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(54) NEW DESIGN OF SPLITTER PLATE HOLDER FOR APPLICATION IN MEDIUM VOLTAGE GAS INSULATED LOAD BREAK SWITCHES

(57) A medium voltage gas insulated switch (100) comprising a first electric contact (102); and a second electric contact (104) that is moveable with respect to the first electric contact and a plurality (200) of splitter plates (200-1, 200-2, ...) configured to interrupt an electric arc (110) between the first electric contact (102) and the second electric contact (104) during the switching operation of the switch; a splitter plate holder (300, 510) that holds the plurality of splitter plates; and wherein at least a part of the plurality (200) of splitter plates is arranged in a non-parallel manner to each other and at substantially the same distance from a trajectory of the moveable second electric contact.

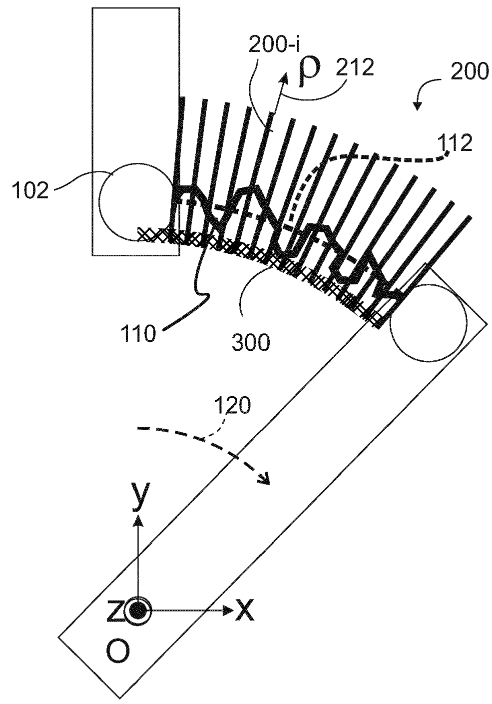

FIG. 4

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Description

TECHNICAL FILED

[0001] The present disclosure relates to gas insulated switches and circuit breakers. In particular the present disclosure relates to a gas insulated switch with an arrangement of splitter plates and a splitter plate holder.

BACKGROUND

[0002] A gas insulated switch is configured to break electric currents, in particular AC currents, for example currents characterized by a root mean square (rms) AC current value. For a given nominal rms AC current the switch may interrupt the circuit with a given nominal probability, for example 50% or more or for example 99% or more or for example 99,999% or more or for example with a probability of substantially 100%. The switch is surrounded by gas and during circuit breaking an electric arc extends from a first contact to a second contact of the switch.

[0003] It is necessary to extinguish said electric arc in order to break the circuit and interrupt the current. For example a voltage difference along the electric arc can be increased in order to reduce the electric current of the arc up to the a point where the arc extinguishes. For AC currents the arc extinction and the opening of the circuit may in particular occur at current zero. To facilitate the arc extinction the arc may be lengthened, for example increasing the physical distance between contacts of the switch and/or the arc may be cooled and/or a section of the arc may be reduced and/or the arc may be split into smaller arcs forming a series.

[0004] Arc splitting is obtained with the use of splitter plates that attract the electric arc between adjacent splitter plates for example by Lorentz forces and segment the original arc into a series of smaller arcs between adjacent splitter plates. The voltage difference along the arc is increased and an extinction of the arc is therefore facilitated, in particular at current zero in the case of AC currents.

[0005] The geometry of the splitter plates and/or materials used for the splitter plates and/or for a splitter plate holder may lead for example to an electric arc that may not extinguish and/or to a failed interruption of an electric current and/or to a damage of for example a splitter plate holder. Further improvements are therefore needed to facilitate the extinction of the electric arc and to avoid damages to the splitter plates and/or to a splitter plate holder. Further improvements are demanded to increase the likelihood of an arc extinction and/or of a circuit interruption in the presence of a given electric current for example without a substantial increase in the dimensions of the gas insulated switch and preventing damages for example to the splitter plates and/or a splitter plate holder.

[0006] Therefore a gas insulated switch with improved splitter plates and/or with an improved splitter plate holder may be beneficial in order to better break an electric current, for example increasing the probability of opening an electric circuit for a given root mean square (rms) value of an AC current.

SUMMARY

[0007] The present disclosure provides in particular improved medium voltage gas insulated switches.

[0008] According to an aspect a medium voltage gas insulated switch is provided including: a first electric contact; and a second electric contact that is moveable with respect to the first electric contact and a plurality of splitter plates configured to interrupt an electric arc between the first electric contact and the second electric contact during the switching operation of the switch; a splitter plate holder that holds the plurality of splitter plates; and wherein at least a part of the plurality of splitter plates is arranged in a non-parallel manner to each other and at substantially the same distance from a trajectory of the moveable second electric contact.

[0009] Further aspects, details and advantages are present from the dependent claims, the further description and the figures.

BRIEF DESCRIPTION OF DRAWINGS

[0010]

FIG. 1 schematically shows a medium voltage gas insulated switch according to embodiments of the present disclosure.

FIG. 2A schematically shows a medium voltage gas insulated switch with a plurality of splitter plates according to embodiments of the present disclosure.

FIG. 2B schematically shows a medium voltage splitter plate according to embodiments of the present disclosure together with a radial distance between the splitter plate and a trajectory of an electric contact of the switch.

FIG. 3 schematically shows a gas insulated switch with a plurality of splitter plates and a splitter plate holder according to some embodiments of the present disclosure.

FIG. 4 schematically shows a gas insulated switch with a plurality of splitter plates and a splitter plate holder according to some embodiments of the present disclosure.

FIG. 5A schematically shows a splitter plate and exterior side walls, inner leg insulting walls and an insulating extension according to some embodiments of the present disclosure.

FIG. 5B schematically shows a plurality of splitter plates and exterior side walls, inner leg insulating walls and insulating extensions according to some embodiment of the present disclosure.

FIG. 5C schematically shows a splitter plate and angled exterior side walls, inner leg insulating walls and an insulating extension according to embodiments of the present disclosure.

FIG. 5D schematically shows a substantially trapezoidal splitter plate, exterior side walls, inner leg insulating walls and an insulating extension according to embodiments of the present disclosure.

FIG. 5E schematically shows exterior side walls of a splitter plate holder according to some embodiments of the present disclosure.

FIG. 5F schematically shows exterior side walls of a splitter plate holder and an insulating extension according to some embodiments of the present disclosure.

FIG. 5G schematically shows exterior side walls and an insulating extension according to some embodiments of the present disclosure.

FIG. 5H shows exterior side walls and inner leg insulating walls according to some embodiments of the present disclosure.

FIG. 5I shows exterior side walls and inner leg insulating walls according to some embodiments of the present disclosure.

FIG. 5J shows exterior side walls of a splitter plate holder according to some embodiments of the present disclosure.

FIG. 5K show exterior side walls with an angled surface according to some embodiments of the present disclosure.

FIG. 5L shows exterior side walls with a convergent profile according to some embodiments of the present disclosure.

FIG. 5M shows exterior side walls with a convergent divergent profile.

FIG. 6 schematically shows a gas insulated switch with a plurality of splitter plates, exterior side walls, inner leg insulating walls, and an insulating extension according to some embodiments of the present disclosure.

FIG. 7 schematically shows a gas insulated switch with a plurality of splitter plates, exterior side walls, inner leg insulating walls, and an insulating extension according to some embodiments of the present disclosure.

DETAILED DESCRIPTION OF EMBODIMENTS

[0011] A gas insulated switch is a device configured to interrupt an electric current between a first electric contact and a second electric contact. Therefore a gas insulated switch is a device configured to open an electric circuit, for example an AC circuit. Typically the switch is also configured to close the electric circuit, such that the circuit can be opened and closed repeatedly operating the switch.

[0012] The switch is typically operated by actuators and configured to interrupt medium voltage circuits.

[0013] FIG. 1 schematically shows a medium voltage gas insulated switch 100 according to embodiments of the present disclosure. The gas insulated switch 100 may for example be a medium voltage gas insulated switch. The gas insulated switch 100 includes a first electric contact 102 and a second electric contact 104. Between the contacts a gas is present, for example air or a CO_2/O_2 mixture or SF_6. The first electric contact 102 may contact the second electric contact 104 in contact areas, indicated schematically by circles in the figures that may have any suitable geometry for an electric contact.

[0014] Embodiments of the present disclosure may in particular improve the performance of switches in the presence of air or a CO_2/O_2 mixture.

[0015] The medium voltage gas insulated switch 100 may further include a casing that contains the gas and encloses the first electric contact and the second electric contact and/or other components of the medium voltage gas insulated switch according to embodiments of the present disclosure.

[0016] The first electric contact 102 is electrically connected to one terminal of an electric circuit and the second electric contact 104 is electrically connected to another terminal of the electric circuit. The second electric contact 104 is movable with respect to the first electric contact 102, for example the second electric contact 104 may be rotatable with respect to the first electric contact 102 around a rotation axis 122. In particular the first electric contact 102 can come in contact with the second electric contact 104 in order to allow a current flow between the first electric contact 102 and the second electric contact 104 closing the electric circuit. The first electric contact 102 and the second electric contact 104 can also be separated, i.e. a physical distance between the two contacts can be increased, in order to break a current flowing between the first electric contact and the second electric contact and/or vice versa.

[0017] The first electric contact 102 and the second electric contact 104 are only schematically shown in the figures. The contacts may be knife contacts and they may have different geometries with respect to each other. The second electric contact 104 may be substantially different from the first electric contact 102. Different components of the switch, not shown in the figures, may lock and/or release the electrical contacts. In embodiments of the present disclosure actuators may be present to automate said rotation and/or movement.

[0018] For example the first electric contact and the second electric contact 104 can rotate relative to each other around a rotation axis 122 identified by a suitable origin O and a unit vector $\vec{z}$ defining a rotation axis z. The origin O may for example be located in correspondence of the second electric contact 104. The unit vector $\vec{z}$ describing the direction of the rotation axis 122 is orthogonal to the plane in which the trajectory of the electric contacts is located. The plane in which the relative trajectory of the electric contacts 102, 104 is located is spanned by orthogonal unit vectors $\vec{x}$, $\vec{y}$. A Cartesian coordinate system 130 is identified by the origin O and the vectors $\vec{x}$, $\vec{y}$, $\vec{z}$ with respective axes x,y,z. The first electric contact 102 is therefore configured to be rotatable with respect to the second electric contact 104 around the rotation axis 122 corresponding to the z axis with a relative rotation 120 in the Oxy plane of the coordinate system 130. The coordinate system 130 is fixed for convenience to better describe embodiments of the present disclosure. The Oxy plane indicates a plane containing the origin O and the axes x and y.

[0019] In alternative embodiments the second electric contact may move away from the first electric contact with a more general trajectory.

[0020] The rotation and/or the movements described in the present disclosure may refer to relative movements. In some embodiments of the present disclosure the first electric contact does not move with respect to the earth and is oriented substantially vertically with respect to the earth. In some embodiments both electric contacts 102, 104 are located above the rotation axis 122 with respect to the earth. Therefore a flow of hot gas flows substantially away from the rotation axis 122 corresponding to the z axis of the coordinate system 130.

[0021] The figures only show schematically some exemplary embodiments of the present disclosure.

[0022] When the second electric contact 104 contacts the first electric contact 102 the electric circuit is closed and a current can flow between the first electric contact 102 and the second electric contact 104. A torque is then applied in order to rotate the second electric contact 104 with respect to the first electric contact 102 or vice versa. When the relative rotation 120 of the electric contacts starts as a consequence of the applied torque, the second electric contact 104 rotates away from the first electric contact 102 with a relative rotation 120 around the rotation axis 122 and an electric arc 110 forms between the first electric contact 102 and the second electric contact 104. The electric arc 110 may on average form in a spatial region 116. The electric arc may extend between the contact areas of the electric contacts and/or between any conducting surface of the electric contacts.

[0023] The position of the electric arc and its trajectory are substantially random in a space between the first electric contact and the second electric contact. The electric arc may be located in a spatial region 116 extending around a curved line 112. The electric arc may have a time varying shape and extend substantially from a tip of the first electric contact to a tip of the second electric contact. The curved line 112 is shown for a more convenient description of the substantially random electric arc 110 in the spatial region 116 around the curved line 112.

[0024] It is necessary to extinguish the electric arc 110 in order to interrupt the current flow between the electric contacts 102, 104 and open the circuit.

[0025] FIG. 2A schematically shows the gas insulated switch 100 with a plurality 200 of splitter plates 200-1, 200-2, ..., 200-i, ... The splitter plate 200-1 is the splitter plate closest to the first electric contact 102 and 200-i denotes the i-th splitter plate in the plurality 200 of splitter plates. It is convenient to fix a cylindrical coordinate system $O\rho\theta z$ where a radial axis ρ 212 extends away from the rotation axis 122, a z axis 214 coincides with the rotation axis 122 of the second electric contact and is identical to the z axis of the Cartesian coordinate system 130 and θ identifies an angle 210 in the Oxy plane where the trajectory of the electric contacts is located. An origin O of the cylindrical coordinate system may coincide with the origin O of the Cartesian coordinate system 130. The ρ coordinate identifies therefore a radial distance ρ from the axis of rotation 122. The θ coordinate 210 identifies a rotation angle in the Oxy plane around the rotation axis 122. For every point in space, a unit vector $\vec{\rho}$ points in the direction of increasing radial distance, i.e. of increasing coordinate ρ. The plane $Oz\rho$ indicates the plane containing the origin O and and the rotation axis 122 of the second electric contact, i.e. the z axis and the radial axis ρ.

[0026] For example the splitter plates 200-1, 200-2, ..., 200-i, ... in the plurality 200 of splitter plates may be substantially planar, for example substantially extending in a radial plane containing the rotation axis 122. For example each splitter plate 200-i in the plurality 200 of splitter plates may be substantially contained in a radial plane containing the rotation axis 122. For example the radial plane containing the splitter plate 200-i may be spanned by rotation axis 122 and by a segment connecting for example the center of mass of the splitter plate 200-i with the rotation axis 122, for example by a segment perpendicular to the rotation axis 122.

[0027] It is intended that the splitter plates are substantially planar, i.e. the thickness of the splitter plate is considered irrelevant, such that it makes sense to consider each splitter plate as substantially contained in a plane, although each splitter plate has a finite thickness.

[0028] For example each splitter plate 200-i may be located in a radial plane $Oz\rho$ containing a z axis corresponding to the rotation axis 122 and a ρ axis extending radially outwards from the rotation axis 122, the ρ axis being indicative of a radial distance from said rotation axis.

