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(54) **AN ELECTRIC HEATER AND A METHOD FOR ITS FABRICATION**

(57) The electric heater (1) comprises a resistive wire (2) and a support (3) around which the resistive wire (2) is wound, the support (3) comprising at least one mica sheet rolled up to form a tube (4), the resistive wire (2) being housed in an impression (5) on the outer surface of the tube (4).

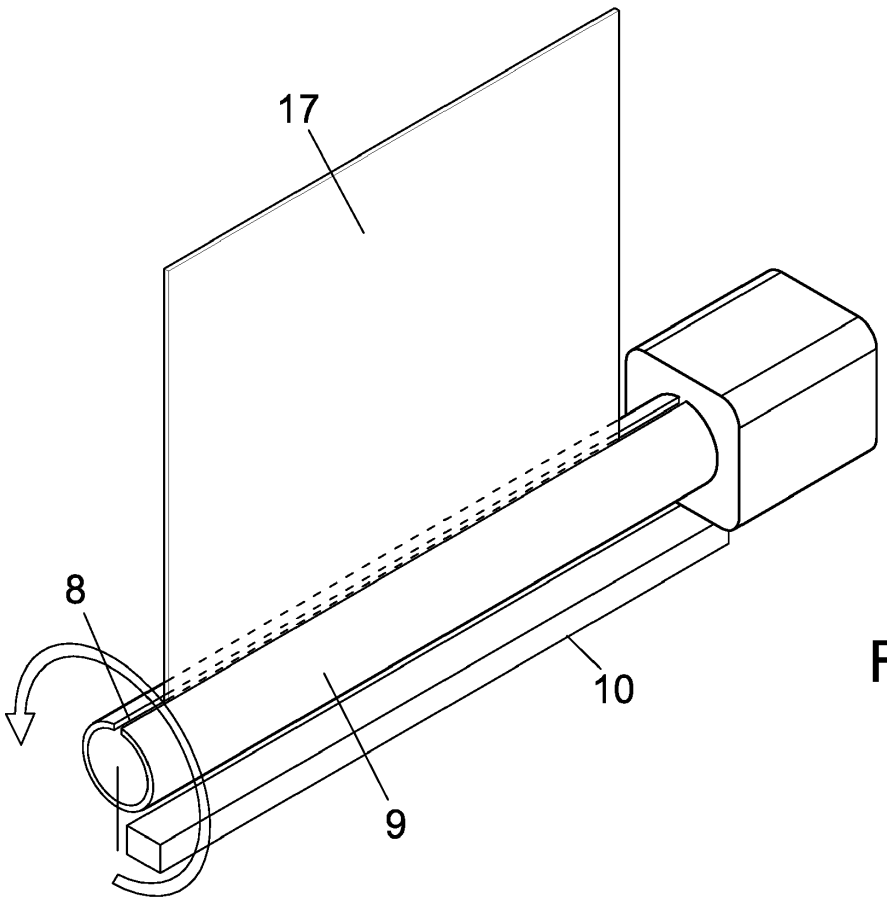

FIG. 1

EP 3 393 203 A1

Description

[0001] The present invention relates to an electric heater and a method for its production.

[0002] The use of electric heaters comprising a resistive electric wire wound around a support is known in many industries.

[0003] For example, cartridge electric heaters are used in water, oil or thermovector fluid electric heaters with similar functions.

[0004] High precision tubular electric heaters, on the other hand, are used for hot runner injection nozzles.

[0005] The process for manufacturing an electric heater largely depends on the specific industry in which it is to be used.

[0006] In the case of cartridge electric heaters, an electrically isolating support formed of a cylinder of compressed magnesium oxide powder is often used, around which the resistive wire is wound in a spiral pattern.

[0007] The magnesium oxide powder is not always easy to process, and the resulting cylindrical supports often tend to be curved, especially if they are very long.

[0008] A loss of straightness is not admissible, since it impedes the correct assembly and operation of the cartridge heater.

[0009] For this reason, if it is necessary to fabricate a very long cartridge electric heater, it is preferable to stack a series of shorter compressed magnesium oxide powder cylinders until the desired length is obtained.

[0010] However, this implies that the resistive wires wound around the compressed magnesium oxide powder cylinders must be connected individually in parallel to the electrodes of the electric heater.

[0011] This obviously complicates the fabrication process, in relation to both the assembly of a large number of components and the alignment between said components.

[0012] GB448360 discloses an electric heater comprising an inner tube in ductile metal on which a first insulating sleeve in micanite is located onto which an electrical conductor is spiral wound. A second insulating sleeve in micanite surrounds the spiral conductor, and the whole is located inside an outer tube in harder metal than the material of which the inner tube is constituted. In this manner it is possible to assemble the electric heater by exerting an outwards radial pressure on the inner tube, so as to crush the internal parts against the outer tube. The disadvantage of this method of assembly consists in the fact that it requires the deformable inner metal tube which must have a containing function on the first insulating sleeve in micanite, which otherwise, in the absence of the inner metal tube, would crumble and be partly lost when subjected to radial pressure.

[0013] The proposed task of this invention is, thus, to eliminate the disadvantages of the prior art, providing an electric heater which is easy to make in the desired sizes and is flexibly adapted to use in a variety of applications.

[0014] In the context of this task, an object of the invention is to make a robust, compact and highly efficient electric heater.

[0015] The task, as well as these and other objects according to this invention are obtained by making an electric heater comprising a resistive wire and a support around which said resistive wire is wound, characterised in that said support comprises at least one mica sheet rolled up to form a tube, and in that said resistive wire is housed in an impression present on the outer surface of said tube.

