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- **Carstensen, Jan**
79761 Waldshut/Tiengen (DE)
- **Bujotzek, Markus**
8050 Zurich (CH)
- **Over, Daniel**
5313 Klingnau (CH)
- **Schwinne, Michael**
5420 Ehrendingen (CH)

(71) Applicant: **ABB Schweiz AG**
5400 Baden (CH)

(74) Representative: **Zimmermann & Partner**
Patentanwälte mbB
Postfach 330 920
80069 München (DE)

(72) Inventors:
 • **RANJAN, Nitesh**
5443 Niederrohrdorf (CH)

(54) **GAS-INSULATED LOW- OR MEDIUM-VOLTAGE LOAD BREAK SWITCH**

(57) The load break switch (1) comprises a housing (2) defining a housing volume for holding an insulation gas; a movable contact (20) and a fixed contact (10) arranged within the housing volume, the movable contact (20) being movable in relation to the fixed contact (10) along an arcuate trajectory (A) of movement and defining an arcing region (52) in which an arc is formed during an opening operation of the switch (1); a pressurizing system (40, 41), actuated by a movement of the movable contact (20) during opening of the switch (1), for pressurizing the insulation gas; a nozzle (30), the nozzle being arranged within the housing volume and being fixed to the movable contact (20) and/or defining a contacting part (20, 24) of the movable contact (20), wherein the nozzle (30) is adapted to blow the pressurized insulation gas into the arcing region (52) substantially tangentially to the arcuate trajectory (A).

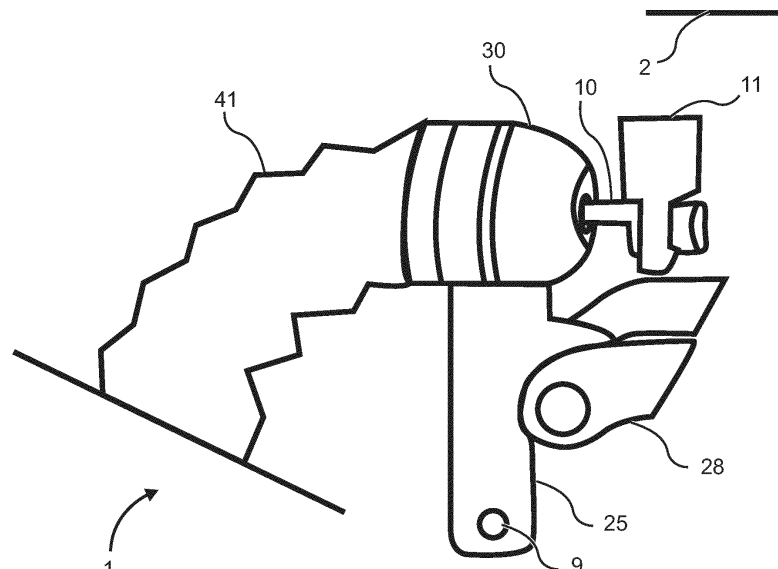


Fig. 3

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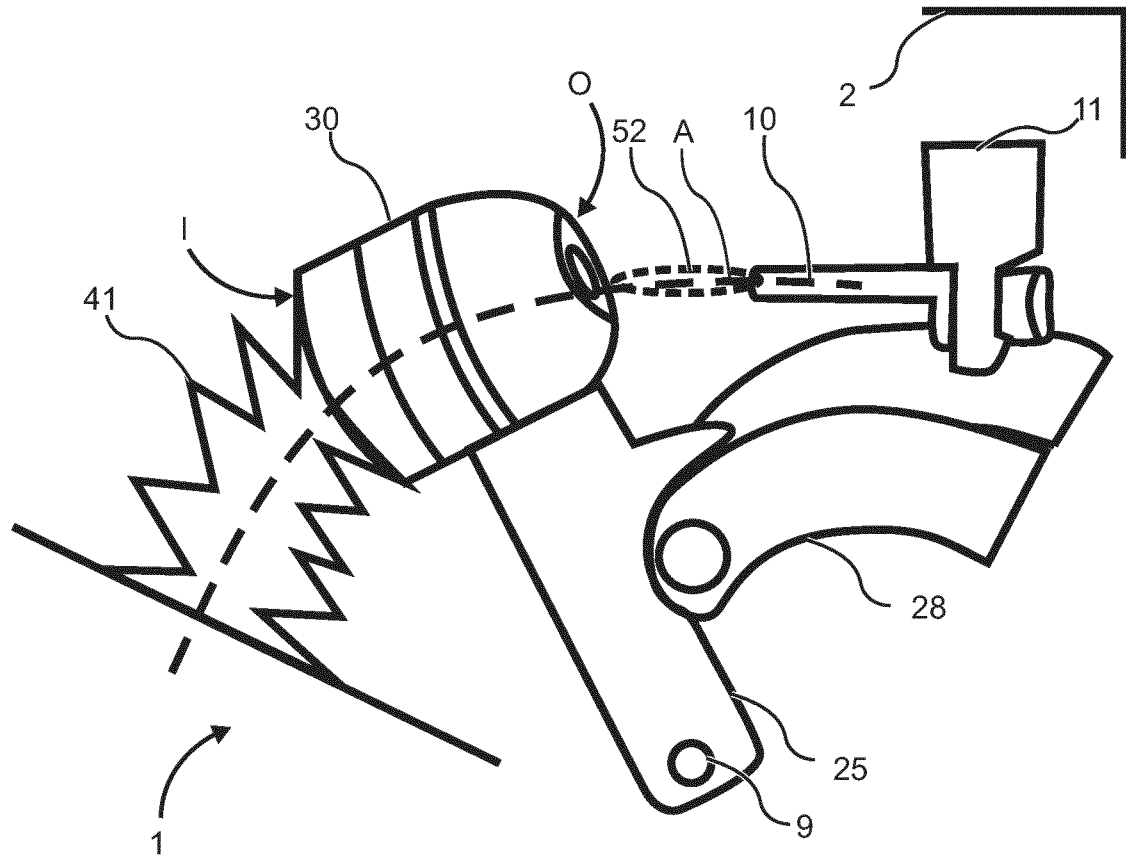


Fig. 4

Description

TECHNICAL FIELD

[0001] The present disclosure generally relates to a gas-insulated low- or medium-voltage load break switch with an arc-extinguishing capability. It further relates to a secondary distribution gas-insulated switchgear having a load break switch, and to the use of a load break switch in a secondary distribution gas-insulated switchgear.

BACKGROUND ART

[0002] Secondary switchgears having a housing that is filled with an insulation gas are generally known as secondary distribution gas-insulated switchgears (Gsec). In a Gsec, a load break switch is arranged and used to interrupt load currents in a typical range of 200-800 A (rms) and at a voltage ranging from 12-24 kV. A typical load break switch in a Gsec is a three-position switch that can be switched from a closed (line) position to an open (floating) position to an earthing position, and vice-versa. Typically, Gsecs are applied in supplying lines, as a transformer protection (in combination with a fuse or a circuit breaker) and/or ring networks.

[0003] Traditional Gsecs are filled with SF₆ as an insulation gas. A traditional load break switch uses a knife switch, wherein a knife moves through a splitter plate arrangement from the closed position of the switch to the open position of the switch. When interrupting a large current, e. g. a current in the range discussed above at the voltages discussed above, an arc is established between the stationary contact and the moving knife. Due to the magnetic forces within the arrangement, the arc moves to an area between the splitter plates. The arc is mainly extinguished by the geometrical properties of the splitter plates in combination with the arc quenching properties of the SF₆ gas.

