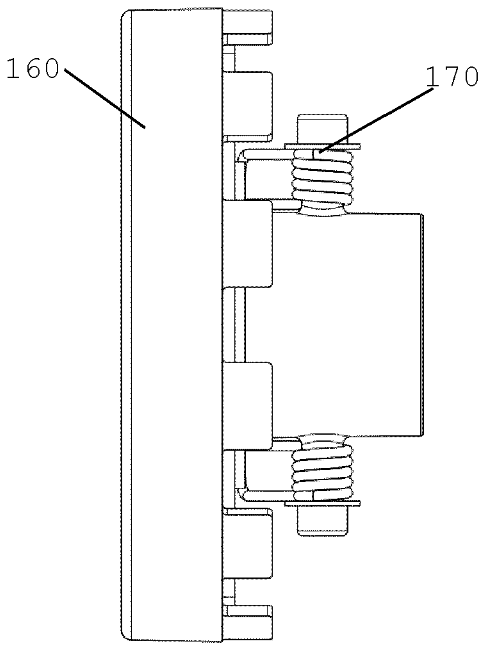

FIG 7

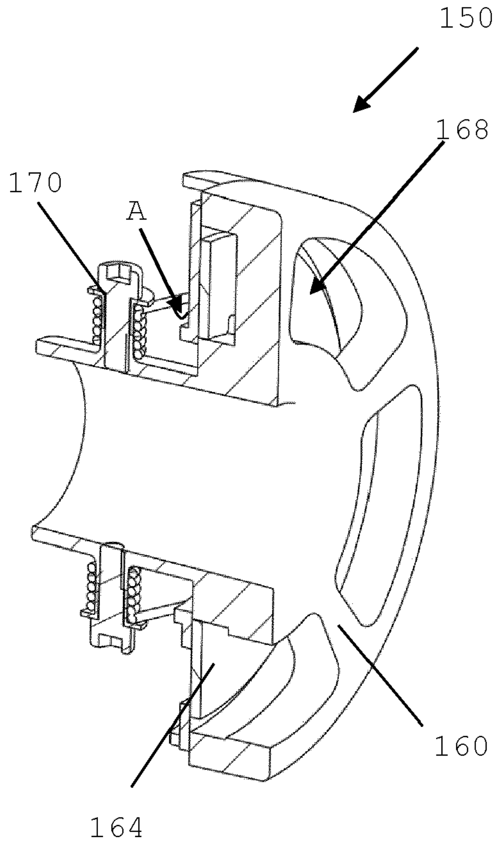

FIG 8

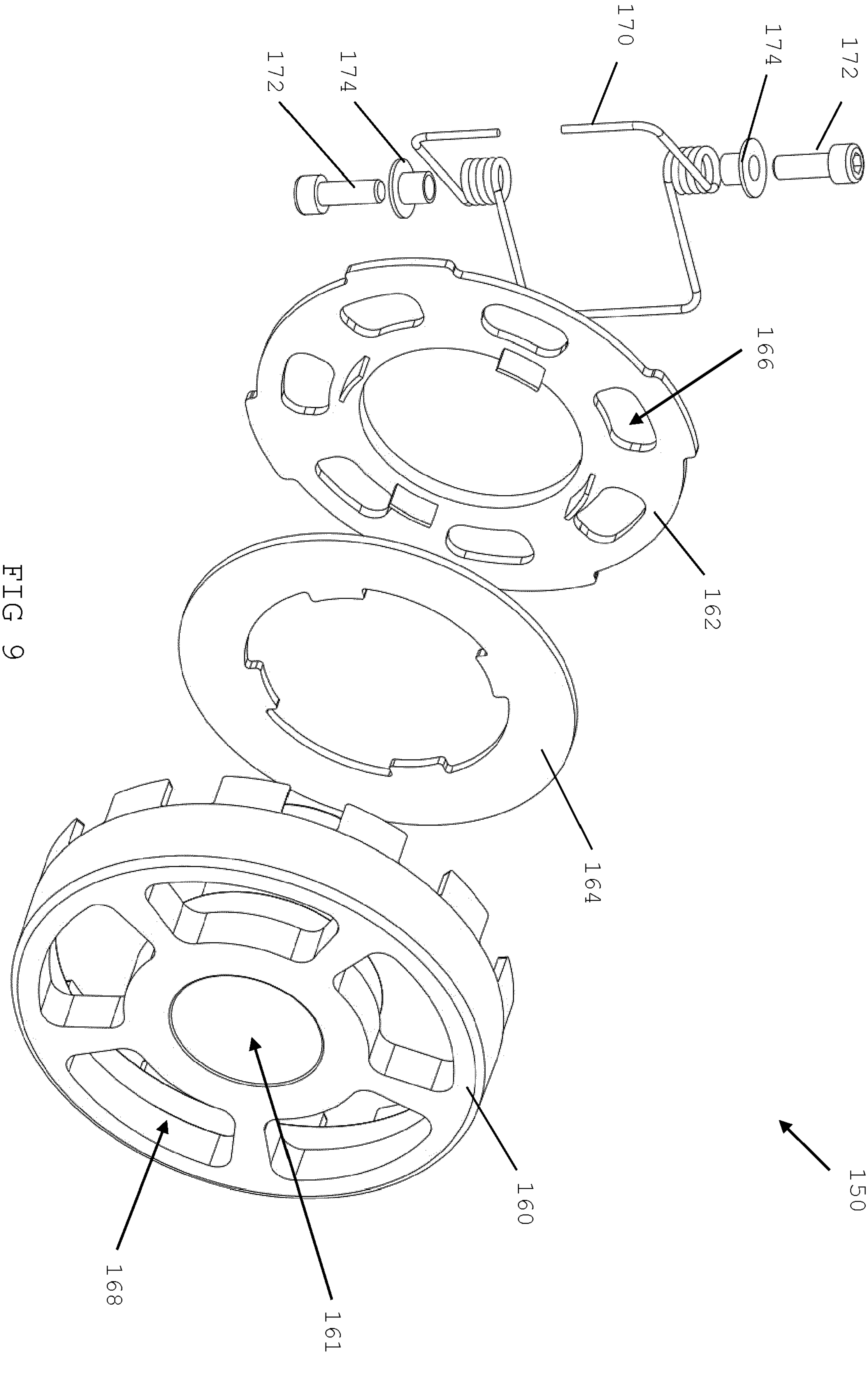

FIG 9