[0029] The splitter plate 200-i denotes a generic splitter plate in the plurality 200 and therefore the properties and features of the generic splitter plate 200-i hold for all the splitter plates in the plurality 200 of splitter plates. 200-(i-1) and 200-(i+1) indicate, if present, the predecessor and the successor of the splitter plate 200-i in the plurality 200 respectively.

[0030] The arrangement of splitter plates is used to attract the electric arc between adjacent splitter plates by Lorentz forces. In a splitting process, the electric arc is segmented in segments located between adjacent splitter plates and it becomes possible to more easily extinguish the arc. For example a resistance of the arc is increased.

[0031] The arrangement of splitter plates 200-1, 200-2, ..., 200-i, ... is formed by splitter plates that extend in a radial direction ρ and each splitter plate in the plurality 200 is located in a plane that contains the rotation axis 122 and the z axis of the coordinate system 130. Therefore when the electric arc 110 is attracted towards the splitter plates by Lorentz forces, the marc moves radially away from the curved line 112.

[0032] The splitter plates 200-1, 200-2, ..., 200-i, ... may form a non-parallel arrangement of splitter plates.

[0033] FIG. 2B shows the generic i-th splitter plate 200-i of the plurality 200 of splitter plates. The splitter plate 200-i is substantially located in a radial *Ozp* plane, with z denoting the rotation axis 122 of the second electric contact and ρ denoting a radial axis perpendicular to the rotation axis.

[0034] The radial plane *Ozp* that contains the substantially planar splitter plate 200-i, and the rotation axis of the second electric contact, depends on the splitter plate 200-i, i.e. different splitter plates are contained in different radial planes

[0035] The second electric contact 104 passes at least in part in a region 230 for the transit of the second electric contact. Therefore the trajectory of the second electric contact 104 during the rotation 120 around the rotation axis 122 intersects the *Ozp* plane spanned by the axes 212, 214 in a region 220.

[0036] A point may be considered as part of the electric arc if the intensity of a local current describing a flow of electrons of the arc passing through the point exceeds a threshold, for example a relative threshold with respect to a total current flowing in the first electric contact. The set of points part of the electric arc may describe a position of the arc. The set of the points considered part of the electric arc is time varying, such that also the position of the arc varies over time forming a trajectory of the arc. Further temporal or spatial averaging of the points in the set of points describing the position of the arc may be considered. Therefore a position of the arc in space and time has to be intended as defined based at least in part on local currents of the arc in space and time, e.g. based at least in part on a flow of electrons of the electric arc at given points at given time instants, typically with the consideration of some average and/or a comparison with a threshold.

[0037] The splitter plates in the plurality 200 of splitter plates may be ferromagnetic and configured to attract the electric arc 110 in the direction of increasing ρ coordinate along the axis 212 by Lorentz forces.

[0038] The distance 240 denotes a radial distance between the splitter plate 200-i and the curved line 112 around which the electric arc 110 extends. To facilitate the understanding, in FIG. 2B a circle 112- *Oz*ρ indicates the position where the curved line 112 intersects the plane of the figure, i.e. the radial plane *Oz*ρ. When the second electric contact during its rotation is located in correspondence to the splitter plate 200-i, the electric arc may extend in a region around the curved line 112, for example within said circle. Nevertheless, the position of the electric ars is substantially random, such that the electric arc may extend along the whole conducting surface of the second electric contact.

[0039] The distance 240 typically corresponds to the length of a segment in the region 230 for the transit of the second electric contact, the segment being oriented in the radial direction ρ and connecting the splitter plate 200-i to a point in the region 220 indicating the intersection of the trajectory of the second electric contact with the radial plane *Ozp*.

[0040] Due to Lorentz forces due to the ferromagnetism of the splitter plates in the plurality 200, the electric arc 110 travels substantially upwards in the direction of increasing radial coordinate along the axis 212 overcoming the distance 240.

[0041] The electric arc 110 further leaves the region 230 entering a region between adjacent splitter plates 200-i and 200-(i+1) and/or between adjacent splitter plates 200-i and 200-(i-1). When the electric arc leaves the region 230 traveling substantially upwards in the direction of increasing ρ coordinate along the axis 212, a current flowing in the region 230 is prevented or reduced and a voltage drop across the electric arc increases in such a way that the electric arc easily extinguishes.

[0042] In embodiments of the present disclosure the distance 240, i.e. the radial distance between the curved line 112 around which the electric arc extends and the splitter plate 200-i in the plurality 200 of splitter plates may be substantially constant.

[0043] For example the radial distances between a trajectory of the second electric contact and each of the splitter plates may be constant. A radial distance may be a difference of radial coordinates ρ of two points radially aligned, e.g. aligned orthogonally to the rotation axis of the second electric contact. Therefore each splitter plate 200-i of the plurality of splitter plates may be arranged at the same radial distance from the trajectory of the second electric contact. Each splitter plate 200-i may therefore be at the same distance from the region 220 indicating the intersection of the trajectory of the second electric contact with the radial plane *Ozp*.

[0044] For example each splitter plate 200-i in the plurality 200 may be arranged in a corresponding radial *Ozp* plane in a substantially identical way. For example each splitter plate 200-i in the plurality 200 of splitter plates may be substantially contained in a plane that also contains the axis of rotation 122, the splitter plate 200-i being arranged at substantially the same distance from said axis of rotation 122. For example each splitter plate in the plurality of splitter plates may extend radially outwardly at substantially the same distance from the axis of rotation 122.

[0045] In embodiments of the present disclosure the splitter plates are not parallel to each other and are for example radially arranged. For example each splitter plate in the plurality 200 of splitter plates may be located in a plane that contains the axis of rotation 122. For example the intersection of all the planes that contain a splitter plate of the plurality 200 may be the rotation axis 122 and each splitter plate may be arranged at substantially the same distance from said rotation axis 122.

[0046] In some embodiments of the present disclosure the plurality 200 of splitter plates does not move relative to the first electric contact 102.

[0047] In some alternative embodiments of the present disclosure the second electric contact may not only rotate with respect to the first electric contact and may for example also translate with respect to the first electric contact. In such embodiments for each splitter plate 200-i of the plurality 200 of splitter plates a distance between the trajectory of the moveable, i.e. translatable and/or rotatable, contact and the splitter plate 200-i is still constant for each splitter plate 200-i in the plurality 200 of splitter plates.

[0048] In embodiments where the first electric contact and the second electric contact also translate relative to each other the previously stated properties and features hold analogously with the difference that the splitter plates are not necessarily radially aligned with respect to an axis of rotation.

[0049] In some embodiments multiple axis of rotation may be present, i.e. the first and second electric contact may for example rotate piecewise with respect to each other with different axes of rotation for each piecewise rotational interval.

[0050] Having a distance between the trajectory of the second electric contact and the i-th splitter plate that is constant produces the effect that the electric arc is more uniformly guided in the space between adjacent splitter plates of the plurality of splitter plates and/or out of the region 230 for the transit of the second electric contact. All the splitter plates in the plurality 200 of splitter plates provide uniformly the same benefits. A more uniform upwards movement of the electric arc into the space between adjacent splitter plates is provided and each pair of splitter plates more uniformly contributes in attracting the arc.

[0051] The non-parallel arrangement of the splitter plates further increases a voltage drop of the electric arc once split. When the electric arc 110 travels upwards, a distance between adjacent splitter plates that the electric arc must overcome increases over time. This improves a voltage drop along the electric arc facilitating an extinction of the electric arc 110.

[0052] The typical angle between adjacent splitter plates is between 1 and 10 degrees, depending on number of splitter plates. A number of 10-20 splitter plates may be present. The distance between splitter plates and contact may be 5-20 mm. The splitter plates are about 50x50x1.5. The application is for medium voltage (1-72 kV), in particular for a voltage from 12 kV to 36 kV. The gases can be air, CO2/O2, Airplus or even SF6. The length increase with the radial distance ρ, instead of being always the same for parallel plates . A material for splitter plates may be ferromagnetic steel. The holder are any polymer, pmma, pa6, pbt. Interrupted currents may be load currents from 100 A to 2-4 kA.

[0053] FIG. 3 schematically shows a gas insulated switch with a plurality of splitter plates 200 and a splitter plate holder 300 according to some embodiments of the present disclosure. The gas insulated switch may be in particular configured to interrupt an AC current in a medium voltage electric circuit. In particular a gas different from SF_6 may be used, for example air and/or a CO_2/O_2 mixture.

[0054] The plurality 200 of splitter plates 200-1, 200-2, ..., 200-i, ... may be supported by a splitter plate holder 300 of electrically insulating material. The splitter plate holder 300 may have the form of a circular arc. In some embodiments, the radius of the circular arc may be greater than a radius of the curved line 112. In some alternative embodiments, the radius of the circular arc may be smaller than a radius of the curved line 112.

[0055] The maximal radial distance of the second electric contact from the rotation axis is a maximal radial distance of material points forming the second electric contact from the rotation axis, for example a distance of a tip of the second electric contact from the rotation axis. Said distance is time invariant and constant when the second electric contact rotates.

[0056] In some embodiments, as exemplarily shown in FIG: 3, the splitter plate holder 300 has substantially the form of a circular arc. The radius of the circular arc may be greater than a radial distance of the second electric contact from the rotation axis (122, z).

[0057] In FIG. 3 the splitter plate holder 300 has the form of a circular arc and is made at least in part of electrically insulating material. The radius of the circular arc formed by the splitter plate holder 300 is greater that the tip of the second electric contact 104 and therefore greater than a radial distance of the second electric contact from the rotation axis z.

[0058] The splitter plate holder 300 may be formed at least in part by electrically insulating material in order to mutually electrically insulate each pair of splitter plates in the plurality 200 of splitter plates.

[0059] The splitter plate holder may further be fixed to the first electric contact 102. The first electric contact 102, the splitter plate holder 300 and the splitter plates in the plurality 200 of splitter plates may form therefore a unity and/or may be configured to be a rigid body.

[0060] FIG 4 schematically shows a gas insulated switch with a plurality of splitter plates and a splitter plate holder 300 according to other embodiments of the present disclosure. The splitter plate holder 300 may have the form of a circular arc and the radius of the circular arc may be lower than a radius of the curved line 112 around which the electric arc extends. Therefore the electric arc may on average be located at a greater radial distance from the rotation axis 122 than the splitter plate holder 300.

[0061] In some embodiments, as exemplarily shown in FIG. 4 the splitter plate holder 300 has substantially the form of a circular arc. The radius of the circular arc may be smaller than a maximal radial distance of the second electric contact from the rotation axis z.

[0062] The splitter plate holder 300 may be formed at least in part by electrically insulating material in order to mutually electrically insulate each pair of splitter plates in the plurality 200 of splitter plates. The splitter plate holder 300 may be fixed to the first electric contact. The splitter plate holder may be at least in part of plastic material.

[0063] In yet other embodiments the splitter plates may be located along any circular arc at a radial distance ρ from the rotation axis 122 as long as the splitter plate holder is configured to hold the splitter plates.

[0064] FIG. 5A schematically shows a splitter plate 200-i, an insulating extension 506, inner leg insulation walls 502 and exterior side walls 500 according to some embodiments of the present disclosure.

[0065] Each splitter plate 200-i of the plurality 200 of splitter plates may be at least in part covered/enclosed by inner leg insulations walls 502 that cover at least in part the legs of the splitter plate in the region 230 for the transit of the second electric contact 104.

[0066] The splitter plate 200-i may be substantially "U" shaped, with the legs of the splitter plate, i.e. the legs of the "U" directed towards the rotation axis z, 214 of the second electric contact.

[0067] The inner leg insulating walls 502 may prevent that the electric arc attaches to legs of the splitter plate 200-i and/or to a region of the splitter plates characterized by low radial coordinates. The inner leg insulating walls 502 may further insulate/cover the bottom of the splitter plate legs, i.e. sides of the splitter plate legs facing towards the rotation axis of the second electric contact. In particular the inner leg insulating walls 502, extending substantially perpendicular to the splitter plates and covering the sides and the bottom of the legs of the splitter plates, may block any downward propagation of hot gas near the legs of the splitter plates and prevent the arc from attaching to the bottom of the splitter plate legs.

[0068] The inner leg insulating walls are used to prevent that hot gas present in the inter-splitter plate region propagates radially downwards, i.e. towards the rotation axis of the second electric contact, blocking any flow of gas near the legs of the splitter plates, in particular in the region between the legs of adjacent splitter plates.

[0069] An upper insulating extension 506 may extend radially outwardly, i.e. in the direction of increasing radial coordinate ρ. The insulating upper extension may allow a flow of gas to travel radially outwardly, but prevent a propagation of the electric arc, for example avoiding that the electric arc may bridge around the splitter plate 200-i, i.e. skip the splitter plate 200-i.

[0070] Furthermore exterior side walls 500 may be provided that extend orthogonally to the radial $Oz\rho$ plane containing the splitter plate 200-i and the rotation axis 122.

[0071] Therefore the exterior side walls 500 that are made of nonconductive material laterally enclose the space between adjacent splitter plates 200-i and 200-(i+1) and/or between adjacent splitter plates 200-(i-1) and 200-i. The insulating extension 506 extends in the plane $Oz\rho$ containing the rotation axis z of the second electric contact and a radial axis ρ perpendicular to z and passing through the splitter plate 200-i. The exterior side walls 500 extend substantially perpendicular to the insulating extension 506 and substantially parallel to the curved line 112 around which the region 116 is located where the electric arc 110 extends, or at least the exterior side walls include points at substantial distance from the plane $Oz\rho$.

[0072] The inner leg insulating walls 502 extend substantially parallel to the exterior side walls 500. The inner leg insulating walls 502 and the exterior side walls 500 extend in the splace between adjacent splitter plates blocking a flow of gas in a direction parallel to the rotation axis z of the second electric contact. The insulating extensions 506 blocks the propagation of the electric arc, but does not block a flow of gas in a radial direction, i.e. along the radial axis ρ.

[0073] The inner leg insulating walls 502, the insulating extension 506 and the exterior side walls 500 are made of electrically insulating material, like for example plastic, ceramic, polymer, etc.

[0074] The material of the exterior side walls 500 and/or the inner leg insulating walls 502 and/or the insulating extension 506 may be non-conducting plastic, like for example POM, PTFE, PA6 and/or non-conducting ceramic, polymer, etc.

[0075] FIG. 5B schematically shows a plurality of splitter plates and exterior side walls, inner leg insulating walls and insulating extensions according to some embodiment of the present disclosure.

