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(54) **ARCING CONTACT TULIP WITH FLOW OPTIMIZED SLITS AND INTEGRATED STRESS RELIEF FEATURE**

(57) A tulip contact for a power switch, comprises a rotationally symmetric contact body 100 having a first end 120, a second end, and a plurality of slits 210, 220. The slits are arranged in the body and extend parallel to the symmetrical axis 140 of the body. The slits define a length between the first end and a root of the slits.The slits have a first width at the first end and a second width at the root of the slits, wherein the first width is bigger than the second width. A stress-relief element 400 is provided to mitigate mechanical stress in the material of the body 100 in case the slits 210, 220 close.

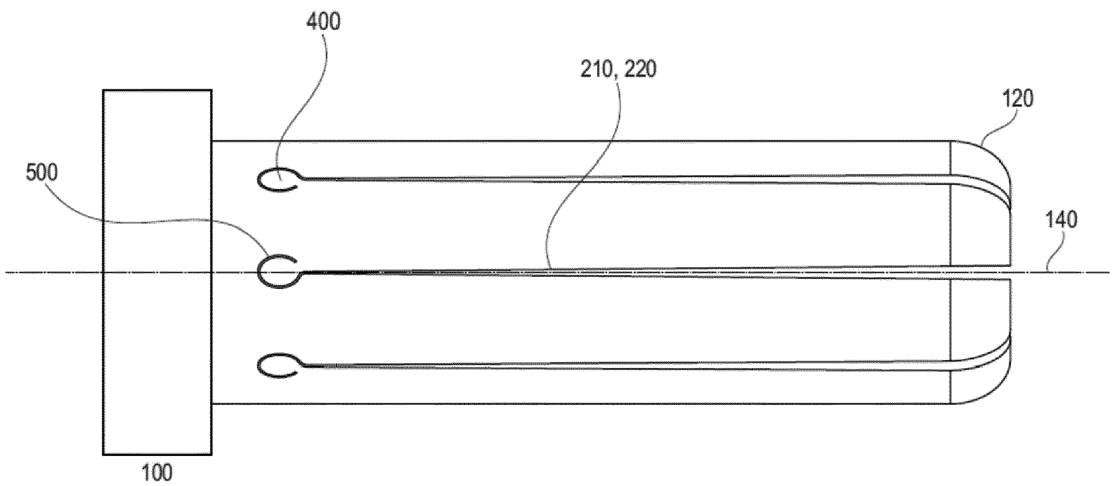


FIG. 5

EP 3 826 042 A1

Description

FIELD OF INVENTION

[0001] The disclosure relates to the field of electrical switching devices, for example load break switches or circuit breakers (CB), in particular for a high or medium voltage circuit breaker (HVCB, MVCB) with an arc-extinguishing capability. In particular, the application concerns tulip-type arcing contacts used in such load break switches and circuit breakers.

BACKGROUND OF INVENTION

[0002] Electrical switching devices, for example load break switches or circuit breakers (CB), in particular for a high or medium voltage circuit breaker (HVCB, MVCB), may constitute an integral part of units assigned to the task of switching load currents, with typical load currents being in a range of 1 kA to 300 kA root mean square. The load break switch is opened or closed by a relative movement of contacts, e. g. a plug contact and a tulip-type contact. When the contacts are moved away from each other during a current-breaking operation, an electric arc may be formed between the separating contacts which may be also called "arcing-contacts".

[0003] In load break switches or circuit breakers (CB), generally a compressed fluid (e.g. a gas) may be used to extinguish an arc between the arcing contacts. To interrupt the current flow between the arcing contacts, an electric conductivity of the medium between the arcing contacts may be sufficiently reduced to stop the current from flowing in the opposite direction after current zero (arc quenching). In addition, the interrupting medium may be configured to regain sufficient dielectric strength to avoid breakdown and re-ignition of the electric arc, as the breaker must sustain the total voltage of the interrupted circuit (recovery). Both arc quenching and recovery must be successful to ensure a successful interruption.

[0004] This compressed fluid/gas may be provided by several ways. In some load break switches with an arc-extinguishing capability, e.g. a mechanism may be employed, called a puffer mechanism. A quenching gas, like e.g. SF6, is compressed in a puffer volume and released into an arcing region or arc quenching region.

[0005] During an opening operation, a piston moves through a displacement stroke. The quenching gas may be compressed and an overpressure may occur in a compression chamber. At the same time, a tulip contact is pulled away from the plug contact, and the electric arc is generated. During the interruption, the arc heats up the gas volume around the contacts.

[0006] Hot insulation gas has a lower insulation capability than the same insulation gas at a lower temperature. The hot gas increases a risk of a dielectric re-strike, even if the arc was successfully interrupted beforehand (i. e., even if a preceding thermal interruption was successful). Therefore, cool gas with a sufficient pressure has to be directed to the arcing region.

[0007] The generated arc between arcing contacts evaporate a thin layer of an insulating material, which may surround the arcing region. This evaporation process, and the resulting gas/vapor, may cool the arc, cause a reduction in arc conductivity and improve the arc-quenching properties.

[0008] Thermal radiation from the arc may cause ablation of e.g. a polytetrafluoroethylene (PTFE) vapor from a nozzle which may surround the arcing region, leading to flow from the high pressure arc zone to a heating volume. This may be known as back heating. In the case of high current, the arc may be said to be "ablation controlled" at this time.

[0009] The pressure increases in the heating volume and begins to decrease in the arc zone as current zero (CZ) is approached and ablation is reduced. At the time when the heating volume pressure equals the arc zone pressure flow, reversal takes place.

[0010] The flow may be directed from the heating volume to the arc zone thereafter and the arc may be axially blown. The arc may be extinguished at CZ.

