

(22) Date of filing: 11.06.2010

(74) Representative: **ABB Patent Attorneys**
C/o ABB Schweiz AG
Intellectual Property (CH-LC/IP)
Brown Boveri Strasse 6
CH-5400 Baden (CH)

Fig.1

Description

BACKGROUND OF THE INVENTION

[0001] The subject matter described herein relates generally to a gas-insulated high-voltage circuit breaker, and more particularly, to a particular arrangement of a contact rod for transferring an interruption current to one of the breaker contacts of the circuit breaker.

[0002] The increase in size of electrical power transmission networks experienced over the last decades have resulted in an increase of the maximum interruption current (also referred to as short-circuit current) that a circuit breaker can safely interrupt. In particular, high-voltage circuit breakers (i.e. suitable for high-voltage applications) based on gas insulation are known for their capacity to safely interrupt high currents between the two breaker contacts of the circuit breaker. In gas-insulated circuit breakers, a gas, such as sulfur hexafluoride, is used for extinguishing the arc generated when a current is interrupted.

[0003] At least some known gas-insulated high-voltage circuit breakers include an elongated contact rod which is movable with respect to its encapsulating casing and along a switching axis. The contact rod is movable for separating two arcing contacts, so that the interruption current is carried by an arc formed between the arcing contacts. The formed arc is quenched by a gas blast of sufficient intensity. During the current interruption operation, the interruption current is further carried by the moving contact rod and transferred through a mating contact portion, which generally is constituted as a stationary contact, to the breaker contact proximal to the contact rod.

[0004] In at least some known gas-insulated high-voltage circuit breakers, the contact rod includes a cylindrical portion. Generally, the mating contact portion is formed as a tulip-shaped contact having a ring of contact fingers, which fingers surround the cylindrical portion for establishing an electrical contact therewith. Generally, during a current interruption operation, the tulip-shaped contact slides on the cylindrical portion. Thereby, the mating contact portion and the cylindrical portion are continuously electrically contacted upon translation of the contact rod, so that the interruption current flows through the circuit breaker during the current interruption operation.

[0005] However, the maximum interruption current which can be carried by the circuit breaker is limited. If this maximum interruption current is exceeded, the safety of the circuit breaker cannot be assured. In particular, one weak link may be the transfer of the interruption current from the contact rod to the contact fingers.

[0006] Accordingly, it is desirable to provide a gas-insulated high-voltage circuit breaker which facilitates an effective transfer of the interruption current from the contact rod to the corresponding breaker contact of the circuit breaker during a current interruption operation.

BRIEF DESCRIPTION OF THE INVENTION

[0007] The embodiments described herein include a gas-insulated high-voltage circuit breaker with a contact rod including a substantially cylindrical portion, which contact rod further includes a first contact portion rigidly and electrically connected to the cylindrical portion via at least one lateral protrusion of the contact rod. The first contact portion and a mating contact portion (typically constituted as a stationary contact) of a first breaker contact of the circuit breaker form part of a pole contact arrangement. Thereby, an interruption current may flow through an interruption current path leading from the cylindrical portion of the contact rod, through the at least one lateral protrusion and via the pole contact arrangement, to the first breaker contact. That is, the interruption current may be transferred from the contact rod to the first breaker contact in a manner such that the contact area for transferring the interruption current between the first contact portion and the mating contact is not limited by the geometry and dimensions of the cylindrical portion of the contact rod. It should be noted that, generally, the dimensions of the cylindrical portion is determined by other dimensions of the circuit breaker, which imposes a limit on the available contact area for transferring the interruption current in the known circuit breakers referred to above.

[0008] In one aspect, a gas-insulated high-voltage circuit breaker for interrupting a current between a first breaker contact and a second breaker contact is provided. The circuit breaker has a disconnectable arc interruption current path between the first breaker contact and the second breaker contact. A portion of the disconnectable arc interruption current path leads from a second arcing contact through a first arcing contact of an elongated contact rod and via a pole contact arrangement to the first breaker contact. The contact rod includes a substantially cylindrical portion extending in a direction of a switching axis. The pole contact arrangement is formed by a first contact portion of the contact rod and a mating contact portion of the first breaker contact and the pole contact arrangement is configured such that the first contact portion is continuously electrically contacted to the mating contact portion. The contact rod includes at least one lateral protrusion extending in a radial direction away from the switching axis and is arranged in between the first contact portion and the cylindrical portion such that the first contact portion is rigidly and electrically connected to the cylindrical portion via the at least one lateral protrusion and such that a portion of the interruption current path leads from the cylindrical portion through the at least one lateral protrusion via the pole contact arrangement to the first breaker contact.

[0009] Further aspects, advantages and features of the present invention are apparent from the dependent claims, the description and the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] A full and enabling disclosure, including the best mode thereof, to one of ordinary skill in the art, is set forth more particularly in the remainder of the specification, including reference to the accompanying figures wherein:

[0011] Fig. 1 is a schematic cross-sectional view of a portion of an exemplary gas-insulated high-voltage circuit breaker;

[0012] Fig. 2 is a schematic cross-sectional view of a portion of another exemplary gas-insulated high-voltage circuit breaker;

[0013] Fig. 3 is a schematic cross-sectional view of the portion of the exemplary gas-insulated high-voltage circuit breaker of Fig. 2 along line A-A;

[0014] Fig. 4 is a schematic cross-sectional view of a portion of yet another exemplary gas-insulated high-voltage circuit breaker;

[0015] Fig. 5 is a schematic cross-sectional view of the portion of the exemplary gas-insulated high-voltage circuit breaker of Fig. 4 along line B-B;

[0016] Fig. 6 is a schematic cross-sectional view of a portion of a further exemplary gas-insulated high-voltage circuit breaker;

[0017] Fig. 7 is a schematic cross-sectional view of a portion of a still further exemplary gas-insulated high-voltage circuit breaker in a closed position;

[0018] Fig. 8 is a schematic perspective view of the portion of the exemplary gas-insulated high-voltage circuit breaker of Fig. 7 from line C-C;

[0019] Fig. 9 is a schematic cross-sectional view of the portion of the exemplary gas-insulated high-voltage circuit breaker of Fig. 7 in an open position;

[0020] Fig. 10 is a schematic perspective view of the portion of the exemplary gas-insulated high-voltage circuit breaker of Fig. 9 from line C-C;

[0021] Fig. 11 is a schematic cross-sectional view of a contact rod of an exemplary gas-insulated high-voltage circuit breaker; and

[0022] Fig. 12 is a schematic cross-sectional view of the contact rod of Fig. 12 along line D-D.

DETAILED DESCRIPTION OF THE INVENTION

[0023] Reference will now be made in detail to the various embodiments, one or more examples of which are illustrated in each figure. Each example is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet further embodiments. It is intended that the present disclosure includes such modifications and variations.

[0024] The embodiments described herein include a gas-insulated high-voltage circuit breaker for interrupting a current between a first breaker contact and a second breaker contact. The breaker contacts are typically

adapted for electrically interconnecting the circuit breaker to the electrical circuit to be protected. According to embodiments herein, a high voltage is a voltage of at least about 70 kV or higher. As used in this specification and the claims, a high-voltage circuit breaker is a circuit breaker rated to a voltage of at least about 70 kV or higher.

[0025] In a gas circuit breaker, the arc-extinguishing medium consists of a gas. Typically, the circuit breaker includes an encapsulating case which defines a volume for the gas. Furthermore, the circuit breaker typically includes a gas blast system configured to extinguish an arc formed between a first arcing contact and a second arcing contact of the circuit breaker during a stage of the current interruption operation.

[0026] A circuit breaker according to embodiments described herein includes an elongated contact rod. As used in this specification and the claims, an elongated contact rod of a circuit breaker shall be understood as a, typically rigid, contact member which includes, at least, an arcing contact portion, a substantially cylindrical portion and another contact portion (hereinafter referred to as first contact portion) typically configured for establishing an electrical contact with a mating contact portion of a breaker contact of the circuit breaker. The term elongated should be understood as specifying that the contact rod includes an essentially cylindrical shape wherein the term cylindrical should not be understood in a limiting way such as having a strictly circular cross-section but such that its longitudinal extension in the direction of the switching axis is substantial compared to a lateral extension, e.g. in diameter. The arcing contact portion is typically formed on the end of the contact rod disposed proximal to the other arcing contact of the circuit breaker. The first contact portion is typically disposed at an outer section of the contact rod with respect to its longest longitudinal axis.

[0027] A circuit breaker according to embodiments described herein includes a disconnectable arc interruption current path between the first breaker contact and the second breaker contact. As used in this specification and the claims, an interruption current is a current flowing between the two breaker contacts of the circuit breaker during a current interruption operation thereof. A portion of the disconnectable arc interruption current path leads from an arcing contact, typically connected to the second breaker contact, through another arcing contact of an elongated contact rod and via a pole contact arrangement, to the first breaker contact. Typically, the contact rod is movable along a switching axis for disconnecting the arc interruption current path. In particular, a displacement of the contact rod along the switching axis typically results in a separation of the arcing contacts. Thereby, the interruption current path may be disconnected. Therefore, according to typical embodiments of the present disclosure, a circuit breaker includes an interruption current path formed in a manner such that, during a current interruption operation, the interruption current

flows between both breaker contacts, either through a mechanical contact thereof or an electric arc formed therebetween. Furthermore, this interruption current is further carried by, at least, by the contact rod and by a pole contact arrangement in which the interruption current is transferred from the contact rod to one of the breaker contacts.

[0028] According to embodiments of the present disclosure, the contact rod includes a substantially cylindrical portion extending in a direction of a switching axis. Typically, the contact rod is arranged in a manner such that the substantially cylindrical portion is disposed concentrically to the switching axis. As set forth above, it is typical that the contact rod is movable along the switching axis. In particular, it is typical that the contact rod, which includes an arcing contact, is movable relative to an encapsulating case of the circuit breaker, along the switching axis, and away from another arcing contact, so that the interruption path referred to above is disconnected and, therefore, a current flowing between the breaker contacts of the circuit breaker can be interrupted.

