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(54) SWITCHGEAR DEVICE WITH ARC MANAGEMENT ARRANGEMENT

(57) A switchgear device (100) is described, comprising a housing (102), an ON contact (104), a conducting rod (110), and an arc management arrangement (120) which comprises a nozzle assembly (126) arranged inside the housing. The nozzle assembly comprises a nozzle holder (128) with a base (132) having a first aperture (136) and a plurality of first gas openings (138), and a nozzle top (130) engaged inside the nozzle holder and having a second aperture (140). When the conducting rod moves from an ON position to an OFF position, the conducting rod engages and moves the nozzle assembly therewith, resulting in a gas provided in a first space (100a) of the housing getting compressed and passing through the first gas openings and a first gap (G1) between the nozzle top and the conducting rod to a second space (100b) of the housing.

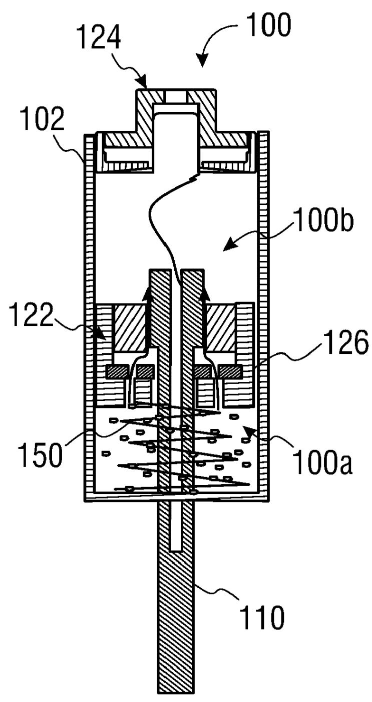

FIG 6C

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Description

[0001] The present disclosure generally relates to electric power distribution, and more particularly to a clean-air medium-voltage switchgear device for opening and closing a circuit in electric power distribution.

[0002] A switchgear device (also commonly known as switching device or simply switchgear) is an apparatus used for controlling, regulating, and switching on and off the electrical circuit in electrical power distribution. The switchgear device is typically placed in both high and low voltage sides of a power transformer, and is used for de-energizing the equipment for testing and maintenance and for clearing the fault. Generally, 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] The switchgear device needs to provide a high dielectric strength to withstand high voltages. In the case of switchgear device, and even other devices such as transformer (s), power line (s) (especially high-voltage electrical power transmission line (s)), busbar (s), circuit breaker, switch disconnector, earthing switch, (Switching) contactor (s), waveguides, etc., and where large electrical voltages (from about 1 kV and greater) and / or strong electric fields may occur, typically a gas or gas mixture for electrical insulation of the electrically active (i.e. exposed to electrical or a strong electric field exposed) parts is used. Gas insulation offers significantly improved dielectric strength compared to atmospheric air. In the switchgear device, the electrical contacts are sealed inside a tank with pressurized insulating medium.

[0004] In the case of gas-insulated system designs, Sulfur Hexafluoride (SF6) is the predominant insulation medium in which the individual functional gas spaces are hermetically encapsulated. SF6 offers very good insulating properties (dielectric strength about 2.7 times better than air) as well as very good extinguishing properties (no conductive decomposition products). In addition, SF6 encapsulated systems provide a very high level of reliability, personal protection (SF6 is chemically very stable) and lifetime (up to 30 years) and require only a very low level of maintenance. Since SF6 gas has very good dielectric properties, it is possible to keep the clearance much closer within suitable dielectric rating of the switchgear.

[0005] FIG 1 shows a traditional load break switch 10 for medium voltage switchgears (such as, 12 kV or 24 kV), in which SF6 gas may be utilized for providing dielectric clearance between a feeder 12 and a busbar 14. In the load break switch 10, the feeder 12 and the busbar 14 are used to connect to electrical system and control the flow of electric power. The feeder 12 is the electrical cable that carries the electric power from a source to the load break switch 10, and the busbar 14 is a conductor that provides a common connection point for multiple feeders 12 in the load break switch 10. As shown, the load break switch 10 is configured to be disposed in a closed position (as referred by ‘C’), an open position (as referred by ’O’) and an earthed position (as referred by ‘E’). Herein, the closed position ’C’ refers to a state where the electrical circuit is completed and current is flowing through the load break switch 10. The closed position ’C’ is used to energize the circuit and power any connected devices. The open position ’O’ refers to a state where the electrical circuit is interrupted and current is not flowing through the load break switch 10. The open position ’O’ is used to safely disconnect the circuit and ensure that there is no danger of electric shock. The earthed position ’E’ refers to a state where the electrical circuit is connected to the earth ground. The earthed position ’E’ helps to dissipate any residual voltage in the circuit, making it safer for maintenance or repair work. In the load break switch 10, an arc can occur when it is switched from the closed position ’C’ to the open position ’O’ or vice versa. The arc can be dangerous because it creates heat and can potentially cause damage to the load break switch 10 and/or the electrical system.

[0006] FIGS 2A and 2B depict operations of a traditional puffing arrangement 20 implemented in load break switches (such as, the traditional load break switch 10) in which SF6 gas may help with arc quenching. The load break switches for high voltage applications use the puffing arrangement 20 for quenching of arcs during the opening operation of the circuit breaker. Herein, the puffing arrangement 20 utilizes a movable cylinder 22 that is connected to a movable contact 24 of the circuit breaker. When the movable contact 24 moves linearly, the movable cylinder 22 also moves and compresses the trapped SF6 gas against a fixed piston 26. The compressed SF6 gas then exits through a nozzle 28 at high speed, taking out heat from the arc and extinguishing it. This is made possible as SF6 gas has excellent dielectric properties along with very good thermal conductivity, which helps to reduce heating effect and quenching of arc during load breaking operation.

[0007] However, SF6 has a relatively high global warming potential (GWP), even considered with respect to carbon dioxide (CO2). Due to its high global warming potential SF6 was included in the list of gases whose entry into the atmosphere is to be limited, according to the Kyoto Protocol of 1997. Therefore, alternative insulation mediums are being researched to reduce the environmental impact of high voltage equipment. As per EU guidelines for clean air switchgear, some manufacturers have started to build a portfolio in medium voltage switchgear to shift from SF6 gas insulated switchgear to clean air solution. That said, using the existing puffing arrangement (as discussed with reference to FIGS 2A and 2B) in the clean air insulation system for the load break switch is not feasible due to the bulkiness. Clean air insulation medium has less thermal conductivity and dielectric properties, which makes a huge impact on arc quenching during opening operation of the load break switchgears.

[0008] Hence, there is a need to develop new mechanism for switchgear device which can safely work within the limitations of dielectric strength of alternative insulating mediums (such as, clean air) and solve the issue of arc management for a switchgear device in a compact manner.

[0009] One object of the present disclosure is to provide a switchgear device for electric power distribution which can work with clean air insulating medium, such as SF6 free gases, like mixture of carbon dioxide gas and nitrogen gas. The use of clean air insulation medium requires utilizing an arc management arrangement employing multiple arc quenching principles in a single switchgear to overcome limited thermal conductivity and dielectric properties of such insulation medium for arc quenching. Combining different arc quenching principles in a single housing is challenging from space and dielectric clearances for SF6 free switchgear. The present disclosure proposes an arc management arrangement for the switchgear device utilizing one or more arc quenching principles with the use of optimized components to keep the overall switchgear device compact.

[0010] The object of the present disclosure is achieved by a switchgear device as described herein.

[0011] The switchgear device comprises a housing having a top and a bottom. The switchgear device also comprises an ON contact provided at the top of the housing. The switchgear device further comprises a conducting rod having a first portion and a second portion with the second portion having a larger diameter than the first portion. The conducting rod is configured to move linearly, between an ON position and an OFF position inside the housing, with the second portion in contact with the ON contact during the ON position. The switchgear device further comprises an arc management arrangement comprising an arc quenching arrangement. The arc quenching arrangement comprises a nozzle assembly arranged inside the housing. The nozzle assembly comprises a nozzle holder. The nozzle holder comprises a base. The base has a first aperture defined therein. The base further has a plurality of first gas openings defined therein. The first aperture is adapted to allow passage of the first portion of the conducting rod therethrough and block passage of the second portion of the conducting rod therethrough. The nozzle assembly also comprises a nozzle top engaged inside the nozzle holder and having a second aperture to allow passage of the conducting rod including the second portion thereof with a first gap left therebetween. The switchgear device further comprises a gas provided in a first space between the base of the nozzle holder of the nozzle assembly and the bottom of the housing. Herein, when the conducting rod moves from the ON position to the OFF position thereof, the second portion of the conducting rod gets engaged with the base of the nozzle holder to cause the nozzle assembly to move therewith and resulting in the gas being compressed and passing through the plurality of first gas openings and the first gap between the nozzle top and the conducting rod to a second space between the nozzle assembly and the top of the housing.

[0012] In an embodiment, the switchgear device further comprises a spring member arranged between the base of the nozzle holder of the nozzle assembly and the bottom of the housing. The spring member is configured to get compressed when the conducting rod moves from the ON position to the OFF position thereof due to the movement of the nozzle assembly, and de-compressed when the conducting rod moves from the OFF position to the ON position due to disengagement of the second portion of the conducting rod with the base of the nozzle holder and thereby provide a biasing force to move the nozzle assembly back to an initial position thereof.

[0013] In an embodiment, the spring member is a conical spring.

[0014] In an embodiment, the nozzle holder further comprises a side wall having an inner surface with a first engaging part and the nozzle top has an outer surface with a second engaging part complementary to the first engaging part of the nozzle holder, such that the first engaging part couples with the second engaging part to engage the nozzle top inside the nozzle holder.

