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(71) Applicant: **ABB SCHWEIZ AG**
5400 Baden (CH)

(72) Inventor: **JONSSON, Erik**
7054 Ranheim (NO)

(74) Representative: **Kransell & Wennborg KB**
P.O. Box 27834
115 93 Stockholm (SE)

(54) **AN ELECTRIC CURRENT KNIFE SWITCH**

(57) The present invention relates to an electric current switch (100) comprising: a contact lever (104;) comprising a proximal end (106) and a distal end (108), the contact lever is rotatable at a pivot point (110) at the distal end, the contact lever comprising a lever main contact area (141) and a lever arcing area (114) at the proximal end; a fixed contact assembly (116) configured to receive the contact lever in a closed position of the contact lever, the fixed contact assembly comprising a fixed main contact (152) and a fixed arcing contact (115), the fixed contact assembly being fixed relative the pivot point (110); the contact lever is configured to rotate about the pivot point between the closed position and an open position, the electric current switch further comprising a set of cooling gas outlets surrounding the fixed arcing contact (115) to provide a joint flow of cooling gas that encompasses an arc formation point of the fixed arcing contact (115), the joint flow is directed to guide an arc towards the lever arcing area (114) of the contact lever.

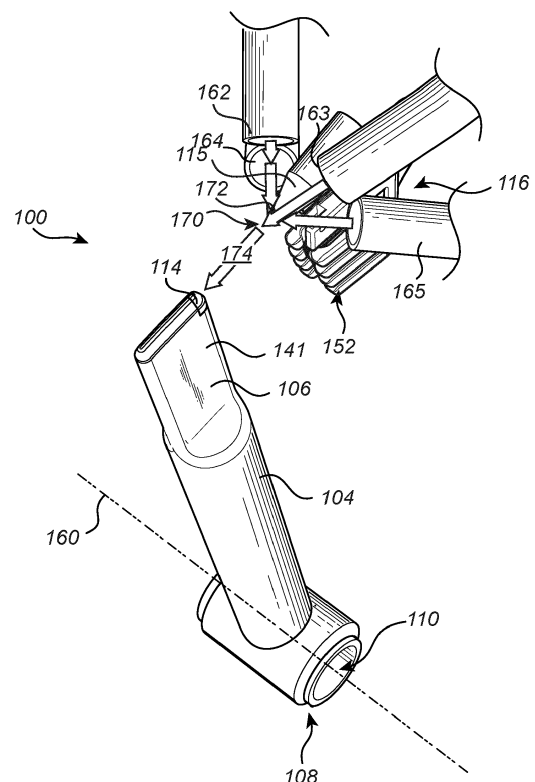


Fig. 1

Description

Field of the Invention

[0001] The present invention relates to an electric current switch.

Background

[0002] Electric switches for medium- and high voltage switchgear are subject to electric arcing during current interruption and contact making events. Suppressing the arcs is important to protect the electric switch itself and electric devices connected to the electric switch.

[0003] Effects of arcs may be suppressed by appropriate material selection of arcing contact areas of the connecting parts of the electric switch that can withstand and reduce the arcing. Further, arc-extinction can be provided by application of an appropriate gas onto the arc, such as the often-used gas SF₆.

[0004] However, there is still room for improvements with regards to arc-extinction as is set out in more detail below.

Summary

[0005] In view of the above-mentioned and other drawbacks of the prior art, it is an object of the present invention to provide an electric current switch that at least partly alleviates the deficiencies with prior art.

[0006] According to a first aspect of the invention, there is provided an electric current switch comprising: a contact lever comprising a proximal end and a distal end, the contact lever is rotatable at a pivot point at the distal end, the contact lever comprising a lever main contact area and a lever arcing area at the proximal end; a fixed contact assembly configured to receive the contact lever in a closed position of the contact lever, the fixed contact assembly comprising a fixed main contact and a fixed arcing contact, the fixed contact assembly being fixed relative the pivot point; the contact lever is configured to rotate about the pivot point between the closed position and an open position, wherein the electric current switch further comprising a set of cooling gas outlets surrounding the fixed arcing contact to provide a joint flow of cooling gas that encompasses an arc formation point of the fixed arcing contact, the joint flow is directed to guide an arc towards the lever arcing area of the contact lever.

[0007] The present invention is at least partly based on the realization that a joint flow of cooling gas achieved from a set of different flow directions from outlets surrounding the arcing contact allows for trapping and stabilizing the arc inside the gas flow. Further, the gas flow towards the contact lever is such that hot gases at the fixed arcing contact is transported away from the fixed arcing contact and along the arc towards the movable contact lever. Thus, the arc is less likely to commutate to other matrix parts during an electric current interruption

event. Overall, the present invention provides for more efficient cooling and arc extinction in front of the fixed arcing contact such that an electric current can be interrupted. It may further eliminate the need for the traditionally used perfluorotetraethylene (PTFE) nozzles.

[0008] Further, the proposed electric current switch the contact lever rotates for switching between the closed and the open positions, whereas the outlets and the fixed contact assembly are static with respect to the housing, thereby requiring only a small number of moving parts.