[0029] According to embodiments of the present disclosure, the pole contact arrangement is formed by a first contact portion of the contact rod and a mating contact portion of the first breaker contact. In particular, it is typical that the first contact portion of the contact rod and the mating contact portion are configured complementary to each other for establishing an electrical contact and thereby forming the pole contact arrangement. Typically, the mating contact portion is disposed stationarily relative to an encapsulating case of the circuit breaker. According to embodiments of the present disclosure, the pole contact arrangement is configured in a manner such that the first contact portion is continuously electrically contacted to the mating contact portion. In particular, the pole contact arrangement is typically configured in a manner such that the electrical contact between the first contact portion and the mating contact portion is maintained upon translation of the contact rod along the switching axis of the circuit breaker.

[0030] According to embodiments of the present disclosure, the contact rod comprises at least one lateral protrusion. According to embodiments included herein, a lateral protrusion is an element of the contact rod protruding from the cylindrical portion thereof and being disposed cylindrically asymmetrically with respect to the longitudinal axis of the cylindrical portion. According to embodiments of the present disclosure, the lateral protrusion extends in a radial direction away from the switching axis. According to embodiments of the present disclosure, the lateral protrusion is arranged in between the first contact portion and the cylindrical portion in a manner such that the first contact portion is rigidly and electrically connected to the cylindrical portion via the at least one lateral protrusion. Thereby, the lateral protrusion connects the cylindrical portion and the first contact portion in the contact rod, so that an interruption current can flow from the first arcing contact to the first contact portion via

the cylindrical portion and the lateral protrusion.

[0031] Furthermore, according to embodiments of the present disclosure, the lateral protrusion is configured in a manner such that a portion of the interruption current path leads from the cylindrical portion through the at least one lateral protrusion via the pole contact arrangement to one of the breaker contacts of the circuit breaker. Thereby, the interruption current is transferred from the contact rod to this breaker contact of the breaker contact during a current interruption operation. In this manner, the interruption current is transferred from the first contact portion of the contact rod to the mating contact, which is typically stationarily disposed.

[0032] In the prior art devices referred to earlier in this description, the contact area between the cylindrical portion of the contact rod and the mating contact portion determines the density of the transferred interruption current. The dimension of this contact area may cause that a too high current density flows between the cylindrical portion and the mating contact portion. An excessive current density may generate a high electro-mechanical friction between the elements of the sliding contact, which friction may cause damages on the contact rod and/or the mating contact portion. In particular, when the interruption current is transferred through a mating contact portion constituted as a tulip-shaped contact, as described above, a too high electro-mechanical friction may generate marks in the form of recesses in the cylindrical portion and/or damage the fingers of the tulip-shaped contact upon translation of the contact rod. Thereby, the friction between the contact rod and the mating contact portion generally increases with operation of the circuit breaker and reduce its operating life. Moreover, in certain applications, the contact area for transferring the interruption current from the cylindrical portion to the mating contact portion may be even insufficient for transferring the interruption current from the contact rod to the corresponding contact of the circuit breaker.

[0033] Moreover, in the prior art devices referred to above the dimensions of the cylindrical portion of the contact rod depend on the required pressure build-up and the ampacity of the contact rod. For transferring the interrupting current from the movable contact rod to its dedicated stationary breaker contact sleeve-like sliding contacts are employed in many prior art devices. Since the diameter of the contact rod is desirably kept low in order to comply with the confined space available, the rod weight to be moved by the motion drive and other conditions, the only opportunity for increasing the contact area in between the sliding contact of the stationary breaker contact and the movable contact rod resided in adjusting the length of the sleeve-like sliding contact are very limited since further limitations such as the maximum stroke length of the motion as well as the cycle time must be met, too.

[0034] The presence of at least one lateral protrusion extending in a radial direction away from the switching axis avoids the lurking danger of having a poor electric

contact at the sliding contact such as in prior art devices by dislocating the contact area from the pin surface of the contact rod to a radially more remote region at a distal end of the lateral protrusion. Arranging the contact area proximate to said distal end where less constraints are present than closer to the switching axis allows an increased contact area compared to prior art devices and thus contributes essentially to the electrical contact quality of the movable contact rod and the dedicated stationary breaker contact. Expressed differently, the dislocation of the contact area from the pin surface of the contact rod to a radially more remote region at a distal end of the lateral protrusion enables designing a sufficiently large contact area of the sliding contact and its dedicated stationary breaker contact. Having a large contact area is advantageous in turns of reliability of the interruption path.

[0035] Therefore, a circuit breaker according to embodiments of the present disclosure facilitates a design in which a sufficiently large contact area can be provided, so that the interruption current can be transferred between the contact portion of the contact rod and the mating contact portion with an adequate density. In particular, embodiments of the present disclosure facilitate that the density of the current being transferred between the first contact portion and the mating contact portion is sufficiently low to avoid damage of elements of the circuit breaker. Furthermore, in the case that the pole contact arrangement is formed as a sliding contact comprising the contact portion and the mating contact portion, such a sufficiently large contact area facilitates keeping sufficiently low electro-mechanical friction between the sliding parts in the pole contact arrangement. Thereby, the operating life of the circuit breaker is typically increased and the service requirements are typically reduced. Furthermore, such a decrease of electro-mechanical friction between sliding parts of the circuit breaker typically results in a significant reduction of the operating energy required for performing a current interruption operation.

[0036] Within the following description of the drawings, the same reference numbers refer to the same components. Generally, only the differences with respect to the individual embodiments are described.

[0037] Fig. 1 schematically shows a cross-sectional view of a portion of an exemplary gas-insulated high-voltage circuit breaker 200. Exemplary circuit breaker 200 is configured to interrupt a current between a first breaker contact 132 and a second breaker contact 134. In typical embodiments of the present disclosure, the breaker contacts are adapted for being electrically connected to the circuit to be protected by circuit breaker 200 (i.e., the protected circuit). Exemplary circuit breaker 200 includes an encapsulating case 80 which defines a volume for a gas. Typically, stationary casing 80 is constituted as an insulating envelope, such as, but not limited to, a ceramic housing. Such insulating envelope is typically mounted on a suitable structure configured to support circuit breaker 200.

[0038] In the exemplary embodiment, circuit breaker 200 includes a first arcing contact 10 and a second arcing contact 12, the arcing contacts being adapted to form a burn contact. According to typical embodiments, first arcing contact 10 is electrically connected to first breaker pole 132 and second arcing contact 12 is electrically connected to second breaker pole 134. Arcing contacts 10 and 12 are constituted in a manner such that they can conveniently carry an interruption current, so that the arcing contacts do not generate excessive heating and withstand the heat of an arc generated during a current interruption operation of the circuit breaker. In particular, arcing contacts 10 and 12 are made of any suitable material, typically arc-resistant, that enables circuit breaker 200 to function as described herein, such as, but not limited to, copper or copper alloys, silver alloys, or a combination thereof. In particular, these materials are typically chosen on the basis of their electrical conductivity, hardness (i.e., resistance to abrasive wear), mechanical strength, low cost, and/or chemical properties.

[0039] In the exemplary embodiment, first arcing contact 10 forms part of a contact rod 20, which rod further includes a substantially cylindrical portion 22, a lateral protrusion 30 and a first contact portion 55. Contact rod 20 is typically arranged in a manner such that cylindrical portion 10 is disposed concentrically to a switching axis 25. In typical embodiments, contact rod 20 is movable relative to encapsulating case 80 and along switching axis 25 in a direction away from second arcing contact 12. According to certain embodiments, contact rod 20 is integrally built as a single piece. In alternative embodiments, contact rod 20 is modularly built, so that it is constituted by multiple pieces which are brought together, typically in a releasable manner. An integrally built contact rod typically facilitates reducing costs of fabrication and optimizing its electrical and mechanical properties. A modularly built contact rod typically facilitates servicing of its parts. For example, a modularly built contact rod 20 may be configured in a manner such that first arcing contact 10, which typically is subject to erosion through the electric arc, can be easily exchanged.

[0040] Typically, contact rod 20 is made of any suitable conductive material which enables circuit breaker 200 to function as described herein, such as, but not limited to, copper. If required, the contact rod 20 may be made of different materials, for example, different parts thereof may be made of different materials or be coated with a material which provides adequate electrical and/or mechanical properties to each of these parts.

[0041] Lateral protrusion 30 extends in a radial direction and away from switching axis 25. Furthermore, lateral protrusion 30 is arranged in between first contact portion 55 and cylindrical portion 22 and is configured in a manner such it rigidly and electrically connects these portions to each other. In particular, in the exemplary embodiment, lateral protrusion 30 branches out from a middle part of cylindrical portion 22 and extends in a direction perpendicular to switching axis 25. In alternative

embodiments, lateral protrusion 30 may branch out from a part of cylindrical portion 22 distal from first arcing contact 10 and/or may extend along a direction which forms an oblique angle with switching axis 25.

[0042] In the exemplary embodiment, lateral protrusion 30 is formed substantially flat and coplanar to switching axis 25. Typically, lateral protrusion 30 is formed as a portion of contact rod 20 which protrudes from cylindrical portion 22 and is formed cylindrically asymmetric with respect to the longitudinal axis of cylindrical portion 22. In particular, lateral protrusion 30 is formed as an element protruding from cylindrical portion 22 and having a cross-section along a plane parallel to switching axis 25, which cross-section is suitable for carrying the maximum interruption current that circuit breaker 200 is required to safely interrupt a current between the breaker contacts. Such a cross-section of lateral protrusion 30 may have any suitable shape, such as, but not limited to, an oval, circular, or rectangular shape. Furthermore, the dimensions, shape and materials of lateral protrusion 30 are typically chosen so that mechanical stability of contact rod 20 is not compromised. A lateral protrusion according to embodiments of the present disclosure typically provide a cross-section adequate for conducting an interruption current from cylindrical portion 22 to first contact portion 55, while providing a versatile geometry which facilitates implementation of contact rod 20 in circuit breaker 200.