[0015] In an embodiment, the first engaging part is in the form of internal threads at the inner surface of the side wall of the nozzle holder and the second engaging part is in the form of external threads at the outer surface of the nozzle top complementary to the internal threads at the inner surface of the side wall of the nozzle holder.

[0016] In an embodiment, the first engaging part and the second engaging part are configured to snap fit together to engage the nozzle top inside the nozzle holder.

[0017] In an embodiment, the nozzle top is engaged inside the nozzle holder with a second gap left between the nozzle top and the base of the nozzle holder to allow for the gas passing from the plurality of first gas openings to reach the first gap between the nozzle top and the conducting rod.

[0018] In an embodiment, the first aperture has a diameter larger than a diameter of the first portion of the conducting rod and smaller than a diameter of the second portion of the conducting rod.

[0019] In an embodiment, the switchgear device further comprises a contact ring placed onto the base of the nozzle holder. The contact ring has a third aperture and a plurality of second gas openings defined therein complementary to the first aperture and the plurality of first gas openings, respectively, in the base of the nozzle holder.

[0020] In an embodiment, the gas is natural air.

[0021] In an embodiment, the arc management arrangement further comprises an arc rotation arrangement. The arc rotation arrangement comprises a vortex ring arranged inside the housing. The vortex ring provides a cavity to, at least partially, support the ON contact therein. The vortex ring comprises a base with a fourth aperture to allow passage of the second portion of the conducting rod therethrough to be in contact with the ON contact. The arc rotation arrangement further comprises a permanent magnet placed between the ON contact and the base of the vortex ring and configured to provide a magnetic field. The permanent magnet has a fifth aperture to allow passage of the second portion of the conducting rod therethrough to be in contact with the ON contact. Herein, when the conducting rod moves from the ON position to the OFF position thereof, an electric arc generated between the base of the vortex ring and the second portion of the conducting rod is constantly moved due to the magnetic field provided by the permanent magnet.

[0022] In an embodiment, the magnetic field provided by the permanent magnet causes rotation of the electric arc at the base of the vortex ring.

[0023] In an embodiment, the ON contact has external threads, and the cavity of the vortex ring has internal threads to engage with the external threads of the ON contact to support the ON contact in the cavity with a third gap from the permanent magnet.

[0024] In an embodiment, the permanent magnet is a NdFeB magnet.

[0025] In an embodiment, the switchgear device further comprises a rotary shaft connected to the conducting rod. The rotary shaft configured to covert a rotary motion thereof into a linear movement of the conducting rod. The switchgear device also comprises a feeder contact provided at the bottom of the housing to support the conducting rod and dispose the conducting rod in an EARTH position when in contact therewith.

[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 1 is a diagrammatic view representation of a traditional load break switch;

FIG 2A is a diagrammatic view representation of a traditional puffing arrangement for the load break switch at an unengaged state;

FIG 2B is a diagrammatic view representation of the traditional puffing arrangement for the load break switch of FIG 2A at an engaged state for performing arc quenching;

FIG 3 is a diagrammatic section view representation of a switchgear device, in accordance with one or more embodiments of the present disclosure;

FIG 4 is a diagrammatic detailed view representation of the switchgear device of FIG 3 showing an arc management arrangement therein, in accordance with one or more embodiments of the present disclosure;

FIG 5A is a diagrammatic assembled view representation of a nozzle assembly for the switchgear device, in accordance with one or more embodiments of the present disclosure;

FIG 5B is a diagrammatic exploded view representation of the nozzle assembly of FIG 5A, in accordance with one or more embodiments of the present disclosure;

FIG 5C is a diagrammatic view representation of the nozzle assembly with a conducting rod, in accordance with one or more embodiments of the present disclosure;

FIGS 6A-6C are diagrammatic view representations depicting operation of an arc quenching arrangement, as part of the arc management arrangement, for the switchgear device, in accordance with one or more embodiments of the present disclosure;

FIG 7A is a diagrammatic assembled view representation of an arc rotation arrangement, as part of the arc management arrangement with the conducting rod, for the switchgear device, in accordance with one or more embodiments of the present disclosure;

FIG 7B is a diagrammatic exploded view representation of the arc rotation arrangement of FIG 7A with the conducting rod, in accordance with one or more embodiments of the present disclosure;

FIG 8 is a diagrammatic view representation depicting operation of the arc rotation arrangement, in accordance with one or more embodiments of the present disclosure;

FIG 9A is a simulated representation depicting rotation of electric arc as achieved by utilizing the arc rotation arrangement, in accordance with one or more embodiments of the present disclosure;

FIG 9B is a simulated representation depicting magnetic flux density across the arc rotation arrangement with generation of arcs, in accordance with one or more embodiments of the present disclosure;

FIG 9C is a simulated representation depicting force enacted on the arcs by utilizing the arc rotation arrangement, in accordance with one or more embodiments of the present disclosure; and

FIG 9D is a simulated representation depicting deformation of the arcs by utilizing the arc rotation arrangement, in accordance with one or more embodiments 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] Referring to FIGS 3 and 4, in combination, illustrated are diagrammatic view representations of a switchgear device 100, in accordance with one or more embodiments of the present disclosure. In particular, FIGS 3 and 4 depict a load breaker switch of the switchgear device 100, excluding other details for brevity. Hereinafter, the two terms "switchgear device 100" and "load breaker switch 100" have been used interchangeably for purposes of the present disclosure. The switchgear device 100, as described herein, may be a vacuum interrupter based switchgear which may be included in a medium voltage switchgear unit. Such switchgear device 100 may be used in several different applications, for instance, for capacitor switching or for sectionalizing a line or system of switches. The switchgear device 100 may also be molded into a "load break" elbow connector to interrupt currents of medium voltage distribution systems. The switchgear device 100 may be connected to a generator or to a consumer line, in which the generator or the consumer line is disconnectable from or connectable to the energy line by means of the switching device, as per the embodiments of the present disclosure.

[0029] In the present embodiments, the switchgear device 100 may be implemented as a gas-insulated switchgear. Herein, the load breaker switch 100 is a component that is used to open and close electrical circuits. The load breaker switch 100 is designed to handle high voltage and current, and it is typically used in medium and high voltage electrical power distribution systems. The load break switch 100 is further designed to provide a safe and reliable way to isolate a circuit for maintenance or repair, or to interrupt the flow of electricity in case of an emergency.

[0030] In an example, the switchgear device 100 may be a three-phase medium voltage switchgear, that is to say the switchgear 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 such case, the switchgear device 100 and further modules of the switchgear device 100, and therefore the entire polyphase switchgear device 100, are designed for three phases; however, it may be contemplated that for the purposes of the present disclosure, the switchgear device 100 may be a single phase or any other type of switchgear as known in the art. The switchgear device 100 may include an enclosure supporting three pole assemblies therein, with each pole assembly (sometimes, simply referred to as a pole) responsible for a single phase in the three-phase switchgear device 100 of the present disclosure. The switchgear device 100 may further include a control panel (generally represented by the numeral) which acts on a switching shaft (not shown) common to all the poles of the switchgear device 100.

[0031] As illustrated in FIGS 3 and 4, the load breaker switch 100 includes a housing 102. The housing 102 is generally hollow and may have any suitable shape based on the design and configuration of the switchgear device 100. In the present embodiments, the housing 102 is designed to be cylindrical in shape. As shown, the housing 102 has a top 102a and a bottom 102b. In the present implementation, the housing 102 is made of electrically insulating material. In an example, the housing 102 is made of plastic material.

[0032] Further, the switchgear device 100 includes contacts, which are conductive parts that are responsible for making and breaking the electrical connection. Such contacts are usually made of copper or silver and are designed to withstand high temperatures and arcing. Herein, the switchgear device 100 includes an ON contact 104 provided at the top 102a of the housing 102. The switchgear device 100 further includes an earth contact 106 (as better shown in FIG 3) and a feeder contact 108 (as better shown in FIG 4). In some examples, the housing 102 may be designed in two parts, with a top chamber and a bottom chamber. These two parts are assembled to form the housing 102 for three phases with the ON contact 104 being assembled in the top chamber, and the feeder contact 108 being assembled in the bottom chamber without departing from the sprit and the scope of the present disclosure.

[0033] The switchgear device 100 further includes a conducting rod 110. The conducting rod 110 is arranged inside in the housing 102 and is adapted to move linear therein. Herein, the feeder contact 108 is provided at the bottom 102b of the housing 102 to support the conducting rod 110 and dispose the conducting rod 110 in an EARTH position when in contact therewith. The switchgear device 100 also includes a rotary shaft 112, which is rotary operated blade shaft for earth contact. The rotary shaft 112 is connected to the conducting rod 110. The rotary shaft 112 is configured to covert a rotary motion thereof into a linear movement of the conducting rod 110. In an example, the rotary shaft 112 is operated by a spring-operated mechanism, such as a spring-operated mechanical drive to have high speed movement of the conducting rod 110. The switchgear device 100 also includes a lever mechanism 114 coupled to the rotary shaft 112 which converts the rotary motion to linear movement of the conducting rod 110. In particular, a slotted lever, as part of the lever mechanism 114, is placed on the rotating shaft which converts the rotary motion to linear operation of the conducting rod 110. Such mechanism may be contemplated by a person skilled in the art and thus not explained herein for brevity of the present disclosure.

