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(54) INTERRUPTER UNIT FOR GAS-INSULATED HIGH OR MEDIUM VOLTAGE DEVICE AND GAS-INSULATED HIGH OR MEDIUM VOLTAGE DEVICE

(57) The invention relates to an interrupter unit (10) for a gas-insulated high or medium voltage device comprising a first arcing contact (12) and a second arcing contact (14), wherein at least one of the arcing contacts (12,14) is axially movable along a switching axis (16), a nozzle (18), wherein the nozzle (18) comprises a heating channel (20) for guiding an arc extinguishing gas in a flow-guiding direction (22) to an arcing region (24) formed between the first (12) and the second arcing contact (14) during an opening operation of the arcing contacts (12,14), wherein the heating channel (20) comprises at an opening (30) of the heating channel (20) into the arcing region (24) a terminal section (32), where a radial component of the flow-guiding direction (22) is equal to or greater than an axial component of the flow-guiding direction (22), wherein the terminal section (32) is rotationally symmetric around the switching axis (16), and wherein the terminal section (32) comprises a segment (34), in which a cross-section area orthogonal to the flow-guiding direction (22) is constant with respect to the flow-guiding direction (22) of the heating channel (20).

Furthermore, the invention relates to a gas-insulated high or medium voltage device comprising the above interrupter unit (10).

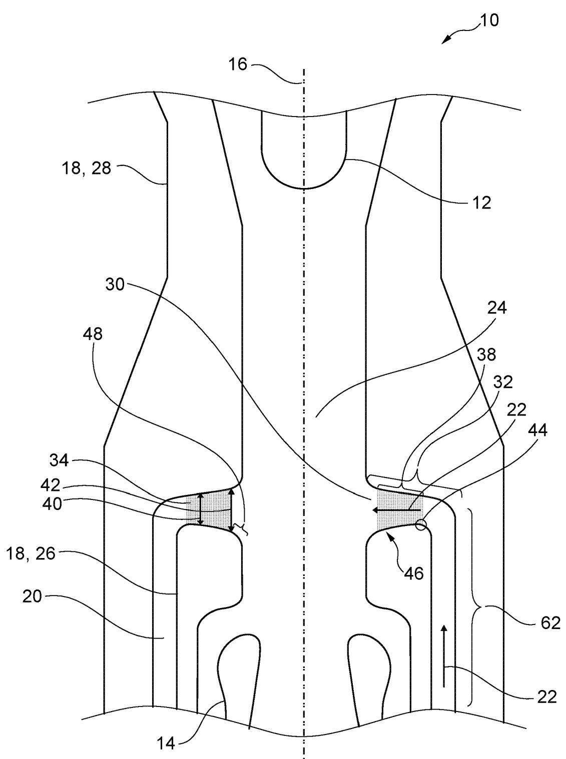

Fig. 1

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Description

Technical Field

[0001] The invention relates to an interrupter unit for a gas-insulated high or medium voltage device.

[0002] The present invention also relates to a gas-insulated high or medium voltage device comprising the above interrupter unit.

Background Art

[0003] High or medium voltage devices, such as circuit breakers and switchgears are essential for the protection of technical equipment, especially in the high voltage range. For example, circuit breakers are predominantly used for interrupting a current, when an electrical fault occurs. As an example, circuit breakers have the task of opening arcing contacts, quench an arc, and keeping the arcing contacts apart from one another in order to avoid a current flow even in case of high electrical potential originating from the electrical fault itself. Circuit breakers, may break medium to high short circuit currents of typically 1 kA to 80 kA at medium to high voltages of 12 kV to 72 kV and up to 1200 kV. Thus, high or medium voltage devices accommodate high-voltage conductors such as lead conductors to which a high voltage is applied.

[0004] Some high or medium voltage devices, namely gas-insulated high or medium voltage devices comprise an insulation gas, for example SF_6, in order to shield and insulate the high-voltage conductor from other component and/or to improve quenching of an arc, when operating arcing contacts.

[0005] In particular the insulation gas is used for extinguishing the arc generated in an arcing region between the arcing contacts when a current is interrupted and is thus also called arc extinguishing gas. The arcing region is typically surrounded by an insulating nozzle. The nozzle typically also serves for guiding a stream of the insulation gas for extinguishing, or blowing off, the arc. Thereby, the insulation gas is typically guided by a dedicated passage in the nozzle, also called heating channel, which ends close to the arcing region. Thus, the insulation gas is guided directly onto the developing arc.

[0006] An electric arc is made up by a flux of electrons and a flux of ions which circulate in opposite directions between the arcing contacts. When the temperature of the arc decreases, ions and electrons recombine and the insulation gas resumes its isolating properties. In a gas insulated circuit breakers, a gaseous mantle surrounds a core of the arc. The temperature of the gaseous mantle decreases as the distance from the arc axis is increased. The current flow is interrupted when an efficient blast of insulation gas is applied to cool the arc and extinguish it.

[0007] Sulphur hexafluoride (SF_6) is widely used as arc extinguishing gas, as it is known for its high dielectric strength and thermal interruption capability. However, SF_6 might have some environmental impact when released into the atmosphere, in particular due to its relatively high global warming potential and its relatively long lifetime in the atmosphere.

[0008] Thus, efforts have been made to substitute SF_6 with different more environmentally friendly arc extinguishing gases or to reduce the SF_6 content in the arc extinguishing gas mixture. For example, one candidate for substituting SF_6 as insulation gas is CO_2. However, the arc extinguishing capability of CO_2 is inferior to that of SF_6. Thus, for a circuit breaker of a conventional design, a sufficient interruption performance is thus often not achieved when CO_2 is used as a quenching gas instead of SF_6. This is particularly the case for relatively high short-circuit currents and voltage ratings.

[0009] However, the thermal interruption capacity of the high or medium voltage device is not only influenced by the type of insulation gas. Also, the design of the nozzle influences the thermal interruption capacity of the high or medium voltage device.

[0010] WO 2013/153112 A1 describes a circuit breaker including two contacts, a pressurization chamber, a nozzle arrangement designed to blow an arc in a quenching region, with a narrowest passage of a pressurization chamber outflow channel to be passed by outflowing quenching gas defining a pressurization chamber outflow limiting area, a narrowest passage of a nozzle channel to be passed by outflowing quenching gas defining a nozzle outflow limiting area, the smaller area of which defining an absolute outflow limiting area, with quenching gas having a global warming potential lower than the one of SF_6 over an interval of 100 years; wherein a ratio of the pressurization chamber outflow limiting area to the nozzle outflow limiting area is less than 1.1:1.

