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(54) CONDUCTOR FOR OVERHEAD POWER LINES, COMPRISING AN OPTICAL FIBRE SENSOR ELEMENT

(57) Described herein is a conductor for overhead power lines, which comprises a sensor element comprising: a tube, a solid filling material, partially filling the inner volume of said tube; at least one optical fibre, arranged within said tube and buried in said filling material; wherein said filling material fills said inner volume of said tube by at least 80% by volume; wherein said filling material has a density in the range of 0.8 g/cm^3 to 2 g/cm^3.

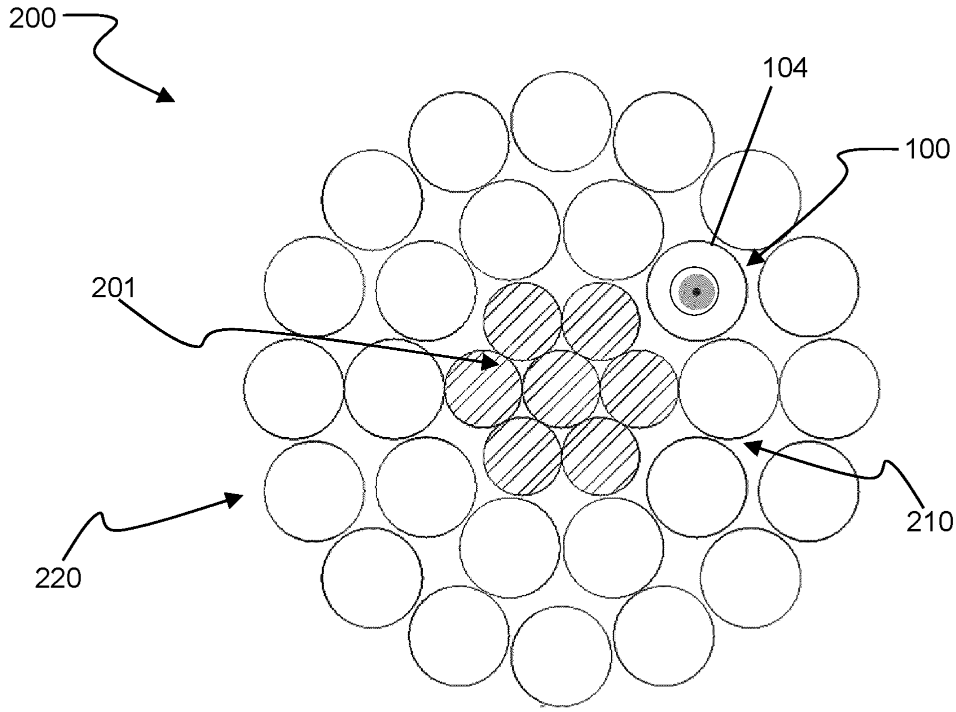

FIG. 3

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Description

Field of the invention

[0001] The present invention concerns, in general, the field of conductors for overhead power lines, preferably conductors for bare overhead power lines. More specifically, the present invention relates to a conductor for overhead power lines which comprises a sensor element that, when coupled to a monitoring system, makes it possible to monitor the state of the power line continuously and in real time.

Description of the prior art

[0002] As is known, conductors employed in overhead power lines are passive elements, their only function being to transport electric energy.

[0003] The Applicant observes that monitoring the operating conditions of a power line is of fundamental importance. Currently, the behaviour of a conductor is studied and modelled by software, based on operating conditions dictated by standards in force in the region where the conductor will have to be installed. In general, such standards apply, at national level, to different groups of geographical areas, for which standard values are specified which depend on statistically determined weather and seasonal conditions.

[0004] Since these are parameters that are defined on a statistical basis, ample precautionary limits must be considered in order to guarantee safe operating conditions, to the detriment of line optimization.

[0005] As is known, aiming at obtaining more reliable and accurate data, punctual sensors are installed directly on the conductor. Such punctual sensors are adapted to provide information about the operating conditions of the conductor. Disadvantageously, it is impossible to obtain global information about the entire line, because the sensors can only provide results concerning a neighbourhood of their point of application.

