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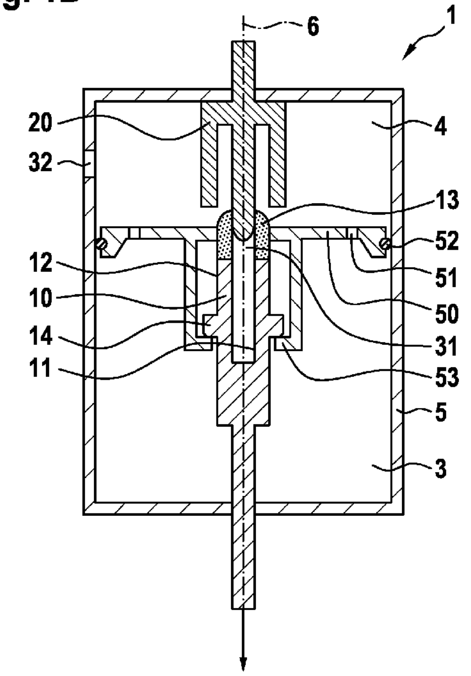
(54) **Title:** GAS-INSULATED MEDIUM-VOLTAGE SWITCH WITH SHIELD DEVICE

Fig. 1B



(57) **Abstract:** According to a first aspect of the invention, a gas-insulated medium-voltage switch (1, 2) is provided. The switch (1, 2) comprises a first contact element (10) having a nominal contact surface (12), a second contact element (20) and a shield (50), wherein the shield (50) and the first contact element (10) are movable relative to each other between an exposing configuration and a shielding configuration, wherein in the exposing configuration, the shield (50) and the first contact element (10) are arranged to expose the nominal contact surface (12) to the second contact element (20), and in the shielding configuration, the shield (50) and the first contact element (10) are arranged to shield the nominal contact surface (12) from the second contact element (20). According to a second aspect of the invention, a method of performing a current breaking operation by a switch (1, 2) is provided.

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GAS-INSULATED MEDIUM-VOLTAGE SWITCH WITH SHIELD DEVICE

TECHNICAL FIELD

Aspects of the present invention generally relate to a gas-insulated medium-voltage switch with the capability to suppress arc re-ignition, to a distribution network, Ring Main Unit, or secondary distribution gas-insulated switchgear having such a switch, and to a method of breaking a current using the switch.

BACKGROUND ART

A gas-insulated switch includes electrically insulating gas within its enclosure. Gas-insulated medium-voltage switches are used in a variety of settings such as in a distribution networks, Ring Main Units, or secondary distribution gas-insulated switchgear. When switching a current, the switch is opened by relative movement of the contacts (plug and pipe) away from each other, whereby an arc can form between the separating contacts.

In order to extinguish an arc generated in a current breaking operation, some types of switches are equipped with an arc-extinguishing system. In one type of switch, an arc-extinguishing system operates by releasing a quenching gas towards the arc for cooling down and finally extinguishing the arc.

Typically, low cost and reliability of operation are two main factors for medium-voltage switches. Therefore, it is generally desired to use simple and cost-efficient components for each part of the switch. In particular, a design enabling a low-cost drive of the switch is generally favoured. Further, one aspect affecting reliability of operation is that the heating of the electrically insulating gas caused by the extinguishing of the arc changes the dielectric properties of the heated gas which accumulates in the region around the two contacts. Thereby, the risk of unwanted arc re-ignition or other discharges during or after arc extinction may increase.

SUMMARY OF THE INVENTION

An object of the invention is to provide an improved gas-insulated medium-voltage switch, which allows for reliable operation while still maintaining at least to some extent a relatively low-cost and compact design.

In view of the above, a gas-insulated medium-voltage switch according to claim 1, and a method of performing a current breaking operation according to claim 14 are provided.

According to a first aspect of the invention, a gas-insulated medium-voltage switch is provided. The switch comprises a first contact element having an arcing contact surface and a nominal contact surface, wherein the first contact element is movable along an axis of the switch for opening and closing the switch, a second contact element configured to make contact with the first contact element for closing the switch, and a shield, wherein the shield and the first contact element are movable relative to each other along the axis between an exposing configuration and a shielding configuration, such that the shield and the first contact element are in the exposing configuration when the switch is in a closed state and in the shielding configuration during opening of the switch, wherein in the exposing configuration, the shield and the first contact element are arranged to expose the nominal contact surface to the second contact element, and in the shielding configuration, the shield and the first contact element are arranged to shield the nominal contact surface of the first contact element from the second contact element.

According to a second aspect of the invention, a method of performing a current breaking operation by a switch is provided, wherein the switch comprises a first contact element, a second contact element and a shield, the first contact element having an arcing contact surface defining an arcing region and a nominal contact surface, wherein the shield and the first contact element are movable relative to each other along an axis. The method comprises separating the first contact element from the second contact element by relative movement away from each other along the axis of the switch so that an arc is formed in the arcing region, and moving the first contact element and the shield relative to each other from an exposing configuration wherein the nominal contact surface is exposed to the second contact element to a shielding configuration wherein the nominal contact surface is shielded from the second contact element.

According to a further aspect, the switch is a load break switch. As defined herein, a load break switch has a capability to switch load currents, but does not have a short-circuit switching capability. The load current is also referred to as the rated current or nominal current of the switch, and is up to 2000 A, preferably up to 1250 A, more preferably up to 1000 A. Currents in this range are typical rated currents used in distribution networks, ring main units, and secondary distribution gas-insulated switch. 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 breaker, the rated current is herein indicated in terms of the rms current.

Herein, a medium voltage is defined as a voltage in the range of 1 kV to 72 kV. The medium-voltage switch therefore has a rated voltage of at most 72 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.

Embodiments of the invention enable a current breaking operation to be performed with reduced occurrence of a re-ignition of an arc, especially between the nominal contacts of the switch, compared with a conventional design, and thus enable a more reliable operation. Such embodiments are especially advantageous for thermally interrupting the load currents for a wide range of possible load break scenarios and environmental conditions. Also, such embodiments are especially suitable for an alternative quenching gas as mentioned herein.

Further advantages, features, aspects and details that can be combined with embodiments described herein are evident from the dependent claims, the description and the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

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

Figs. 1a-1d show a cross-sectional view of a load break switch according to an embodiment of the invention, in a closed state (Fig. 1a), an opening state (Fig. 1b), an open state (Fig. 1c) and a closing state (Fig. 1d);

Figs. 2a-2d show a cross-sectional view of a load break switch according to an embodiment of the invention, in a closed state (Fig. 2a), an opening state (Fig. 2b), an open state (Fig. 2c) and a closing state (Fig. 2d); and

Fig. 3 shows a flow chart of a method of performing a current breaking operation according to an embodiment of the invention.

DETAILED DESCRIPTION OF DRAWINGS

Within the following description of embodiments shown in the drawings, the same reference numbers refer to the same or to similar components. Generally, only the differences with respect to the individual embodiments are described. Unless specified otherwise, the description of a part or aspect in one embodiment applies to a corresponding part or aspect in another embodiment as well.

