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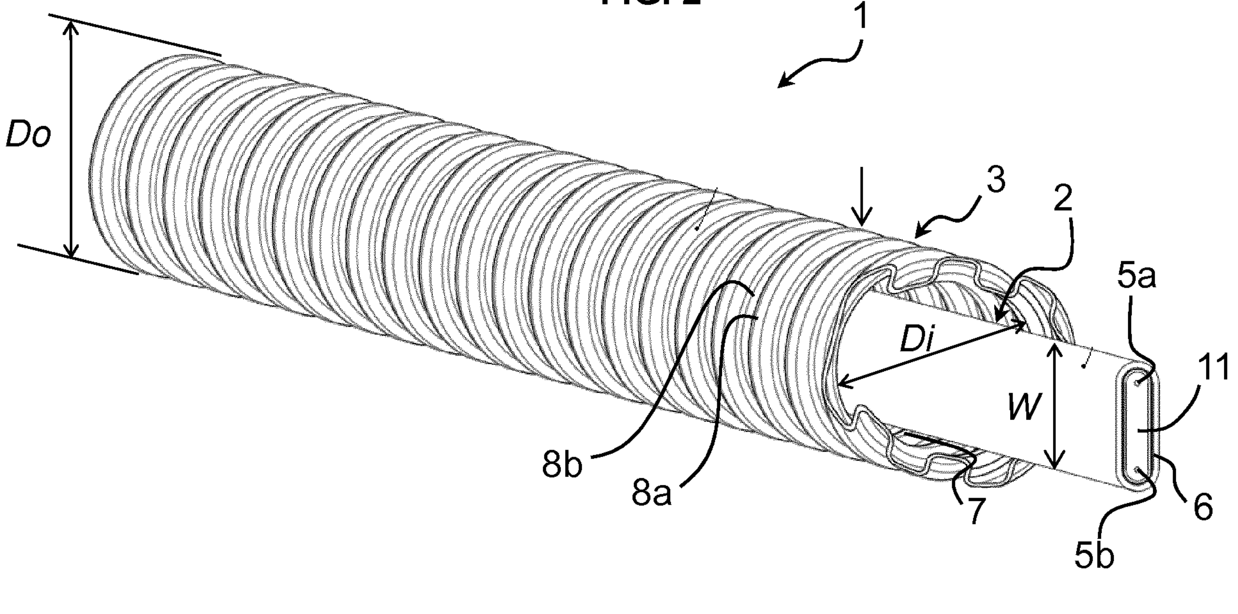
(54) ANTI-ICING HEATING CABLE DEVICE

(57) An anti-icing heating cable (1) adapted for mounting in or on man-made structures including gutters, drainpipes and roofs, comprising an electrical heating cable (2) including at least one electrical conducting wire (5, 5a, 5b) surrounded by an insulator (6). The anti-icing heating cable further comprises a tubular metal pipe (3) comprising an inner cavity (7) within which the electrical heating cable (2) is mounted.

FIG. 2



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Description

Field of the Invention

[0001] The present invention relates to an anti-icing heating device to prevent the formation of ice, or to melt ice or snow, in particular in gutters and drainpipes, and on roofs. The anti-icing heating device may also be used in other applications such as on sidewalks and roads and other surfaces which could be covered with ice or snow in cold weather

Background of the Invention

[0002] It is known to install anti-icing heating systems on the roofs of buildings, in gutters and drainpipes for evacuation of water from roofs and building structures, and along channels and sidewalks. Typically, anti-icing heating systems are either based on a heated fluid flowing in pipes that are installed in areas where the anti-icing function is required, or by electrical heating cables. Electrical cables have the advantage of greater flexibility and ease of installment. Pipes carrying heated liquids typically require higher installation costs and are less easy to adapt to the geometry of different structures compared to electrical heating cables that are easy to install and connect to a heating control unit. Electrical heating cables typically comprise conducting wires embedded in an insulating material that is adapted for supporting the heat generated by the joule effect in the conducting wire.

