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(54) HIGH VOLTAGE CONNECTION

(57) According to an example aspect of the present invention, there is provided a high voltage connection (1) comprising a housing (2) comprising a base (3) and a perimeter wall (4) protruding from the base (3), thus providing a cavity (13) and an opening (14) into the cavity (13), a circuit board (5) placed within the cavity (13), a connector (6) comprising a tube (7), a banana jack connector (8) and an electric wire (9), wherein the banana jack connector (8) is coupled to a first end (10) of the tube (7), wherein the banana jack connector (8) and the circuit board (5) are electrically connected by the electric wire (9), further electric wiring (11) electrically connected to the circuit board (5), and an insulating material layer (12) within the cavity (13), wherein the circuit board (5), a part of the tube (7) comprising the first end (10), the banana jack connector (8), the electric wire (9) and a first part of the further electric wiring (11) are embedded in the insulation material layer (12), wherein a second part of the further electric wiring (11) and a second end (16) of the tube (7) are located outside of the housing (2).

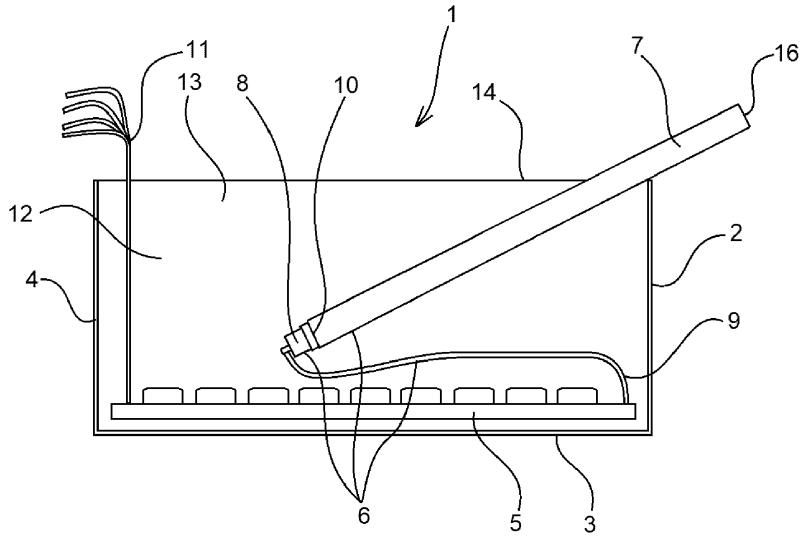

Fig. 1

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Description

FIELD

[0001] The present invention relates to a high voltage connection.

[0002] Further, the present invention relates to an arrangement comprising a first high voltage connection, a second high voltage connection and a device electrically connected to the first and second high voltage connections. According to certain embodiments, the device is a part of a system for separating material in the form of particles and/or drops from a gas flow.

[0003] Furthermore, the present invention relates to use of a high voltage connection in connection with a device for separating material in the form of particles and/or drops from a gas flow.

[0004] Additionally, the present invention relates to a method of manufacturing a high voltage connection.

BACKGROUND

[0005] High voltage connections are required in various applications. For example, a device for separating materials in the form of particles and/or drops from a gas flow typically requires a connection to a high voltage source.

[0006] Document EP 3409372 B1 describes a device and method for separating materials. The device comprises an inlet for incoming air to be purified, a collection chamber, an outlet for the purified air, a voltage source and a fastening column to which ion yield tips have been coupled. The ion yield tips protrude from a surface of the fastening column into a cavity of the collection chamber. The device is configured to direct high tension to the ion yield tips providing ion beams from the ion yield tips to a collection surface in order to separate material in the form of particles and/or drops from a gas flow. The device is configured to direct voltage of opposite sign to the ion yield tips than the voltage directed to the collection surface. A voltage may be in a range between 10 kV to 100 kV, preferably 10 kV to 60 kV. A current may be in a range between 50 μA to 5000 μA, preferably between 400 μA to 2300 μA.

[0007] In view of the foregoing, it would be beneficial to provide a high voltage connection for an electrical device, for example a device as disclosed in EP 3409372 B1. Manufacturing of such high voltage connection should be simple and cost efficient. Additionally, connecting a high voltage source to such high voltage connection should be safe and simple for a user.