Figs. 1A-1D show a cross-sectional view of a load break switch 1 according to an embodiment of the invention. Fig. 1A shows the switch in a closed state, Fig. 1B shows the switch during a current breaking operation in an opening state, Fig. 1C shows the switch in an opened state, and Fig. 1D shows the switch in a closing state.

The switch 1 has a gas-tight housing 5 whose inner volume is filled with an electrically insulating gas at an ambient pressure p_0.

Within the housing 5 is a first contact element 10 and a second contact element 20. The first contact element 10 is a movable pipe-type contact, and the second contact element 20 is a stationary pin-type contact. The first contact element 10 has an arcing contact surface 11 and a nominal contact surface 12.

The switch 1 further includes a shield 50. The shield 50 may have a flat disc shape extending radially outwards from the axis 6 of the switch 1 such that the shield 50 divides the inner volume of the housing 5 into a first region 3 and a second region 4. The shield 50 further includes an opening at its center for surrounding the first contact element 10, such that the inner surface of the opening is in sliding contact with the nominal contact surface 12 of the first contact element 10.

The shield 50 may be moveable in the direction of the axis 6 of the switch 1 relative to the first contact element 10 and/or the housing 5. A friction element 52 provided on shield 50 is in frictional contact with the inner surface of housing 5 such that the shield 50 requires a moving force which is larger in magnitude than the moving force for moving the first contact element 10. The friction element 52 may include a seal, for example a rubber O-ring, so that the electrically insulating gas in the first region 3 may not flow between the shield 50 and the inner surface of housing 5 into the second region 4.

During movement of the shield 50 in the direction of axis 6 of the switch 1, the volumes of the first region 3 and the second region 4 will change. At least an opening 51 in shield 50 allow for electrically insulating gas to flow from the first region 3 to the second region 4, such that gas pressure is equalized between the two regions. The shield 50 may include a plurality of openings 51. Opening 51 are to be positioned closer to the periphery of the shield 50 in a region close to the housing 5, particularly opening 51 should be positioned away from the first contact element 10 to avoid an arc re-igniting between the nominal contact surface 12 and the second contact element 20 through opening 51.

Since the first contact element 10 and the shield 50 are moveable relative to one another, the first contact element 10 and the shield 50 may be configured to be in one of two configurations.

As shown in Figs. 1A and 1D, the first contact element 10 and the shield 50 may be considered to be in an exposed configuration when the first contact element 10 is extended outward from shield 50 such that the nominal contact surface 12 is exposed to the second contact element 20. In the exposed configuration, the nominal contact surface 12 can make contact with the second contact element 20 so that electrical current may flow through the switch 1.

However, in the exposed configuration, re-ignition of an arc between the nominal contact surface 12 and the second contact element 20 can occur during a current breaking operation. As shown in Figs. 1B and 1C, the first contact element 10 and the shield 50 may be considered to be in a shielding configuration when the first contact element 10 is retracted behind shield 50 such that the nominal contact surface 12 is shielded from the second contact element 20. In the shielded configuration, the communication between the nominal contact surface 12 and the second contact element 20 via the electrically insulating gas is substantially restricted. Restricting the exposure of the nominal contact surface 12 to the second contact element 20 greatly reduces the occurrence of re-ignition of an arc between the nominal contact surface 12 and the second contact element 20.

In the context of the present invention, the term “shielding” is understood as a mechanical shielding, i.e., a mechanical (preferably insulating) shield is provided in a space that would otherwise be prone to arcing and/or electrical discharge between conductors on opposite sides of that space.

The first contact element 10 may further include at least a first contact actuating element 14, and the shield 50 may further include at least a shield actuating element 53. The first actuating element 14 and shield actuating element 53 define a mechanical limit or stop with respect to the amount of relative movement of the first contact element 10 and the shield 50. At the limit of relative movement, the first actuating element 14 engages the shield actuating element 53 such that any further movement of the first contact element 10 causes the shield 50 to move.

As an example of a current breaking operation, or an operation of opening the switch, the first contact element 10 and the shield 50 are moved relative to the second contact element 20.

A first opening movement is performed wherein the first contact element 10 is separated from the second contact element 20 and retracted into the shield 50. During this first opening movement, the shield 50 remains stationary with respect to the second contact element 20 and the housing 5, due to the friction element 52. The first contact element 10 is moved along the axis 6 of the switch 1 until the first contact actuating element 14 engages with the shield actuating element 53.

Towards the end of the first opening movement, the first contact element 10 separates from the second contact element 20. Thereby, an arc is formed between the second contact element 20 and the arcing contact surface 11 in the arcing region 31. Further, the nominal contact surface 12 of the first contact element 10 is moved behind the shield 50 such that the first contact element 10 and the shield 50 are in the shielding configuration. At the end of the first opening movement, the first actuating element 14 engages the shield actuating element 53 as shown in Fig. 1B.

A second opening movement is performed wherein the first contact element 10 continues to be moved along the axis 6 of the switch in a direction away from the second contact element 20. First actuating element 14, engaged with the shield actuating element 53, causes the shield 50 to move along the axis 6 of the switch 1 with the first contact element 10.

During the second opening movement, the electrically insulating gas in the second region 4 may flow through the opening 51 into the first region 3 such that the gas pressure is equalized. Movement of the first contact 10 continues until the switch is completely opened, as shown in Fig. 1C. Insulating gas in the second region is heated by the extinguishing of the arc formed in the arcing region 31. The nominal contact surface 12 continues to be shielded from the second contact element 20 by the shield 50, thereby suppressing the re-ignition of an arc between the nominal contact surface 12 and the second contact element 20 despite the modified dielectric properties of the accumulating heated insulating gas in the second region 4.

Similarly, as an example of a current make operation, or an operation of closing the switch, the first contact element 10 and the shield 50 are moved relative to the second contact element 20.

A first closing movement is performed wherein the first contact element 10 is moved along the axis 6 of the switch 1, 2 towards the second contact element 20. In this first closing movement, the shield 50, due to the friction element 52, remains in a stationary position relative to the second contact element 20. The first contact element 10 is moved along the axis 6 of the switch 1, 2 until the first contact actuating element 14 engages with the shield 50.

Towards the end of the first closing movement, the relative movement of the first contact element 10 causes the first contact element 10 and the shield 50 to move from the shielded configuration to the exposed configuration, wherein the nominal contact surface 12 is moved from behind the shield 50 to be exposed to the second contact element 20. At the end of the first closing movement, the first actuating element 14 engages the shield 50 as shown in Fig. 1D.

A second closing movement is performed wherein the first contact element 10 continues to be moved along the axis 6 of the switch in a direction towards the second contact element 20. First actuating element 14, engaged with the shield 50, causes the shield 50 to move along the axis 6 of the switch 1 with the first contact element 10.