[0076] In some embodiments of the present disclosure the splitter plate holder is a splitter plate holder 510 that may include side walls 500 and/or inner leg insulating walls 502 that may in particular cover legs of the splitter plates. In some embodiments an insulating extension 506 may extend radially outwardly to prevent a propagation of the electric arc, but allowing a radial flow of gas.

In some embodiments, further splitter plate holder elements 700 may be configured to reinforce the side walls 500 and/or to keep the splitter plates in place. Therefore in some embodiments the splitter plate holder 510 may further include splitter plate holder elements 700 in particular for providing an improved mechanical stability.

[0077] The material of the slitter plate holder may be any insulating polymer or epoxy, for example Pmma, PBT, PTFE,.. The splitter plates are usually ferromagnetic steel. The extension upwards 506 is between 1-20 mm.

[0078] The exterior side walls 500 may extend parallel to the the Oxy plane that contains the rotational trajectory of the second electric contact. Side walls on both sides of the splitter plates enclose the rotational trajectory of the second electric contact. For each splitter plate 200-i in the plurality 200 of splitter plates the insulating extension 506 extends orthogonally to said Oxy plane and parallel to the splitter plate.

[0079] Between each pair of adjacent splitter plates a space remains present not covered by plastic. The exterior side walls 500 only extend on two extremities of the splitter plates and the insulating extension 506 does not or at least not fully cover the surface of the splitter plates. Therefore the surface of the splitter plate 200-i will face a corresponding surface of the splitter plate 200-(i+1) and/or 200-(i-1) without the presence of any plastic in-between and the electric arc 110 can still extend from the metallic surface of the splitter plate 200-i to a corresponding metallic surface of the splitter plate 200-(i+1) and/or 200-(i-1) without the presence of plastic. Therefore the exterior side walls 500 together with the inner leg insulating walls 502 still allow a substantially upwards movement of the electric arc e.g. due to Lorentz forces and furthermore allow heated gas to escape radially outwardly as exemplarily shown by the flow of gas 520 for a pair of adjacent splitter plates. In particular the insulating extension 506 of the splitter plate 200-i allows the flow of gas 520.

[0080] The exterior side walls 500 prevent the electric arc from moving outside the space between adjacent splitter plates. The electric arc 110 cannot therefore move along the z axis in such a way to circumvent a splitter plate. For example the electric arc cannot pass directly from a surface of the splitter plate 200-(i-1) to a surface of a further distant splitter plate 200-(i+1) without intersecting and/or touching a surface of the intermediate splitter plate 200-i.

[0081] The exterior side walls 500 and/or the inner leg insulating walls 502 and/or the insulating extension 506 further prevent a flow of gas parallel to the z axis such that the gas can only flow radially outwardly as exemplarily illustrated by the flow of gas 520.

[0082] The presence of the inner leg insulating walls 502 of the splitter plate 200-i may guide the trajectory of the electric arc upwardly and may create a vortex of gas that is further beneficial to extinguish the electric arc.

[0083] The figures only exemplarily show the geometry of the splitter plates and/or of the exterior side walls and/or of the inner leg insulating walls and/or the insulating extension. In some embodiments different or alternative geometries may be present.

[0084] FIG. 5C schematically shows a splitter plate and angled exterior side walls, inner leg insulating walls and an insulating extension according to embodiments of the present disclosure.

[0085] The side walls 500 may be angled to form an angled surface 550 of the exterior side walls 500. The angles surface 550 may extend away from the rotation axis in order for example to provide a chimney effect that further improves the flow of gas in the region between adj acent splitter plates.

[0086] FIG. 5D schematically shows a substantially trapezoidal splitter plate, exterior side walls, inner leg insulating walls and an insulating extension according to embodiments of the present disclosure.

[0087] The splitter plate 200-i may have a different shape, for example a trapezoidal shape of the outer perimeter. For example one exterior side of the splitter plate 200-i may be angled following an angled segment 560 of the splitter plate 200-i converging to the distant exterior side wall 500 with increasing radial distance from the rotation axis. Therefore the splitter plate holder 200-i may be substantially trapezoidal. This may also further improve a flow of gas between splitter plates improving the extinction of the electric arc.

[0088] In embodiments of the present disclosure, the splitter plates are held in place by the exterior side walls and/or by a splitter plate holder and a direct contact between splitter plates is prevented.

[0089] The inner leg insulating walls 502 and the exterior side walls 500 may form a single body, for example a substantially rigid body. Also the splitter plate holder, the splitter plates and the first electric contact may form a substantially rigid body, whereas the second electric contact is e.g. rotatable with respect to the rigid body. The splitter plate holder is at least in part made of electrically insulating material to avoid an electric contact between different splitter plates.

[0090] The Figures from FIG. 5E to FIG. 5M show details of splitter plate holders according to embodiments of the present disclosure, in particular details of the exterior side walls and/or of the inner leg insulating walls and/or of the insulating extension.

[0091] FIG. 5E illustrates exterior side walls 500 of the splitter plate holder 510 laterally enclosing the splitter plate 200-i to allow a flow of gas 520 in increasing radial direction, i.e. in the direction of increasing radial coordinates ρ.

[0092] The side walls 500 force a flow of gas to flow in a substantially radial direction away from the rotation axis of the second electric contact, i.e. in the direction of the flow of gas 520, i.e. radially outwardly.

[0093] The flow of gas may be produced by the electric arc ionizing the gas and may be a flow of hot gas.

[0094] FIG. 5F shows the presence of an electrically insulating extension 506 extending radially outwardly. The insulating extension 506 may block the electric arc 110 but allow the flow 520 of hot gas.

[0095] FIG. 5G shows the insulating extension 506 partially overlapping with the splitter plate 200-i. The insulating extension 506 leaves at least in part a surface of the splitter plate 200-i uncovered in order to allow the electric arc to extend between conducting surfaces of adjacent splitter plates, i.e. between a conducting surface of the splitter plate 200-i and the adjacent splitter plate 200-(i+1) and/or 200-(i-1).

[0096] FIG. 5H shows that the inner leg insulating wall 502 may fill all the space surrounding a legs of the splitter plate 200-i or at least surrounding a portion of a legs of the splitter plate 200-i. In embodiments according to FIG. 5H, the inner leg insulating wall 502 therefore not only forms a wall parallel to the exterior side wall 500, but fills all the space in a region around a legs of the splitter plate 200-i and/or around an extremity of a leg of the splitter plate.FIG. 5I shows inner leg insulating walls 502 of the splitter plate 200-i covering legs of the splitter plate 200-i. In FIG. 5I the inner leg insulating walls 502 covers a greater surface of the legs of the splitter plate 200-i than in FIG. 5H.

[0097] FIG. 5J show a substantially trapezoidal splitter plate 200-i and exterior side walls 500 substantially following the angled geometry of the sides of the splitter plate 200-i.

[0098] FIG. 5K shows exterior side walls 500 with an angled surfaces 550 facilitating the flow of gas 520 in a radial outward direction. The exterior side walls 500 with the angled surfaces 550 facilitate in particular an outflow of hot gas, flowing radially outwardly from the spatioal region 116 where the electric arc is present.

[0099] FIG. 5L shows exterior side walls 500 with a convergent profile to facilitate an inflow of gas towards the spatial region 116 where the electric arc is present. The flow of gas 520 is facilitated in a region closer to the rotation axis, i.e. an inflow of gas is facilitated towards the region where the electric arc extends, as schematically illustrated by the two arrows at the bottom of FIG. 5L.

[0100] FIG. 5M shows exterior side walls 500 with a convergent-divergent profile combining the benefits of the side walls illustrated in FIG. 5K with the benefits of the side walls illustrated in FIG. 5L. The convergent divergent profile of the exterior side walls 500 of FIG. 5M facilitates both an inflow and an outflow of hot gas.

[0101] FIG. 6 schematically shows a gas insulated switch with a plurality of splitter plates, exterior side walls, inner leg insulating walls, and an insulating extension according to some embodiments of the present disclosure.

[0102] . The exterior side walls 500 may be fixed with the first electric contact 102. The first electric contact 102, the exterior side walls 500, the inner leg insulating walls 502 and the splitter plates 200-1, 200-2, ..., 200-i, ...of the plurality 200 of splitter plates may therefore form a rigid body that may in addition include the insulating extension 506

[0103] When the second electric contact 104 rotates with respect to the first electric contact 102, the electric arc 110 around the curved line 112 substantially located in the region 230 travels substantially upwards in a direction of increasing radial coordinate ρ. The splitter plate holder 510 my be located substantially vertically above the rotation axis of the second electric contact and fixes to the first electric contact.

[0104] The electric arc becomes trapped between adjacent metallic surfaces of the splitter plates, i.e. between surfaces not covered by plastic/insulators, without the possibility of escaping sideways as a consequence of the presence of the exterior side walls 500. The hot and/or ionized gas produced by the electric arc flows also substantially upwards in a direction of increasing radial ρ coordinates away from the rotation axis, for example parallel to the flow of gas 520.

[0105] FIG. 7 schematically shows a gas insulated switch with a plurality of splitter plates, exterior side walls, inner leg insulating walls, and an insulating extension according to some embodiments of the present disclosure.

[0106] The side walls are fully closed on the side, the hot gas cannot go along the z direction. The side walls and the holder may be the same piece and/or form a rigid body.

[0107] For example the exterior side walls 500 may be reinforced by further splitter plate holder elements 700 that may be integrated with the side walls 500 to form a single rigid body. One or more of such elements may be present that may be located at one or more radial distances from the axis of rotation.

[0108] The present disclosure therefore provides a curved holder with side walls for secondary gas insulated switches in particular with nonparallel splitter plates.

[0109] The curved splitter plate holder 300 geometry with exterior side walls 500 forming side covers, which also hold the splitter plates 200-1, 200-2, ..., 200-i, ..., forms an arrangement that leads to a better cooling of the electric arc 110, a better interaction of the electric arc 110 with the splitter plates and to a better control of the arc movement between the splitter plates. The arrangement experimentally leads to a significant improvement in the interruption performance both in air and CO_2/O_2 or airplus or SF_6 as a background gas. Some embodiments of the present disclosure overcome the problems related to splitter plate arrangements involving a stack of parallel splitter plates mounted on a straight holder. In splitter plate arrangements involving a stack of parallel splitter plates mounted on a straight holder after a splitting process of the electric arc, resulting arc segments located between splitter plates undergo various unpredictable instabilities that might drive them toward the splitter plate edges. In this case, the arc segments bypass certain splitter plates and consequently the interruption performance is lowered. In splitter plate arrangements involving a stack of parallel splitter plates mounted on a straight holder, as the trajectory of the moving electric contact is a rotation, it follows that its distance with respect to the splitter plates grows during its swiveling. As a result, the electric arc has a reduced probability to undergo a splitting process by the latest splitter plates and the interruption performance is lowered.

[0110] According to the present disclosure, in some embodiments said problems are overcome. According to some embodiments of the present disclosure, the splitter plates are arranged on curved splitter plate holder, for example on the splitter plate holder 300 or the splitter plate holder elements 700 or the exterior side walls 500, that follow the trajectory of the moving contact, for example of the second electric contact 104 such that a constant distance between the moving second electric contact 104 and the splitter plates 200-1, 200-2, ..., 200-i, ... throughout the travel of the moving second electric contact 104 is maintained. According to embodiments of the present disclosure, various approaches can be implemented to hold the splitter plates. In some embodiments the splitter plates are held from the top, i.e. radially distant from the rotation axis. In some embodiments the splitter plates are held from the bottom, i.e. close to the rotation axis. In some embodiments the splitter plats may be held from the side. The splitter plates may be substantially vertically above a rotation axis of the second electric contact and for example fixed to the first electric contact. The splitter plates and/or the splitter plate holder may be substantially suspended therefore preventing surface currents on a casing of the medium voltage gas insulated switch. The casing may contain the gas together with the first electric contact, the second electric contact, the plurality of splitter plates and the splitter plate holder.

[0111] According to embodiments of the present disclosure, the radial distance between the moving contact, for example the second electric contact 104, and the splitter plates is kept constant for all splitter plates 200-1, 200-2, ..., 200-i, ... All the splitter plates in the plurality 200 interact with the electric arc 110 and participate effectively to its cooling. A radial distance may be defined as a difference of radial ρ coordinates of points lying on a segment parallel to the radial axis, i.e. an axis perpendicular to the rotation axis of the second electric contact. Therefore the radial distance between the moving second electric contact and the splitter plates may be the minimum difference of radial ρ coordinates for pair of points on a segment parallel to the radial axis, i.e. perpendicular to the rotation axis of the second electric contact, such that the first point in the pair is in the splitter plate holder and the second point in the pair is in the second electric contact.

[0112] The use of the curved splitter plate holder with splitter plates leads to a constant radial distance between the splitter plates and the moving contact. With this geometry, the radial distance between the splitter plates and the moving contact is maintained constant for the entire travel of the moving contact.

[0113] As a further consequence of such an arrangement, two successive splitter plates 200-i and 200-(i+1) and/or 200-(i-1) and 200-i form a divergent geometry, i.e. with increasing radial coordinate ρ a point located on the surface of a splitter plate 200-i becomes more distant from the adjacent splitter plate 200-(i+1) and/or 200-(i-1). This arrangement leads to a better cooling of the arc and also prevents the arc from moving sideways and bridge along the edges of the splitter plates.

[0114] In straight splitter plates holders, a few splitter plates might not interact with the electric arc as the distance between the electric arc and the splitter plates is higher than in embodiments of the present disclosure. According to embodiments of the present disclosure, all the splitter plates interact with the electric arc as the distance between the arc and the splitter plates is maintained constant. The distance between the splitter plates and the moving contact remains the same even if the number of splitter plates is increased. As a direct consequence of the higher number of splitter plates, the current interruption performance is augmented.

[0115] According to some embodiments of the present invention, a stabilization of the flow pattern and of the arc inside the splitter plate pack is obtained. The mixing at zero current is increased. Non-conducting side walls 500 along the splitter plate pack are present and also the legs of the splitter plate are surrounded with the same non-conducting material, for example plastic. The sidewalls, for example the side walls 500, are also used as a holder for the splitter plates.

[0116] A gas insulated switches according to the present disclosure may include a knife contact that swivels through a splitter plate arrangement during a current breaking operation. The ferromagnetic properties of the splitter plates in the plurality 200 of splitter plates attracts the electric arc 110, which enters the splitter plate pack formed by the plurality of splitter plates.