[0009] A housing may provide an assembly base for the electric switch. The pivot point is preferably fixed in relation to the housing. The contact lever and the fixed contact assembly may be housed inside the housing.

[0010] The set of cooling gas outlets may be fixed in relation to the fixed contact assembly.

[0011] In the closed position of the contact lever, an electric current may pass between the lever main contact area and the fixed main contact. In the open position, the contact lever and the fixed contact are not in contact whereby an electric current may not pass between them.

[0012] In the closed position, the lever main contact area mate with the fixed main contact.

[0013] The cooling gas may for example comprise at least one background gas component selected from the

group consisting of CO₂, O₂, N₂, H₂, air, N₂O, that may be used alone or in a mixture with a hydrocarbon or an organo fluorine compound. For example, the cooling gas may comprise dry air or technical air. The cooling gas

may in particular comprise an organofluorine compound selected from the group comprising of: a fluoroether, an oxirane, a fluoramine, a fluoroketone, a fluoroolefin, a fluoronitrile, and mixtures and/or decomposition products thereof. In particular, the cooling gas may comprise as a

hydrocarbon at least CH₄, a perfluorinated and/or partially hydrogenated organofluorine compound, and mixtures thereof. The organofluorine compound is preferably selected from the group comprising of: a fluorocarbon, a fluoroether, a fluoroamine, a fluoronitrile, and a fluoroketone; and preferably is a fluoroketone and/or a fluoroether, more preferably a perfluoroketone and/or a hydro

fluoroether, more preferably a perfluoroketone having from 4 to 12 carbon atoms and even more preferably a perfluoroketone having 4, 5 or 6 carbon atoms. In particular, the perfluoroketone is or comprises at least one of:

C₂F₅C(O)CF(CF₃)₂ or dodecafluoro-2-methylpentan-3-one, and CF₃C(O)CF(CF₃)₂ or decafluoro-3-methylbutan-2-one. The cooling gas preferably comprises the fluoroketone mixed with air or an air component such as N₂, O₂, and/or CO₂. Another possible cooling gas is SF₆.

[0014] The electric current switch may further comprise an earth contact configured to receive the contact lever in an earthed position of the contact lever, the contact lever is configured to rotate about the pivot point between the earthed position, the closed position, and the open position. The earth contact may be fixed in relation to the housing. Thus, the contact lever may be moved to three positions, while the earth contact, the

fixed contact, and the cooling gas outlets may be fixed in relation to the housing. The fixed contact and the earth contact may be stationary with respect to the pivot point when the contact lever moves between the earthed position, the closed position, and the open position.

[0015] In embodiments, the set of cooling gas outlets may comprise a first subset of outlets arranged on one side of a rotation plane of the contact lever and a second subset of outlets arranged on the opposite side of the rotation plane. As the contact lever rotates about the pivot point, it moves in a rotation plane. Arranging subsets of outlets on opposite sides of the rotation plane, angled towards the fixed arcing contact, advantageously provides for a concentrated flow of cooling gas that improves the cooling of the arc in front of the fixed arcing contact.

[0016] In embodiments, a total flow rate of cooling gas outlets from the first subset of outlets may be substantially equal to a total flow rate of cooling gas from the second subset of outlets. Thereby, the direction of the cooling gas flow is more accurately in the direction of the contact lever to thereby more efficiently gas the arc in that direction.

[0017] In embodiments, the first subset of outlets and the second subset of outlets may be directed to generate a joint flow substantially in the rotation plane of the contact lever. This may further improve the directing of the cooling gas flow in the direction of the contact lever to thereby more efficiently gas the arc in that direction.

[0018] In embodiments, the electric current switch may comprise two dielectric shields arranged on opposite sides of the fixed main contact, wherein the dielectric shields each comprise at least one cooling gas outlet. Accordingly, the outlets may be integrated in another structure of the electric switch, thereby providing for a more compact electric current switch with fewer parts.

[0019] In embodiments, each dielectric shields may comprise at least two cooling gas outlets configured to direct cooling gas towards the arcing contact front end.

[0020] In embodiments, the dielectric shields may be arranged separated from each other with an opening towards the distal end, where the proximal end of the contact lever is receivable between the dielectric shields. The rotation plane of the contact lever may lie in the opening between the dielectric shields.

[0021] In embodiments, the electric current switch may comprise a nozzle that comprises the set of cooling gas outlets. Thus, the outlets may be formed in one integral nozzle.

[0022] In embodiments, the nozzle may be conical with the fixed arcing contact attached at the tip of the nozzle.

[0023] In embodiments, the fixed arcing contact may be conical. This provides for a well-defined an arc formation point at the tip of the conical fixed arcing contact.

[0024] In embodiments, the set of cooling gas outlets may be located in an inclined face of the conical nozzle. The cooling gas outlets may provide parallel flows or may each be configured to direct the cooling gas towards the tip of the nozzle along the outer inclined face of the conical

nozzle.

[0025] In embodiments, the electric current switch may comprise at least four cooling gas outlets, preferably at least six cooling gas outlets.