SUMMARY OF THE INVENTION

[0008] The invention is defined by the features of the independent claims. Some specific embodiments are defined in the dependent claims.

[0009] According to a first aspect of the present invention, there is provided a high voltage connection comprising a housing comprising a base and a perimeter wall protruding from the base, thus providing a cavity and an opening into the cavity, a circuit board placed within the cavity, a connector comprising a tube, a banana jack connector and an electric wire, wherein the banana jack connector is coupled to a first end of the tube, wherein the banana jack connector and the circuit board are electrically connected by the electric wire, further electric wiring electrically connected to the circuit board, and an insulating material layer within the cavity, wherein the circuit board, a part of the tube comprising the first end, the banana jack connector, the electric wire and a first part of the further electric wiring are embedded in the insulation material layer, wherein a second part of the further electric wiring and a second end of the tube are located outside of the housing.

[0010] Various embodiments of the first aspect may comprise at least one feature from the following bulleted list:

- a heat shrink tube is arranged partially around the banana jack connector and at least partially around the tube
- the heat shrink tube is embedded in the insulating material layer
- the cavity is entirely filled with insulating material of the insulating material layer
- a material of the insulting material layer is a resin or a polyurethane based filler
- a diameter of the tube is in a range between 8 mm to 20 mm, for example 10 mm or 12 mm
- a length of the tube is in a range between 100 mm to 250 mm, for example 170 mm
- a length of the electric wire is in a range between 100 mm and 200 mm, for example 150 mm
- a length of the heat shrink tube is in a range between 50 mm and 100 mm, for example 60 mm
- the further electric wiring and the tube both extend through the opening from the insulating material layer to the outside of the housing
- the circuit board is a cascade board

[0011] According to a second aspect of the present invention, there is provided an arrangement comprising a first high voltage connection according to any one of claims 1 - 9, wherein the first high voltage connection is capable of providing positive voltage, a second high voltage connection according to any one of claims 1-9,

wherein the second high voltage connection is capable of providing negative voltage, and a device electrically connected to the first and second high voltage connections.

[0012] According to a third aspect of the present invention, there is provided use of the high voltage connection according to any one of claims 1 - 9 in connection with a device for separating materials in the form of particles and/or drops from a gas flow.

[0013] According to a fourth aspect of the present invention, there is provided a method of manufacturing a high voltage connection, the method comprising providing a housing comprising a base and a perimeter wall protruding from the base, thus providing a cavity and an opening into the cavity, placing a circuit board within the cavity, providing a connector comprising a tube, a banana jack connector and an electric wire, wherein the banana jack connector is coupled to a first end of the tube, electrically connecting the banana jack connector and the circuit board by the electric wire, electrically connecting further electric wiring to the circuit board, and providing an insulating material layer within the cavity, wherein the circuit board, a part of the tube comprising the first end, the banana jack connector, the electric wire and a first part of the further electric wiring are embedded in the insulation material layer, wherein a second part of the further electric wiring and a second end of the tube are located outside of the housing.

[0014] Various embodiments of the fourth aspect may comprise at least one feature from the following bulleted list:

- the method comprises coupling a heat shrink tube to at least a part of the tube and at least a part of the banana jack connector and applying heat to the heat shrink tube prior to embedding the connector in the insulating material
- the method comprises filling the cavity entirely with insulating material of the insulating material layer
- the circuit board is a cascade board

[0015] Considerable advantages are obtained by certain embodiments of the invention. A high voltage connection is provided according to the present invention. The high voltage connection can be easily mounted due to its modular design. For example, the high voltage connection can be easily mounted on a substrate of another device by attaching the housing of the high voltage connection to the substrate. Further, the high voltage connection can be easily electrically connected to a device by pushing a high voltage cable having a male plug into the tube at its second end, thus electrically connecting the high voltage cable with the banana jack connector having a female socket embedded in the insulating material. The high voltage connection can be further of positive or negative type.

[0016] The high voltage connection is a compact module or unit having a limited amount of parts. Manufacturing of the high voltage connection can be easily done in a cost effective manner. Further, connecting a high voltage source to the high voltage connection is safe and simple for a user. The high voltage connection according to the present invention has particularly large creepage distances.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017]

FIGURE 1 illustrates a schematic view of a high voltage connection in accordance with at least some embodiments of the present invention, and

FIGURE 2 illustrates a schematic view of a connector of a high voltage connection in accordance with at least some embodiments of the present invention.