[0117] When the splitter plates are only held at the top and no side walls are present, the electric arc can move outside of the splitter plate pack. The arc may burn on the side of the splitter plates and may short circuit many splitter plates and therefore the current may fail to interrupt. The failure is observed in particular when a gas different from SF_6 is present between the splitter plates. Without the side walls 500 of the present disclosure, the gas is poorly mixed in particular at zero current. The hot gas flows out in upwards, side-ways, as for example parallel to rotation axis, and downwards direction, flowing in all directions from the central arcing region. A large flow cross section leads to lower flow velocity. The gas can flow in all directions, for example in particular parallel to the rotation axis, and there is therefore no specific direction for the flow. The exterior side walls 500 of the present disclosure align the gas flow in a radial direction, for example parallel to the ρ axis as exemplarily illustrated by the flow of gas 520. The flow flows in one direction and away from the hot arcing region.

[0118] For example, a splitter plate holder, that is held from the fix contact side, for example the side of the first electric contact 102, having a plastic part that blocks the arc from moving upwards, may allow the electric arc to burn the plastic, which produces hot gas that is pushed back between the two contacts.

[0119] With side covers around the splitter plates according to embodiments of the present disclosure a set of benefits is achieved.

[0120] For example with the exterior side walls 500 according to the present disclosure no obstruction of the arc is produced and hot gases move upwards and away from the arcing region. The sidewalls 500 may further act as a holder for the splitter plate pack 200. The presence of the side walls 500 prevents the arc to burn along the edges of the splitter plates. The inner surfaces of the side-walls also have groves in them to prevent the splitter plate to bend and touch each other. This prevents the arc from bridging along the edge of the splitter plates which may otherwise lead to failed interruption of the electric current.

[0121] The presence of side walls helps to cool the arc in multiple ways. Different mechanism improve a cooling of the arc in the presence of side-walls according to the present disclosure.

[0122] With the presence of side walls, the flow is blocked in the direction of the rotation axis 122, z and the flow can only pass through the top, as illustrated for example by the flow 520, top which is left open to increase the outlets. In embodiments of the present disclosure, the flow is constantly going from the contact area, e.g. the area in which the second electric contact is located, and through the splitter plates. A chimney effect is created with a defined flow pattern inside the splitter plate pack. Furthermore a vortex is created to increase the mixing at zero current.

[0123] The legs of the splitter plates may be surrounded by a wall. There are no outlets at the bottom of the legs of the splitter plates and therefore the flow is reflected to the center creating a vortex. If the arc goes to the legs of the splitter plates, a pressure builds up and at zero current the arc will be pushed back to the center of the splitter plate 200-i.

[0124] At the top of the sidewalls 500, the plastic may detach outwardly from the splitter plates with a 60° angle in order to create an outlet that disperse the hot gas forming an angled surface 550.

[0125] In some embodiments one exterior side wall 500 may be at least partially oblique corresponding to an angled segment 560 of the splitter plate 200-i, with an angle of for example 60° with respect to a segment having constant radial distance from the rotation axis 122. The insulating extension 506 may be smaller than the lower part of the splitter plate, the insulating extension 506 being located substantially radially further away from the rotation axis. Accordingly also the splitter plate 200-i may have a substantially trapezoidal shape with a bigger extension closer to the rotation axis. In other embodiments the angled segment 560 of the splitter plate 200-i may form an angle of 60° or of 40° with respect to a segment perpendicular to the rotation axis 122 extending radially away from the rotation axis and intersecting the splitter plate 200-i. In yet other embodiment the angle may be different. The angle may facilitate a vortex of the hot gas.

[0126] The upper part of the exterior side walls 500 may also be angled, for example with an angle of 60° with respect to a segment having constant radial coordinate , forming angled surfaces 550, the angle extending away from the region 230 for the transit of the second electric contact in order to create an outlet that better disperses hot gas, for example facilitating a chimney effect that disperses the gas substantially radially away from the rotation axis 122. In other embodiments the angled surfaces 550 may form an angle of 60° or of 40° with a radial axis perpendicular to the rotation axis and intersecting the splitter plate 200-i, such that the angled surfaces 550 extend outwardly away from the region 230 for the transit of the second electric contact. The angle may facilitate a chimney effect to disperse the hot gas substantially vertically upwardly and/or radially away from the rotation axis.

[0127] The side walls 500 of the present disclosure are designed to match perfectly the splitter plates 200-i on the lower part leaving only the place for the arc to enter the splitter plate. The top is left open. The sidewalls 500 may serve as a holder for the splitter plate and are attached to the fix contact 102 on the side. In this way the arc does not burn against any plastic part. The material of the sidewalls may be non-conducting plastic, like for example POM, PTFE, PA6.

[0128] Embodiments of the present disclosure may have sidewalls for producing a chimney effect and to prevent arc bridging along the edges of the splitter plates. The splitter plates may be held at the bottom, with the outlet at the top far away from the contact. The bottom may be for example characterized by low radial coordinates ρ whereas the top is characterized by higher radial coordinates ρ. An angle at the top of the plastic outlet may make it harder for the arc to attach and short circuit.

[0129] The legs of the splitter plates may be surrounded by plastic and in this way a vortex is created.

[0130] Groves to hold the splitter plates prevent the splitter plates to touch each other.

[0131] An attachment of the splitter plate holder with side walls on the side of the fix contact, for example on the sides of the first electric contact 102, prevents the arc from burning nearby plastic.

[0132] Embodiments of the present disclosure provide an improved medium voltage gas insulated switch including a first electric contact (102); and a second electric contact (104) that is moveable with respect to the first electric contact and a plurality (200) of splitter plates (200-1, 200-2, ...) configured to interrupt an electric arc (110) between the first electric contact (102) and the second electric contact (104) during the switching operation of the switch; a splitter plate holder (300, 510) that holds the plurality of splitter plates; and wherein at least a part of the plurality (200) of splitter plates is arranged in a non-parallel manner to each other and at substantially the same distance from a trajectory of the moveable second electric contact;

[0133] Each splitter plate in the plurality of splitter plates may therefore have substantially the same distance from the trajectory of the moveable second electric contact. For example, the minimum distance between each splitter plate and the second electric contact during a motion of the second electric contact is constant for all the splitter plates in the plurality of the splitter plates.

[0134] In some embodiments, the medium voltage gas insulated switch further includes a casing that encloses the first electric contact, the second electric contact and the splitter plate holder (300, 510) containing an electrically insulating gas; and the splitter plate holder is substantially suspended and configured to prevent a current flowing on a surface of the casing of the medium voltage gas insulated switch, in particular the splitter plate holder is fixed to the first electric contact;

[0135] In some embodiments, the electrically insulating gas does not include SF_6 and/or the electrically insulating gas may comprise at least one gas component selected from the group consisting of CO_2, O_2, N_2, H_2, air, N_2O, a hydrocarbon, in particular CH_4, a perfluorinated or partially hydrogenated organofluorine compound, and mixtures thereof or the insulation gas may comprise a background gas, in particular selected from the group consisting CO_2, O_2, N_2, H_2, air, in a mixture with an organofluorine compound selected from the group consisting of: fluoroether, oxirane, fluoramine, fluoroketone, fluoroolefin, fluoronitrile, and mixtures and/or decomposition products thereof.

[0136] In some embodiments the second electric contact (104) is rotatable with respect to the first electric contact (102) around a rotation axis (122, z) of the second electric contact (104), the second electric contact (104) being configured to rotate away from the first electric contact (102) around the rotation axis (122, z) during a switching operation for interrupting a current between the electric contacts; and each splitter plate of the plurality of splitter plates lies in a plane containing the rotation axis (122, z) of the second electric contact such that a radial distance between each splitter plate of the plurality of splitter plates and the rotation axis is substantially constant.

[0137] In some embodiments the distances between the trajectory of the second electric contact and each of the splitter plates (200-i) in the plurality (200) of splitter plates are substantially constant.

[0138] In some embodiments, at least a portion of the splitter plates are ferromagnetic and configured to attract the electric arc by Lorentz force, in particular all the splitter plates may be ferromagnetic or ferromagnetic splitter plates may alternate with non-ferromagnetic splitter plates.

[0139] In some embodiments the splitter plates are ferromagnetic and configured to attract the electric arc by Lorentz force.

[0140] In some embodiments the splitter plate holder (300, 510) has substantially the form of a circular arc.

[0141] In some embodiments the radius of the circular arc is greater than a maximal radial distance of the second electric contact from the rotation axis (122, z).

[0142] In some embodiments the radius of the circular arc is smaller than a maximal radial distance of the second electric contact from the rotation axis (122, z).

[0143] The maximal radial distance of the second electric contact from the rotation axis is a maximal radial distance of material points forming the second electric contact from the rotation axis, for example a distance of a tip of the second electric contact from the rotation axis. Said distance is time invariant and constant when the second electric contact rotates.

[0144] In some embodiments the splitter plate holder does not move with respect to the first electric contact.

[0145] In some embodiments wherein splitter plates 200-1, 200-2, ... have substantially a "U" shaped form, the top of the "U" being directed towards the rotation axis 122, z; and the splitter plate holder 510 further includes exterior side walls 500 along the sides of the "U", inner leg insulating walls 502 covering legs of the "U", and an insulating extension 506 of the bottom of the "U" directed away from the rotation axis 122.

[0146] For example the height of the "U" shaped form of the splitter plates may be around 65mm, the inner distance between the legs of the "U" may be for example 30mm. For example the legs of the "U" may have a width in the range of 10 mm to 20 mm.

[0147] The typical intervals between splitter plates are 1 to 10 mm with 1 to 40 splitter plates. The thickness of the splitter plates may be from 1 to 5 mm.

[0148] In some embodiments the side walls (500) of the splitter plate holder (510) is configured to block a side flow of gas and to prevent a bridging of the electric arc around the splitter plates.

[0149] In some embodiments the insulating extension (506) does not block a flow of gas, but blocks a propagation of the electric arc

[0150] In some embodiments the splitter plates arranged in a non-parallel manner to each other are configured such that an electric arc during a switching operation travels radially away from the rotation axis (122).

[0151] In some embodiments the exterior side walls (500) have a divergent profile or a convergent-divergent inner profile to enhance the characteristics of a flow of hot gas.

[0152] In some embodiments a length of the electric arc between adjacent splitter plates increases during the switching operation.

[0153] In some embodiments, the splitter plates arranged in a non-parallel manner to each other are configured such that an electric arc during a switching operation travels radially away from the rotation axis (122).

[0154] In some embodiments the exterior side walls 500 are configured to hold the plurality 200 of splitter plates. In some embodiments the splitter plate holder may be formed by the exterior side walls 500 in combination with further splitter plate holder elements 700 to reinforce the exterior side walls 500. The splitter plate holder does prevent an electrical conduction between different splitter plates. The splitter plate holder, for example formed according to the splitter plate holder 300 and/or according to the exterior side walls 500 and/or according to the exterior side walls 500 combined with at least one splitter plate holder element 700, is at least in part electrically insulating in order to prevent a low resistance electric connection between different splitter plates in the plurality 200 of splitter plates.

[0155] The second electric contact 104 may be rotatable with respect to the first electric contact 102 around a rotation axis 122 of the second electric contact, the second electric contact being configured to rotate away from the first electric contact around the rotation axis 122 during a switching operation for interrupting a current flow between the electric contacts (102, 104); and each splitter plate of the plurality of splitter plates 200 lie in a plane containing the rotation axis 122 of the second electric contact such that a radial distance between each splitter plate of the plurality of splitter plates and the rotation axis is substantially constant.

[0156] The rotation axis 122 may be the z axis of the coordinate system 130.

[0157] The radial distance between the splitter plate 200-i and the rotation axis 122 may be the radial coordinate ρ of the center of mass of the splitter plate 200-i.

[0158] The electric arc may extend in a region around a curved line 112, i.e. with a given probability the electric arc may be found within said region around the curved line 112 substantially between the first and the second electric contact.

[0159] In some embodiments, during the switching operation electrons of an electric arc 110 between the first electric contact 102 and the second electric contact 104 are attracted in a space between adjacent splitter plates by a force acting substantially radially with respect to the rotation axis 122 of the second electric contact 104, the force moving the electrons away from the rotation axis 122;

[0160] In some embodiments the splitter plate holder is formed by the splitter plate holder 510 that includes in particular exterior side walls 500 and inner leg insulating walls 502.

[0161] In some embodiments the splitter plate holder 510 further includes splitter plate holder elements 700 that may in particular reinforce the side walls 500. The splitter plate holder electrically insulates different splitter plates in the plurality of splitter plates.

[0162] In some embodiments, the splitter plate holder does not move with respect to the first electric contact and is substantially suspended.

[0163] The splitter plates may have substantially a "U" shaped form, the top of the "U" being directed towards the rotation axis; and wherein the splitter plate holder further includes exterior side walls 500 along the sides of the "U", an interior cover of the legs of the "U", and an insulating extension of the bottom of the "U" directed away from the rotation axis. For example, the splitter plate 200-i may have substantially a "U" shaped form. The top of the "U" may correspond to the region 230 and may be directed towards the rotation axis 122. The exterior side walls may be the exterior side walls 500, the interior cover may correspond to the inner leg insulating walls 502 and the insulating extension of the bottom of the "U" may correspond to the insulating extension 506. The splitter plate holder may therefore include the exterior side walls 500, further including the inner leg insulating walls 502 for covering in particular the legs of the splitter plate and an insulating extension 506. In some embodiments additional splitter plate holder elements 700 may further reinforce the splitter plate holder, for example reinforcing the exterior side walls 500 of the splitter plate holder.

[0164] In other embodiments the legs of the "U" may not be parallel and/or be angled with at least one angle, for example in correspondence of an angled segment 560 of the splitter plate. For example in some embodiments the splitter plates may be substantially trapezoidal such that the outer perimeter of the "U" can be inscribed in a trapeze. In some embodiments the trapeze is a rectangle. A region 230 for the transit of the second electric contact and/or legs of the splitter plates may be present for different shapes of the splitter plates, like for example substantially rectangular shapes or substantially trapezoidal shapes. The trapezoidal splitter plates may be wider near the region 230 for the transit of the second electric contact and narrower further away in a radially outward direction, i.e. in the direction of increasing radial coordinate ρ.

[0165] The side walls of the splitter plate holder may corresponds to the exterior side walls 500 forming a splitter plate holder and/or to the exterior side walls 500 forming a splitter plate holder in combination with splitter plate holder elements 700. An electrical insulation between different splitter plates in the plurality 200 of splitter plates is maintained by the splitter plate holder 300 and/or the exterior side walls 500 and/or the splitter plate holder elements 700 in combination with the exterior side walls 500 and/or any combination thereof in particular to prevent a low resistance connection between different splitter plates in the plurality of splitter plates.