[0016] In a preferred embodiment of the invention said impression extends in a spiral around the axis of said tube.

[0017] In a preferred embodiment of the invention said resistive wire is wound in a spiral around the outer surface of said tube with sufficient tension to form said impression.

[0018] The invention has application in a variety of fields.

[0019] In particular, the electric heater may be used in a heating tube with open ends for the axial passage through it of a fluid to be heated, for example water, air, oil.

[0020] The heating tube may also comprise more than one electric heater with open ends, with the electric heaters located co-axially one inside the other and delimiting a gap for the axial passage of the fluid to be heated.

[0021] In general, the electric heater may be used in a heat exchanger for fluids.

[0022] The present invention also discloses a method for manufacturing an electric heater characterized in that a mica sheet is rolled up to form a tube and a resistive wire is spiral wound around the outer surface of said tube, applying to the resistive wire sufficient tension to form on the outer surface of said tube an impression of said wire in which the coils of the said resistive wire are firmly retained.

[0023] Mica is a mineral formed of aluminium silicates and alkaline metals (potassium, sodium and lithium), to which bivalent metals, such as magnesium and iron, are sometimes added; sometimes fluorine and hydrogen (acid) are also present.

[0024] Advantageously, of all the varieties of flexible mica sheet, sheets of muscovite, or potassium mica, and phlogopite, or magnesium mica, have been selected. Both varieties of flexible sheet are characterised in that they are easily processed, even in large sheets, and in that they have excellent resistance to high temperatures together with high dielectric strength. They can work at temperatures in excess of 900 °C.

[0025] The mica tube, advantageously provided with a very thin sheet thickness of 0.1 mm to 0.5 mm, has a dielectric strength in excess of 1700 Volts AC.

[0026] Further characteristics and advantages will become more apparent from the detailed description of the electric heater according to the invention, illustrated by way of example in the accompanying figures, in which:

figure 1 shows a perspective view of the system for

fabricating the heater during the step of rolling the mica sheet;
figures 2 and 3 show cross-sectional views of the system in figure 1 before and after formation of the tube;
figure 4 shows the system for fabricating the heater during the step of winding the resistive wire;
figures 5 and 6 show the tube with the resistive wire wound onto it, during and after the passage of an end of the resistive wire from one end to the other of the tube;
figure 7 shows an enlarged detail of figure 6;
figure 8 shows a partially sectioned perspective view of the electric heater;
figure 9 shows a cross-sectional view of the electric heater;
figure 10 shows a longitudinal section of a length of the electric heater; and figure 11 shows an enlarged detail of figure 10.

[0027] With reference to the cited figures, a cartridge heater is shown, in particular an electric immersion heater for electric radiators employing oil, water or thermovector fluid with similar functions, indicated as a whole with the reference number 1.

[0028] The cartridge electric heater 1 comprises a resistive wire 2 wound around a support 3.

[0029] The spiral wound resistive wire 2 is in high temperature alloy, for example in NiCr, FeCrAl or similar alloy.

[0030] The scope of the invention extends more generally to all electric heaters having a resistive wire wound around a support.

[0031] For example, the scope of the invention extends to tubular electric heaters inside which a hot runner injection nozzle is mounted.

[0032] A salient aspect of the invention consists in the fact that the support 3 comprises at least one mica sheet 17 rolled up to form a tube 4 around the outer surface of which the resistive wire 2 is wound. In particular, the resistive wire 2 is wound in a spiral around the axis of the tube 4.

[0033] The coils of the wire 2 are precisely housed in a spiral-shaped impression 5 which extends around the outer surface of the tube 4.

[0034] In the illustrated preferred embodiment of the invention, advantageously the wire 2 is spiral wound around the outer surface of the tube 4 with sufficient tension to deform the outer surface of the tube 4 to form the impression 5.

[0035] The resistive wire 2 is thus firmly retained in position in its impression 5 formed on the outer surface of the tube 4 and all relative movement of the coils of the wire 2 is impeded.

[0036] The mica sheet 17 used to fabricate the support 3 is of phlogopite or muscovite, but a synthetic mica may also be used.

[0037] The mica sheet 17 in phlogopite or muscovite has a thickness of 0.1 to 0,5 mm and ensures a dielectric strength of the secondary insulation thus obtained of no less than 1750 Volts AC.

[0038] In the illustrated preferred embodiment of the invention, a single mica sheet 17 is used, but, in another embodiment of the invention, it is possible to provide several distinct mica sheets rolled and arranged one inside the other to form co-axial tubes, around each of which a corresponding resistive wire is wound in a spiral.

[0039] In this case, each wire 2 must be wound in a spiral around the outer surface of the corresponding tube 4 with sufficient tension to deform the outer surface of the tube 4 to form the impression 5.

[0040] The tube 4 must be closed laterally to ensure complete electrical insulation of the resistive wire 2.

[0041] In the illustrated preferred embodiment of the invention the mica sheet is rolled with more than one turn, for example at least one and a half turns, so as to overlap the two opposite edges of the mica sheet.

[0042] The tube 4 may have different shapes and dimensions in relation to the application. For example, the tube 4 may have a cylindrical shape or a tapered shape.

[0043] The resistive wire 2 may also be arranged on the support 3 in different ways in relation to the application to modulate its thermal power delivery.

[0044] For example, the wire 2 may have coils of constant or variable pitch along the axis of the support 3.

[0045] The wire 2 has a first terminal portion of wire 2a comprising a first end 2a' of the wire 2 and a second terminal portion of wire 2b comprising a second end 2b' of the wire 2 connected to the power electrodes 6.

[0046] The first terminal portion of wire 2a and the second terminal portion of wire 2b are not constrained to the impression 5 so as to be freely conformed in relation to the position selected for the power electrodes 6.