EMBODIMENTS

[0018] In FIGURE 1 a schematic view of a high voltage connection 1 in accordance with at least some embodiments of the present invention is illustrated.

[0019] The high voltage connection 1 comprises a housing 2 comprising a base 3 and a perimeter wall 4 protruding from the base 3, thus providing a cavity 13 and an opening 14 into the cavity 13. The housing 2 is typically made from plastic material.

[0020] Further, the high voltage connection 1 comprises a circuit board 5 placed within the cavity 13. The circuit board 5 may be a printed circuit board. The circuit board 5 may be a cascade board, for instance. A voltage may be increased by the cascade board, for example from 1 kV to 60 kV. The cascade board 5 may be either of positive or negative type and can provide either positive voltage or negative voltage, respectively, for a high voltage circuit. The difference between the two types of cascades is the assembly direction of the diodes comprised by the cascade board. Components of the circuit board 5 are typically hole mount through components. Soldering of components on the circuit board 5 may take place with wave-soldering or hand-soldering, for instance. The solder connections on the circuit board 5 have typically a rounded shape, i.e. no sharp edges, to ensure minimum corona discharges and electron migration effect through insulating material of the circuit board 5. After the soldering process the components are typically placed in upright position, i.e. perpendicular to the circuit board 5.

[0021] Furthermore, the high voltage connection 1 comprises a connector 6 comprising a tube 7, a banana jack connector 8 having a female socket and an electric wire 9. The tube 7 may be, for example, an acrylic tube. The banana jack connector 8 is coupled to a first end 10 of the tube 7. A heat shrink tube 15 may be arranged partially around the banana jack connector 8 and at least

partially around the tube 7 as shown in FIGURE 2. The banana jack connector 8 and the circuit board 5 are electrically connected by the electric wire 9. The electric wire 9 may be, for example, an electric wire with PVC insulation, 300 V. Typically, the electric wire 9 is soldered at one end to the pin of the banana jack connector 8 located outside of the tube 7 and soldered at the other end to the circuit board 5. Both soldering points of the electric wire 9 are typically made having a rounded shape, i.e. with no sharp edges, to ensure minimum corona discharges and electron migration effect through the insulation materials. A diameter of the tube 7 may be, for example, in a range between 8 mm to 20 mm. A length of the tube 7 may be, for example, in a range between 100 mm to 250 mm. A length of the electric wire 9 may be, for example, in a range between 100 mm and 200 mm.

[0022] Yet further, the high voltage connection 1 comprises further electric wiring 11 electrically connected to the circuit board 5. The further electric wiring typically comprises a number of further electric wires, which are typically each soldered to the circuit board 5 at one end. A plug or pin connector may be provided at another end of at least some wires of the further electric wiring 11. The further electric wiring 11 may, for example, comprise the following further electric wires:

- high voltage cable, 10 kV
- high voltage cable, 10 kV
- electric wire with PVC insulation, 300 V
- electric wire with PVC insulation, 300 V

[0023] Additionally, the high voltage connection 1 comprises an insulating material layer 12 within the cavity 13. The circuit board 5, a part of the tube 7 comprising the first end 10, the banana jack connector 8 having the female socket, the electric wire 9 and a first part of the further electric wiring 11 are embedded in the insulation material layer 12. A second part of the further electric wiring 11 and a second end 16 of the tube 7 are located outside of the housing 2. In other words, a high voltage-cable having a male plug can be inserted from the outside into the tube 7 of the high voltage connection 1 via the second end 16 of the tube 7 and electrically connected to the high voltage connection 1 by plugging the high voltage cable to the banana jack connector 8 having the female socket embedded in the insulating material layer.

[0024] The further electric wiring 11 and the tube 7 both extend through the opening 14 from the insulating material layer 12 to the outside of the housing 2. Typically, the cavity 13 is entirely filled with the insulating material layer 12. A material of the insulting material layer 12 may be a resin, for instant. Another example material is a polyurethane based filler. Voids such as bubbles or air pockets are to be avoided during manufacturing of the insulating layer 12 in order to provide optimum insulating properties.

[0025] Typically, the electric wiring 11 is embedded in the insulating material layer 12 such that at least a 10 N pulling force is allowed without dismounting of the further electric wiring 11.