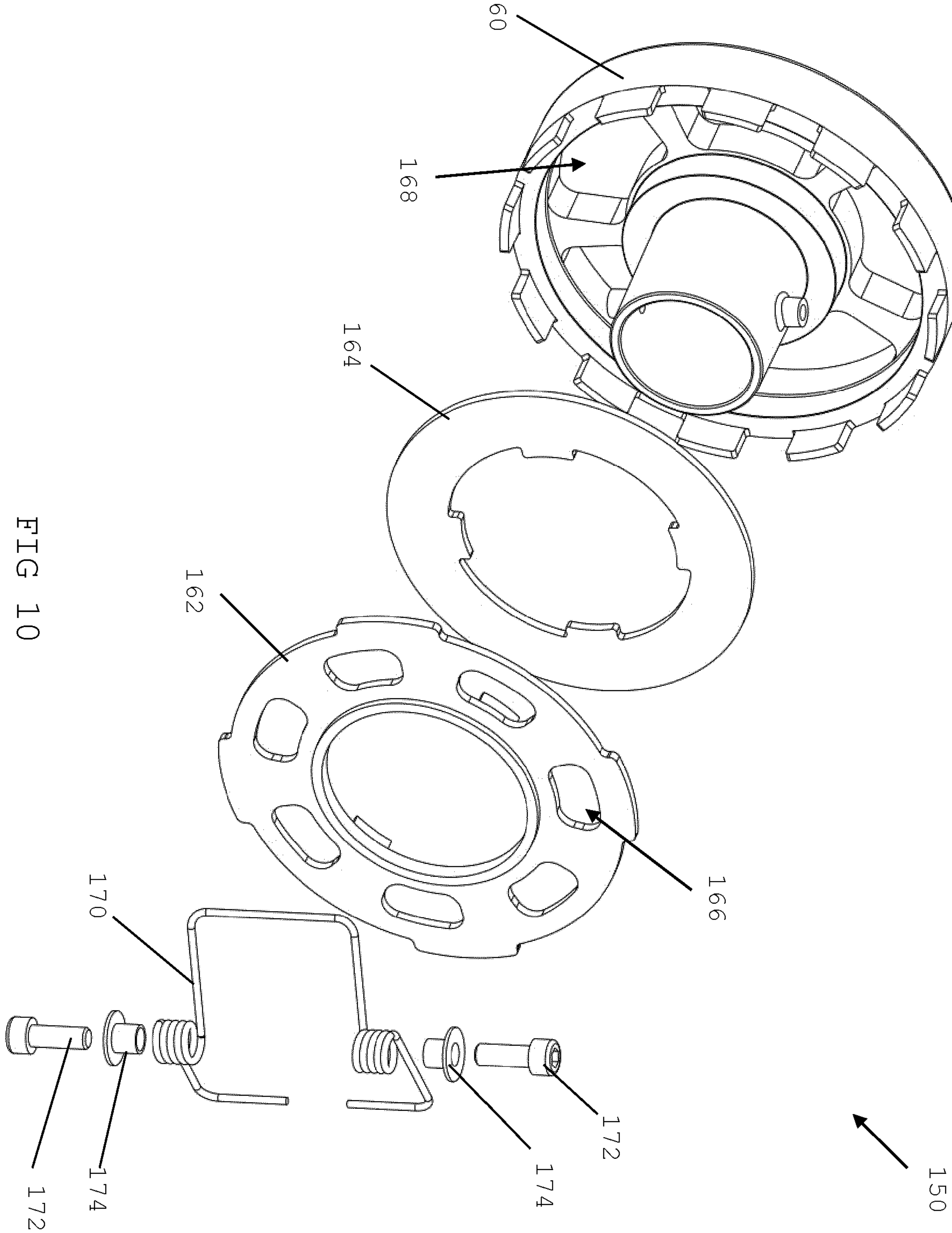

FIG 10

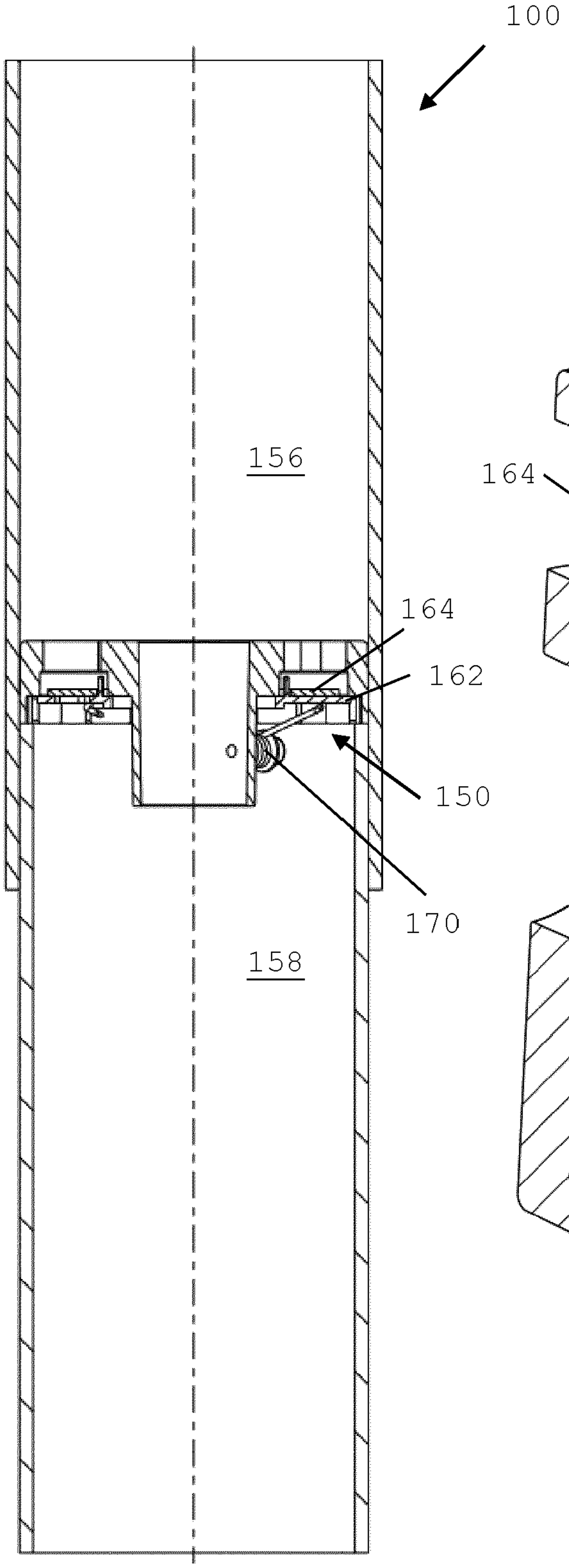

FIG 11

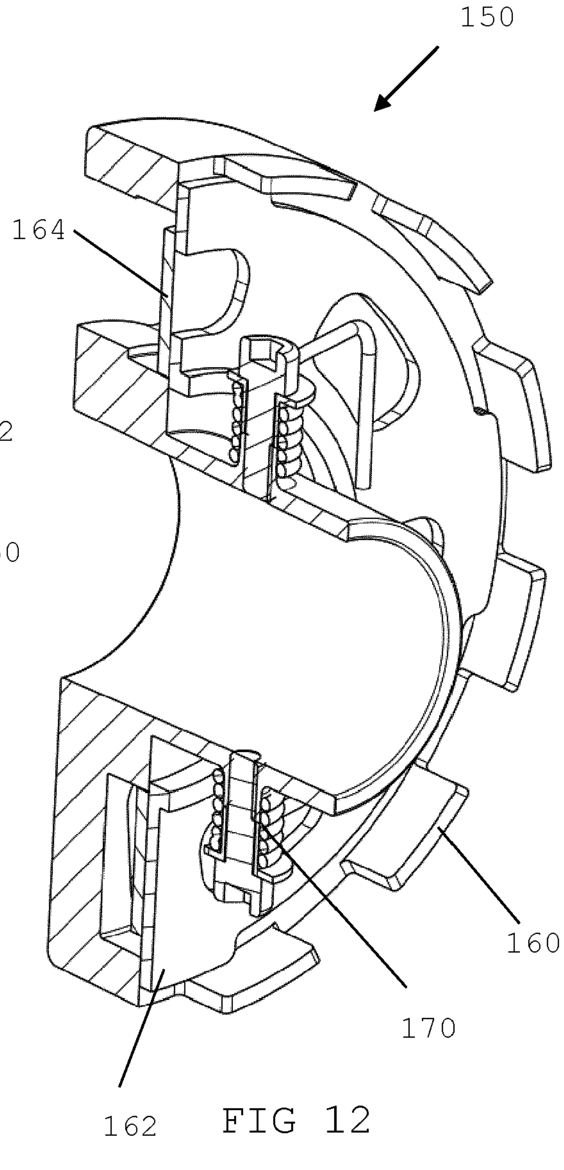

FIG 12