[0003] A drawback of electrical heating cables for anti-icing systems is the small surface area for heat transfer since the outer surface of the heating cable has a relatively small diameter in comparison to the drainpipes, gutters and other elements in which the cable is installed. Although electrical resistive cables are very easy to install, they have a relatively low mechanical endurance the outer insulating layers of such cables are subject to environmental degradation in particular when exposed to the ultra-violet rays in sunlight. The service life and reliability of electrical heating cables is thus generally unsatisfactory.

[0004] The disadvantages of known anti-icing systems based on electrical heating cables may thus be summarized as: low energy efficiency, small area for heat transfer, possible overheating of the cable, as well as the low mechanical endurance and service life.

Summary of the Invention

[0005] In view of the foregoing, it is an object of the invention to provide an anti-icing heating system that is easy to install and to control, yet is very effective for melting snow or ice or preventing formation of snow or ice in building structures, in particular on roofs, along roof edges, in roof gutters and drainpipes and in other areas where ice may form along buildings or manmade structures.

[0006] It is advantageous to provide an anti-icing heating system that is durable in harsh environmental conditions, in particular installed in outdoor environments.

[0007] It is advantageous to provide an anti-icing heating system that has a uniform heat transfer to the surrounding environment, in particular adapted for placement in gutters, drainpipes and other channels in which water may flow or collect.

[0008] Objects of this invention have been achieved by providing the anti-icing heating cable device according to claim 1. Dependent claims describe various advantageous embodiments of the invention. Further advantages and objects of the invention will be apparent from the following detailed description of embodiments of the invention and figures.

[0009] Disclosed herein is an anti-icing heating cable device adapted for mounting in or on man-made structures including gutters, drainpipes and roofs, comprising an electrical heating cable including at least one electrical conducting wire surrounded by an insulator. The anti-icing heating cable further comprises a tubular metal pipe comprising an inner cavity within which the electrical heating cable is mounted.

[0010] In an embodiment, the electrical heating cable is an electrical resistive heating cable.

[0011] In another embodiment, the electrical heating cable is a self-regulating heating cable.

[0012] In an advantageous embodiment, the tubular metal pipe comprises corrugations comprising juxtaposed radially outer ring portions and radially inner ring portion surrounding the inner cavity.

[0013] In an advantageous embodiment, a ratio Di / W of an inner diameter (Di) of the tubular metal pipe relative to a maximum thickness or diameter (W) of the electrical heating cable is in a range of 1.1 to 3, preferably in a range of 1.2 to 2.

[0014] In an advantageous embodiment, the anti-icing heating cable further comprises a thermal regulation filler mounted inside the inner cavity between the electrical heating cable and metal pipe.

[0015] In an embodiment, the thermal regulation filler comprises quartz particles.

[0016] In an embodiment, the thermal regulation filler comprises polymer particles or beads.

[0017] In an advantageous embodiment, the metal pipe comprises orifices allowing the passage of fluids between the inside and outside of the metal pipe.

[0018] In an advantageous embodiment, the orifices are arranged in an inner ring portion of corrugations of the metal pipe.

[0019] In an advantageous embodiment, a plurality of orifices are distributed circumferentially around the inner cavity.

[0020] In an embodiment, the metal pipe is made of copper alloy.

[0021] In an embodiment, the metal pipe is made of a steel alloy.

[0022] In an embodiment, the metal pipe is coated with a polymer layer.

[0023] In an embodiment, the metal pipe is painted with a color.

Brief description of the figures

[0024]

Figure 1 is a schematic representation of a gutter and drainpipe in which an anti-icing heating cable device according to an embodiment of the invention is installed;

Figure 2 is perspective view of a section of an anti-icing heating cable device according to a first embodiment of the invention;

Figure 3 is perspective view of a section of an anti-icing heating cable device according to a second embodiment of the invention;

Figure 4 is a schematic perspective view of a section of anti-icing heating cable device according to a third embodiment of the invention.