Summary of invention

[0011] It is an object of the invention to provide means to improve the thermal interruption performance of gas-insulated high or medium voltage devices, particularly during high current duties.

[0012] The object of the invention is solved by the features of the independent claims. Modified embodiments are detailed in the dependent claims.

[0013] Thus, the object is solved by an interrupter unit for a gas-insulated high or medium voltage device comprising a first arcing contact and a second arcing contact, wherein at least one of the arcing contacts is axially movable along a switching axis, a nozzle, wherein the nozzle at least partially encloses one of the arcing contacts, wherein the nozzle comprises a heating channel for guiding an arc extinguishing gas in a flow-guiding direction to an arcing region formed between the first and the second arcing contact during an opening operation of the arcing contacts, wherein the heating channel comprises at an opening of the heating channel into the arcing region a terminal section, where a radial component of the flow-guiding direction is equal to or greater than an axial component of the flow-guiding direction, wherein the terminal section is rotationally symmetric around the switching axis, and wherein the terminal section comprises a segment, in which a cross-section area orthogonal to the flow-guiding direction is constant with respect to the flow-guiding direction of the heating channel.

[0014] Furthermore, the object is solved by a gas-insulated high or medium voltage device comprising the above interrupter unit, and wherein the high or medium voltage device comprises an arc extinguishing gas.

[0015] Preferably the arc extinguishing gas is selected from CO_2, mixtures with CO_2, SF_6, mixtures of SF_6 with a carrier gas and/or mixtures of fluoroketons and/or fluoronitriles with a carrier gas. The carrier gas for use with fluoroketons and/or fluoronitriles and/or SF_6 may comprise air, N_2, CO_2, and mixtures thereof. Further preferably the insulation gas may have a reduced fluorine content or may even be essentially fluorine free.

[0016] According to another preferred embodiment of the invention the gas-insulated high or medium voltage device is preferably a circuit breaker and more preferably the gas-insulated high or medium voltage device is configured as a puffer-type circuit breaker, a self-blast circuit breaker, or a combined puffer-type and self-blast circuit breaker. In the context of this invention medium to high voltages means voltages of 12 kV to 72 kV (medium voltage) and up to 1200 kV (high voltage).

[0017] In the present interruption unit, the cross-section area of the heating channel orthogonal to the flow-guiding direction in the segment in the terminal section of the heating channel is constant with respect to the flow-guiding direction of the heating channel. Due to the rotational symmetry of the heating channel in the terminal section, a form of the cross-section area preferably corresponds to a surface of revolution.

[0018] The heating channel preferably links a pressurization chamber of the arc extinguishing gas, which is also called insulation gas, with the arcing region during movement of the at least one arcing contact along the switching axis and is also known as pressurization chamber outflow channel.

[0019] The heating channel comprises at the opening of the heating channel into the arcing region the terminal section, where a radial component of the flow-guiding direction is equal to or greater than an axial component of the flow-guiding direction. The axial component of the flow-guiding direction is colinear to the switching axis. The radial component of the flow-guiding direction is orthogonal to the switching axis and defined by the rotational symmetry of the terminal section of the heating channel around the switching axis.

[0020] Being rotationally symmetric around the switching axis preferably means that the terminal section of the heating channel is such that the switching axis is with respect to the terminal section an infinite rotational symmetry axis C_∞.

[0021] The flow-guiding direction is preferably defined by sidewalls of the nozzle encompassing the heating channel. Preferably the flow-guiding direction at a point in the heating channel is parallel or antiparallel to the direction of the normal vector of a plane through that point, wherein said plain corresponds to a sectional plane of least area through the heating channel.

[0022] Having the radial component of the flow-guiding direction being equal to or greater than the axial component of the flow-guiding direction in the terminal section of the heating channel preferably means in other words that a course of the heating channel is predominantly towards the switching axis - i.e. an angle of the flow-guiding direction with respect to the switching axis is 90° $\pm$ 45° in the terminal section.

[0023] During circuit breaking operation of the high or medium voltage device, the insulation gas preferably flows along the flow-guiding direction towards the arcing region and passes the terminal section of the heating channel before it enters the arcing region. The fluid dynamics of the insulation gas are particularly influenced by the cross-section area of the heating channel orthogonal to the flow-guiding direction.

[0024] The segment with the constant cross-section area with respect to the flow-guiding direction in the terminal section of the heating channel is preferably the narrowest passage the insulation gas passes during its flow from the pressurization chamber to the arcing region and thus preferably constitutes a pressurization chamber out-flow limiting area. After the insulation gas has reached the arcing region, it preferably flows out of the arcing region by passing a nozzle outflow limiting area. The nozzle outflow limiting area, as will be described in more detail later, can be formed by several channels.

[0025] The constant cross-section area of the heating channel in the segment within the terminal section leads to a situation wherein a ratio of the pressurization chamber outflow limiting area to the nozzle outflow limiting area decreases more and more pronounced as the current duties of the medium or high voltage device are increased, due to nozzle ablation. The decrease of such an area ratio establishes more favourable conditions for the quenching of the arc in high current duties, thus improving the thermal interruption capability of the high to medium voltage device in short-line-fault (SLF) test duties.

[0026] In high current duties the nozzle gets severely worn by ablation of material due to the large current, which normally results in a decrease of the quenching capacity of the insulation gas flow, as it changes the pressurization chamber outflow limiting area and thus decreases the driving force that moves the gas flow inside the nozzle. Hence, the gas is flushed less effectively from the nozzle. In turn this leads to a reduction of the safety margin with which the current is interrupted throughout a prescribed breaking sequence. The described segment of the terminal section of the heating channel, which has a constant cross-section area with respect to the flow-guiding direction, allows to increase the safety margin. This is possible as the ablation does not decrease the pressurization chamber outflow limiting area, as it is constant with respect to the flow-guiding direction. Thus, the decrease of the ratio of the pressurization chamber outflow limiting area to the nozzle outflow limiting area helps defer the decrease of the thermal interruption performance of the high or medium voltage device due to the change in the nozzle's contours brought about by ablation.