[0043] According to embodiments of the present disclosure, contact rod 20 includes first contact portion 55, which first contact portion 55 is rigidly and electrically connected to cylindrical portion 22 via at least one lateral protrusion 30, in the exemplary embodiment, via one lateral protrusion 30. Thereby, contact rod 20 is typically constituted in a manner such that an interruption current can flow from first arcing contact 10, through cylindrical portion 22 and lateral protrusion 30, to first contact portion 55. First contact portion 55 may be formed as any suitable contact portion that enable contact arrangement 60 to function as described herein. According to certain embodiments, first contact portion 55 is formed substantially cylindrically asymmetrically with respect to a longitudinal axis of cylindrical portion 22, which axis is typically coincident with switching axis 25.

[0044] According to certain embodiments, first contact portion 55 includes a contact blade. In the exemplary embodiment, first contact portion 55 is in particular formed as a contact blade substantially coplanar to the longitudinal axis of cylindrical portion 22 which is coincident with switching axis 25. In the exemplary embodiment, first contact portion 55 is formed as an elongated contact blade extending in the direction of switching axis 25. Such a contact blade typically provides a sufficiently large contact area for transferring an interruption current from contact rod 20 to first breaker contact 132. In particular, such contact area provided by a contact blade is not limited by the cylindrical geometry of cylindrical portion 22. Furthermore, a first contact portion 55 including

a contact blade typically provides a first contact portion 55 with appropriate mechanical properties and which can be cost-effectively manufactured.

[0045] According to embodiments of the present disclosure, first breaker contact 132 includes a mating contact portion 90. In typical embodiments, mating contact portion 90 is an electrically conducting element which is disposed stationarily relative to encapsulating case 80 and is adapted for transmitting a current to first breaker contact 132. In the exemplary embodiment, mating contact portion 90 is disposed stationarily relative to encapsulating case 80 and complementary to first contact portion 55 in order to form a contact with a surface thereof. Mating contact portion 90 may be formed as any suitable contact portion that enables contact arrangement 60 to function as described herein. For example, mating contact portion 90 may be formed as a spring finger contact which is disposed exerting a mechanical loading force on a surface of first contact portion 55 in a manner such that these portions are mechanically and electrically contacted to each other, thereby forming contact arrangement 60.

[0046] According to embodiments disclosed herein, pole contact arrangement 60 is formed by first contact portion 55 and mating contact portion 90 and is configured in a manner such that first contact portion 55 is continuously electrically contacted to mating contact portion 90. As described above, a disconnectable interruption current path is established between the breaker contacts of circuit breaker 200. Typically, the continuous electrical contact in contact arrangement 60 is realized in a manner such that the portion of the arc interruption current path between first arcing contact 22 and first breaker contact 132 is maintained upon translation of contact rod 10 along switching axis 25. In particular, pole contact arrangement 60 is formed as any suitable contact which enables first contact portion 55 to continuously electrically contact mating contact portion 90, such as, but not limited to, a brush contact, a plug-and-socket connector having an elongated contact section, a flexible band connector or a blade connector. In particular, according to certain embodiments, pole contact arrangement 60 is formed as a sliding contact comprising first contact portion 55 and mating contact portion 90. In such sliding contact, it is typical that first contact portion 55 slides in contact along a surface of mating contact portion 90, as detailed below.

[0047] According to certain embodiments, first contact portion 55 includes a pole-contact surface 57 extending in the direction of switching axis 25. Typically, pole-contact surface 57 is arranged substantially non-cylindrically about the longitudinal axis of cylindrical portion 22. For example, pole-contact surface 57 may be arranged substantially planar. Alternatively, pole-contact surface 57 may be arranged substantially cylindrically about switching axis 25. Typically, pole-contact surface 57 is continuously mechanically and electrically contacted to mating contact portion 90 during a current interruption operation in which contact rod 20 is moved along switching axis

25. According to certain embodiments, the area of pole-contact surface 57 is larger than at least 200 % of the cylindrical area of the segment of cylindrical portion 22 extending along lateral protrusion 30 in the direction of the switching axis 25. The larger the area of pole-contact surface 57 is larger than 200%, e.g. 250% or even 300% of the segment of cylindrical portion 22 extending along lateral protrusion 30 is, the better the interruption current may be transferred.

[0048] In the exemplary embodiment, contact blade 55 slides on mating contact portion 90, which mating contact portion is formed as a spring finger contact. The continuous electrical contact in contact arrangement 60 of the exemplary circuit breaker is realized through the mechanical loading force exerted by the spring finger of mating contact portion 90 on a surface of first contact portion 55. In the exemplary embodiment, these portions are spatially disposed in a manner such that the electrical contact is continuously maintained upon translation of contact rod 20 along switching axis 25. In particular, first contact portion 55 is disposed with its longitudinal axis aligned with the longitudinal axis of mating contact portion 90, both axes being parallel to switching axis 25. According to certain embodiments, such as the exemplary circuit breaker 200 shown in Fig. 1, pole-contact surface 57 extends in a direction perpendicular to switching axis 25.

[0049] According to typical embodiments, circuit breaker 200 includes an actuating system, typically constituted as a gear system, for moving contact rod 20 along switching axis 25 and away from second arcing contact 12 during a current interruption operation. Thereby, the interruption current path referred to above is typically disconnected by the separation of arcing contacts, which separation is caused by the translation of contact rod 20. In the exemplary embodiment, circuit breaker 200 includes a gear system 105 which is operatively coupled to contact rod 20 for translation thereof along switching axis 25. Typically, gear system 105 is driven by a drive (not shown). In the exemplary embodiment, gear system 105 includes a distal gear element coupled to contact rod 20 and another distal gear element coupled to a stationary part of circuit breaker 200 and operatively associated to the drive. Thereby, a movement of contact rod 20 relative to encapsulating case 80 can be engendered. Gear system 105 include any suitable structure, configuration, arrangement, and/or components which facilitate moving contact rod 20 during an interruption operation of circuit breaker 200, such as, but not limited to, a set of drives 110 operatively coupling drive 105 to contact rod 20, further driving elements, transmission elements, slotted link disks or rotatably mounted bolts.

[0050] According to certain embodiments, second arcing contact 12 is adapted for being displaced along switching axis 25 during a current interruption operation. In particular, according to certain embodiments, both arcing contacts 10 12 are disposed movable relative to encapsulating case 80, and circuit breaker 200 is configured

in a manner such that first and second arcing contacts are moved in opposite directions along switching axis 25 during a current interruption operation. Thereby, circuit breaker 200 is constituted as a double motion circuit breaker. By such a configuration, an important decrease of the operating energy of the circuit breaker is facilitated by reducing the kinetic energy consumed during the current interruption operation. Furthermore, since a circuit breaker according to embodiments of the present typically keeps low electro-mechanical friction during a current interruption operation, this kinetic energy can be further reduced.

[0051] In such a double motion configuration, it is typical to displace the arcing contacts in a manner such that the arc speed relative to the stationary speed during a current interruption operation is half of that of a circuit breaker having a single movable contact. Typically, double motion is realized by providing circuit breaker 200 with gear system 105 described above, and an auxiliary gear system operatively coupled to second arcing contact 12 for translation thereof along switching axis 25.

[0052] The exemplary embodiment further includes a gas blast system 220 configured to apply a gas blast on an arc formed between first arcing contact 10 and second arcing contact 12 during a stage of a current interruption operation. Gas blast system 220 may include any suitable structure, configuration, arrangement, and/or components that enable to extinguish an electric arc between the arcing contacts. For example, but not limited to, gas blast system 220 may include appropriate valves, blast pistons, nozzles, arc heaters, or pressure chambers for the self-blast volume and/or for the compression volume. Further elements from known gas blasts systems with which a person of skill in the art will be familiar can be used with at least some of the embodiments described herein without this being described in more detail here. Typically, the gas blasted by gas blast system 220 is any suitable gas that enables to adequately extinguish the electric arc formed between the arcing contacts during a current interruption operation, such as, but not limited, to an inert gas as, for example, sulphur hexafluoride.

[0053] In the exemplary embodiment, circuit breaker 200 includes rated current contact pieces (not illustrated in Fig. 1), so that circuit breaker 200 can be configured to establish a rated current path between first breaker contact 132 and second breaker contact 134 in a closed configuration of circuit breaker 200. In typical embodiments, the rated current path includes a rated-only current path portion. Typically, circuit breaker 200 is configured for commutating, during a current interruption operation, an interruption current from the rated-only current path portion to an interruption current path portion being different from the rated-only current path portion. Typically, this portion of the interruption current path is formed at least between second arcing contact 12 and contact rod 20, such that an interruption current flows between first and second breaker contacts, being carried by contact rod 20 and being transferred from movable

contact rod 20 to the stationary part of the current path through contact arrangement 30. Such a rated-only current path is further illustrated below with regard to Fig. 6.

[0054] According to certain embodiments, circuit breaker 200 includes a disconnectable rated current path between first breaker contact 132 and second breaker contact 134, which rated current path is different from the disconnectable arc interruption current path in at least that pole contact arrangement 60 does not participate in the disconnectable rated current path (i.e., does not form part of the disconnectable rated current path). Typically, the commutation of current is realized by electrically interconnecting the rated current path and the interruption current path in a manner such that when the rated current path is disconnected, typically by separating two rated current contacts, the current originated by a voltage difference between the breaker contact flows through the interruption current path. In these embodiments, the resistivity of the elements forming the rated current path and the interruption current path are chosen in a manner such that when circuit breaker 200 is in a closed position (i.e., both current paths are connected), current substantially only flows through the rated current path.

