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(54) Gas-insulated high-voltage circuit breaker

(57) The gas-insulated high-voltage circuit breaker comprises in coaxial arrangement two arcing contact members (20, 30) which are movable relative to one another along an axis (A) and of which a first (30) is realized as an axially extended contact pin (31) and a second (20) as a first contact tulip (31) with an axially extended flow duct (25) which forms a flexible nozzle throat (24) and which receives the contact pin (31) during current making: During current breaking pressurized arc-extinguishing gas flows from an arcing zone (Z), which takes a switching arc (S), through the flexible nozzle throat (24) to an expansion room (11) and applies an axially aligned first force (F_1) to a root of the switching arc (S) when the root is located in the flow duct (25) of the contact tulip (31).

In order to increase the current interrupting performance the contact tulip (31) comprises a swirl chamber (70) for creating a predominantly circumferentially aligned second force (F_2) and for applying the second force (F_2) to the root of the switching arc (S).

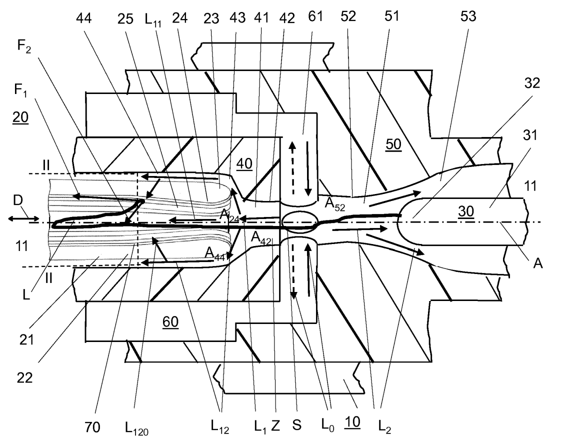

Fig.1

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Description

TECHNICAL FIELD

[0001] The invention relates to a gas-insulated high-voltage circuit breaker according to the introductory part of claim 1.

[0002] The circuit breaker is equipped with a contact assembly which in coaxial arrangement comprises two arcing contact members movable relative to one another along an axis. A first of the two arcing contact members is realized as an axially extended contact pin. The second contact member is realized as a contact tulip with an axially extended flow duct which forms a flexible nozzle throat and which receives the contact pin during current making.

[0003] During current breaking pressurized arc-extinguishing gas flows from an arcing zone, which takes a switching arc, through the nozzle throat of the contact tulip to an expansion room. The gas flow cools the switching arc and additionally applies an axially aligned first force to a root of the switching arc when the root is located in the flow duct of the contact tulip. The first force displaces the root of the switching arc downstream in the flexible nozzle throat and thereby increases the length and thus also the voltage drop of the switching arc. However, the size of the voltage drop and thus also the current interrupting performance depend from a plurality of parameters, which randomly change the length of the switching arc.

PRIOR ART

[0004] Typical gas-insulated circuit breaker of the afore-mentioned type are described in EP 1 630 841 B1, EP 0836 209 B1, EP 0228 099 B1 and US 5,898,149A.

DESCRIPTION OF THE INVENTION

[0005] It is an object of the invention as described in the patent claims to specify a gas-insulated high-voltage circuit breaker of the afore-mentioned type which comprises a high current interrupting performance.

[0006] The invention supplies a gas-insulated high-voltage circuit breaker with a contact assembly comprising in coaxial arrangement two arcing contact members movable relative to one another along an axis, a first of which being realized as an axially extended contact pin and a second as a first contact tulip with an axially extended flow duct which forms a flexible nozzle throat and which receives the contact pin during current making: During current breaking pressurized arc-extinguishing gas flows from an arcing zone, which takes a switching arc, through the nozzle throat of the contact tulip to an expansion room and applies an axially aligned first force to a root of the switching arc when the root is located in the flow duct of the contact tulip.

[0007] The contact tulip comprises a swirl chamber for creating a predominantly circumferentially aligned second force and for applying the second force to the root of the switching arc.

[0008] In the circuit breaker according to the invention the current breaking process uses the combined effect of the axially aligned first force due to the gas flowing through the nozzle throat of the contact tulip to the expansion volume and the circumferentially aligned second force which the swirl chamber creates. These two forces displace the root of the switching arc. The switching arc attaches downstream from the nozzle throat of the contact tulip and rotates predominantly circumferentially on the inner wall of the contact tube. At the same time also the column of the switching arc rotates around the axis and stabilizes a loop which elongates the length of the arc. This enhances the cooling and the resistance of the switching arc and thus the interruption performance of the circuit breaker.

[0009] The second force is a mechanical force caused by a predominantly circumferentially aligned flow of arc-extinguishing gas, a predominantly circumferentially aligned electromagnetic force or a combination of these two forces.

[0010] In order to create an effective, spirally wound swirl flow of arc-extinguishing gas at the location of the root the swirl chamber can comprises at least two slits which are arranged in a section of a tubular wall of the contact tube, wherein the at least two slits connect a by-pass flow duct with the interior of the contact tulip, wherein the by-pass flow duct surrounds at least an annular tip section of the contact tulip facing a nozzle throat of a first insulating nozzle, and wherein the at least two slits are predominantly extended along the axis and open out into the interior of the contact tulip with an outlet that is inclined with respect to the direction of the radius of the tubular wall.