[0027] According to a preferred embodiment of the invention, the nozzle comprises an auxiliary nozzle and an insulating nozzle arranged around the auxiliary nozzle, wherein the heating channel is formed in between the insulating nozzle and the auxiliary nozzle, wherein in a unworn state of the interrupter unit, axial side walls of the auxiliary nozzle and the insulating nozzle facing the arcing region are rotationally symmetric around the switching axis, and are configured such that a sum of a first narrowest cross-section area orthogonal to the switching-axis encompassed by the axial side wall of the auxiliary nozzle with a second narrowest cross-section area orthogonal to the switching-axis encompassed by the axial side wall of the insulating nozzle is lower than the cross-section area of the heating channel orthogonal to the flow-guiding direction in the segment within the terminal section of the heating channel.

[0028] In other words, the nozzle preferably comprises two parts, the insulating nozzle, which is also called the main nozzle, and the auxiliary nozzle. The insulating nozzle is preferably arranged around the auxiliary nozzle and forming the heating channel in between the insulating nozzle and the auxiliary nozzle. The insulating nozzle and the auxiliary nozzle are preferably at least in the terminal part of the heating channel rotationally symmetric about the switching axis.

[0029] Furthermore, the arcing region preferably comprises two outlets through which the insulation gas can flow out. Thus, the nozzle outflow limiting area is formed by the sum of the first narrowest cross-section area and of the second narrowest cross-section area.

[0030] Although it might be possible - e.g. for medium voltage applications - that only one nozzle with one nozzle outlet is provided, the nozzle preferably comprises the insulating nozzle and the auxiliary nozzle. The axial side walls of the auxiliary nozzle facing the arcing region preferably define the auxiliary nozzle channel, wherein at an auxiliary nozzle throat the auxiliary nozzle channel has a narrowest cross-section with the first narrowest cross-section area. The axial side walls of the insulating nozzle facing the arcing region preferably define the insulating nozzle channel, wherein at an insulating nozzle throat the insulating nozzle channel has a narrowest cross-section with the second narrowest cross-section area.

[0031] The described configuration that the sum of the first narrowest cross-section area (also called auxiliary nozzle throat cross section area) and the second narrowest cross-section area (also called auxiliary nozzle throat cross section area) is lower than the cross-section area of the heating channel in the segment within the terminal section of the heating channel combines the advantage of having the ratio of the pressurization chamber outflow limiting area to the nozzle out-flow limiting area ≥1 in low current duty operations, thereby reducing the risk of dielectric breakdown, with the advantage of having the ratio of the pressurization chamber outflow limiting area to the nozzle out-flow limiting area <1 towards the end of the prescribed breaking sequence in SLF duties. Indeed, the nozzle wear caused by the high-current arc in SLF duties, induces a decrease of the ratio of the pressurization chamber outflow limiting area to the nozzle outflow limiting area towards lower values, since the numerator remains constant by design while the denominator increases due to wear, which in turn leads to an increased thermal interruption performance.

[0032] According to another preferred embodiment of the invention, an interrupter unit is provided, wherein in the unworn state of the interrupter unit, the axial side walls of the auxiliary nozzle and the insulating nozzle facing the arcing region and adjacent to the opening of the heating channel into the arcing region extend at least partially parallel to the switching axis. Preferably, in the unworn state the auxiliary nozzle throat and the insulating nozzle throat have at least at the opening of the heating channel a form corresponding to a right cylinder. Further preferably the diameter of the auxiliary nozzle throat is equal to or smaller than the diameter of the insulating nozzle throat.

[0033] The course of the heating channel from the pressurization chamber to the opening at the arcing region can in principle have any form, as long as within the terminal section of the heating channel the radial component of the flow-guiding direction is equal to or greater than the axial component of the flow-guiding direction. For example, the heating channel can first have a course parallel to the nozzle throat and then change its direction in order to have in the terminal section a course perpendicular to the nozzle throat. In this regard and according to preferred embodiment of the invention, the terminal section comprises a subsection where the flow-guiding direction of the heating channel exclusively has a radial component, and wherein the segment with the constant cross-section area extends at least in part along said subsection. Preferably the segment with the constant cross-section area extends along the whole subsection.

[0034] According to another preferred embodiment of the invention, an interrupter unit is provided, wherein with respect to the flow-guiding direction the segment with the constant cross-section area starts at the beginning of the terminal section, or wherein with respect to the flow-guiding direction the segment with the constant cross-section area starts at the beginning of the subsection where the flow-guiding direction of the heating channel exclusively has a radial component. The segment in the terminal part of the heating channel with the constant cross-section area can start at different points in the terminal section.

[0035] In this regard and according to another embodiment of the invention the nozzle comprises the auxiliary nozzle and the insulating nozzle arranged around the auxiliary nozzle, wherein the heating channel is formed in between the insulating nozzle and the auxiliary nozzle and wherein the segment with the constant cross-section area starts, where a sidewall of the auxiliary nozzle facing the heating channel has its maximal axial extent. The sidewall of the auxiliary nozzle facing the heating channel may at a start of the heating channel be predominantly oriented parallel to the switching axis. Preferably, as the course of the heating channel changes towards the switching axis also the orientation of the sidewall of the auxiliary nozzle changes. The sidewall of the auxiliary nozzle facing the heating channel may be such that the sidewall comprises a turning point, where with respect to the switching axis the sidewall reaches a maximum. Preferably, the segment with the constant cross-section area starts at said turning point.

[0036] According to another preferred embodiment the nozzle comprises the auxiliary nozzle and the insulating nozzle arranged around the auxiliary nozzle, wherein the heating channel is formed in between the insulating nozzle and the auxiliary nozzle and wherein sidewalls of the insulating nozzle and auxiliary nozzle facing the heating channel within the segment with the constant cross-section area are not parallel to each other. As the area of the cross-section is constant with respect to the flow-guiding direction and as the flow-guiding direction comprises a radial component, the sidewalls of the heating channel within the segment are preferably not parallel to each other. In case of parallel sidewalls, the area of the cross-section would indeed decrease along the flow-guiding direction as a radius of a surface of revolution describing the cross-section area decreases.

[0037] In this regard and according to another preferred embodiment the nozzle comprises the auxiliary nozzle and the insulating nozzle arranged around the auxiliary nozzle, wherein the heating channel is formed in between the insulating nozzle and the auxiliary nozzle and wherein within the segment with the constant cross-section area a shortest distance between a sidewall of the insulating nozzle facing the heating channel and a sidewall of the auxiliary nozzle facing the heating channel increases with respect to the flow-guiding direction.