[0055] Circuit breaker 200 may include, in addition to the elements described above, other further components, such as, but not limited to auxiliary chambers, controllers, cable supports, or any other element which enables circuit breaker 200 to function as desired in a particular application thereof.

[0056] During normal operation, the exemplary circuit breaker 200 shown in Fig. 1 is typically in a closed state. In the closed state, both the rated and the interruption current paths are connected. In certain embodiments, both current paths electrically interconnect the breaker contacts in a closed position of circuit breaker 200. In such embodiments, the rated current path constitutes the current path interconnecting the breaker contacts with a lower resistance, so that a rated current flowing between the breaker contacts is carried by the rated current path. In typical embodiments, when a fault condition of the protected circuit is detected, a control system (not shown) operatively coupled to circuit breaker 200 operates a current interruption mechanism for performing a current interruption operation, in which the current flowing between first breaker contact 132 and second breaker contact 134 is interrupted. The fault condition is detected by any suitable structure, configuration, arrangement, and/or components such as, but not limited to, a pilot device which is configured to sense a fault current in the protected circuit.

[0057] In a first phase of the current interruption operation, the exemplary circuit breaker 200 commutes the current flowing between first breaker contact 132 and second breaker contact 134 from the rated-only current path portion to a portion of the interruption current path. Typically, this commutation is performed by opening the rated current contacts by actuating the rated current path pieces through a gear system. In certain embodiments,

the rated current path pieces are coupled to contact rod 20 in a manner such that the rated current path pieces and contact rod 20 are both actuated by the same gear system 105. In particular, the rated current path pieces may comprise a contact piece, such as a cylinder, rigidly coupled to contact rod 20 and movable therewith. Such contact piece may form a sliding contact with a complementary piece. This sliding contact is typically configured for being opened upon translation of contact rod 20, and consequently of the coupled contact piece, along switching axis 25 thereby disconnecting the rated current path. In such embodiments, first arcing contact 10 and second arcing contact 12 are disposed for still being in contact when the rated current path has been disconnected. Thereby, the rated current path is disconnected while the interruption path is still closed, so that the current flowing through circuit breaker 200 is commutated to the interruption current path, in particular to contact rod 20.

[0058] As set forth above, it is typical that the interruption current path portion between the moving element (i.e., contact rod 20) and first breaker contact 132 is continuously maintained through contact arrangement 60 upon translation of contact rod 20. Thereby, the interruption current is maintained between the breaker contacts during the current interruption operation. In a further phase of the current interruption operation, the interruption current path is disconnected by separating the arcing contacts through translation of contact rod 20 along switching axis 25. After contact separation, the interruption current is typically carried by an electrical arc formed between first arcing contact 10 and second arcing contact 12, this current being further carried by contact rod 20 and contact arrangement 60.

[0059] In a further phase, the formed electrical arc is extended in the direction of switching axis 25 by increasing the separation of the arcing contact through a further translation of contact rod 20. In the exemplary embodiment, gas blast system 220 is then operated for generating an increase of pressure of the extinguishing gas in interrupting chamber 27. Depending on the embodiment of the circuit breaker this increase of pressure of the extinguishing gas is performed by a combination of opening and closing valves, and/or compression pistons or by the circuit breaker being a self-blast circuit breaker. Furthermore, circuit breaker 200 is typically configured in a manner such that the formed electrical arc heats the extinguishing gas, thereby increasing the gas pressure. When the gas pressure reaches a sufficient intensity, the electric arc is cooled and quenched until the current is interrupted.

[0060] During all the phases above, the continuous contact of first contact portion 55 and mating contact portion 90 in contact arrangement 60 facilitates a current transfer from the moving contact rod 20 to the stationary first breaker contact 132. Since the contact area between first contact portion 55 and mating contact portion 90 is not limited by the geometry and dimensions of cylindrical portion 22, this current transfer can be performed by the

flow of an adequate current intensity, so that the interruption current can be adequately transferred between first contact portion 55 and mating contact portion 90 during the current interruption operation. Furthermore, a circuit breaker 200 according to embodiments of the present disclosure facilitates the design of a contact arrangement 60 for limiting electro-mechanical friction between the first contact portion 55 and the mating contact portion 90 during the current interruption operation.

[0061] Fig. 2 schematically shows a cross-sectional view of a portion of another exemplary gas-insulated high-voltage circuit breaker 200. According to certain embodiment, and as illustrated in the exemplary contact rod 20 of Fig. 2, first contact portion 55 is formed as at least two contact blades 55A 55B symmetrically distributed with respect to the longitudinal axis of cylindrical portion 22. In the exemplary contact rod 20, its longitudinal axis is coincident with switching axis 25 when disposed in a circuit breaker. Each contact blade 55A 55B is rigidly and electrically connected to cylindrical portion 22 through a respective lateral protrusion 30A and 30B. In the exemplary embodiment, contact blades 55A 55B and the respective lateral protrusions are axis-symmetrically distributed about the longitudinal axis of cylindrical portion 22.

[0062] In the exemplary embodiment, contact arrangement 60 is formed by contact blades 55A 55B and two mating contact portions 90A 90B, each of mating contact portions 90A 90B being formed complementary to a respective blade. Thereby, contact arrangement 60 is formed by two sliding contacts axis-symmetrically disposed about switching axis 25. By providing multiple contact blades in first contact arrangement 55, a higher contact area for transferring the interruption current between contact rod 20 and the corresponding breaker contact is facilitated. Furthermore, as shown in the exemplary embodiment, the interruption current flowing through contact rod 20 is typically symmetrically distributed about the longitudinal axis of cylindrical axis 25. Thereby, it is further facilitated that the intensity of the current being transferred between the contact blades and the mating contact portion is kept low.

[0063] According to certain embodiments, as shown in Figs. 2 to 11, contact rod 20 comprises a plurality of lateral protrusions 30. In such embodiments, the interruption current can flow from cylindrical portion 20 to first contact portion 55 through multiple, spatially separated, current paths. Thereby, a higher current transmission capacity of contact rod 20 is typically facilitated. Such multiple lateral protrusions may be arranged to allow placement of other devices, such as a gear system, adjacent to cylindrical portion 20. Thereby, a particularly compact design of circuit breaker 200 is facilitated. Such multiple lateral protrusions enable a design of contact rod 20 with a symmetric current distribution, as detailed below.

[0064] According to certain embodiments, first contact portion 55 is formed by a plurality of separate contact sub-portions 55A 55B. In such embodiments, it is typical

that each of contact sub-portions 55A 55B is rigidly and electrically connected to cylindrical portion 22 via at least one of a plurality of lateral protrusions 30. Thereby, a higher surface area for transferring the interruption current from first contact portion 55 to mating contact 90, typically formed as a stationary contact, is facilitated. Consequently, such embodiments typically facilitate a low density of the current transferred from the moving contact portion to the stationary contact portion, so that electro-mechanical friction can be kept low.

[0065] Fig. 3 schematically shows a cross-sectional view of the portion of exemplary gas-insulated high-voltage circuit breaker 200 of Fig. 2 along line A-A. For the sake of clarity the cross-section has not been hatched although it is a cross-sectional view. According to certain embodiments, and as illustrated by the exemplary contact rod 20 in Fig. 3, a pole-contact surface 57 of contact portion 55 includes at least two, mutually opposing, pole-contact sub-surfaces formed substantially parallel to each other. In the exemplary embodiment, each contact blade 55A 55B comprises respective pairs of mutually opposing pole-contact sub-surfaces 57A-57A' 57B-57B', which surfaces extend in the direction of switching axis 25. Typically, as illustrated in the exemplary embodiment, the pole-contact surfaces extend substantially parallel to switching axis 25. In the exemplary embodiment, the pole-contact surfaces are continuously mechanically and electrically contacted to mating contact portions 90A 90B. This mechanical and electrical contact is constituted as a sliding contact which is maintained during a current interruption operation in which contact rod 20 is moved along switching axis 25.

[0066] According to certain embodiments, mating contact portion 90 is arranged complementary to mutually opposing pole-contact sub-surfaces of first contact portion 55 for establishing a mechanical and electrical contact therewith and, typically, for maintaining this contact upon translation of contact rod 20. In the exemplary embodiment, each mating contact portion 90A 90B includes a respective pair of contact elements 92A-92A' 92B-92B'. Typically, each of these pairs is arranged complementary to corresponding pole-contact sub-surfaces 57A-57A' 57B-57B'. Typically, contact elements 92A-92A' 92B-92B' are constituted as complementary spring finger contacts. In the exemplary embodiment, contact elements 92A-92A' 92B-92B' of each pair are configured to exert mutually opposing mechanical loading forces on blades 55A 55B, so that each spring finger contact continuously contacts a respective pole contact surfaces. Thereby, a stable and continuous electrical contact between the mating contacts and the respective blades is facilitated, in particular when contact member 20 is moved along switching axis 25 during a current interruption operation.

[0067] In the exemplary embodiment, a gear system 105 is operatively coupled to contact rod 20. Gear system 105 is configured to move contact rod 20 along switching axis 25 during a current interruption operation. As illustrated in Figs. 3 and 5, at least a portion of gear system

105 may be arranged in a free volume 16 formed between a portion of contact rod 20 and first contact portion 55. Thereby, a particular compact design of circuit breaker 200 is facilitated. In the particular embodiment, gear system 105 is disposed in a free volume between contact blades 55A, 55B and cylindrical portion 22. Gear system 105 includes a drive 105 fixed to a stationary part (not shown) of circuit breaker 200 and a set of drives 110 operatively coupling drive 105 to contact rod 20 for translation thereof along switching axis 25, so that the current interruption path can be disconnected.

