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(54) **Gas-insulated high-voltage circuit breaker with obstructing member**

(57) The present invention relates to a gas-insulated high-voltage circuit breaker (1), comprising arcing contacts (11, 21) and a nozzle (30) providing a channel (32) for gas flow and arc extinction, and further having an obstructing member (90) being movable within the channel (32) relative to one of the contacts (21) and to the

nozzle (30) for varying the gas outflow cross section as a function of the position of the obstructing member (90) in such a way that an improved gas pressurizing configuration (301) or gas pressurizing phase and a subsequent gas clearing configuration (302) or gas clearing phase are realized.

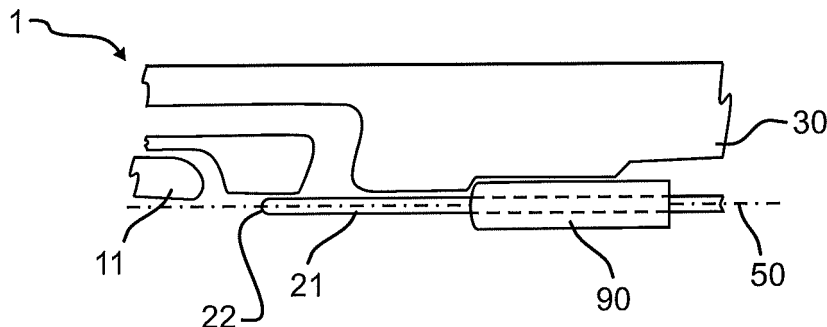


Fig. 1B

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Description**TECHNICAL FIELD**

5 **[0001]** The present invention in general relates to high-voltage circuit breakers. In particular, the present invention relates to a gas-insulated circuit breaker.

BACKGROUND OF THE INVENTION

10 **[0002]** High-voltage (HV) circuit breakers often interrupt electrical current by the separation of two conducting electrical contacts within a dielectric gas, which can aid in the interruption of the flow of electric current. Soon after initial separation of the two contacts, the electrical current continues to flow and is carried by an arc between the two contacts. Many technical features of HV circuit breakers (HVCBs) are designed to address problems associated with extinguishing the arc, which generates heat and pressure that may lead to the damage of components of the circuit breaker. Thus, a
15 problem in the field of HVCBs is that of extinguishing the arc, which may occur by the flow of an insulating gas across or through the arcing region.

[0003] WO 2009/124582 A1 shows a gas-insulated high-voltage switch. The switch contains two arcing contacts which can move relative to one another along an axis, and an insulating nozzle having a long constriction which contains two sections with different flow cross section; the first section which is contiguous to an inlet of the nozzle has a smaller
20 minimum flow cross-section than the second section.

[0004] FR 2692414 A1 shows an electrical circuit-breaker with a contact formed from a metal tube. A stopper can be made in the form of a concentric cylinder on the outside of the tube. When a strong current is cut, the force of the gas against the front face of the stopper causes it to retract against the effort of a spring and ensure full blowing of the nozzle aperture.

25 **[0005]** EP 2 099 047 A1 discloses a circuit breaker with a gas-flow regulating element for increasing gas density in the arcing region after arc extinction to avoid gas density minima, which could otherwise reduce dielectric strength and cause arc restriking during an exhaust-gas out-blowing phase.

SUMMARY

30 **[0006]** It is an object of the present invention to provide a gas-insulated HVCB and method of interrupting electrical current in a gas-insulated HVCV that overcome at least some of the problems in the art, such as of extinguishing the arc. A gas-insulated HVCB according to independent claim 1 and a method of interrupting electrical current in a gas-insulated HVCV according to independent claim 11 are provided.

35 **[0007]** Further aspects, advantages, and features of the present invention are apparent from the claims, the description, and the accompanying drawings.

[0008] According to an embodiment, a gas-insulated high-voltage circuit breaker 1 comprises arcing contacts and a nozzle providing a channel for gas flow and arc extinction, and further having an obstructing member being movable within the channel relative to one of the contacts and to the nozzle for varying the gas outflow cross section as a function
40 of the position of the obstructing member in such a way that a prolonged gas pressurizing configuration or gas pressurizing phase and a subsequent gas clearing configuration or gas clearing phase are realized.

[0009] According to an embodiment, the gas pressurizing configuration occurs during a pressure-build-up phase of the circuit breaker, in particular a pressure-build-up phase in an arcing region and/or puffer volume and/or heating volume of the circuit breaker, and/or the gas clearing configuration occurs during an arc-blowing or arc-extinguishing phase of
45 the circuit breaker, in particular in an arcing region of the circuit breaker. Therefore, during the gas pressurizing configuration or phase the arcing contacts are at least partially separated and an arc is burning between the arcing contacts, and during at least a first phase of the gas clearing configuration the arcing contacts are at least partially separated and an arc is burning between the arcing contacts.

[0010] According to an embodiment, a gas-insulated high-voltage circuit breaker is provided comprising: two arcing
50 contacts comprising a first arcing contact and a second arcing contact, the second arcing contact having a tip, wherein each of the two arcing contacts is axially movable along an axis; a nozzle surrounding an axially extending channel, the channel allowing movement therein of at least a portion of the second arcing contact; and an obstructing member, the obstructing member being movable within the channel relative to the second arcing contact and to the nozzle for variably obstructing the channel depending on a position of the obstructing member.

55 **[0011]** According to another embodiment, a method of interrupting electrical current in a gas-insulated high-voltage circuit breaker is provided comprising: moving both of a first and second arcing contact of the breaker along an axis, thereby separating the first and the second arcing contact, the second arcing contact being disposed within a nozzle; forming an arc between the first and second arcing contacts by the passage of electrical current between the at least

partially separated first and second arcing contacts; pressurizing a gas within the nozzle by the arc; at least partially obstructing at least during the or part of the gas pressurizing phase a flow of the gas through a channel in the nozzle by an obstructing member; at least partially clearing the nozzle for the flow of the gas by moving the obstructing member from an obstructing position to a clearing position in a gas clearing phase; and then extinguishing the arc by the flow of gas through the nozzle.

[0012] In an embodiment of the method, during the step of at least partially obstructing, during the pressurizing configuration or phase, the flow of the gas through the channel in the nozzle, the gas is further pressurized, in particular in an arcing region and/or puffer volume and/or heating volume of the circuit breaker, by the presence of the obstructing member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] Typical embodiments are depicted in the drawings and are detailed in the description which follows. In the drawings:

Fig. 1A illustrates a cross-section of a high-voltage circuit breaker in a closed configuration, according to an embodiment disclosed herein;

Fig. 1B illustrates a cross-section of a high-voltage circuit breaker in a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 1C illustrates a cross-section of a high-voltage circuit breaker in a gas clearing configuration, according to an embodiment disclosed herein;

Fig. 2A is a schematic of a method of interrupting current, according to an embodiment disclosed herein;

Fig. 2B is a schematic of a method of interrupting current, according to an embodiment disclosed herein;

Fig. 3A is a schematic of part of a method of interrupting current, according to an embodiment disclosed herein;

Fig. 3B is a schematic of inducing a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 3C is a schematic of inducing a gas clearing configuration, according to an embodiment disclosed herein;

Fig. 4A illustrates a plot of positions of circuit breaker components in reference to a coordinate, according to embodiments disclosed herein;

Fig. 4B illustrates a plot of relative positions of circuit breaker components in reference to a coordinate, according to embodiments disclosed herein;

Fig. 4C illustrates a plot of relative speeds of circuit breaker components in reference to a coordinate, according to embodiments disclosed herein;

Fig. 5A illustrates a cross-section of a high-voltage circuit breaker in a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 5B illustrates a cross-section of a high-voltage circuit breaker in a gas clearing configuration, according to an embodiment disclosed herein;

Fig. 5C illustrates components of a high-voltage circuit breaker, according to an embodiment disclosed herein;

Fig. 6A illustrates a cross-section of a high-voltage circuit breaker with a motion coupling device in a closed configuration, according to an embodiment disclosed herein;

Fig. 6B illustrates a cross-section of a high-voltage circuit breaker with a motion coupling device in a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 6C illustrates a cross-section of a high-voltage circuit breaker with a motion coupling device in a gas clearing

configuration, according to an embodiment disclosed herein;

Fig. 7A illustrates a cross-section of a high-voltage circuit breaker in a closed configuration, according to an embodiment disclosed herein;

Fig. 7B illustrates components of a high-voltage circuit breaker in a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 8A illustrates components of a high-voltage circuit breaker, according to an embodiment disclosed herein;

Fig. 8B illustrates components of a high-voltage circuit breaker, according to an embodiment disclosed herein;

Fig. 9A illustrates components of a high-voltage circuit breaker, according to an embodiment disclosed herein;

Fig. 9B illustrates a cross-section of a high-voltage circuit breaker in a pressurizing configuration, according to an embodiment disclosed herein;

Fig. 9C illustrates a cross-section of a high-voltage circuit breaker in a gas clearing configuration, according to an embodiment disclosed herein.

DETAILED DESCRIPTION OF EMBODIMENTS

[0014] Reference will now be made in detail to the various embodiments of the invention, one or more examples of which are illustrated in the figures. Within the following description of the drawings, the same reference numbers refer to same components. Generally, only the differences with respect to individual embodiments are described. Each example is provided by way of explanation of the invention and is not meant as a limitation of the invention. Furthermore, features illustrated or described as part of one embodiment can be used on or in conjunction with other embodiments to yield yet a further embodiment. It is intended that the description includes such modifications and variations.

[0015] Herein, CB, HVCB, and breaker are intended to mean high-voltage circuit breaker. Typically, high-voltage means approximately 72.5 kV or higher. Herein, interrupting current is intended to mean the interruption of electrical current. Herein, pressurizing configuration and gas pressurizing configuration are used interchangeably. Herein, narrows, narrow channel, and narrow channel section are used interchangeably. Herein, nozzle may be used to indicate a component surrounding a chamber or may be the chamber itself, the boundary of which is defined by nozzle. Herein, obstruction or impedance to the flow of gas, especially caused by a movable obstructing member, is used especially to indicate the obstruction to the flow of gas through at least part of the nozzle, particularly through a channel, for example through a narrow region (e.g. narrows) toward a wide region of the nozzle which can be flared. The obstruction may be partial, and/or comparative; for example an obstructed nozzle may be more obstructed than otherwise, although even when described as obstructed, it is not completely obstructed or closed or clogged. Obstructed and obstructing, as used herein, are intended to mean at least partially obstructed and/or at least partially obstructing, for example with respect to the flow or flux of gas.