[0004] The traditional knife switch is relatively compact, as the knife is moved in an arcuate manner. With the arcuate movement, the three-position configuration is easy to achieve. However, the compact size and easy arrangement rely on the arc quenching properties of SF₆ as the insulation gas. The environmental impact of SF₆ is high, and efforts are made to replace SF₆ with alternative gases in combination with a background gas, such as, but not limited to, air, dry air, CO₂, CO₂ and O₂, etc.

[0005] It is generally known to use a puffer mechanism to cool and extinguish an arc in a high-voltage circuit breaker. Circuit breakers are employed to interrupt short-circuit currents in a range of tens of kA and voltages above 52 kV. As such, circuit breakers have an extinguishing-gas pressurizing system including a pressurization chamber or a self-blasting heating chamber. Typically, in circuit breakers, the arc-blowing gas is accelerated to a velocity above the speed of sound. Circuit breakers generally employ contacts moving along a straight, linear axis.

[0006] Circuit breakers are different from load break switches, as discussed herein. Load break switches are designed for distributing electric energy at relatively low currents of several hundreds of amperes and at voltages up to, for example, 36 kV or up to 24 kV or up to 12 kV. A load break switch can safely switch off (only) nominal load currents, typically of at most 2 kA. However, in contrast to circuit breakers, load break switches are generally not designed to interrupt short-circuit currents.

[0007] CN 105 448 589 A describes a pressure load switch having a nozzle assembly. In this prior art, the nozzle assembly includes a rotary piston. The rotary piston is installed in a cylinder. This conventional technology has a knife-blade structure. The knife part is movable and comprises a first blade and a second blade, wherein a gap is formed between the first and second blades. The side of the first blade and the second blade has a wedge-shaped portion. A main nozzle is formed between the first blade and the second blade; a first side nozzle is formed between an outer arc surface of the wedge portion of the first blade and a first side edge; and a second side nozzle is formed between the first side of the second blade and a second side edge. When the rotary piston rotates in an opening operation, the insulation gas inside a cylinder is compressed and ejected through each of the nozzles. This conventional prior art thus distributes the compressed gas to a plurality of nozzles.

SUMMARY OF THE INVENTION

[0008] An object of the invention is to provide a gas-insulated low-voltage or medium-voltage load break switch whose arc extinction properties are improved, while maintaining to some extent a compact design and a simple arrangement.

[0009] In view of the above, a gas-insulated low- or medium-voltage load break switch according to claim 1, a secondary distribution gas-insulated switchgear according to claim 13 having the load break switch, and use of the load break switch according to claim 14 are provided. According to an aspect, a gas-insulated low-voltage or medium-voltage load break switch is provided. As defined herein, a load break switch has a capability to switch load currents, but does not have a short-circuit-current switching capability. The load currents are also referred to as rated currents or nominal currents and may for example be up to 2000 A, preferably up to 1250 A or up to 1000 A, which are typical rated currents used in distribution networks, ring main units, and in secondary distribution GIS. The rated currents may on the other hand be more than 1 A, more preferably more than 100 A, more preferably more than 400 A. In case of an AC load break switch, the rated current is herein indicated in terms of the rms current.

[0010] Herein, a low or medium voltage is defined as a voltage of up to at most 52 kV. The low- or medium-voltage load break switch therefore has a rated voltage of at most 52 kV. The rated voltage may, in particular, be

at most 52 kV, or preferred at most 36 kV, or more preferred at most 24 kV, or most preferred at most 12 kV. The voltage rating may be at least 1 kV. In an aspect of the invention, the rated voltage of the switch is at most 52 kV, preferably at most 36 kV, more preferably at most 24 kV and most preferably at most 12 kV. Alternatively or additionally, in an aspect of the invention, the load break switch is rated for switching nominal currents in a range of up to 2 kA, preferably up to 1.25 kA and more preferably up to 1 kA.

[0011] The load break switch according to the aspect comprises a housing defining a housing volume for holding an insulation gas; a movable contact and a fixed contact arranged within the housing volume, the movable contact being movable in relation to the fixed contact with an arcuate trajectory of movement and defining an arcing region in which an arc is formed during an opening operation of the switch; a pressurizing system, actuated by a movement of the movable contact during the opening operation of the switch, for pressurizing the insulation gas; and a nozzle.

[0012] The nozzle is arranged within the housing volume and is fixed to the movable contact and/or the nozzle is arranged within the housing volume and defines a contacting part of the movable contact, wherein the nozzle is adapted to blow the pressurized insulation gas into the arcing region substantially tangentially to, in particular tangentially to, or along or substantially along or at least partly along the arcuate trajectory.

[0013] The housing acts as a gas enclosure for the insulation gas. The insulation gas may be any appropriately selected insulation gas. In some aspects, the insulation gas has a global warming potential lower than the one of SF₆ (e.g. over an interval of 100 years). For example, the insulation gas comprises at least one of: air, dry air, technically dried air, N₂ and O₂, technical air, CO₂, N₂, N₂O, O₂. Preferably, the insulation gas comprises at least one background gas component selected from the group consisting of: CO₂, O₂, N₂, H₂, air, N₂O, in a mixture with a hydrocarbon or an organofluorine compound. The insulation gas may in particular comprise an organofluorine compound selected from the group consisting of: a fluoroether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin, a fluoronitrile, and mixtures and/or decomposition products thereof. In particular, the insulation gas may comprise as a hydrocarbon at least CH₄, a perfluorinated and/or partially hydrogenated organofluorine compound, and mixtures thereof. The organofluorine compound is preferably selected from the group consisting of: a fluorocarbon, a fluoroether, a fluoroamine, a fluoronitrile, and a fluoroketone; and preferably is a fluoroketone and/or a fluoroether, more preferably a perfluoroketone and/or a hydro fluoroether, more preferably a perfluoroketone having from 4 to 12 carbon atoms and even more preferably a perfluoroketone having 4, 5 or 6 carbon atoms. The insulation gas preferably comprises the fluoroketone mixed with air or an air component such as N₂, O₂, and/or CO₂.

[0014] In specific cases, the fluoronitrile mentioned above is a perfluoronitrile, in particular a perfluoronitrile containing two carbon atoms, and/or three carbon atoms, and/or four carbon atoms. More particularly, the fluoronitrile can be a perfluoroalkylnitrile, specifically perfluoroacetonitrile, perfluoropropionitrile (C₂F₅CN) and/or perfluorobutyronitrile (C₃F₇CN). Most particularly, the fluoronitrile can be perfluoroisobutyronitrile (according to formula (CF₃)₂CFCN) and/or perfluoro-2-methoxypropanenitrile (according to formula CF₃CF(OCF₃)CN). Of these, perfluoroisobutyronitrile is particularly preferred due to its low toxicity.

[0015] An arcuate trajectory of movement describes a movement trajectory that is not along a substantially straight line (i. e. not a linear trajectory) and may include, without limitation, an arcuate shape, in particular a circular arcuate shape (or ring segment shape). The arcuate trajectory of movement may be achieved by fixing the nozzle on a lever (e.g. at a first end of the lever), while a second end of the lever is rotatably fixed to a support structure. The lever may be an element of the movable contact. The rotatably fixed end (second end) of the lever may be electrically contacted to a nominal contact of the load break switch. Likewise, the fixed contact may be electrically contacted to another nominal contact of the load break switch. The nozzle may be fixed to the first end of the lever.