[0034] In the switchgear device 100, the conducting rod 110 is designed to move linearly in order to open or close the contacts of the switch. The conducting rod 110 is typically connected to the moving contact of the switchgear device 100, which is responsible for making and breaking the electrical connection. The conducting rod 110 is usually cylindrical in shape, with a smooth and polished surface to reduce friction and wear. Further, the conducting rod 110 is typically made of copper or silver and is designed to withstand high temperatures and arcing. As shown, the conducting rod 110 has a first portion 110a and a second portion 11 0b. The first portion 110a generally forms a bottom section of the conducting rod 110 while the second portion 110b forms an upper section of the conducting rod 110. Herein, the second portion 110b has a larger diameter than the first portion 110a. The conducting rod 110 is configured to move linearly, between an ON position and an OFF position inside the housing 102, with the second portion 110b in contact with the ON contact 104 during the ON position (i.e., when the conducting rod 110 is at the ON position), and away and disconnected from the ON contact 104 during the OFF position (i.e., when the conducting rod 110 is at the OFF position) thereof.

[0035] It may be understood by a person skilled in the art that the linear motion of the conducting rod 110 helps with achieving the desired switching position (like ON and OFF) of the switchgear device 100, and when switching may happen from ON to OFF, an arc may appear at two points between the ON contact 104 and the conducting rod 110. As better shown in FIG 4, the switchgear device 100 of the present disclosure provides an arc management arrangement 120 including an arc quenching arrangement 122 which helps with quenching of generated arc by providing gas puffing action with the clean air insulating medium and an arc rotation arrangement 124 which minimizes the deteriorating effect of the arc on components of the switchgear device 100, specifically the conducting rod 110, by moving the arc around to not be concentrated at a single point on the ON contact 104 and/or the conducting rod 110.

[0036] Further, as illustrated in FIG 4, the arc quenching arrangement 122 includes a nozzle assembly 126. The nozzle assembly 126 is arranged inside the housing 102. In particular, at a rest or initial position, the nozzle assembly 126 is arranged between the ON position and the OFF position of the conducting rod 110. The nozzle assembly 126 is adapted to move linearly inside the housing 102 by engaging with the conducting rod 110 and moving along therewith.

[0037] FIGS 5A-5C are diagrammatic view representations of the nozzle assembly 126. In the present examples, as illustrated in FIGS 5A-5C, the nozzle assembly 126 is designed in two parts, a nozzle holder 128 and a nozzle top 130, with its details described in the proceeding paragraphs. Further, as illustrated, the nozzle holder 128 includes a base 132 and a side wall 134. With the housing 102 being cylindrical in shape and having a circular cross-section, the base 132 is generally in the form of a circular disc. The base 132 has a first aperture 136 defined therein, which may be located at a centre of the base 132. The base 132 further has a plurality of first gas openings 138 defined therein. As may be seen, the first gas openings 138 may be defined around the first aperture 136 in the base 132. Herein, the first aperture 136 has a diameter slightly larger than a diameter of the first portion 110a of the conducting rod 110 while smaller than a diameter of the second portion 110b of the conducting rod 110. Thereby, the first aperture 136 is adapted to allow passage of the first portion 110a of the conducting rod 110 therethrough and block passage of the second portion 110b of the conducting rod 110 therethrough.

[0038] Further, the nozzle top 130 is engaged inside the nozzle holder 128. In particular, the side wall 134 of the nozzle holder 128 has an inner surface 134a with a first engaging part (not shown) and the nozzle top 130 has an outer surface 130a with a second engaging part (not shown) complementary to the first engaging part of the nozzle holder 128. Herein, the first engaging part of the nozzle holder 128 couples with the second engaging part of the nozzle top 130 to engage the nozzle top 130 inside the nozzle holder 128. In an example, the first engaging part is in the form of internal threads at the inner surface 134a of the side wall 134 of the nozzle holder 128 and the second engaging part is in the form of external threads at the outer surface 130a of the nozzle top 130 complementary to the internal threads at the inner surface 134a of the side wall 134 of the nozzle holder 128. In another example, the first engaging part and the second engaging part are configured to snap fit together to engage the nozzle top 130 inside the nozzle holder 128.

[0039] As may be seen, the nozzle top 130 is in the form of an annular ring. Furthermore, as shown, the nozzle top 130 has a second aperture 140. Herein, the second aperture 140 has a diameter slightly larger than a diameter of the second portion 110b of the conducting rod 110. Thereby, the second aperture 140 allows passage of the conducting rod 110 including the second portion 110b thereof with a first gap ‘G1’ (as better shown in FIG 5C) left therebetween. Further, as shown, the nozzle top 130 is engaged inside the nozzle holder 128 with a second gap ‘G2’ (as better shown in FIG 5A) left between the nozzle top 130 and the base 132 of the nozzle holder 128.

[0040] In some examples, the nozzle assembly 126 further includes a contact ring 142. The contact ring 142 is in the form of a disc with a diameter generally equal to an internal diameter of the nozzle holder 128. The contact ring 142 is placed onto the base 132 of the nozzle holder 128. It may be understood that by making the nozzle assembly 126 in two parts, i.e., the nozzle holder 128 and the nozzle top 130, it would be possible to mount the contact ring 142 in between these parts. The contact ring 142 has a third aperture 144 defined therein complementary to the first aperture 136 in the base 132 of the nozzle holder 128. The third aperture 144 may be defined at a centre of the contact ring 142. The contact ring 142 also has a plurality of second gas openings 146 defined therein complementary to the plurality of first gas openings 138 in the base 132 of the nozzle holder 128. As may be seen, the second gas openings 146 are arranged around the third aperture 144 in the contact ring 142.

[0041] Now referring back to FIGS 3 and 4, the switchgear device 100 includes a gas provided in a first space (as represented by reference numeral 100a) between the base 132 of the nozzle holder 128 of the nozzle assembly 126 and the bottom 102b of the housing 102. In the present embodiments, the gas is sulfur hexafluoride (SF6) free gas. In a particular embodiment, the gas is an eco-friendly gas, such as natural air, or comprising a mixture of carbon dioxide gas and nitrogen gas. It may be appreciated that the given ratios are exemplary only and shall not be construed as limiting to the present disclosure in any manner. Alternatively, as a gaseous insulating medium, various gases, in particular hydrofluoroolefins, perfluoroketones, perfluoronitriles, hydrofluoroxiranes, perfluoroxiranes, hydrofluoroethers, perfluoroether, or a mixture of said gases may be utilized without any limitations. These are media which, at the operating temperature of the high or medium-voltage arrangements, are generally gaseous, or liquid and gaseous with a gaseous fraction having a high dielectric strength. It may be understood that in order to accommodate the gas, the housing 102 is sealed and in turn may preferably be made of a material which is gas-impermeable, such as glass, polymers or resins.

[0042] Further, as shown in FIGS 6A-6C, the switchgear device 100 includes a spring member 150. The spring member 150 is arranged between the base 132 of the nozzle holder 128 of the nozzle assembly 126 and the bottom 102b of the housing 102. As discussed, the nozzle assembly 126 is adapted to move linearly inside the housing 102 by engaging with the conducting rod 110 and moving along therewith. Thereby, as shown in FIGS 6A-6C, the spring member 150 is configured to get compressed when the conducting rod 110 moves from the ON position to the OFF position thereof due to the movement of the nozzle assembly 126, and de-compressed when the conducting rod 110 moves from the OFF position to the ON position due to disengagement of the second portion 110b of the conducting rod 110 with the base 132 of the nozzle holder 128 and thereby provide a biasing force to move the nozzle assembly 126 back to the initial position thereof. The spring member 150 also ensures that the nozzle assembly 126 is touching the ON contact 104 when the switch is ON, and keep ready for next OFF operation with gas puffing.

[0043] In an example embodiment, the spring member 150 is a conical spring. Conical springs have a high force density, which means that they can generate a large amount of force with a relatively small size. This makes the conical spring a good choice for applications where space is limited, such as in the present switchgear device 100. That said, other suitable types of springs may be utilized as the spring member 150 without departing from the spirit and the scope of the present disclosure.

[0044] As depicted in sequence in FIGS 6A-6C, in the arc quenching arrangement 122, when the conducting rod 110 moves from the ON position to the OFF position thereof, the second portion 110b of the conducting rod 110 gets engaged with the base 132 of the nozzle holder 128 (by sitting thereon) to cause the nozzle assembly 126 to move therewith and resulting in the gas being compressed and passing through the plurality of first gas openings 138 and the first gap ‘G1’ between the nozzle top 130 and the conducting rod 110 to a second space (as represented by reference numeral 100b) between the nozzle assembly 126 and the top 102a of the housing 102. Herein, the second gap ’G2’ left between the nozzle top 130 and the base 132 of the nozzle holder 128 allow for the gas passing from the plurality of first gas openings 138 to reach the first gap ’G1’ between the nozzle top 130 and the conducting rod 110 to reach the second space 100b in the switchgear device 100. The gas in the second space 100b may cause gas puffing action to quench (extinguish) any arc that may be generated therein by taking out heat from such arc.

[0045] Specifically, when the rotary shaft 112 rotates, the conducting rod 110 starts moving linearly. During initial movement, the conducting rod 110 comes out from the ON contact 104, and the nozzle assembly 126 stays at the initial position. When the first portion 110a of the conducting rod 110 has passed through the nozzle assembly 126, the second portion 110b of the conducting rod 110 gets engaged with the nozzle assembly 126, and the nozzle assembly 126 start moving linearly along thereof. During the movement of the nozzle assembly 126, the gas in the first space 100a gets compressed. The nozzle holder 128 of the nozzle assembly 126 is designed with the first gas openings 138, so the compressed gas enters in the nozzle holder 128 and goes out at very high speed, first through the second gap ‘G2’ between the nozzle top 130 and the base 132 of the nozzle holder 128, and then through the first gap ‘G1’ between the nozzle top 130 and the conducting rod 110. As discussed, when the conducting rod 110 comes out of the ON contact 104, an electric arc gets formed between them. The compressed gas comes from the nozzle assembly 126 at very high speed, flows in line with the electric arc and take out the heat from it which help with the quenching of the electric arc. Further, during ON to

OFF movement of the conducting rod 110, the spring member 150 also get compressed. When OFF to ON operation starts, the conducting rod 110 moves independently from the nozzle assembly 126. In particular, during upward movement, the conducting rod 110 gets disengaged from the contact ring 142 of the nozzle assembly 126, so that the nozzle assembly 126 does not move with the conducting rod 110. At the same time, the energy stored in the spring member 150 gets released and push the nozzle assembly 126 upwards to its initial position to be ready for next ON to OFF operation of the switchgear device 100.