[0047] For example, if the two electrodes 6 are to be positioned inside the tube 4, the first terminal portion of wire 2a and the second terminal portion of wire 2b are both folded inside the tube 4.

[0048] In any case, a system for retaining the terminal portions 2a, 2b of the wire 2 is provided, for example, notches 12, 13 at the ends of the tube 4 which retain the terminal portions 2a, 2b of the wire 2.

[0049] To consolidate the retention of the wire 2 on the support 3 it is additionally possible to lock a portion of the wire 2 between the turns of the roll.

[0050] As mentioned, a preferred method for manufacturing the electric heater consists in rolling up a mica sheet to form the tube 4 and winding the resistive wire 2 in a spiral around the outer surface of the tube 4, applying to the wire 2 sufficient tension to form, on the outer surface of the tube 4, the impression 5 of the wire 2 in which the coils of the wire 2 are firmly retained.

[0051] To form the tube 4 an edge of the mica sheet is inserted and held in an axial slot 8 of a spindle 9, then the spindle 9 driven in rotation to roll up the mica sheet 17 and obtain the tube 4.

[0052] A profiling cam 10 may potentially adapt the mi-

ca sheet to the profile of the spindle 9.

[0053] The wire 2 is supplied from a reel 7 to a head 11 equipped with a tensioner 11a. The head 11 supplying the resistive wire 2 translates in the direction of the axis of the spindle 9 while the spindle 9 is rotating.

[0054] The wire 2 is wound in a spiral from one end to the other of the tube 4.

[0055] At the opposite ends of the tube 4 the terminal portions 2a, 2b of the wire 2 are left unwound.

[0056] One of the unwound terminal portions 2a, 2b of the wire 2, for example the terminal portion 2b, is left at a length greater than the length of the tube 4.

[0057] The terminal portion 2a of the wire 2 is retained by the notch 12 and is folded back into the tube 4 to exit from the opposite end of the tube 4 in the vicinity of which is the other terminal portion 2b of the wire 2 which is retained by notch 13.

[0058] In this position, the terminal portions 2a, 2b of the wire 2 are ready for connection to the electrodes 6.

[0059] With reference to the illustrated cartridge electric heater 1, the mica tube 4 is covered externally by an electric insulator 16.

[0060] In particular, the mica tube 4 is covered by a metal tube 15 which delimits with the mica tube 4 a gap filled with the electric insulator 16 formed, for example, of compressed magnesium oxide powder.

[0061] The magnesium oxide may be substituted by an equivalent material, for example a friable talc at a moderate or high degree of compression, or by sintered insulating materials such as steatite, alumina, cordierite or thermoelectric material.

[0062] Potentially, to give consistency to the structure of the electric heater while improving its electric insulation, the axial cavity of the tube 4 may itself be filled with electric insulation.

[0063] The metal tube 15, on the other hand, is made of steel, for example AISI 304, but may be in another material, and comprises a cylindrical side wall, a bottom plate and a cap which delimit a closed chamber containing the tube 4.

[0064] As mentioned, the field of application of the invention is very wide and not limited to cartridge electric heaters.

[0065] For example, the tube 4 around which the resistive wire 2 is wound may represent the tubular structure inside the axial cavity of which a hot runner injection nozzle is inserted for moulding plastic.

[0066] In general, the electric heater may be used in a heat exchanger for fluids.

[0067] The heat exchanger may be a heating tube with open ends for the axial passage through it of the fluid to be heated, for example water, air, oil.

[0068] For example, the structure of the heating tube comprises an inner metal tube, an outer metal tube, a first mica tube around which the resistive wire is wound as described above, and at least a second mica tube wound around the first mica tube to provide electrical insulation for the resistive wire, the mica tubes being interposed between the inner metal tube and the outer metal tube.

[0069] At least a double electric insulation of the resistive wire may also be provided.

[0070] Furthermore, a structure of heating tube may be provided, formed by two or more heating tubes of the type above described, arranged co-axially one inside the other and delimiting one or more gaps for the axial passage of the fluid to be heated.

Claims

1. An electric heater (1) comprising a resistive wire (2) and a support (3) around which said resistive wire (2) is wound, **characterized in that** said support (3) comprises at least one mica sheet rolled up to form a tube (4), and **in that** the resistive wire (2) is housed in an impression (5) on the outer surface of said tube (4).

2. The electric heater (1) according to claim 1, **characterized in that** said impression (5) spirals around the axis of said tube (4).

3. The electric heater (1) according to claim 2, **characterized in that** said resistive wire (2) is spiral wound around the outer surface of said tube (4) with sufficient tension to form said impression (5).

4. The electric heater (1) according to claim 1, **characterized in that** said tube (4) is closed laterally.

5. The electric heater (1) according to the preceding claim, **characterized in that** said tube (4) is formed by rolling for more than one turn said mica sheet.

6. The electric heater (1) according to claim 1, **characterized in that** said mica sheet is of phlogopite or muscovite or synthetic mica.

7. The electric heater (1) according to claim 1, **characterized in that** said wire (2) has a first and a second opposite terminal portions (2a, 2b) which exit from said impression (5) and are hooked to notches (12, 13) present at the opposite ends of said tube.

8. The electric heater (1) according to claim 2, **characterised in that** the concentration of the coils of the said wire (2) is variable along the axis of the tube (5) so as to modulate the delivered thermal power.

9. The electric heater (1) according to any of the preceding claims, **characterized in that** said tube (4) of mica is covered externally by an electrical insulator (16).

10. A heating tube **characterized in that** it comprises

at least one electric heater (1) according to any of the preceding claims having the ends open for the axial passage through it of a fluid to be heated.