[0016] Herein, HVCB configurations such as a closed configuration, open configuration, pressurizing configuration, and gas clearing configuration are described in order to explain in detail various features and operations, i.e. workings, of the features, and the HVCB configurations described are not intended to be exhaustive of all possible configurations, but rather a representative sampling of configurations that aid in the detailed description of features of embodiments and their workings, and may also aid in description of the workings of the HVCB and advantages and aspects. The HVCB configurations described herein are not necessarily intended to be strictly limiting. Herein, the tip of the obstructing member and end of the obstructing member are used synonymously. Herein obstructing member and movable obstructing member are used interchangeably.

[0017] Typically, the HVCB is at least somewhat axially symmetric, so that many figures are provided herein that illustrate only portions of cross-sections. For example, the nozzle is typically axially symmetric, thus only the top half of the nozzle is shown in many figures. For example, in comparing Fig. 1A with 1B, many symmetrically disposed features are not shown in Fig. 1B.

[0018] Fig. 1A shows a cross-section of a portion of a gas-insulated HVCB 1 in a closed circuit configuration, or simply closed configuration, with a first arcing contact 11 and second arcing contact 21, the second arcing contact 21 having a tip 22. In a closed configuration, passage of electrical current is possible without arcing via the contact of the first and second contacts 11,21.

[0019] Tulip contacts are typical, and can be consistent with the embodiment shown in Fig. 1A, so that the first contact 11 can have a tulip-like shape, comprising radially arranged fingers (only a cross-section through two fingers is illustrated,

symmetrically disposed above and below the second contact 21), and the second contact 21 can be a plunger, pin, stem, or the like.

[0020] Each of the two arcing contacts 11, 21 can be moved axially along an axis 50, and at least a portion of the second arcing contact 21 is movable in an axially extending channel 32 of a nozzle 30, i.e. the nozzle 30 (for example an insulating nozzle) surrounds an axially extending channel 32. An obstructing member 90 can be moved within at least part of the channel 32 relative to the second arcing contact 21 and the nozzle 30 for variably obstructing the channel 32, depending on a position of the obstructing member 90. The channel 32 can also allow movement therein of at least a portion of the second arcing contact 21. Optionally, the channel 32 can comprise a narrows 36 (or a narrow channel section) and further optionally a countersunk region 34, for example so that at least part of the obstructing member 90 extends within the countersunk region 32 in the closed configuration. Optionally, an end of the obstructing member 90 can abut the narrows 36 or be disposed near the narrows 36, in the closed configuration. The diameter of the obstructing member can be larger than the narrows.

[0021] Fig. 1B and Fig. 1C show cross-sections of a portion of a gas-insulated HVCB 1 in open circuit configurations, more specifically Fig. 1B shows a gas pressurizing configuration (or, simply, pressurizing configuration), and Fig. 1C shows a gas clearing configuration, according to embodiments. The first and second arcing contacts 11, 21 are at least partially separated in the open configurations. In a pressurizing configuration illustrated in Fig. 1B, the obstructing member 90 obstructs the flow of gas through at least part of the nozzle (e.g. the channel 32 and/or the regions other than the channel) more than in the gas clearing configuration illustrated in Fig. 1C. During interruption of electrical current, the HVCB, beginning in a closed configuration (e.g. Fig. 1A) can pass into the gas pressurizing configuration (e.g. Fig. 1B) followed by the gas clearing configuration (e.g. Fig. 1C) by movement of the two arcing contacts 11, 21 and the obstructing member 90.

[0022] In an embodiment, the HVCB is a double motion breaker, adapted for oppositely directed motions of each of the arcing contacts 11, 21 along the axis 50; and the motion of the first arcing contact 11 is in the same direction as the nozzle 30. Alternatively or additionally, the first arcing contact 11 can rigidly be attached to the nozzle 30 so that their motions during operation of the breaker, such as interruption of current or closing of the circuit, to name two examples, are substantially shared, i.e. are same or similar.

[0023] In an embodiment, the nozzle 30 comprises a wide region 38 leading to the narrows 36, and the wide region 38 is possibly flared so as to aid in the exhaust of gas. The flow of the gas through countersunk region 34, and/or wide region 38) can be variably restricted, for example by the position of the obstructing member 90. In an embodiment, the nozzle 30 can be suitable for at least partially allowing movement therein of the second contact 21 and the movable obstructing member 90.

[0024] In an embodiment, the movable obstructing member 90 is a sleeve which is disposed coaxially between the axis 50 and the nozzle 30. The sleeve can allow at least partial movement therein of the second contact 21, which can be a pin of a diameter slightly smaller than the inner diameter of the sleeve. In other words, the second arcing contact 21 can slide with respect to the sleeve. In an embodiment, the sleeve blocks the nozzle (or at least partially obstructs at least a region of the nozzle to the flow of gas) until the second contact 21 has reached a certain stroke (i.e. a position during a current interruption process), which increases the gas pressure within a region of the channel (e.g. the arcing region and its vicinity on the first contact side of the obstructing member). The increase in gas pressure can be as a result of maintaining a relatively small effective volume by obstructing part of the volume of the nozzle; thereafter, when the obstructing member is moved, a greater flux of gas through the nozzle can be achieved, which can more effectively clear the arcing region.

[0025] Fig. 2A shows a flow-diagram of a process of interrupting current, according to an embodiment. The first and second arcing contacts are separated, which can be by moving both of them, e.g. moving both of them with respect to the housing of the HVCB, along an axis. Typically, the second arcing contact is disposed within a nozzle, and the second contact is moved at least partially therein, particularly in a channel of the nozzle. An arc is formed between the first and second arcing contacts, as they are at least partially separated, as electrical current continues to flow. A gas is pressurized within the nozzle by the arc, e.g. by transition to a gas pressurizing configuration of the HVCB from the closed configuration. The flow of the gas is at least partially obstructed or impeded, e.g. by the position of an obstructing member which at least partially obstructs the gas flow through at least part of the nozzle, e.g. a channel in the nozzle. The obstructing member is moved, and the obstruction or impedance to the gas flow is reduced, e.g. in reaching a gas clearing configuration, and/or the nozzle is at least partially cleared (e.g. the obstructing member is moved out of the channel). The arc can then be extinguished, e.g. by the flow of gas. Typically or for example, the HVCB is a self-blast type HVCB. An advantage of obstructing the flow of gas is that the pressure of the gas within at least a portion of the nozzle, particularly for example the narrows 36 can be increased, and the subsequent thermal clearing performance (e.g. the rate or efficiency of the removal of heat and/or thermally or electrically created species such as gaseous ions from the region of the arc) is improved, for example at the instant of current interruption and/or extinguishing of the arc.

[0026] In an embodiment, during the step of at least partially obstructing or impeding the flow of gas, the gas is further pressurized. In other words, the pressurization of the gas, which typically occurs while the arc exists between the first

and second arcing contacts and can begin at the moment the first and second contacts are moved enough to make a gap between them, can be enhanced further during the step of at least partially obstructing the flow of the gas through the nozzle or part of the nozzle (e.g. channel). The pressurization can continue for part of the time of movement of the obstructing member, which can be moved to eventually reach a gas clearing configuration which can at least partially clear the nozzle or part thereof (e.g. channel) and allow less impeded flow of gas which can extinguish the arc.

[0027] According to an embodiment illustrated in Fig. 2B, the step of moving an obstructing member can be or can comprise coupling the movement of at least one of the contacts, particularly the second arcing contact 21, to the movement of the obstructing member. Alternatively or additionally, the coupling can be coupling of the obstructing member to at least one of the first and second arcing contacts, the nozzle, the housing, and a nominal contact of the circuit breaker. The coupling of the movement of the obstructing member to another component of the HVCB can enable the transition from a gas pressurizing configuration to a gas clearing configuration, and/or reduce the impedance of gas flow. The arc can then be extinguished, such as by the flow of gas, particularly in the gas clearing configuration. Typically, the HVCB is a self-blast type HVCB.

[0028] In an embodiment, the coupling of the separating movement of the arcing contacts 11, 21 to the movement of the obstructing member 90 is by a motion coupling device 200 (see e.g. Fig. 6A to 6C), for example a motion coupling device that comprises at least one of: a spring, a lever, a plurality of levers, a plurality of springs, a gear, and a plurality of gears.

[0029] Another illustration, according to an embodiment, of a method of interrupting current appears in Fig. 3A. The method comprises separating the contacts, inducing a pressurizing configuration, and inducing a gas clearing configuration. Fig. 3B illustrates an embodiment of inducing a pressurizing configuration, and Fig. 3C illustrates an embodiment of inducing a gas clearing configuration. Inducing a pressurizing configuration, as illustrated in Fig. 3B, comprises forming an arc and pressurizing a gas, and can also comprise separating the contacts, e.g. further separating the contacts. Inducing a pressurizing configuration can also comprise impeding or obstructing a flow of gas, which can occur while the contacts are being separated or while they are being moved, and/or during the formation of the arc. Inducing a gas clearing configuration, as illustrated in Fig. 3C, comprises moving an obstructing member and reducing the impedance or obstruction to the flow of gas, for example moving an obstructing member away from a narrows and/or a channel. Inducing a gas clearing configuration can additionally comprise coupling the motion of an obstructing member 90 to at least one other HVCB component, particularly at least one of the contacts 11, 21 (e.g. the second contact 21), as well as optionally further separating the arcing contacts. The coupling of the separating movement of the arcing contacts 11, 21 can occur by a motion coupling device 200 such as a spring. The spring can be optionally shielded to prevent direct contact to hot gas and/or electrically exposed regions.