During the second closing movement, the electrically insulating gas in the first region 3 may flow through the opening 51 into the second region 4 such that the gas pressure is equalized. Movement of the first contact 10 continues until the switch is completely closed, as shown in Fig. 1A. The nominal contact surface 12 continues to be exposed to the second contact element 20 by the shield 50, thereby allowing an electrical connection to be made between the nominal contact surface 12 and the second contact element 20.

According to an embodiment of the invention, which may be combined with other embodiments described herein, the first contact element 10 may include an insulating tip 13 at a distal axial position relative to the nominal contact surface 12. The insulating tip 13 may include an electrically non-conductive material.

When the first contact element 10 and the shield 50 are in a shielding configuration, the insulating tip 13 may be positioned such that the opening in the center of the shield 50 is in sliding contact with the outer surface of the insulating tip 13. The insulating tip 13 may have a tube shape such that, when the switch is in a closed state, the second contact element 20 may protrude through the insulating tip 13 and make electrical contact with the first contact element 10.According to an embodiment of the invention, which may be combined with other embodiments described herein, the first contact element 10 may have a tube shape. In this case, the arcing contact surface 11 is the inner surface of the tube-shaped first contact element 10, and the nominal contact surface 12 is the outer surface of the tube-shaped first contact element

10. Further, the second contact element 20 may have a pin shape such that the pin-shaped second contact element 20 is configured to be inserted into the tube-shaped first contact element 10 when the switch is in a closed state.

Referring now to Figs. 2A to 2D, the switch 2 may further include a gas pressurization system for actively extinguishing the arc formed in the arcing region 31.According to an embodiment of the invention, which may be combined with other embodiments described herein, the switch 2 further includes a piston 30 for pressurizing a quenching gas during the current breaking operation, wherein the piston is configured to compress the quenching gas, the compressed gas blowing through the inside of the first contact element 10 and the insulating tip 13 in an axial direction towards the second contact element 20 to extinguish the arc formed in the arcing region 31.Integrated in the first contact 10 is an arc-extinguishing system for extinguishing the arc. The arc-extinguishing system has a pressurizing system (puffer system) and a nozzle including the tube-shaped first contact element 10 and the insulating tip 13. The pressurizing system includes the first region 3 having a quenching gas contained therein. The quenching gas is a portion of the electrically insulating gas contained in the housing 5 of the switch. A pressurizing chamber is delimited by the housing 5 and a piston 30 for compressing the quenching gas within the first region 3 during the current breaking operation. To this purpose, the piston 30 moves jointly with the first contact element 10 so that the piston 30 pressurizes the quenching gas within the pressurizing chamber when the first contact element 10 is moved away from the second contact 20 for opening the switch, as shown in Figs. 2B and 2C. Thereby, the energy for pressurizing the quenching gas is ultimately provided by the drive driving the first contact element 10.

The nozzle including the tube-shaped first contact element 10 and the insulating tip 13 is adapted for blowing the pressurized quenching gas from the pressurization system onto the arc formed in the arcing region 31 during the current breaking operation. The nozzle has at least a nozzle inlet 15 connected to the first region 3 for receiving the pressurized quenching gas from the first region 3, and a nozzle outlet to the second region 4 via the arcing region 31.

The pressurizing system and the nozzle including the tube-shaped first contact element 10 and the insulating tip 13 are dimensioned such that the flow of the quenching gas is subsonic. This subsonic flow amounts to a relatively low quenching pressure p_{quench} in the pressurizing chamber ($p_{quench} < 1{,}8*p_0$, as defined herein), and therefore imposes only modest requirements on the drive of the switch.

The piston 30 may have a flat disc shape extending radially outwards from the axis 6 of the switch 1 such that the piston 30 and the shield 50 divide the inner volume of the housing 5 into a first region 3 and a second region 4. The piston 30 is fixed at its center to the first contact element 10, such that the piston 30 moves with the first contact element 10.

The shield 50 further includes a shield skirt portion 54 which extends in the direction away from the second contact element 20 parallel to the housing 5 and including the shield actuating element 53. The outer surface of the piston 30 is in sliding contact with the shield skirt portion 54 of the shield 50 such that the first contact element 10 can freely move relative to the shield 50.

During movement of the first contact element 10, and hence piston 30, in the direction of axis 6 of the switch 2, the volume of the region between the piston 30 and the shield 50 will change. At least an opening 51 in shield 50 allows for electrically insulating gas to flow from the second region 3 to the region between the piston 30 and the shield 50, such that gas pressure is equalized between the two regions. Since the movement of the piston 30 relative to the shield 50 occurs substantially before the separation of the first contact element 10 and the second contact element 20, and before the formation of an arc in the arcing region 31, the insulating gas drawn into the region between the piston 30 and the shield 50 is in a state which is substantially unheated by the extinguishing of the arc. Thereby, the insulating gas in the region between the piston 30 and the shield 50, particularly the insulating gas surrounding the nominal contact surface 12 when in the shielding configuration, has not undergone a significant change in dielectric properties due to the extinguishing of the arc, further suppressing the re-ignition of an arc between the nominal contact surface 12 and the second contact element 20.

The piston 30 is configured to engage with the shield actuating element 53 for moving the shield 50. The piston 30 and shield actuating element 53 define a mechanical limit or stop with respect to the amount of relative movement of the first contact element 10 and the shield 50. At the limit of relative movement, the piston 30 engages the shield actuating element 53 such that any further movement of the first contact element 10 causes the shield 50 to move.According to the embodiment shown in Figs. 2A to 2D, as an example of a current breaking operation, or an operation of opening the switch 2, the first contact element 10 and the shield 50 are moved relative to the second contact element 20.

A first opening movement is performed wherein the first contact element 10 is separated from the second contact element 20 and retracted into the shield 50. During this first opening movement, the shield 50 remains stationary with respect to the second contact element 20 and the housing 5, due to the friction element 52. The first contact element 10 is moved along the axis 6 of the switch 1 until the piston 30 engages with the shield actuating element 53.

Towards the end of the first opening movement, the first contact element 10 separates from the second contact element 20. Thereby, an arc is formed between the second contact element 20 and the arcing contact surface 11 in the arcing region 31. Further, the nominal contact surface 12 of the first contact element 10 is moved behind the shield 50 such that the first contact element 10 and the shield 50 are in the shielding configuration. At the end of the first opening movement, the piston 30 engages the shield actuating element 53 as shown in Fig. 2B.

During the first opening movement, the electrically insulating gas in the second region 4 may flow through the opening 51 into the region between the piston 30 and the shield 50 such that the gas pressure is equalized.

A second opening movement is performed wherein the first contact element 10 continues to be moved along the axis 6 of the switch in a direction away from the second contact element 20. Piston 30, engaged with the shield actuating element 53, causes the shield 50 to move along the axis 6 of the switch 1 with the first contact element 10.