[0011] At least two slits can extend to an end face of the annular tip section of the contact tulip. The flow cross-section of a section of the at least two slits, which section is positioned in the annular tip section, can be negligible with respect to the flow cross-section of the flexible nozzle throat.

[0012] In a further embodiment of the circuit breaker according to the invention the flow cross-section of a section of the at least two slits, which section is positioned in the annular tip section, can be somewhat smaller than the flow cross-section of the flexible nozzle throat. An outside surface of the annular tip section can then be surrounded with a gas-tight jacket.

[0013] A first electric insulating layer can be arranged downstream from the flexible nozzle throat on an inside surface of the contact tulip.The first electric insulating layer can axially extend from a diverging to a tubular section of the flow duct which sections join the flexible nozzle throat. The first insulating layer prevents the root of the switching arc to stay on the nozzle throat or on the diverging section of the flow duct of the contact tulip and ensures a sufficient axial extension of the arc and thus an effective interaction of the swirl flow and the switching arc within the swirl chamber. Furthermore, the first electric insulating layer can axially extend downstream the diverging section only on the tubular section. The first insulating layer then ensures the attachment of the root downstream from the nozzle throat and the diverging section and thus ensures the formation of a maximized loop and of a large length of the switching arc.

[0014] In order to prevent the root from attaching the tip of the contact tulip a second electric insulating layer can extend upstream from the flexible nozzle throat to an outside surface of the annular tip section of the contact tulip.

[0015] At least one of the first and the second electric insulating layers can comprise a thickness of some 100 μm to some mm and can preferably be manufactured from a thermoplastic or duroplastic material, like PTFE or epoxy.

[0016] The swirl chamber can comprises a guide arrangement for controlling the predominantly circumferentially aligned flow of arc-extinguishing gas. The guide arrangement can be realized by means of blades which are arranged on an inner surface of the swirl chamber. The guide arrangement can also be realized by means of the design of the at least two slits, and the inclination of the slits can vary from an outer to an inner surface of the swirl chamber.

[0017] In a high-performance embodiment of the circuit breaker according to the invention a further contact tulip can be arranged downstream from a nozzle throat in a flow duct of a second insulating nozzle. The further contact tulip can comprise a swirl chamber for creating a predominantly circumferentially aligned third force in the interior of the further current tulip during breaking of the current and for applying the third force to another root of the switching arc.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] These and other characteristics of the invention will be clear from the following description of preferential forms, given as non-restrictive examples, with reference to the attached drawings, wherein:

Fig.1 is a longitudinal section extended along an axis of a first embodiment of a gas-insulated high-voltage circuit breaker according to the invention during the breaking of a current,

Fig.2 an enlarged view from the right on a cross section along II-II of a contact tulip of the circuit breaker according to fig.1,

Fig.3 a view on a longitudinal section extended along the axis of the contact tulip according to fig.2,

Fig.4 a view on a longitudinal section extended along the axis of a modified contact tulip of a second embodiment of the circuit breaker according to the invention,

Fig.5 a view on a longitudinal section extended along the axis of a modified contact tulip of a third embodiment of the circuit breaker according to the invention,

Fig.6 a view on a longitudinal section extended along the axis of a modified contact tulip of a fourth embodiment of the circuit breaker according to the invention,

Fig.7 an enlarged view on a cross section of the contact tulip of a fifth embodiment of the circuit breaker according to the invention, and

Fig.8 a longitudinal section extended along the axis of a sixth embodiment of the circuit breaker according to the invention during the breaking of a current.

DETAILD DESCRIPTION OF PREFERENTIAL EMBODIMENTS OF THE INVENTION

[0019] In the figures same reference symbols are used for identical parts and repetitive reference symbols may be omitted.

[0020] The embodiments of the gas-insulated high-voltage circuit breaker according to the invention shown in the figures comprise a tubular housing 10 which is extended along an axis A. The housing 10 is filled with a dielectric insulating medium having arc-extinguishing properties, in particular a gas on the basis of sulfur hexafluoride, nitrogen or carbon dioxide or a mixture comprising one or more of these gases. Typically the insulating gas is pressurized up to some bar, for instance five to eight bar.

[0021] A further dielectric insulating medium, may it be gaseous and/or liquid, can in particular be a dielectric insulation gas or arc quenching gas. Such dielectric insulation medium can for example encompass media comprising an organofluorine compound, such organofluorine compound being selected from the group consisting of: a fluoroether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin and mixtures and/or decomposition products thereof. Herein, the terms "fluoroether", "oxirane", "fluoroamine", "fluoroketone" and "fluoroolefin" refer to at least partially fluorinated compounds. In particular, the term "fluoroether" encompasses both hydrofluoroethers and perfluoroethers, the term "oxirane" encompasses both hydrofluorooxiranes and perfluorooxiranes, the term "fluoroamine" encompasses both hydrofluoroamines and perfluoroamines, the term "fluoroketone" encompasses both hydrofluoroketones and perfluoroketones, and the term "fluoroolefin" encompasses both hydrofluoroolefins and perfluoroolefins. It can thereby be preferred that the fluoroether, the oxirane, the fluoroamine and the fluoroketone are fully fluorinated, i.e. perfluorinated.

[0022] In embodiments, the dielectric insulation medium is selected from the group consisting of: a (or several) hydrofluoroether(s), a (or several) perfluoroketone(s), a (or several) hydrofluoroolefin(s), and mixtures thereof.