[0030] Optionally, the spring has a nonlinear spring constant, or an effectively nonlinear spring constant, so that during a closing operation the impact of the obstructing member on the nozzle or wall of the nozzle does not induce excessive stress on parts, for example PTFE parts, e.g. the nozzle. In an embodiment, the nonlinear spring constant or the like can be weak in response in a few millimeters of movement of the obstructing from a position of contact with the nozzle or a wall of the nozzle.

[0031] Fig. 4A, 4B, and 4C, which are intended to illustrate, without necessarily being limiting, representative positions and movements of some HVCB components during operation (e.g. opening and closing of the circuit), are described herein by the opening of the circuit. Closing of the circuit is typically the reverse of opening.

[0032] Fig. 4A is a representative graph of a position 501 (vertical axis) to illustrate the position of components of the HVCB with reference to a coordinate 500 (horizontal axis), such as time or configuration, according to an embodiment. For example, the coordinate 500 can illustrate: a fully closed circuit configuration at the intersection of the coordinate 500 axis with the vertical axis (position 501); a pressurizing configuration 301 between the position axis 501 and a transition region 550 or transition point; and a gas clearing configuration 302 at the right of the figure (Fig. 4A) and/or at the right of the transition region 550. Alternatively and/or additionally, the coordinate 500 can be time, such that the graph illustrates the dynamic positions of HVCB components during a current interruption process (as the graph of Fig. 4A is read left to right); and further alternatively and/or additionally, the graph can illustrate the dynamic positions of HVCB components during a re-closing operation (as the graph of Fig. 4A is read right to left), e.g. the circuit begins in a fully open position and is closed.

[0033] Fig. 4A illustrates, according to an embodiment, the position of the second arcing contact 521, the position of the nozzle 530, and the position of the obstructing member 590, which for purposes of illustration are overlapping positions in the closed configuration, corresponding to the point at the intersection of axes (i.e. coordinate 500 and position 501). Fig. 4A illustrates, as read from left to read, the movement of the second arcing contact 521 which moves oppositely to the nozzle 530, e.g. during a current interruption process; thus, the HVCB can pass from a closed configuration through a pressurizing configuration 301 into a gas clearing configuration 302, as the position of the second arcing contact 521 moves in one direction and the position of the nozzle 530 moves in the opposite direction. As Fig. 4A is read from left to right, e.g. during current interruption: the position of the obstructing member 590 initially (e.g. while in the pressurizing configuration 301) conforms at least somewhat with the position of the nozzle 530 until approximately

the transition region 550; subsequently (e.g. as the configuration passes into the gas clearing configuration 302), the movement of the obstructing member diverges from the movement of the nozzle, and conforms more to the movement of the position of the second arcing contact 521.

[0034] Fig. 4B illustrates, according to an embodiment, the relative positions 502 of some HVCB components along the coordinate 500. For example, during current interruption, reading the graph of Fig. 4B from left to right: the motion of the second contact with respect to the nozzle 2130 is motion in a constant direction (the relative motion of the first contact and the second contact, not shown, would be similarly constant). Near the transition region 550, the position of the obstructing member changes from being coupled to the nozzle to being coupled to the second contact, e.g. in going from the pressurizing configuration 301 to the gas clearing configuration 302.

[0035] The relative position of the obstructing member with respect to the nozzle 9030 is initially constant (e.g. in the pressurizing configuration), because they are moving little or not at all with respect to each other (although they are both moving with respect to the first contact). After the transition region 550, the obstructing member is moving with respect to the nozzle 9030 in the gas clearing configuration 302 (or to induce the gas clearing configuration).

[0036] The position of the obstructing member with respect to the nozzle 9030 follows somewhat the opposite trend as the position of the obstructing member with respect to the second contact 9021. In other words, the position of the obstructing member with respect to the nozzle 9030 is constant through the pressurizing configuration 301 until the movement of the obstructing member is coupled to the movement of the second contact at the transition 550, after which their relative positions 9030 change.

[0037] Fig. 4C illustrates relative speeds 505 of some HVCB components along the coordinate 500, depicting the relative speeds of the obstructing member with respect to the nozzle 930 and second arcing contact 921, according to an embodiment. For example, during current interruption, reading the graph of Fig. 4B from left to right: in the pressurizing configuration 301, the relative speed of the obstructing member with respect to the nozzle 930 is less than the relative speed of the obstructing member with respect to the second arcing contact 921; and in the gas clearing configuration 302, the relative speed of the obstructing member with respect to the nozzle 930 is greater than the relative speed of the obstructing member with respect to the second arcing contact 921.

[0038] Typically or exemplarily, components of the HVCB, such as the contacts 11, 21, and obstructing member 90, are not moving substantially when the HVCB is fully open or closed.

[0039] Fig. 5A shows, according to an embodiment, a cross-section of a portion of a gas-insulated HVCB 1 in a gas pressurizing configuration, with at least partially separated first 11 and second 21 arcing contacts, the second 21 having a tip 22; the movable obstructing member 90, e.g. axially movable with respect to the nozzle 30 and the second arcing contact 21, can be a sleeve, disposed within the nozzle 30 coaxial to the second arcing contact 21. The obstructing member 90 can have an end 122 (e.g. a front end) which is directed toward the first arcing contact 11. In the closed configuration (not shown) the first and second contacts 11, 21 are in contact, and optionally the end 122 of the obstructing member 90 is disposed near to, or possibly abuts, a wall of the nozzle 30 near the narrows 36. Typically or exemplarily, the diameter of the sleeve is larger than the diameter of the narrows 36, but is smaller than the diameter of an optional countersunk region 34.

[0040] Typical exemplary dimensions of HVCB components are (without intending to be limiting): a nozzle length of about 10-70 mm; a second arcing contact 21 diameter of about 15 to 30 mm; a sleeve as an obstructing member 90 with a length and/or outer width of about 20-40 mm, and thickness of about 3-10 mm; a narrows 36 length of about 10-40 mm, a narrows 36 diameter of about 0.1-5 mm greater than the second arcing contact 21, a countersunk region 34 of about 20 mm to 50 mm length, a cross-sectional area of the countersunk region 34 that is at least approximately 10% larger than the cross-sectional area of the narrows 36 and/or a diameter of the countersunk region 34 that is about 0.1-5 mm larger than the outer diameter of the obstructing member 90. For example, the transition from the pressurizing configuration to the gas clearing configuration occurs at a contact separation of about 30-100 mm.

[0041] A feature illustrated in the pressurizing configuration illustrated in Fig. 5A is that the tip 22 of the second arcing contact 21 is more separated from the first contact 11 in comparison to the pressurizing configuration illustrated in Fig. 1B; the position of the obstructing member 90, in contrast, is nearly the same in the pressurizing configurations illustrated by both Fig. 1B and Fig. 5A.

[0042] For example, the end 122 of the obstructing member 90 is disposed within the countersunk region 34 in the closed configuration and in the pressurizing configuration, so that the obstructing member 90 (e.g. a sleeve 90) can at least partially obstruct the flow of gas, particularly through at least a region of the nozzle, such as the channel 32. The opposite end of the obstructing member 90 can optionally extend into a wide region 38 of the nozzle 30. An advantage of the position of the obstructing member 90 in the pressurizing configuration is that it allows the pressure of the gas to be raised in a section of the nozzle 30 (e.g. the region between the arcing contacts 11, 21 or between the first arcing contact 11 and the end 122 of the obstructing member 90). The raised pressure can subsequently enhance the thermal clearing capability of the gas that flows through the arcing region and nearby region.

[0043] Fig. 5B shows, according to an embodiment, a cross-section of a portion of a gas-insulated HVCB 1 in a gas clearing configuration, in which there is a gap between the tip 122 of the movable obstructing member 90 (e.g. a sleeve

90 which may be conductive or insulating) and a nearby (e.g. the nearest) wall of the nozzle 30. The movable obstructing member 90 can be made of metal or another material that resists mechanical stress. A gas can pass through the nozzle 30 from the left to the right more easily when the tip 122 of the obstructing member 90 is located outside of the countersunk region 34 and/or relatively far from the narrows 36 (e.g. in the clearing configuration) compared to when the tip 122 is within the countersunk region 34, near the narrows 36, and/or abutting the narrows 36 (e.g. the HVCB is in a pressurizing configuration). In other words, the obstructing member 90 obstructs the channel 32, narrows 36, countersunk region 34, wide region 38 of the nozzle 30, and/or nozzle 30 more in the pressurizing configuration (an example of which is Fig. 5A) than in a gas clearing configuration (an example of which is Fig. 5B). Typically or exemplarily, the distance between the first and second contacts 11, 21 is greater in the gas clearing configuration than in the pressurizing configuration. Moreover, typically or exemplarily, the distance between the end of the obstructing member 122 and a point near the center of the channel 32 or nearby (e.g. nearest) wall of the nozzle 30 is greater in the gas clearing configuration than in the pressurizing configuration. Typically or exemplarily, the nozzle 30 comprises a flared region, disposed on the opposite side as the narrows 36, so that for example when the tip 122 of the obstructing member is disposed in the flared region, the gas flow is relatively unobstructed.

[0044] Fig. 5C shows components of the HVCB, according to an embodiment. The end 122 of the obstructing member 90 can be beveled, which has the effect of more robustly centering one or both of the obstructing member 90 and second arcing contact 21 in the nozzle 30, particularly in the closed and pressurizing configurations. Optionally, the region of the nozzle 30 between the narrows 36 and countersunk region 34 can be beveled; an additional option is to bevel the region between the wide region, e.g. if the optional countersunk region is omitted, and in this case the optionally flared wide region may serve naturally as the beveled region. Optional beveling can aid in centering the obstructing member 90 and/or second arcing contact 21 in the nozzle 30.

[0045] Fig. 6A shows a cross-section of a portion of a gas-insulated HVCB 1 with a motion coupling device 200 (e.g. a spring 200) in a closed circuit configuration, according to an embodiment. For example, a spring 200 can press the obstructing member 90 against a wall of the nozzle 30 so that an end 122 of the obstructing member 90 resides within the countersunk region 34. For example, the opposite end of the spring 200 may be in contact with the end of the second arcing contact 21 that is opposite to the tip of the second arcing contact 21; alternatively, the spring 200 can be in contact with the plug cover or another component of the HVCB.