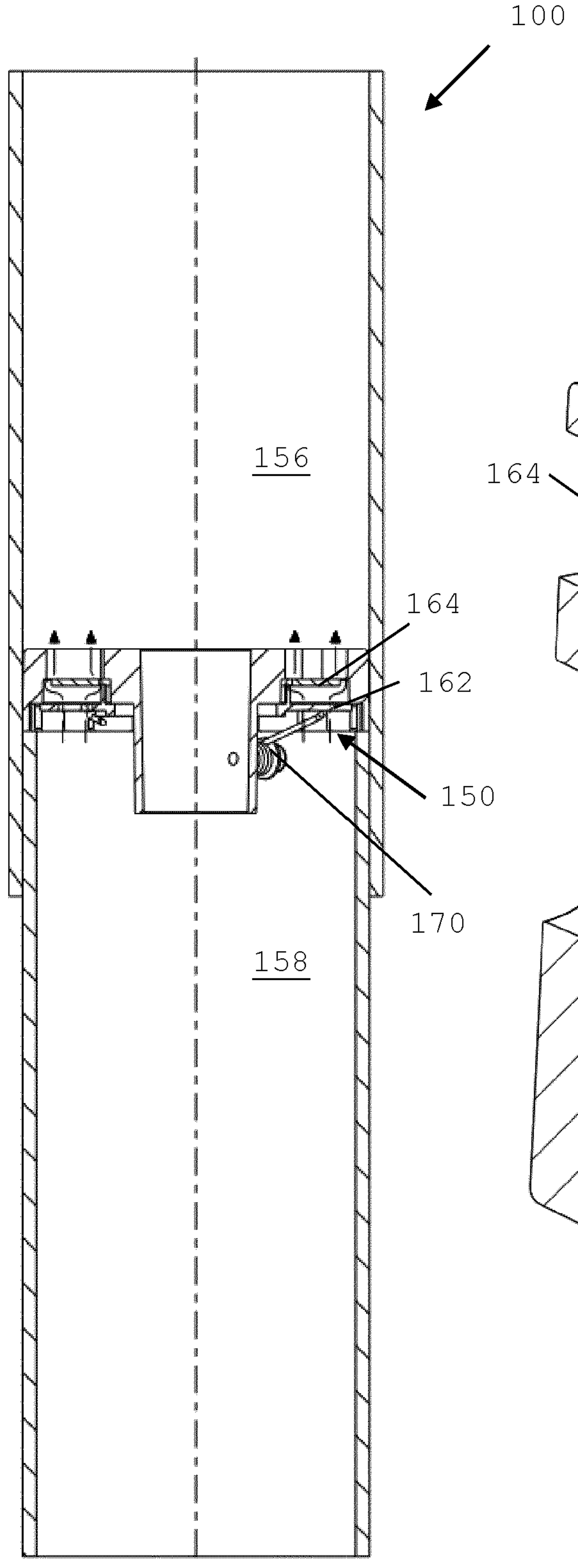

FIG 13

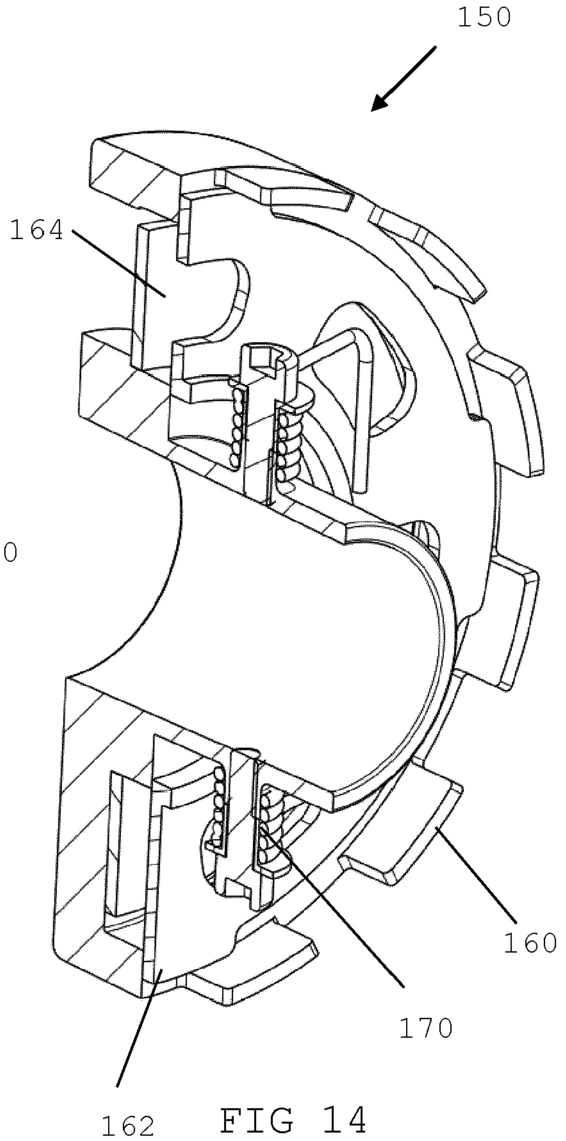

FIG 14

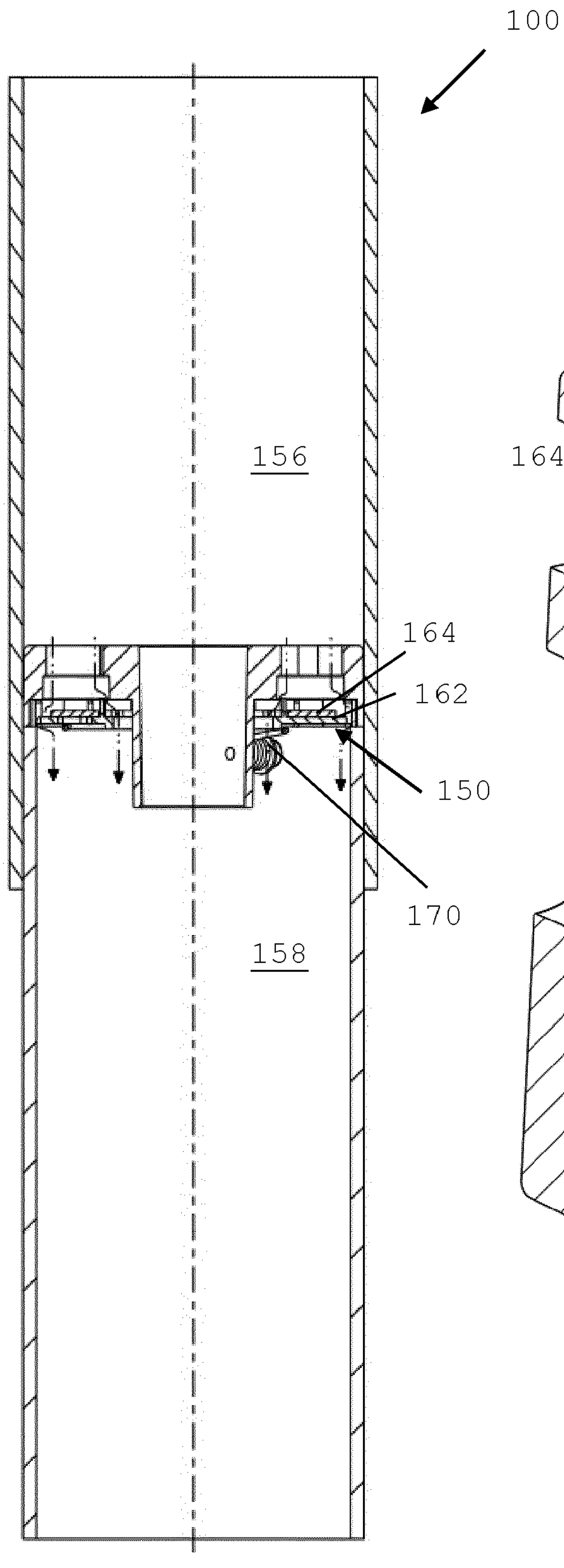

FIG 15