[0016] In some embodiments, the lever is movable between an open position and a closed position. In the closed position, an electrically conducting path is established from the rotatably fixed end of the lever, via the lever, to the fixed contact. In the open position, an electrically conducting path between the rotatably fixed end of the lever and the fixed contact is interrupted. Herein, in the open position, the electrically conducting path between the rotatably fixed end of the lever and the fixed contact is interrupted, and the switch state is a floating state.

[0017] In some embodiments, in addition to being movable between the open position and the closed position, the load break switch further comprises an earthing contact, and the lever is also movable to an earthing position. In the earthing position, an electrically conducting path is established between the rotatably fixed end of the lever and the earthing contact.

[0018] According to aspects of the invention, the nozzle is fixed to the movable contact and/or the nozzle defines a contacting part of the movable contact. By way of example, the nozzle has an internal electrically conductive element, such as a tulip contact, and a means for electrically contacting a further part of the movable contact, such as the lever described above.

[0019] According to aspects, the nozzle is adapted to blow the pressurized insulation gas into the arcing region. The gas is blown out substantially tangentially, in particular tangentially, to the movement trajectory. That is, the blown-out gas leaves the nozzle, at each instant during the movement of the movable contact, substantially tan-

gentially to the direction of movement or along the arcuate trajectory of movement.

[0020] Upon an opening operation of the load break switch, the movable contact is separated from the fixed contact by the movement along the arcuate trajectory. At rated current/rated voltage conditions, or even below, an arc is formed between the movable contact and the fixed contact. By the movement, insulation gas is compressed, or pressurized, by the pressurizing system. The compressed insulation gas is blown out of the nozzle. The blown-out gas may help to extinguish, or quench, the arc, and the current is interrupted.

[0021] Further aspects, that can be appropriately combined with each other and with the embodiments described herein, are apparent from the dependent claims and/or the description below.

[0022] According to a further aspect, the movable contact is a tulip-nozzle type contact. A tulip-nozzle type contact typically comprises an adoption part or receiving part for a rod-like or pin-like structure. The tulip-nozzle type contact of the movable contact has a contact area inside the nozzle, i. e. at the adoption or receiving part. According to the aspect, the fixed contact is a pin contact. Via the contact area, an electrical contact from the pin to the outside of the nozzle can be achieved.

[0023] In a further aspect, the contact area is bent according to the arcuate trajectory of movement, and the pin contact is likewise bent according to the arcuate trajectory of movement. This may help to achieve a smoother movement of the tulip-nozzle relative to the pin, and of the movable contact as a whole.

[0024] According to a further aspect, the pressurizing system comprises a compression cylinder. The insulation gas inside the compression cylinder is pressurized by the nozzle sliding inside the compression cylinder when the movable contact is moved during an opening operation. Preferably, the compression cylinder has a bent shape, more preferably, a bent shape according to the arcuate trajectory of movement. With the bent compression cylinder, the effective volume needed for a sufficient amount of insulation gas blown out of the nozzle can be fitted inside a compact housing, thus rendering the load break switch as a whole more compact than in the case of a linear compression cylinder.

[0025] Alternatively, the pressurizing system comprises a flexible conduit. A flexible conduit may be a flexible hose that typically has a bellow shape, but is not limited thereto. The flexible conduit is connected, typically in a gas-tight manner, to an inlet side of the nozzle. The flexible conduit is reduced in volume during the opening operation of the switch. In other words: The internal volume of the flexible conduit is reduced along with the movement operation of the movable contact during the opening operation. By reducing the internal volume, the insulation gas inside the flexible conduit is compressed, and the compressed gas flows through an inlet on the inlet side of the nozzle through the nozzle and out of an outlet on the outlet side of the nozzle.

[0026] In a further aspect, the nozzle defines a flow pattern for the pressurized insulation gas, the flow pattern including a stagnation point at which the flow essentially stops. An upstream region of the gas flow inside the nozzle flows towards the stagnation point in a predominantly radially inward direction, with "radially inward direction" being defined with respect to the axis of the nozzle. A downstream region of the gas flow inside the nozzle flows away from the stagnation point in a predominantly axial direction, with "axial direction" being defined by the axis of the nozzle. As used herein, "upstream" and "downstream" does not necessarily imply that the insulation gas has travelled through the stagnation point.

[0027] At the stagnation point, or locally around the stagnation point, the flow pattern of the pressurized gas, or quenching gas, has an essentially vanishing velocity during a steady-state flow of the quenching gas during an arc-free operation. Thus, the quenching gas flows towards the stagnation point from a predominantly radial direction with respect to the axis of the nozzle, whereby it decelerates. Then, the gas flows in a predominantly axial direction with respect to the nozzle away from the stagnation point, whereby it accelerates axially. This, and the blowing onto the arc in the axis direction, may lead to an enhanced cooling and extinguishing of the arc.

[0028] In a further aspect, the pressurizing system is configured for pressurizing the insulation gas during the opening operation from an ambient pressure p_0 to an elevated pressure p_e , wherein at least one of the following conditions is fulfilled:

$$p_e < 1.8 p_0, \text{ preferably } p_e < 1.5 p_0, \text{ more preferably } p_e < 1.3 p_0;$$

$$p_e < p_0 + 800 \text{ mbar, preferably } p_e < p_0 + 500 \text{ mbar, more preferably } p_e < p_0 + 300 \text{ mbar.}$$

[0029] In embodiments, the ambient pressure of the (bulk) insulation gas in the housing p_0 is ≤ 3 bar, more preferably $p_0 \leq 1.5$ bar, and even more preferably $p_0 \leq 1.3$ bar.

[0030] According to a further aspect, the relationship of an average cross sectional area of a gaseous or fluid connection from an inflow side of the nozzle to an outflow side of the nozzle to an averaged total cross sectional area of the nozzle is at least 0.2, preferably at least 0.3, more preferably at least 0.35. Herein, for example, the cross sectional area of the nozzle is an area of the cross section for each cross sectional plane perpendicular to an elongate axis of the nozzle; the average total cross sectional area is an average value (arithmetic average, arithmetical mean) of all these cross sections; the cross sectional area of the gaseous connection from the inflow side of the nozzle to the outflow side of the nozzle is a summarized area of the cross sections of all gaseous channels in the nozzle from the inflow side of the nozzle to the outflow side of the nozzle for each cross sectional plane perpendicular to the axis or elongate axis or flow

axis of the nozzle; and the average cross sectional area of the gaseous connection is an average value (arithmetic average, arithmetical mean) of all these cross sections. A sufficiently large cross section area may help to minimize the pressure losses, whereby simpler pressure conditions can be achieved.

[0031] According to a further aspect, the load break switch is not a circuit breaker, in particular not a circuit breaker for high voltages above 52 kV; and/or wherein the pressurizing system is devoid of a heating chamber for providing a self-blasting effect.

[0032] In high-voltage circuit breakers (buffer type and self-blast type), the flow conditions are supersonic in order to maximize the cooling of the arc. Thereby, a much higher pressure built-up (e. g. considerably above $1,8 \cdot p_0$ and considerably above $p_0 + 800$ mbar), is required. This imposes strong requirements on the drive of these high-voltage circuit breakers, which are disadvantageous or even prohibitive, from a cost standpoint, for the low-voltage and medium-voltage load break switches considered herein. These low- and medium-voltage load break switches are a completely different type of switch for completely different applications, design and market than circuit breakers. In particular, a load break switch is not rated for or is incapable of switching a fault current or short-circuit current.

[0033] According to a further aspect, the load break switch is designed for breaking load currents in a secondary distribution gas-insulated switchgear. In a further aspect, a secondary distribution gas-insulated switchgear comprises a load break switch as described herein. In a further aspect, the load break switch has a closed position, a floating open position, and an earthing position.