[0046] In an embodiment, as current interruption proceeds, the first contact 11 and second contact 21 are both moved, so that a gap widens between them, as illustrated in Fig. 6B, which also illustrates that the end 122 of the obstructing member 90 resides near the narrows 36 and/or within the countersunk region 34 during the initial current interruption process (e.g. in a pressurizing configuration), according to an embodiment.

[0047] As illustrated in Fig. 6C, which shows an embodiment of a HVCB 1, the motion coupling device 200 (e.g. a spring 200) can apply a pulling force for moving the obstructing member 90, so that for example the tip 122 of the obstructing member 90 can move away from the channel 32, away from the narrows 36, through the countersunk region 34, and/or toward the wide region 38 of the nozzle 30. Alternatively or additionally, other forces (e.g. the gas pressure) can also cause motion of the obstructing member 90, working for example against or with the force of the spring 200. In an embodiment, the spring 200 is disposed so as to always apply a force on the obstructing member 90 towards the first contact 11, but in the end of the pressurizing configuration and/or during beginning of the gas clearing configuration, the force of gas pressure on the obstructing member 90 is greater than the force of the spring 200, thus causing the obstructing member 90 to move to clear the channel 32. Alternatively or additionally, the motion coupling device 200 comprises a gear and/or lever to couple the motion of the second contact 21 to the obstructing member 90 (e.g. a sleeve 90), particularly so that after moving from a closed configuration to a pressurizing configuration, the obstructing member 90 is subsequently moved to the gas clearing configuration.

[0048] For example, during interruption of current, the obstructing member 90 moves approximately 30-60 mm with the nozzle 30 (and the spring 200 is lengthened, i.e. stretched from its previous state), and then about 5-50 mm with the second arcing contact 21 (and the spring 200 is shortened, i.e. compressed from its previous state). For example, the springs natural length is 50-200 mm, and the spring 200 is compressed by about 30-60 mm when the HVCB is in a closed configuration and is compressed from about 5 to 50 mm in the fully open configuration (and/or at the extreme or final configuration of a gas clearing configuration).

[0049] Fig. 7A illustrates a cross-section of a portion of a gas-insulated HVCB 1 in a closed circuit configuration, according to an embodiment, with a wide portion 222 of the second contact 21, optionally disposed at its tip. In an embodiment, as the contacts 11, 21 are moved the obstructing member 90 (e.g. a sleeve 90) initially remains disposed near the narrows 36 (e.g. in a pressurizing configuration), until, as illustrated in Fig. 7B, the wide portion 222 of the second contact 21 reaches near the end 122 of the movable obstructing member 90. According to an embodiment, the wide portion 222 couples the motion of the second contact 21 with the obstructing member 90 (e.g. at the end of the pressurizing configuration) to move the obstructing member 90 (e.g. to induce a gas clearing configuration in which the end 122 of the obstructing member 90 is exited from the countersunk region 34). According to an embodiment, the motion coupling device 200 comprises the second contact 21, for example with a second contact 21 with a wide region

222 which can be near or at the tip of the second contact 21. The motion coupling device 200 can further comprise a spring (as shown for example in Fig. 6A) or other means (e.g. a gear and/or lever) for coupling or contributing to the coupling of the motion of the obstructing member 90 (e.g. a sleeve 90) with the second arcing contact 21.

[0050] In an embodiment, the motion coupling device 200 comprises a spring and a wide portion 222 of the second arcing contact 21, wherein the spring is disposed in a compressed state in all configurations of the HVCB. Alternatively, the spring can be in a compressed state in the closed configuration and at least part of the pressurizing configuration, and the spring can be optionally combined with additional means for coupling the motion of the contact 21 with the movable obstructing member 90.

[0051] Fig. 8A and 8B show, according to embodiments, the second arcing contact 21 having a wide region 222, and the movable obstructing member 90 having an end 122. In an embodiment, the wide region 222 of the contact 21 is wider than the hole in the obstructing member 90 through which the second contact 21 is disposed in order to couple the motion of the second contact 21 with the obstructing member 90 (e.g. to enable the transition from the pressurizing configuration to the gas clearing configuration).

[0052] Typical embodiments having a wide region 222 of the second contact 21 are such that the outer diameter of the obstructing member 90 is slightly larger than the wide region 222 of the second arcing contact 21; the inner diameter of the obstructing member 90 is slightly larger than the width of the second arcing contact 21 and smaller than the wide region 222. For example, to allow motion of the second arcing contact 21 within the obstructing member 90, the inner diameter of the obstructing member 90 is slightly larger than the shaft of the second arcing contact 21 to allow the contact to move (e.g. slide) within the obstructing member 90; and the diameter of the wide region 222 of the second arcing contact 21 is larger than the inner diameter of the obstructing member 90 in order for example to couple the motion of the obstructing member 90 to the second contact 21, in inducing transition to a gas clearing configuration from a pressurizing configuration; and the outer diameter of the obstructing member 90 is larger than the diameter of the wide region 222 of the second contact 21 in order that the obstructing member 90 can for example abut a wall of the narrows (e.g. in a closed configuration and/or a pressurizing configuration), or be wider than the narrows 36, wherein movement of at least a portion of the second arcing contact 21 is possible.

[0053] Fig. 9A illustrates a cross-section of a portion of a gas-insulated HVCB 1 in approximately a closed circuit configuration, or at an early stage of a pressurizing configuration, according to an embodiment, with a nozzle 30 surrounding an axially extending channel 32 in which the second arcing contact 21 (or at least a portion thereof) can move, and a wide region 38 of the nozzle 30 which comprises a flared region. The obstructing member 90 is optionally a ring or sleeve 90, which can be disposed near or abutting the narrows 32 in the closed and/or pressurizing configuration.

[0054] As illustrated in the embodiment of Fig. 9B, the second arcing contact 21 can be moved through the channel 32 (during for example comparatively early events of current interruption, e.g. in a pressurizing configuration), and the obstructing member 90 obstructs the narrows 36 and/or flow of gas through the channel 32 and/or nozzle 30 (e.g. in a pressurizing configuration).

[0055] Fig. 9C shows, according to an embodiment, a gas clearing configuration, in which the narrows 36 and/or channel 32 is less obstructed by the obstructing member 90 than in the pressurizing configuration, e.g. the obstructing member 90 (e.g. a sleeve 90) is moved away from the narrows 36.

[0056] An advantage of the disclosed embodiments is that a higher gas pressure can be obtained, e.g. during current interruption, particularly before extinguishing the arc and/or before a gas clearing configuration is reached. A further advantage is that a higher flux of gas, for example in a clearing configuration and/or during extinguishing of the arc can be obtained, which can increase the efficacy of thermal clearing and/or clearing of gaseous ions and/or other products formed by the arc. A further advantage can be that the longer time of pressurization is made possible, because the flux of gas is at least partially obstructed until the obstructing member (and possibly the second arcing contact) are moved at least partially out of the channel.

[0057] While the foregoing is directed to embodiments of the invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

LIST OF REFERENCE NUMERALS

[0058]

gas-insulated HV-CB	1
first contact, first arcing contact	11
second contact, second arcing contact	21
tip of second contact	22
nozzle	30

	wide region of nozzle	38
	channel of nozzle	32
5	countersunk region	34
	narrows, narrow channel section	36
	obstructing member, sleeve	90
10	tip of obstructing member, tip of sleeve	122
	motion coupling device, spring	200
15	wide portion of 2nd contact	222
	(gas) pressurizing configuration	301
	(gas) clearing configuration	302
20	time	500
	position	501
25	relative position	502
	relative speed	505
	transition point	550
30	contact position	521
	obstructing member position	590
35	nozzle position	530
	RELATIVE POSITIONS (obstructing member 90, e.g. sleeve 90)	
	sleeve relative to nozzle	9030
40	sleeve relative to contact	9021
	relative position axis	502
45	contact relative to nozzle	2130
	sleeve relative to contact	9021
	RELATIVE SPEEDS	
50	sleeve relative to nozzle	930
	sleeve relative to contact	921

55

Claims

1. A gas-insulated high-voltage circuit breaker (1) comprising:

- two arcing contacts (11, 21) comprising a first arcing contact (11) and a second arcing contact (21), the second arcing contact having a tip (22), wherein at least one, in particular each, of the two arcing contacts (11, 21) is axially movable along an axis (50);
- a nozzle (30) surrounding an axially extending channel (32),
- the channel (32) allowing movement therein of at least a portion of the second arcing contact (21); and
- an obstructing member (90), the obstructing member (90) being movable within the channel (32) relative to the second arcing contact (21) and to the nozzle (30) for variably obstructing the channel (32) depending on a position of the obstructing member (90).

2. The gas-insulated high-voltage circuit breaker (1) of claim 1, wherein the obstructing member (90) is movable between a gas pressurizing configuration (301) and a gas clearing configuration (302) of the circuit breaker (1); wherein the channel (32) is more obstructed by the obstructing member (90) in the pressurizing configuration (301) than in the clearing configuration (302), in particular wherein further:

the gas pressurizing configuration (301) occurs during a pressure-build-up phase of the circuit breaker (1), in particular in an arcing region and/or puffer volume and/or heating volume of the circuit breaker (1), and/or the gas clearing configuration (302) occurs during an arc-blowing phase of the circuit breaker (1).

3. The gas-insulated high-voltage circuit breaker (1) any of the preceding claims, wherein the first arcing contact (11) is in contact with the second arcing contact (21) to allow the passage of electrical current in a closed configuration of the circuit breaker (1); and/or the arcing contacts (11, 21) are at least partially separated and an arc is burning between the arcing contacts (11, 21) in a or the gas pressurizing configuration (301) of the circuit breaker (1); and/or the arcing contacts (11, 21) are at least partially separated and an arc is burning between the arcing contacts (11, 21) in a or the gas clearing configuration (302) of the circuit breaker (1).