Movement of the first contact 10 continues until the switch is completely opened, as shown in Fig. 1C. The arc formed in the arcing region 31 is extinguished by the pressurized quenching gas being forced through the nozzle including the tube-shaped first contact element 10 and the insulating tip 13. The nominal contact surface 12 continues to be shielded from the second contact element 20 by the shield 50, thereby suppressing the re-ignition of an arc between the nominal contact surface 12 and the second contact element 20 despite the modified dielectric properties of the accumulating heated insulating gas in the second region 4.

Similarly, as an example of a current make operation, or an operation of closing the switch, the first contact element 10 and the shield 50 are moved relative to the second contact element 20.

A first closing movement is performed wherein the first contact element 10 is moved along the axis 6 of the switch 2 towards the second contact element 20. In this first closing movement, the shield 50, due to the friction element 52, remains in a stationary position relative to the second contact element 20. The first contact element 10 is moved along the axis 6 of the switch 2 until the first contact actuating element 14 engages with the shield 50.

During the first closing movement, the electrically insulating gas in the region between the piston 30 and the shield 50 may flow through the opening 51 into the second region 4 such that the gas pressure is equalized.

Towards the end of the first closing movement, the relative movement of the first contact element 10 causes the first contact element 10 and the shield 50 to move from the shielded configuration to the exposed configuration, wherein the nominal contact surface 12 is moved from behind the shield 50 to be exposed to the second contact element 20. At the end of the first closing movement, the first actuating element 14 engages the shield 50 as shown in Fig. 2D.

A second closing movement is performed wherein the first contact element 10 continues to be moved along the axis 6 of the switch in a direction towards the second contact element 20. First actuating element 14, engaged with the shield 50, causes the shield 50 to move along the axis 6 of the switch 2 with the first contact element 10.

Movement of the first contact 10 continues until the switch is completely closed, as shown in Fig. 1A. The nominal contact surface 12 continues to be exposed to the second contact element 20 by the shield 50, thereby allowing an electrical connection to be made between the nominal contact surface 12 and the second contact element 20.

GENERAL PREFERRED ASPECTS OF THE INVENTION

These advantages are not limited to the embodiments shown in Figs. 2a to 5, but the switch may be modified in a plurality of ways. In the following, some general preferred (i.e., optional) aspects of the invention are described. The description uses the reference signs of Figs. 1A-1D and 2A-2D for illustration, but the aspects are not limited to this embodiment. Each of these aspects can be used only by itself or combined with any other aspect(s) described herein.

According to a further aspect of the invention, the switch 2 may further include at least a gas outlet 32 for exhausting quenching gas from inside the housing 5 to outside the housing 5. The gas outlet 32 is positioned in the housing 5 in the second region 4, and is configured to vent a portion of the quenching gas from inside the housing 5. During extinguishing of an arc generated in the arcing region 31, the quenching gas is heated and expands in the second region 4, which may allow a portion of the heated quenching gas to flow through the openings 51 in the shield 50. Venting this heated quenching gas reduces the effect of the change in dielectric properties of the quenching gas during a current break operation to further suppress the re-ignition of an arc between the nominal contact surface 12 and the second contact element 20.

According to a further aspect of the invention, the load break switch 1, 2 is of single-motion type. According to an aspect, the first contact element 10 is a movable contact and can be moved along the axis 6 away from the second contact element 20 for opening the switch. The second contact element 20 may be stationary, for example, fixed to the housing 5. The first contact element 10 is driven by a drive.

According to a further aspect, the first contact element 10 and second contact element 20 have a maximum contact separation of up to 150 mm, preferably up to 110 mm, and/or of at least 10 mm, and preferably of 25 to 75 mm.

According to a further aspect, the housing 5 has a (radial) diameter of 40 to 80 mm, and/or a maximum (axial) length of 40 to 200 mm.

In a further aspect, the pressurizing system may be configured for pressurizing the quenching gas during the current breaking operation to a quenching pressure $p_{quench} < 1,8*p_0$, where p_0 is the ambient (equilibrium) pressure of the insulation gas in the bulk volume 6 of the housing, and p_{quench} is the (maximum overall) pressure of the pressurized insulation gas, also referred to as quenching gas, in the pressurizing chamber during the current breaking operation. This condition on the quenching pressure ensures that the flow of quenching gas is subsonic, and at the same time limits the requirement of the drive which usually delivers the work of pressurizing the quenching gas.

More preferably the quenching pressure satisfies $p_{quench} < 1,5*p_0$ or $p_{quench} < 1,3*p_0$ or even $p_{quench} < 1,1*p_0$. On the other hand, the quenching pressure preferably satisfies $p_{quench} > 1,01*p_0$, so that the pressure buid-up is sufficient for extinguishing the arc.

According to a further aspect, the quenching pressure satisfies $p_{quench} < p_0 + 800$ mbar, preferably $p_{quench} < p_0 + 500$ mbar, more preferably $p_{quench} < p_0 + 300$ mbar, and even more preferably $p_{quench} < p_0 + 100$ mbar. On the other hand, the quenching pressure preferably satisfies $p_{quench} > p_0 + 10$ mbar.

Typically the ambient pressure of the (bulk) insulation gas in the housing p_0 is <= 3 bar, more preferably p_0 <= 1,5 bar, and even more preferably p_0 <= 1,3 bar.

A pressure difference meeting at least one of these conditions allows not only for subsonic flow pattern of the quenching gas but also keeps low the requirements, and hence the cost, of the drive of the switch. These limits nevertheless still allow for reasonable arc extinguishing properties within the ratings of a medium-voltage load break switch. Typically p_0 <= 3 bar, preferably p_0 <= 1,5 bar, more preferably p_0 <= 1,3 bar.

These pressure conditions are very different from typical flow conditions in high-voltage circuit breakers (rated voltage above 72 kV). In these high-voltage circuit breakers (puffer and self-blast type), the flow conditions are sonic in order to maximize the cooling of the arc. Thereby a much higher pressure built-up, p_{quench} 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 medium-voltage load breakers considered here. These medium-voltage load breakers are a completely different type of switch for completely different applications, design and market than high-voltage circuit breakers.

Next, aspects regarding the insulation gas are described.

In a switch according to the present invention, the electrically insulating gas may include SF6. SF6 has excellent dielectric and arc quenching properties, and has therefore been conventionally used in gas-insulated switchgear. However, due to its high global warming potential, there have been large efforts to reduce the emission and eventually stop the usage of such greenhouse gases, and thus to find alternative gases by which SF6 may be replaced.

Such alternative gases have already been proposed for other types of switches. For example, WO2014154292 A1 discloses an SF6 free switch with an alternative electrically insulating gas. Replacing SF6 by such alternative gases is technologically challenging, as SF6 has extremely good switching and insulation properties, due to its intrinsic capability to cool the arc.

According to an aspect, the present configuration allows the use of an alternative gas (e.g., as described in WO2014154292 A1) 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.