[0038] An end of the segment with the constant cross-section area within the terminal section of the heating channel can in general be at different points of the terminal section. According to another preferred embodiment of the invention an interrupter unit is provided, wherein with respect to the flow-guiding direction the segment with the constant cross-section area ends at the opening of the heating channel into the arcing region, or wherein with respect to the flow-guiding direction the segment with the constant cross-section area ends at the beginning of a fillet region at the opening of the heating channel into the arcing region.

[0039] In other words, the segment with constant cross-section area preferably extends until the opening of the heating channel at the arcing region. However, as edges of the opening of the heating channel may be rounded and/or may be configured as fillet edges, it is also possible that the segment with the constant cross-section area ends with the beginning of the fillet region.

[0040] As already mentioned, the course of the heating channel from the pressurization chamber to the opening at the arcing region can in principle have any form, as long as within the terminal section of the heating channel the radial component of the flow-guiding direction is equal to or greater than the axial component of the flow-guiding direction. However, according to another preferred embodiment of the invention an interrupter unit is provided, wherein the heating channel comprises with respect to the flow-guiding direction upstream to the terminal section and adjacent to the terminal section, a further section, where the radial component of the flow-guiding direction is lower than the axial component of the flow-guiding direction, wherein the further section is rotationally symmetric around the switching axis, and wherein the further section is configured such that the further section comprises a further segment, where a cross-section area of the heating channel orthogonal to the flow-guiding direction is constant with respect to the flow-guiding direction.

[0041] Further preferably the further segment with the constant cross-section area in the further section of the heating channel is preferably adjacent to the segment with the constant cross-section area in the terminal section of the heating channel.

[0042] According to another preferred embodiment of the invention an interrupter unit is provided, wherein with respect to the flow-guiding direction the further segment with the constant cross-section area ends at the beginning of the terminal section. Further preferably the cross-section area within the further segment and within the segment are the same.

[0043] According to another preferred embodiment the further section comprises a further subsection, where the flow-guiding direction of the channel exclusively has an axial component.

[0044] According to another preferred embodiment of the invention, the cross-section area of the heating channel orthogonal to the flow-guiding direction within the segment with the constant cross-section area has a form corresponding to a lateral surface of a right circular cylinder or to a lateral surface of a conical frustum, and/or wherein the cross-section area of the heating channel orthogonal to the flow-guiding direction within the further segment with the constant cross-section area has a form corresponding to a lateral surface of a conical frustum or to an annulus.

[0045] As already mentioned, the cross-section area preferably has a form that corresponds to a surface of revolution. Depending on the course of the heating channel, the surface of revolution can have different forms and/or can correspond to lateral surfaces of different bodies of revolution. Preferably in connection to the terminal section of the heating channel, the form of the cross-section area corresponds to the lateral surface of a right circular cylinder or to the lateral surface of a conical frustum. Further preferably, in the subsection of the section, where the flow-guiding direction of the heating channel exclusively has a radial component, the form of the cross-section area corresponds to the lateral surface of a right circular cylinder.

[0046] Further preferably in connection to the further section of the heating channel, the form of the cross-section area corresponds to the lateral surface of a conical frustum or to an annulus. Further preferably, in the further subsection of the further section, where the flow-guiding direction of the heating channel exclusively has an axial component, the form of the cross-section area corresponds to an annulus.

[0047] These and other aspects of the invention will be apparent from and elucidated with reference to the embodiments described hereinafter.

[0048] In the drawings:

Fig. 1 schematically shows an interrupter unit for a gas-insulated high voltage circuit breaker, according to a preferred embodiment.

Fig. 2 schematically shows the interrupter unit of figure 1 in an unworn state and in a worn state,

Fig. 3 schematically shows two exemplary cross-sectional areas of a heating channel within a segment of the heating channel of the interrupter unit of figure 1, and

Fig. 4 schematically shows an interrupter unit for a gas-insulated high voltage circuit breaker, according to another preferred embodiment.

Description of embodiments

[0049] Fig. 1 schematically shows an interrupter unit 10 for a gas-insulated high or medium circuit breaker, according to a preferred embodiment. The interrupter unit 10 comprising a first arcing contact 12 and a second arcing contact 14. In this embodiment the first arcing contact 12 has the form of a plug contact 12 and the second arcing contact 14 is configured as tulip contact 14. The plug contact 12 is axially movable along a switching axis 16. The tulip contact 14 is configured to engage around a proximal portion of the plug contact 12, in the closed position of the contacts 12, 14 (not shown in figure 1). In the open position of the contacts 12, 14 the plug contact 12 and tulip contact 14 are apart from each other, as shown in figure 1.

[0050] The interrupter unit 10 further comprises a nozzle 18, wherein the nozzle 18 at least partially encloses the arcing contacts 12, 14. The nozzle 18 comprises a heating channel 20 for guiding an arc extinguishing gas in a flow-guiding direction 22 to an arcing region 24 formed between the first arcing contact 12 and the second arcing contact 14 during the opening operation of the arcing contacts 12, 14. The heating channel 20 links a pressurization chamber of the arc extinguishing gas (not shown in figure 1), with the arcing region 24 during the relative movement of the arcing contacts 12 and 14 along the switching axis 16.

[0051] In this embodiment the nozzle 18 comprises an auxiliary nozzle 26 and an insulating nozzle 28 arranged around the auxiliary nozzle 26 and the heating channel 20 is formed in between the insulating nozzle 28 and the auxiliary nozzle 26. The heating channel 20 comprises at an opening 30 of the heating channel 20 into the arcing region 24 a terminal section 32, where a radial component of the flow-guiding direction 22 is equal to or greater than an axial component of the flow-guiding direction 22. The terminal section 32 of the heating channel 20 is rotationally symmetric around the switching axis 16. The axial component of the flow-guiding direction 22 is the component colinear to the switching axis 16. The radial component of the flow-guiding direction 22 is orthogonal to the switching axis 26 and defined by the rotational symmetry of the terminal section 32 around the switching axis 16.

[0052] The terminal section 32 comprises a segment 34, in figure 1 the shaded area 34, where a cross-section area of the heating channel 20 orthogonal to the flow-guiding direction 22 is constant with respect to the flow-guiding direction 22 of the heating channel 20.