4. The gas-insulated high-voltage circuit breaker (1) of any preceding claim, wherein the circuit breaker (1) is a double-motion circuit breaker (1), adapted for oppositely directed motions of each of the arcing contacts (11, 21) along the axis, wherein the motion of the first arcing contact (11) is in the same direction as the motion of the nozzle (30).

5. The gas-insulated high-voltage circuit breaker (1) of any preceding claim, further comprising:

a motion coupling device (200); in particular a motion coupling device (200) comprising or consisting of at least one of a spring (200), a gear, a lever, or a combination of such elements; coupled to the movable obstructing member (90), and adapted to move the movable obstructing member (90) between a or the gas pressurizing configuration (301) and a or the gas clearing configuration (302); wherein the gas pressurizing configuration (301) is such that a relative speed (930) of the obstructing member (90) with respect to the nozzle (30) is less than a relative speed (921) of the obstructing member (90) with respect to the second arcing contact (21); and wherein the gas clearing configuration (302) is such that the relative speed (930) of the obstructing member (90) with respect to the nozzle (30) is greater than the relative speed (921) of the obstructing member (90) with respect to the second arcing contact (21).

6. The gas-insulated high-voltage circuit breaker (1) of any preceding claim, wherein:

the movable obstructing member (90) is a sleeve (90) disposed within the nozzle (30) coaxially to the second arcing contact (21), and the sleeve (90) has a front end (122) directed toward the first arcing contact (11); and wherein the sleeve is axially movable with respect to the nozzle (30) and the second arcing contact (21).

7. The gas-insulated high-voltage circuit breaker (1) of any of the preceding claims, wherein:

the channel (32) comprises a narrow channel section (36) with a width sufficiently large for allowing movement of the second arcing contact (21) therein; wherein the width of the narrow channel section (36) is smaller than the diameter of the obstructing member (90) thereby preventing the obstructing member (90) from entering the narrow channel section (36); and wherein a wide region (38) of the nozzle has a cross-section sufficiently large for allowing movement of both the second arcing contact (21) and the obstructing member (90) therein.

8. The gas-insulated high-voltage circuit breaker (1) of claim 7, wherein:

the channel (32) of the nozzle (30) comprises a countersunk region (34) adjacent to the wide region (38) of the nozzle (30) sufficiently large for at least partially allowing movement therein of the obstructing member (90), and in particular wherein the countersunk region (38) is arranged between the narrow channel section (36) and the wide region (38) of the nozzle (30).

5 9. The gas-insulated high-voltage circuit breaker (1) of any of the preceding claims, wherein:

a distance between the first arcing contact (11) and the second arcing contact (21) is greater in a or the gas clearing configuration (302) than in a or the pressurizing configuration (301).

10 10. The gas-insulated high-voltage circuit breaker (1) of claim 7-9, wherein the wide region (38) of the nozzle (30) comprises a flared region, and/or the obstructing member (90) is either conductive or insulating.

15 11. A method of interrupting electrical current in a gas-insulated high-voltage circuit breaker (1), in particular in the gas-insulated high-voltage circuit breaker (1) of any of the preceding claims 1-10, the method comprising:

moving at least one, in particular each, of a first and second arcing contact (11, 21) of the breaker (1) along an axis (50), thereby separating the first arcing contact (11) and the second arcing contact (21) from one another, the second arcing contact (21) being disposed within a nozzle (30);

20 forming an arc between the first and second arcing contacts (11, 21) by the passage of electrical current between the at least partially separated first and second arcing contacts (11, 21);

pressurizing a gas within the nozzle (30) by the arc;

at least partially obstructing during the pressurizing a flow of the gas through a channel (32) in the nozzle (30) by an obstructing member (90);

25 at least partially clearing the nozzle (30) for the flow of the gas by moving the obstructing member (90) from an obstructing position to a clearing position; and then extinguishing the arc by the flow of gas through the nozzle (30).

30 12. The method of interrupting current in the circuit breaker (1) of claim 11, wherein during the step of at least partially obstructing during the pressurizing the flow of the gas through the channel (32) in the nozzle (30), the gas is further pressurized, in particular in an arcing region and/or puffer volume and/or heating volume of the circuit breaker (1), by the presence of the obstructing member (90).

35 13. The method of interrupting current in the circuit breaker (1) of any of the claims 11-12, wherein moving the obstructing member (90) comprises

coupling a movement of at least one of: the first arcing contact (11), the second arcing contact (21), the nozzle (30), and a nominal contact of the circuit breaker (1), to the movement of the obstructing member (90).

40 14. The method of interrupting current in a high-voltage circuit breaker (1) of any one of the claims 11-13, wherein the coupling of a or the separating movement of at least one of the arcing contacts (11, 21) to the movement of the obstructing member (90) is by a motion coupling device (200), in particular by at least one of a spring (200), a gear, a lever, or a combination of such elements.

45 15. The method of interrupting current in a high-voltage circuit breaker (1) of any one of the claims 11-14, wherein the high-voltage circuit breaker (1) is a self-blast type circuit breaker (1).