5 **[0026]** The cooling gas outlets may be located a distance away from the arcing zone, such as no or little hot gas is touching them during current interruption.

10 **[0027]** In embodiments, the diameter of the cooling gas outlets may be about 1 mm or larger, such as 2 mm or larger, such as about 3 mm. A larger opening provides less stringent requirements on the pressure needed to eject cooling gas from the outlet.

15 **[0028]** In embodiments, the contact lever may be a knife contact, and the electric current switch may be a knife switch.

20 **[0029]** In a further aspect of the present invention, there is provided an electric current switch comprising: a contact lever comprising a proximal end and a distal end, the contact lever is rotatable at a pivot point at the distal end, the contact lever comprising a lever main contact area and a lever arcing area at the proximal end; a fixed contact assembly configured to receive the contact lever in a closed position of the contact lever, the fixed contact assembly comprising a fixed main contact and a fixed arcing contact, the fixed contact assembly being fixed relative the pivot point; the contact lever is configured to rotate about the pivot point between the closed position and an open position, the electric current switch further comprising a ring-shaped cooling gas outlet surrounding the fixed arcing contact to provide a flow of cooling gas that encompasses an arc formation point of the fixed arcing contact, the joint flow is directed to guide an arc towards the lever arcing area of the contact lever.

30 **[0030]** A ring-shaped outlet may provide a flow that encompasses the arc formation point. The ring-shaped outlet may be part of a conical nozzle but may equally well be formed from a double wall hose or pipe.

35 **[0031]** Further effects and features of the second aspect of the invention are largely analogous to those described above in connection with the first aspect of the invention.

40 **[0032]** Further features of, and advantages with, the present invention will become apparent when studying the appended claims and the following description. The skilled person realizes that different features of the present invention may be combined to create embodiments other than those described in the following, without departing from the scope of the present invention.

50 Brief Description of the Drawings

55 **[0033]** These and other aspects of the present invention will now be described in more detail, with reference to the appended drawings showing an example embodiment of the invention, wherein:

Fig. 1 illustrates an example electric current switch according to embodiments of the invention;

Fig. 2 illustrates an example electric current switch according to embodiments of the invention;

Fig. 3 illustrates an example electric current switch with a nozzle according to embodiments of the invention;

Fig. 4A is a first perspective of a nozzle according to embodiments of the invention; and

Fig. 4B is a second perspective of the nozzle according to embodiments of the invention.

Detailed Description of Example Embodiments

[0034] In the present detailed description, various embodiments of the present invention are herein described with reference to specific implementations. In describing embodiments, specific terminology is employed for the sake of clarity. However, the invention is not intended to be limited to the specific terminology so selected. While specific exemplary embodiments are discussed, it should be understood that this is done for illustration purposes only. A person skilled in the relevant art will recognize that other components and configurations can be used without parting from the scope of the invention.

[0035] Fig. 1 conceptually illustrates an electric current switch 100 according to embodiments of the present invention.

[0036] The electric current switch comprises a contact lever 104 comprising a proximal end 106 and a distal end 108. The contact lever 104 is rotatable at a pivot point 110 at the distal end 108. The contact lever 104 comprises a lever main contact area 141 and a lever arcing area 114 at the proximal end 104.

[0037] The electric current switch 100 further comprises a fixed contact assembly 116 configured to receive the contact lever 104 in a closed position. The fixed contact assembly 116 comprises a fixed main contact 152 and a fixed arcing contact 115. The fixed contact assembly 116, that is, the fixed main contact 152 and the fixed arcing contact 115 are fixed in position relative the pivot point 110.

[0038] The contact lever 104 is configured to rotate about the pivot point 110, and rotation axis 160 between the closed position and an open position.

[0039] The rotation of the contact lever 104 is in a rotation plane that coincides with the mating fixed main contact 152. In other words, contact lever moves in a single plane between an open position where it is not connected to the main contact 152 and a closed position where it is connected, in physical contact, with the main contact 152.

[0040] Furthermore, the electric current switch 100 further comprises a set of cooling gas outlets 162, 163, 164, 165 surrounding the fixed arcing contact 115. The cooling gas outlets 162, 163, 164, 165 are arranged to provide a joint flow of cooling gas that encompasses an arc formation point 170 of the fixed arcing contact 115. Further, the joint flow is directed to guide an arc towards the lever arcing area 114 of the contact lever.

[0041] The electric current switch 100 may be a knife switch. Thereby, the contact lever 104 is a knife contact or a blade contact. For example, the contact lever 104 may be bar of copper with a protecting CuW insert as arcing contact area 114. The contact lever may be about 5 mm to 20 mm thick at the main contact area. The thickness is in the direction perpendicular to the rotation plane of the knife or blade. In one preferred embodiment, the thickness of the knife or blade at the main contact area is about 8 mm.

[0042] The arc formation point 170 is at a root of the arc once formed and is just in front of the arcing contact 115. In front of the arcing contact 115 is herein on the side of the arcing contact 115 facing the contact lever 104 as it approaches the fixed main contact to make contact.