[0011] Generally, tulip contacts are used as arcing contacts in medium and/or high voltage circuit breakers which are typically used for interrupting short circuit current when an electrical fault occurs. The tulip type contact is advantageously configured to transmit or break or make short circuit current, in a range from at least 1 kA up to 300 kA.

[0012] Typically, a tulip contact may comprise multiple contact fingers for establishing and disconnecting an electrical contact with a mating contact, such as a corresponding plug. The gap between the contact fingers may be considered as a "slit". The tulip contacts may be equipped with material which may be specifically heat resistant against the influence of the arc, e.g. Tungsten or its alloys.

[0013] Traditional arcing contact tulips have slits in order to accommodate mechanical and electrical contact with the plug contact. These slits contribute to gas-pressure build-up or gas-pressure loss in the arc zone. The slits in the contact body of the tulip contact provide the multiple contact fingers for establishing and disconnecting an electrical contact with a mating contact (second arcing contact; plug contact).

[0014] Due to electro-mechanical forces, the slits of the commonly known tulip contacts are partially closed and the gap between the slits is undefined. This may lead to significant scatter and probably uncontrolled movement of the contact fingers (vibration) in thermal interruption performance of the breakers and an unwanted behavior.

[0015] Tulip slits in the contact body, during high power test duties, get squeezed due to electromagnetic and quenching-gas pressure forces. This may happen at current peak. If the current approaches its natural zero (zero-crossing of the current sine-wave), these forces tend to be lower. The slits open again due to material elasticity (spring-force of the material).

[0016] The opening and closing of the slits, and in particular the gaps due to an incomplete closing of the slits, have an influence on gas pressure in the arc-zone and in turn on the interruption performance of the breaker. The flow area in the tulip (slits area) may also have an influence on the pressure build-up. Closed slits advantageously contribute to the pressure build-up. This has been proven through tests. For better and stable interruption performance of the circuit breaker, it is therefore desired that opening and closing of the slits in the arcing tulip contact is defined and should not vary.

[0017] An object of the disclosure is therefore to provide an improved tulip contact which may improve a pressure behavior and therefore may have a better extinguishing capacity. Additionally, mechanical stability of the tulip contact may be improved by different measures which are described in the following.

SUMMARY OF INVENTION

[0018] In order to address the foregoing and other potential problems, embodiments of the present disclosure propose:

In a first aspect, a tulip contact for a power switch is disclosed. The tulip contact may comprise a rotationally symmetric contact body, having a first end and a second end.

[0019] The contact body may have a plurality of slits. The slits may be arranged in the rotationally symmetric contact body and may extend substantially parallel to a symmetrical axis of the symmetrical contact body of the tulip contact and may form "contact-fingers" in the rotationally symmetric contact body.

[0020] Further, the slits may define a length 1 between the first end of the slits and a root of the slits. The length 1 of the slits is shorter than a length of the contact body.

[0021] The slits may have a first width at the first end and a second width at the root of the slits wherein the first width may be bigger than the second width.

[0022] In another aspect of the present disclosure, a switchgear, e.g. a gas insulated switchgear for medium- or high voltage applications is disclosed. The switchgear is equipped with a tulip contact according to other aspects as disclosed.

[0023] Further details, aspects and embodiments of the present disclosure become apparent from the claims, the detailled description and the accompanying drawings.

BRIEF DESCRIPTION OF DRAWINGS

[0024] Embodiments of the present disclosure will be presented in the sense of examples and their advantages are explained in greater detail below, with reference to the accompanying drawings, wherein:

FIG. 1 shows a tulip contact according to prior art;

FIG. 2 shows a tulip contact according to embodiments of the present application;

FIG. 3 shows forms of slits for a tulip contact according to embodiments;

FIG. 4 shows a slit with stress relief elements;

FIG. 5 shows another tulip contact according to embodiments of the present application.

DETAILED DESCRIPTION OF EMBODIMENTS

[0025] Hereinafter, the principle and spirit of the present disclosure will be described with reference to the illustrative embodiments. It should be understood that all of these embodiments are given merely for the skilled in the art to better understand and further practice the present disclosure, but not for limiting the scope of the present disclosure. For example, features illustrated or described as part of one embodiment may be used with another embodiment to yield still a further embodiment.

[0026] In the interest of clarity, not all features of an actual implementation are described in this specification. It will of course be appreciated that in the development of any such actual embodiment, numerous implementation-specific decisions should be made to achieve the developer's specific goals, such as compliance with system-related and business-related constraints, which will vary from one implementation to another. Moreover, it will be appreciated that such a development effort might be complex and time-consuming, but would nevertheless be a routine undertaking for those of ordinary skill in the art having the benefit of this disclosure.

[0027] The disclosed subject matter will now be described with reference to the attached figures. Various structures, systems and devices are schematically depicted in the drawings for purposes of explanation only and so as to not obscure the description with details that are well known to those skilled in the art. Nevertheless, the attached drawings are included to describe and explain illustrative examples of the disclosed subject matter. The words and phrases used herein should be understood and interpreted to have a meaning consistent with the understanding of those words and phrases by those skilled in the relevant art.

[0028] No special definition of a term or phrase, i.e. a definition that is different from the ordinary and customary meaning as understood by those skilled in the art, is intended to be implied by consistent usage of the term or phrase herein. To the extent that a term or phrase is intended to have a special meaning, i.e. a meaning other than that understood by skilled artisans, such a special definition will be expressly set forth in the specification in a definitional manner that directly and unequivocally provides the special definition for the term or phrase.

[0029] One of the aspects of the present application is to introduce an alternative and improved form of the slits 110, 210 in the contact body 100 to control gas flow in the arcing zone. A V-form of the slits, in particular a reversed V-shape, as introduced, may allow for a better, in particular a full closing along the entire length of the slits 110, 210.