Detailed description of embodiments of the invention

[0025] Referring to the figures, an anti-icing heating cable device 1 according to embodiments of the invention comprises an electrical heating cable 2 and a tubular metal pipe 3, the electrical heating cable extending within an inner cavity 7 of the metal pipe 3.

[0026] The tubular metal pipe 3 completely encircles the electrical heating cable 2. The inner cavity 7 of the metal pipe has a diameter *Di* that is greater than the maximum diameter or width W of the electrical heating cable 2 such that a gap is formed between the electrical heating cable and the metal pipe 3. The gap may be filled with air as illustrated in the embodiments of figures 2 and 3, or may be filled with a thermoregulating material 4 as illustrated in figure 4.

[0027] The anti-icing heating cable 1 may be easily installed in a gutter 10a, for instance a gutter at the edge of a building rooftop, or on a rooftop, by laying the cable in the gutter so that it rests on the bottom of the gutter, respectively by laying the cable on the rooftop. The anti-icing heating cable 1 may also be easily installed in a drainpipe 10b by simply pulling it through the drainpipe. The anti-icing heating cable may be fixed, for instance at discrete intervals, by rivets, clamps, screws, welding, or bonding with an adhesive, or by other fixing means, to the gutter, drainpipe or other building structure along which it is installed. The anti-icing heating cable may also be fixed on flat structures in a linear fashion or bent into curved shapes as needed to adjust to the desired topology of the structure to which it is attached and the surface area to be covered by the anti-icing system.

[0028] The electrical heating cable 2 may be a cable of a type that is per se well-known for anti-icing applications in buildings and other manmade structures, such cables typically comprising one or more electrical conducting wires 5a, 5b surrounded by at least an insulator 6. In an embodiment, the heating cable may be a resistive heating cable. In another embodiment the heating cable may be a self-regulating heating cable. In the case of a self-regulating heating cable, the electrical conducting wires are embedded in a conductive core 11, for instance of a conductive polymer matrix, that is surrounded by the insulator 6, such electrical heating cables being *per se* well known.

[0029] Electrical heating cables may be connected to a control system that regulates the current based on temperature measurements by temperature sensors to ensure that the temperature in the immediate surrounding of the cable is above freezing point. In a *per* se known variant, the heating cable may be a self-regulating temperature level cable that does not require a feed-back from temperature sensors. Auto regulation of such a cable is performed by the resistance properties of the conducting wires embedded in the core, where the rise in temperature increases the resistance such that the current is reduced and the power output remain at a level configured to keep the temperature in the immediate surrounding of the cable above freezing point, for instance in a range of typically 1 to 5 degrees centigrade.

[0030] Such electrical heating cables are *per se* well known and do not need to be further described herein.

[0031] The metal pipe 3 according to preferred embodiments of the invention comprises corrugations 8, each corrugation defined by an outer ring portion 8a adjacent to an inner ring portion 8b, the outer ring portion forming (when viewed in a longitudinal cross-section along the axis A of the inner cavity 7) a protuberance projecting radially outwards and the inner ring portion forming a trough directed radially inwardly. The corrugations 8 may be formed as rings that are juxtaposed and surround the central longitudinal axis A of the metal pipe, or in a variant may be formed as a continuous helical thread.

[0032] In the illustrated embodiments, the radially inner 8b and outer 8a portions forming the corrugations 8 encircle the inner cavity by 360 degrees. However, in a variant (not illustrated), the radially inner and radially outer portions 8a, 8b forming the corrugations may only partially surround the inner cavity 7, for instance forming sectors interconnected by flat portions.

[0033] The corrugations 8 advantageously provide increased mechanical resistance against crushing of the tube compared to a non-corrugated cylindrical tube, as well as a greater surface area for heat transfer to the surrounding environment. The corrugations also advantageously allow the cable 1 to be bent into curved shapes without buckling of the pipe.