The electrically insulating gas preferably has a global warming potential lower than the one of

SF6 over an interval of 100 years. The insulation gas may for example comprise at least one background gas component selected from the group consisting of CO_2, O_2, N_2, H_2, air, N_2O, in a mixture with a hydrocarbon or an organofluorine compound. For example, the dielectric insulating medium may comprise dry air or technical air. The dielectric insulating medium may in particular comprise an organofluorine compound selected from the group consisting of: a fluoroether, an oxirane, a fluoramine, 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 CH_4, 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 hydrofluoroether, 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 N_2, O_2, and/or CO_2.

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 perfluoro-acetonitrile, perfluoropropionitrile (C_2F_5CN) and/or perfluorobutyronitrile (C_3F_7CN). Most particularly, the fluoronitrile can be perfluoroisobutyronitrile (according to formula $(CF_3)_2CFCN$) and/or perfluoro-2-methoxypropanenitrile (according to formula $CF_3CF(OCF_3)CN$). Of these, perfluoroisobutyronitrile is particularly preferred due to its low toxicity.

FURTHER ASPECTS

The switch may further include other parts such as a drive, a controller, and the like, which may have been omitted in the Figures and are not described herein. These parts are provided in analog to a conventional medium-voltage load break switch.

The load break switch may be used as a medium-voltage load break switch. This includes the use as a disconnector in a setting in which an arc cannot be excluded, and/or as a switch-fuse combination switch.

The load break switch may be provided as a part of a gas-insulated ring main unit. Thus, according to a further aspect of the invention, a distribution network, Ring Main Unit, or secondary distribution gas-insulated switchgear is provided, having a load break switch as described herein.

CLAIMS

1. Gas-insulated medium-voltage switch (1, 2) comprising:

- a first contact element (10) having an arcing contact surface (11) and a nominal contact surface (12), wherein the first contact element (10) is moveable along an axis (6) of the switch (1, 2) for opening and closing the switch (1, 2);

- a second contact element (20) configured to make contact with the first contact element (10) for closing the switch (1, 2); and

- a shield (50),

wherein the shield (50) and the first contact element (10) are movable relative to each other along the axis (6) between an exposing configuration and a shielding configuration, such that the shield (50) and the first contact element (10) are in the exposing configuration when the switch (1, 2) is in a closed state and in the shielding configuration during opening of the switch (1, 2),

wherein in the exposing configuration, the shield (50) and the first contact element (10) are arranged to expose the nominal contact surface (12) to the second contact element (20), and in the shielding configuration, the shield (50) and the first contact element (10) are arranged to shield the nominal contact surface (12) of the first contact element (10) from the second contact element (20).

2. Switch (1, 2) according to claim 1, wherein the first contact element (10) comprises an insulating tip (13) at a distal axial position relative to the nominal contact surface (12).

3. Switch (1, 2) according to any of claims 1 and 2, wherein the shield (50) defines a first region (3) and a second region (4) of a housing (5), and wherein the shield (50) further comprises at least an opening (51) positioned closer to the periphery of shield (50) than the axis (6) of switch (1, 2) for equalizing pressure between the first region (3) and the second region (4).

4. Switch (1, 2) according to any of claims 1 to 3, wherein the shield (50) is configured to be moved during a current breaking operation along the axis (6) of the switch (1, 2) between the exposing configuration and the shielding configuration.

5. Switch (1, 2) according to any of claims 1 to 4, wherein the shield (50) comprises a

friction element (52) positioned between the shield (50) and the housing (5).

6. Switch (1) according to any of claims 1 to 5, wherein the shield (50) comprises at least a shield actuating element (53) and the first contact element (10) comprises at least a first contact actuating element (14), wherein the shield actuating element (53) engages with at least one of the first contact element (10) and the first contact actuating element (14) to move shield (50).

7. Switch (1, 2) according to any of claims 1 to 6, wherein the first contact element (10) forms a tube, the second contact element (20) forms a pin, the first and second contact elements defining an arcing region (31), and the second contact element (20) is configured to insert into the first contact element (10) when the switch (1, 2) is in a closed state, wherein the arcing contact surface (11) is an inner surface of the tube and the nominal contact surface (12) is an outer surface portion of the tube, wherein the shield (50) extends outwardly from the nominal contact surface (12) in a radial direction, and an inner surface of the shield (50) is in sliding contact with the nominal contact surface (12).

8. Switch (2) according to claim 7, further comprising:

- a piston (30) for pressurizing a quenching gas during the current breaking operation,

wherein the piston is configured to compress the quenching gas, the compressed quenching gas blowing through the inside of the first contact element (10) and the insulating tip (13) in an axial direction towards the second contact element (20) to extinguish the arc formed in the arcing region (31).

9. Switch (2) according to claim 8, further comprising at least a gas outlet (32) for exhausting quenching gas from inside the housing (5) to outside the housing (5).

10. Switch (2) according to any of claims 8 and 9, wherein the shield (50) comprises at least a shield actuating element (53), wherein the shield actuating element (53) engages with at least one of the first contact element (10) and the piston (30) to move the shield (50).

11. Switch (1, 2) according to any of claims 1 to 10, wherein the switch (1, 2) is configured for a rated system voltages in a range of 1 to 72 kV, and for up to 2000 A rated current.

12. Switch (1, 2) according to any of claims 1 to 11, wherein the switch (1, 2) is a load break switch.

13. Distribution network, Ring Main Unit or secondary distribution switchgear having a load break switch (1, 2) according to claim 12.

14. Method (3) of performing a current breaking operation by a switch (1, 2) comprising a first contact element (10), a second contact element (20) and a shield (50), the first contact element (10) having an arcing contact surface (11) defining an arcing region (31) and a nominal contact surface (12), wherein the shield (50) and the first contact element (10) are movable relative to each other along an axis (6), the method comprising:

- a first movement (301) of separating the first contact element (10) from the second contact element (20) by relative movement away from each other along the axis (6) of the switch (1, 2) so that an arc is formed in the arcing region (31);

- a second movement (302) of moving the first contact element (10) and the shield (50) relative to each other from an exposing configuration wherein the nominal contact surface (12) is exposed to the second contact element (20) to a shielding configuration wherein the nominal contact surface (12) is shielded from the second contact element (20); and

- starting a shielding (303) of the nominal contact surface (12) from the second contact element (20) during opening of the switch (1, 2).

15. Method (3) according to claim 14, further comprising:

- compressing (304) a quenching gas; and

- blowing (305) the quenching gas through the first contact element (10) in an axial direction towards the second contact element (20) to extinguish the arc formed in the arcing region (31).