[0026] In FIGURE 2 a schematic view of a connector 6 of a high voltage connection in accordance with at least some embodiments of the present invention is illustrated. The connector 6 comprises a tube 7, a banana jack connector 8 coupled to a first end 10 of the tube 7 and an electric wire 9 electrically connected to a pin of the banana jack connector 8 as described above in connection with FIGURE 1. A heat shrink tube 15 is further arranged partially around the banana jack connector 8 and at least partially around the tube 7 in order to improve the coupling of the tube 7 and the banana jack connector 8 and to further avoid insulating material of the insulating material layer 12 to enter the tube 7 during manufacturing of the high voltage connection 1. The inner diameter of the heat shrink tube 15 is typically greater than the outer diameter of the tube 7 prior to shrinking the heat shrink tube 15 by applying heat to the heat shrink tube 15.

[0027] According to certain embodiments, glue is further applied to one end of the pin of the banana jack connector 8 in order to avoid insulating material of the insulating material layer 12 to enter the tube 7 during manufacturing of the high voltage connection 1.

[0028] It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[0029] Reference throughout this specification to one embodiment or an embodiment means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present invention. Thus, appearances of the phrases "in one embodiment" or "in an embodiment" in various places throughout this specification are not necessarily all referring to the same embodiment. Where reference is made to a numerical value using a term such as, for example, about or substantially, the exact numerical value is also disclosed.

[0030] As used herein, a plurality of items, structural elements, compositional elements, and/or materials may be presented in a common list for convenience. However, these lists should be construed as though each member of the list is individually identified as a separate and unique member. Thus, no individual member of such list should be construed as a de facto equivalent of any other member of the same list solely based on their presentation in a common group without indications to the contrary. In addition, various embodiments and example of the present invention may be referred to herein along with alternatives for the various components thereof. It

is understood that such embodiments, examples, and alternatives are not to be construed as de facto equivalents of one another, but are to be considered as separate and autonomous representations of the present invention.

[0031] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the description, numerous specific details are provided, such as examples of lengths, widths, shapes, etc., to provide a thorough understanding of embodiments of the invention. One skilled in the relevant art will recognize, however, that the invention can be practiced without one or more of the specific details, or with other methods, components, materials, etc. In other instances, well-known structures, materials, or operations are not shown or described in detail to avoid obscuring aspects of the invention.

[0032] While the forgoing examples are illustrative of the principles of the present invention in one or more particular applications, it will be apparent to those of ordinary skill in the art that numerous modifications in form, usage and details of implementation can be made without the exercise of inventive faculty, and without departing from the principles and concepts of the invention. Accordingly, it is not intended that the invention be limited, except as by the claims set forth below.

[0033] The verbs "to comprise" and "to include" are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in depending claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", that is, a singular form, throughout this document does not exclude a plurality.

INDUSTRIAL APPLICABILITY

[0034] At least some embodiments of the present invention find industrial application in electrically connecting a high voltage power supply source to an electric device.

REFERENCE SIGNS LIST

[0035]

1 high voltage connection
2 housing
3 base
4 perimeter wall
5 circuit board
6 connector
7 tube
8 banana jack connector
9 electric wire
10 first end of tube
11 further electric wiring
12 insulating material layer
13 cavity
14 opening
15 heat shrink tube
16 second end of tube
17 device
18 arrangement

CITATION LIST

Patent Literature

[0036] EP 3409372 B1

Claims

1. A high voltage connection (1) comprising:

- a housing (2) comprising a base (3) and a perimeter wall (4) protruding from the base (3), thus providing a cavity (13) and an opening (14) into the cavity (13),
- a circuit board (5) placed within the cavity (13),
- a connector (6) comprising a tube (7), a banana jack connector (8) and an electric wire (9), wherein the banana jack connector (8) is coupled to a first end (10) of the tube (7), wherein the banana jack connector (8) and the circuit board (5) are electrically connected by the electric wire (9),
- further electric wiring (11) electrically connected to the circuit board (5), and
- an insulating material layer (12) within the cavity (13), wherein the circuit board (5), a part of the tube (7) comprising the first end (10), the banana jack connector (8), the electric wire (9) and a first part of the further electric wiring (11) are embedded in the insulation material layer (12), wherein a second part of the further electric wiring (11) and a second end (16) of the tube (7) are located outside of the housing (2).