[0034] The metal pipe 3 may advantageously be made of a copper alloy in view of the ductility of copper allowing it to be easily bent in order to follow the structure in which it is installed or to provide a meandering shape to cover a larger surface area of a structure.

[0035] In a variant, the metallic tube 3 may however be made of other metals, for instance of a steel alloy that may be galvanized or otherwise treated against corrosion.

[0036] The metallic tube 3 advantageously allows for a better heat transfer between the electrical cable and the surrounding environment, on the one hand by increasing the surface area as well as distributing the heat around the cable due to high conductivity of the metallic material of the tube. Moreover, the metallic tube advantageously protects the electrical cable against the outer environmental conditions including protection against ultra-violet rays of sunlight and mechanical protection against sharp objects. The tube also provides protection against crushing of the cable that may damage the outer insulation layer and impair function of the cable. The metal pipe 3, in particular the embodiments with the corrugations 8, also advantageously facilitates installation by allowing the metal pipe to be plastically deformed and bent into various shapes yet nevertheless provide a high structural rigidity. Thus, the need to fix the ant-icing heating cable device at certain intervals is reduced and the fixing intervals can be increased and in certain areas that are difficult to access fixing elements can be avoided due to the positional rigidity provided by the bent metallic tube.

[0037] The metallic tube 3 may, in an embodiment, be painted with any selected color, for various purposes, for instance to enable easy recognition of the cable among other cables. In another embodiment, the metallic tube 3 may be coated with a polymer layer, for various purposes, for instance to protect the metallic tube against shocks and damage, and/or to modify the thermal conductivity of the tube, and/or to provide a selected color, and/or to protect against environmental factors such as UV light and chemicals.

[0038] The outer diameter Do relative to the largest thickness or diameter W of the electrical heating cable 2 may advantageously be in a range of 1.2 to 2 *(i.e.* $1.2<Do/W<2$*)*. This enables the heating cable to have an outer diameter Do that allows easy installation in gutters, drainpipes and other areas without increasing the difficulty of installation compared to the heating cable alone, yet providing the aforementioned advantages of better distributed heat transfer to the surrounding environment over a large surface area, mechanical protection against the external environment and objects, and protection against UV radiation, thus increasing the durability and service life of the heating cable 1.

[0039] Referring to figure 3, in an advantageous embodiment, the metal pipe 3 comprises orifices 9 arranged at intervals along the length of the metal pipe 3, whereby in the illustrated embodiment the orifices 9 are provided in the troughs formed by the inner ring portion 8b of the corrugations 8. The orifices 9 may advantageously extend over a certain arc angle α and there may be a plurality of orifices circumferentially distributed around the metal pipe, for instance between 2 to 4 orifices.

[0040] In the illustrated embodiment, orifices 9 are provided in each of the successive inner ring portions 8b, however orifices may be positioned at intervals of two or more corrugations depending on the requirements for the specific heating application. The corrugations allow water from the surrounding environment to enter into the inner cavity 7 of the metal pipe 3, the water coming from melted ice or snow, or being water flowing around the metal pipe that has not been frozen. The water entering into the metal pipe 3 serves as a heat transfer medium to distribute heat to the surrounding environment.

[0041] The orifices 9 may also have the effect of improving the bending deformation of the tube for adapting the shape of the tube to the desired geometry of the structure on which it is installed.

[0042] In another embodiment, as illustrated in figure 4, the free space (i.e. gap) between the electrical heating cable 2 and the metal pipe 3 may contain a thermal regulation filler 4, that may substantially completely fill the free inner space, or may only partially fill the free inner space.

[0043] In an embodiment, the thermal regulation filler 4 may comprise loose particles of a material selected for its heat capacity and/or conductive properties to regulate the transfer of heat between the electrical heating cable 2 and the metal pipe 3, and to regulate the heat latency, for a smoother fluctuation of the change in temperature as a function of the electrical current flowing in the electrical heating cable 2.