[0034] In a further aspect, a load break switch as described herein is used in a secondary distribution gas-insulated switchgear. According to an aspect of the use, the load break switch has a controller, in particular the controller having a network interface for being connected to a data network, such that the load break switch is operatively connected to the network interface for at least one of: sending device status information to the data network, carrying out a command received from the data network; in particular the data network being at least one of: LAN, WAN or the internet.

[0035] Further advantages, features, aspects and details that can be combined with embodiments described herein and are disclosed in the dependent claims and claim combinations, in the description and in the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0036] The invention will be explained in greater detail with reference to the accompanying drawings, wherein

Fig. 1 is a schematic semi-perspective view of a load break switch according to embodiments, in a

closed state;

Fig. 2 is a schematic semi-perspective view of the load break switch of Fig. 1, in an opened state;

Fig. 3 is a schematic semi-perspective view of a load break switch according to another embodiment, in a closed state;

Fig. 4 is a schematic semi-perspective view of the load break switch of Fig. 3, in an opened state;

Fig. 5 is a cross-sectional side view of a nozzle of a load break switch according to an embodiment;

Fig. 6 is a cross-sectional front view of the nozzle of Fig. 5;

Fig. 7 is a perspective view of the nozzle of Fig. 5; and

Fig. 8 is a diagram showing measurement results of the pressure inside parts of the load break switch according to an embodiment, in a pressure curve over time.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0037] Reference will now be made in detail to the various aspects and embodiments. Each aspect and embodiment is provided by way of explanation and is not meant as a limitation. For example, features illustrated or described as part of one aspect or embodiment can be used on or in conjunction with any other aspect or embodiment. It is intended that the present disclosure includes such combinations and modifications. In the description of the embodiments, like parts are denoted with the same reference numerals, and the repeated description of the same or corresponding parts in the embodiments is omitted.

[0038] Fig. 1 shows, in a schematic semi-perspective view, a load break switch 1 according to an embodiment. In Fig. 1, the load break switch 1 is in a closed state. A housing 2 encloses an insulation gas, i. e. the load break switch 1 inside the housing 2 operates in an insulation gas atmosphere.

[0039] The load break switch 1 comprises a fixed contact 10 in the form of a pin 10. The fixed contact 10 is fastened to a support 11 which establishes an electrical connection to the outside. An electrically conductive lever 25 is rotatably supported and fastened by a bolt 9. The lever 25 can be rotated around the fixation at the bolt 9 via an operating rod 28.

[0040] A nozzle 30 has a tulip 20 inside the nozzle and comprises a movable contact therein which, in the closed state shown in Fig. 1, closes an electrically conductive path from the fixed contact 10, via the movable contact and the lever 25, to the point of fixation of the lever 25 at the bolt 9.

[0041] The nozzle 30 is movable inside a compression chamber 40. Fig. 2 shows the arrangement of Fig. 1 in a state where the movable contact, via the nozzle 30, has been moved into a state in which the movable contact is separated from the fixed, or stationary, contact 10. A trajectory curve A is non-linear (i. e. is not following a straight line), but instead is bent or curved. The bent shape of the curve A is called an arcuate shape. In the embodiment depicted in Figs. 1 and 2, the arcuate shape is a circular arc or ring segment, but it is generally not limited to such a circular or ring segment shape.

[0042] During a switching operation, as shown in Fig. 2, the movable contact is moved along the curve A away from the stationary contact 10. That is, the movable contact is moved in an arcuate manner along the curve A, i. e. with an arcuate trajectory. Thereby, the contacts are separated from one another, and an arc forms in the arcing region 52, or quenching region, between both contacts.

[0043] The nozzle 30 is moved together with the movable contact during the switching operation. When the nozzle 30 is moved inside the bent compression chamber 40, the insulation gas is compressed on an inlet side I of the nozzle 30. The compressed, or pressurized, insulation gas on the inlet side I flows into the nozzle 30, and, via ducts inside the nozzle 30, out on an outlet side O of the nozzle 30. At any instant of time during an opening operation of the load break switch, the gas on the outlet side O that momentarily flows out of the nozzle 30 is blown substantially tangentially or tangentially to the curve A, i. e. substantially tangentially or tangentially to the direction of the movement trajectory.

[0044] Figs. 3 and 4 schematically illustrate another embodiment of the load break switch 1, wherein Fig. 3 shows a closed state, and Fig. 4 shows an open state. In Figs. 3 and 4, that correspond to Figs. 1 and 2, respectively, the compression chamber 40 is replaced with a flexible conduit 41. The flexible conduit 41 may have the configuration of a bellowed hose, as shown in Figs. 3 and 4. During an opening operation of the load break switch 1, the internal volume of the flexible conduit 41 is reduced, whereupon the insulation gas inside the flexible conduit 41 is pressurized, or compressed, and blown out of the nozzle 30. On the outlet side O of the nozzle 30, again, the gas that momentarily flows out of the nozzle 30 is blown substantially tangentially or tangentially to the curve A.

[0045] It is noted that in the simplified embodiments of Figs. 1-2 and Figs. 3-4, the fixed contact 10, or contact pin 10, is shown in a simplified manner. In an actual embodiment, the contact pin may be bent according to the trajectory curve A, i. e. having substantially or exactly the same bending radius, or radius of curvature, as the trajectory curve A. Likewise, a duct inside the nozzle 30, and/or the nozzle itself, may be bent according to the trajectory curve A, i. e. having substantially or exactly the same bending radius, or radius of curvature, as the trajectory curve A.

[0046] Fig. 5 is a cross-sectional side view of the nozzle 30 of the load break switch 1 according to any one of the embodiments shown in Figs. 1-2 or Figs. 3-4. Fig. 6 illustrates the nozzle of Fig. 5 in a cross-sectional front view. Fig. 7 illustrates a perspective view of the nozzle 30. In the following, Figs. 5-7 are described in a common manner.

[0047] A nozzle guide part 34 extends in the direction towards a nozzle tip 33 of the nozzle 30 on the outlet side O. The nozzle tip 33 is adapted to let the fixed contact 10 pass through. The fixed contact 10, or contact pin, is received, via the nozzle tip 33, by the movable contact 20 inside the nozzle 30. The movable contact 20 has a tube-like geometry, which may be bent according to the arcuate trajectory curve A, with a tube portion 24 and a hollow section 26.

[0048] When the nozzle 30 is moved, during a switching operation, into the open state of the load break switch 1, the contact pin 10 is separated from the movable contact 20 inside the nozzle 30. The movement causes a pressure buildup of the insulation gas inside the compression chamber 40 or inside the flexible conduit 41 on the inlet side I, whereby the insulation gas is caused to flow through the nozzle 30. The insulation gas flows into the nozzle 30 through an inlet passage 46, passes through an internal duct 32, or channel, of the nozzle 30 and out of the nozzle 30 at the nozzle tip 33 on the outlet side O.

[0049] The nozzle 30 defines a flow pattern of the blown-out or to-be-blown-out gas. In Fig. 5, the flow pattern includes a stagnation point 64, at which the flow of quenching gas essentially stops. More precisely, the stagnation point 64 is defined as the region in which the flow pattern of the quenching gas has an essentially vanishing velocity. In quantitative terms, the velocity of the gas essentially vanishes, if the magnitude v_{gas} of the gas velocity satisfies the inequality

$$v_{gas} \leq c \sqrt{2\Delta p / \rho}$$

wherein $\Delta p = p - p_0$ is the pressure difference of the pressurized (quenching) gas (having maximum pressure p) and the ambient gas pressure (bulk pressure p_0); ρ is the gas density of the pressurized (quenching) gas in the compression volume (at maximum compression), and c is a predetermined constant coefficient smaller than 1, preferably selected in a range $c < 0.2$, for example $c = 0.01$, more preferably $c = 0.1$.