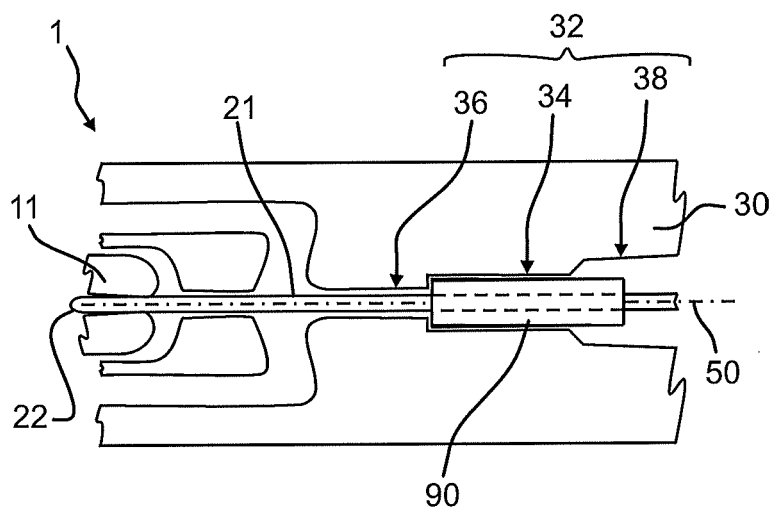


Fig. 1A

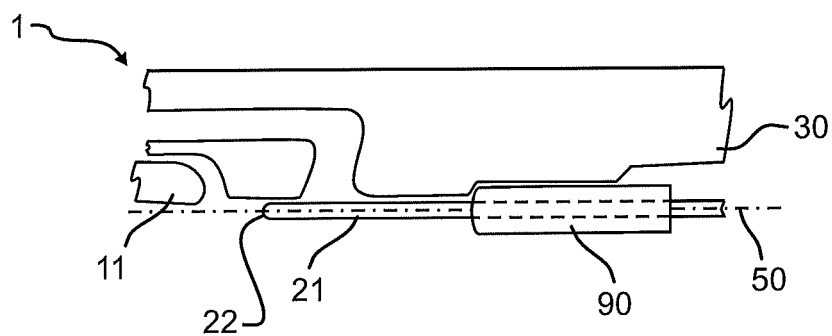


Fig. 1B

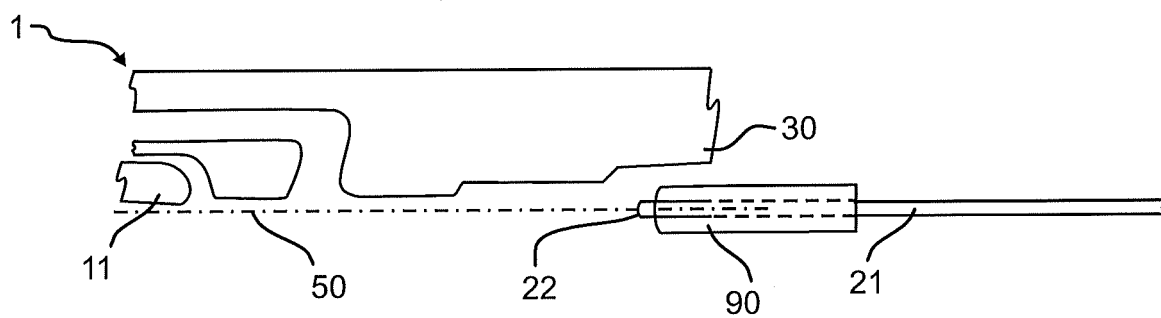


Fig. 1C

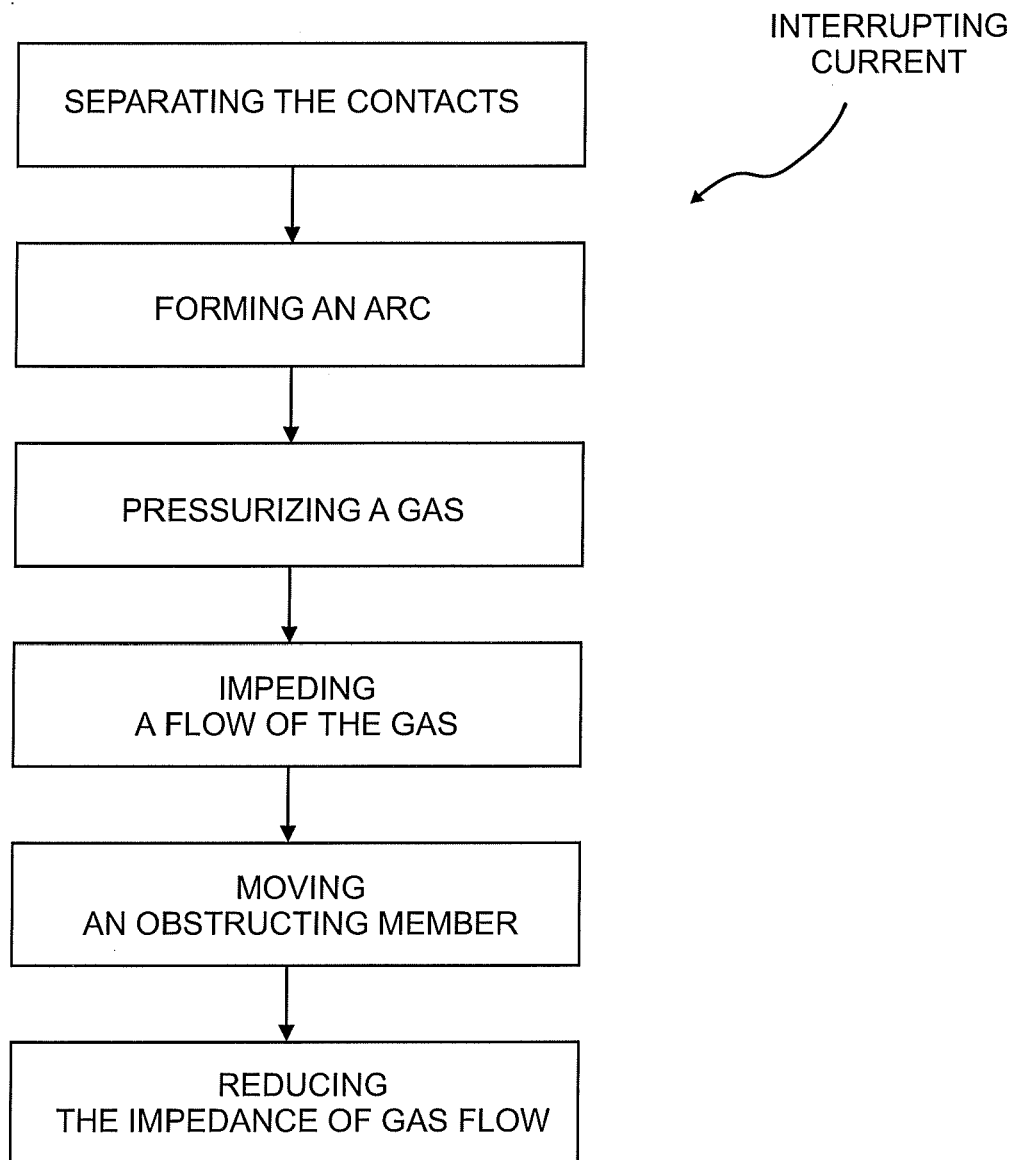


Fig. 2A

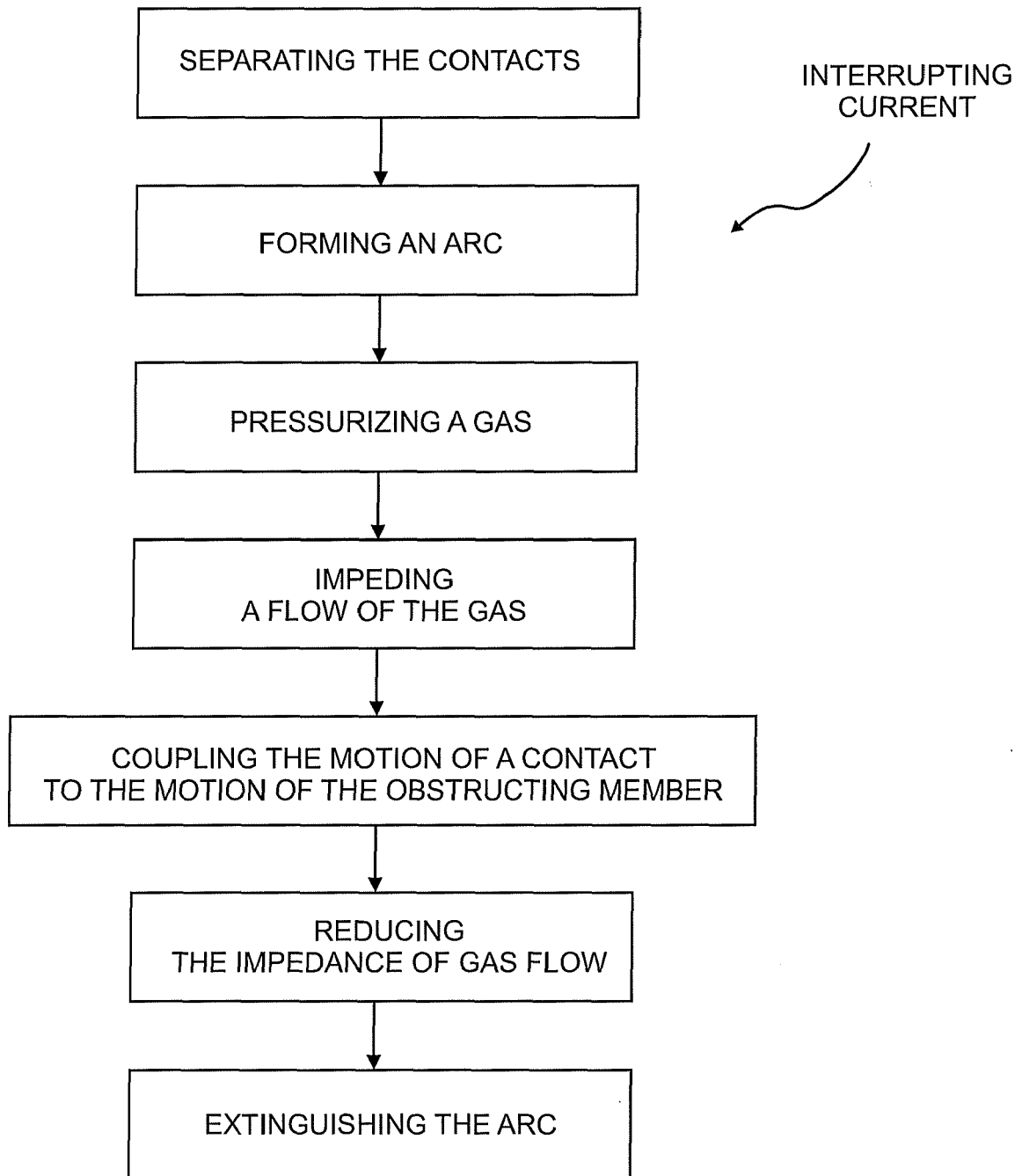


Fig. 2B

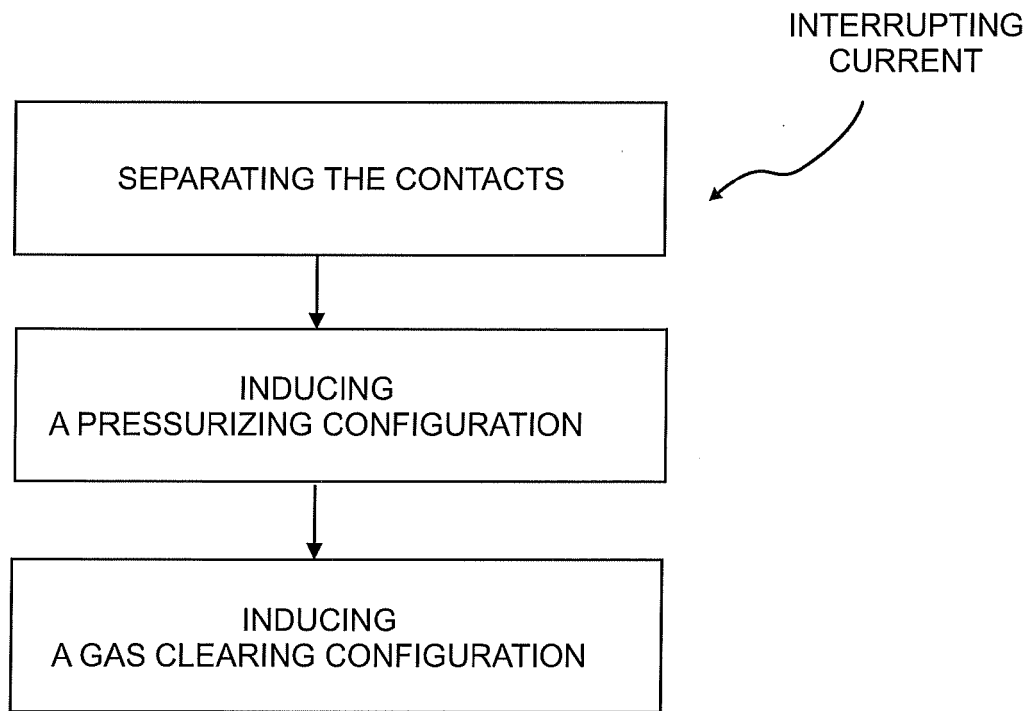


Fig. 3A

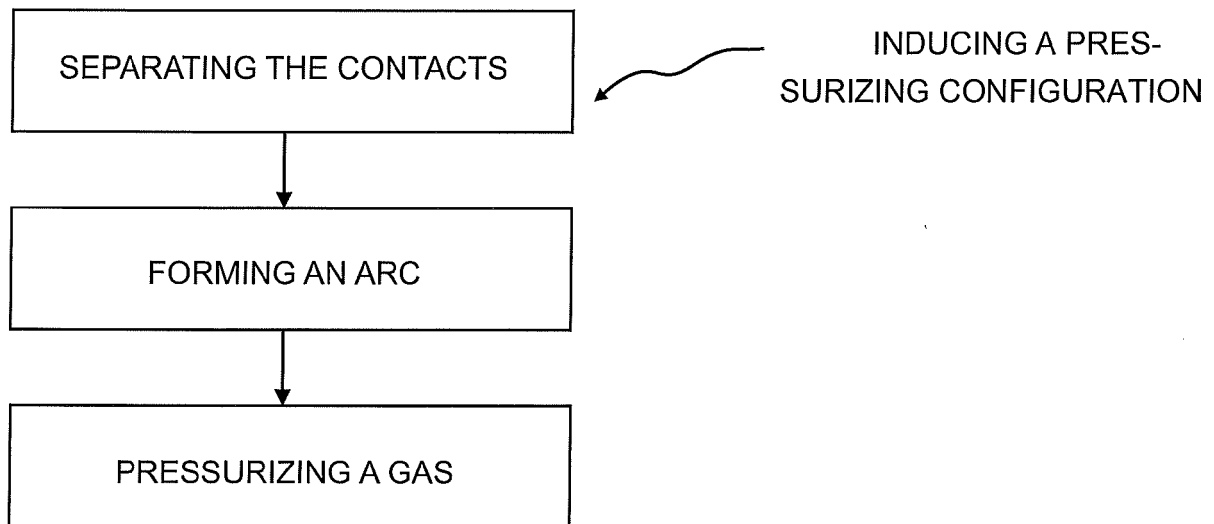


Fig. 3B

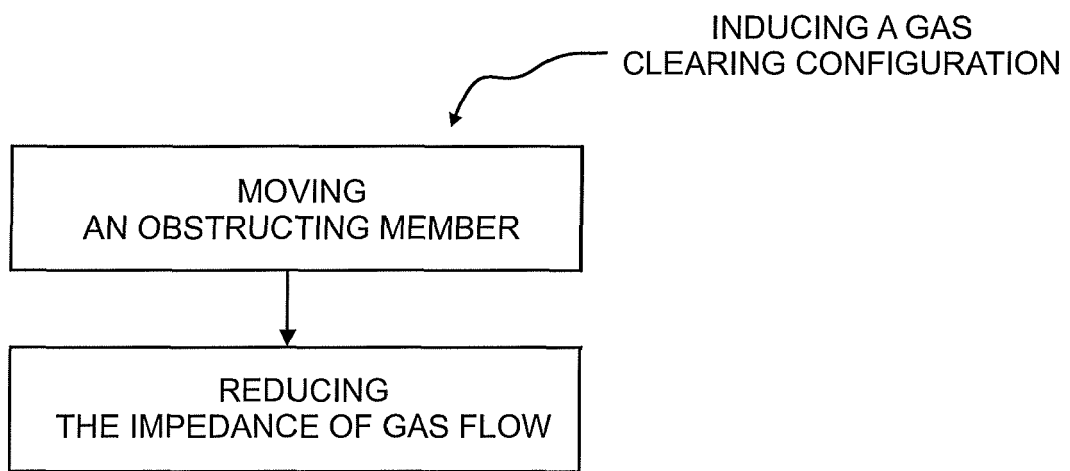


Fig. 3C

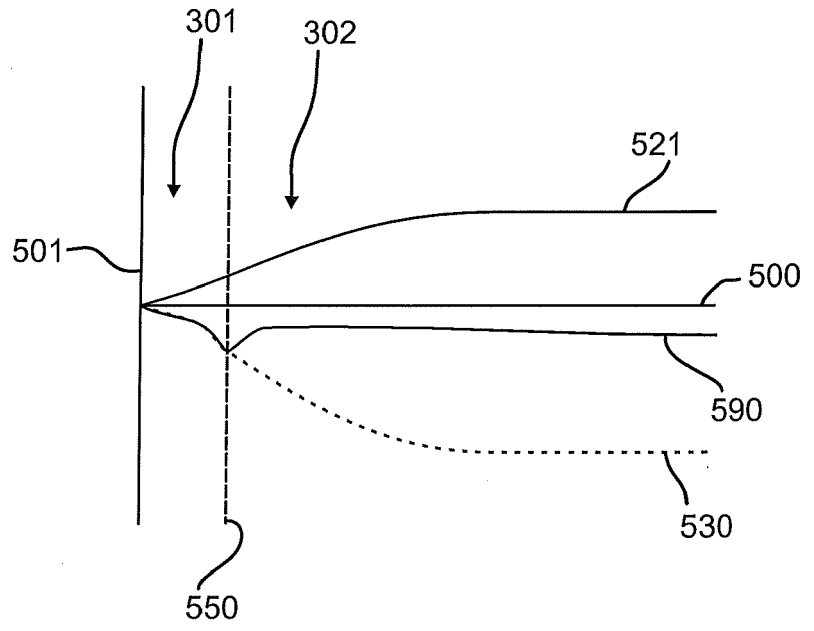


Fig. 4A

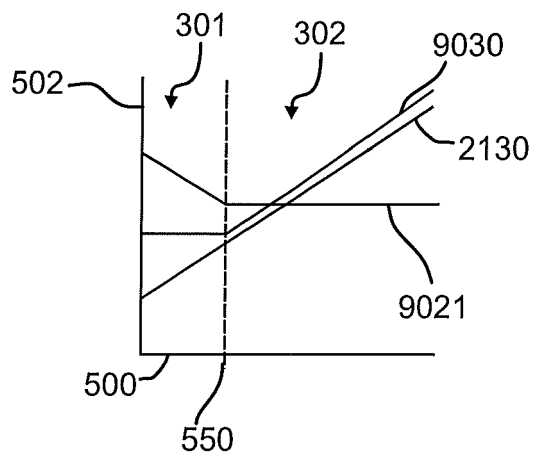


Fig. 4B

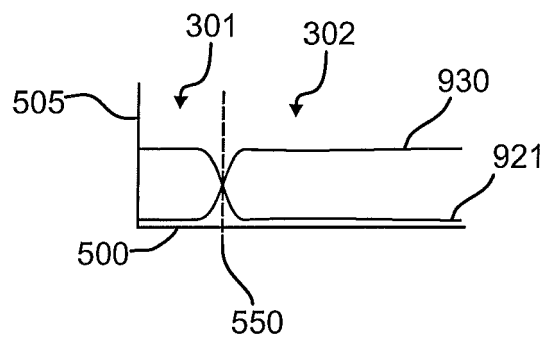


Fig. 4C

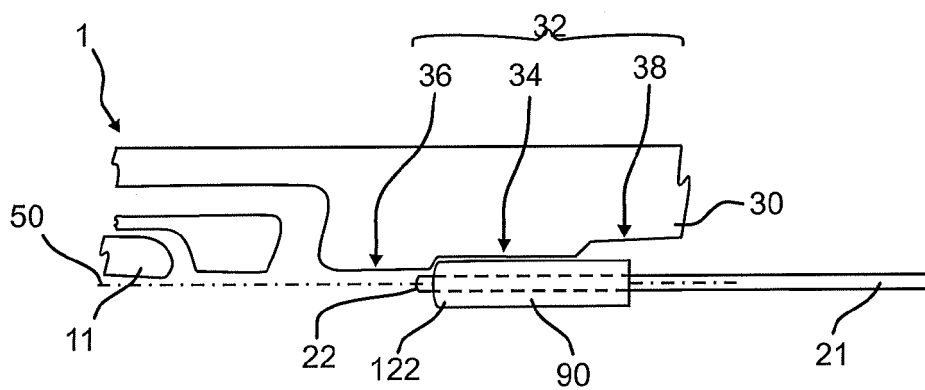


Fig. 5A

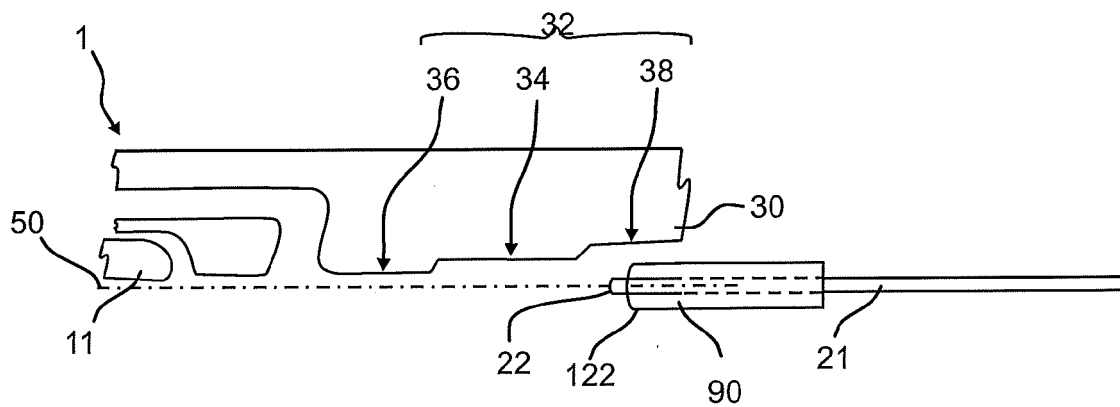


Fig. 5B

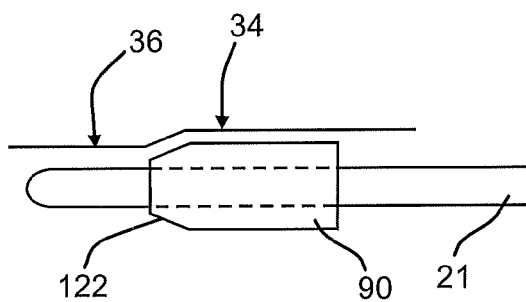


Fig. 5C

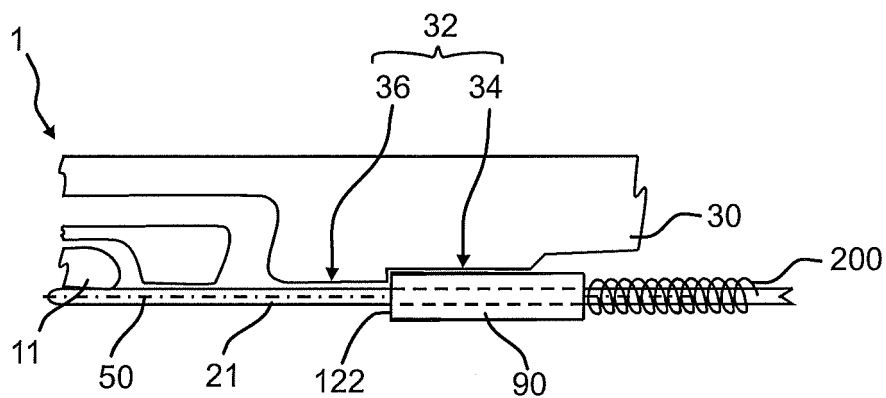


Fig. 6A

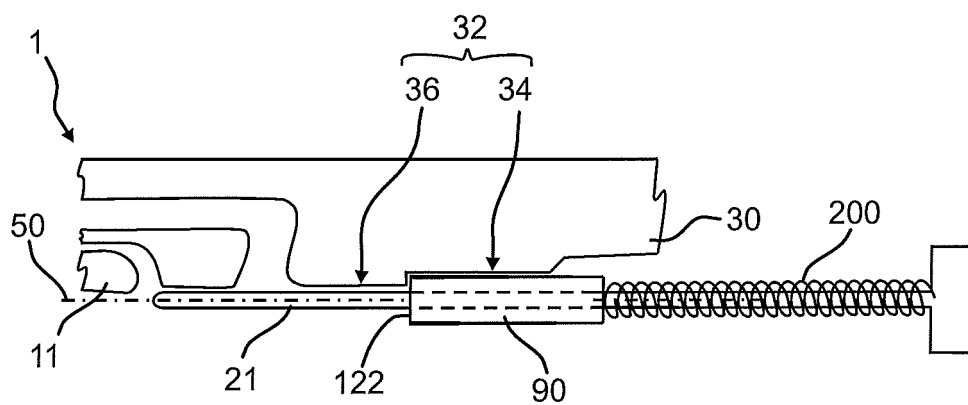


Fig. 6B

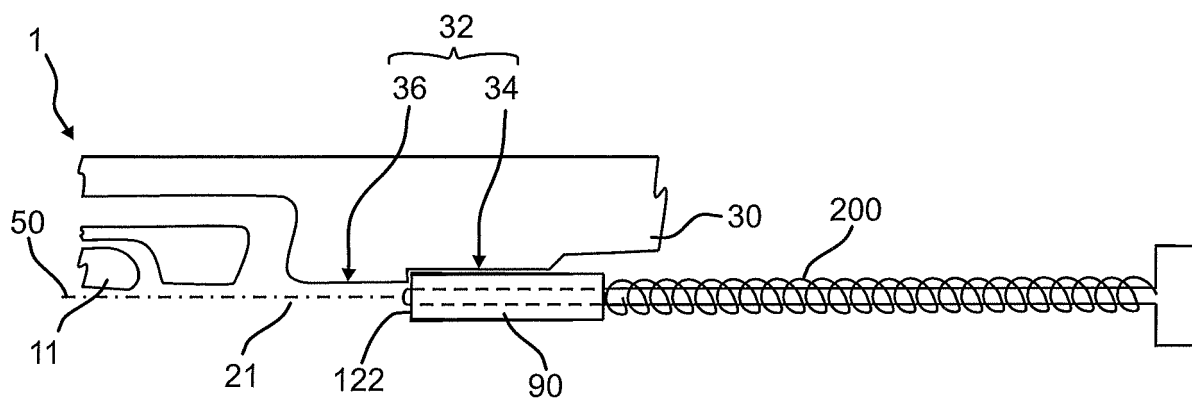