[0053] In this embodiment the terminal section 32 further comprises a subsection 38, where the flow-guiding direction 22 of the heating channel 20 exclusively has a radial component. In other words, and as can be seen in figure 1, in this subsection 38, the course of the heating channel 20 is such that the flow-guiding direction 22 is orthogonal to the switching axis 26. The segment 34 with the constant cross-section area extends at least in part along said subsection 38.

[0054] Furthermore, and as is also illustrated in figure 3, in the embodiment shown in figure 1 the cross-section area of the heating channel 20 orthogonal to the flow-guiding direction 22 within the segment 34 with the constant cross-section area has a form 36 corresponding to a lateral surface of a cylinder. Figure 3 illustrates two exemplary forms 36 of the cross-section areas, which correspond to the cross-sections indicated by the arrows 40, 42 in figure 1. As can also be seen in figure 3, is that the height of the cylinders, which are also indicated by the arrows 40, 42 increases when the radius of the cylinder decreases. As the height of the cylinder corresponds to a shortest distance between the sidewall of the insulating nozzle 28 facing the heating channel 20 and a sidewall 46 of the auxiliary nozzle 26 facing the heating channel 20, figure 3 and 1 also illustrate that in the segment 34 the heating channel 20 is formed such that the shortest distance increases with respect to the flow guiding direction 22.

[0055] In another preferred embodiment shown in figure 4 the course of the heating channel 20 in the terminal section 32 is different from the embodiment as shown in figure 1. In the embodiment shown in figure 4 the course of the heating channel 20 in the terminal section 32 is such that the flow guiding direction 22 has in addition to the radial component also an axial component. For simplicity only one halve of the rotationally symmetric part of the interrupter unit 10 is shown in figure 4 and also only the second arcing contact 14 of the first and second arcing contacts 12, 14 is shown in figure 4. In the embodiment shown in figure 4, the form of the constant cross-section area would correspond to a lateral surface of a conical frustrum.

[0056] Furthermore, and with regard to the segment 34 with the constant cross-section area, in the embodiments shown in figures 1 and 4 the segment 34 starts with respect to the flow-guiding direction 22 at a point 44, where a sidewall 46 of the auxiliary nozzle 26 facing the heating channel 20 has its maximal axial extent. As can be seen in figures 1 and 3, at a beginning of the heating channel 20 the sidewall 46 of the auxiliary nozzle 26 facing the heating channel 20 is predominantly oriented parallel to the switching axis 16. However, as the course of the heating channel 20 changes towards the switching axis 16 also the orientation of the sidewall 46 changes. The segment 34 starts at the point 44, where the sidewall 46 has a turning point and the axial extent of the sidewall 46 reaches its maximum.

[0057] As can also be seen in figure 1, the edges of the opening 30 of the heating channel 20 into the arcing region 24 are rounded and configured as fillet edges. The end of the segment 34 with the constant cross-section area within the terminal section 32 of the heating channel 20 ends in this embodiment at the beginning of the fillet region 48 at the opening 30 of the heating channel 20 into the arcing region 24.

[0058] With respect to figure 2, which shows the interrupter unit 10 of figure 1 in an unworn state (indicated by a continuous line of the contour) and in a worn state, where sidewalls 50, 50', 52, 52' of the nozzle 18 are ablated (indicated by a dashed line of the contour), axial side walls 50 of the auxiliary nozzle 26 and axial side walls 52 of the insulating nozzle 28 facing the arcing region 24 and adjacent to the opening 30 of the heating channel 20 extend at least partially parallel to the switching axis 16 in the unworn state of the nozzle 18.

[0059] The axial side walls 50 of the auxiliary nozzle 26 define an auxiliary nozzle channel 54 and the axial side walls 52 of the insulating nozzle 28 define an insulating nozzle channel 56. In the embodiment shown in figure 2, in the unworn state of the interrupter unit 10, a diameter 58 of the auxiliary nozzle channel 54 and a diameter 60 of the insulating nozzle channel 56 are the same.

[0060] In the embodiment shown in figure 2 the segment 34 with the constant cross-section area within the terminal section 32 of the heating channel 20 is the narrowest passage the arc extinguishing gas passes during its flow from the pressurization chamber to the arcing region 24 and constitutes a pressurization chamber outflow limiting area.

[0061] Furthermore, in the unworn state, a nozzle outflow limiting area is defined by the sum of a first narrowest cross-section area defined by the the diameter 58 of the auxiliary nozzle channel 54 and encompassed by the axial side wall 50 of the auxiliary nozzle 26 with a second narrowest cross-section area defined by the the diameter 60 of the insulating nozzle channel 56 and encompassed by the axial side wall 52 of the insulating nozzle 28.

[0062] In the worn state the nozzle outflow limiting area is defined by the sum of a first narrowest cross-section area defined by the the diameter 58' of the auxiliary nozzle channel 54 and encompassed by the axial side wall 50' of the auxiliary nozzle 26 with a second narrowest cross-section area defined by the the diameter 60' of the insulating nozzle channel 56 and encompassed by the axial side wall 52' of the insulating nozzle 28.

[0063] In the embodiment shown in figure 2 the interruption unit 10 is configured such that in the unworn state a ratio between the pressurization chamber outflow limiting area to the nozzle outflow limiting area is ≥1 and changes to <1 in the worn state.

[0064] As can be further seen in figure 1, the heating channel 20 comprises with respect to the flow-guiding direction 22 upstream to the terminal section 32 and adjacent to the terminal section 32, a further section 62, where the radial component of the flow-guiding direction 22 is lower than the axial component of the flow-guiding direction 22. Furthermore, in the embodiment shown in figure 1, the further section 62 is rotationally symmetric around the switching axis 16, and comprises a further segment, where a cross-section area of the heating channel 20 orthogonal to the flow-guiding direction 22 is constant with respect to the flow-guiding direction 22.

[0065] While the invention has been illustrated and described in detail in the drawings and foregoing description, such illustration and description are to be considered illustrative or exemplary and not restrictive; the invention is not limited to the disclosed embodiments. Other variations to be disclosed embodiments can be understood and effected by those skilled in the art in practicing the claimed invention, from a study of the drawings, the disclosed, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage. Any reference signs in the claims should not be construed as limiting scope.