[0166] The insulating extension is configured to allow the flow of gas 520.

[0167] The gas insulated switch according to embodiments of the present disclosure may be further configured such that a length of the electric arc between adjacent splitter plates increases during the switching operation. Said increase may result as a consequence of the nonparallel arrangement of the splitter plates in the plurality 200 of splitter plates.

[0168] The gas insulated switch including the splitter plates and the splitter plate holder form an arc quenching apparatus for medium voltages operating in particular with non-SF6 background gases, comprising a quenching space in which each phase has a stationary contact and a knife contact pivotable in relation thereto, and a quenching chamber including: a stack of suspended splitter plates made of ferromagnetic material and disposed/arranged following a curved stack design in order to maintain essentially constant the minimum distance between each splitter plate and the moving contact during the moving contact swiveling motion. The minimum distance corresponds to the shortest distance between the SP and moving contact during its opening. In some embodiments, the splitter plates are arranged in a nonparallel fashion following a fan-like disposition.

[0169] Embodiments of the present disclosure provide an improved gas insulated switch, which facilitates the extinction of the electric arc during a circuit breaking operation, for example increasing a voltage difference across the electric arc and/or a distance of the electric arc due to the nonparallel arrangement of the splitter plates and/or preventing a bridging of the arc and/or improving a flow of gas in order for example to create a vortex that facilitates the extinction of the arc. In some embodiments, the electric arc is kept in the space between adjacent splitter plates by side walls and/or each splitter plate contributes more uniformly in the extinction of the arc due to a curved geometry of the splitter plate holder, for example a geometry of a circular arc. Am improved extinction of the electric arc is therefore provided.

Claims

1. A medium voltage gas insulated switch (100) comprising

    a first electric contact (102);
    and a second electric contact (104) that is moveable with respect to the first electric contact and a plurality (200) of splitter plates (200-1, 200-2, ...) configured to interrupt an electric arc (110) between the first electric contact (102) and the second electric contact (104) during the switching operation of the switch;
    a splitter plate holder (300, 510) that holds the plurality of splitter plates;
    and wherein at least a part of the plurality (200) of splitter plates is arranged in a non-parallel manner to each other and at substantially the same distance from a trajectory of the moveable second electric contact.

2. The medium voltage gas insulated switch of claim 1 further comprising a casing that encloses the first electric contact, the second electric contact and the splitter plate holder (300, 510) containing an electrically insulating gas; and wherein the splitter plate holder is substantially suspended and configured to prevent a current flowing on a surface of the casing of the medium voltage gas insulated switch, in particular wherein the splitter plate holder is fixed to the first electric contact.

3. The medium voltage gas insulated switch of claim 2,wherein the electrically insulating gas comprises at least one gas component selected from the group consisting of CO_2, O_2, N_2, H_2, air, N_2O, a hydrocarbon, in particular CH_4, a perfluorinated or partially hydrogenated organofluorine compound, and mixtures thereof or wherein the insulation gas comprises a background gas, in particular selected from the group consisting CO_2, O_2, N_2, H_2, air, in a mixture with an organofluorine compound selected from the group consisting of: fluoroether, oxirane, fluoramine, fluoroketone, fluoroolefin, fluoronitrile, and mixtures and/or decomposition products thereof.

4. The medium voltage gas insulated switch of any of claims from 1 to 3 wherein the second electric contact (104) is rotatable with respect to the first electric contact (102) around a rotation axis (122, z) of the second electric contact (104), the second electric contact (104) being configured to rotate away from the first electric contact (102) around the rotation axis (122, z) during a switching operation for interrupting a current between the electric contacts; and wherein each splitter plate of the plurality of splitter plates lies in a plane containing the rotation axis (122, z) of the second electric contact such that a radial distance between each splitter plate of the plurality of splitter plates and the rotation axis is substantially constant.

5. The medium voltage gas insulated switch of any of claims from 1 to 4, wherein the distances between the trajectory of the second electric contact and each of the splitter plates (200-i) in the plurality (200) of splitter plates are substantially constant.

6. The medium voltage gas insulated switch of any of claims from 1 to 5, wherein at least a portion of the splitter plates are ferromagnetic and configured to attract the electric arc by Lorentz force, in particular where all the splitter plates are ferromagnetic or ferromagnetic splitter plates alternate with non-ferromagnetic splitter plates.

7. The gas insulated switch of any of claims from 1 to 6 wherein the splitter plate holder (300, 510) has substantially the form of a circular arc.

8. The medium voltage gas insulated switch of claim 7 wherein the radius of the circular arc is greater than a maximal radial distance of the second electric contact from the rotation axis (122, z).

9. The medium voltage gas insulated switch of claim 7 wherein the radius of the circular arc is smaller than a maximal radial distance of the second electric con-

tact from the rotation axis (122, z).

10. The medium voltage gas insulated switch of any of claims from 1 to 9 wherein the splitter plate holder does not move with respect to the first electric contact.

11. The medium voltage gas insulated switch of any of claims from 1 to 10 wherein splitter plates (200-1, 200-2, ...) have substantially a "U" shaped form, the top of the "U" being directed towards the rotation axis (122, z); and wherein the splitter plate holder (510) further includes exterior side walls (500) along the sides of the "U", inner leg insulating walls (502) covering interior legs of the "U", and an insulating extension(506) of the bottom of the "U" directed away from the rotation axis (122).

12. The medium voltage gas insulated switch of claim 11 wherein the side walls (500) of the splitter plate holder (510) is configured to block a side flow of gas and to prevent a bridging of the electric arc around the splitter plates.

13. The medium voltage gas insulated switch of claim 11 or of claim 12 wherein the insulating extension (506) does not block a flow of gas, but blocks a propagation of the electric arc.

14. The medium voltage gas insulated switch of any of claims from 11 to 13, wherein the exterior side walls (500) have a divergent profile or a convergent-divergent inner profile to enhance the characteristics of a flow of hot gas.

15. The medium voltage gas insulated switch of any of claims from 1 to 14 wherein the splitter plates arranged in a non-parallel manner to each other are configured such that an electric arc during a switching operation travels radially away from the rotation axis (122).