[0046] Now referring to FIGS 7A and 7B, illustrated are diagrammatic view representations of the arc rotation arrangement 124, in accordance with one or more embodiments of the present disclosure. Hereinafter, the arc rotation arrangement 124 of FIGS 7A and 7B has been discussed in combination with FIG 4 for reference. As shown, the arc rotation arrangement 124 includes a vortex ring 160. Herein, the vortex ring 160 may be made of stainless steel or copper. As seen from FIG 4, the vortex ring 160 is arranged inside the housing 102. The vortex ring 160 is in the form of an annular member with a base 162 and a sidewall extending therefrom. Thereby, the vortex ring 160 provides a cavity 164 to, at least partially, support the ON contact 104 therein. Also, as shown, the base 162 of the vortex ring 160 has a fourth aperture 166 defined therein. The fourth aperture 166 is generally located at a centre of the base 162 of the vortex ring 160. The fourth aperture 166 is designed to allow passage of the second portion 110b of the conducting rod 110 therethrough to be in contact with the ON contact 104.

[0047] Further, as shown in FIGS 7A and 7B in combination with FIG 4, the arc rotation arrangement 124 includes a permanent magnet 170. Herein, the permanent magnet 170 is generally in the form of an annular member. The permanent magnet 170 is placed between the ON contact 104 and the base 162 of the vortex ring 160 (illustrated halved in FIG 7B to show inner details thereof). In the arc rotation arrangement 124, the permanent magnet 170 is configured to provide a magnetic field (as later discussed in detail with reference to FIG 8). As shown, the permanent magnet 170 has a fifth aperture 172. The fifth aperture 172 is located at a centre of the permanent magnet 170. The fifth aperture 172 is designed to allow passage of the second portion 110b of the conducting rod 110 therethrough to be in contact with the ON contact 104. In an example embodiments, the permanent magnet 170 is a Neodymium (NdFeB) magnet. In particular, the permanent magnet 170 is a NdFeB 37 magnet.

[0048] Further, as shown, the cavity 164 of the vortex ring 160 has internal threads 168. Also, the ON contact 104 has external threads 104a defined therein. Thereby, the internal threads 168 of the cavity 164 of the vortex ring 160 engages with the external threads 104a of the ON contact 104 to support the ON contact 104 in the cavity 164. In an example, the internal threads 168 of the cavity 164 of the vortex ring 160 are defined such that the ON contact 104 is supported in the cavity 164 with a third gap ‘G3’ from the permanent magnet 170 also supported in the cavity 164 of the vortex ring 160. This is made possible by supporting the permanent magnet 170 by using a supporting member 105 along with the ON contact 104 (as shown in FIG. 7B).

[0049] As discussed, when the conducting rod moves from the ON position to the OFF position thereof, an electric arc is generated. Herein, in particular, the electric arc is generated between the base 162 of the vortex ring 160 and the second portion 110b of the conducting rod 110. As illustrated in FIG 8, due to presence of the permanent magnet 170, the said electric arc as generated between the base 162 of the vortex ring 160 and the second portion 110b of the conducting rod 110 is constantly moved due to the magnetic field provided by the permanent magnet 170. Specifically, in the arc rotation arrangement 124, the magnetic field provided by the permanent magnet 170 causes rotation (as represented by ’R’) of the electric arc at the base 162 of the vortex ring 160. By moving the electric arc around, the arc rotation arrangement 124 ensures that the energy of the electric arc is not concentrated at a single point on the ON contact 104 and/or the conducting rod 110, and thus prevents damage thereto.

[0050] Referring to FIGS 9A-9D, illustrated are simulated representations showing effect of operation of the arc rotation arrangement 124, in accordance with one or more embodiments of the present disclosure. Simulated diagram 900A of FIG 9A depicts rotation of the electric arc as achieved due to the magnetic field provided by a permanent magnet (such as, the permanent magnet 170 of the arc rotation arrangement 124). The simulated diagram 900A is a 3D Model with 6 arcs and simulates effect with the permanent magnet being NdFeB 37 (Mur= 1.048). The simulated diagram 900A verifies the effect of the arc rotation arrangement 124. Simulated diagram 900B of FIG 9B depicts density of magnetic flux in a switchgear device (such as, the switchgear device 100) due to use of an arc rotation arrangement (such as, the arc rotation arrangement 124). The simulated diagram 900B implements Magnetic Flux Density Element Nodal Averaged Magnitude with minimum = 0.000 T and maximum = 0.806 T. As may be seen, the magnetic flux density is strongest at a region where the electric arc is generated, and thus the arc rotation arrangement (such as, the arc rotation arrangement 124) may effectively help with rotation of the electric arc to minimize its effect. Simulated diagram 900C of FIG 9C depicts consistent strong force (Lorentz force) being enacted on the generated electric arc by use of an arc rotation arrangement (such as, the arc rotation arrangement 124) to cause required rotation of the electric arc. Simulated diagram 900D of FIG 9D depicts consistent deformation taking place on the generated electric arc by use of an arc rotation arrangement (such as, the arc rotation arrangement 124) to cause required rotation of the electric arc.

[0051] In the traditional load break switch 10, SF6 gas is used as an insulation medium. As SF6 gas has excellent dielectric properties along with very good thermal conductivity, this helps to reduce heating effect and quenching of arc during load breaking operation. In contrast, the switchgear device 100 using clean air insulation medium or the like has a significant impact on arc quenching during load breaking operation thereof, due to comparatively much less thermal conductivity and reduced dielectric properties of the used insulation medium. The switchgear device 100 of the present disclosure with the arc management arrangement 120, including the arc quenching arrangement 122 and the arc rotation arrangement 124, achieves management of generated electric arc due to its operation even with use of clean air insulating medium, while disposing the added components required for arc management within the housing 102, to keep itself compact. With the proposed design, it is possible to combine different arc quenching principles, like quenching/puffing and arc rotation together, for SF6 free load break switch. By not rigidly fixing the nozzle assembly 126 on the conducting rod 110, the nozzle assembly 126 will get activated only during the ON to OFF movement of the conducting rod 110, which, in turn, helps with optimizing energy of the mechanical drive as employed. Further, during OFF to ON operation, the nozzle assembly 126 gets disengaged from the conducting rod and moves independently, which helps with further optimizing energy of the mechanical drive.

[0052] In the switchgear device 100 of the present disclosure, the nozzle assembly 126 is not rigidly fixed on the conducting rod 110. The nozzle assembly 126 may only engage when the conducting rod 110 moves from the ON position to the OFF position thereof and disengages when the conducting rod 110 moves from the OFF position to the ON position thereof, which helps to optimize the mechanical drive energy in the switchgear device 100. The spring member 150 placed between the base 132 of the nozzle holder 128 of the nozzle assembly 126 and the bottom 102b of the housing 102 gets compressed when the conducting rod 110 moves from the ON position to the OFF position thereof, and energy stored in the spring member 150 is used to move the nozzle assembly 126 upwards when the conducting rod 110 disengages and moves from the OFF position to the ON position. The spring member 150 also ensures that the nozzle assembly 126 is engaged with the conducting rod 110 for performing required operation. Such arrangement helps to keep the switchgear device 100 compact in size without particularly needing SF6 gas as insulation medium for arc management therein.

[0053] 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

traditional load break switch	10
feeder	12
busbar	14
traditional puffing arrangement	20
movable cylinder	22
movable contact	24
fixed piston	26
nozzle	28
switchgear device	100
first space	100a
second space	100b
housing	102
top	102a
bottom	102b
ON contact	104
external threads	104a
supporting member	105
earth contact	106
feeder contact	108
conducting rod	110
first portion of the conducting rod	110a
second portion of the conducting rod	110b
rotary shaft	112
lever mechanism	114
arc management arrangement	120
arc quenching arrangement	122
arc rotation arrangement	124
nozzle assembly	126
nozzle holder	128
nozzle top	130
outer surface of the nozzle top	130a
base	132
side wall	134
inner surface of the side wall	134a
first aperture	136
first gas openings	138
second aperture	140
first gap	G1
second gap	G2
contact ring	142
third aperture	144
second gas openings	146
spring member	150
vortex ring	160
base	162
cavity	164

(continued)

fourth aperture	166
internal threads	168
permanent magnet	170
fifth aperture	172
third gap	G3
rotation	R
Simulated diagram	900A
Simulated diagram	900B
Simulated diagram	900C
Simulated diagram	900D

Claims

1. A switchgear device (100) comprising:

a housing (102) having a top (102a) and a bottom (102b);
an ON contact (104) provided at the top (102a) of the housing (102);
a conducting rod (110) having a first portion (110a) and a second portion (110b) with the second portion (110b) having a larger diameter than the first portion (110a), the conducting rod (110) configured to move linearly, between an ON position and an OFF position inside the housing (102), with the second portion (110b) in contact with the ON contact (104) during the ON position;
an arc management arrangement (120) comprising an arc quenching arrangement (122), the arc quenching arrangement (122) comprising:

a nozzle assembly (126) arranged inside the housing (102), the nozzle assembly (126) comprising:

a nozzle holder (128) comprising a base (132), the base (132) having a first aperture (136) defined therein, the base (132) further having a plurality of first gas openings (138) defined therein, the first aperture (136) adapted to allow passage of the first portion (110a) of the conducting rod (110) therethrough and block passage of the second portion (110b) of the conducting rod (110) therethrough;
a nozzle top (130) engaged inside the nozzle holder (128) and having a second aperture (140) to allow passage of the conducting rod (110) including the second portion (110b) thereof with a first gap (G1) left therebetween;
a gas provided in a first space (100a) between the base (132) of the nozzle holder (128) of the nozzle assembly (126) and the bottom (102b) of the housing (102),

wherein when the conducting rod (110) moves from the ON position to the OFF position thereof, the second portion (110b) of the conducting rod (110) gets engaged with the base (132) of the nozzle holder (128) to cause the nozzle assembly (126) to move therewith and resulting in the gas being compressed and passing through the plurality of first gas openings (138) and the first gap (G1) between the nozzle top (130) and the conducting rod (110) to a second space (100b) between the nozzle assembly (126) and the top (102a) of the housing (102).