[0043] Furthermore, the cooling gas outlets 162, 163, 164, 165 are arranged behind the arc formation point 170. In this way, the cooling gas outlets 162, 163, 164, 165 directs their flow of cooling gas obliquely towards the contact lever proximal end 104 during arc formation. Stated otherwise, the cooling gas outlets 162, 163, 164, 165 directs their flow of cooling gas from obliquely behind the front tip 172 of the arcing contact 115. The angle between flow direction from each the outlets and the rotation plane may be about 10 degrees to about 60 degrees, such as preferably about 45 degrees.

[0044] Thereby a joint flow 174 is provided that guides an arc formed at arc formation point 170 towards the lever arcing area 114 of the contact lever 104. Further, hot gas is also guided away from the fixed arcing contact and along the arc towards the movable contact lever 104.

[0045] Here, a first subset of outlets 162, 164 are arranged on one side of the rotation plane of the contact lever 104 and a second subset of outlets 163, 165 are arranged on the opposite side of the rotation plane. This facilitates providing a joint flow that traps the arc inside the flow. Furthermore, a total flow rate of cooling gas from the outlets 162, 164 of the first subset of outlets is substantially equal to a total flow rate of cooling gas from the second subset of outlets 163, 165. Substantially equal allows a small deviation between the total flow rates, for example as caused by manufacturing tolerances or misalignments of the outlets that may be compensated for. Generally, the flow rates should not deviate by more than about 5-10% to be substantially equal.

[0046] The contact lever 104 moves in its rotation plane during current interruption events. Thereby, to guide an arc towards the contact lever 104 arcing area 114, it is advantageous to also guide the joint flow in that rotation plane. In other words, the first subset of outlets 162, 164 and the second subset of outlets 163, 165 are directed to generate a joint flow substantially in the rotation plane of the contact lever 104. For this, the direction of the individual flows from the outlets 162, 163, 164, 164, and their flow rates are tuned accordingly to achieve a joint flow in the rotation plane of the contact lever 104.

[0047] A puffer may be employed for proving pressu-

rized cooling gas to the outlets. The operation of puffers is known *per se*, but as a general note, during a current making event, when the contact lever 104 moves into the main contact 152 from the open position, a drive mechanism moves to push a piston inside a puffer volume to force cooling gas out from the volume. The puffer can be filled during a current making events in various ways. For example, by implementing one-way gas vent for the puffer gas can freely fill the puffer without creating a counter force on the contact lever 104. Alternatively, by letting the piston move in slowly by the before the contact lever 104 starts the current making operation. As a further alternative, the puffer can be filled by sucking in gas through outlets.

[0048] The flows from the outlets 162, 163, 164, 164 should be at rates that ensure successful current interruption, which is achieved by an upstream pressure difference between the inside of the puffer, compared to the background pressure (e.g., ambient pressure), in the range 0.05 - 0.5 bar. This flow rate will also be sufficient to ensure that the arc stays inside the flow, prohibiting the arc to commutate to nearby components.

[0049] Turning to fig. 2 illustrating the electric current switch 100 according to one embodiment. Here, the electric current switch 100 comprises dielectric shields 202 that may be either made of metal or conducting plastic, or a combination of plastic and a conductive material. The dielectric shields 202 are arranged on opposite sides of the fixed main contact 152. The dielectric shields 202 surrounds the fixed arcing contact 115 and the fixed main contact 152 to protect surrounding components from commuting arcs. In order to provide a compact electric current switch 100, the dielectric shields 202 each comprise at least one cooling gas outlet 204. Preferably, each dielectric shields 202 comprise at least two cooling gas outlets 204 configured to direct cooling gas e.g., received from a puffer 210 towards the arcing contact front end 172.

[0050] A diameter of the outlet holes 204 may be in the range of 3-6 mm, such as 4 mm or 5 mm.

[0051] To allow for the contact lever 104 to pivot into the main contact 152, the dielectric shields 202 are arranged separated from each other with an opening 176 towards the distal end, where the proximal end 106 of the contact lever 104 is receivable between the dielectric shields.

[0052] Fig 3 illustrates a further embodiment of the electric current switch 100. In this embodiment, the electric current switch 100 comprises a nozzle 302 having a set of cooling gas outlets 304. The nozzle 302 is also shown in fig. 4A.

[0053] The nozzle 100 may be made from brass or another metal. The nozzle 302 is fixed to a hose 306 connected to for example a puffer that pressurized the cooling gas.

[0054] The nozzle 302 has a front portion 308 facing the contact lever 104 when it is in an intermediate position between the open and closed positions. The front portion

308 is opposite from the rear 310 where the nozzle is attached to the hose 306 to receive cooling gas.

[0055] The fixed arcing contact 312 is attached to the tip of the nozzle, at the front portion 308. That is, the fixed arcing contact 312 is at the front-most part of the nozzle 302. More specifically, the nozzle 302 is here conical with the fixed arcing contact 312 attached at the tip of the conical nozzle 302.

[0056] The fixed arcing contact may be attached by means of forming a material on the metal nozzle suitable for an arcing contact, such as CuW. Preferably, also the fixed arcing contact 312 is conical.