11. The heating tube according to the preceding claim, **characterized in that** it comprises at least two electric heaters (1) open at the ends placed coaxially the one inside the other and delimiting a gap for the axial passage of said fluid to be heated.

12. A heat exchanger for fluids **characterized in that** it comprises at least one electric heater (1) according to any one of claims 1 - 9.

13. A hot runner injection nozzle **characterized in that** it presents an electric heater (1) according to any one of claims 1 to 9, fitted on it.

14. A method for manufacturing an electric heater (1) **characterized in that** a mica sheet (17) is rolled up to form a tube (4) and a resistive wire (2) is spiral wound around the outer surface of said tube (4) applying to the resistive wire (2) sufficient tension to form on the outer surface of said tube (4) an impression (5) of said resistive wire (2) in which the coils of the said resistive wire (2) are firmly retained.

15. The method for manufacturing an electric heater (1) according to the preceding claim, **characterized in that** in order to form said tube (4) an edge of the mica sheet is fully inserted and retained in an axial slit of a spindle (9), then the spindle (9) is driven in rotation so that it rolls up the mica sheet (17), while for winding said wire (2) around the tube (4) thus formed said wire (2) is fed by a head (11) equipped with a tensioner (11a) that translates in the direction of the axis of the said spindle (9) while said spindle (9) turns.