[0068] Fig. 4 schematically shows a cross-sectional view of a portion of yet another exemplary gas-insulated high-voltage circuit breaker 200. Fig. 5 shows a cross-sectional view of the exemplary circuit breaker 200. Again, for the sake of clarity the cross-section has not been hatched although it is a cross-sectional view. In certain embodiments, as shown in Figs. 4 and 5, first contact portion 55 is formed as an integrally single portion and is rigidly and electrically connected to cylindrical portion 22 via a plurality of lateral protrusions 30. In the exemplary embodiment, first contact portion 55 is formed cylindrically and concentrically to the longitudinal axis of cylindrical portion 22 (in this embodiment, arranged coincident with switching axis 25). First contact portion 55 is rigidly and electrically connected to cylindrical portion 22 via two lateral protrusions 30A and 30B formed as branches of cylindrical portion 22. In alternative embodiments, the lateral protrusions may further extend along the longitudinal axis of cylindrical portion 22. Thereby, it is typically facilitated a higher mechanical strength and current capacity of contact rod 20. In alternative embodiments, first contact portion 55 may be connected to cylindrical portion 22 via three or more lateral protrusions, so that a higher mechanical strength and current capacity of contact rod 20 is facilitated.

[0069] In the exemplary embodiment, a mating contact portion 90 is formed complementary to a portion of the outer surface of first contact portion 90. In alternative embodiments, mating contact portion 90 is formed surrounding and partially or completely covering the outer surface of mating contact portion 90. A gear system 105 operatively coupled to contact rod 20 may be disposed, at least partially, within a free volume 16 formed between cylindrical portion 22 and first contact portion 55.

[0070] According to certain embodiments, mating contact portion 90 is formed by a plurality of contact fingers arranged complementary to first contact portion 55 for establishing a mechanical and electrical contact therewith. Fig. 6 schematically shows a cross-sectional view of a portion of a further exemplary gas-insulated high-voltage circuit breaker 200 which illustrates a plurality of contact fingers 120 forming part of mating contact portions 90A 90B. In the exemplary embodiment, contact fingers are constituted as a plurality of elongated contact elements arranged complementary to a respective contact blade 55A 55B. Typically, contact fingers 120 have a length-to-width ration of at least 3 to 2. Typically, mating

contact portion 90A 90B includes at least one further plurality of contact fingers (not shown) arranged at the other side of a respective contact blade 55A 55B, so that two set of contact fingers are arranged complementary to the respective contact blade 55A 55B and symmetrically with respect to an axial plane thereof.

[0071] In the exemplary embodiment, each of the contact fingers is spring-loaded against a corresponding surface of the respective contact blade 55A 55B. Thereby, contact fingers 120 establish a mechanical and electrical contact with contact blades 55A 55B. Typically, contact fingers 120 are arranged complementary to blades 55A 55B, so that a contact there-between is maintained upon translation of contact rod along switching axis 25 during a current interruption operation. For example, in the exemplary embodiment, the longitudinal axis of contact fingers 120 is disposed parallel to switching axis 25 and aligned with a longitudinal axis of blades 55A 55B.

[0072] The exemplary contact breaker 200 includes a first rated current contact piece 136 associated to first breaker contact 132 and a second rated current contact piece 138 associated to second breaker contact 134. At least one of rated current contact pieces 136 138 is disposed movable for separating a rated current contact formed between both contact pieces. Thereby, rated current contact pieces 136 138 of the exemplary circuit breaker 200 constitute a portion of the disconnectable rated current path detailed above. Rated current pieces 136 138 are typically constituted having a lower resistivity than the disconnectable interruption current path. Thereby, when circuit breaker 200 is in a closed position (i.e., as shown in Fig. 6), pole contact arrangement 60 does not participate in the disconnectable rated current path. In the exemplary embodiment, during a current interruption operation, rated current pieces are firstly separated for disconnecting the rated current path, so that the current flowing between breaker contacts 132 134 automatically commutates to the interruption current path. Thereby, the interruption current path leads through the arcing contacts 12, 10, the contact rod 20, and the contact arrangements 60A and 60B.

[0073] In the exemplary embodiment, the contact rod is coupled, electrically isolated, to a guiding element 14, and a capsule 112 for guiding translation of contact rod 20 during a current interruption operation. Guiding element 14 is disposed encapsulating a section of cylindrical portion 22. Capsule 112 is disposed encapsulating another section of cylindrical portion 22, from which section two lateral protrusions 30A 30B branch out. Typically, capsule 112 is constituted in a manner such that it does not interfere with a lateral protrusion of contact rod 20 upon translation thereof. In the exemplary embodiment, capsule 112 is provided with two lateral elongated gaps 116A, 116B along which lateral protrusions 30A, 30B are displaced upon translation of contact rod 20 during a current interruption operation. Such guiding element 14 and/or capsule 112 facilitate mechanical stability of circuit breaker 200 and reproducibility of the translation of con-

tact rod 20 along switching axis 25.

[0074] Figs. 7 and 9, and their respective cross-sections in Figs. 8 and 9, schematically show a portion of a still further exemplary gas-insulated high-voltage circuit breaker 200 in a closed position (Figs. 7 and 8) and in an open position (Figs. 9 and 10). The exemplary contact rod 20 is encapsulated by a capsule 112. In the exemplary contact rod 20 two lateral protrusions 30A, 30B extend symmetrically opposed to switching axis 25. Each lateral protrusion extends through a respective elongated gap 116A, 116B. Elongated gaps 116A, 116B extend in the direction of switching axis 25, so that capsule 112 does not interfere with lateral protrusions 30A 30B upon translation of contact rod 20.

[0075] The exemplary embodiment further includes a gear system 105, which is driven by a drive 107. Drive 107 is rigidly coupled to capsule 112 through an attaching element 109. Gear system 105 includes a set of gear elements coupled to contact rod 20 and operatively associated to drive 107 for actuation of contact rod 20 during a current interruption operation. In the exemplary embodiment, gear system 105 is compactly disposed in the proximity of capsule 112. Lateral protrusions 30A 30B enable to dispose contact blades 55A and 55B away of gear system 105 and without interfering therewith. Thereby, the contact area for transferring the current from a moving element of circuit breaker 200, to a stationary part thereof, is not limited by the spatial arrangement of other elements of circuit breaker 200, such as, in this case, gear system 105 or capsule 112.

[0076] As mentioned above, first contact portion 55 may be formed as a plurality of contact blades symmetrically distributed with respect to the longitudinal axis of cylindrical portion 22. Fig. 11 and the cross section in Fig. 12 exemplarily illustrate such an embodiment. In the exemplary embodiment, contact rod 20 comprises four contact blades 55A to 55D symmetrically disposed about the longitudinal axis of cylindrical portion 22. Each contact blade 55A to 55D is rigidly and electrically connected to cylindrical portion 22 through a respective connecting portion 30A to 30D. Contact rod 20 may include any number of contact blades, such as, three, five or six. Thereby, the contact area for transferring an interruption current can be further extended. Furthermore, by a symmetrical disposition of the contact blades, a symmetrical distribution of the interruption current being transferred from contact rod 20 to the corresponding breaker contact is facilitated. Thereby, it is avoided the generation of a too high electro-mechanical stress in the contact arrangement for transferring the interruption current. For the sake of clarity the cross-section has not been hatched although it is a cross-sectional view of fig. 12.

[0077] Embodiments according to the present disclosure include a gas-insulated high-voltage circuit breaker for interrupting a current between a first breaker contact and a second breaker contact in an arc interruption current path other than the rated current path. For that purpose, an elongated contact rod is provided that compris-

es at least one lateral protrusion extending in a radial direction away from a switching axis and being arranged in between a first contact portion and a cylindrical portion of the contact rod such that the first contact portion is rigidly and electrically and mechanically rigidly connected to the cylindrical portion via the at least one lateral protrusion. The first contact portion engages with a mating contact portion of the first breaker contact such that the elongated contact rod is continuously electrically contacted to the first breaker contact.

[0078] Embodiments of the present disclosure also include the use of a contact rod according to the description above in a circuit breaker. Furthermore, embodiments of the present disclosure also include the use of a circuit breaker according to the description above for interrupting the current in a circuit.

[0079] Exemplary embodiments of systems and methods for a circuit breaker are described above in detail. The systems and methods are not limited to the specific embodiments described herein, but rather, components of the systems and/or steps of the methods may be utilized independently and separately from other components and/or steps described herein, and are not limited to practice with only a circuit breaker as described herein. Rather, the exemplary embodiments can be implemented and utilized in connection with many other circuit breaker applications.

[0080] Although specific features of various embodiments of the invention may be shown in some drawings and not in others, this is for convenience only. In accordance with the principles of the invention, any feature of a drawing may be referenced and/or claimed in combination with any feature of any other drawing. In particular, Fig. 1 illustrates different aspects which may be combined with other general aspects of the present disclosure.

[0081] This written description uses examples to disclose the invention, including the best mode, and also to enable any person skilled in the art to practice the invention, including making and using any devices or systems and performing any incorporated methods. While various specific embodiments have been disclosed in the foregoing, those skilled in the art will recognize that the spirit and scope of the claims allows for equally effective modifications. Especially, mutually non-exclusive features of the embodiments described above may be combined with each other. The patentable scope of the invention is defined by the claims, and may include other examples that occur to those skilled in the art. Such other examples are intended to be within the scope of the claims if they have structural elements that do not differ from the literal language of the claims, or if they include equivalent structural elements with insubstantial differences from the literal language of the claims.