2. The high voltage connection (1) according to claim 1, wherein a heat shrink tube (15) is arranged partially around the banana jack connector (8) and at least partially around the tube (7).

3. The high voltage connection (1) according to claim 1 or 2, wherein the cavity (13) is entirely filled with insulating material of the insulating material layer (12).

4. The high voltage connection (1) according to any one of claims 1-3, wherein a material of the insulting material layer is a resin or a polyurethane based filler.

5. The high voltage connection (1) according to any

one of claims 1-4, wherein a diameter of the tube (7) is in a range between 8 mm to 20 mm.

6. The high voltage connection (1) according to any one of claims 1-5, wherein a length of the tube (7) is in a range between 100 mm to 250 mm.

7. The high voltage connection (1) according to any one of claims 1-6, wherein a length of the electric wire (9) is in a range between 100 mm and 200 mm.

8. The high voltage connection (1) according to any one of claims 1-7, wherein the further electric wiring (11) and the tube (7) both extend through the opening (14) from the insulating material layer (12) to the outside of the housing (2).

9. The high voltage connection (1) according to any one of claims 1-8, wherein the circuit board (5) is a cascade board.

10. An arrangement comprising:

- a first high voltage connection (1) according to any one of claims 1-9, wherein the first high voltage connection (1) is capable of providing positive voltage,
- a second high voltage connection (1) according to any one of claims 1-9, wherein the second high voltage connection (1) is capable of providing negative voltage, and
- a device (17) electrically connected to the first and second high voltage connections (1).

11. Use of the high voltage connection (1) according to any one of claims 1 - 9 in connection with a device for separating materials (17) in the form of particles and/or drops from a gas flow.

12. A method of manufacturing a high voltage connection (1), the method comprising:

- providing a housing (2) comprising a base (3) and a perimeter wall (4) protruding from the base (3), thus providing a cavity (13) and an opening (14) into the cavity (13),
- placing a circuit board (5) within the cavity (13),
- providing a connector (6) comprising a tube (7), a banana jack connector (8) and an electric wire (9), wherein the banana jack connector (8) is coupled to a first end (10) of the tube (7),
- electrically connecting the banana jack connector (8) and the circuit board (5) by the electric wire (9),
- electrically connecting further electric wiring (11) to the circuit board (5), and
- providing an insulating material layer (12) within the cavity (13), wherein the circuit board (5), a part of the tube (7) comprising the first end (10), the banana jack connector (8), the electric wire (9) and a first part of the further electric wiring (11) are embedded in the insulation material layer (12), wherein a second part of the further electric wiring (11) and a second end (16) of the tube (7) are located outside of the housing (2).

13. The method according to claim 12, wherein the method comprises coupling a heat shrink tube (15) to at least a part of the tube (7) and at least a part of the banana jack connector (8) and applying heat to the heat shrink tube (15) prior to embedding the connector (6) in the insulating material (12).

14. The method according to claim 12 or 13, wherein the method comprises filling the cavity (13) entirely with insulating material of the insulating material layer (12).