2. The switchgear device (100) according to claim 1 further comprising a spring member (150) arranged between the base (132) of the nozzle holder (128) of the nozzle assembly (126) and the bottom (102b) of the housing (102), the spring member (150) configured to get compressed when the conducting rod (110) moves from the ON position to the OFF position thereof due to the movement of the nozzle assembly (126), and de-compressed when the conducting rod (110) moves from the OFF position to the ON position due to disengagement of the second portion (110b) of the conducting rod (110) with the base (132) of the nozzle holder (128) and thereby provide a biasing force to move the nozzle assembly (126) back to an initial position thereof.

3. The switchgear device (100) according to claim 2, wherein the spring member (150) is a conical spring.

4. The switchgear device (100) according to claim 1, wherein the nozzle holder (128) further comprises a side wall (134) having an inner surface (134a) with a first engaging part and the nozzle top (130) has an outer surface (130a) with a second engaging part complementary to the first engaging part of the nozzle holder (128), such that the first engaging part couples with the second engaging part to engage the nozzle top (130) inside the nozzle holder (128).

5. The switchgear device (100) according to claim 4, wherein the first engaging part is in the form of internal threads at the inner surface (134a) of the side wall (134) of the nozzle holder (128) and the second engaging part is in the form of external threads at the outer surface (130a) of the nozzle top (130) complementary to the internal threads at the inner surface (134a) of the side wall (134) of the nozzle holder (128).

6. The switchgear device (100) according to claim 4, wherein the first engaging part and the second engaging part are configured to snap fit together to engage the nozzle top (130) inside the nozzle holder (128).

7. The switchgear device (100) according to claim 1, wherein the nozzle top (130) is engaged inside the nozzle holder (128) with a second gap (G2) left between the nozzle top (130) and the base (132) of the nozzle holder (128) to allow for the gas passing from the plurality of first gas openings (138) to reach the first gap (G1) between the nozzle top (130) and the conducting rod (110).

8. The switchgear device (100) according to claim 1, wherein the first aperture (136) has a diameter larger than a diameter of the first portion (110a) of the conducting rod (110) and smaller than a diameter of the second portion (110b) of the conducting rod (110).

9. The switchgear device (100) according to claim 1 further comprising a contact ring (142) placed onto the base (132) of the nozzle holder (128), the contact ring (142) having a third aperture (144) and a plurality of second gas openings (146) defined therein complementary to the first aperture (136) and the plurality of first gas openings (138), respectively, in the base (132) of the nozzle holder (128).

10. The switchgear device (100) according to claim 1, wherein the gas is natural air.

11. The switchgear device (100) according to claim 1, wherein the arc management arrangement (120) further comprises an arc rotation arrangement (124), the arc rotation arrangement (124) comprising:

a vortex ring (160) arranged inside the housing (102), the vortex ring (160) providing a cavity (164) to, at least partially, support the ON contact (104) therein, the vortex ring (160) comprising a base (162) with a fourth aperture (166) to allow passage of the second portion (110b) of the conducting rod (110) therethrough to be in contact with the ON contact (104);
a permanent magnet (170) placed between the ON contact (104) and the base (162) of the vortex ring (160) and configured to provide a magnetic field, the permanent magnet (170) having a fifth aperture (172) to allow passage of the second portion (110b) of the conducting rod (110) therethrough to be in contact with the ON contact (104),
wherein when the conducting rod (110) moves from the ON position to the OFF position thereof, an electric arc generated between the base (162) of the vortex ring (160) and the second portion (110b) of the conducting rod (110) is constantly moved due to the magnetic field provided by the permanent magnet (170).

12. The switchgear device (100) according to claim 11, wherein the magnetic field provided by the permanent magnet (170) causes rotation of the electric arc at the base (162) of the vortex ring (160).

13. The switchgear device (100) according to claim 11, wherein the ON contact (104) has external threads (104a), and the cavity (164) of the vortex ring (160) has internal threads (168) to engage with the external threads (104a) of the ON contact (104) to support the ON contact (104) in the cavity (164) with a third gap (G3) from the permanent magnet (170).

14. The switchgear device (100) according to claim 11, wherein the permanent magnet (170) is a NdFeB magnet.

15. The switchgear device (100) according to claim 1 further comprising:

a rotary shaft (112) connected to the conducting rod (110), the rotary shaft (112) configured to covert a rotary motion thereof into a linear movement of the conducting rod (110); and
a feeder contact (108) provided at the bottom (102b) of the housing (102) to support the conducting rod (110) and dispose the conducting rod (110) in an EARTH position when in contact therewith.

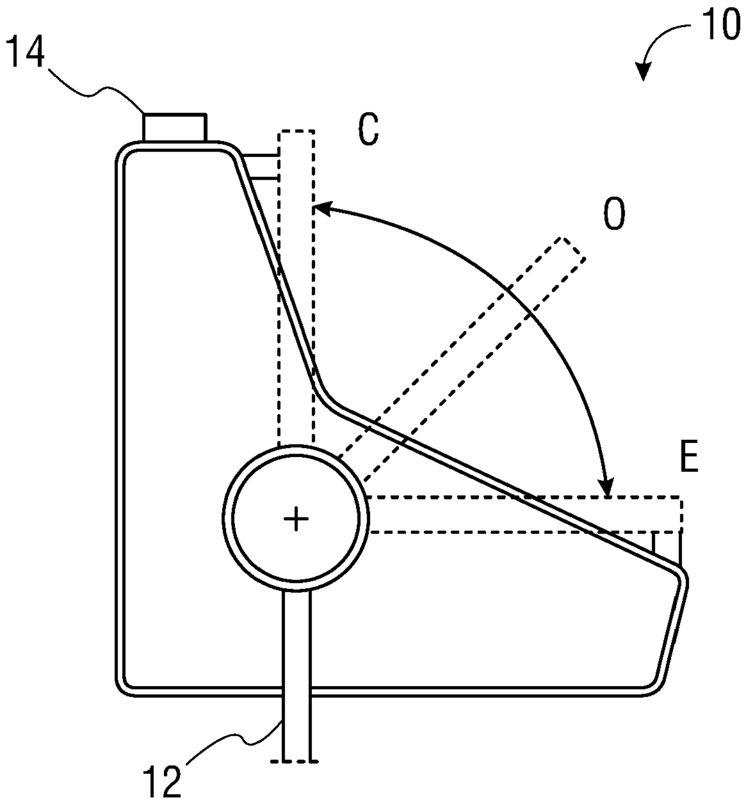

FIG 1
(Prior-art)

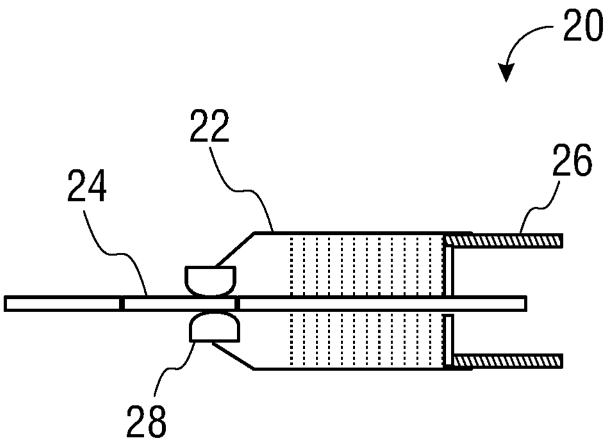

FIG 2A
(Prior-art)

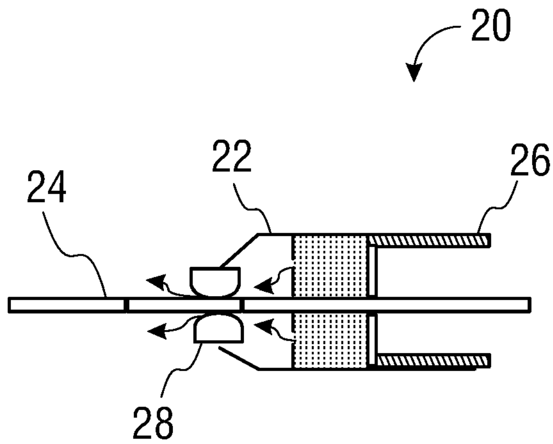

FIG 2B
(Prior-art)