[0050] Herein, the stagnation point 64 is defined as the region, in which the above inequality is met during steady-state flow of the quenching gas during an arc-free operation, e.g. during an opening movement of the switch without current (no-load operation). The above inequality is preferably defined in the absence of an arc (in particular without an arc generating current).

[0051] The stagnation point 64 thus describes a region

(i.e. stagnation region). In addition, the stagnation point 64 may also refer to any point within this region, and in particular refers to a center of this region.

[0052] The flow pattern further includes an upstream region towards the stagnation point 64, i.e. upstream of the stagnation point 64 (i.e. with overall decelerating flow towards the stagnation point 64), and a downstream region of accelerating flow in a predominantly axial direction away from the stagnation point 64, i.e. downstream of the stagnation point 64. Here, "upstream" and "downstream" does not necessarily imply that the gas has travelled through the stagnation point 64.

[0053] The nozzle 30 may comprise a separation wall 45 at a distal end of the hollow section 26 of the nozzle. In case the separation wall 45 is provided, the gas in the downstream region away from the stagnation point 64 may only flow in a substantially unhindered manner out of the nozzle at the outlet end O, i.e. have a single-direction flow or single flow. In case the separation wall 45 is not provided, the gas in the downstream region away from the stagnation point 64 may flow out of the nozzle 33 at the outlet end O, and furthermore through the hollow section 26 beyond the place where the separation wall 45 is not provided. In the latter case, the gas stream has a double-direction flow or double flow.

[0054] By applying the flow pattern described herein to a low- or medium-voltage load break switch, its thermal interruption performance can significantly be improved. This permits, for example, the use with an insulation gas being different from SF₆. SF₆ has excellent dielectric and arc quenching properties, and has therefore conventionally been used in gas-insulated switchgear. However, due to its high global warming potential, there have been made large efforts to reduce the emission and eventually stop the usage of such greenhouse gases, and thus to find alternative gases for replacement of SF₆.

[0055] The present configuration allows the use of such an alternative gas having a global warming potential lower than the one of SF₆ in a load break switch, even if the alternative gas does not fully match the interruption performance of SF₆.

[0056] The insulation gas preferably has a global warming potential lower than the one of SF₆ over an interval of 100 years. The insulation gas preferably comprises at least one gas component selected from the group consisting of CO₂, O₂, N₂, H₂, air, N₂O, a hydrocarbon, in particular CH₄, a perfluorinated or partially hydrogenated organofluorine compound, and any mixtures thereof.

[0057] The organofluorine compound is preferably selected from the group consisting of: a fluorocarbon, a fluoroether, a fluoroamine, a fluoronitrile, a fluoroketone, and a mixture and/or decomposition product thereof, and preferably is a fluoroketone and/or a fluoroether, more preferably a perfluoroketone and/or a hydrofluoroether, most preferably a perfluoroketone having from 4 to 12 carbon atoms. The insulation gas preferably comprises the fluoroketone or fluoronitrile mixed with air, e.g. dried

air or technical air, or mixed with an air component such as N₂, O₂, CO₂, and mixtures thereof, most preferably mixed with N₂ and O₂ or mixed with CO₂ and O₂.

[0058] Coupling the compression chamber or flexible conduit 41 (the compression volume) with the arcuate (in embodiments: rotational) motion of the nozzle 30 creates a sufficiently high pressure for extinguishing an arc formed in the arcing region 52. A diagram in Fig. 8 shows simplified graphs of actual measurement results of the pressure buildup in an actual load break switch 1. The curve denoted S shows a so-called single-flow case in which the separation wall 45 (see Fig. 5) is present. The curve denoted D shows a so-called double-flow case in which the separation wall 45 is not present. As shown in the diagram of Fig. 8, the movement starts approximately at a point in time t_{start} , the pressure builds up to p_e , S in the single-flow case and up to p_e , D in the double-flow case, and the movement ends approximately at a point in time t_{end} . The time scale from t_{start} to t_{end} is in the scale of tens of milliseconds. p_e , S and p_e , D each fulfil the inequality of $p_e < 1.8 p_0$.

[0059] While the invention has been described in embodiments and aspects, a person skilled in the art will recognize that various combinations of the embodiments and aspects described herein can be devised, and that various features may be replaced by equivalents and/or omitted as appropriate, without departing from the scope of the invention that is defined by the claims.

Claims

1. A gas-insulated low-voltage or medium-voltage load break switch (1), comprising:

a housing (2) defining a housing volume for holding an insulation gas;
 a movable contact (20) and a fixed contact (10) arranged within the housing volume, the movable contact (20) being movable in relation to the fixed contact (10) with an arcuate trajectory (A) of movement and defining an arcing region (52) in which an arc is formed during an opening operation of the load break switch (1);
 a pressurizing system (40, 41), actuated by a movement of the movable contact (20) during the opening operation of the load break switch (1), for pressurizing the insulation gas;
 a nozzle (30), the nozzle (30) being arranged within the housing volume and being fixed to the movable contact (20) and/or the nozzle (30) being arranged within the housing volume and defining a contacting part (24) of the movable contact (20), wherein the nozzle (30) is adapted to blow the pressurized insulation gas into the arcing region (52) substantially tangentially, in particular tangentially, to the arcuate trajectory (A).

2. The load break switch (1) according to claim 1, having a rated voltage of at most 52 kV, preferably of at most 36 kV, more preferably of at most 24 kV and most preferably of at most 12 kV; and/or the load break switch being rated for switching nominal currents in a range of up to 2 kA, preferably of up to 1.25 kA and more preferably of up to 1 kA. 5
3. The load break switch (1) of any one of the preceding claims, wherein the movable contact (20) is a tulip-nozzle type contact having a contact area (24) inside the nozzle (30), and wherein the fixed contact (10) is a pin contact. 10
4. The load break switch (1) of claim 3, wherein the contact area (24) is bent according to the arcuate trajectory (A), and wherein the pin contact (10) is bent according to the arcuate trajectory (A). 15
5. The load break switch (1) of any one of the preceding claims, wherein the pressurizing system (40, 41) comprises a compression cylinder (40), preferably a compression cylinder that has a bent shape, more preferably a compression cylinder that has a shape that is bent according to the arcuate trajectory (A), the insulation gas inside the compression cylinder (40) being pressurized by the nozzle (30) sliding inside the compression cylinder. 20 25
6. The load break switch of any one of the claims 1-4, wherein the pressurizing system (40, 41) comprises a flexible conduit (41), the flexible conduit (41) being connected to an inlet side (I) of the nozzle (30) and being reduced in volume during the opening operation of the load break switch (1). 30 35
7. The load break switch according to any one of the preceding claims, wherein the nozzle (30) defines a flow pattern for the pressurized insulation gas, the flow pattern including a stagnation point (64) at which the flow essentially stops, an upstream region of the gas flow inside the nozzle flowing towards the stagnation point in a predominantly radially inward direction with respect to the axis of the nozzle (30), and a downstream region of the gas flow inside the nozzle (30) flows away from the stagnation point in a predominantly axial direction with respect to the axis of the nozzle (30). 40 45
8. The load break switch (1) according to any one of the preceding claims, wherein the pressurizing system (40, 41) configured for pressurizing the insulation gas during the opening operation from an ambient pressure p_0 to an elevated pressure p_e , thereby satisfying at least one of the following conditions: 50 55

$p_e < 1.8 p_0$, preferably $p_e < 1.5 p_0$, more preferably $p_e < 1.3 p_0$;

$p_e < p_0 + 800$ mbar, preferably $p_e < p_0 + 500$ mbar, more preferably $p_e < p_0 + 300$ mbar.