[0023] In particular, the term "fluoroketone" as used in the context of the present invention shall be interpreted broadly and shall encompass both fluoromonoketones and fluorodiketones or generally fluoropolyketones. Explicity, more than a single carbonyl group flanked by carbon atoms may be present in the molecule. The term shall also encompass both saturated compounds and unsaturated compounds including double and/or triple bonds between carbon atoms. The at least partially fluorinated alkyl chain of the fluoroketones can be linear or branched and can optionally form a ring.

[0024] In embodiments, the dielectric insulation medium comprises at least one compound being a fluoromonoketone and/or comprising also heteroatoms incorporated into the carbon backbone of the molecules, such as at least one of: a nitrogen atom, oxygen atom and sulphur atom, replacing one or more carbon atoms. More preferably, the fluoromonoketone, in particular perfluoroketone, can have from 3 to 15 or from 4 to 12 carbon atoms and particularly from 5 to 9 carbon atoms. Most preferably, it may comprise exactly 5 carbon atoms and/or exactly 6 carbon atoms and/or exactly 7 carbon atoms and/or exactly 8 carbon atoms.

[0025] In embodiments, the dielectric insulation medium comprises at least one compound being a fluoroolefin selected from the group consisting of: hydrofluoroolefins (HFO) comprising at least three carbon atoms, hydrofluoroolefins (HFO) comprising exactly three carbon atoms, trans-1,3,3,3-tetrafluoro-1-propene (HFO-1234ze), 2,3,3,3-tetrafluoro-1-propene (HFO-1234yf), trans-1,2,3,3,3 pentafluoroprop-1-ene (HFO-1225ye (E-isomer)), cis-1,2,3,3,3 pentafluoroprop-1-ene (HFO-1225ye (Z-isomer)) and mixtures thereof.

[0026] The dielectric insulation medium can further comprise a background gas or carrier gas different from the organofluorine compound (in particular different from the fluoroether, the oxirane, the fluoroamine, the fluoroketone and the fluoroolefin) and can in embodiments be selected from the group consisting of: air, N_2, O_2, CO_2, a noble gas, H_2; NO_2, NO, N_2O; fluorocarbons and in particular perfluorocarbons, such as CF_4; CF_3I, SF_6; and mixtures thereof.

[0027] The housing 10 encloses a contact assembly with two contact members 20, 30 which by means of a drive D can be moved relative to each other along the axis A. The contact member 20 comprises in coaxial arrangement a centrally positioned arcing contact which is realized as a contact tulip 21, two insulating nozzles 40 and 50 and a heating volume 60 for storing arc-extinguishing gas. The contact member 30 comprises a centrally positioned arcing contact which is realized as contact pin 31.

[0028] The contact tulip 21 is arranged downstream from a throat 42 of a flow duct 41 passing through the insulating nozzle 40 from left to right along the axis A and comprises an annulus of contact fingers 22 which are arranged largely parallel to the axis A. The contact fingers 22 comprise free ends which form an annular tip section 23 of the contact tulip 21. In a current-making position of the circuit breaker the contact fingers are elastically deformed and their free ends rest with contact force on a free end 32 of the contact pin 31. In a current-breaking process the contact fingers 22 by means of their spring properties are forced to move inwardly, such that their free ends support each other. The annular tip section 23 of the contact tulip 21 then forms a flexible nozzle throat 24 of a flow duct 25 which passes through the contact tulip 21 along the axis A. The flow cross-section of the nozzle throat 24 is A_{24}.

[0029] The insulating nozzles 40 and 50 are preferably manufactured of a polymer on the basis of a polytetrafluorethylene (PTFE). The insulating nozzle 40 encircles the annular tip section 23 of the contact tulip 21 and together with the surrounding insulating nozzle 50 borders the ring-shaped heating volume 60 and a heating channel 61 which connects the heating volume 60 with an arcing zone Z that during the breaking of a current includes a switching arc S. A flow duct 41 which forms a nozzle throat 42 of the insulating nozzle 40 and a flow duct 51 which forms a nozzle throat 52 of the insulating nozzle 50 border the arcing zone Z radially. The flow cross-section of the nozzle throat 42 resp. 52 is A_{42} resp. A_{52}.

[0030] Though not shown, the housing 10 encloses one or more further components, like control valves, current terminals and nominal contacts. The nominal contacts surround the insulating nozzles 40, 50, the contact tulip 21, the contact pin 31 and the heating volume 60.

[0031] In a current breaking process the drive D moves the contact member 20 to the left. The contact pin 31 which can be realized as a stationary or a as movable part passes the flow ducts 25, 41 and 51. The switching arc S appears as soon as the contact tulip 21 and the contact pin 31 separate. The switching arc S generates pressurized arcing gas in the arcing zone Z. When the contact pin 31 releases the heating channel 61 a flow of hot pressurized arcing gas L_0

(shown with dotted arrows) is guided via the heating channel 61 to the heating volume 60 in which the pressurized hot arcing gas is mixed with cool insulating gas and stored as arc-extinguishing gas.