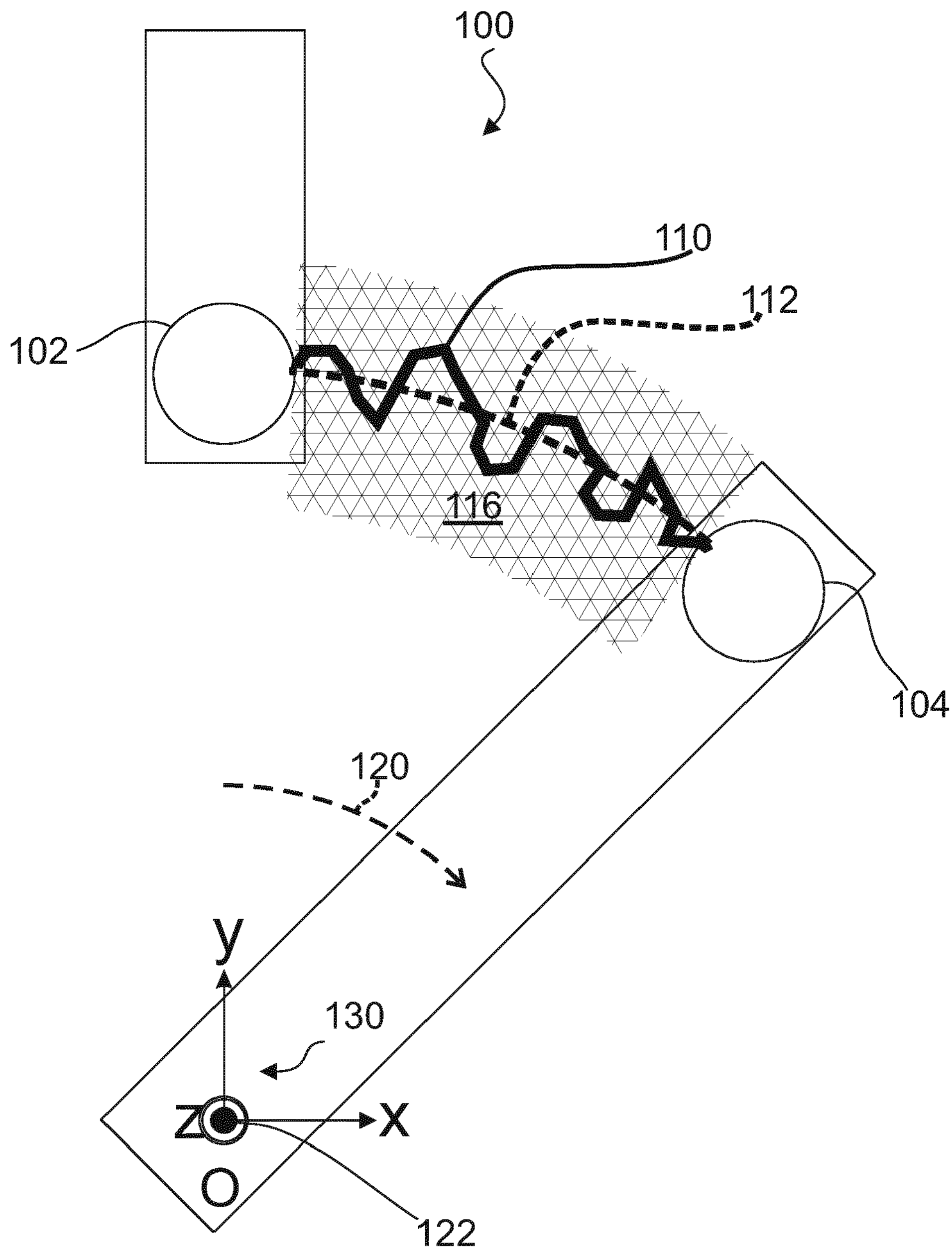

FIG. 1

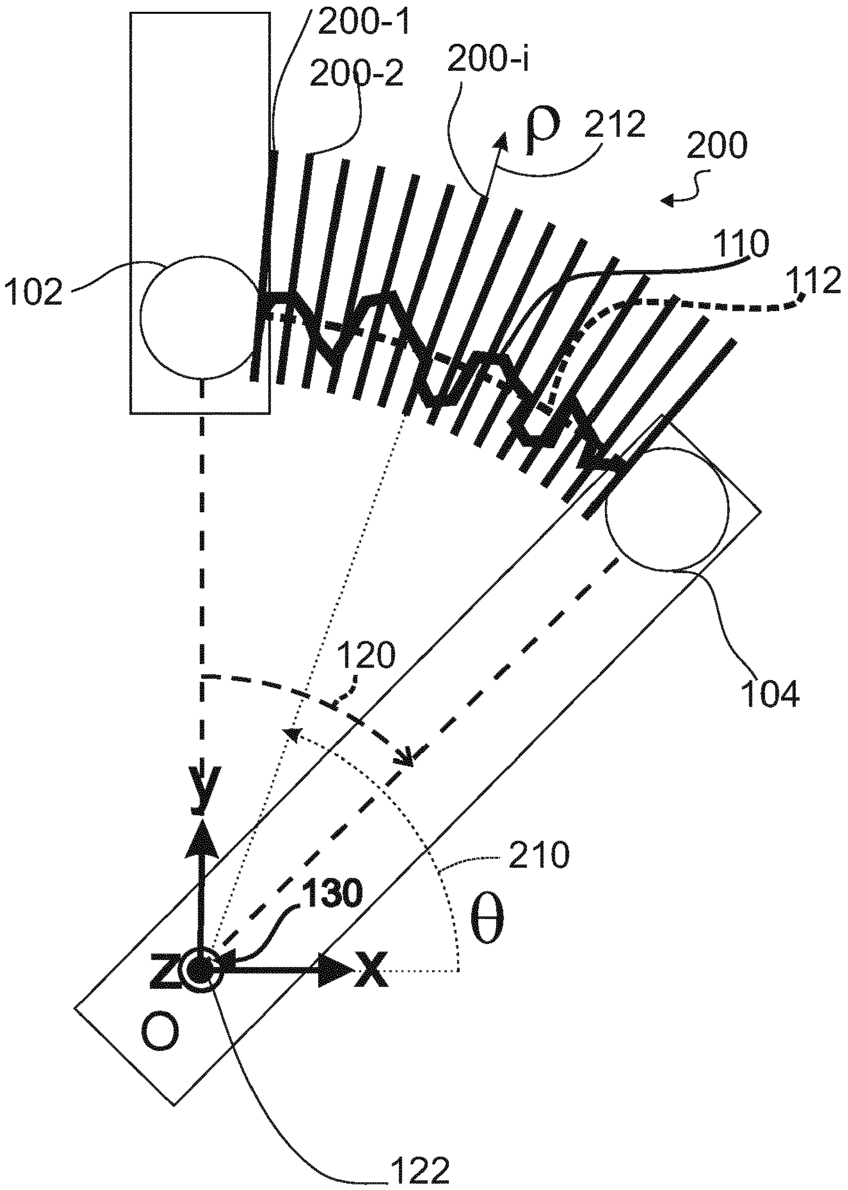

FIG. 2A

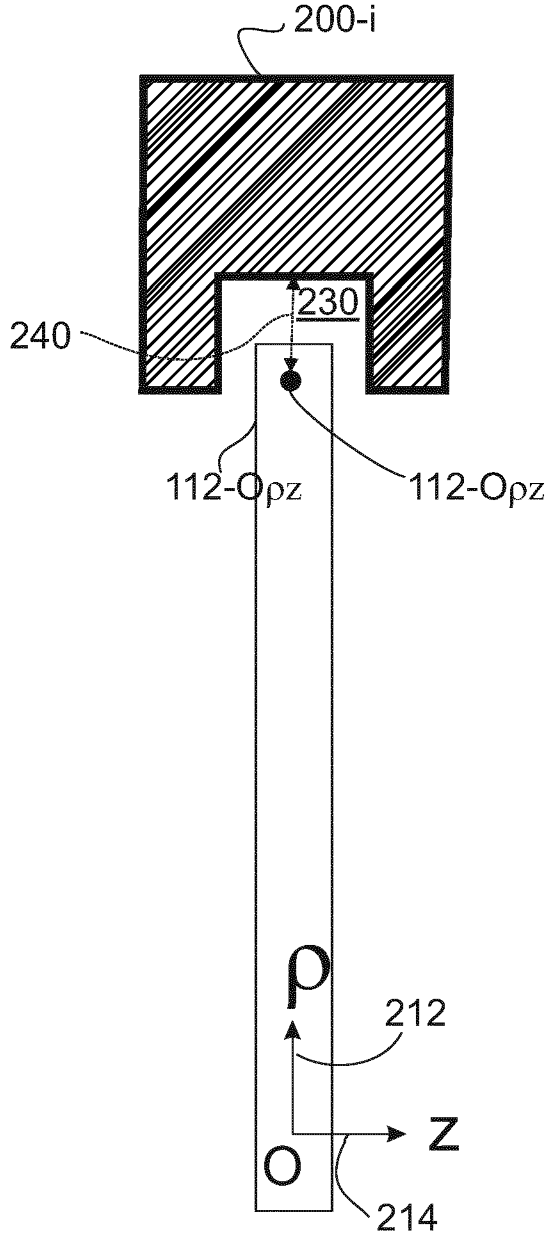

FIG. 2B

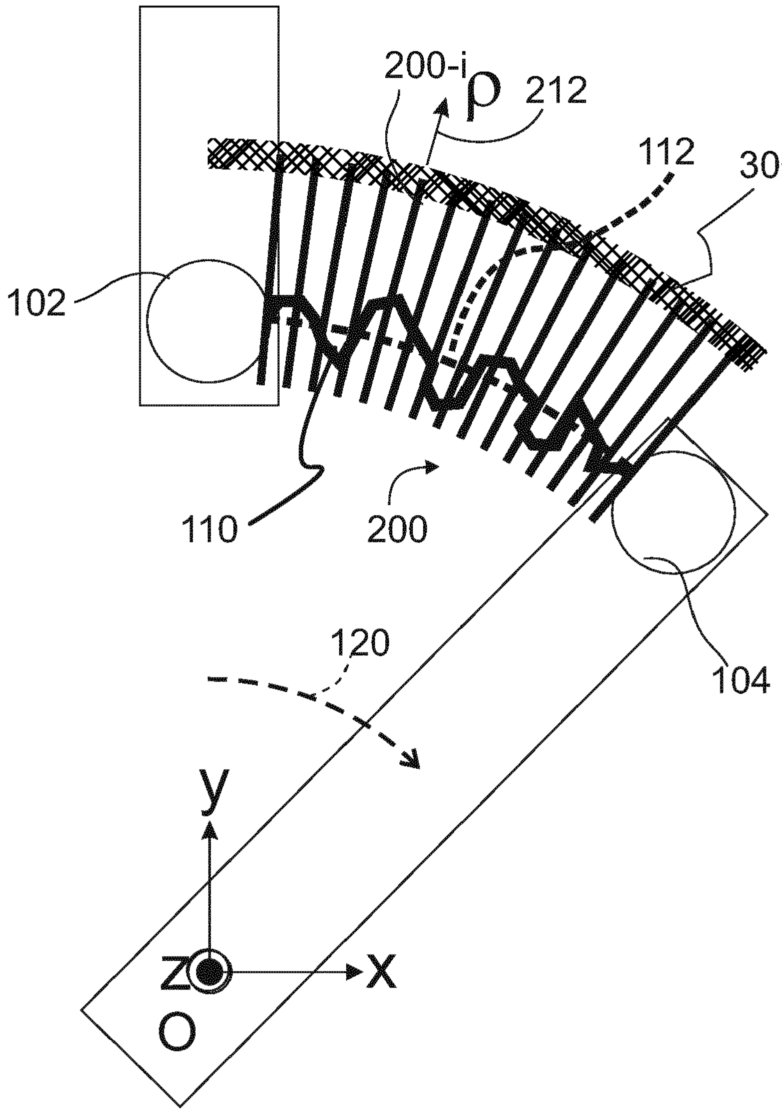

FIG. 3

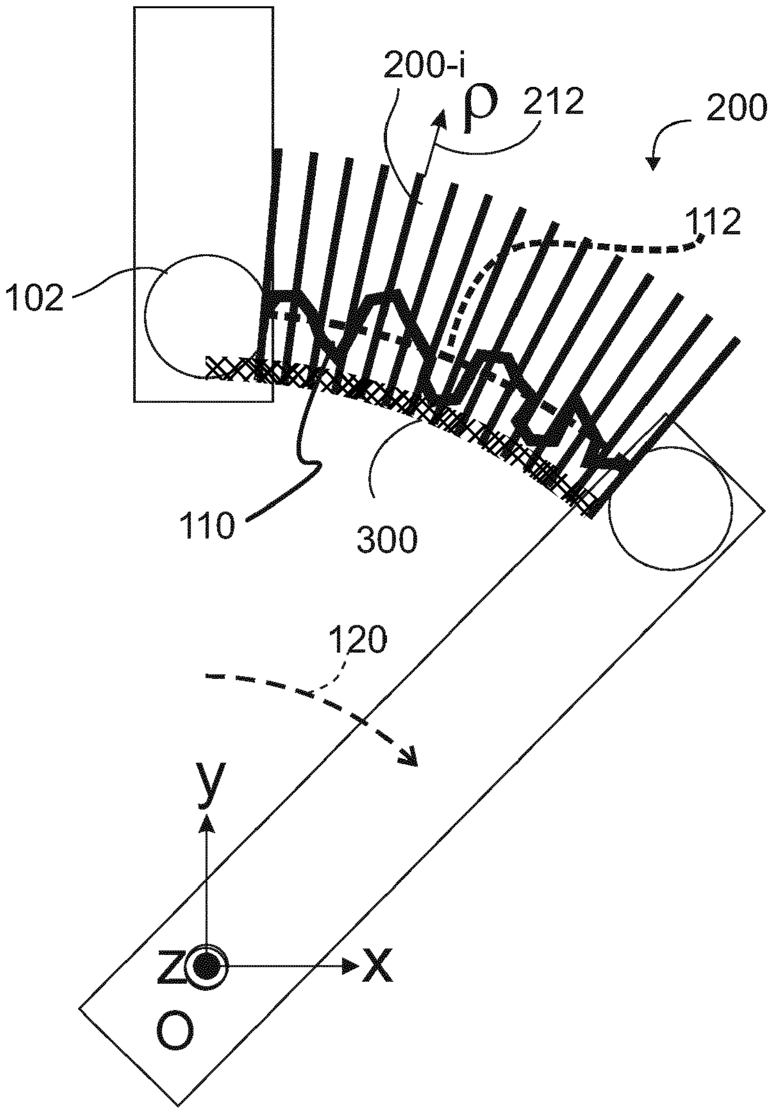

FIG. 4