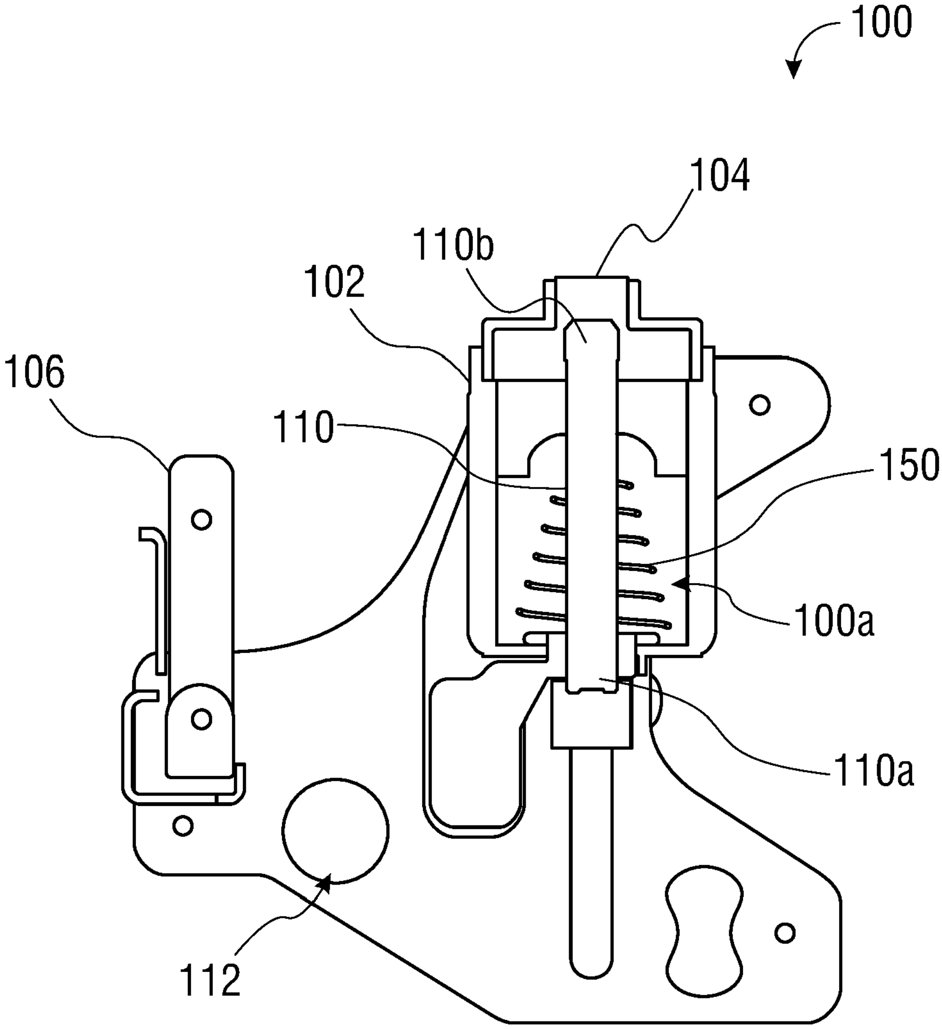

FIG 3

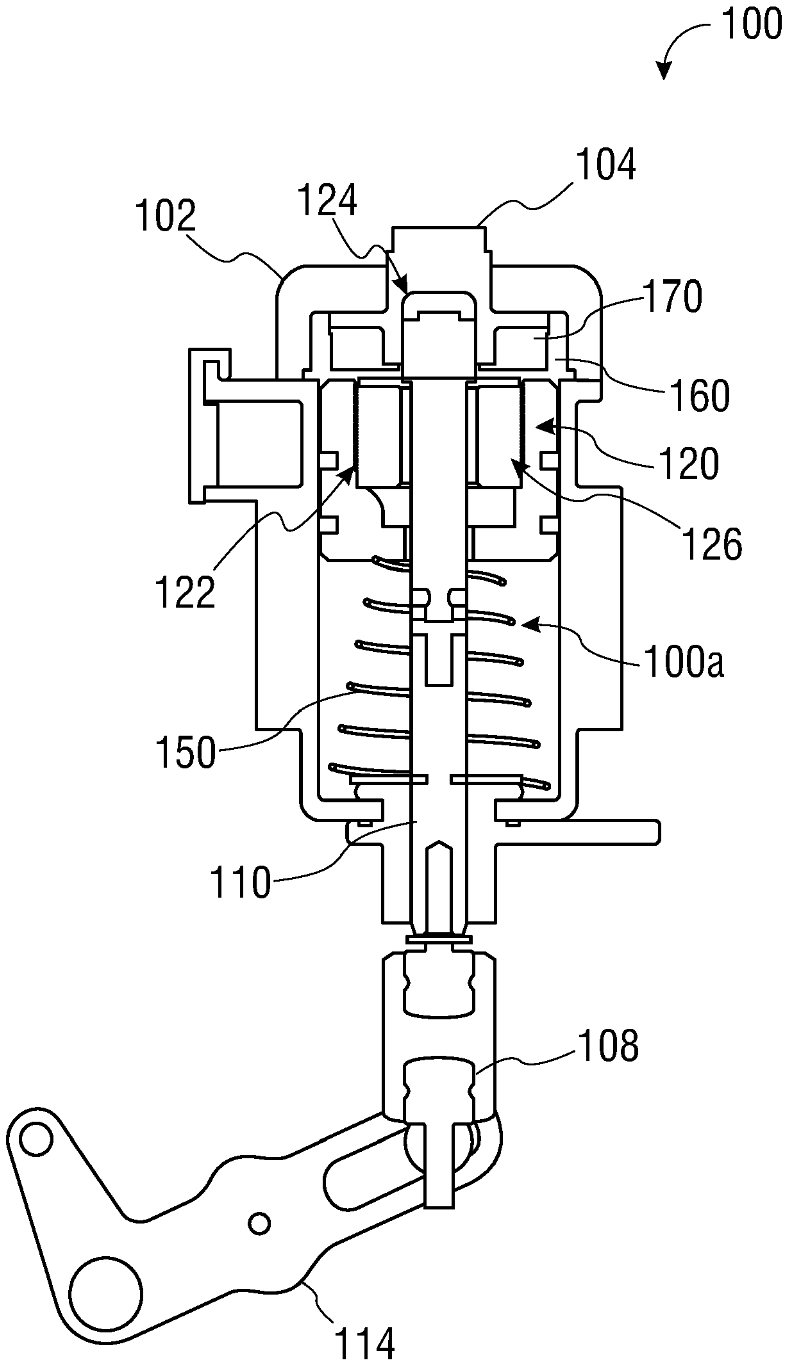

FIG 4

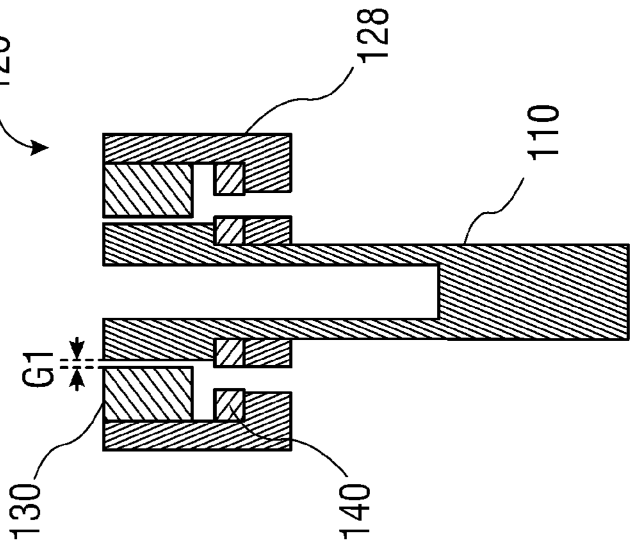

FIG 5C

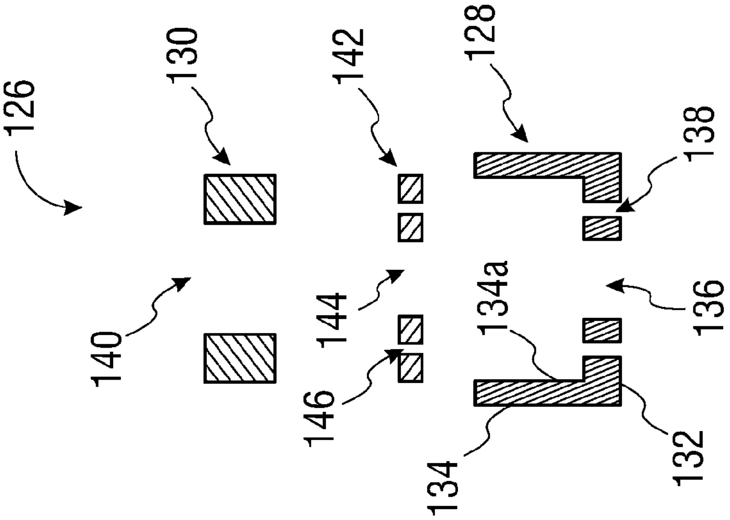

FIG 5B

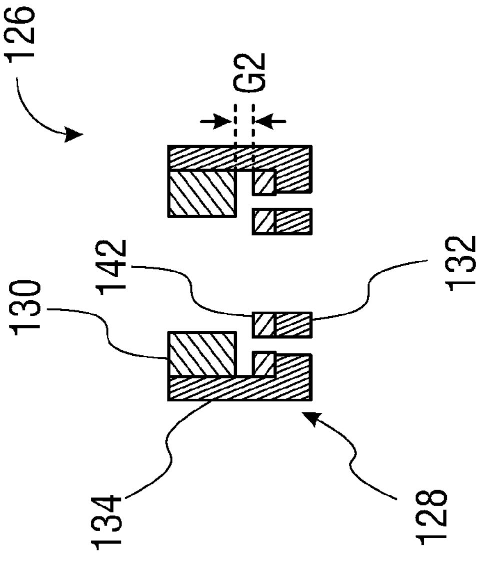

FIG 5A

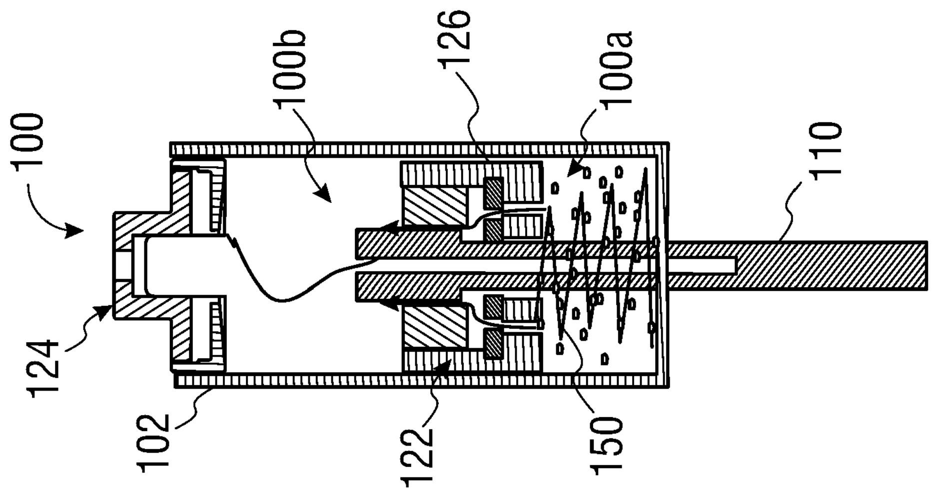