9. The load break switch (1) according to claim 8, wherein the relationship of an average cross sectional area of a gaseous connection from an inflow side of the nozzle to an outflow side of the nozzle to an average total cross sectional area of the nozzle is at least 0.2, preferably at least 0.3, more preferably at least 0.35. 5
10. The load break switch (1) according to any one of the preceding claims, wherein the load break switch (1) is not a circuit breaker, in particular not a circuit breaker for high voltages above 52 kV; and/or wherein the pressurizing system (40, 41) is devoid of a heating chamber for providing a self-blasting effect; and/or wherein the load break switch (1) is designed for breaking load currents or nominal currents in a secondary distribution gas-insulated switchgear. 10
11. The load break switch (1) according to any one of the preceding claims, wherein the insulation gas comprises an organofluorine compound, in particular selected from the group consisting of: a fluor-oether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin, a fluoronitrile, and mixtures and/or decomposition products thereof; and the organofluorine compound being in a mixture with a background gas, in particular selected from the group consisting of: air, dry air, technically dried air, N_2 and O_2 , technical air, CO_2 , N_2 , N_2O , O_2 , and mixtures thereof. 20 25 30 35
12. The load break switch (1) according to any one of the preceding claims, wherein the load break switch has a closed position, a floating open position, and an earthing position. 40
13. A secondary distribution gas-insulated switchgear having a load break switch (1) according to any one of the preceding claims. 45
14. A use of a load break (1) switch according to any one of the claims 1-12 in a secondary distribution gas-insulated switchgear. 50
15. The use of claim 14, wherein the load break switch (1) has a controller, in particular the controller having a network interface for being connected to a data network, such that the load break switch is operatively connected to the network interface for at least one of: sending device status information to the data network, carrying out a command received from the data network, in particular the data network being at least one of: LAN, WAN or the internet. 55