15. The method according to any one of claims 12 - 14, wherein the circuit board (5) is a cascade board.

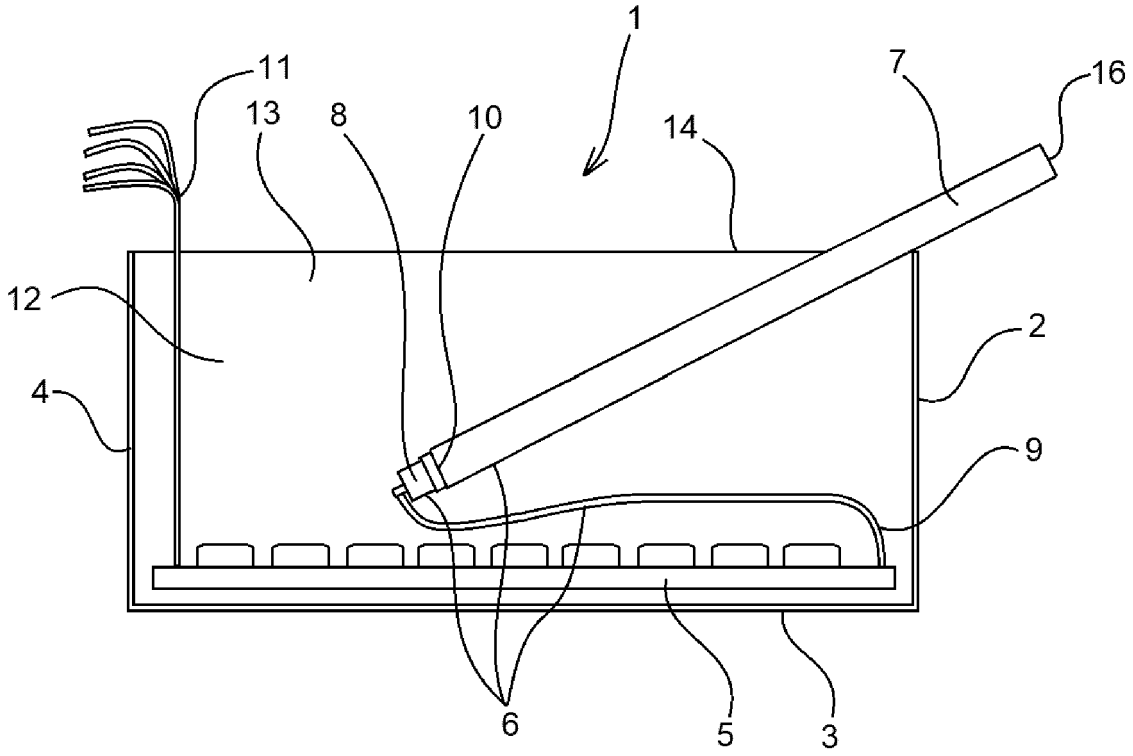

Fig. 1

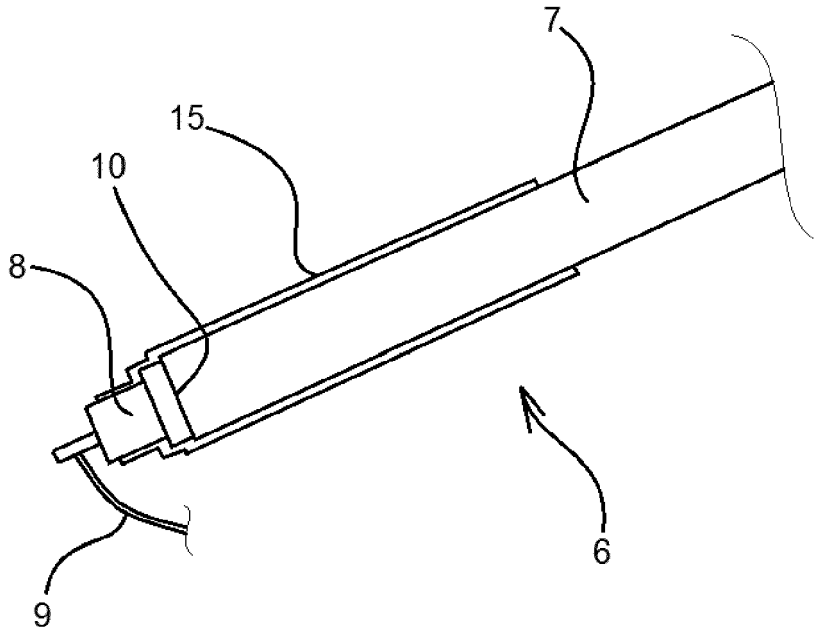

Fig. 2

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EUROPEAN SEARCH REPORT

Application Number
EP 23 20 7274

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 0 114 244 A1 (ANT NACHRICHTENTECH [DE]) 1 August 1984 (1984-08-01) * page 3, line 16 - page 6, line 15; figures 1-6 *	1-15	INV. H01R4/70 H01R13/405 H01R13/53 B03C3/41
Y	US 2018/287294 A1 (IMESON CHRISTOPHER A [CA] ET AL) 4 October 2018 (2018-10-04) * paragraph [0037] - paragraph [0063]; figures 2-5 *	1-15	ADD. H01R4/72 H01R13/05 H01R101/00

TECHNICAL FIELDS SEARCHED (IPC)

B03C
H01R

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
The Hague	19 March 2024	Gomes Sirenkov E M.

CATEGORY OF CITED DOCUMENTS

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