FIG 6C

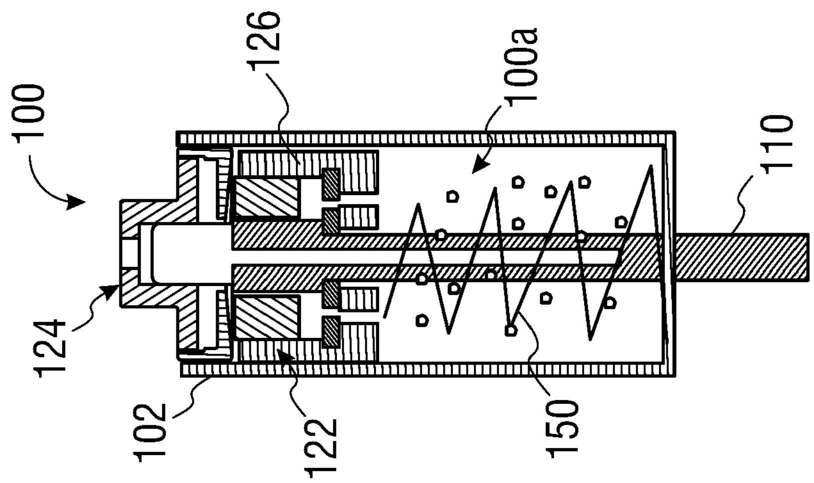

FIG 6B

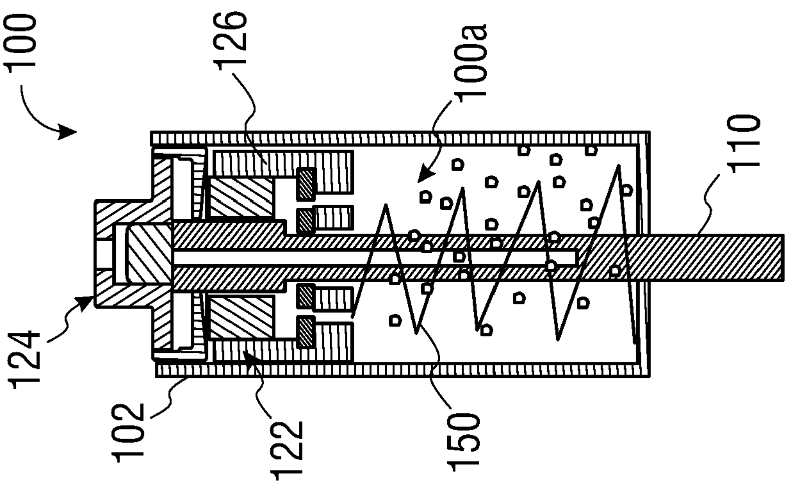

FIG 6A

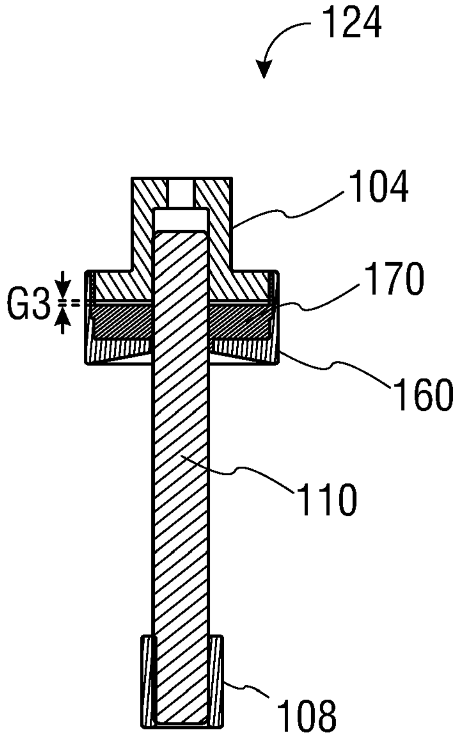
124
104
170
G3
160
110
108

FIG 7A

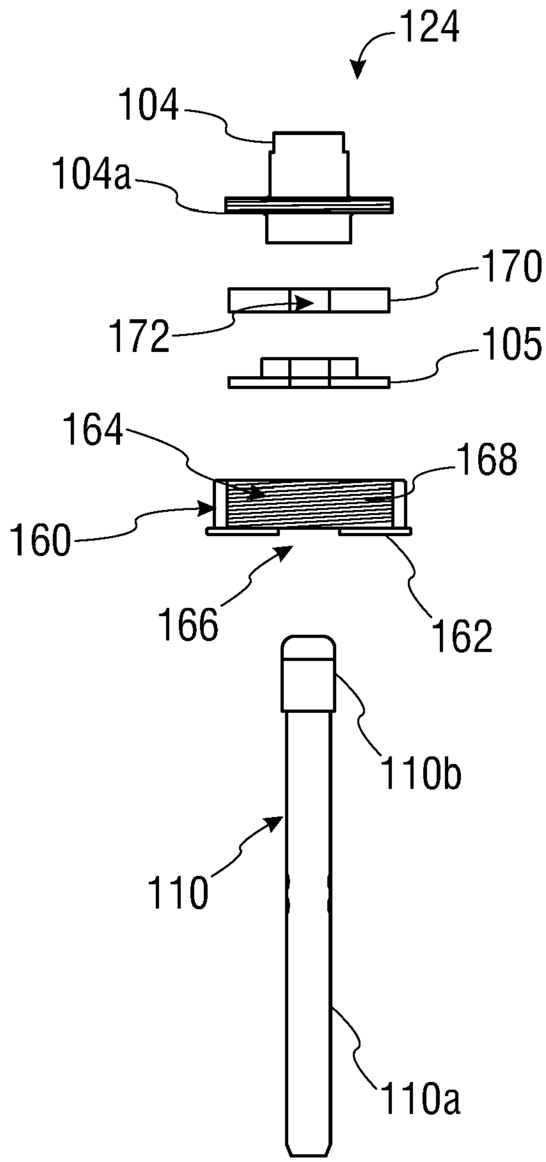
124
104
104a
170
172
105
164
168
160
166
162
110b
110
110a