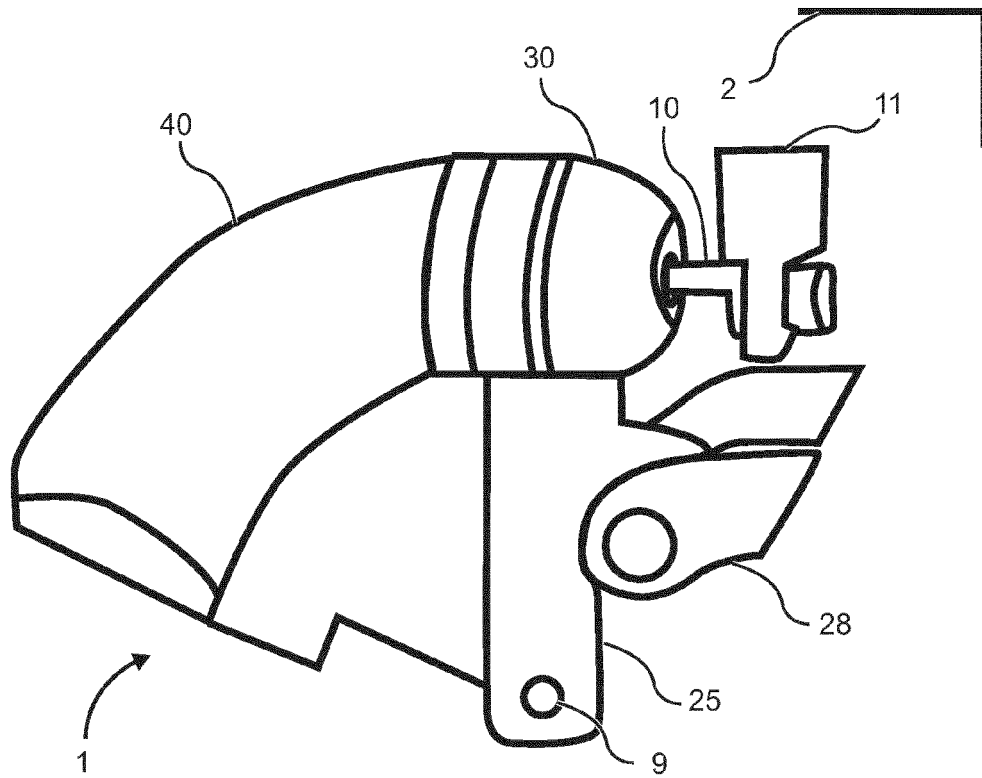


Fig. 1

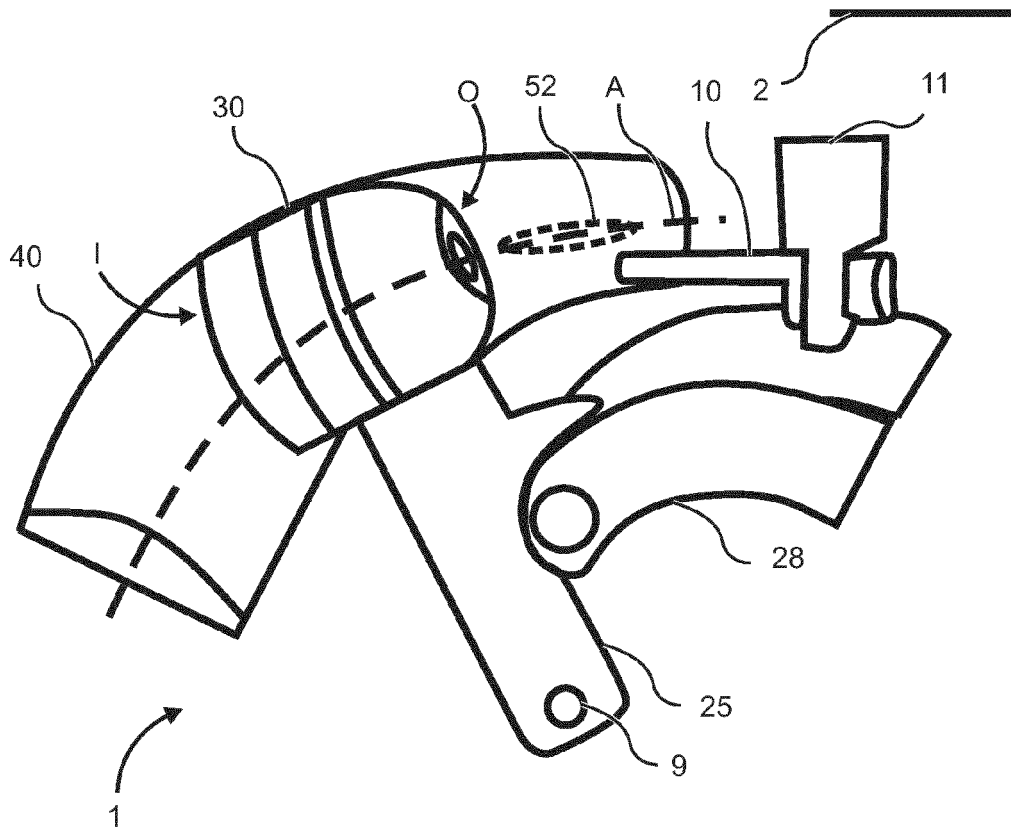


Fig. 2

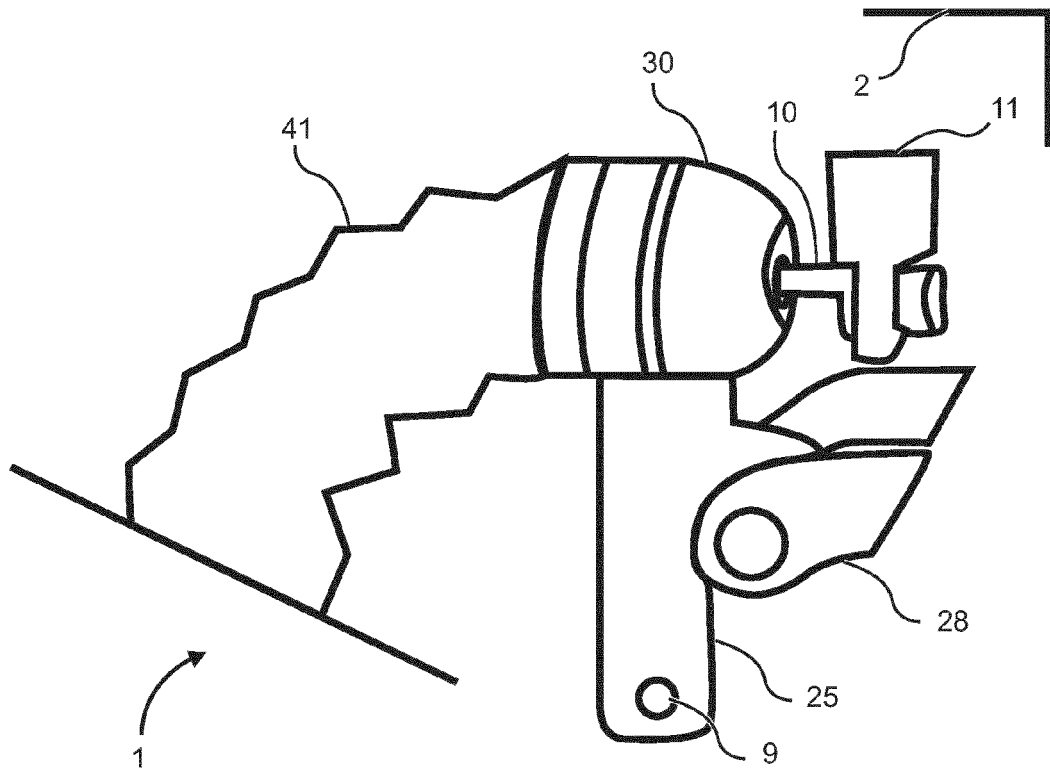


Fig. 3

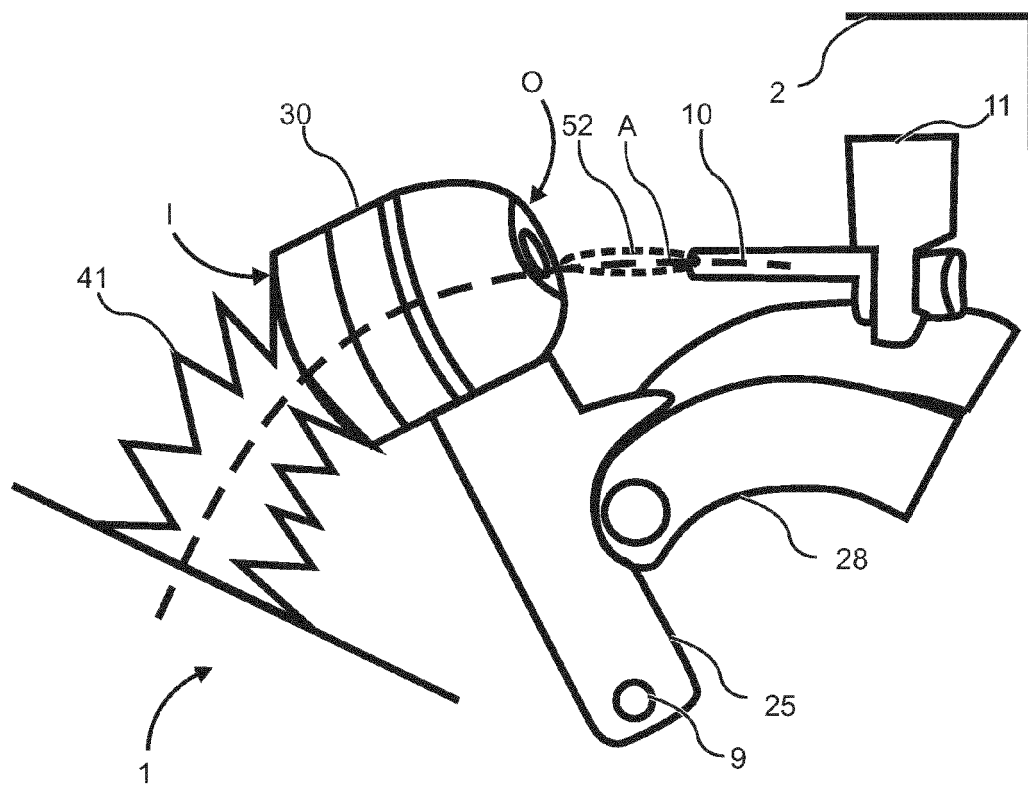


Fig. 4

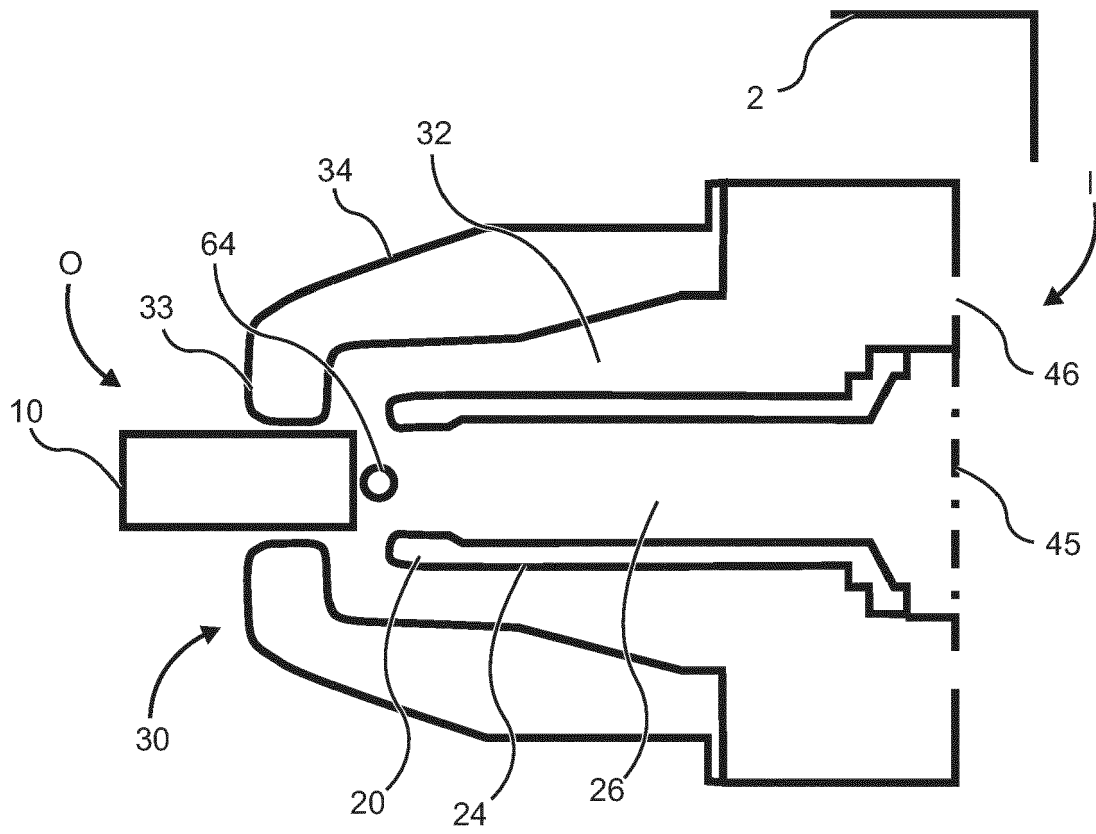


Fig. 5

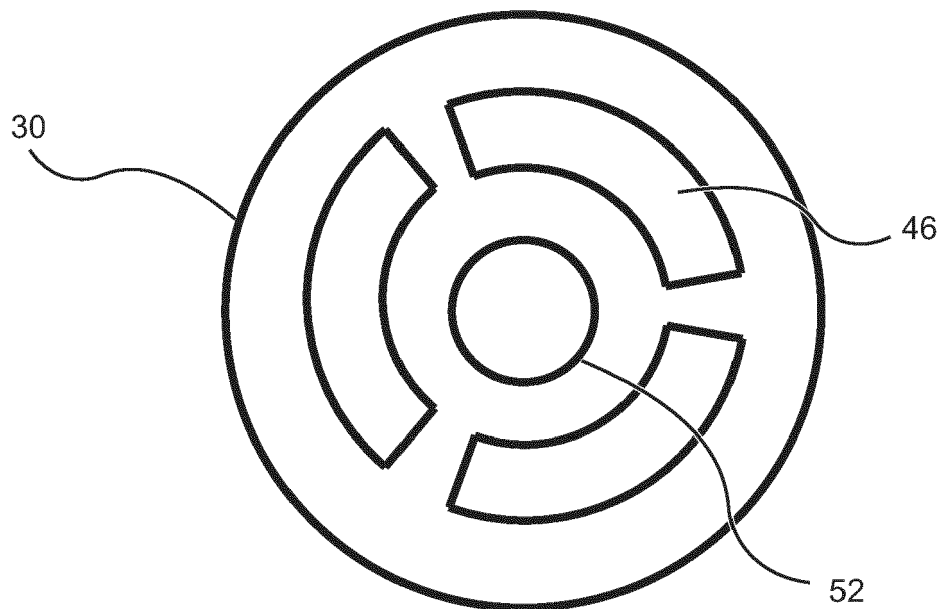


Fig. 6

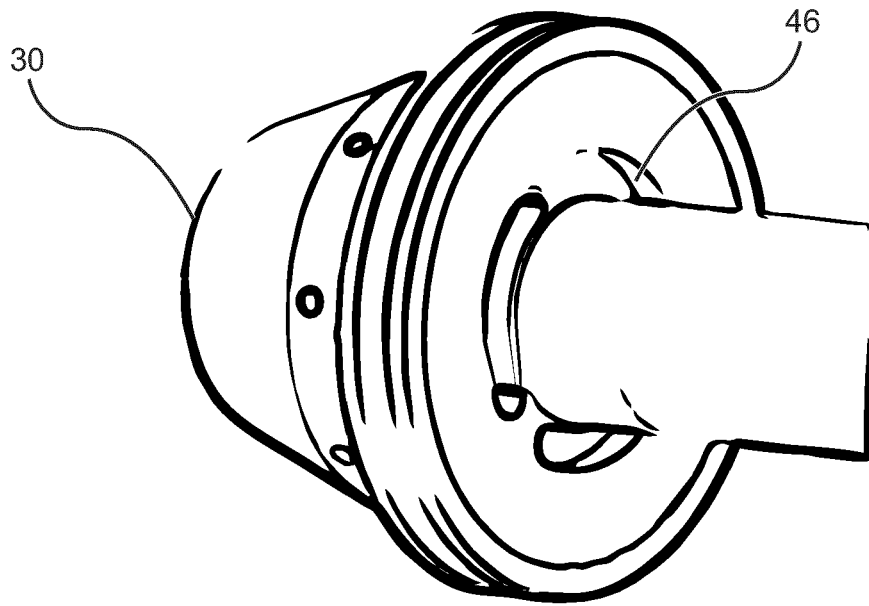


Fig. 7

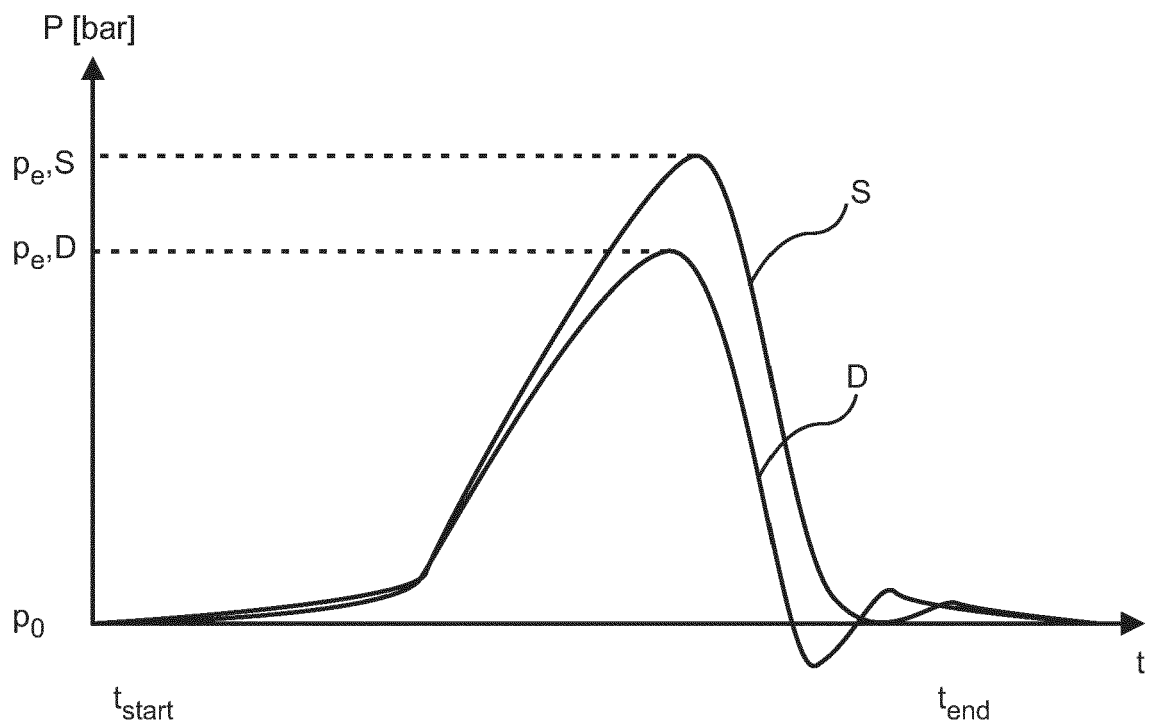


Fig. 8



EUROPEAN SEARCH REPORT

Application Number
EP 18 18 9231

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X	DE 38 03 117 A1 (SACHSENWERK AG [DE]) 17 August 1989 (1989-08-17) * abstract; claim 1 * * column 1, line 66 - column 2, line 52 * * column 3, line 60 - column 4, line 68; figures 1-5 *	1-4,6-15	
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Place of search Munich		Date of completion of the search 24 January 2019	Examiner Meyer, Jan
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The members are as contained in the European Patent Office EDP file on
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