[0030] FIG. 1 shows the effect of traditional slits 110 in a commonly used arrangement of slits 110 in a contact body 100 for a tulip contact. The drawings on the left show that the slits from tip 120 to root 160 have a rectangular form, when no load is attached. That is there is zero-current through the contact and therefore no electromagnetic pinching forces. The contact body may be hollow as can be seen, so that it may contain an arc extinguishing fluid/gas.

[0031] The right side in FIG. 1 shows the contact body 100 of the tulip contact under load, symbolized by the arrows designated with "Current in" and "Current out". The slit 110 is closed at the tip 120 of the tulip, forming an elongated triangle with a base at its root 160, due to electromagnetic forces, caused by high current. That is, slit 110 remains open towards the root 160 of the slits. Building up a gas pressure will be difficult, since the gas leaves the contact body 100 through the partially opened slits 110, in particular at the broadening end part towards the root 160.

[0032] Moreover, the material of the metallic contact-body 100, in particular in the area of the root 160, is exposed to mechanical bending forces which act against the electromagnetic closing forces due to the current. This may lead to increased fatigue of the material and breaking off of contact fingers from the contact body 100 which may lead to increased maintenance work.

[0033] Therefore, in a first embodiment of the present application, a tulip contact 100 for a power switch is disclosed. The tulip contact may comprise a rotationally symmetric contact body 100, having a first end 120 and a second end 130. The tulip contact-body 100 is e.g. a hollow body of a conductive material which may additionally be configured to receive a plug contact as a second arcing contact. The hollow body of the tulip contact 100 may be configured to receive and contain an arc extinguishing fluid during an arcing event.

[0034] The rotationally symmetric contact body 100 may have a plurality of slits 110, 210, 220. The slits 110, 210, 220 may be arranged in the rotationally symmetric contact body 100. The slits may extend substantially parallel to a symmetrical axis 140 of the rotationally symmetric contact body 100. The slits 110, 210, 220 in the rotationally symmetric contact body may form "contact-fingers" which have a certain elasticity due to the used material.

[0035] The slits 110, 210, 220 may define a length 1 150 between the first end 120 of the rotationally symmetric contact body and a root 160 of the slits 110, 210, 220. The length l 150 of the slit(s) 110, 210, 220 may be shorter than a length of the rotationally symmetric contact body 100. This means that the slits 110, 210, 220 may have a length such that the rotationally symmetric contact body is not separated into a plurality of single parts.

[0036] Further, slits 110, 210, 220 may have a first width 300 at the first end 120 of the rotationally symmetric contact body 100 and a second width 310 at the root 160 of the slits 110, 210, 220, wherein the first width 300 is bigger than the second width 310.

[0037] FIG. 2 shows the contact body 100 with an improved slit -shape (left FIGs A) in a "non-load" condition. The newly introduced V-shaped slits 210 are in an "open" condition here. Under a current load, represented on the right side of the figure (right Figs B) by arrows "current in" "current out", electromagnetic forces due to the current flow through the contact body 100 close the slits 210.

[0038] The contact body 100 now has a closed, at least a nearly closed, surface along its axis 140 as can be seen in the right part of FIG. 2. Quenching gas, e.g. a ptfe vapor generated by an ablation process by the burning arc from a nozzle (not shown), within the hollow contact body 100, cannot flow through the slits or at least the flow is considerably reduced. A pressure of the quenching gas in the (hollow) contact body 100 can build up which is higher than in the normally shaped slits (see FIG. 1). A higher amount of quenching gas with an increased pressure can be directed towards the arcing zone (which is in the "current out" direction).

[0039] Due to the arc, a considerable pressure difference around the tulip contact may be built up. Now, there may be a lower pressure in the tulip throat and a higher pressure around the tulip body 100, which also exercises pressure to close the slits in addition to the electromagnetic forces. The new form of the slits may reduce the area of the slits by more than 40% compared to traditional slits and supports extinguishing the arc in an advantageous manner.

[0040] A central idea of this disclosure is therefore to introduce so called V-shape slits, which may substantially fully close along the entire length of the slits. The effect is demonstrated in Fig. 4. Electro-mechanical forces pinch the fingers together, which closes the slits along the entire length. A traditional tulip stays close towards the tulip throat under load and is open at end; new slits (V-shape) may ensure that they may remain completely close. In effect, pressure at CZ (current zero) may not substantially vary due to the change in flow area through the tulip.

[0041] Through the closed (or nearly closed) tulip slits 110, 210 there may be a considerably reduced flow of quenching gas. The quenching gas in the tulip may be e.g ptfe vapors which may be generated by ablation and vaporization of ptfe material surrounding the arcing zone (e.g. a nozzle made of ptfe).

[0042] Physical principles of generation of quenching gas by an ablation process due to the arc in the arcing zone shall not be considered here. The physical background of the flow effects of the generated gas (ptfe vapour) is also not considered here. The mentioning of ptfe vapors is not considered to be limiting here. Other materials suitable for an ablation process and to generate an arc extinguishing vapor are possible (e.g. POM).

[0043] It is noted that the tulip contact presented here is suitable to be used in breakers with all known quenching gases, comprising e.g. CO_2, SF_6, etc. and is not limited to quenching gas generated by ablation process.

[0044] No or at least a significant reduction of quenching gas flow through the tulip slits occurs, which means no loss of e.g. ptfe vapors. This may lead to a considerable increase in blowing pressure to extinguish the arc at current zero and to prevent a new ignition of the arc.

[0045] Another aspect of the present application may provide an improved mechanical stability of the tulip contact 100. In order to reduce the stress in the material of the contact body at the end (root/base) of the slits 110, 210, providing stress relief elements 400, in the form of an opening at the root 160 of the tulip slits or making the slits longer, may help.

[0046] Both options, the V-shaped slits 110, 210 and the stress relief element 400 may increase the quenching gas flow area through the tulip throat and reduce flow over the surface of the contact body 100. The stress relief elements 400 may have to be introduced in some cases in order to avoid fatigue failures.