[0032] When the current approaches current zero the gas flow L_0 (shown with continuous arrows) reverses its direction and arc-extinguishing gas now flows from the heating volume 60 through the heating channel 61 into the arcing zone Z. This gas flow enters the arcing zone Z radially and at a stagnation point is split into two oppositely aligned arc-extinguishing gas flows L_1 and L_2. The arc-extinguishing gas flow L_1 is guided through the flow duct 41 to an expansion room 11 and hereby passes the nozzle throat 42 and the contact tulip 21 which is arranged downstream the nozzle throat 42. The arc-extinguishing gas flow L_2 is guided oppositely through the flow channel 51 to the expansion room 11 and hereby passes the nozzle throat 52. Both arc-extinguishing gas flows L_1 and L_2 blow the switching arc S until the arc is extinguished and the current is broken.

[0033] An efficient blowing of the switching arc S and thus a successful breaking of the current requires a fast removal of the hot arcing gas from the arcing zone Z and a fast transportation of the hot arcing gas in dielectric uncritical areas. Thus the flow cross-section of a section 43 of the flow duct 41 downstream the nozzle throat 42 must increase continuously compared with the flow cross-section A_{42} of the nozzle throat 42. The same is with the flow cross-section of a section 53 of the flow duct 51 which joins the nozzle throat 52 downstream and which increases continuously compared with the flow cross-section A_{52} of the nozzle throat 52.

[0034] However, the contact tulip 21 is arranged in the flow duct section 43. Furthermore, due to the predetermined diameter of the contact pin 31 the flow cross-section A_{24} of the nozzle throat 24 is smaller than the flow cross-section A_{42} of the nozzle throat 42. In order to maintain the fast removal of the hot arcing gases from the arcing zone Z resp. downstream the nozzle throat 42 the contact member 20 comprises a by-pass flow duct 44. The by-pass flow duct 44 connects a part of the flow duct section 43 which is arranged between the annular tip section 23 of the contact tulip 21 and the nozzle throat 42 to a section of the flow duct 25 which is arranged downstream the nozzle throat 24. Thus the arc-extinguishing gas flow L_1 downstream the nozzle throat 42 splits into an partial arc-extinguishing gas flow L_{11} which passes the nozzle throat 24 and a partial arc-extinguishing gas flow L_{12} which passes the by-pass flow duct 44. The sum of the flow cross-sections A_{24} of the nozzle throat 24 and A_{44} of the by-pass flow duct 44 is larger than the flow cross-section A_{42} of the nozzle throat 42. This ensures a quick removal of the hot arcing gas from the flow duct section 43 resp. from the arcing zone Z.

[0035] Fig.1 shows that the arc-extinguishing gas flow L_{11} passes the flow duct 25. Due to an axially aligned mechanical force F_1 the arc-extinguishing gas flow L_{11} moves a root of the switching arc S which is attached to the contact tulip 21 downstream in a section of the flow duct 25 which joins the nozzle throat 24. Fig.1 further shows a swirl chamber 70 comprising means for creating a predominantly circumferentially aligned force F_2 for moving the root of the switching arc S.

[0036] Due to the combined effect of the axially aligned mechanical force F_1 of the gas flow L_{11} and the circumferentially aligned force F_2 the root of the switching arc S is forced to attach downstream and to rotate circumferentially on the inner wall of the contact tube 21. At the same time also the column of the switching arc S rotates around the axis A and stabilizes a loop L which elongates the length of the arc. This enhances the cooling and the resistance of the switching arc S and thus the interruption performance of the circuit breaker.

[0037] In the embodiment according to fig.1 the predominantly circumferentially aligned force F_2 is a mechanical force which is caused by a flow L_{120} of predominantly circumferentially aligned arc-extinguishing gas. The flow L_{120} passes the swirl chamber 70 from the by-pass duct 44 to the interior of the contact tulip 21 and together with the axially aligned gas flow L_{11} induces a spirally wound swirl flow SF which is shown in figures 2 to 6. Such a predominantly circumferentially aligned force F_2 can also be an electromagnetic force caused by an external magnetic field of a current coil or of a permanent magnet applied to the switching arc S.

[0038] As shown in fig.2 the swirl chamber 70 comprises eight slits 71. These slits are arranged in a tubular wall of the contact tube 21 and connect the by-pass flow duct 44 to the interior of the contact tulip 21. The slits 71 are predominantly extended along the axis A and open out into the interior of the contact tulip 21 with an outlet 72 that is inclined with respect to the radius R of the tubular wall with an angle α. In the embodiment according fig.2 the slits 71 are inclined with a constant angle α against the radius R. Thus also the outlet 72 comprises the inclination angle α and the gas flow L_{12} enters the interior of the swirl chamber 70 with the inclination angle α.Typical values of the angle α range between 30° and 90°.

[0039] In such an embodiment of the circuit breaker according to the invention the swirl flow SF moves the arc root attached to the inner wall of the contact tulip 21 and drives the switching arc S to the axis A. Furthermore, the arc attachment only occurs far downstream the tip of the contact tulip 21 facing the nozzle throat 42 of the insulating nozzle 40. The movement of the root and of the switching arc S can be controlled with the magnitude of the flow component L_{120} in comparison to the magnitude of the gas flow L_{11}. The swirl flow SF comprises a suction effect and stabilizes the switching arc S centrally to the axis A. Thus the root of the arc is endeavoured to avoid the tip of the contact tulip 21 and to attach only far downstream the tip of the contact tulip. The rotation of the root always leads to a movement of the root and also of the switching arc S and causes an efficient cooling of the arc and thus to an improved switching performance.