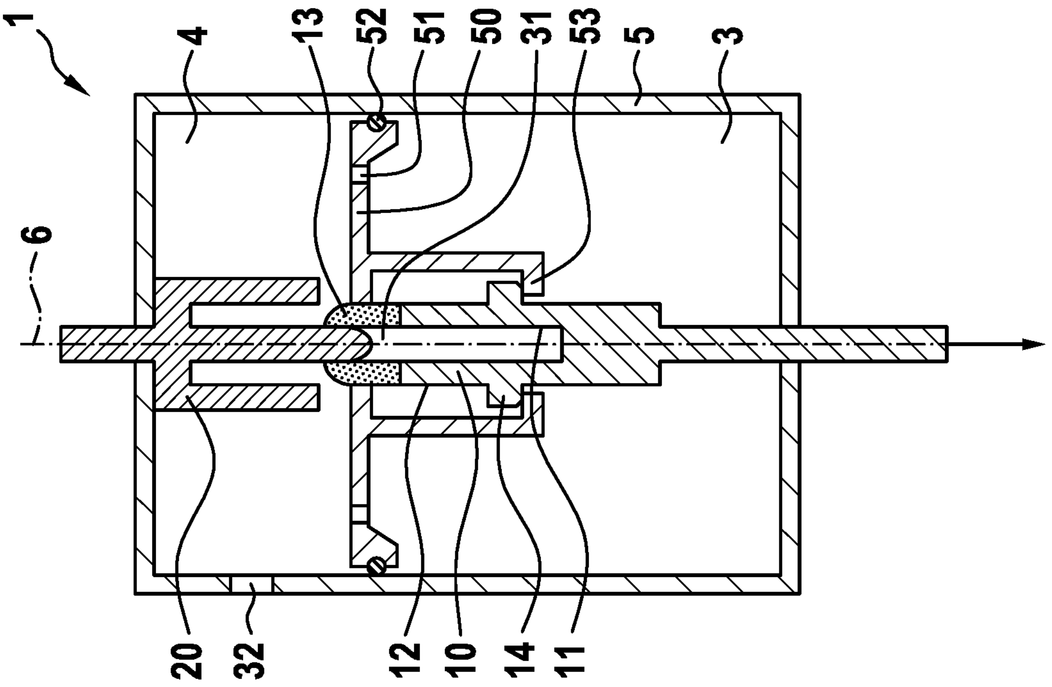
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Fig. 1B

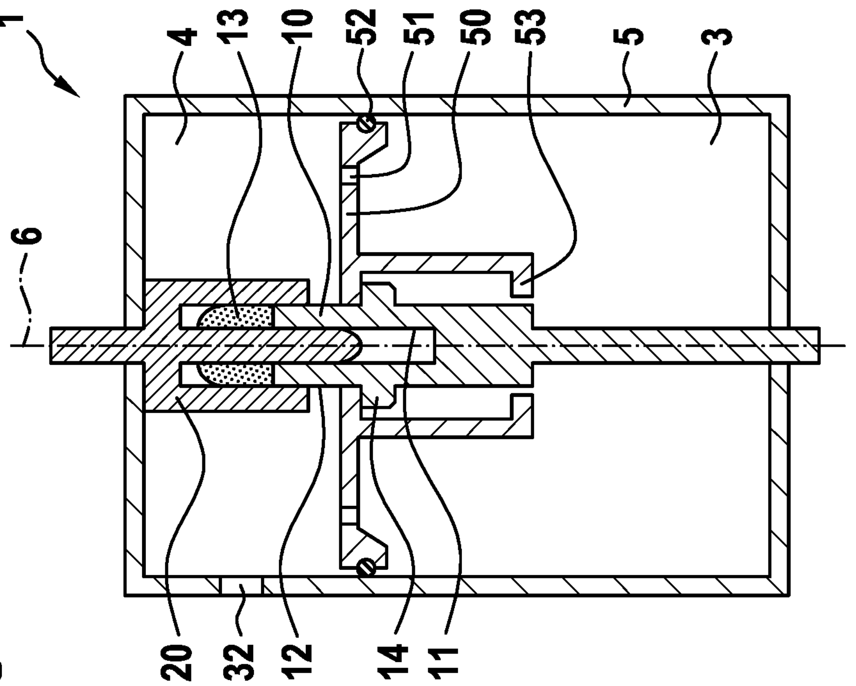
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Fig. 1A

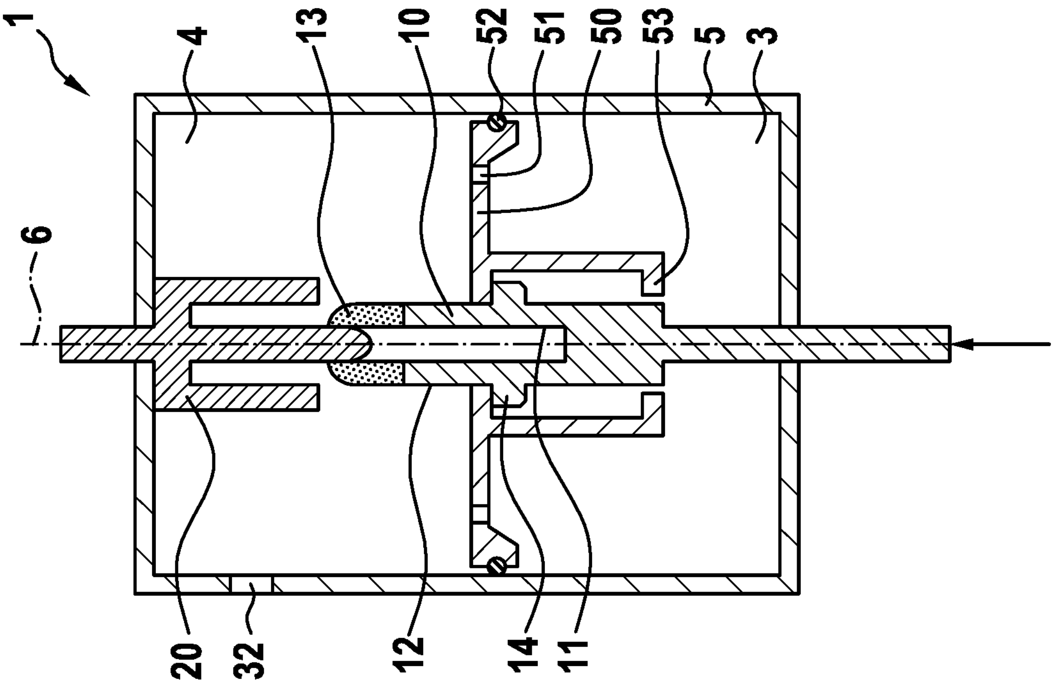
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Fig. 1D