[0047] Therefore, according to a further embodiment of the tulip contact 100 which can be combined with one or more other embodiments, it is disclosed that the root 160 of one or more of the plurality of slits 110, 210, 220 may extend into a stress-relief element 400. The stress-relief elements 400 may be configured to mitigate mechanical stress in the material of the contact body 100 in case the slits 110, 210, 220 are compressed. In addition to the new shape of the slits 110, 210, this may lead to further increased slit-closing capability.

[0048] Finite element mechanical (FEM) analysis of the tulip shows a necessity of a stress relief element in the contact fingers to reduce stress in the material. Mechanical stress may strongly be concentrated at the root 160 of the slit 110, 210. If a stress relief element is introduced, maximal stress may be significantly reduced and may not be longer concentrated at the root 160 of the slit. Reducing the stress at the root 160 not only may improve closing characteristic of the slits 110, 210 in the contact body 100. It may also improve maintenance of load breakers, since contact fingers may not be prone to breaking due to mechanical fatigue. The presented solution therefore may reduce maintenance costs over time.

[0049] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, it is disclosed that the stress relief elements 400 may be an opening in the form of a hole. FIG. 4 exemplarily shows the V-shape slit, the root 160 of which extends continuously into hole 400.

[0050] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, it is disclosed that the stress relief element 400 may be a hook-shaped extension 500 of the slit(s) instead of a hole. FIG. 5 shows this embodiment of a stress relief element. The hook-shaped stress relief element immediately follows the root 160 of the slit and forms a continuous path.

[0051] The hook shaped design may also reduce gas-turbulence inside the tulip by leaving base material compared to the hole. This feature can be integrated with the V-shaped slits as well as with the variants in other embodiments which are described herein.

[0052] Compared with a stress relief element 400 in the form of a hole, the hook-shaped stress relief element 500 leaves more material in the contact body. The area through which gas can leak is therefore minimized. At the same time, the stress on the material near the root 160 of the slit, when the slits are squeezed, is minimized in the same way as the stress relief element in the form of a hole 400 would provide.

[0053] A benefit of the feature of the hook-shaped stress relief element is that the length of the tulip slits may be restricted to a required or needed minimum length. This means that the hook-shaped stress relief element may further minimize the flow area through the slits 110, 210.

[0054] The roots 160 of the slits ideally should be as narrow as possible. Very thin tools or tools enabling very thin cuts may be used e.g. wire cutting, very fine cutting blades or industrial lasers may cut the respective slits into the contact body 100.

[0055] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, it is disclosed that the slits 110, 210, 220 may taper in a direction from the first 120 end to the root 160 of the slit 110, 210, 220. In other words, the width of the slits 110, 210, 220 may change continuously from the tip 120 of the rotationally symmetrical contact body of the tulip contact towards the root 160 of the slit(s) 110, 210, 220.

[0056] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the slits 110, 210, 220 may narrow from the first width 300 to the second width 310 in at least one discrete step 320. This variant of the V-shape slit is easy to manufacture and can be realized e.g. by cutting the slit with two saw blades of different thicknesses. According to embodiments of the tulip contact which can be combined with one or more other embodiments, the form of the slits may be a V-shaped form 210, extending from the first end 120 of the tulip contact to the root 160 of the slit(s). The upper figure in FIG. 3 shows the basic idea of the slits, namely the V-shaped form of a slit. The slit tapers continuously from the first width 300 to its root 160. The V-shaped slit has its smallest width 310 at the root 160 of the slit.

[0057] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the slits 110, 210, 220 may taper between the first width 120 and the second width 310 in a curved way.

[0058] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the slits 110, 210, 220 may narrow in a step-shape manner with at least one step 320. In other words, the slit is easy to manufacture, e.g. with a milling machine.

[0059] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the form of the slits may be a diverging-shape 220, extending from the first end 120 of the tulip contact to the root 160 of the slit(s).

[0060] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the form of the slits may be a concavely-shaped form 250, extending from the first end 120 of the tulip contact to the root 160 of the slit(s).

[0061] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the form of the slits may be a convexly-shaped form 240, extending from the first end 120 of the tulip contact to the root (160) of the slit.

[0062] According to a further embodiment of the tulip contact which can be combined with one or more other embodiments, the form of the slits is a semi-straight shaped form 260, extending from the first end 120 of the tulip contact to the root 160 of the slit.

[0063] All different forms of the slits may have in common that they allow for a better closure in the tulip contact body due to completely closed slits by the current force. By this, the pressure build-up can be increased and scatter in thermal interruption performance can be reduced. V-shaped slits may also extend the arc erosion capability of the tulip.

[0064] According to a further embodiment, an electrical switching device for medium- or high voltage applications with a tulip contact according to other embodiments is disclosed.

[0065] The electrical switching device for medium- or high voltage applications may be e.g. a gas-insulated switchgear for medium- or high voltage applications.

[0066] According to a further embodiment, a dielectric insulation medium, in particular a dielectric insulation gas, is present inside an enclosure of the electrical switching device. The dielectric insulation medium may comprise an organofluorine compound. The organofluorine compound may be selected from a group: a fluoroether or a fluoroamine or a fluoroketone or mixtures thereof.

[0067] The fluid used in the encapsulated or non-encapsulated electric apparatus can be SF_6 gas or any other dielectric insulation medium, may it be gaseous and/or liquid, and in particular can be a dielectric insulation gas or arc quenching gas. Such dielectric insulation mediums can for example encompass media comprising an organofluorine compound, such an organofluorine compound being selected from the group consisting of: a fluoroether, an oxirane, a fluoroamine, a fluoroketone, a fluoroolefin, a fluoronitrile, and mixtures and/or decomposition products thereof. Herein, the terms "fluoroether", "oxirane", "fluoroamine", "fluoroketone", "fluoroolefin", and "fluoronitrile" refer to at least partially fluorinated compounds.