[0040] Fig.3 show that the slits 71 extend to an end face of the annular tip section 23 of the contact tulip 21 which according to fig.1 faces the nozzle throat 42 of the insulating nozzle 40. The annular tip section 23 forms the flexible nozzle throat 24 and extends from the afore-defined end face somewhat downstream the nozzle throat 24.

[0041] In the embodiment of the circuit breaker according to fig.3 the flow cross-section of the section of the slits 71 positioned in the annular tip section 23 is somewhat smaller than the flow cross-section A_{24} of the flexible nozzle throat 24. The swirl chamber 70 then extends from the end face of the annular tip section 23 of the contact tulip 21 downstream. Thus the swirl flow SF is formed in and downstream the nozzle throat 24.

[0042] In the embodiment of the circuit breaker according to fig.4 the flow cross-section of a section of the slits 71 positioned in the annular tip section 23 is negligible with respect to the flow cross-section A_{24} of the flexible nozzle throat 24. The negligible flow cross-section of the slits 71 in the annular tip section 23 avoids nearly any gas flow in the annular tip section 23 and thus avoids the formation of the swirl flow SF in the nozzle throat 24. Thus the swirl chamber 70 is arranged downstream the nozzle throat 24 and the swirl flow SF is formed only downstream the nozzle throat 24.

[0043] In the embodiment according to fig.5 an outside surface of the annular tip section 23 is surrounded with a gas-tight jacket 73. Such a jacket forms an axially aligned gas flow L_{110} which assists the gas flow L_{11} in driving the root of the switching arc S into the swirl chamber 70.

[0044] In further embodiments of the circuit breaker according to the invention an electric insulating layer is arranged downstream from the flexible nozzle throat 24 on an inside surface of the contact tulip 21. Such an insulating layer is shown in figures 5 and 6 and is marked with the reference sign 74.

[0045] In the embodiment according to fig.5 the electric insulating layer 74 axially extends from a diverging section 26 to a tubular section 27 of the flow duct 25. Thereby the diverging section 26 joins the flexible nozzle throat 24 and the tubular section 27 joins the diverging section 26. The layer 74 prevents the root of the switching arc S to stay on the nozzle throat 24 of the flow duct 25 and ensures a sufficient axial extension of the arc and thus an effective interaction of the swirl flow SF and the switching arc S within the swirl chamber 70.

[0046] In the embodiment according to fig.6 the electric insulating layer 74 axially extends downstream from the diverging section 26 only on the tubular section 27. The layer 74 then ensures the attachment of the root within the flow duct 25 only somewhat downstream the nozzle throat 24 and thus ensures the formation of a maximized loop L of the switching arc S. The interaction between the switching arc S and the swirl flow (not shown) in the swirl chamber 70 is then also very effective.

[0047] In order to prevent the root from attaching the tip of the contact tulip 21 in the embodiments according to figures 5 and 6 a further electric insulating layer 74' extends upstream from the flexible nozzle throat 24 to an outside surface of the annular tip section 23 of the contact tulip.

[0048] Fig.7 shows an embodiment of the circuit breaker according to the invention in which the swirl chamber 70 comprises a guide arrangement for controlling the swirl flow. Such a guide arrangement comprise preferably blades 75 which are arranged on an inner surface of the swirl chamber 70 and which force the gas flow L_{120} to enter the swirl chamber 70 with the afore-defined specific angle α. The control function of the guide arrangement can also be achieved with slits 71' whose inclination is varied from the outer to the inner surface of the swirl chamber 70.

[0049] Fig.8 shows an embodiment of the circuit breaker according to the invention in which a contact tulip 33 with a flow duct 34 and a flexible nozzle throat 35 is arranged in the section 53 of the flow duct 51 of the insulating nozzle 50 and in which a by-pass flow duct 54 connects a part of the flow duct section 53 which part is arranged between a tip of the contact tulip 33 and the nozzle throat 52 to a section of the flow duct 34 which is arranged downstream the nozzle throat 35. Thus the arc-extinguishing gas flow L_2 downstream the nozzle throat 52 splits into an partial arc-extinguishing gas flow L_{21} which passes the nozzle throat 35 and a partial arc-extinguishing gas flow L_{22} which passes the by-pass flow duct 54. The sum of the flow cross-sections of the nozzle throat 35 and of the by-pass flow duct 54 is larger than the flow cross-section A_{52} of the nozzle throat 52. This ensures a quick removal of the hot arcing gas from the flow duct section 53 resp. from the arcing zone Z.

[0050] The contact tulip 33 comprises a swirl chamber 80 with inclined slits which connect the by-pass flow duct 54 with the interior of the contact tulip 33. The gas flow L_{22} feeds a gas flow L_{220} which passes the inclined slits and which enters the interior of the contact tulip 33 predominantly circumferentially aligned. During the breaking process one of the two roots of the switching arc S is firstly attached to the end 32 of the contact pin 31. When the contact pin 31 passes the flexible nozzle throat 35 the afore-identified root displaces from the contact pin 31 to the contact tulip 33 and is attached on the inside of the contact tulip 33. The axially aligned gas flow L_{21} moves the root downstream as shown in fig.8 with an axially aligned force F_4. The gas flow L_{220} acts with a predominantly circumferentially extended force F_3 on the root of the switching arc.