[0006] Even more disadvantageously, such sensors are difficult to install. As a matter of fact, since they have to be installed manually, not all sites of interest can be equipped with such sensors.

Brief description of the invention

[0007] It is the object of the present invention to provide a conductor, in particular for overhead power lines.

[0008] Such conductor comprises a sensor element comprising:

- a tube;
- a solid filling material, partially filling the inner volume of said tube;
- at least one optical fibre.

[0009] Such optical fibre is arranged within said tube and buried in said filling material; said filling material fills the inner volume of said tube by at least 80% by volume.

[0010] Preferably, said filling material fills the inner volume of said tube leaving a gap between the outer lateral surface of said filling material and the inner lateral surface of said tube.

[0011] Preferably, the solid filling material has a hardness of less than 80 Shore A. Even more preferably, the solid filling material has a hardness greater than or equal to 0 Shore A.

[0012] Preferably, said filling material has a density greater than or equal to 0.8 g/cm^3. Preferably, said filling material has a density lower than or equal to 2 g/cm^3. For example, said filling material is a polymeric material.

[0013] Advantageously, said conductor permits, through the sensor elements, real-time acquisition of the operating conditions of the conductor along the whole line.

[0014] Advantageously, the use of a solid filling material as specified above allows the optical fibre to withstand all the stresses and deformations undergone by the conductor when in use. Such deformations can be read by means of an optical interrogator, which can even provide real-time indications. In other words, the at least one optical fibre is constrained to the surface of the tube, but can rotate freely within it, so as to undergo the same axial deformations as those undergone by the tube and, consequently, by the conductor.

[0015] Advantageously, a filling material that:

- has a hardness of less than 80 Shore A; and/or
- has a density in the range of 0.8 g/cm^3 to 2 g/cm^3; and/or
- forms said gap with said tube

permits stranding the sensor element with the electric wires that form a skirt of a conductor cable, without damaging the optical fibre within the sensor element.

[0016] Advantageously, such sensor element allows for real-time temperature analysis; in fact, the conductor's temperature variations are read by the optical fibre almost instantaneously, whereas the same operation is slower when the optical fibre is arranged in a loose tube due to the absence of thermal contact between the fibres and the steel tube.

[0017] Advantageously, the adhesion between the interfaces of the filling material and the tube is sufficient to transfer the stress from the conductor to the fibre, such adhesion being however not excessively strong, so as to allow the fibre to rotate and remain undamaged while stranding the conductor and/or installing the conductor in an overhead power line.

[0018] Preferably, said tube is made of stainless steel.

[0019] Preferably, said sensor element comprises a number of fibres ranging from 2 to 24.

[0020] With a plurality of optical fibres, multiple interrogators can advantageously be connected to one sensor element, so that different technologies can be employed for monitoring a power line.

[0021] Advantageously, the presence of two or more fibres provides optical-fibre redundancy, which is useful in the event of a breakdown or accidental failure of an optical fibre, e.g. during installation.

[0022] Preferably, said sensor element comprises an outer covering that envelops the outer lateral surface of said tube.

[0023] Even more preferably, said outer covering has a substantially circular or triangular or trapezoidal cross-section.

[0024] Preferably, said conductor further comprises a central core and a plurality of concentrical skirts disposed around said central core. Each skirt is formed by a plurality of mutually stranded conductor wires. Said sensor element has an outer covering having a cross-section substantially similar to the cross-section of a conductor wire, and is stranded with a respective plurality of conductor wires, thus forming a skirt of said plurality of skirts.

[0025] Advantageously, the sensor element may have a covering that makes the shape/cross-section of the sensor element substantially similar to the shape/cross-section of the conductor wires. Such a shape permits increasing the conductor filling factor when using shaped wires (e.g. trapezoidal sections) instead of round wires. The Applicant observes that:

- for wires having a substantially circular cross-section, the diameters of said wires within the same skirt are preferably substantially similar, more preferably equal;
- for shaped wires, the geometrical characteristics of said conductor wires within the same skirt are preferably the same.

[0026] Preferably, said sensor element is stranded with a respective plurality of conductor wires, thus forming the radially external skirt of said conductor.