[0068] In particular, the term "fluoroether" encompasses both fluoropolyethers (e.g. galden) and fluoromonoethers as well as 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, the term "fluoroolefin" encompasses both hydrofluoroolefins and perfluoroolefins, and the term "fluoronitrile" encompasses both hydrofluoronitriles and perfluoronitriles. It can thereby be preferred that the fluoroether, the oxirane, the fluoroamine, the fluoroketone and the fluoronitrile are fully fluorinated, i.e. perfluorinated.

[0069] In embodiments, the dielectric insulation medium or more specifically the organofluorine compound comprised in the dielectric insulation medium or gas is selected from the group consisting of: fluoroethers, in particular a or several hydrofluoromonoether(s); fluoroketones, in particular a or several perfluoroketone(s); fluoroolefins, in particular a or several hydrofluoroolefin(s); fluoronitriles, in particular a or several perfluoronitrile(s); and mixtures thereof.

[0070] In particular, the term "fluoroketone" as used in the context of the present disclosure may be interpreted broadly and may 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 may 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 may be linear or branched and can optionally form a ring. In embodiments, the dielectric insulation medium may comprise at least one compound being a fluoroketone, which may optionally comprise 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 a corresponding number of carbon atoms. Advantageously, 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 advantageously, 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.

[0071] In embodiments, the dielectric insulation medium comprises at least one compound being a hydrofluoroether selected from the group consisting of: hydrofluoro monoether containing at least three carbon atoms; hydrofluoro monoether containing exactly three or exactly four carbon atoms; hydrofluoro monoether having a ratio of the number of fluorine atoms to the total number of fluorine and hydrogen atoms of at least 5:8; hydrofluoro monoether having a ratio of the number of fluorine atoms to the number of carbon atoms ranging from 1.5:1 to 2:1; pentafluoro-ethyl-methyl ether; 2,2,2-trifluoroethyl-trifluoromethyl ether; and mixtures thereof.

[0072] 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.

[0073] In embodiments, the organofluorine compound can also be a fluoronitrile, in particular a perfluoronitrile. In particular, the organofluorine compound can be a fluoronitrile, specifically a perfluoronitrile, containing two carbon atoms, and/or three carbon atoms, and/or four carbon atoms.

[0074] More particularly, the fluoronitrile can be a perfluoroalkylnitrile, specifically perfluoroacetonitrile, perfluoropropionitrile (C_2F_5CN) and/or perfluorobutyronitrile (C_3F_7CN). Most particularly, the fluoronitrile can be perfluoroisobutyronitrile (according to the formula $(CF_3)_2CFCN$) and/or perfluoro-2-methoxypropanenitrile (according to formula $CF_3CF(OCF_3)CN$). Of these, perfluoroisobutyronitrile is particularly preferred due to its low toxicity.

[0075] According to a further embodiment, which may be combined with other embodiments, the mixtures of gases according to another embodiment may comprise mixtures with a background gas.

[0076] The background gas or carrier gas may be different from the organofluorine compound (in particular different from the fluoroether, the oxirane, the fluoroamine, the fluoroketone, the fluoroolefin and the fluoronitrile) 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.

[0077] According to a further embodiment, a self-blast or puffer circuit breaker with a tulip contact according to one or more other embodiments, is disclosed.

[0078] In summary, the present application discloses a novel and improved tulip contact for a breaker assembly, in particular an arcing tulip contact. The tulip contact advantageously has a rotation symmetrical body. The body of the tulip arcing-contact is hollow, forming a hollow volume. A novel form of slits is introduced which allows for keeping a gas pressure of quenching gas in the hollow volume of the tulip contact at a high level as long as possible to support the arc extinguishing process.

Claims

1. A tulip contact for a load breaker, comprising:

   a rotationally symmetric contact body (100), having a first end (120) and a second end (130); the contact body (100) having a plurality of slits (110, 210, 220), arranged in the body (100) and extending parallel to a symmetrical axis (140) of the body (100);
   the slits (110, 210, 220) defining a length 1 (150) between the first end (120) and a root (160) of the slits (110, 210, 220), wherein the length 1 (150) of the slit (110, 210, 220) is shorter than a length of the contact body (100);
   the slits (110, 210, 220) having a first width (300) at the first end (120) and a second width (310) at the root (160) of the slits (110, 210, 220) wherein the first width (300) is bigger than the second width (310).

2. The tulip contact according to claim 1, wherein the root (160) of one or more of the plurality of slits (110, 210, 220) extends into a stress-relief element (400), the stress-relief element (400) is configured to mitigate mechanical stress in the material of the body (100) in case the slits (110, 210, 220) close.

3. The tulip contact according to claim 2, wherein the stress relief element (400) is an opening in the form of a hole.

4. The tulip contact according to claim 2, wherein the stress relief element (400) is a hook-shaped extension (500) of the slit.

5. The tulip contact according to claim 1 or 2, wherein the slits (110, 210, 220) taper in a direction from the first (120) end to the root (160) of the slit (110, 210, 220).

6. The tulip contact according to claim 1, wherein the slits (110, 210, 220) narrow from the first width (300) to the second width (310) in at least one discrete step (320).

7. The tulip contact according to claim 3, wherein the slits (110, 210, 220) taper between the first width (120) and the second width (310) in a curved way.

8. The tulip contact according to claim 4, wherein the slits (110, 210, 220) narrow in a step-shape manner with at least one step (320).

9. The tulip contact according to any of the preceding claims, wherein the form of the slits is a V-shaped form (210), extending from the first end (120) of the tulip contact to the root (160) of the slit.