Reference signs list

[0066]

10	interrupter unit
12	first arcing contact, plug contact
14	second arcing contact, tulip contact

16 switching axis
18 nozzle
20 heating channel
22 flow guiding direction
24 arcing region
26 auxiliary nozzle
28 insulating nozzle
30 opening of heating channel
32 terminal section
34 segment
36 form of cross-section area of segment 34
38 subsection
40 arrow
42 arrow
44 point where sidewall of heating channel has maximal axial extent
46 sidewall of auxiliary nozzle facing heating channel
48 fillet region
50 side wall of auxiliary nozzle facing arcing region in unworn state
50' side wall of auxiliary nozzle facing arcing region in worn state
52 side wall of insulating nozzle facing arcing region in unworn state
52' side wall of insulating nozzle facing arcing region in worn state
54 auxiliary nozzle channel
56 insulating nozzle channel
58 diameter of auxiliary nozzle channel in unworn state
58' diameter of auxiliary nozzle channel in worn state
60 diameter of insulating nozzle channel in unworn state
60' diameter of insulating nozzle channel in worn state
62 further section

Claims

1. Interrupter unit (10) for a gas-insulated high or medium voltage device comprising

a first arcing contact (12) and a second arcing contact (14), wherein at least one of the arcing contacts (12,14) is axially movable along a switching axis (16),
a nozzle (18), wherein the nozzle (18) at least partially encloses one of the arcing contacts (12,14),
wherein the nozzle (18) comprises a heating channel (20) for guiding an arc extinguishing gas in a flow-guiding direction (22) to an arcing region (24) formed between the first (12) and the second arcing contact (14) during an opening operation of the arcing contacts (12,14),
wherein the heating channel (20) comprises at an opening (30) of the heating channel (20) into the arcing region (24) a terminal section (32), where a radial component of the flow-guiding direction (22) is equal to or greater than an axial component of the flow-guiding direction (22),
wherein the terminal section (32) is rotationally symmetric around the switching axis (16),
and wherein the terminal section (32) comprises a segment (34), in which a cross-section area orthogonal to the flow-guiding direction (22) is constant with respect to the flow-guiding direction (22) of the heating channel (20).

2. The interrupter unit (10) according to claim 1, wherein the nozzle (18) comprises an auxiliary nozzle (26) and an insulating nozzle (28) arranged around the auxiliary nozzle (26), wherein the heating channel (20) is formed in between the insulating nozzle (28) and the auxiliary nozzle (26), wherein in a unworn state of the interrupter unit (10), axial side walls (50,52) of the auxiliary nozzle (26) and the insulating nozzle (28) facing the arcing region (24) are rotationally symmetric around the switching axis (16), and are configured such that a sum of a first narrowest cross-section area orthogonal to the switching-axis (16) encompassed by the axial side wall (50) of the auxiliary nozzle (26) with a second narrowest cross-section area orthogonal to the switching-axis (16) encompassed by the axial side wall (52) of the insulating nozzle (28) is lower than the cross-section area of the heating channel (20) within the segment (34).

3. The interrupter unit (10) according to the previous claims, wherein in the unworn state of the interrupter unit (10), the axial side walls (50,52) of the auxiliary nozzle (26) and the insulating nozzle (28) facing the arcing region (24) and adjacent to the opening (30) of the heating channel (20) into the arcing region (24) extend at least partially parallel to the switching axis (16).

4. The interrupter unit (10) according to any of the previous claims, wherein the terminal section (32) comprises a subsection (38) where the flow-guiding direction (22) of the heating channel (20) exclusively has a radial component, and wherein the segment (34) with the constant cross-section area extends at least in part along said subsection (38).

5. The interrupter unit (10) according to any of the previous claims, wherein with respect to the flow-guiding direction (22) the segment (34) with the constant cross-section area starts at the beginning of the terminal section (32), or wherein with respect to the flow-guiding direction (22) the segment (34) with the constant cross-section area starts at the beginning of the subsection (38) where the flow-guiding direction (22) of the heating channel (20) exclusively has a radial component.

6. The interrupter unit (10) according to any of the previous claims, wherein the nozzle (18) comprises an auxiliary nozzle (26) and an insulating nozzle (28) arranged around the auxiliary nozzle (26), wherein the heating channel (20) is formed in between the insulating nozzle (28) and the auxiliary nozzle (26), and wherein the segment (34) with the constant cross-section area starts, where a sidewall (46) of the auxiliary nozzle (26) facing the heating channel (20) has its maximal axial extent.

7. The interrupter unit (10) according to any of the previous claims, wherein the nozzle (18) comprises an auxiliary nozzle (26) and an insulating nozzle (28) arranged around the auxiliary nozzle (26), wherein the heating channel (20) is formed in between the insulating nozzle (28) and the auxiliary nozzle (26), and wherein sidewalls (46) of the insulating nozzle (28) and auxiliary nozzle (26) facing the heating channel (20) within the segment (34) with the constant cross-section area are not parallel to each other.

8. The interrupter unit (10) according to any of the previous claims, wherein the nozzle (18) comprises an auxiliary nozzle (26) and an insulating nozzle (28) arranged around the auxiliary nozzle (26), wherein the heating channel (20) is formed in between the insulating nozzle (28) and the auxiliary nozzle (26), and wherein within the segment (34) with the constant cross-section area a shortest distance between a sidewall of the insulating nozzle (28) facing the heating channel (20) and a sidewall (46) of the auxiliary nozzle (26) facing the heating channel (20) increases with respect to the flow-guiding direction (22).

9. The interrupter unit (10) according to any of the previous claims, wherein with respect to the flow-guiding direction (10) the segment (34) with the constant cross-section area ends at the opening (30) of the heating channel (20) into the arcing region (24) or wherein with respect to the flow-guiding direction (22) the segment (34) with the constant cross-section area ends at the beginning of a fillet region (48) at the opening (30) of the heating channel (20) into the arcing region (24).

10. The interrupter unit (10) according to any of the previous claims, wherein the heating channel (20) comprises with respect to the flow-guiding direction (22) upstream to the terminal section (32) and adjacent to the terminal section (32), a further section (62), where the radial component of the flow-guiding direction (22) is lower than the axial component of the flow-guiding direction (22), wherein the further section (62) is rotationally symmetric around the switching axis (16), and wherein the further section (62) is configured such that the further section (62) comprises a further segment, where a cross-section area of the heating channel (20) orthogonal to the flow-guiding direction (22) is constant with respect to the flow-guiding direction (22).