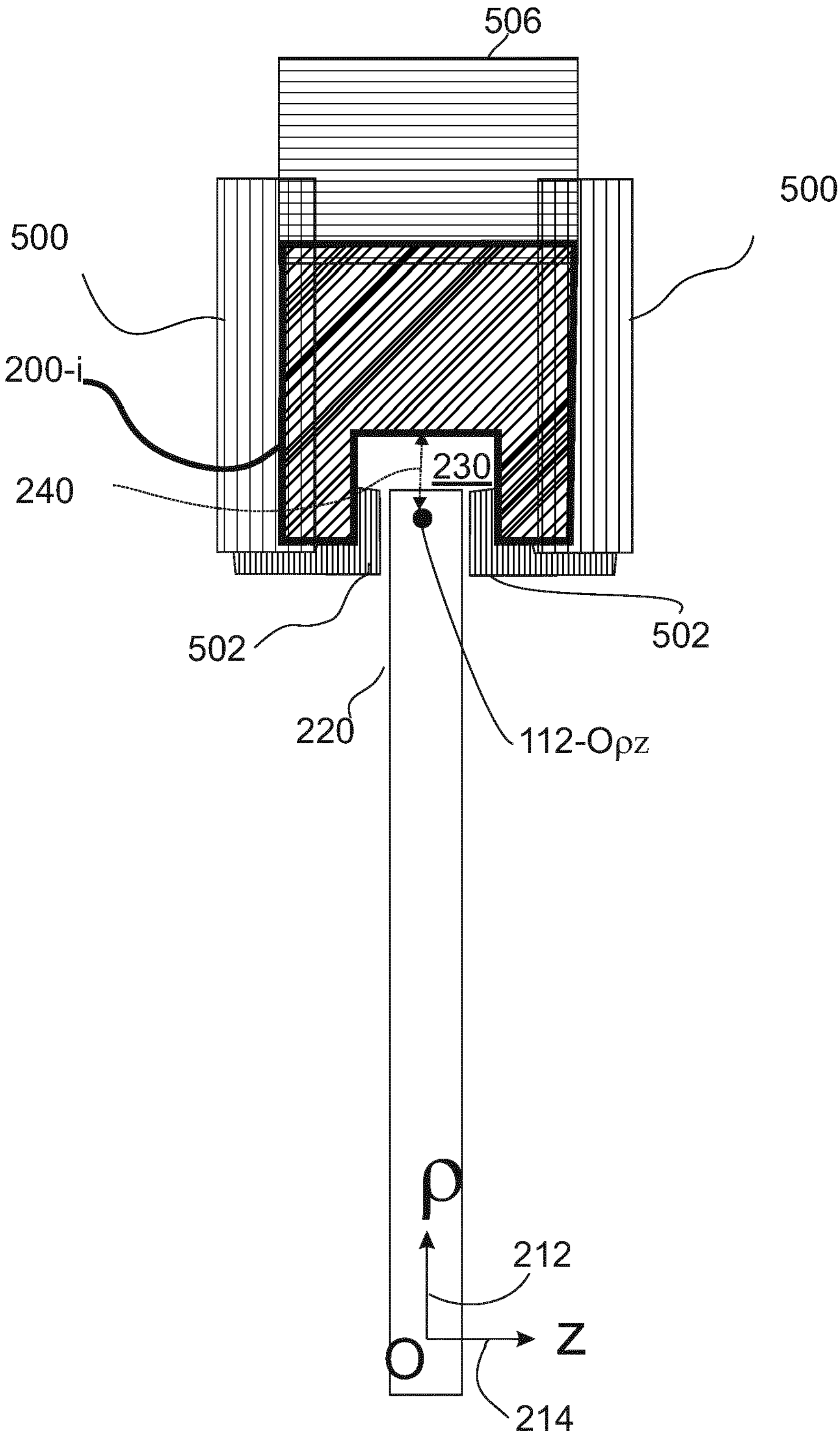

FIG. 5A

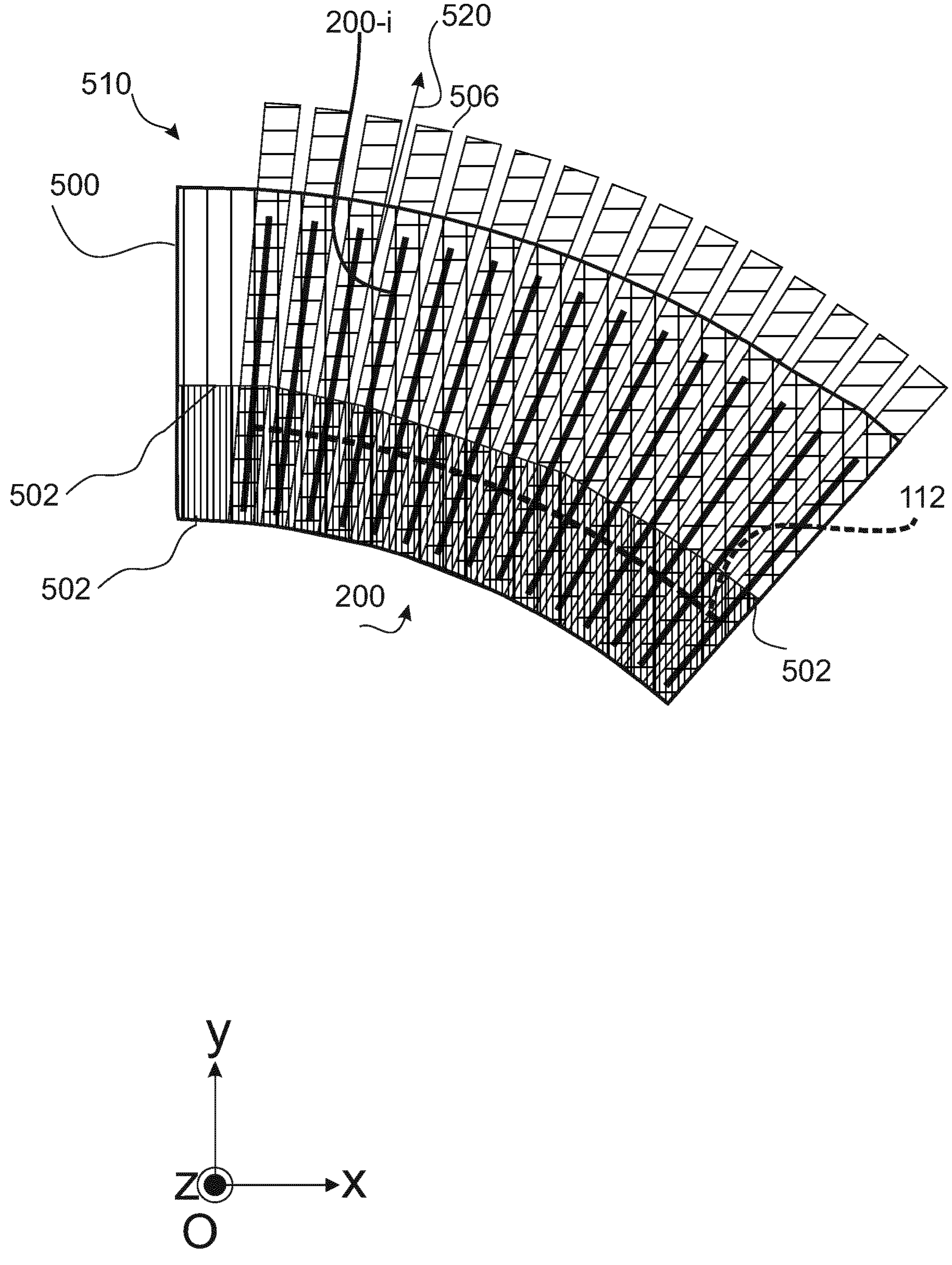

FIG. 5B

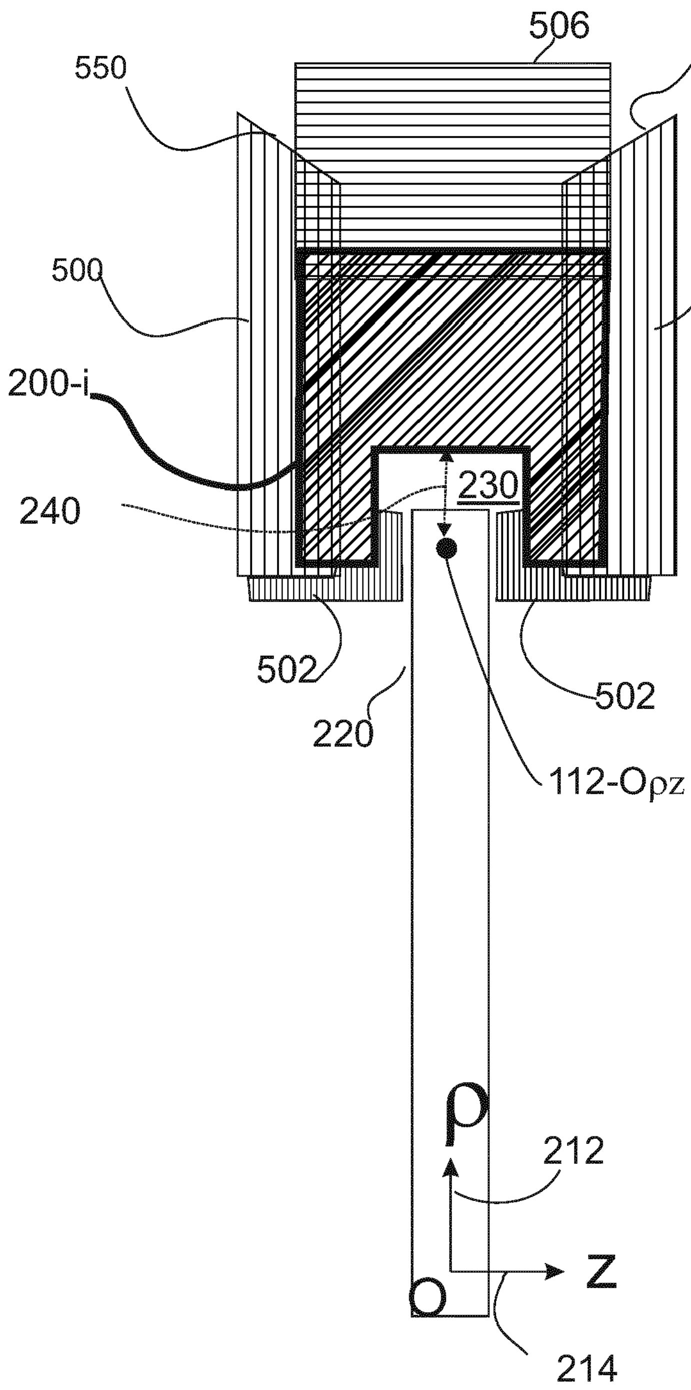

FIG. 5C

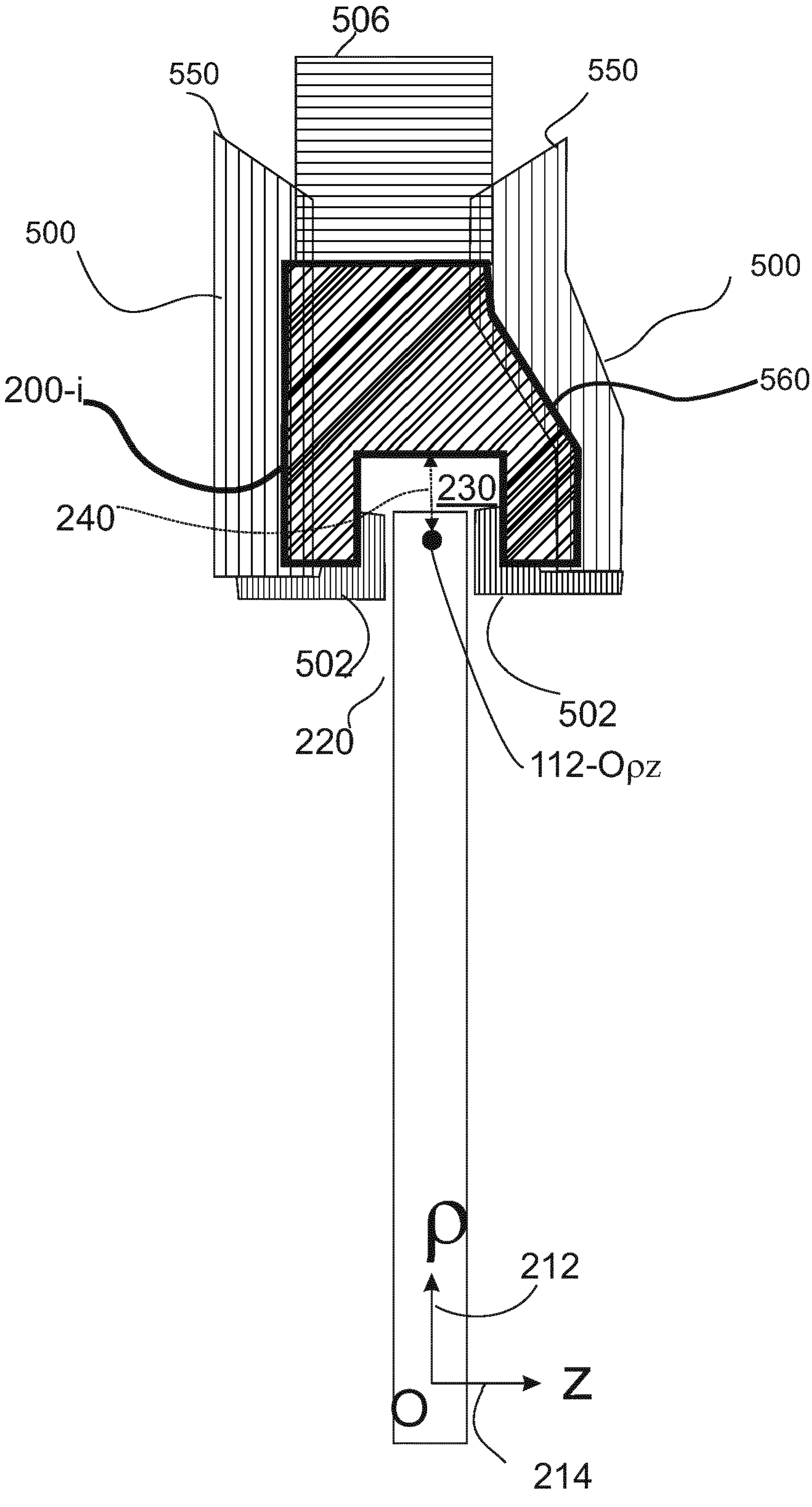
506
550
550
500
500
200-i
560
230
240
502
502
220
112-Oρz
ρ
212
z
O
214