[0051] Due to the combined forces F_4 of the gas flow L_{21} and F_3 of the gas flow L_{220} the root of the switching arc S is forced to attach downstream and to rotate circumferentially on the inner wall of the contact tube 33. At the same time also the column of the switching arc S rotates around the axis and stabilizes a loop which elongates the length of the arc. This enhances the cooling and the resistance of the switching arc S and thus the interruption performance of the circuit breaker additionally.

[0052] Instead of the inclined slits 71 the swirl chamber 70 resp. 80 can also comprise inclined holes of preferably circular or elliptical design which form the predominantly circumferentially adjusted gas flow L_{120} resp. L_{220}. The aforementioned gas flow can also be formed with a combination of inclined slits and inclined holes.

List of Reference Signs

[0053]

10	housing
11	expansion room
20	contact member
21	contact tulip, arcing contact
22	contact fingers
23	annular tip section of the contact tulip 21
24	nozzle throat of contact tulip 21
25	flow duct of contact tulip 21
26	diverging section of the flow duct 25
27	tubular section of the flow duct 25
30	contact member
31	contact pin
32	end of contact pin
33	contact tulip
34	flow duct of the contact tulip 31
35	nozzle throat of the contact tulip 33
40	insulating nozzle
41	flow duct of the insulating nozzle 40
42	nozzle throat of the insulating nozzle 40
43	section of the flow duct 42
44	by-pass flow duct
50	insulating nozzle
51	flow duct of the insulating nozzle 50
52	nozzle throat of the insulating nozzle 50
53	section of the flow duct 52
54	by-pass flow duct
60	heating volume
61	heating channel
70	swirl chamber
71	sl its
72	outlet
73	jacket
74, 74'	electric insulating layers
75	guide arrangement, blades
80	swirl chamber
A	axis
A_{24}	flow cross-section of the nozzle throat 24
A_{42}	flow cross-section of the nozzle throat 42
A_{52}	flow cross-section of the nozzle throat 52
D	drive
F_1, F_4	axially adjusted forces
F_2, F_3	circumferentially adjusted forces
L	loop
L_0, L_1, L_2 L_{11}, L_{12}, L_{21}, L_{22} L_{110}, L_{120}, L_{210}	arc-extinguishing gas flows
S	switching arc
SF	swirl flow
Z	arcing zone

Claims

1. A gas-insulated high-voltage circuit breaker with a contact assembly comprising in coaxial arrangement two arcing contact members (20, 30) movable relative to one another along an axis (A), a first (30) of which being realized as an axially extended contact pin (31) and a second (20) as a contact tulip (21) with an axially extended flow duct (25) which forms a flexible nozzle throat (24) and which receives the contact pin (31) during current making,
in which during current breaking pressurized arc-extinguishing gas flows from an arcing zone (Z), which takes a switching arc (S), through the nozzle throat (24) of the contact tulip (21) to an expansion room (11) and applies an axially aligned first force (F_1) to a root of the switching arc (S) when the root is located in the flow duct (25) of the contact tulip (21),
characterized in
that the contact tulip (21) comprises a swirl chamber (70) for creating a predominantly circumferentially aligned second force (F_2) and for applying the second force (F_2) to the root of the switching arc (S).

2. The circuit breaker according to claim 1,
characterized in
that the second force (F_2) comprises at least one of a mechanical force caused by a predominantly circumferentially adjusted flow (L_{120}) of arc-extinguishing gas and a predominantly circumferentially adjusted electromagnetic force.

3. The circuit breaker according to claim 2,
characterized in
that the swirl chamber (70) comprises at least two slits (71) which are arranged in a section of a tubular wall of the contact tube (21), wherein the at least two slits (71) connect a by-pass flow duct (44) with the interior of the contact tulip (21), wherein the by-pass flow duct (44) surrounds at least an annular tip section (23) of the contact tulip (21) facing a nozzle throat (42) of a first insulating nozzle (40), and wherein the at least two slits (71) are predominantly extended along the axis (A) and open out into the interior of the contact tulip with an outlet section (72) that is inclined with respect to the direction of the radius (R) of the tubular wall.

4. The circuit breaker according to claim 3,
characterized in
that the at least two slits (71) extend to an end face of the annular tip section (23) of the contact tulip (21).

5. The circuit breaker according to claim 4,
characterized in
that the flow cross-section of a section of the at least two slits (71), which section is positioned in the annular tip section (23), is negligible with respect to the flow cross-section (A_{24}) of the flexible nozzle throat (24).

6. The circuit breaker according to claim 4,
characterized in
that the flow cross-section of a section of the at least two slits (71), which section is positioned in the annular tip section (23), is somewhat smaller than the flow cross-section (A_{24}) of the flexible nozzle throat (24).

7. The circuit breaker according to claim 6,
characterized in
that an outside surface of the annular tip section (23) is surrounded with a gas-tight jacket (73).

8. The circuit breaker according any of claims 3 to 7,
characterized in
that a first electric insulating layer (74) is arranged downstream from the flexible nozzle throat (24) on an inside surface of the contact tulip (21).

9. The circuit breaker according to claim 8,
characterized in
that the first electric insulating layer (74) axially extends from a diverging (26) to a tubular section (27) of the flow duct (25) which sections (26, 27) join the flexible nozzle throat (24).