[0044] The choice of the thermal regulation filler 4 depends on the intended application and on the intended installation environment for the anti-icing heating cable 1 according to embodiments of the invention. For applications in which a rapid heat transfer between the electrical heating cable 2 and the metal pipe 3 is desired, the thermal regulation filler 4 may comprise for instance quartz particles. In applications in which the conductivity between the electrical heating cable and metal pipe 3 should have a slower rate, or for the increase in heat latency of the anti-icing heating cable device 1, a filler material comprising for instance polymer beads, or ceramic beads may be used. Many other materials selected for their specific heat conductivity and latent heat storage may be implemented based on the desired heat transfer profile.

[0045] In a variant, the thermal regulation filler 4 may comprise particles, beads or solid structures in a continuous or discrete arrangement within the inner cavity 7 such that they are smaller than the orifices 9 provided in the metal pipe 3 to allow water to pass therethrough. The filler material in such a variant may thus also serve to regulate heat transfer in an embodiment in which water from the external environment can enter into and exit out of the inner cavity 7 of the metal pipe 3.

[0046] Experimental studies have shown that the corrugated metal pipe with an electrical heating cable installed in a drain pipe 10b and gutter 10a, served to form a channel in the ice for the melt water with a total flow area about 10 times greater than the flow area created by the electrical heating cable alone at the same cable heating capacity.

[0047] The results of the experimental studies are explained by the Fourier's law which states that any point on a body (substance) during thermal conductivity is characterized by a relationship between the heat flow and the temperature gradient:

$$\bar{Q} = -\lambda \cdot grad(T) \cdot S ,$$

where

- Q is the heat flow, W;
- *grad(T)* is the gradient of a temperature field (a set of numerical temperature values in different places of the system at a chosen moment in time), units of measurement are K/m;
- S is the heat exchange surface area, m^2;
- A is a thermal conductivity coefficient, W/(m K).

[0048] Embodiments of the invention thus increase the surface area of the heating element and thus increase the heat flow.

[0049] The metal pipe 3 provides greater durability, but also improves protection against vandalism by also hiding and protecting the electrical heating cable from the vandals.

[0050] The temperature in the immediate surrounding of the heating cable is also more smoothly adjusted due to the use of the metal pipe which receives the heat from the heating cable with delay and transfers it to the environment.

[0051] A roof anti-icing system according to the invention enables snow and ice crust removal when placed in gutters, drain pipes and rooftops. During winter, accumulated snow and ice in gutters are melted around the anti-icing heating cable which thus forms a channel therearound for the outflow of melt water. In view of the heat latency of the anti-icing system 1 according to embodiments of the invention, even if the electrical current is interrupted for a short period, stored heat energy in the cable 1 is released over a certain period of time thus preventing rapid re-freezing of water around the cable that would block the melt water channel.

List of references:

<u>Anti-icing heating cable device 1</u>

Electrical heating cable 2

[0052]

Electrical conducting wire(s) 5, 5a, 5b
Insulator 6
Core 11

Metal pipe 3

[0053]

inner cavity 7
corrugations 8

outer ring portion 8a

inner ring portion 8b

orifices 9

Thermal regulation filler 4

[0054]

loose particles, beads
solid element

<u>Building structure</u>

[0055] Roofwater evacuation system 10

gutter 10a
drainpipe 10b

Metal pipe outer diameter: ***Do***
Metal pipe inner diameter: ***Di***
Largest diameter or thickness of the electrical heating cable: ***W***

Claims

1. An anti-icing heating cable device (1) adapted for mounting in or on man-made structures including gutters, drainpipes and roofs, comprising an electrical heating cable (2) including at least one electrical conducting wire (5, 5a, 5b) surrounded by an insulator (6), **characterized in that** the anti-icing heating cable further comprises a tubular metal pipe (3) comprising an inner cavity (7) within which the electrical heating cable (2) is mounted.

2. The anti-icing heating cable device according to claim 1, wherein the electrical heating cable (2) is resistive.

3. The anti-icing heating cable device according to claim 1, wherein the electrical heating cable (2) is self-regulating.