[0027] Advantageously, by positioning the sensor element in the outer skirt of the conductor it is possible to simplify the procedures for installing and connecting the sensor element to the interrogator.

[0028] According to a further aspect, the present invention provides a power line. Said power line comprises a conductor in accordance with the present invention, connected to two substations of said power line; wherein one end of at least one optical fibre of said sensor element is connected to an optical interrogator. Said optical interrogator being configured for detecting operating conditions of said conductor.

[0029] Preferably, said optical interrogator is a Brillouin, or Rayleigh, or Raman, or polarization, or frequency-analysis optical interrogator.

[0030] Preferably, at least two optical fibres of said conductor are connected to respective interrogators of different types.

[0031] Preferably, said end of said conductor is engaged with a respective substation by means of a clamp. A tract of said sensor element is extracted from said conductor at said clamp and connected, from said clamp, to said interrogator.

[0032] Advantageously, the at least one optical fibre, used as a sensing element, can provide information about the operating conditions of the conductor. For example, such information may include:

- operating temperature;
- deformations undergone by the conductor; and
- failure detection, i.e. an indication about a specific location where the conductor is damaged or broken.

[0033] Advantageously, the use of a monitoring system coupled to the conductor in accordance with the present invention makes it possible to establish safety limits on the basis of real operating conditions, so that the potential of the conductor can be exploited at best while still ensuring line safety.

[0034] Advantageously, the monitoring system coupled to the conductor in accordance with the present invention makes it possible to accurately determine the position of any faults, hot points or, in general, any points that require, or may require, service work, ensuring that the necessary intervention will be carried out immediately.

[0035] Advantageously, once the power line has been connected to the optical interrogator and is in operation, the data concerning the operating conditions of the line will be available in real time, thus being immediately accessible.

[0036] In other words, advantageously, the measurements taken by means of the interrogator, e.g. deformation readings, make it possible to identify with the utmost precision the location of any mechanical overloads (e.g. tree fallen on the line, ice sleeves, etc.) and to carry out timely service interventions; the interruption of the optical link (i.e. broken fibre) will permit locating with extreme precision the point where the conductor has broken, resulting in shorter downtime of the power line.

[0037] Preferably, said interrogator is positioned at an electric substation of said power line.

[0038] Advantageously, considering the broad operating ranges of optical instruments, in most cases it will be possible to install the interrogator within the substations, resulting in considerable logistic-operative advantages.

[0039] Advantageously, obtaining the information collected by means of the interrogator directly at the substation will imply an immediate transfer of such information to the control centres, without any problems caused by unstable connections.

[0040] Preferably, the interrogator is an acoustic interrogator, in particular an acoustic interrogator suitable for providing DAS (Dynamic Acoustic Sensing) acoustic analyses.

[0041] Lastly, the sensor element also permits, advantageously, the execution of acoustic analyses on the conductor. In particular, the sensing element provides, through the filling material, the optical fibre and the tube, a microphone with higher sensitivity than a loose-tube microphone; in fact, the transmission of sound waves between the optical fibre and the tube is much more immediate and less damped. The sensor element, when used as a microphone, permits detecting any corona effect of the conductor or identifying any impacts of foreign bodies (e.g. birds) on the conductor.

Brief description of the drawings

[0042] The invention will become more apparent in light of the following detailed description, provided herein merely by way of non-limiting example, wherein reference will be made to the annexed drawings, wherein:

- Figure 1 is a schematic example of an overhead power line suspended between two substations;
- Figure 2 is a schematic example showing the connection between a sensor element and a pylon;
- Figure 3 is a schematic sectional view of an illustrative embodiment of a conductor according to the present invention, wherein the wires of the skirt have a substantially circular cross-section and the sensor element is positioned in an inner skirt;
- Figure 4 is a schematic sectional view of a further illustrative embodiment of a conductor according to the present invention, wherein the wires of the skirt have a substantially circular cross-section and the sensor element is positioned in the outer skirt;
- Figure 5 is a schematic sectional view of a further illustrative embodiment of a conductor according to the present invention, wherein the wires of the skirt have a substantially trapezoidal cross-section and the sensor element is positioned in the outer skirt;
- Figure 6 is a schematic sectional view of a further illustrative embodiment of a conductor according to the present invention, wherein the wires of the skirt have a substantially circular cross-section;
- Figure 7 is a schematic sectional view of a further illustrative embodiment of a conductor according to the present invention, wherein the wires of different skirts have a substantially different cross-section;
- Figure 8 is a schematic sectional view of a first illustrative embodiment of a sensor element according to the present invention;
- Figure 9 is a schematic sectional view of a second illustrative embodiment of a sensor element according to the present invention;
- Figure 10 is a schematic sectional view of a third illustrative embodiment of a sensor element according to the present invention.

[0043] The drawings are not in scale.

Detailed description of some preferred embodiments

[0044] With initial reference to Figure 1, the present invention provides a conductor 200 for an overhead power line 400. For example, said overhead power line 400 is a high-voltage overhead power line, preferably a bare one.

[0045] As shown in Figures 3 and 4, a conductor 200 in accordance with the present invention comprises a core 201. The core 201 may be made up of a plurality of mutually stranded wires. For example, the core 201 comprises a plurality of wires made of galvanized steel or ACS (Aluminium Clad Steel) or ACI (Aluminium Clad Invar).

[0046] The core 201 preferably has a diameter in the range of 5 to 30 mm, e.g. 8 to 12 mm, in particular 10.5 mm.

[0047] As shown in Figures 3-7, the conductor 200 preferably comprises a plurality of skirts 210, 200. For example, as shown in Figure 3 or 4, the core 201 is coated with at least two skirts. For example, the core 201 is coated with an internal first skirt 210 - i.e. a skirt in contact with the core 201 - and with an external second skirt 220 - i.e. a skirt having an outer radial surface not in contact with a further skirt. In other words, the conductor 200 comprises a central core 201 and a plurality of concentrical skirts 210, 220 disposed around the core 201.

[0048] As shown in Figures 3-7, each skirt 210, 220 comprises a plurality of mutually stranded conductor wires. Each conductor wire is made of a metallic material, e.g. crude or annealed aluminium or other aluminium alloys. For example, the first skirt 210 is made up of a plurality of conductor wires having a diameter of 2 to 6 mm; the second skirt 220 is made up of a plurality of conductor wires having a diameter of 2 to 6 mm.

[0049] Preferably, the conductor wires forming a respective skirt 210, 220 are all equal.

[0050] Preferably, each conductor wire forming a respective skirt 210, 220 has a substantially circular, trapezoidal, triangular or Z-shaped cross-section. In particular, the cross-section of each conductor wire is selected as a function of the desired filling factor.

[0051] Preferably, the overall diameter of the conductor 200, i.e. the diameter determined by the outermost skirt 220 of the conductor 200, ranges between 10 and 100 mm.

[0052] According to the present invention, the conductor 200 comprises a sensor element 100. The sensor element 100 is preferably inserted in the place of a conductor wire of a respective skirt of the conductor 200. In particular, as shown in Figures 3-7, the sensor element 100 preferably has an outer covering 104 which has a cross-section that is substantially similar to the cross-section of at least one conductor wire, and which is stranded with a respective plurality of conductor wires, thus forming a skirt 210, 220 of the conductor 200.

[0053] According to a first embodiment, as shown in Figure 3, the sensor element 100 is stranded with a respective plurality of conductor wires to form a radially internal skirt 210 of the conductor 200 (i.e. the sensor element 100 is stranded in a skirt interposed between two skirts of the conductor 200 or between the core 201 and a skirt of the conductor 200). For example, considering a conductor having three skirts, i.e. a first skirt in contact with the core 201 of the conductor; a second, intermediate skirt; a third skirt enveloping the outer surface of the intermediate skirt; the sensor element 100 is stranded in either the first skirt or the second skirt.

[0054] Alternatively, as shown in Figure 4, the sensor element 100 is stranded with a respective plurality of conductor wires to form the radially external skirt 220 of the conductor 200 (i.e. the sensor element 100 is stranded with the radially outermost skirt of the conductor 200).