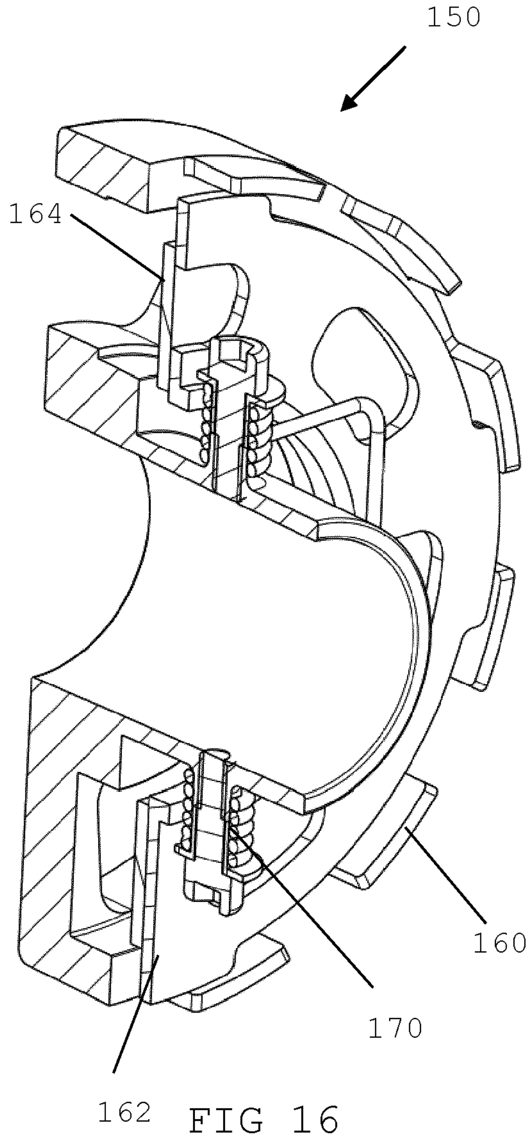

FIG 16

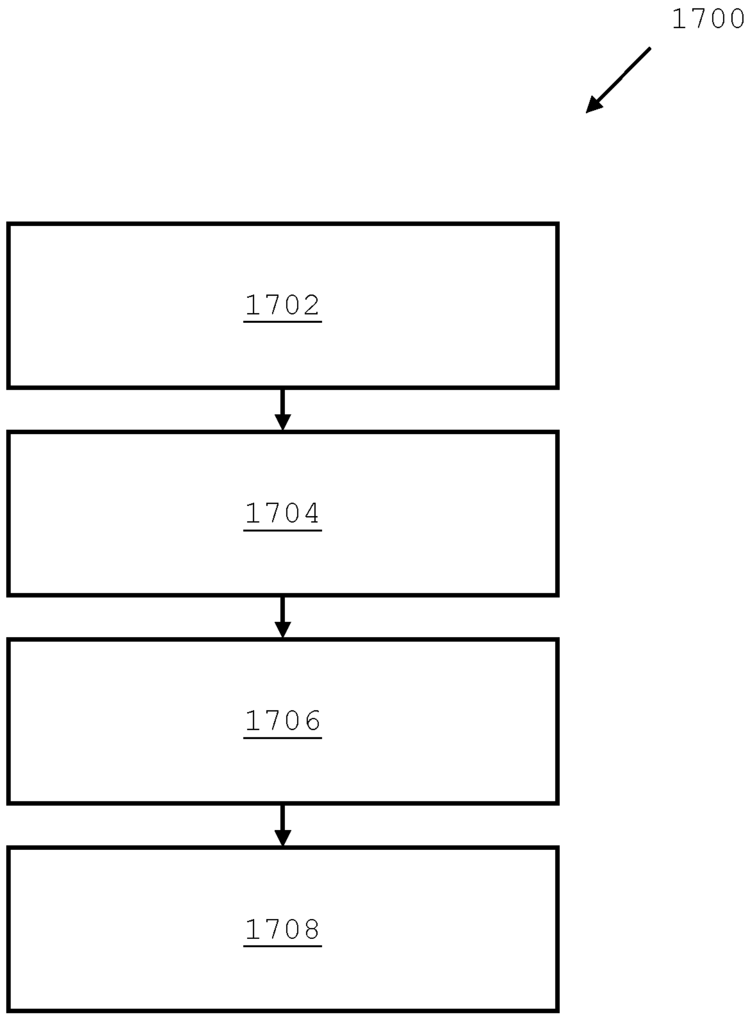

FIG 17

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EUROPEAN SEARCH REPORT

Application Number
EP 20 15 3684

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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H01H

The present search report has been drawn up for all claims

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Place of search	Date of completion of the search	Examiner
Munich	7 May 2020	Findeli, Luc

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07-05-2020

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