4. The anti-icing heating cable device according to any preceding claim, wherein the tubular metal pipe com-

prises corrugations (8) comprising juxtaposed radially outer ring portions (8a) and radially inner ring portion (8b) surrounding the inner cavity.

5. The anti-icing heating cable device according to any preceding claim, wherein a ratio *Di* / *W* of an inner diameter (*Di*) of the tubular metal pipe relative to a maximum thickness or diameter (*W*) of the electrical heating cable is in a range of 1.1 to 3, preferably in a range of 1.2 to 2.

6. The anti-icing heating cable device according to any preceding claim, further comprising a thermal regulation filler (4) mounted inside the inner cavity (7) between the electrical heating cable (2) and metal pipe (3).

7. The anti-icing heating cable device according to the preceding claim, wherein the thermal regulation filler comprises quartz particles.

8. The anti-icing heating cable device according to claim 6, wherein the thermal regulation filler comprises polymer particles or beads.

9. The anti-icing heating cable device according to any preceding claim, wherein the metal pipe (3) comprises orifices (9) allowing the passage of fluids between the inside and outside of the metal pipe.

10. The anti-icing heating cable device according to the preceding claim, wherein the orifices are arranged in an inner ring portion (8b) of corrugations (8) of the metal pipe.

11. The anti-icing heating cable device according to the preceding claim, wherein a plurality of orifices are distributed circumferentially around the inner cavity (7).

12. The anti-icing heating cable device according to any preceding claim, wherein the metal pipe is made of copper alloy.

13. The anti-icing heating cable device according to any preceding claim 1-11, wherein the metal pipe is made of a steel alloy.

14. The anti-icing heating cable device according to any preceding claim, wherein the metal pipe is coated with a polymer layer.

15. The anti-icing heating cable device according to any preceding claim, wherein the metal pipe is painted with a color.