10. The tulip contact according to any of the preceding claims, wherein the form of the slits is a diverging-shape (220), extending from the first end (120) of the tulip contact to the root (160) of the slit.

11. The tulip contact according to any of the preceding claims, wherein the form of the slits is a concavely-shaped form (250), extending from the first end (120) of the tulip contact to the root (160) of the slit.

12. The tulip contact according to any of the preceding claims, wherein the form of the slits is a convexly-shaped form (240), extending from the first end (120) of the tulip contact to the root (160) of the slit.

13. The tulip contact according to any of the preceding claims, wherein the form of the slits is a semi-straight shaped form (260), extending from the first end (120) of the tulip contact to the root (160) of the slit.

14. An electrical switching device for medium- or high voltage applications, with a tulip contact according to any of the previous claims 1 to 13.

15. The electrical switching device according to claim 14, wherein
a dielectric insulation medium, in particular a dielectric insulation gas, is present inside an enclosure of the electrical switching device; wherein the dielectric insulation medium comprises an organofluorine compound selected from a group: a fluoroether or a fluoroamine or a fluoroketone or mixtures thereof.

16. The electrical switching device according to claim 15, wherein the mixtures comprise mixtures with a background gas.

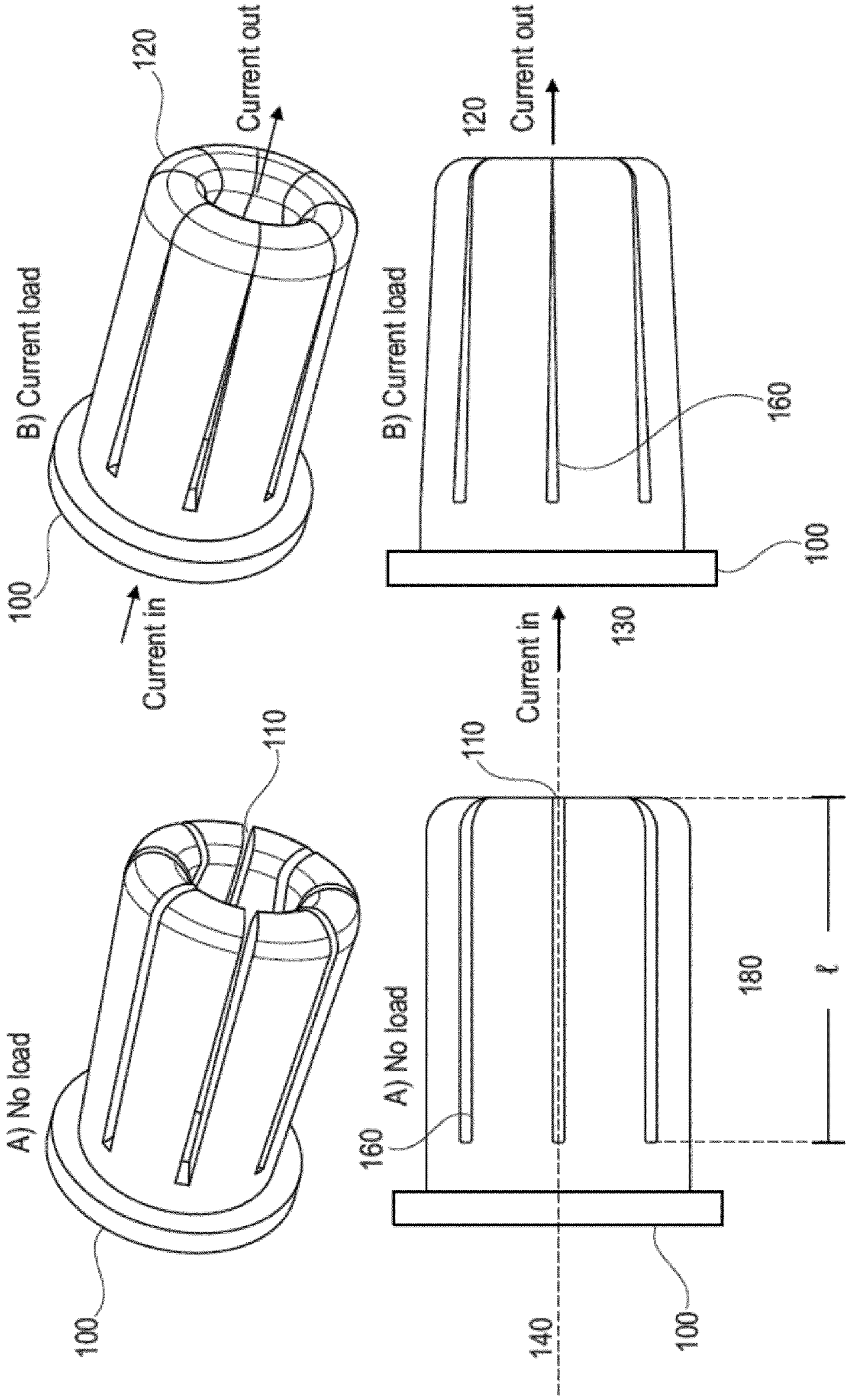
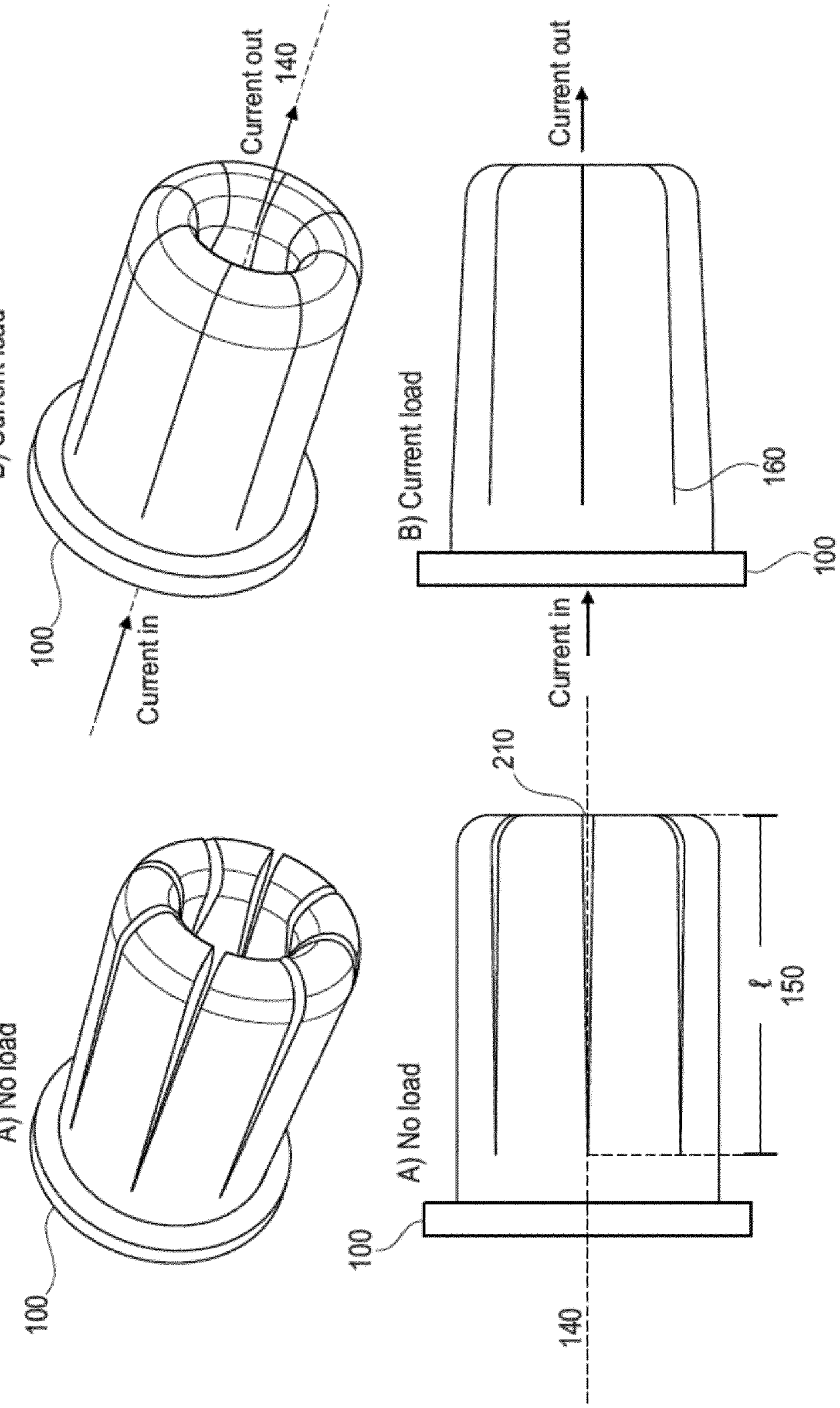