[0057] The conical shape of the nozzle 302 includes an inclined face 316 that reach circumferentially around the nozzle 302. The cooling gas outlets 304 are located in the inclined face 316 of the conical nozzle 302. The cooling gas outlets 304 are here configured to generate parallel streams 320 of cooling gas to encompass the arc formation point 170 just in front of the arcing contact 312.

[0058] Fig. 4B shows the nozzle 302 from the rear end 310. The nozzle may comprise at least four cooling gas outlets 304, or as shown in fig. 4B at least six cooling gas outlets 304. The diameter of the cooling gas outlets 304 may be about 1mm or larger, such as, 2 mm or larger, such as about 3 mm.

[0059] The nozzle 302 is here depicted with six outlets 304. However, it is envisaged that for example two curved outlets that reach around the circumference of the conical nozzle may be used. Thus, the conical nozzle 302 may comprise two curved, or banana-shaped, outlets arranged curved around a perimeter of the conical nozzle to jointly provide a flow of cooling gas that encompasses the arc formation point 170 of the fixed arcing contact 312.

[0060] In one possible implementation, the electric current switch comprises a ring-shaped cooling gas outlet surrounding the fixed arcing contact to provide a flow of cooling gas that encompasses an arc formation point of the fixed arcing contact, the joint flow is directed to guide an arc towards the lever arcing area of the contact lever.

[0061] In the embodiments herein, the set of cooling gas outlets may be fixed in relation to the fixed contact assembly 116.

[0062] Even though the invention has been described with reference to specific exemplifying embodiments thereof, many different alterations, modifications and the like will become apparent for those skilled in the art.

[0063] Additionally, variations to the disclosed embodiments can be understood and effected by the skilled person in practicing the claimed invention, from a study of the drawings, the disclosure, and the appended claims. In the claims, the word "comprising" does not exclude other elements or steps, and the indefinite article "a" or "an" does not exclude a plurality. The mere fact that certain measures are recited in mutually different dependent claims does not indicate that a combination of these measures cannot be used to advantage.

Claims

1. An electric current switch (100) comprising:

a contact lever (104;) comprising a proximal end (106) and a distal end (108), the contact lever is rotatable at a pivot point (110) at the distal end, the contact lever comprising a lever main contact area (141) and a lever arcing area (114) at the proximal end;

a fixed contact assembly (116) configured to receive the contact lever in a closed position of the contact lever, the fixed contact assembly comprising a fixed main contact (152) and a fixed arcing contact (115), the fixed contact assembly being fixed relative the pivot point (110); the contact lever is configured to rotate about the pivot point between the closed position and an open position,

the electric current switch further comprising a set of cooling gas outlets surrounding the fixed arcing contact (115) to provide a joint flow of cooling gas that encompasses an arc formation point of the fixed arcing contact (115), the joint flow is directed to guide an arc towards the lever arcing area (114) of the contact lever.

2. The electric current switch according to claim 1, wherein the set of cooling gas outlets comprises a first subset of outlets (162, 164) arranged on one side of a rotation plane of the contact lever and a second subset of outlets (163, 165) arranged on the opposite side of the rotation plane.

3. The electric current switch according to claim 2, wherein a total flow rate of cooling gas outlets from the first subset of outlets is substantially equal to a total flow rate of cooling gas from the second subset of outlets.

4. The electric current switch according to any one of claims 2 and 3, wherein the first subset of outlets and the second subset of outlets are directed to generate a joint flow (174) substantially in the rotation plane of the contact lever.

5. The electric current switch according to any one of the preceding claims, comprising two dielectric shields (202) arranged on opposite sides of the fixed main contact, wherein the dielectric shields each comprise at least one cooling gas outlet.

6. The electric current switch according to claim 5, wherein each dielectric shields comprise at least two cooling gas outlets configured to direct cooling gas towards the arcing contact front end.

7. The electric current switch according to any one of

claims 4 to 7, wherein the dielectric shields are arranged separated from each other with an opening (176) towards the distal end, where the proximal end of the contact lever is receivable between the dielectric shields.

8. The electric current switch according to any one of claims 1 to 3, comprising a nozzle (302) that comprises the set of cooling gas outlets.

9. The electric current switch according to claim 10, wherein the nozzle is conical with the fixed arcing contact (312) attached at the tip of the nozzle.

10. The electric current switch according to any one of the preceding claims, wherein the fixed arcing contact is conical.

11. The electric current switch according to any one of claims 9 and 10, wherein the set of cooling gas outlets are located in an inclined face (316) of the conical nozzle.

12. The electric current switch according to any one of claims 8 to 11, comprising at least four cooling gas outlets, preferably at least six cooling gas outlets.

13. The electric current switch according to any one of claims 8 to 12, wherein the diameter of the cooling gas outlets is about 1 mm or larger, or 2 mm or larger, such as about 3 mm.

14. The electric current switch according to any one of the preceding claims, wherein the contact lever is a knife contact, and the electric current switch is a knife switch.