FIG. 5D

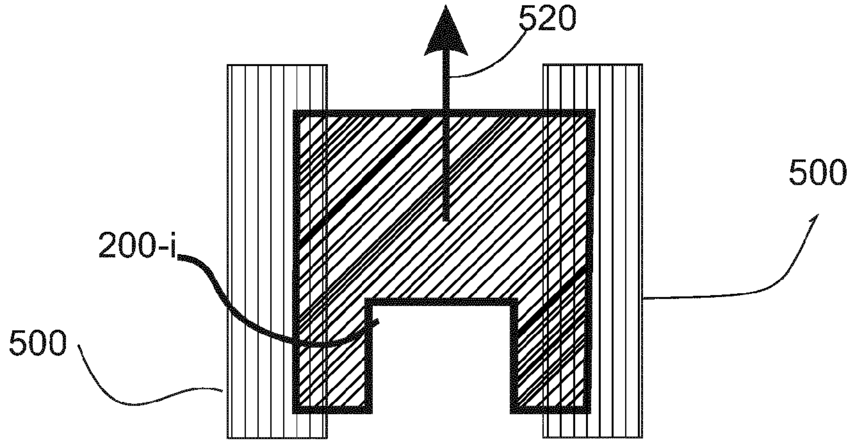

FIG. 5E

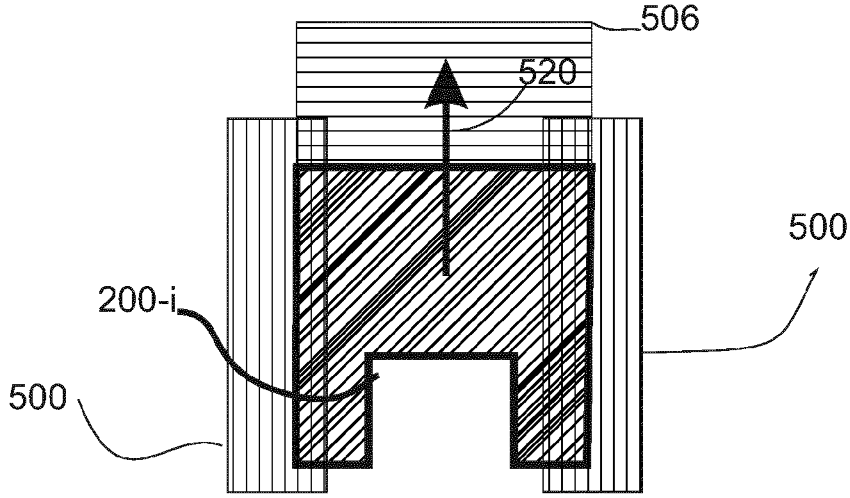

FIG. 5F

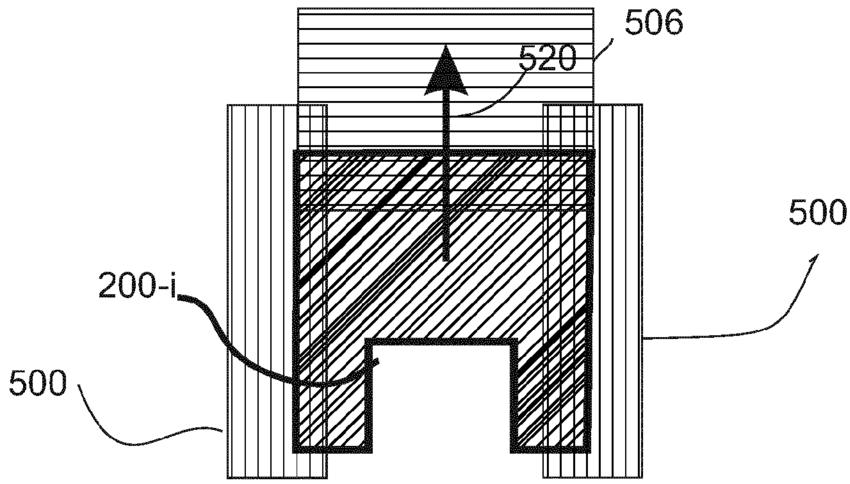

FIG. 5G

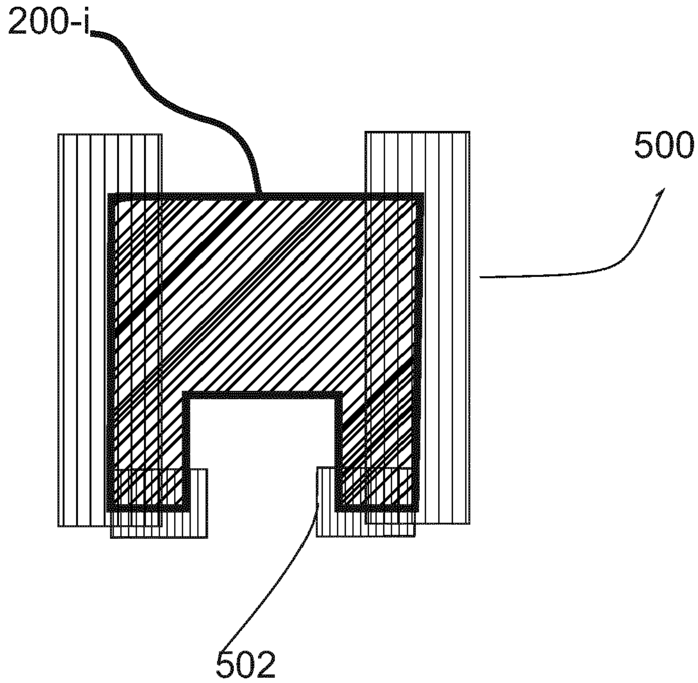

FIG. 5H

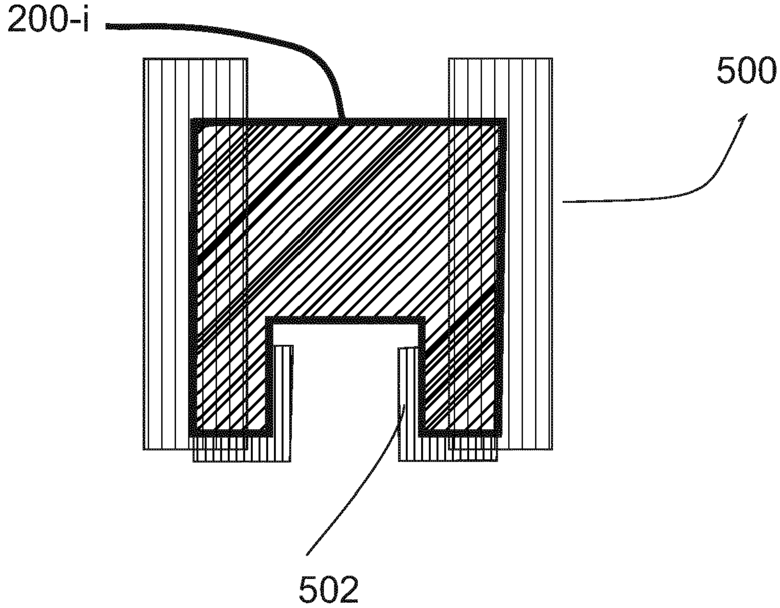

FIG. 5I

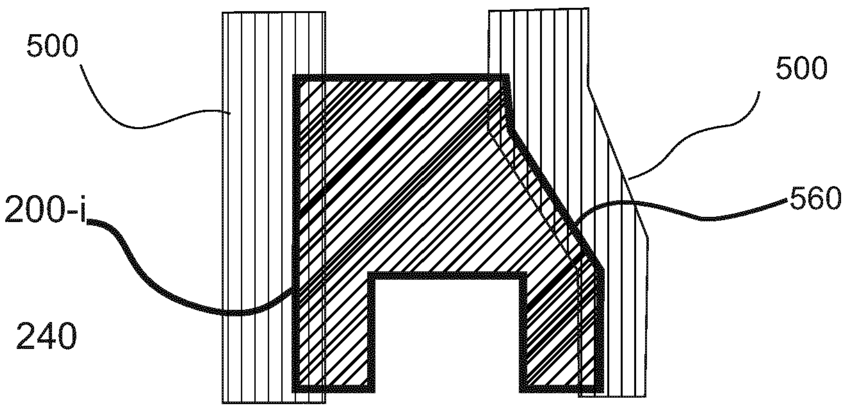

FIG. 5J

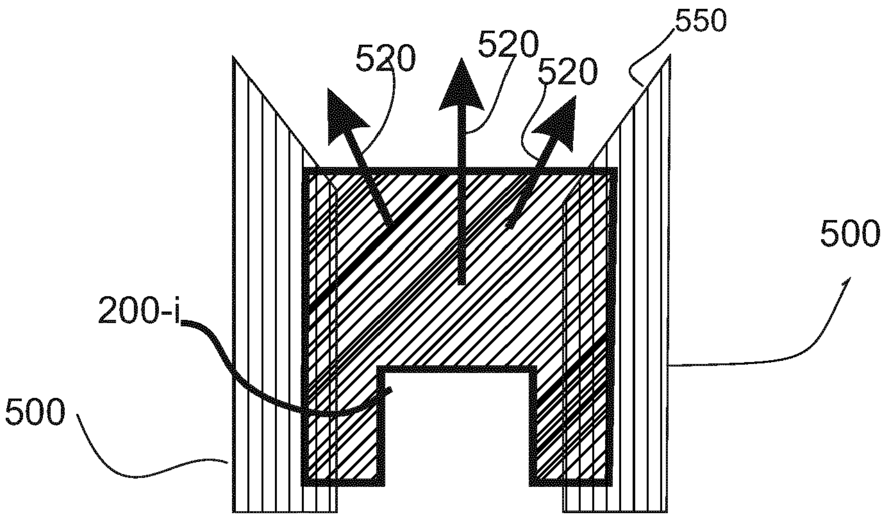

FIG. 5K

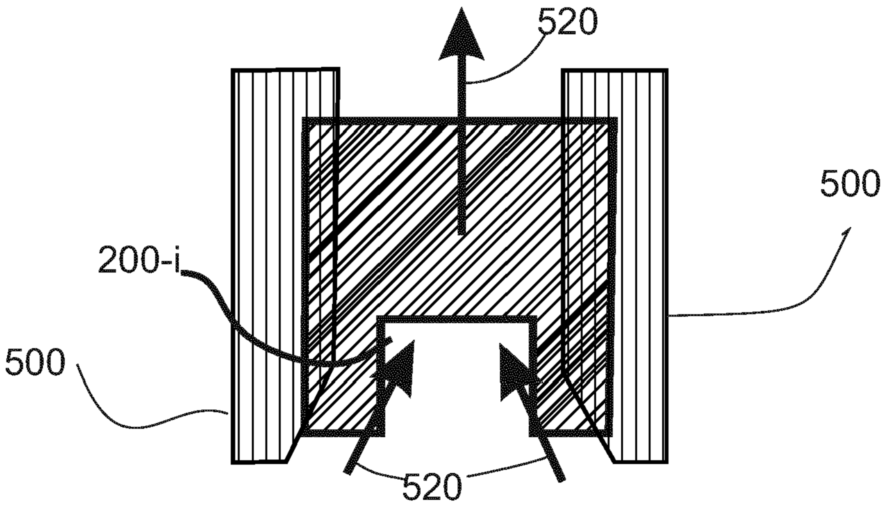

FIG. 5L

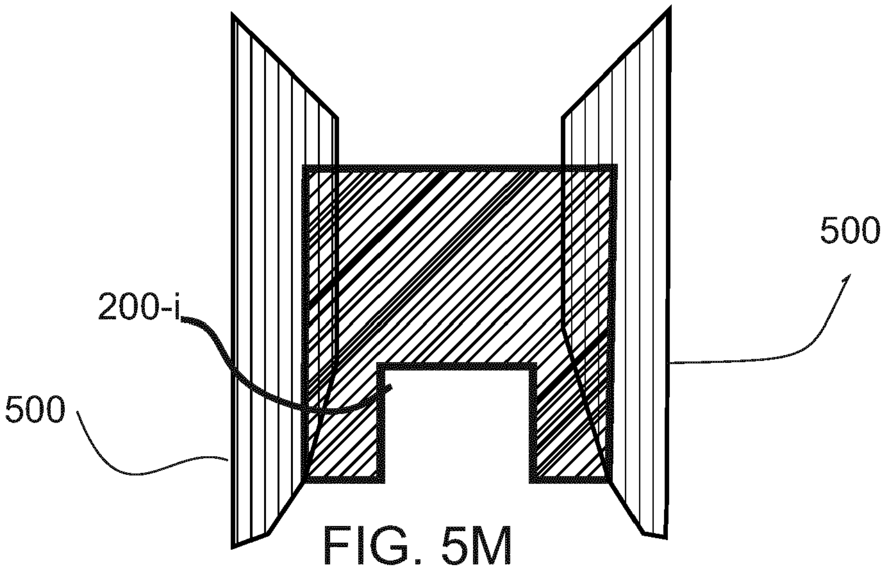

FIG. 5M

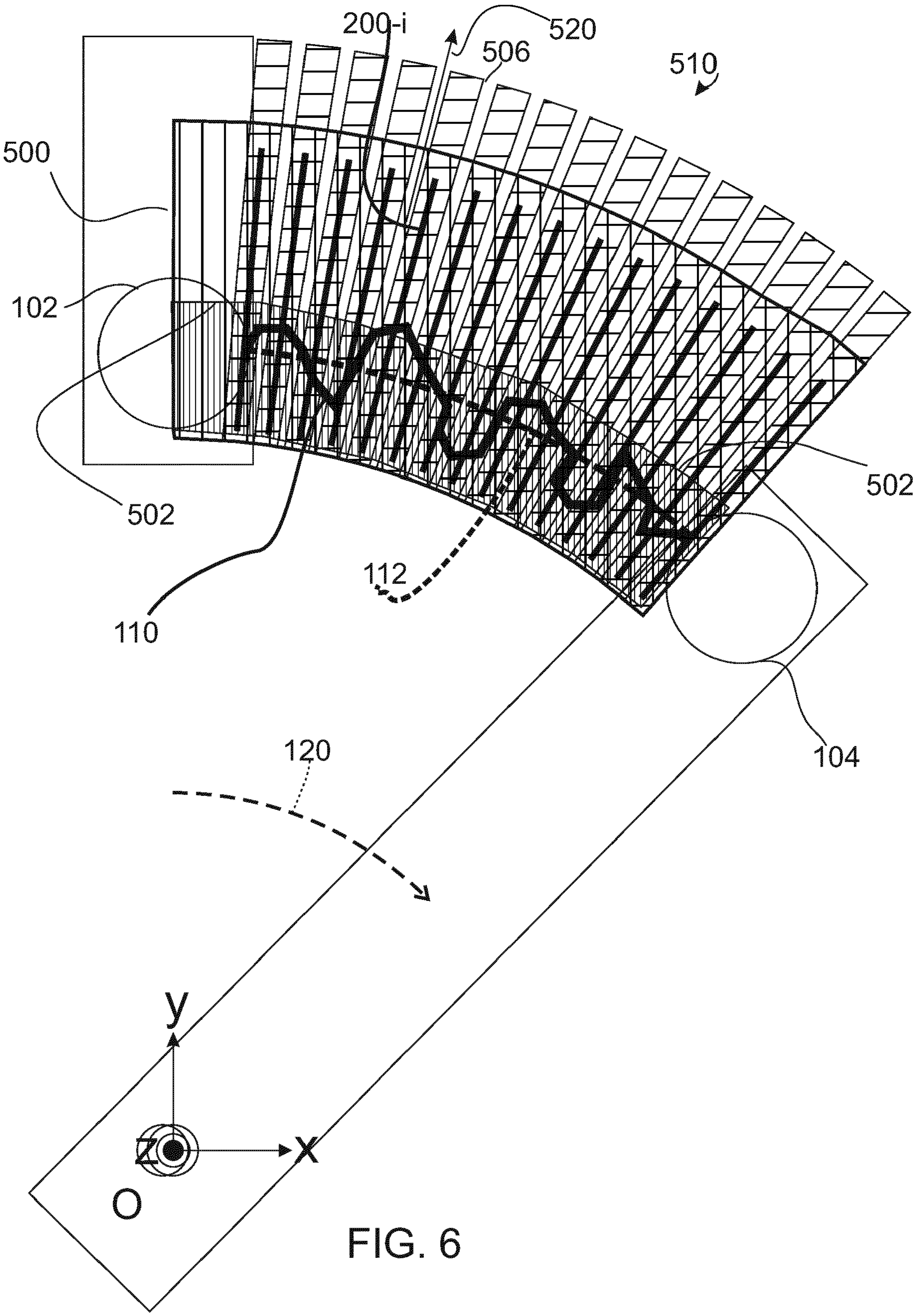

FIG. 6

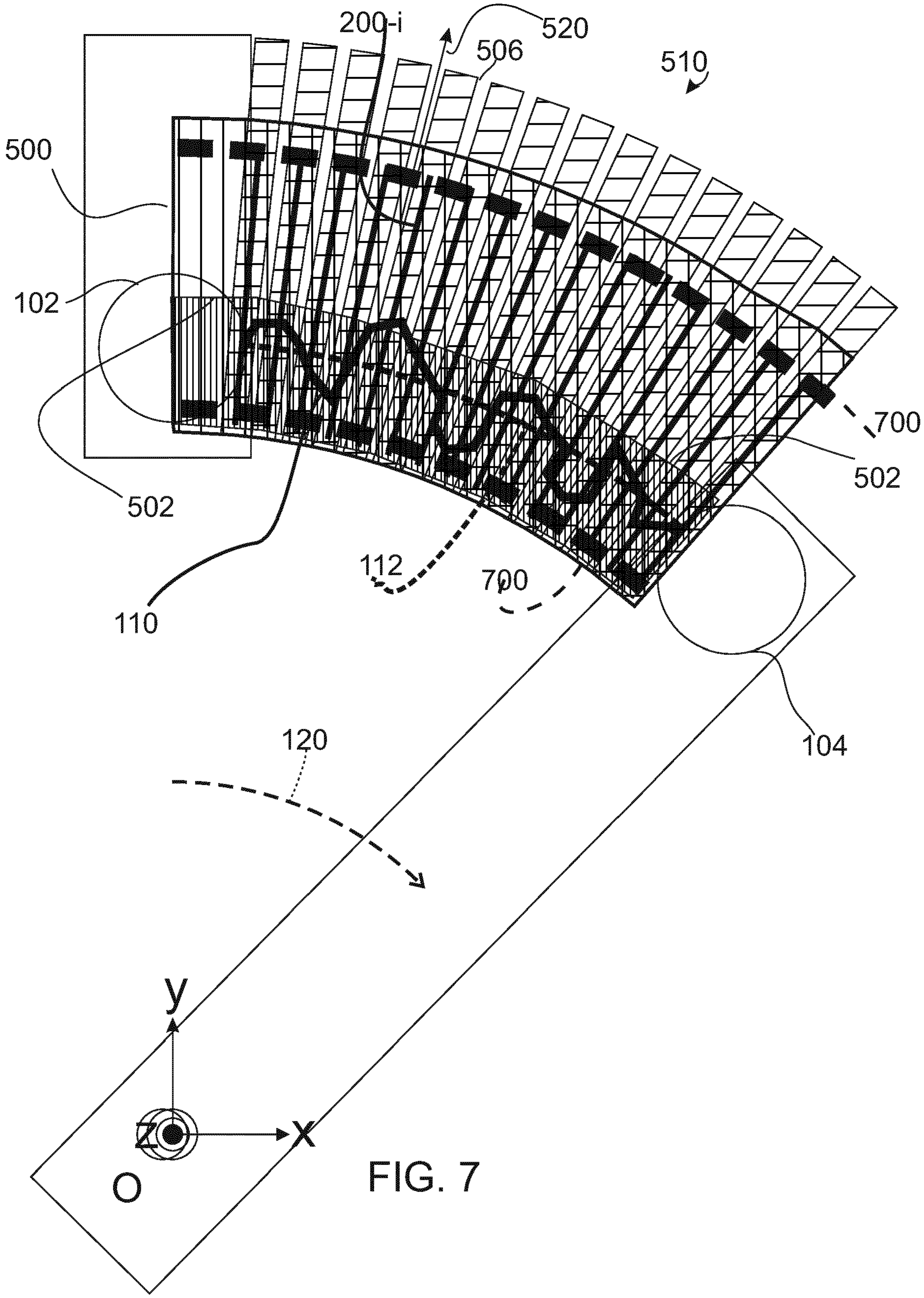

FIG. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 20 17 1867

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y A	CN 105 405 707 B (SHANGHAI TIANLING SWITCHGEAR; PINGGAO GROUP CO LTD ET AL.) 3 April 2018 (2018-04-03) * paragraph [0032] - paragraph [0033]; figure 1 * -----	1-10,15 11-14	INV. H01H33/10
Y	US 2014/246403 A1 (ENGEWALD MANUEL [DE]) 4 September 2014 (2014-09-04) * abstract; figure 1 * -----	1-10,15	
Y	WO 2018/145969 A1 (LUCY ELECTRIC EMS LTD [GB]) 16 August 2018 (2018-08-16) * abstract; figure 7 * -----	2	

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	21 September 2020	Simonini, Stefano

CATEGORY OF CITED DOCUMENTS

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
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21-09-2020

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
CN 105405707 B	03-04-2018	NONE	
US 2014246403 A1	04-09-2014	BR 112014011257 A2	25-04-2017
		CA 2855914 A1	16-05-2013
		CN 103930962 A	16-07-2014
		DE 102011118418 A1	16-05-2013
		DE 202012013255 U1	14-09-2015
		EP 2777057 A1	17-09-2014
		ES 2558789 T3	08-02-2016
		KR 20140096056 A	04-08-2014
		US 2014246403 A1	04-09-2014
		WO 2013068057 A1	16-05-2013
WO 2018145969 A1	16-08-2018	AU 2018217779 A1	15-08-2019
		GB 2560300 A	12-09-2018
		WO 2018145969 A1	16-08-2018

EPO FORM P0459

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