11. The interrupter unit (10) according to the previous claim, wherein with respect to the flow-guiding direction (22) the further segment with the constant cross-section area ends at the beginning of the terminal section (32).

12. The interrupter unit (10) according to any of claims 10 or 11, wherein the further section comprises a further subsection, where the flow-guiding direction (22) of the heating channel (20) exclusively has an axial component.

13. The interrupter unit (10) according to any of the previous claims, wherein the cross-section area of the heating channel (20) orthogonal to the flow-guiding direction (20) within the segment (34) with the constant cross-section area has a form (36) corresponding to a lateral surface of a right circular cylinder or to a lateral surface of a conical frustum, and/or wherein the cross-section area of the heating channel (20) orthogonal to the flow-guiding direction (22) within the further segment with the constant cross-section area has a form corresponding to a lateral surface of a conical frustum or to an annulus.

14. Gas-insulated high or medium voltage device comprising an interrupter unit (10) according to any of the previous claims, and wherein the high or medium voltage device comprises an arc extinguishing gas.

15. Gas-insulated high or medium voltage device according to the previous claim, wherein the gas-insulated high or medium voltage device is configured as a circuit breaker and more preferably as a puffer-type circuit breaker, a self-blast circuit breaker, or a combined puffer-type and self-blast circuit breaker.

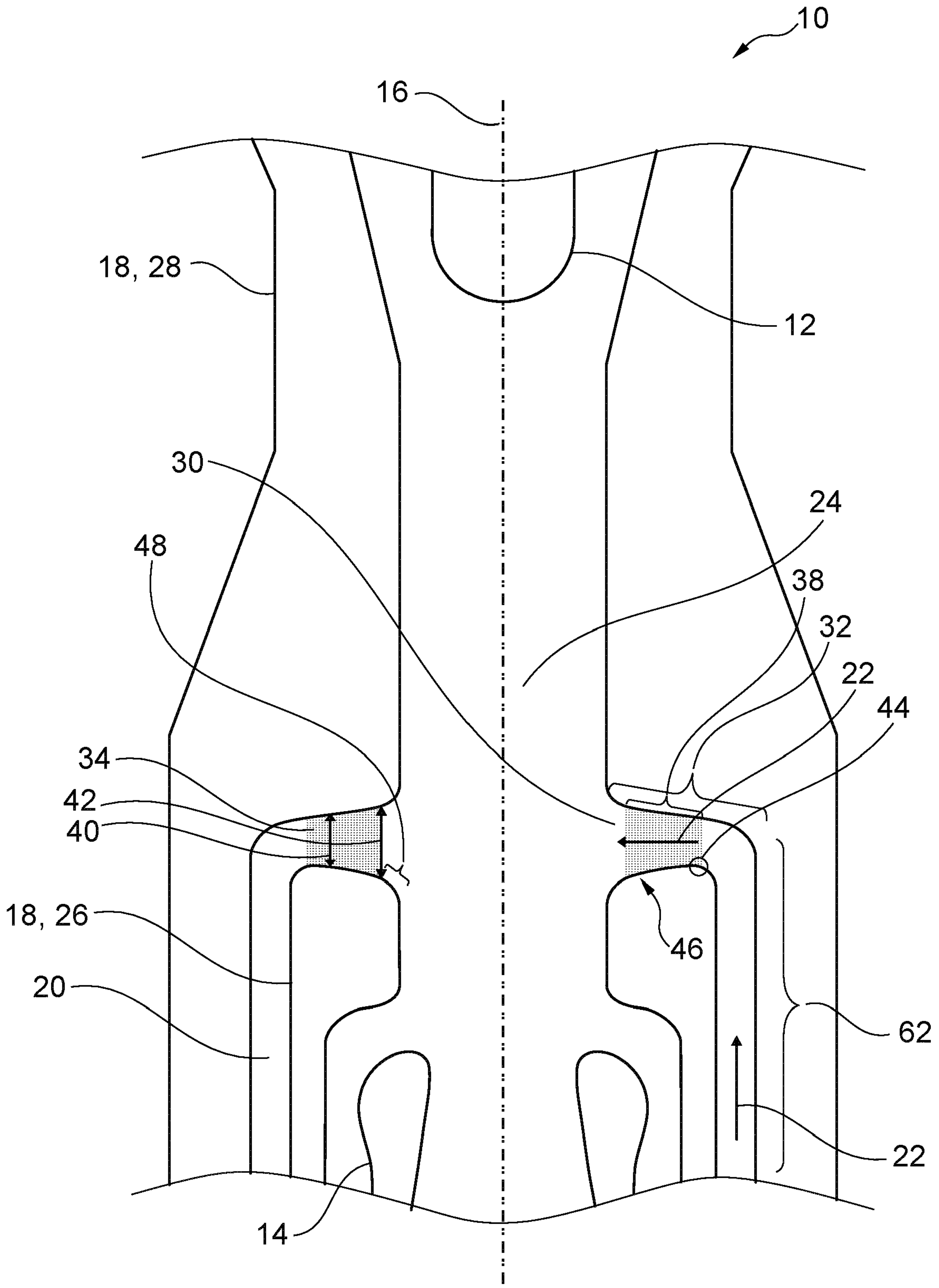
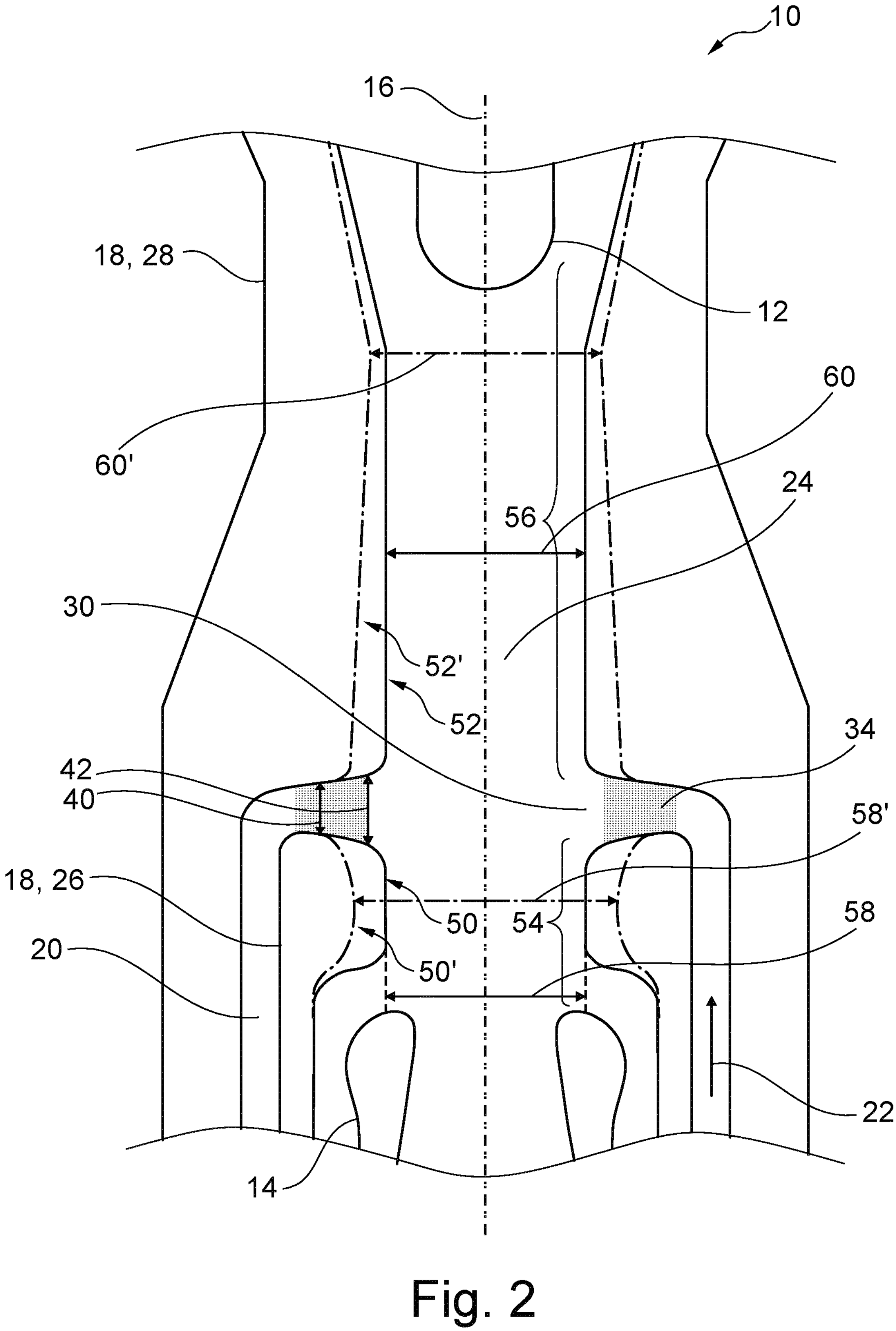