15. An electric current switch (100) comprising:

a contact lever (104;) comprising a proximal end (106) and a distal end (108), the contact lever is rotatable at a pivot point (110) at the distal end, the contact lever comprising a lever main contact area (141) and a lever arcing area (114) at the proximal end;

a fixed contact assembly (116) configured to receive the contact lever in a closed position of the contact lever, the fixed contact assembly comprising a fixed main contact (152) and a fixed arcing contact (312), the fixed contact assembly being fixed relative the pivot point (110); the contact lever is configured to rotate about the pivot point between the closed position and an open position,

the electric current switch further comprising a ring-shaped cooling gas outlet surrounding the fixed arcing contact (312) to provide a flow of cooling gas that encompasses an arc formation

point of the fixed arcing contact (312), the joint flow is directed to guide an arc towards the lever arcing area (114) of the contact lever.

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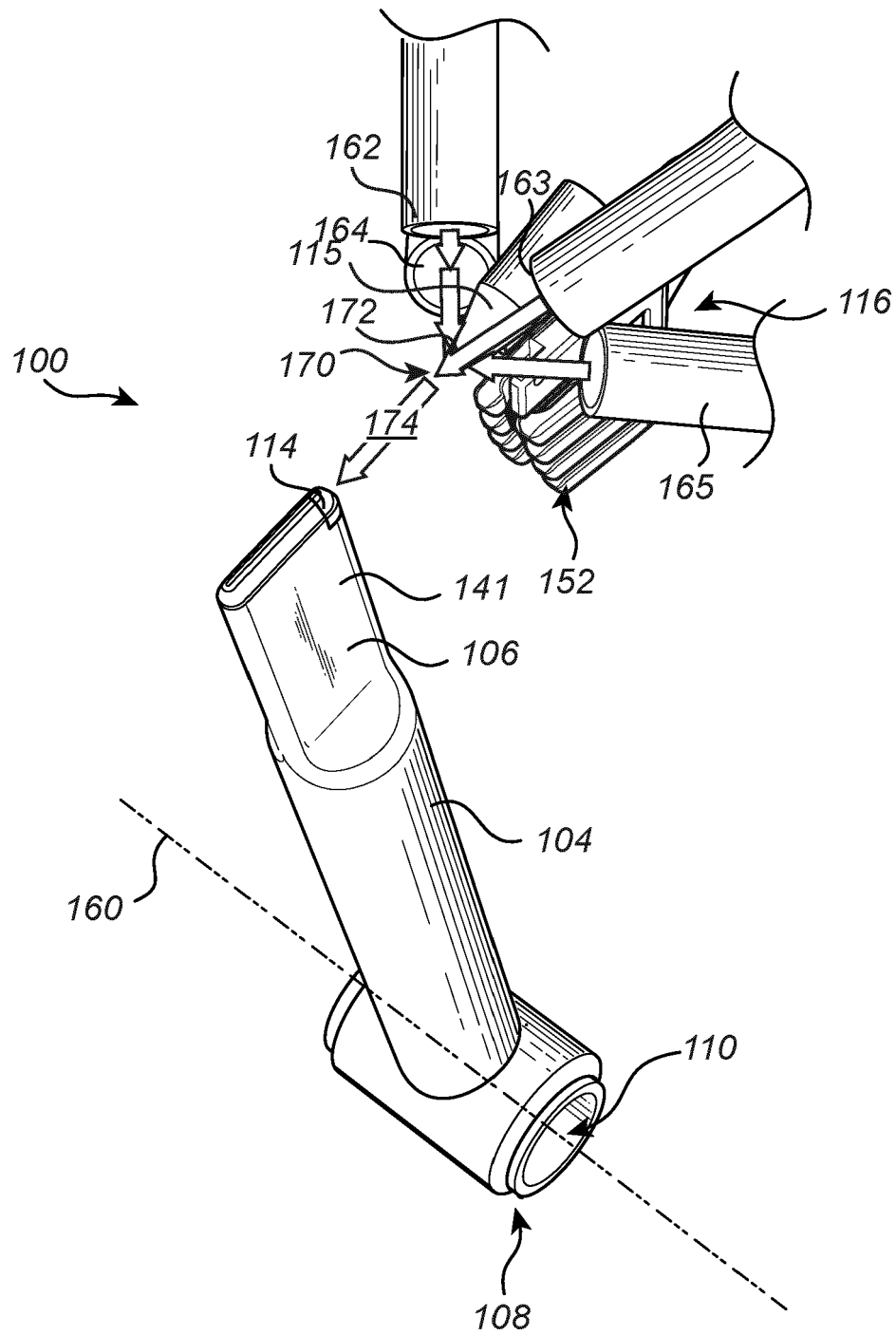