Claims

1. A gas-insulated high-voltage circuit breaker (200) for interrupting a current between a first breaker contact (132) and a second breaker contact (134), the circuit breaker having a disconnectable arc interruption current path between the first breaker contact (132) and the second breaker contact (134), wherein a portion of the disconnectable arc interruption current path leads from a second arcing contact (12) through a first arcing contact (10) of an elongated contact rod (20) and via a pole contact arrangement (60) to the first breaker contact (132), wherein the contact rod (20) comprises a substantially cylindrical portion (22) extending in a direction of a switching axis (25), and wherein the pole contact arrangement (60) is formed by a first contact portion (55) of the contact rod (20) and a mating contact portion (90) of the first breaker contact (132), and the pole contact arrangement (60) is configured such that the first contact portion is continuously electrically contacted to the mating contact portion (90), wherein the contact rod (20) comprises at least one lateral protrusion (30) extending in a radial direction away from the switching axis (25) and being arranged in between the first contact portion (55) and the cylindrical portion (22) such that the first contact portion (55) is rigidly and electrically connected to the cylindrical portion (22) via the at least one lateral protrusion (30) and such that a portion of the interruption current path leads from the cylindrical portion (22) through the at least one lateral protrusion (30) via the pole contact arrangement (60) to the first breaker contact (132).
2. The circuit breaker (200) according to claim 1, wherein the first contact portion (55) is formed substantially cylindrically asymmetrically with respect to a longitudinal axis of the cylindrical portion (22).
3. The circuit breaker (200) according to claim 1 or 2, wherein the pole contact arrangement (60) is formed as a sliding contact comprising the contact portion (55) and the mating contact portion (90).
4. The circuit breaker (200) according to any of the preceding claims, wherein the first contact portion (55) comprises a contact blade.
5. The circuit breaker (200) according to any of the preceding claims, wherein the first contact portion (55) is formed as at least two contact blades symmetrically distributed with respect to the longitudinal axis of the cylindrical portion (22).
6. The circuit breaker (200) according to any of the preceding claims, wherein the mating contact portion (90) is formed by a plurality of contact fingers (120) arranged complementary to the first contact portion (55) for establishing a mechanical and electrical contact therewith.
7. The circuit breaker (200) according to any of the preceding claims, wherein the first contact portion (55) comprises a pole-contact surface (57) extending in the direction of the switching axis (25), which pole-contact surface (57) is continuously mechanically and electrically contacted to the mating contact portion (90) during a current interruption operation in which the contact rod (20) is moved along the switching axis (25).
8. The circuit breaker (200) according to claim 7, wherein the pole-contact surface (57) extends in a direction perpendicular to the switching axis (25).
9. The circuit breaker (200) according to claim 7 or 8, wherein the pole-contact surface (57) comprises at least two, mutually opposing, pole-contact sub-surfaces (57A; 57A'; 57B; 57B') formed substantially parallel to each other.
10. The circuit breaker (200) according to any of claims 7 to 9, wherein the area of the pole-contact surface (57) is larger than at least 200 % of the cylindrical area of the segment of the cylindrical portion (22) extending along the lateral protrusion (30) in the direction of the switching axis (25).
11. The circuit breaker (200) according to any of the preceding claims, wherein the contact rod (20) comprises a plurality of the lateral protrusions (30).
12. The circuit breaker (200) according to claim 11, wherein the first contact portion (55) is formed by a plurality of separate contact sub-portions (55A; 55B), each of the contact sub-portions (55A; 55B) being rigidly and electrically connected to the cylindrical portion (22) via at least one of the plurality of the lateral protrusions (30).
13. The circuit breaker (200) according to any of the preceding claims, further comprising a gear system (105) operatively coupled to the contact rod (20) for translation thereof along the switching axis (25), at least a portion of the gear system (105) being arranged in a volume (16) formed between at least a portion of the contact rod (20) and the first contact portion (55).
14. The circuit breaker (200) according to any of the preceding claims, wherein the second arcing contact (12) is adapted for being displaced along the switching axis (25) during a current interruption operation.

15. The circuit breaker (200) according to any of the preceding claims further comprising a disconnectable rated current path between the first breaker contact (132) and the second breaker contact (134) which is different from the disconnectable arc interruption current path in at least that the pole contact arrangement (60) does not participate in the disconnectable rated current path.