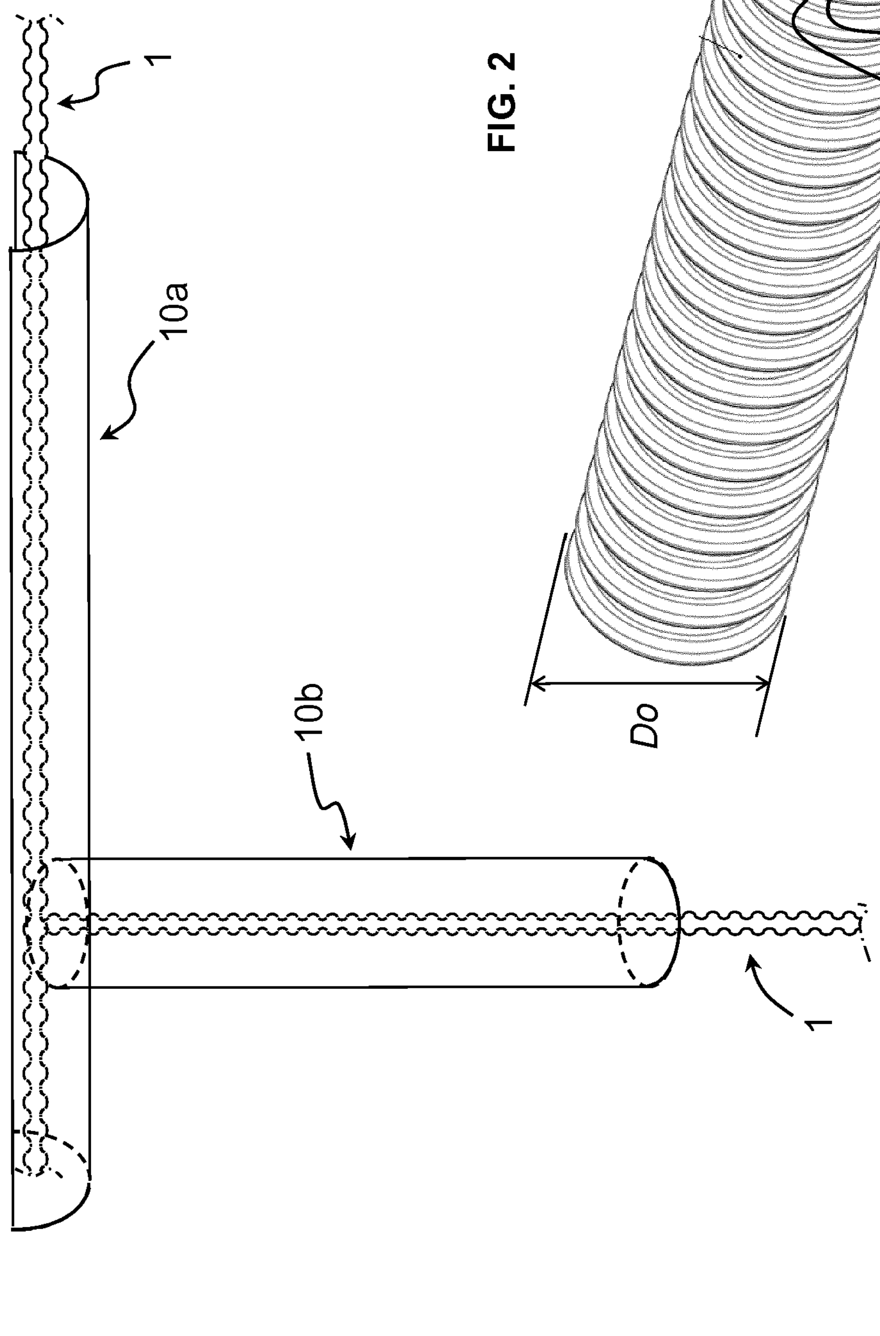

FIG. 1

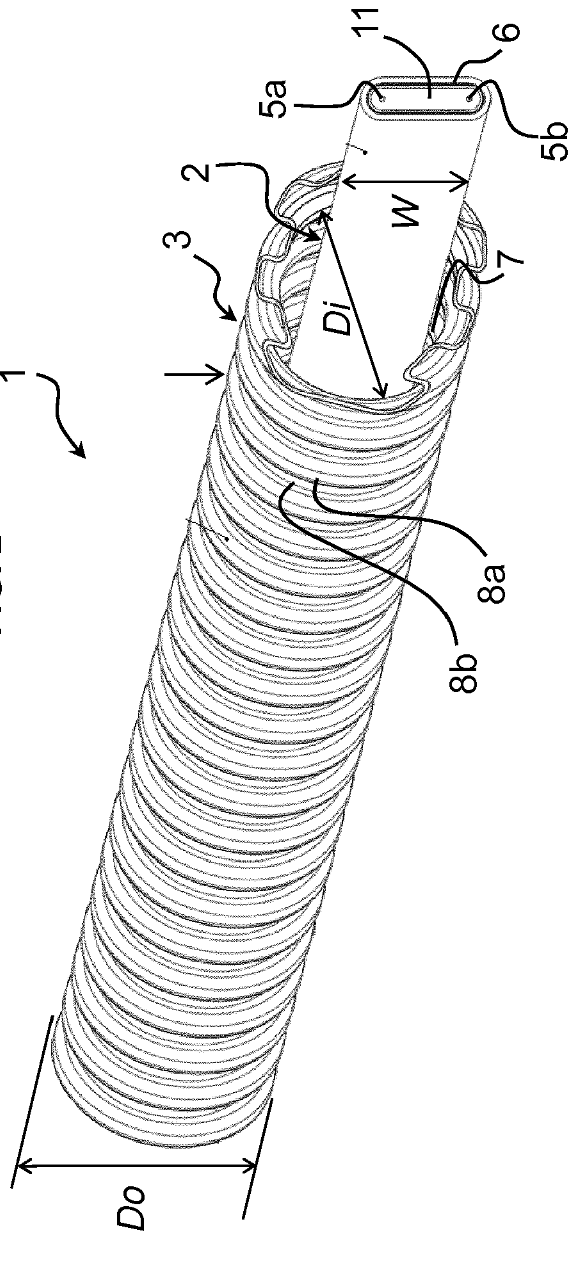

FIG. 2

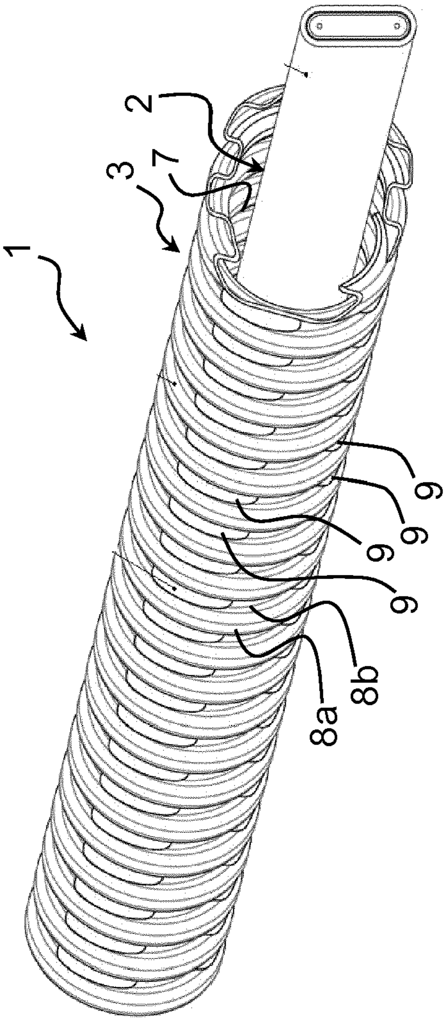

FIG. 3

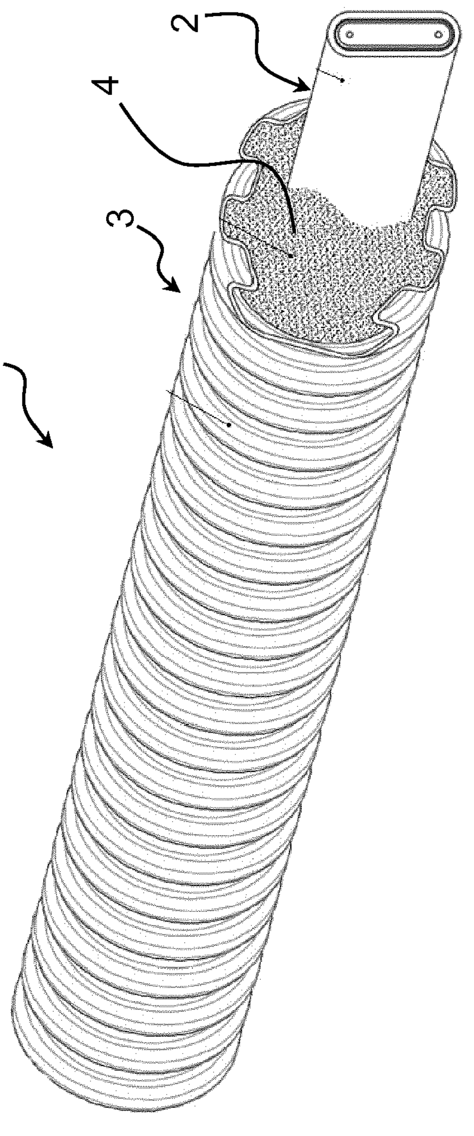

FIG. 4

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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 5884

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The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	20 January 2020	Chelbosu, Liviu

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
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EUROPEAN SEARCH REPORT

Application Number
EP 19 18 5884

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The present search report has been drawn up for all claims

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CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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A : technological background
O : non-written disclosure
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T : theory or principle underlying the invention
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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 19 18 5884

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