Fig. 1

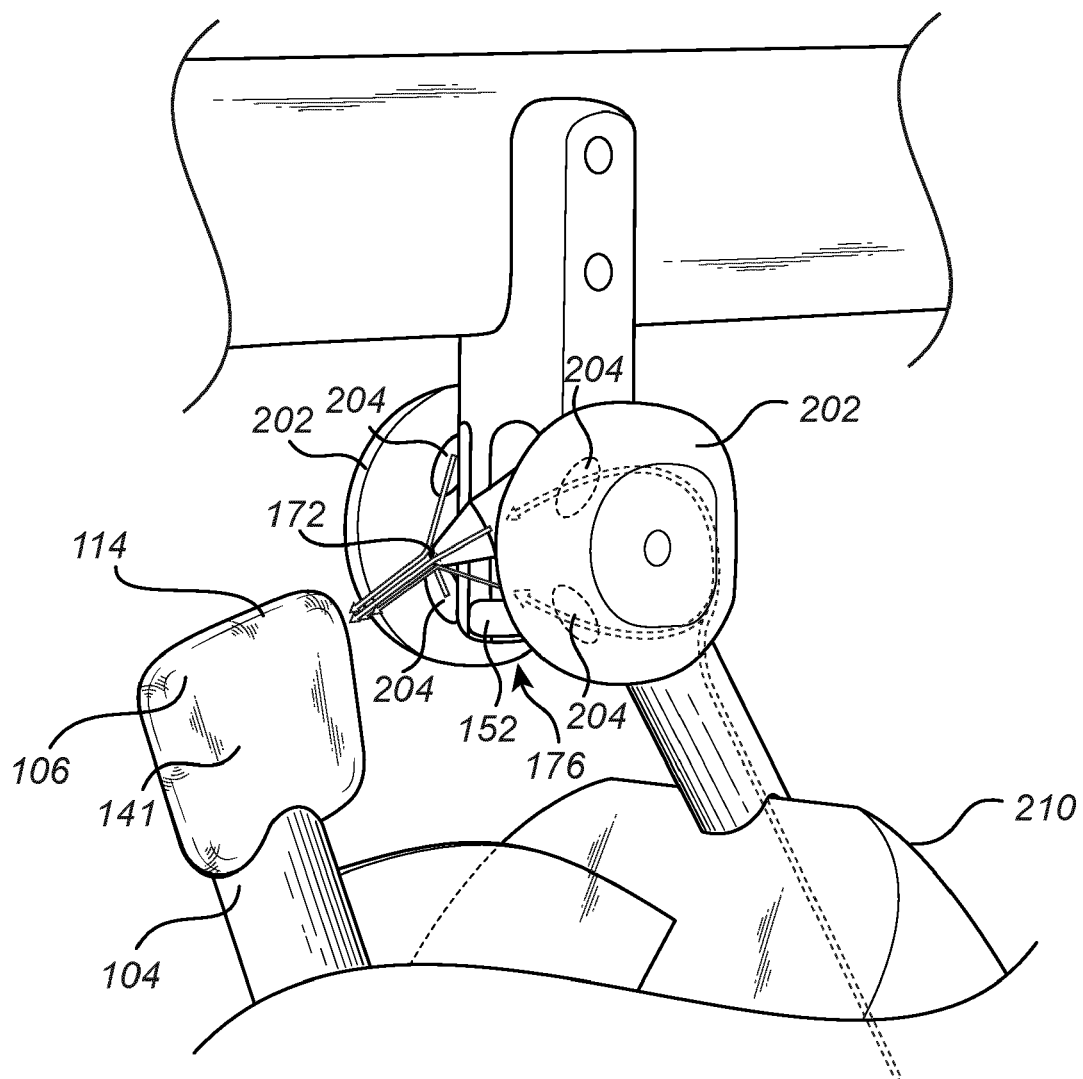


Fig. 2

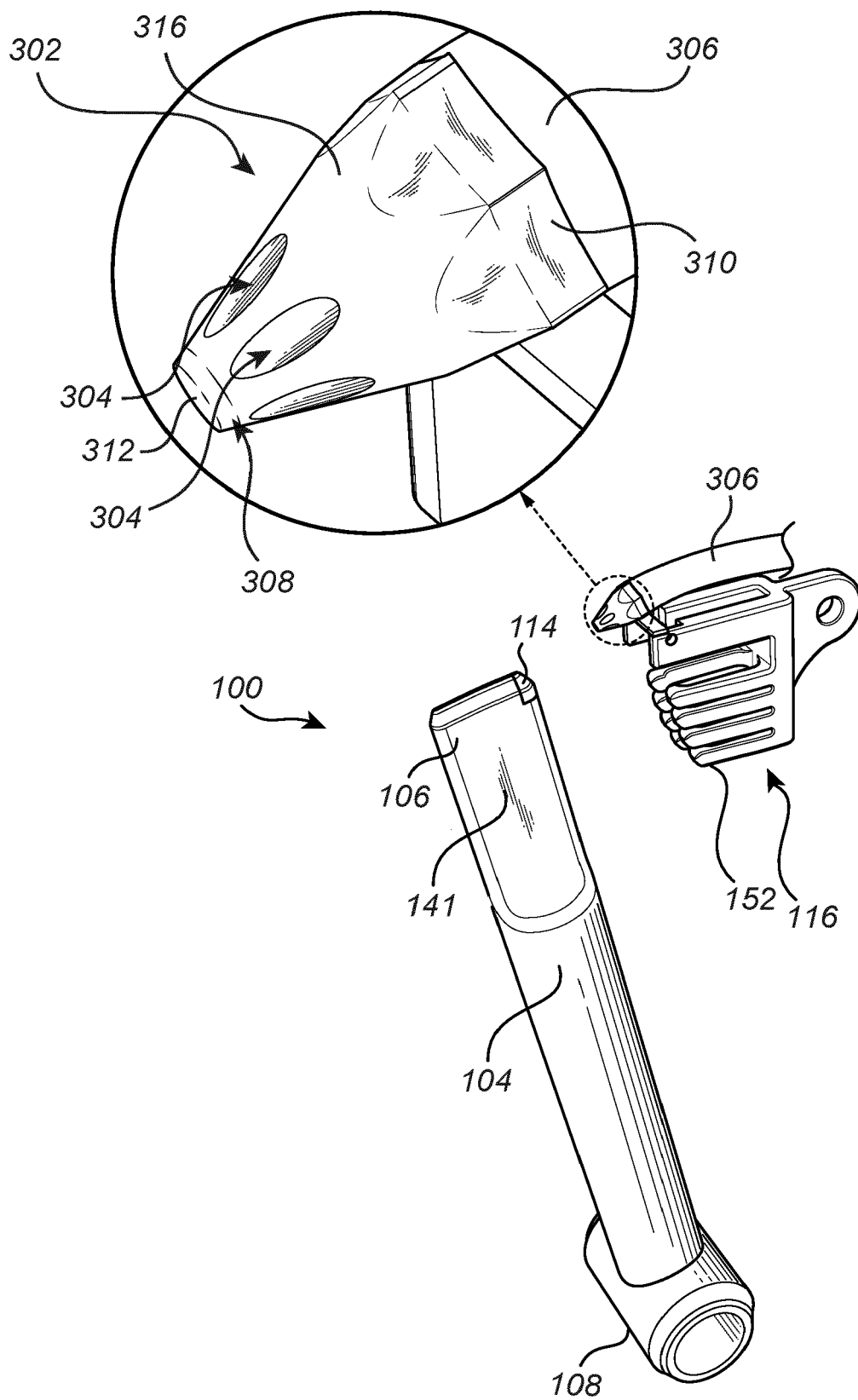


Fig. 3

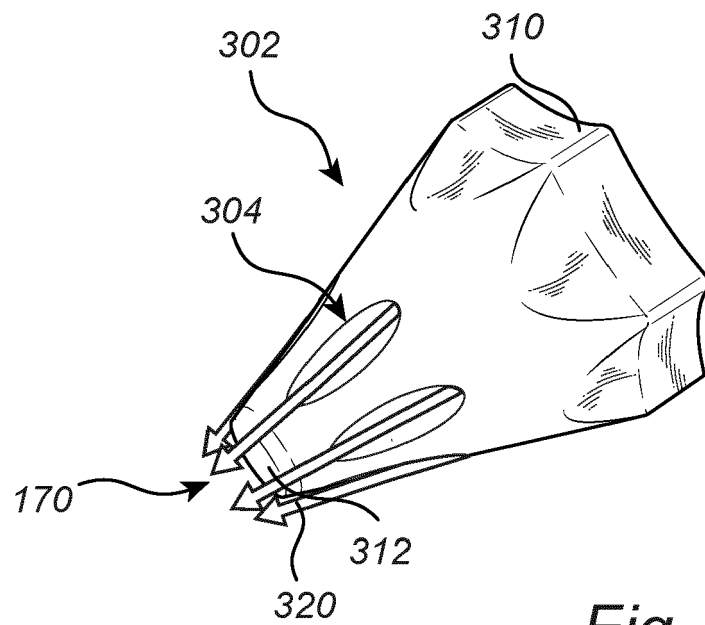


Fig. 4A

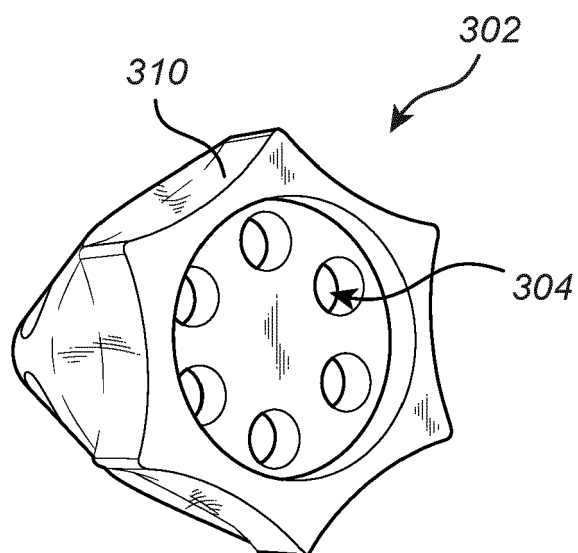


Fig. 4B



EUROPEAN SEARCH REPORT

Application Number

EP 23 15 3851

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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Place of search Munich		Date of completion of the search 30 June 2023	Examiner Bauer, Rodolphe
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	

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

EP 23 15 3851

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