A) No load
100
110
160
140
180
ℓ
B) Current load
Current in
Current out
120
130

FIG. 1



A) No load
100
100
140
210
ℓ
150
B) Current load
100
Current in
Current out
140
B) Current load
Current in
Current out
160
100
A) No load

FIG. 2

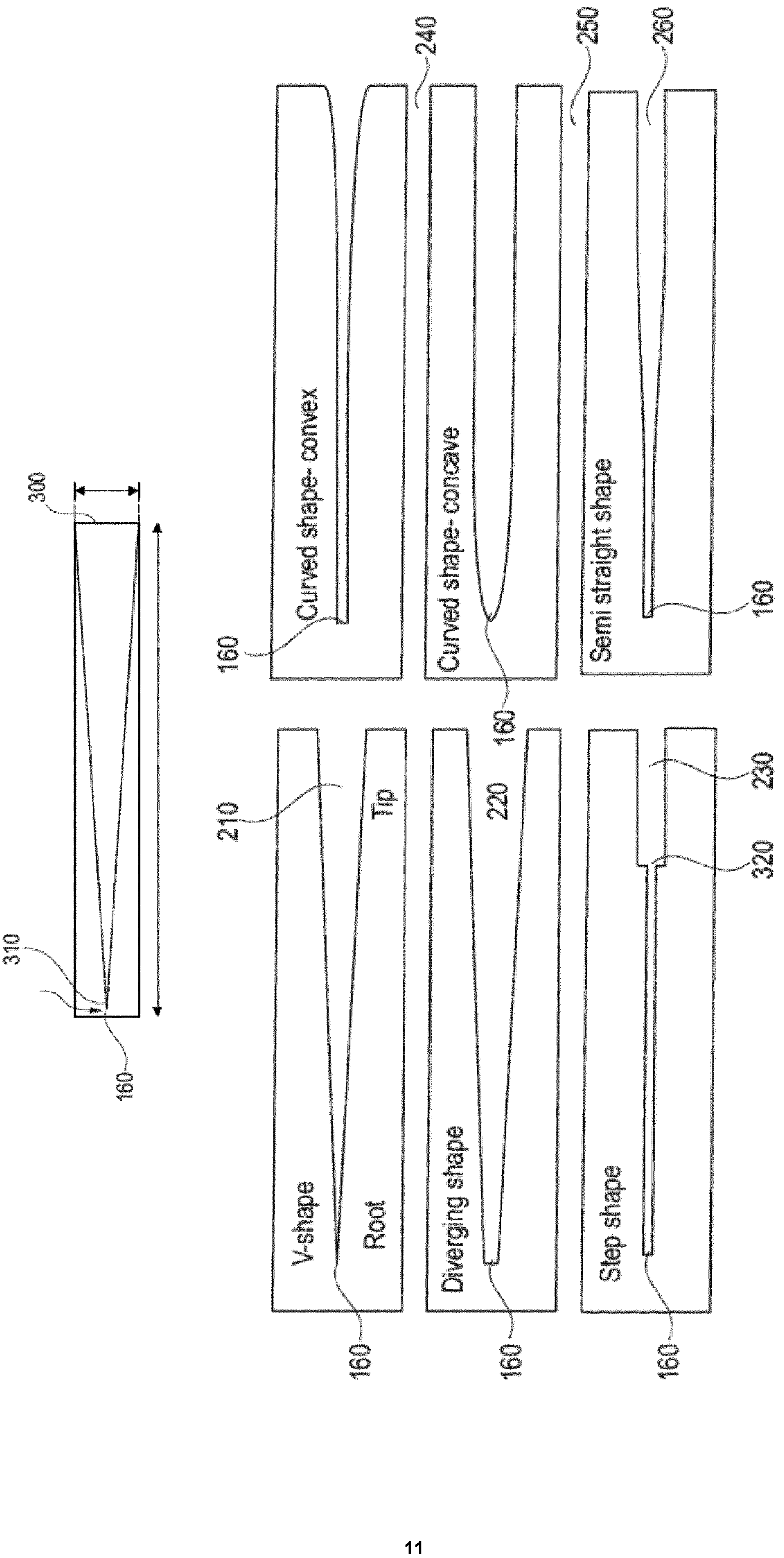

300
310
160
Curved shape- convex
240
160
Curved shape- concave
250
160
Semi straight shape
260
160
V-shape
Root
Tip
210
160
Diverging shape
220
160
Step shape
320
230
160

FIG. 3

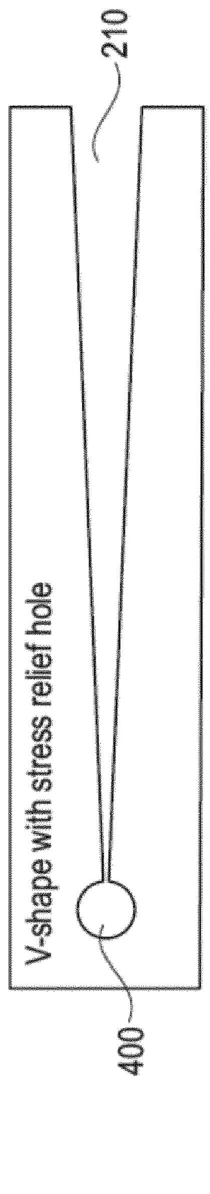

V-shape with stress relief hole
210
400

FIG. 4

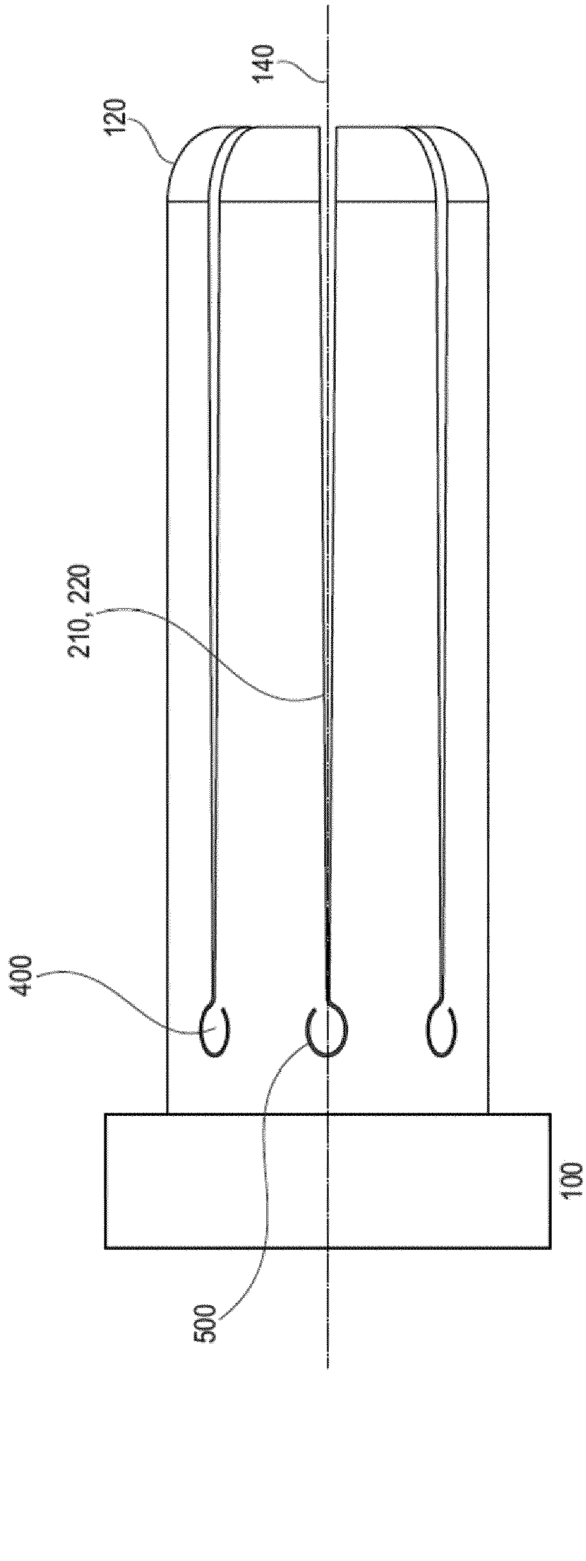

120
140
210, 220
400
500
100

FIG. 5

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EUROPEAN SEARCH REPORT

Application Number
EP 19 21 0974

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H01H

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	24 April 2020	Dobbs, Harvey

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24-04-2020

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