Fig. 6C

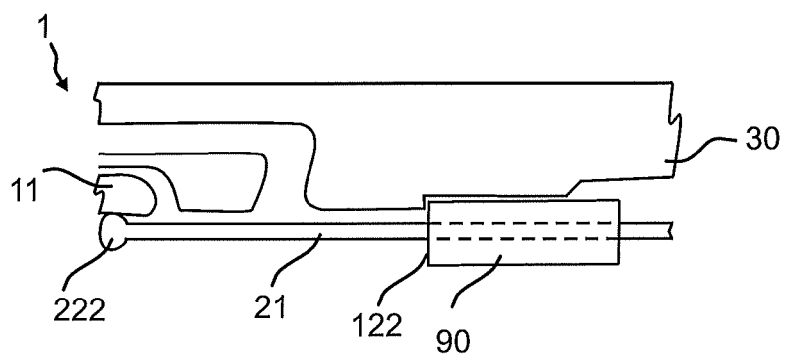


Fig. 7A

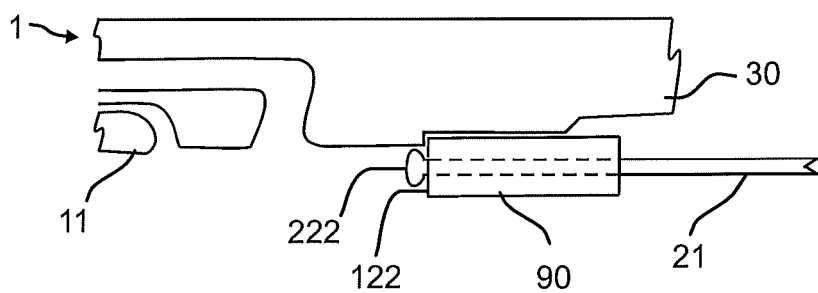


Fig. 7B

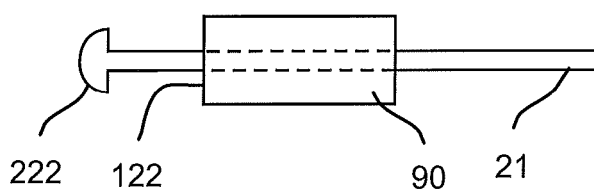


Fig. 8A

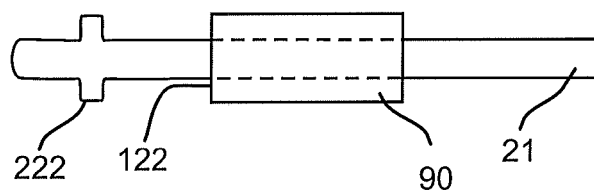


Fig. 8B

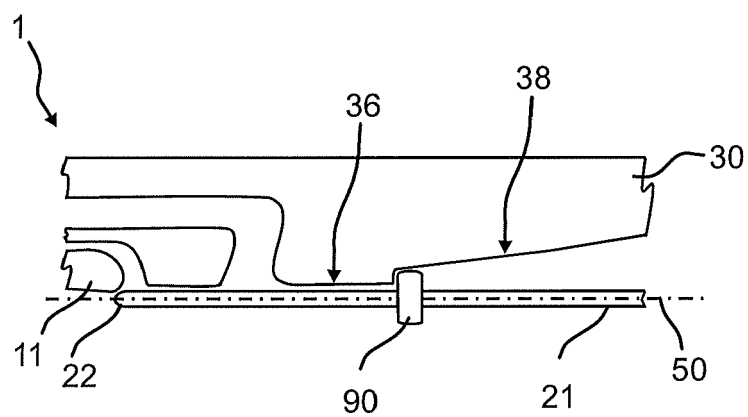


Fig. 9A

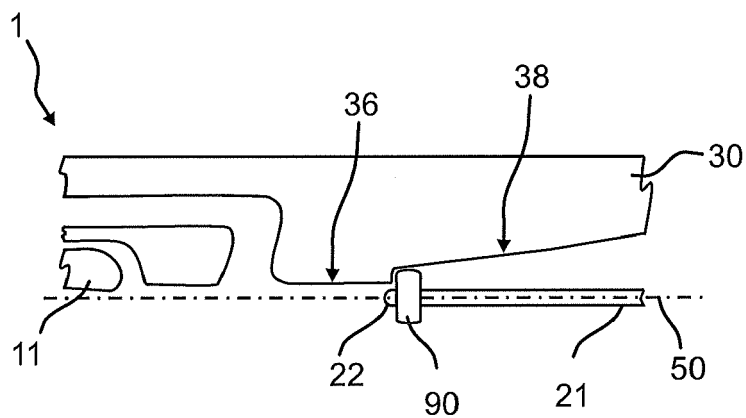


Fig. 9B

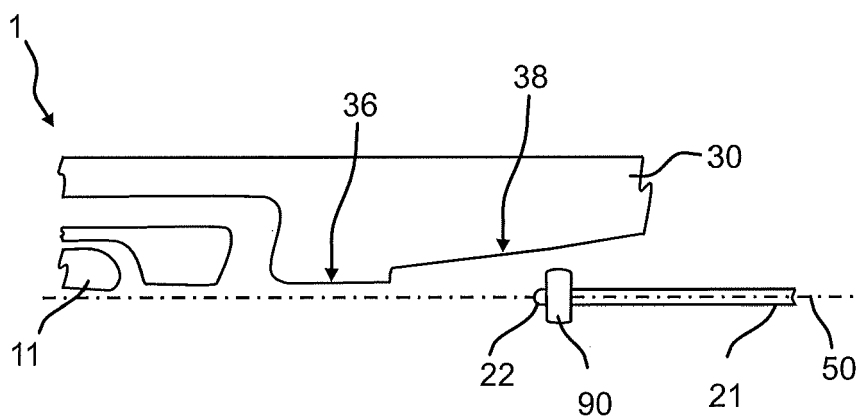


Fig. 9C



EUROPEAN SEARCH REPORT

Application Number
EP 12 15 4881

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X	US 4 211 904 A (KARRENBAUER HERBERT [DE]) 8 July 1980 (1980-07-08)	1-6, 9-11, 13-15	INV. H01H33/70 H01H33/06 H01H33/91
A	* column 3, line 12 - column 7, line 41; claim 1; figures 1-5 * -----	7,8,12	
X	US 4 663 504 A (BARKAN PHILIP [US]) 5 May 1987 (1987-05-05) * column 13, line 48 - column 20, line 44; figures 1-9 * -----	1-5	
X	US 3 140 374 A (COLE FRED H) 7 July 1964 (1964-07-07) * column 2, line 36 - column 4, line 43; figures 1-3 * -----	1	
			TECHNICAL FIELDS SEARCHED (IPC)
			H01H
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 13 July 2012	Examiner Drabko, Jacek
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

1
EPO FORM 1503 03.92 (P04C01)

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

EP 12 15 4881

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
The members are as contained in the European Patent Office EDP file on
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13-07-2012

Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 4211904	A	08-07-1980	DE 2708546 A1 US 4211904 A	31-08-1978 08-07-1980
US 4663504	A	05-05-1987	NONE	
US 3140374	A	07-07-1964	NONE	

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2009124582 A1 [0003]
- FR 2692414 A1 [0004]
- EP 2099047 A1 [0005]