FIG 7B

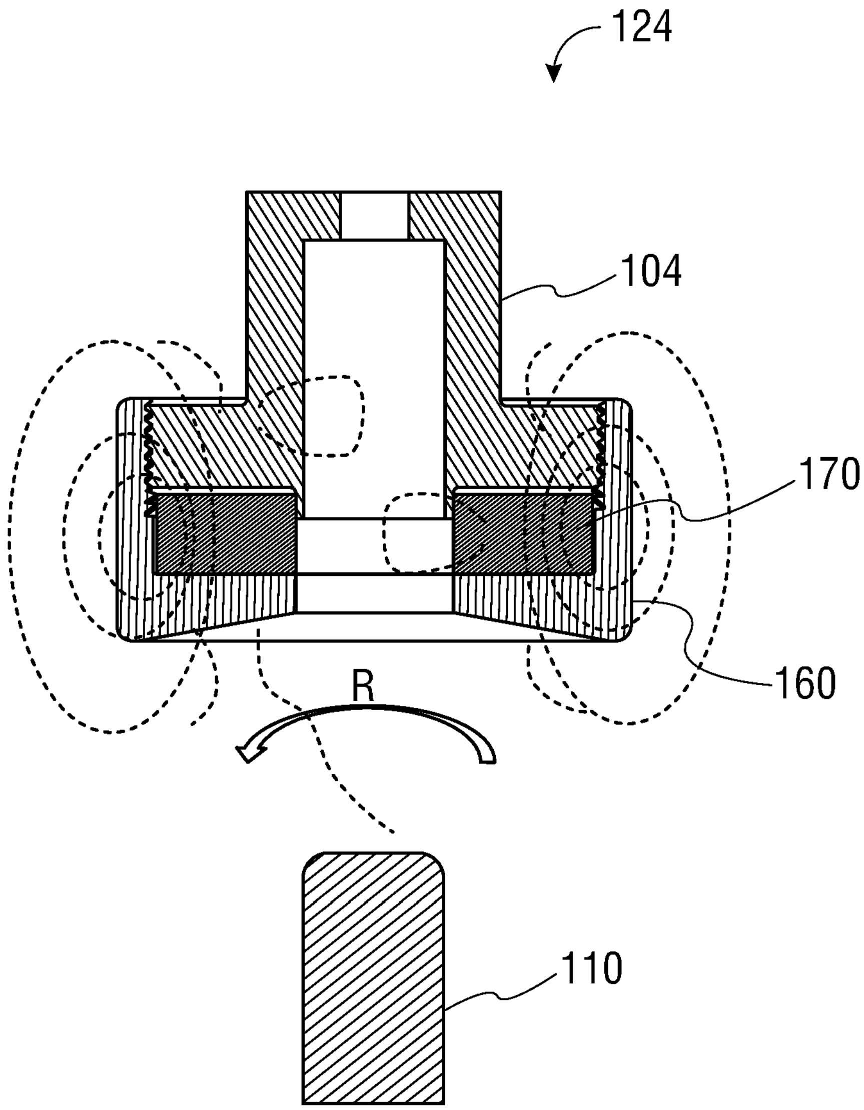

FIG 8

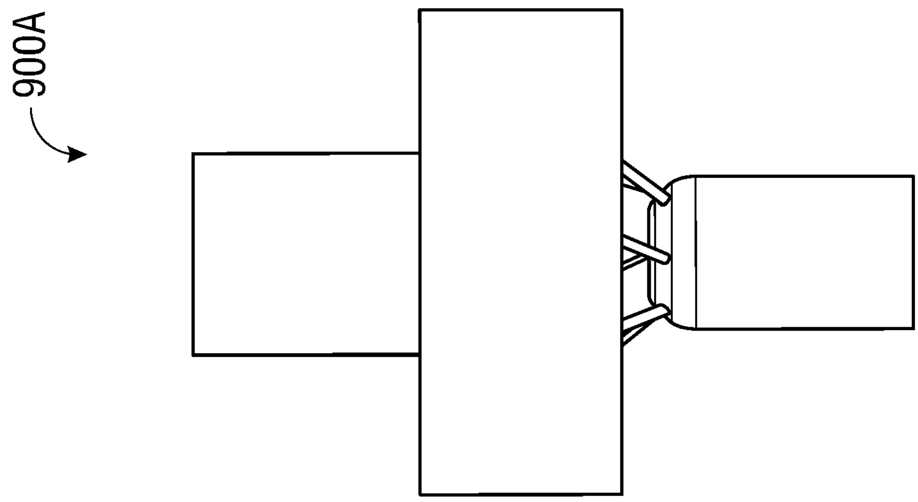
900A

FIG 9A

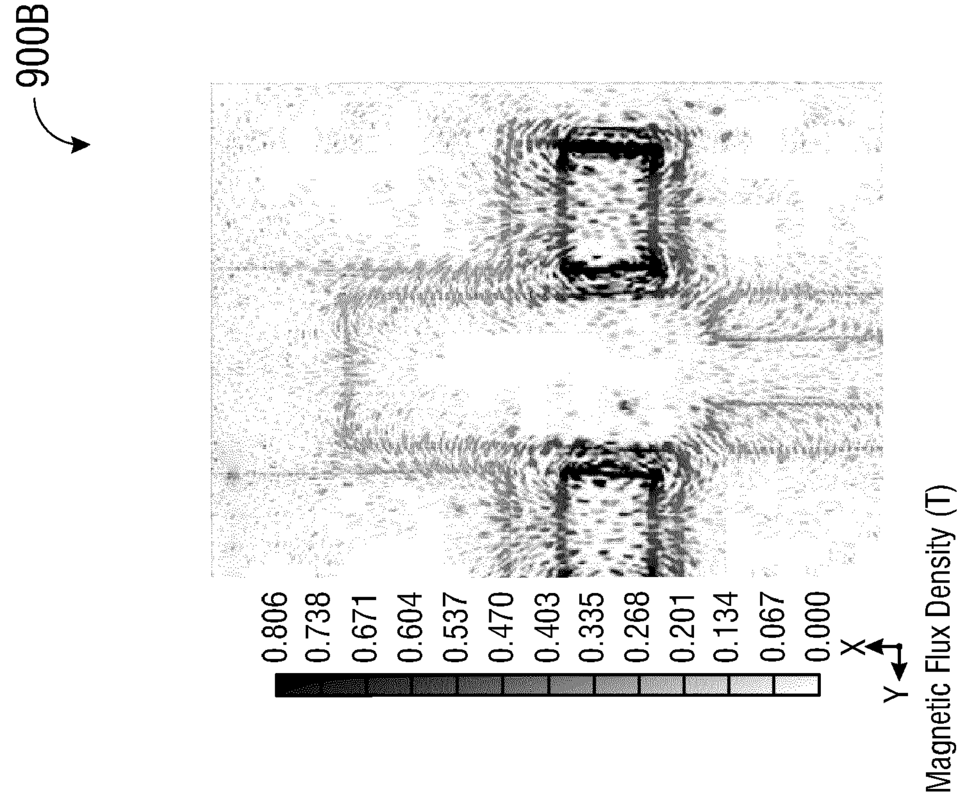
900B
0.806
0.738
0.671
0.604
0.537
0.470
0.403
0.335
0.268
0.201
0.134
0.067
0.000
X
Y
Magnetic Flux Density (T)

FIG 9B

900D

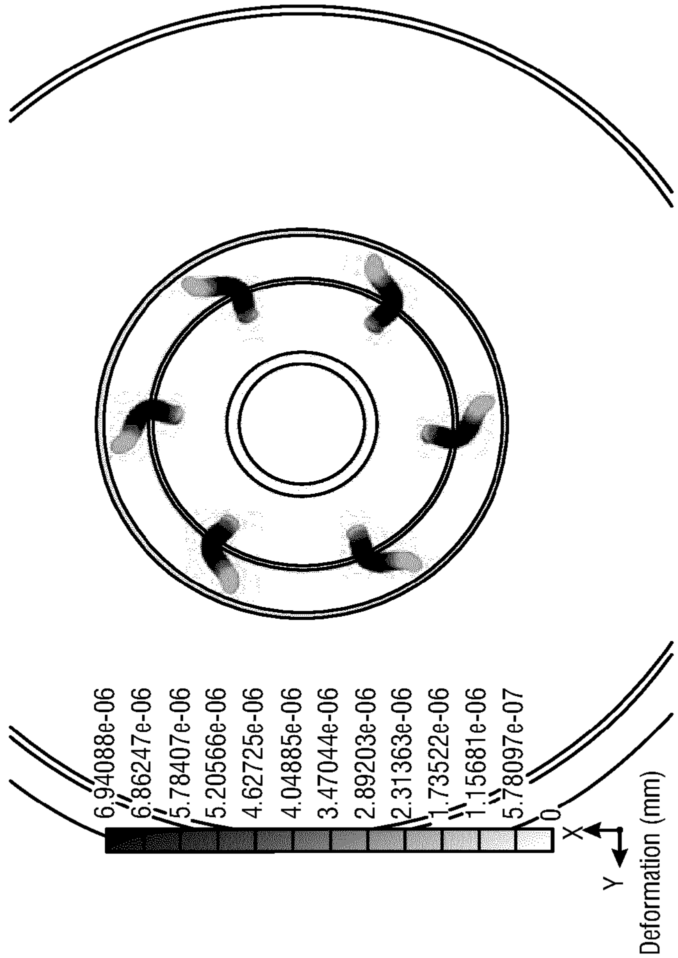

FIG 9D

900C

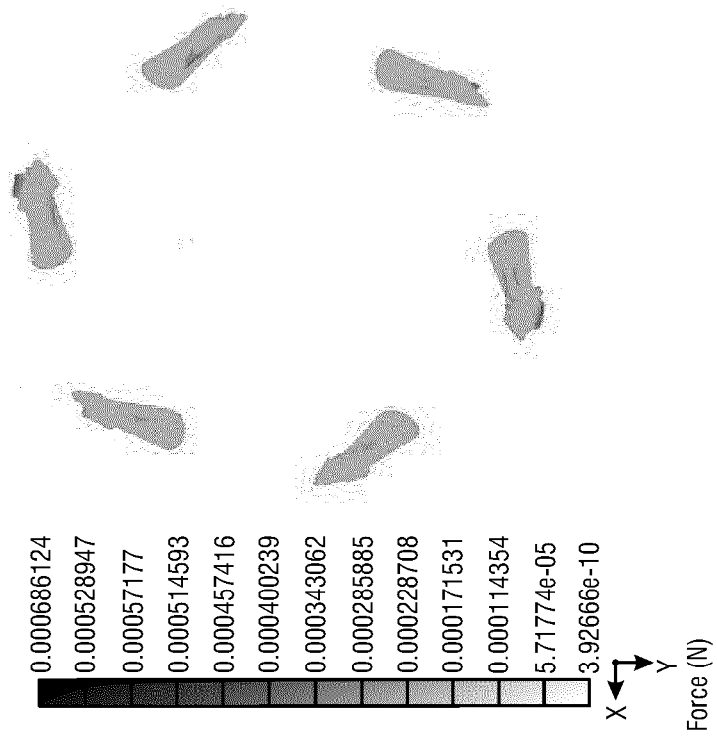

FIG 9C

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 23 15 8854

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
A	WO 2018/114204 A1 (SIEMENS AG [DE]) 28 June 2018 (2018-06-28) * page 14, line 25 - page 20, line 36; figures 1-4 * -----	1	INV. H01H1/38 H01H33/70
A	EP 3 477 675 A1 (ABB SCHWEIZ AG [CH]) 1 May 2019 (2019-05-01) * paragraphs [0038] - [0072]; figures 2A-2D * -----	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	4 August 2023	Arenz, Rainer

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 23 15 8854

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 The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

04-08-2023

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		EP 3477675 A1	01-05-2019
		ES 2913627 T3	03-06-2022
		WO 2019086268 A1	09-05-2019

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