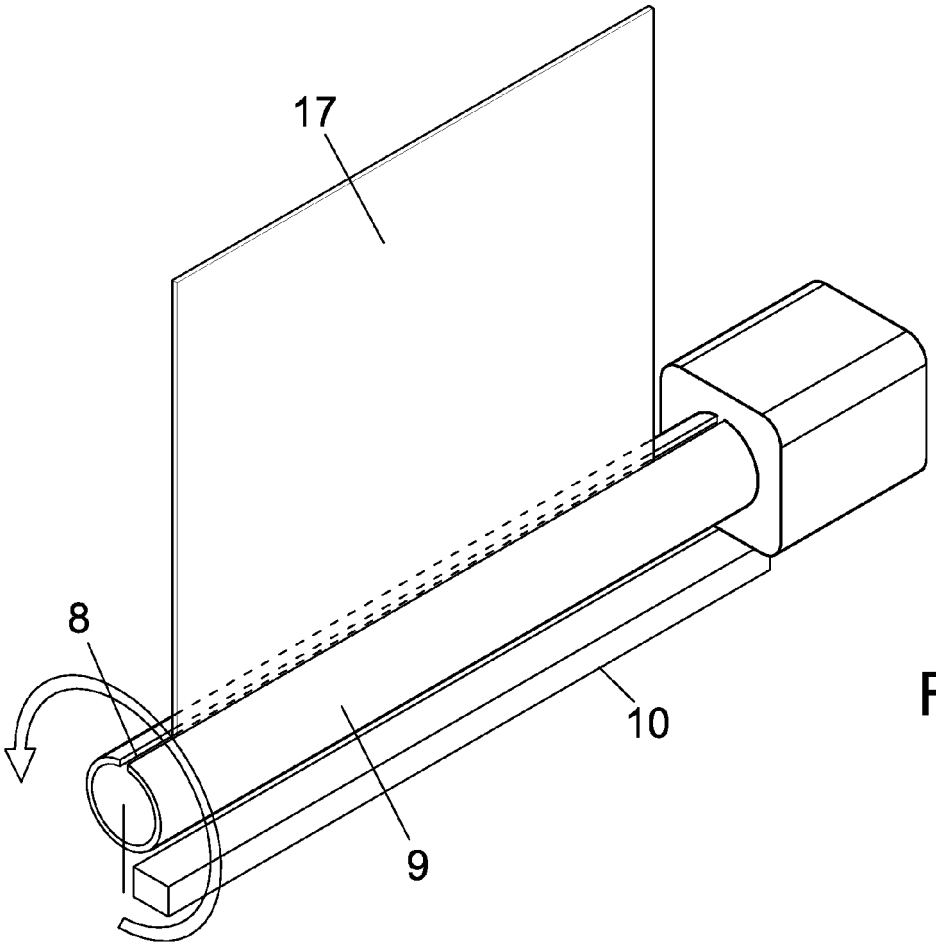

FIG. 1

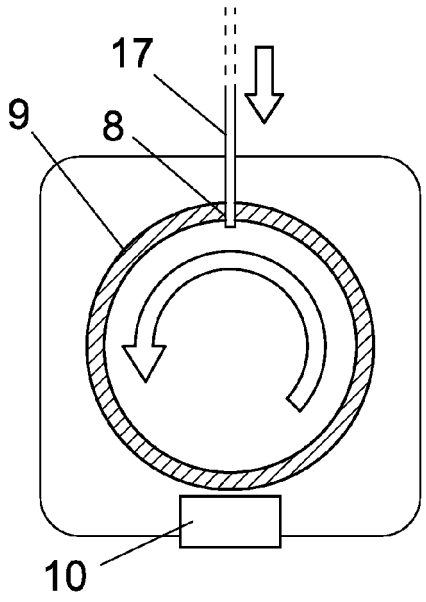

FIG. 2

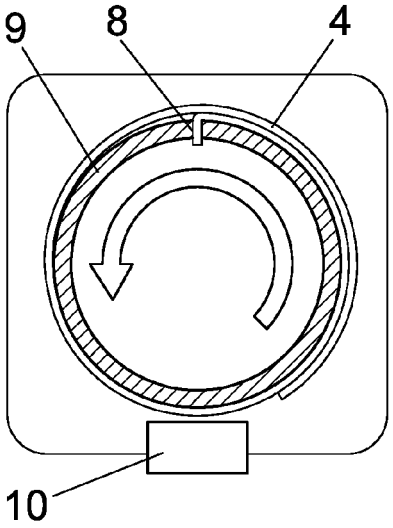

FIG. 3

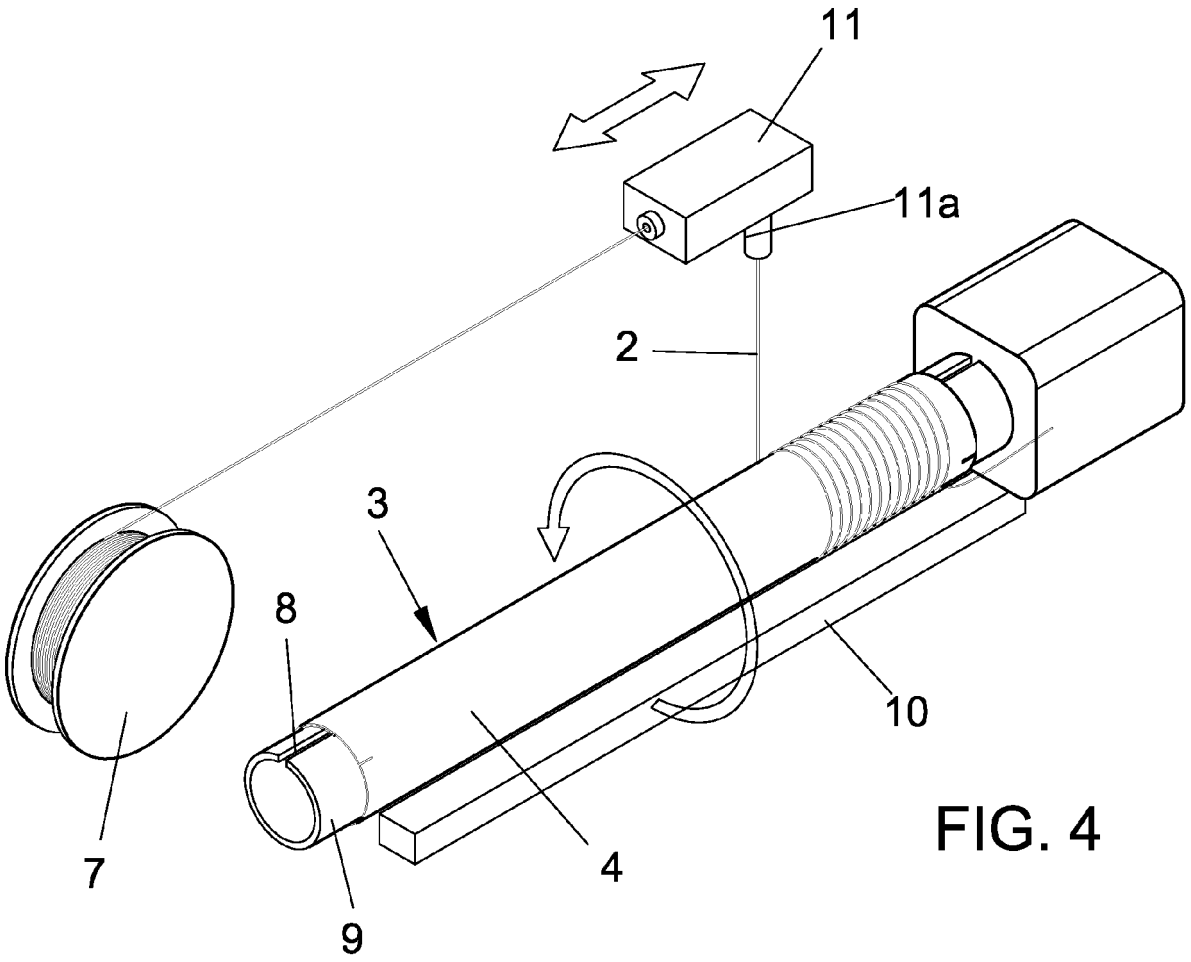

FIG. 4

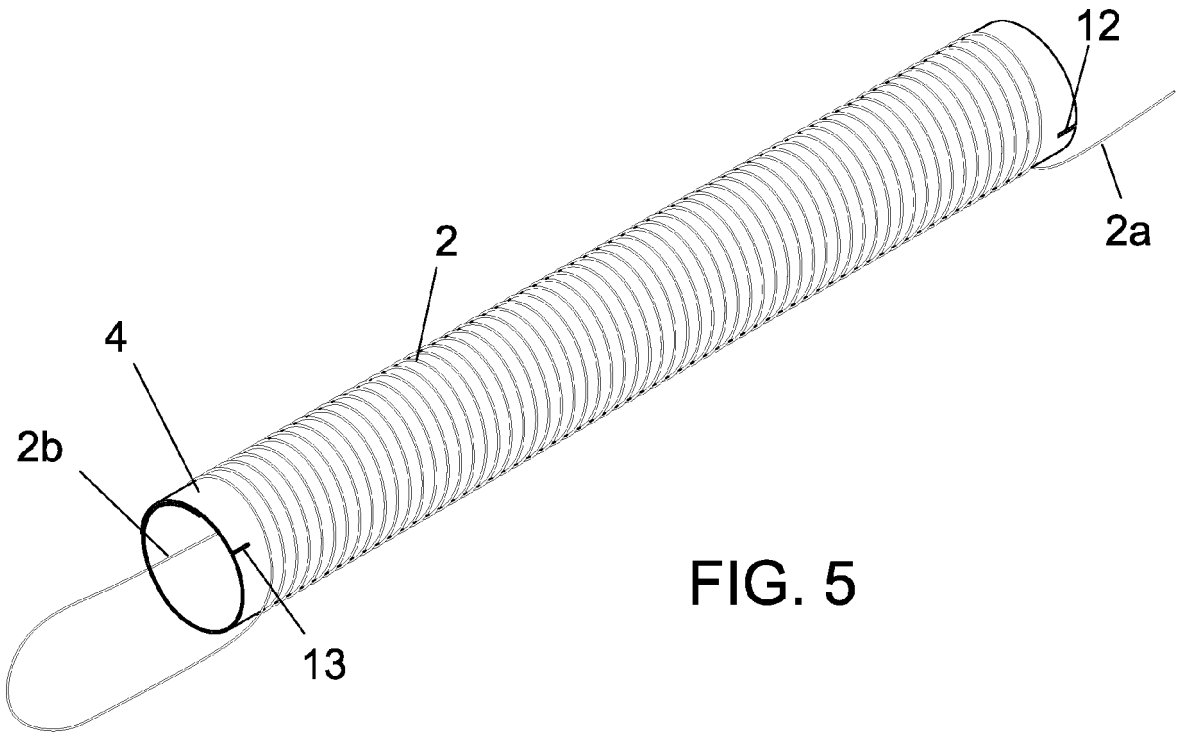

FIG. 5

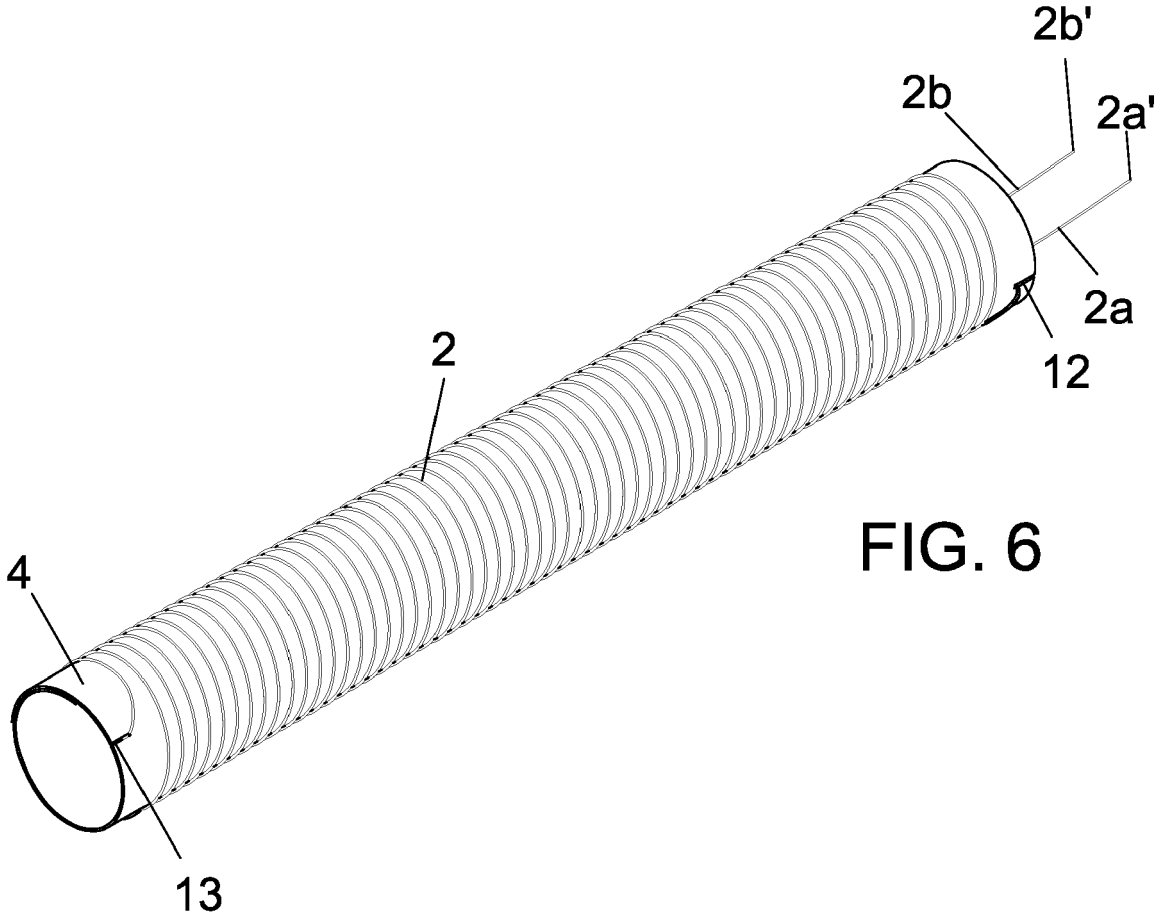

FIG. 6

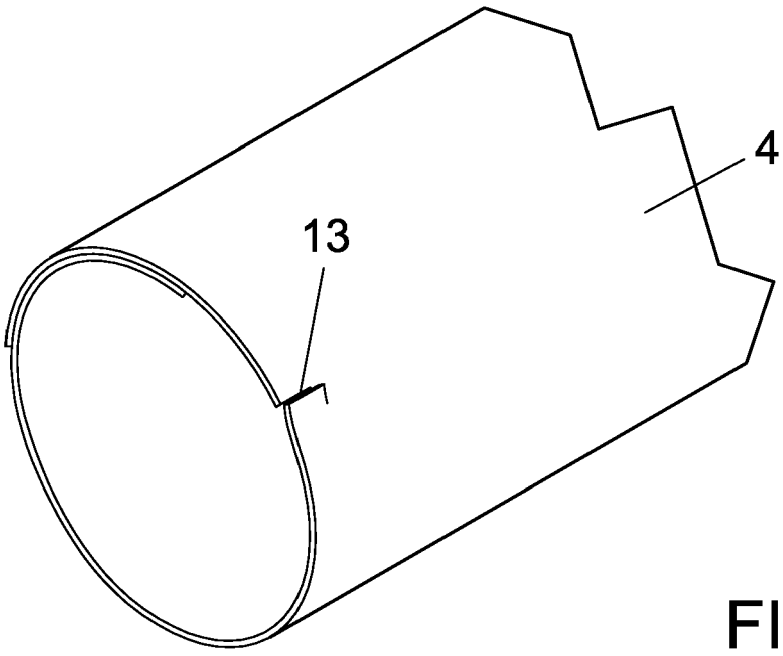

FIG. 7

FIG. 8