Fig. 1


10
16
18, 28
12
60
60'
56
24
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52'
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58'
18, 26
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20
50'
22
14

Fig. 2

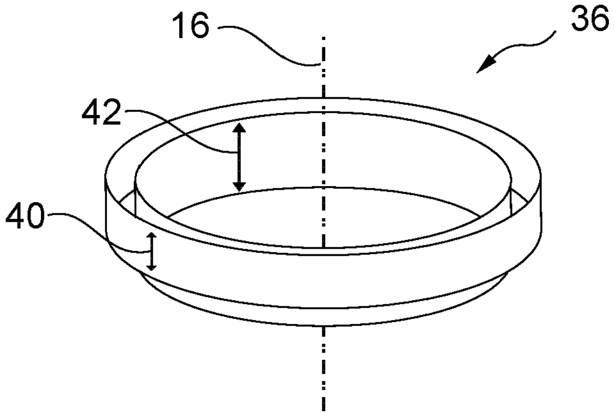

Fig. 3

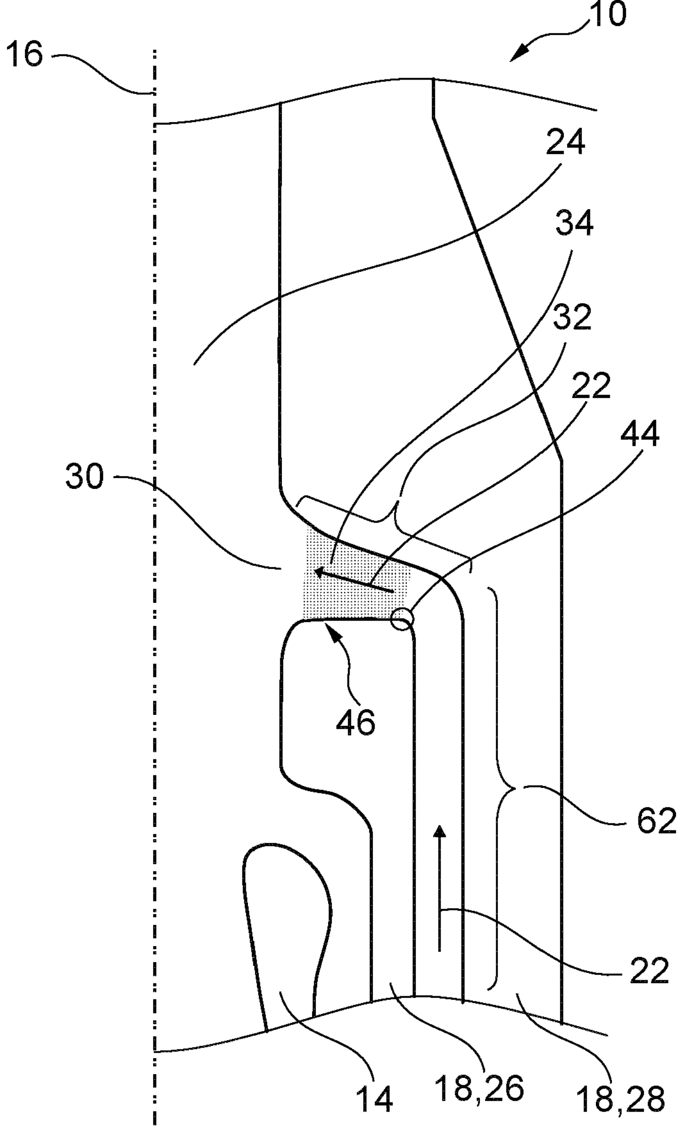

Fig. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 22 16 2161

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The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
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