10. The circuit breaker according to claim 8,
characterized in

that the first electric insulating layer (74) axially extends only downstream a diverging section (26) of the flow duct (25) which diverging section (26) joins the flexible nozzle throat (24).

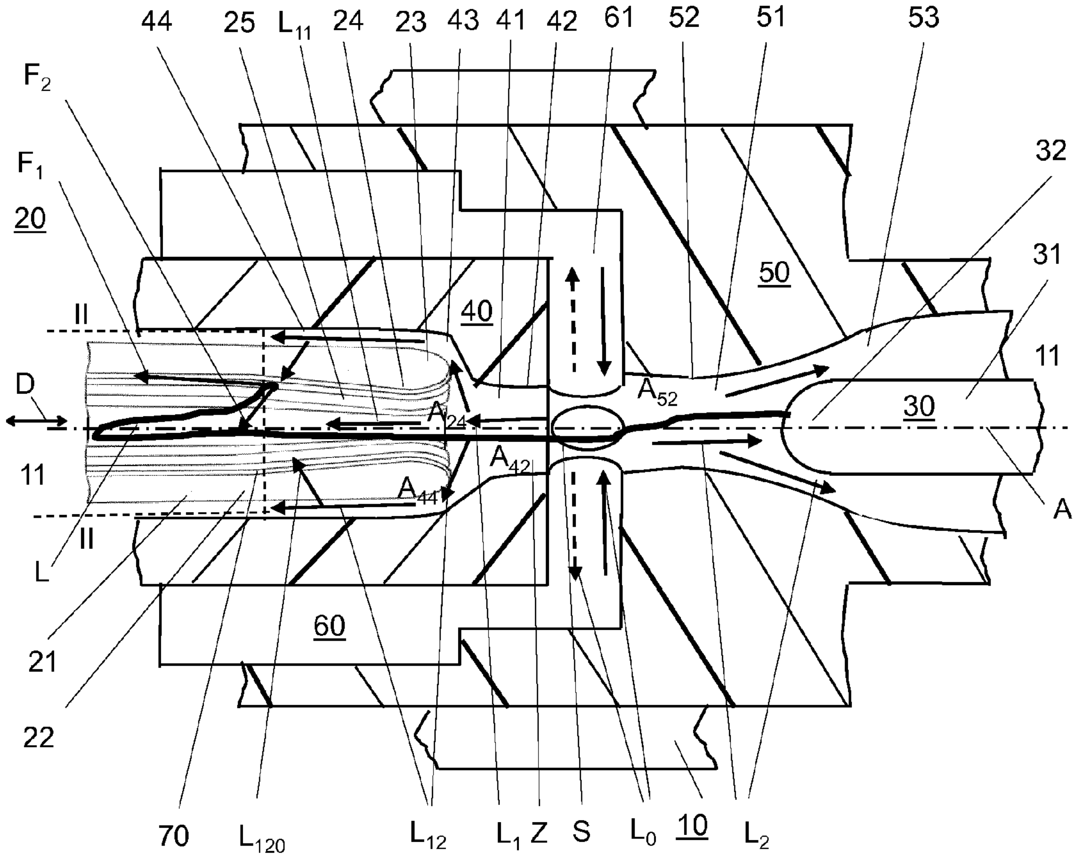
11. The circuit breaker according to any of claims 8 to 10,
characterized in
that a second electric insulating layer (74') extends upstream from the flexible nozzle throat (25) to an outside surface of the annular tip section (23) of the contact tulip (21).

12. The circuit breaker according to any of claims 2 to 11,
characterized in
that the swirl chamber (70) comprises a guide arrangement for controlling the predominantly circumferentially adjusted flow (L_{120}) of arc-extinguishing gas.

13. The circuit breaker according to claim 12,
characterized in
that the guide arrangement is realized by means of blades (75) which are arranged on an inner surface of the swirl chamber (70).

14. The circuit breaker according to claim 12,
characterized in
that the guide arrangement is realized by means of the design of the at least two slits (71), and in that the inclination of the slits (71) varies from an outer to an inner surface of the swirl chamber (70).

15. The circuit breaker according to any of claims 1 to 15,
characterized in
that the gas-insulation of the circuit breaker is realised with a dielectric insulation gas comprising an organofluorine compound selected from the group consisting of: a fluoroether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin; and mixtures and/or decomposition products thereof.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A24
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A42
A44
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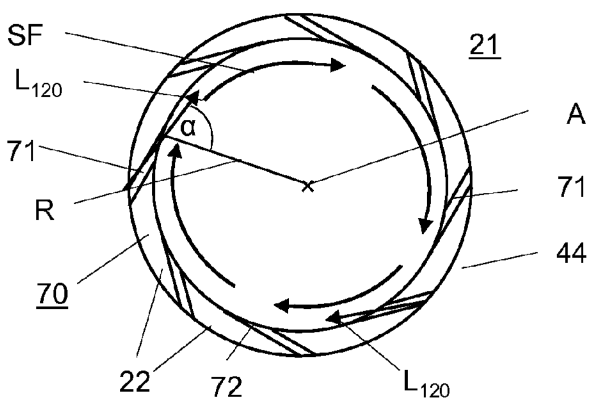
L2

Fig.1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L120
A
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70
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72
L120