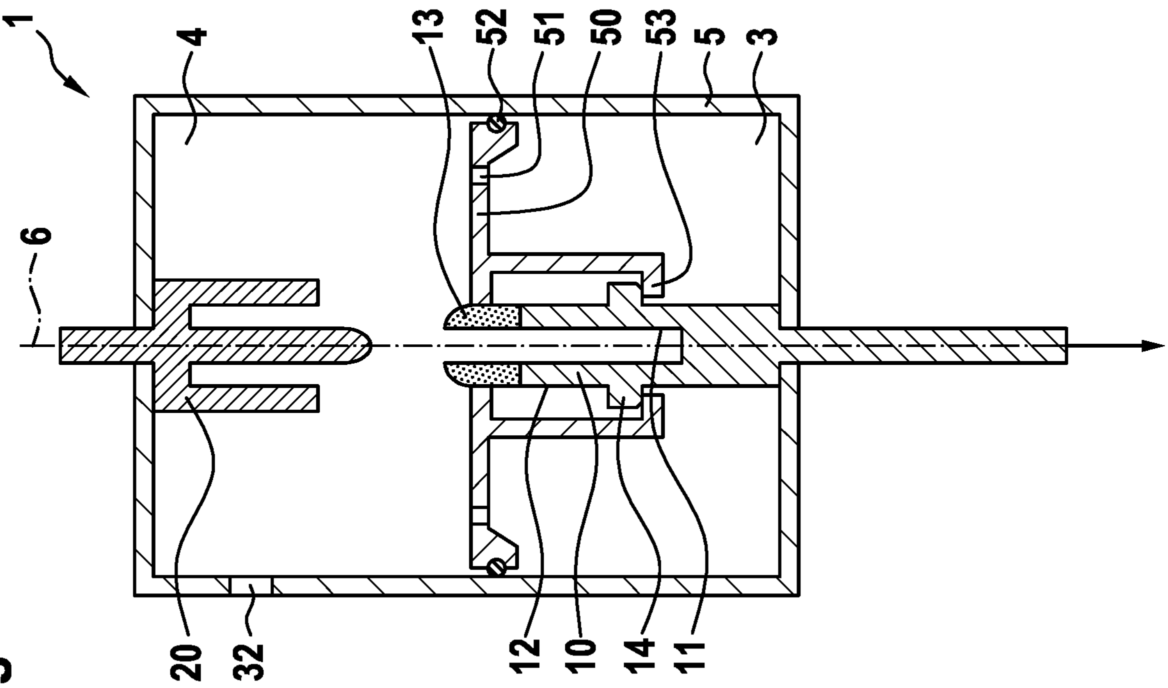
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Fig. 1C

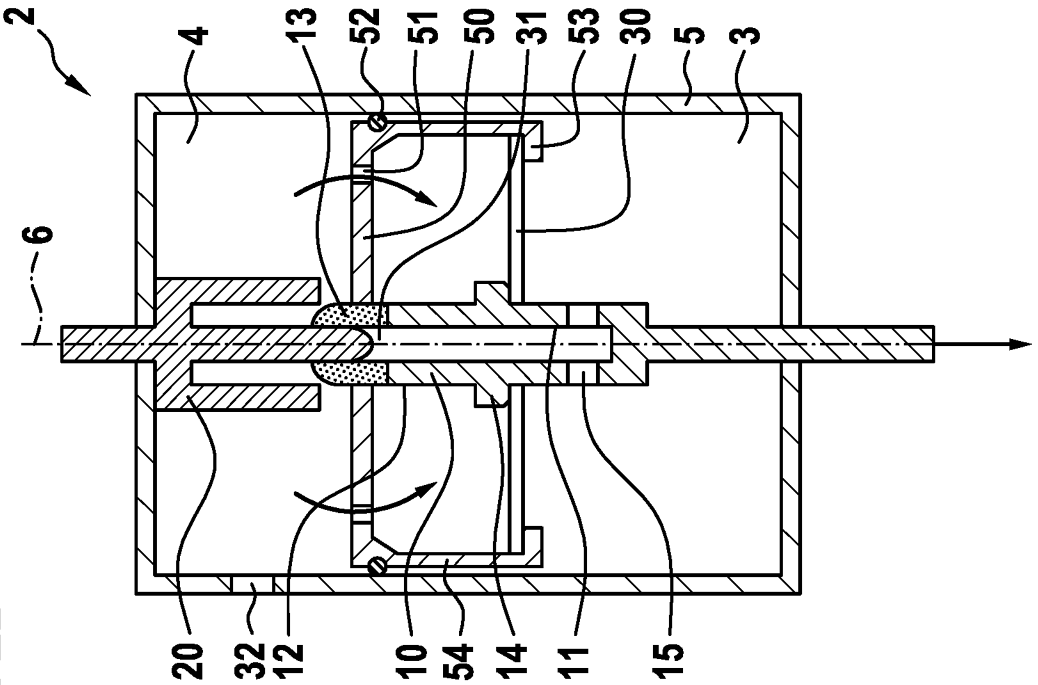
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Fig. 2B

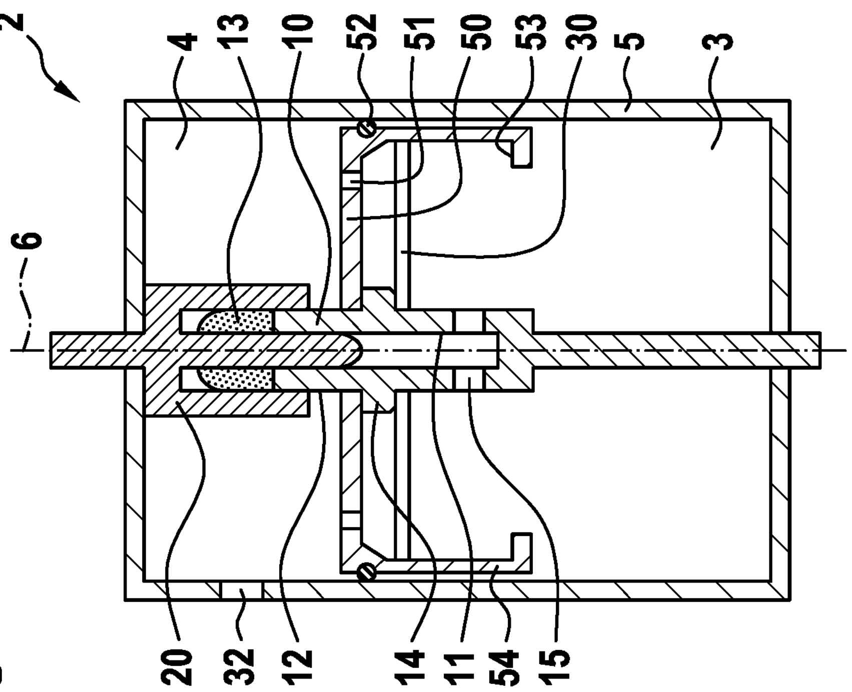
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Fig. 2A