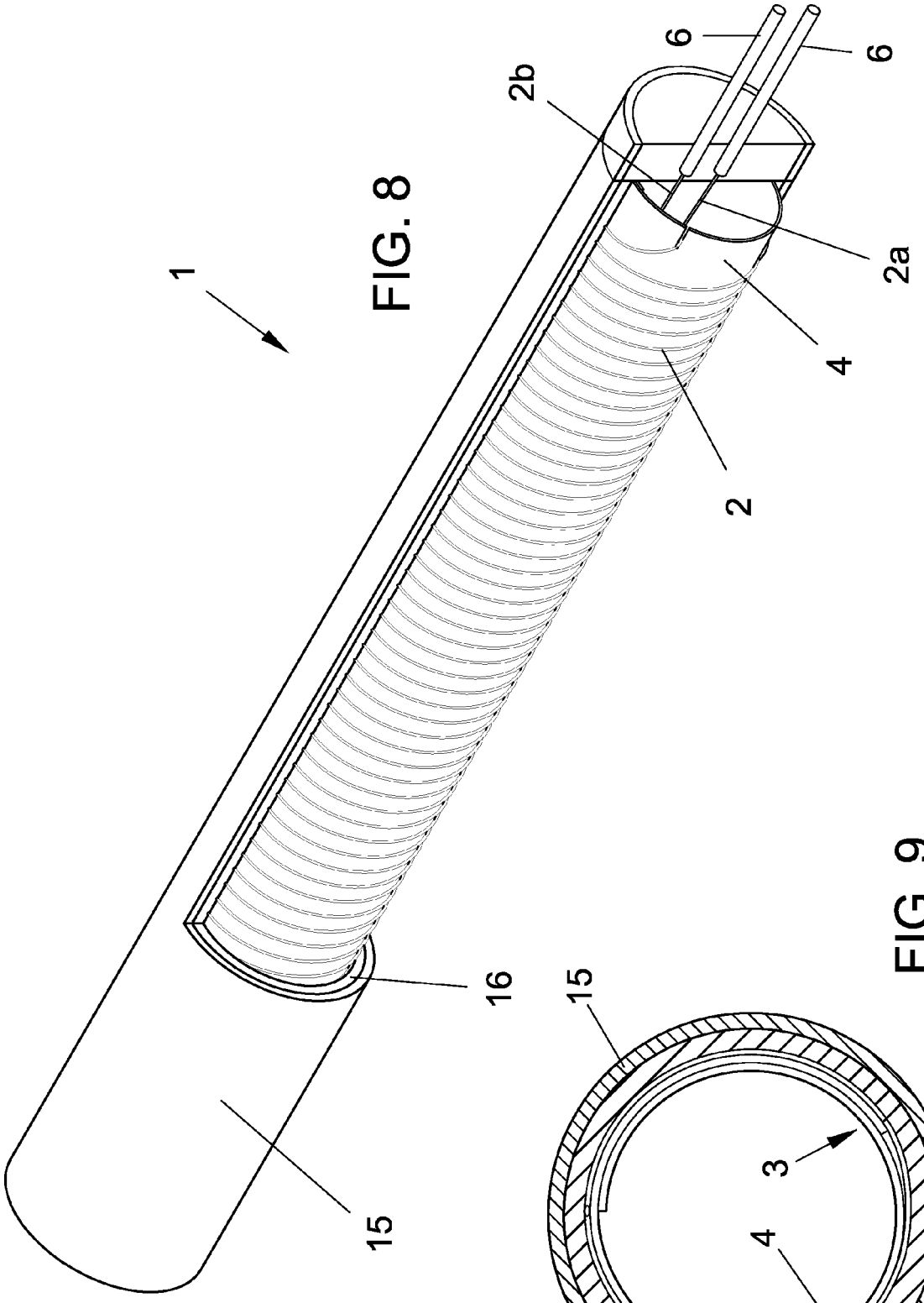

FIG. 9

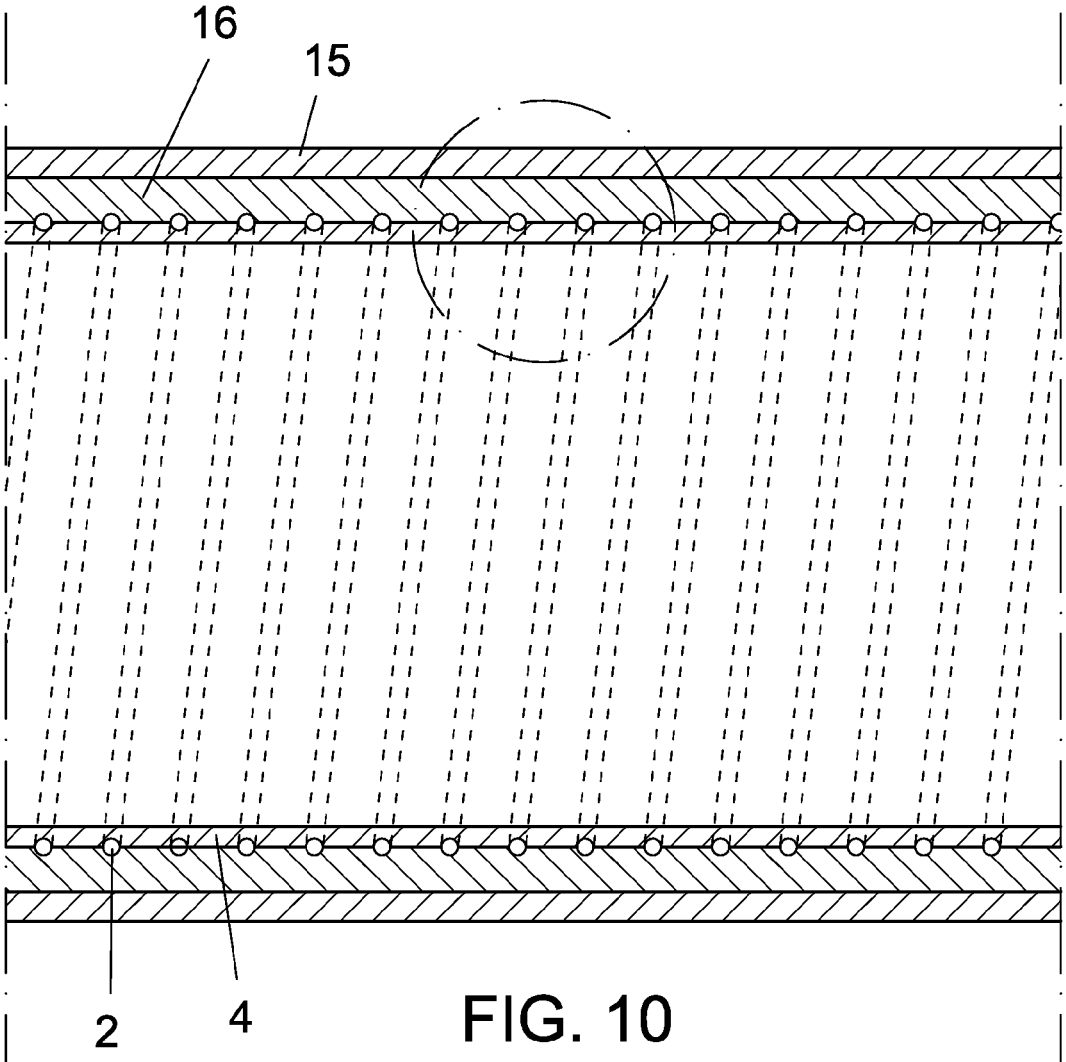

FIG. 10

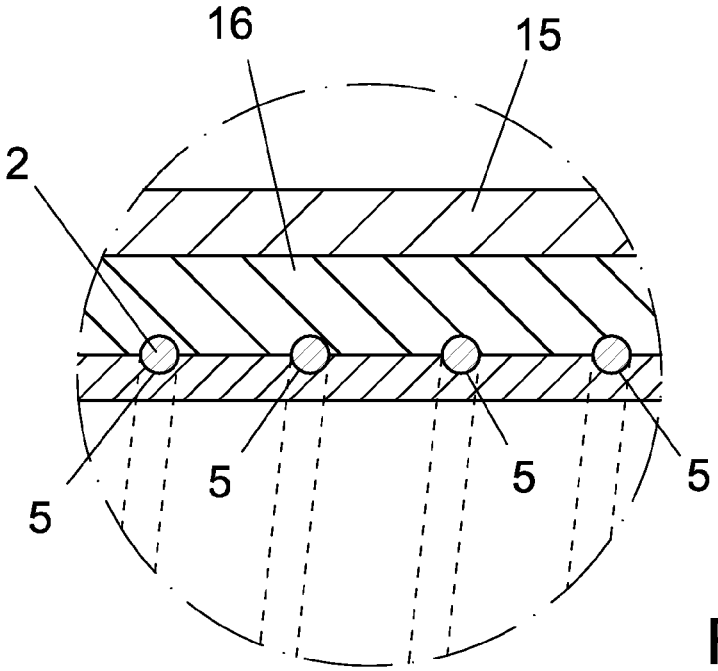

FIG. 11

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EUROPEAN SEARCH REPORT

Application Number
EP 18 16 7549

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	GB 448 360 A (MANUF GENERALE METALLURG SA) 8 June 1936 (1936-06-08) * page 1, lines 10-33,67-97 * * page 1, line 105 - page 2, line 6; figures 1,2 *	1-6,8-15 7	INV. H05B3/42 H05B3/46
Y	FR 3 027 184 A1 (TEXAS DE FRANCE [FR]) 15 April 2016 (2016-04-15) * page 6, lines 6-10 * * page 10, lines 4-29; figure 3 *	7	
A	US 3 934 333 A (CHURCHILL JOHN W) 27 January 1976 (1976-01-27) * column 2, lines 26-40 * * column 4, lines 18-29; figure 2 *	1-15	
A	US 2004/091252 A1 (DIEPHOLZ DEXTER E [US]) 13 May 2004 (2004-05-13) * paragraphs [0029] - [0038]; figures 1,4,5 *	1-15	
			TECHNICAL FIELDS SEARCHED (IPC) H05B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	5 September 2018	Aubry, Sandrine

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

REFERENCES CITED IN THE DESCRIPTION

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