Fig.2

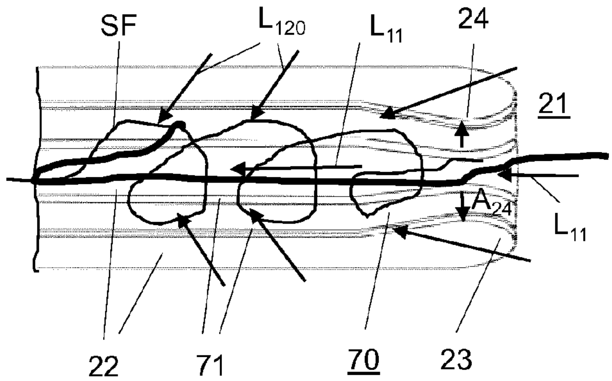

Fig.3

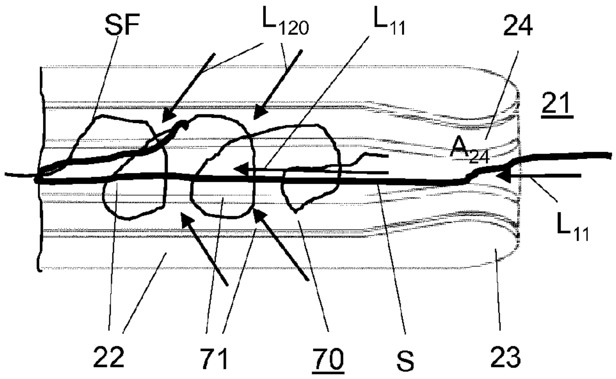

Fig.4

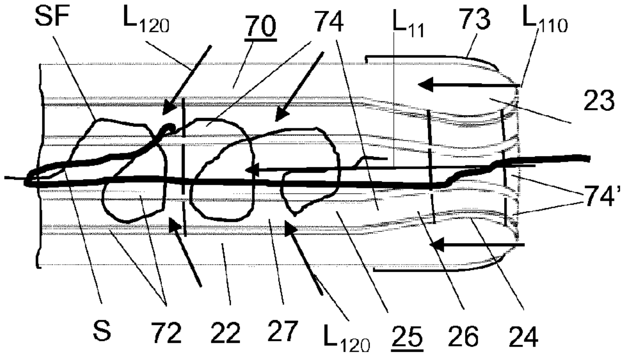

Fig.5

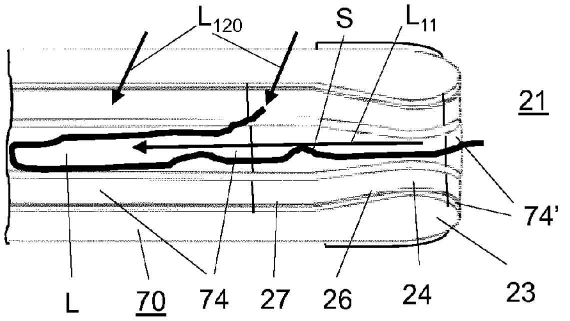

Fig.6

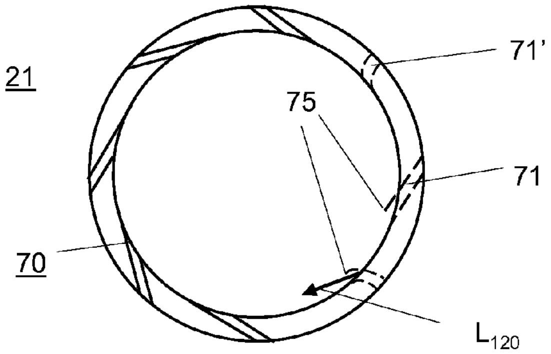

Fig.7

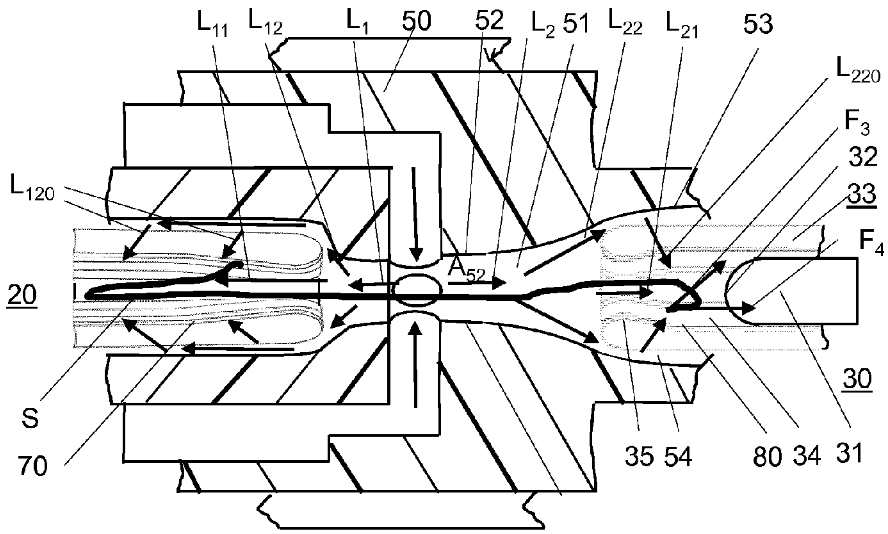

Fig.8

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EUROPEAN SEARCH REPORT

Application Number
EP 13 19 8479

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	7 April 2014	Bilard, Stéphane

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