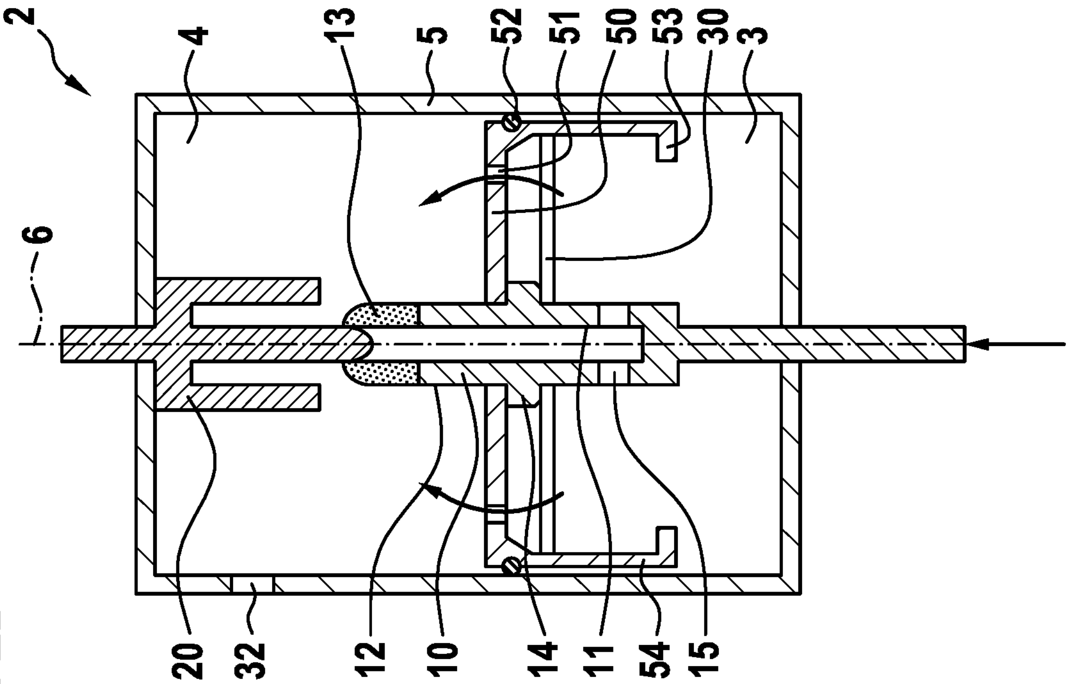
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Fig. 2D

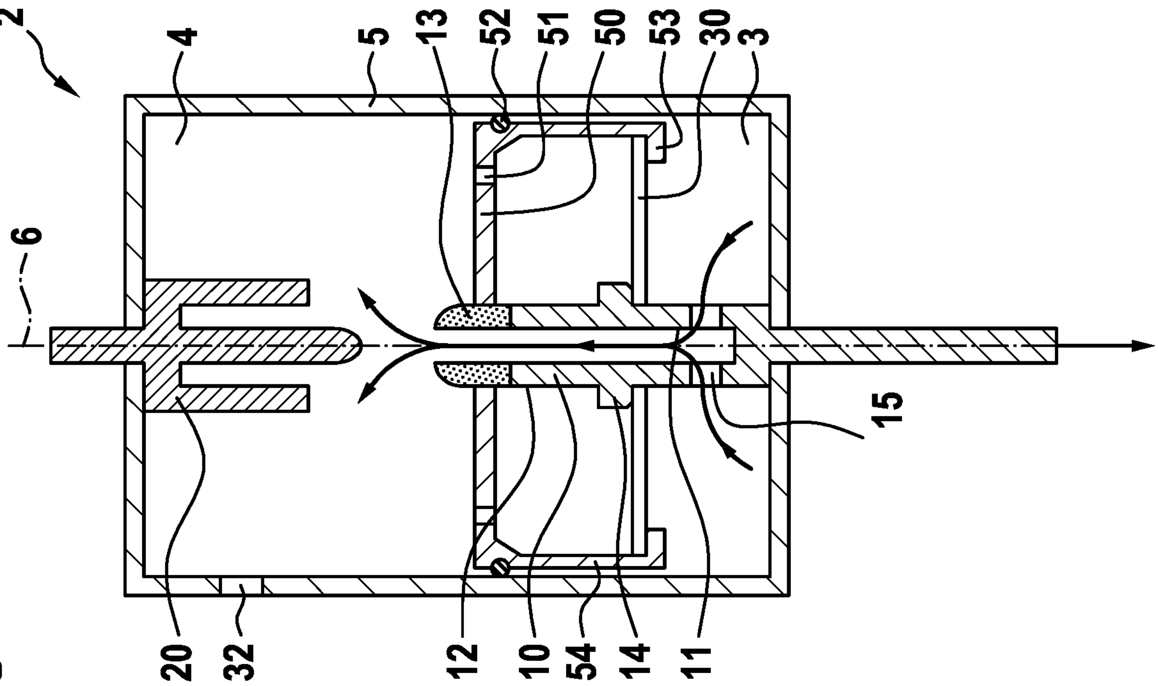
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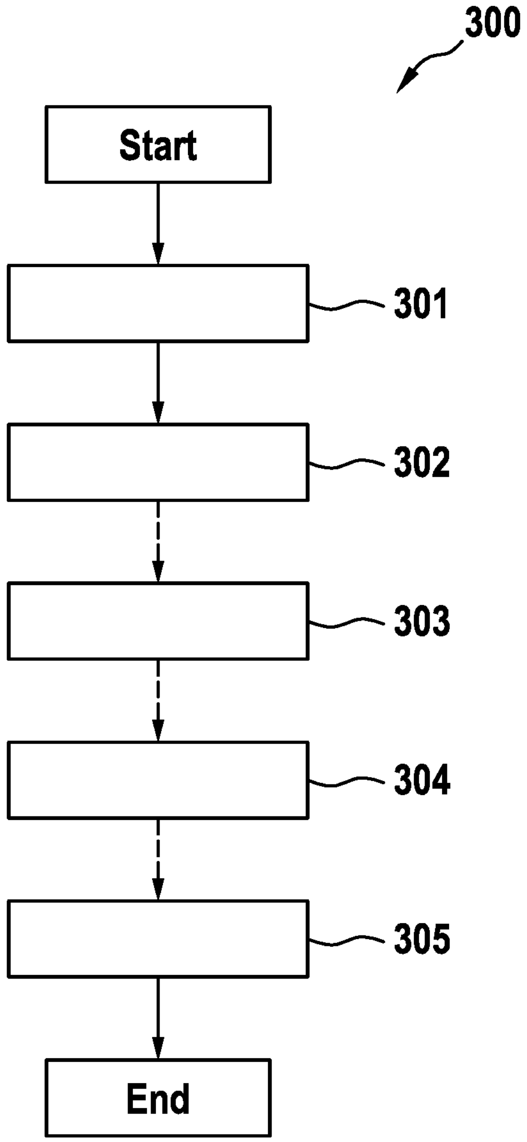
Fig. 2C

Fig. 3



INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2018/078665

A. CLASSIFICATION OF SUBJECT MATTER
INV. H01H33/70 H01H33/90
ADD. H01H1/38

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H01H

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2012/280772 A1 (FUJITA DAISUKE [JP] ET AL) 8 November 2012 (2012-11-08) paragraphs [0032] - [0037] paragraphs [0051] - [0054] figures 1,2,4-7 -----	1,11-14 2-10,15
A	EP 0 016 983 A1 (LICENTIA GMBH [DE]) 15 October 1980 (1980-10-15) page 7, line 19 - page 8, line 16 figure 1 -----	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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"P" document published prior to the international filing date but later than the priority date claimed

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2018	21/12/2018

Name and mailing address of the ISA/	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/EP2018/078665

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