5

10

15

20

25

30

35

40

45

50

55

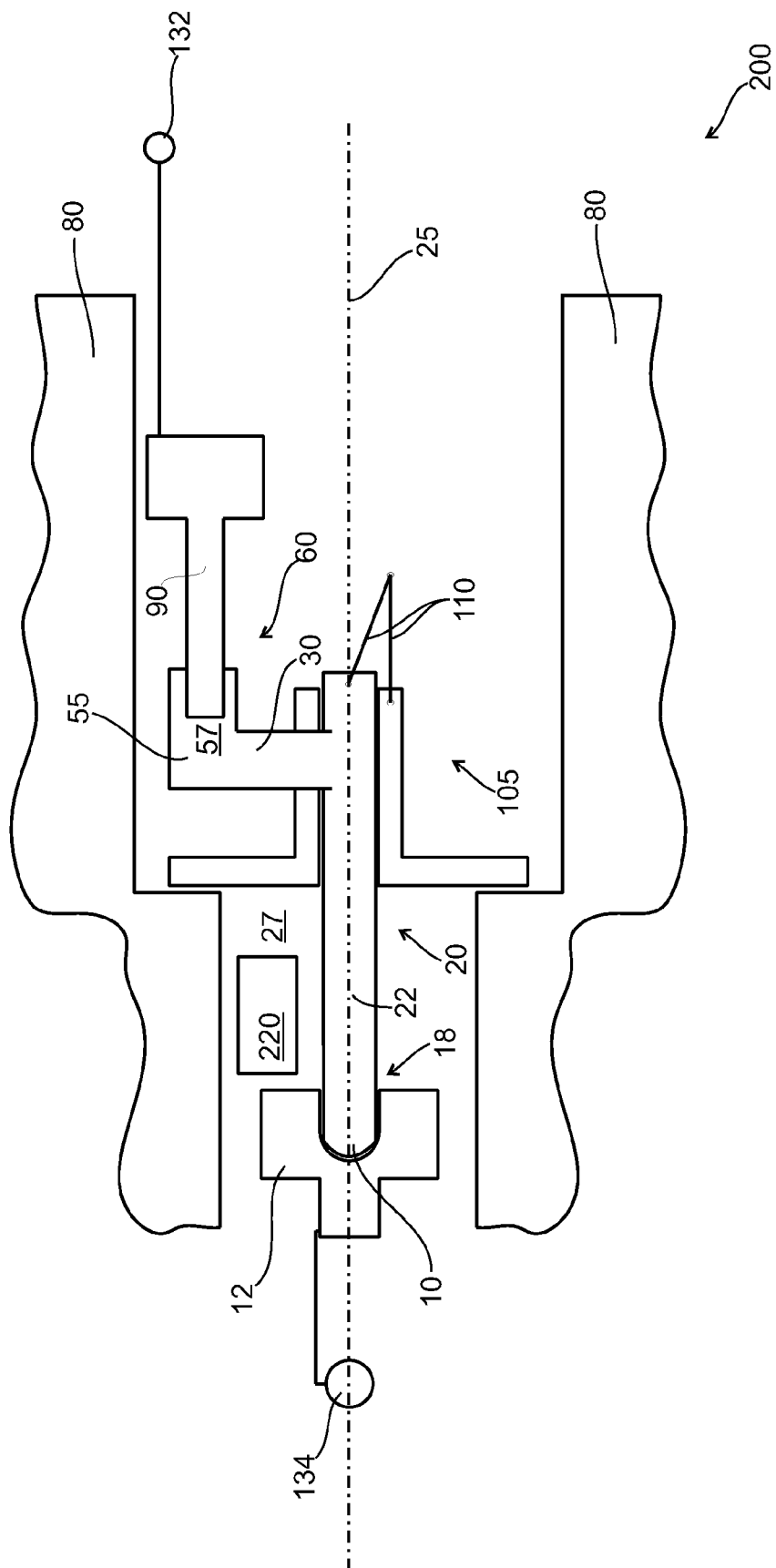


Fig.1

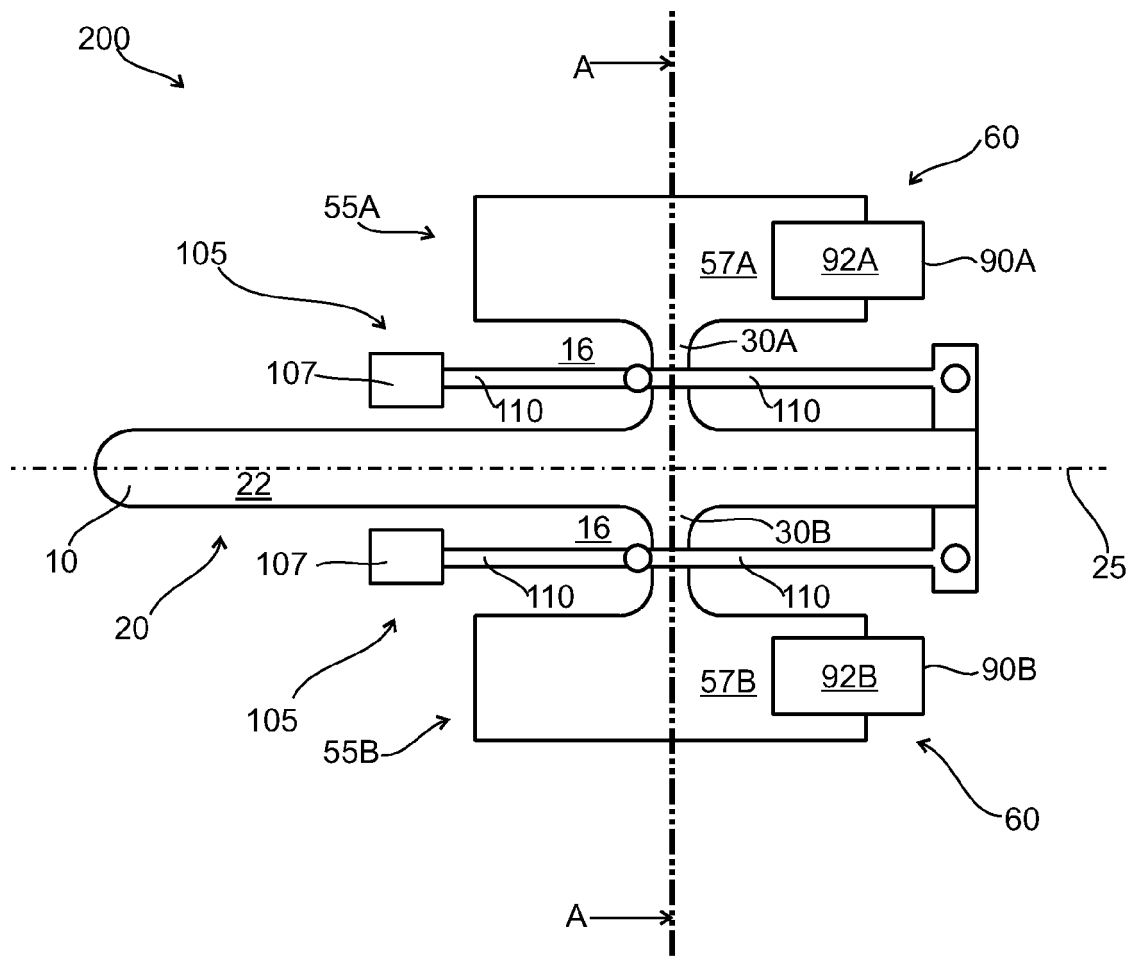


Fig.2

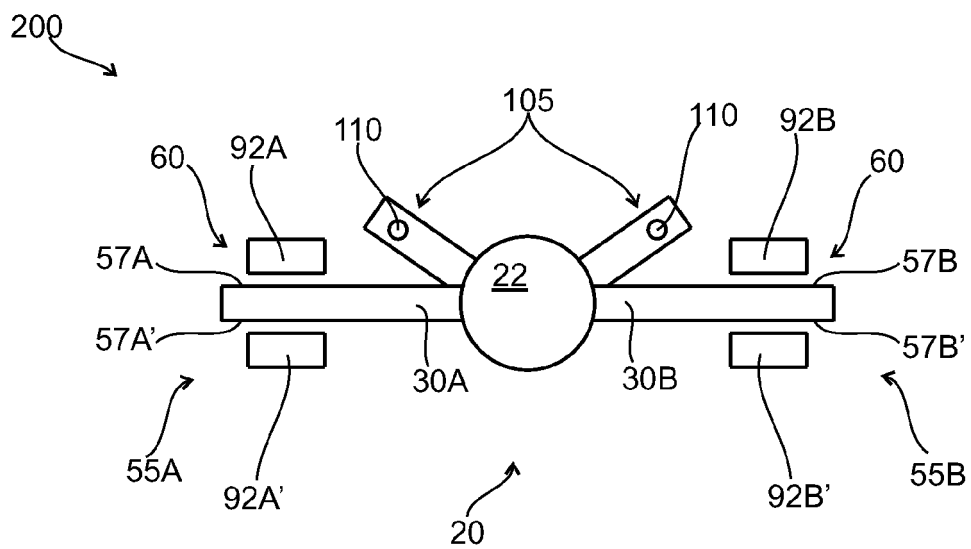


Fig.3

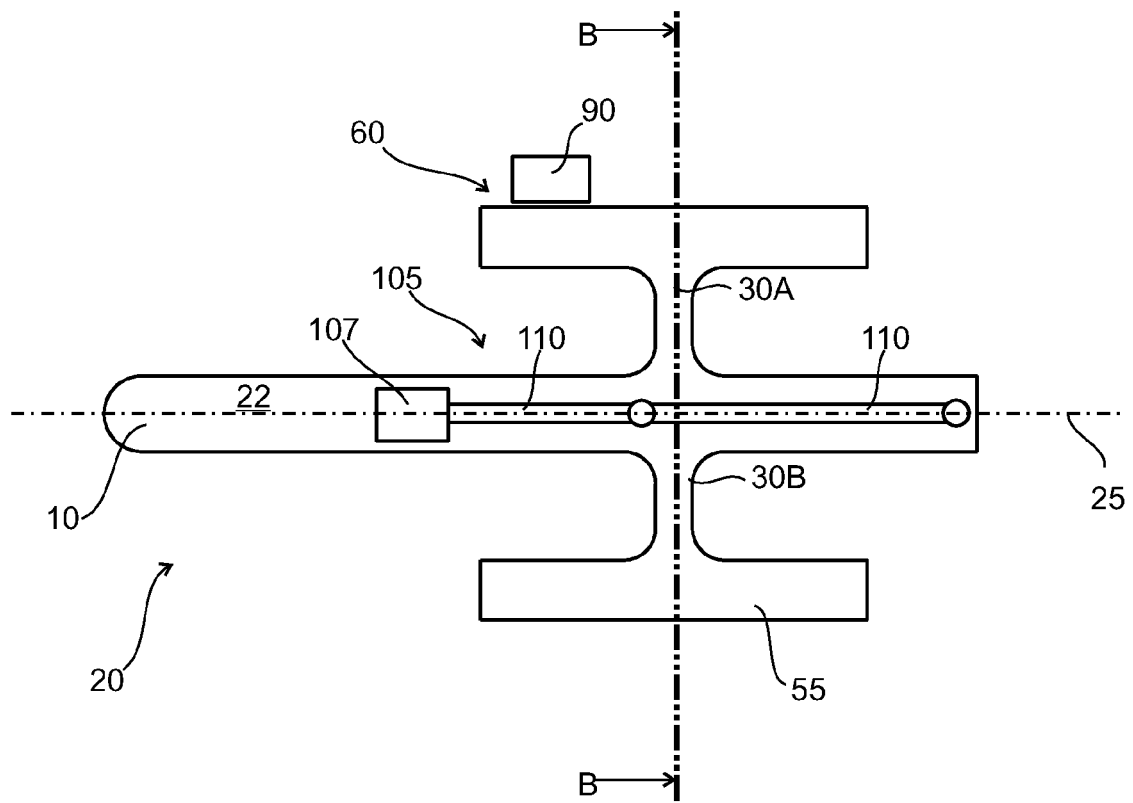


Fig.4

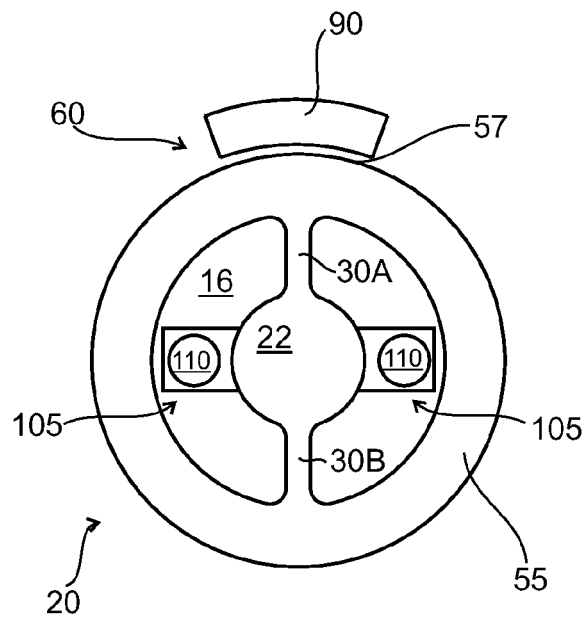


Fig.5

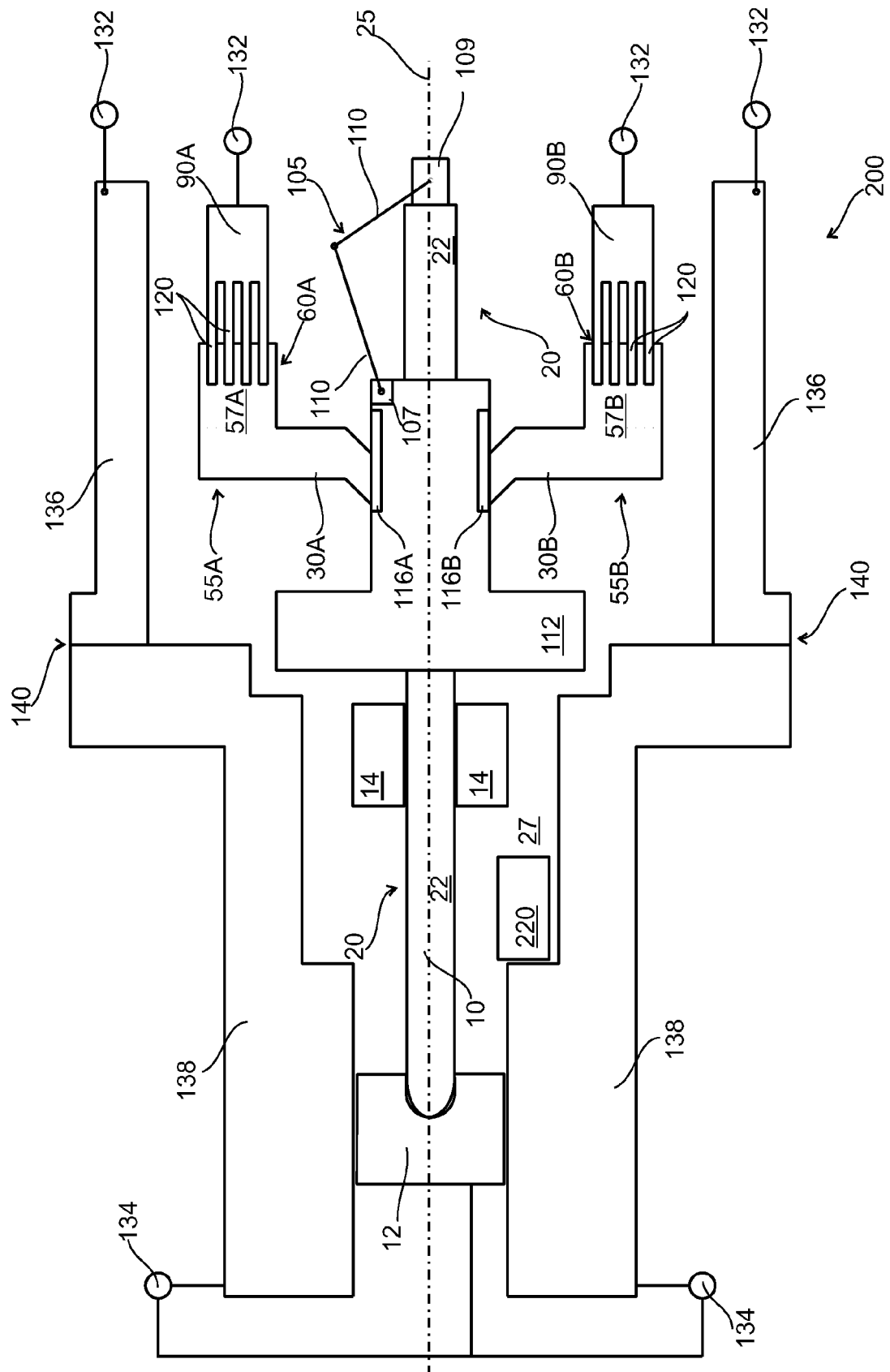


Fig. 6

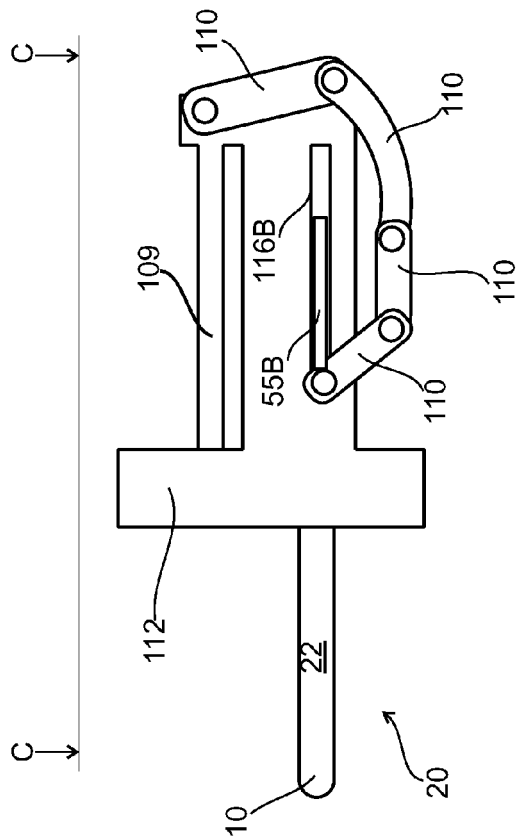


Fig. 7

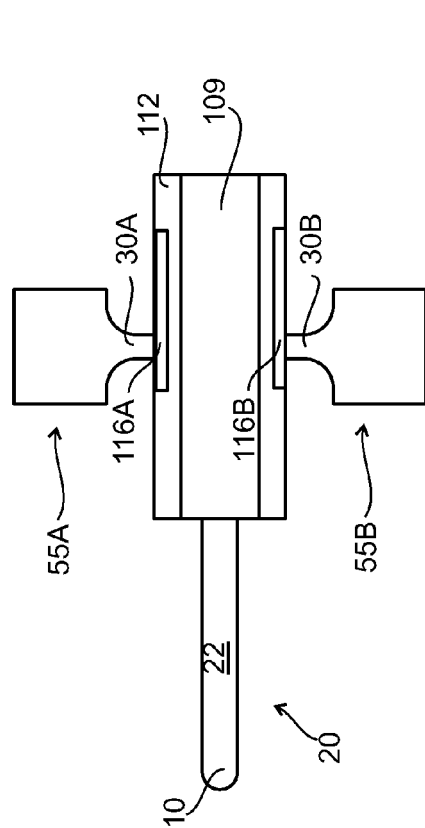


Fig. 8

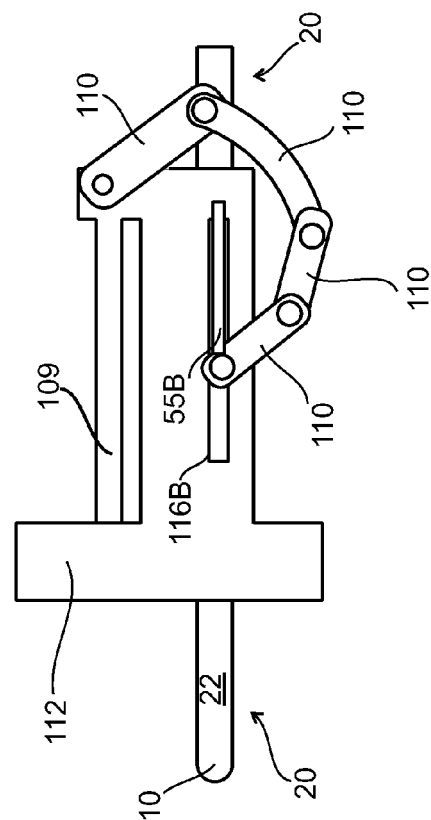


Fig. 9

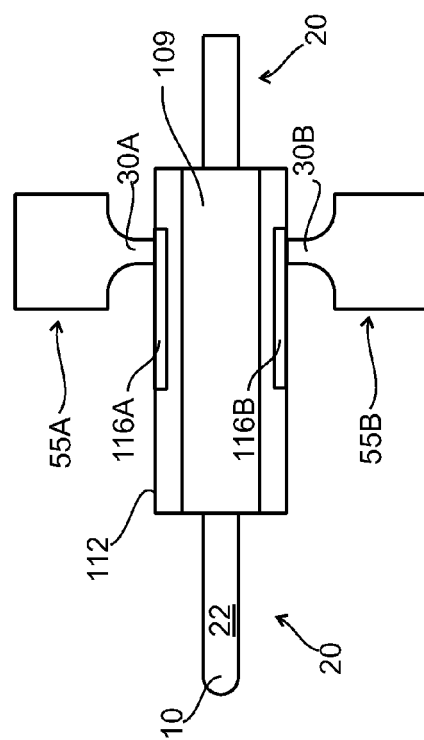


Fig. 10

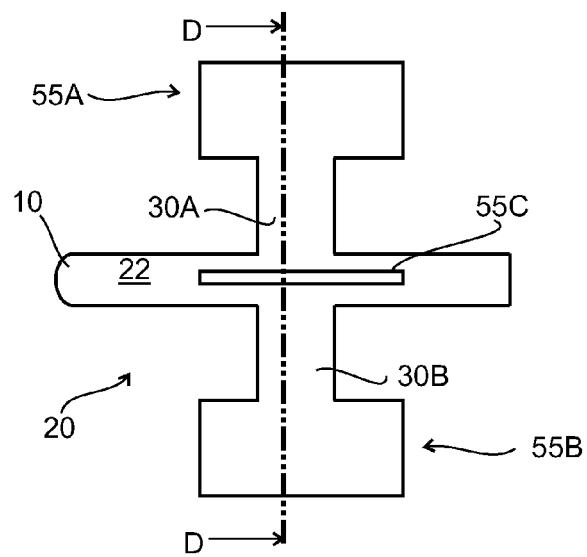


Fig.11

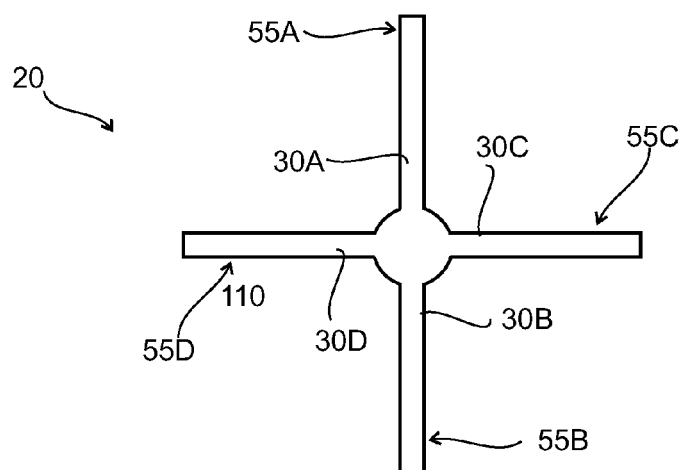


Fig.12



EUROPEAN SEARCH REPORT

Application Number
EP 10 16 5619

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	FR 2 760 126 A1 (GEC ALSTHOM T & D SA [FR]) 28 August 1998 (1998-08-28) * page 2, line 23 - page 4, line 10; figures 1-6 *	1-15	INV. H01H1/58 H01H33/12 H01H1/38
A	US 3 930 709 A (STANGER ROBERT J ET AL) 6 January 1976 (1976-01-06) * column 4, line 23 - column 5, line 23; figures 1,3 *	1	
A	FR 2 478 866 A1 (MERLIN GERIN [FR]) 25 September 1981 (1981-09-25) * page 5, lines 1-21; figure 1 *	1	
A	DE 91 07 208 U1 (SIEMENS AG) 8 August 1991 (1991-08-08) * page 4, line 16 - page 5, line 14; figure 1 *	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 19 November 2010	Examiner Findeli, Luc
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

2
EPO FORM 1503 (03.82 (P04C01))

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 10 16 5619

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.

19-11-2010

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
FR 2760126	A1	28-08-1998	NONE	

US 3930709	A	06-01-1976	BE 839341 A1	09-09-1976
			BR 7601394 A	14-09-1976
			CA 1080315 A1	24-06-1980
			DE 2608955 A1	30-09-1976
			FR 2304197 A1	08-10-1976
			GB 1515995 A	28-06-1978
			JP 51114694 A	08-10-1976
			JP 61013481 U	25-01-1986
			JP 63005190 Y2	12-02-1988

FR 2478866	A1	25-09-1981	JP 57053028 A	29-03-1982

DE 9107208	U1	08-08-1991	NONE	