[0055] Preferably, the sensor element 100 is provided with a covering 104 having substantially the same cross-section as the conductor wires with which it is stranded to form a respective skirt. For example, as shown in Figure 5, the sensor element 100 has a covering 104 having a substantially trapezoidal cross-section and, preferably, a geometrical shape that is substantially similar to the geometrical shape of the conductor wires making up the respective skirt 230. As aforementioned, the sensor element 100 may also be inserted into one of the inner skirts, e.g. as a substitute for a wire of the first skirt 210 or second skirt 220.

[0056] With reference to Figure 6, the core 201 of the conductor 200 may be made up of a plurality of wires, wherein a central wire has a substantially circular cross-section and a plurality of wires having a substantially trapezoidal cross-section enclose said central wire. According to the embodiment shown in Figure 6, the core 201 has also a respective covering, which internally encloses the plurality of wires. The Applicant observes that the core 201 of the conductor may be made in several different ways without any correlation with the geometrical shape chosen for the skirts 210, 220, which may be made using wires having differently shaped cross-section (e.g. circular, trapezoidal, etc.).

[0057] With reference to the embodiment shown in Figure 7, the conductor 200 comprises a plurality of skirts 210, 220; in particular, a skirt 220 of the conductor 200 is made up of wires having a substantially Z-shaped cross-section. Such Z-shaped wires are mutually stranded to form a respective skirt 220 of the conductor 200, preferably with no gaps between adjacent Z-shaped wires.

[0058] The expression "Z-shaped wire" refers to a wire having a first half-part and a second half-part that are substantially rectangular in shape, joined to each other at one side to form a substantially Z-shaped outline.

[0059] The Applicant observes that conductor wires forming different skirts may have different geometrical shapes. For example, with reference to Figure 7, those conductor wires which make up a first skirt 210 may have a substantially trapezoidal cross-section, such conductor wires being also referred to as "trapezoidal sections"; while those conductor wires which form a second skirt 220 may have a cross-section which is different in shape from that of the conductor wires forming the first skirt 210.

[0060] According to the present invention, the conductor 200 may comprise skirts 210, 220 made up of wires having different cross-sections. For example, as shown in Figure 7, a first skirt 210 may be made from substantially trapezoidal wires; a second skirt 220, radially external to the first skirt 210, may be made from substantially Z-shaped wires.

[0061] As is visible in Figures 8-10, the sensor element 100 comprises a tube 103 and a filling material 102. The filling material 102 is a solid filling material.

[0062] Preferably, the solid filling material has a hardness of less than 80 Shore A. Even more preferably, the solid filling material has a hardness greater than or equal to 0 Shore A.

[0063] Preferably, as shown in Figure 8, the filling material 102 fills up the inner volume of the tube 103. Alternatively, the filling material 102 fills the inner volume of the tube 103 only partially.

[0064] Preferably, the filling material 102 is a polymeric material. For example, the filling material 102 may be selected among: PVC (polyvinylchloride), PE (polyethylene), PA (polyamide) and PU (polyurethane).

[0065] Preferably, the filling material 102 is a material having a density greater than or equal to 0.8 g/cm^3, even more preferably greater than or equal to 1 g/cm^3, in particular greater than or equal to 1.2 g/cm^3.

[0066] Preferably, the filling material 102 is a material having a density lower than or equal to 2 g/cm^3, even more preferably lower than or equal to 1.8 g/cm^3, in particular lower than or equal to 1.5 g/cm^3.

[0067] The tube 103 has a substantially elongate cylindrical shape, and is preferably made of a metallic material having a thickness of 0.1 to 1 mm, in particular 0.2 to 0.3 mm. The tube 103 is preferably made of a corrosion-resistant metal alloy, e.g. stainless steel.

[0068] As shown in Figures 8-10, the sensor element 100 comprises at least one optical fibre 101. The at least one optical fibre 101 is arranged within the tube 103 and buried in the filling material 102.

[0069] Preferably, the at least one optical fibre 101 is an optical fibre selected among the known G.651, G.652, G.653, G.654, G.655, G.656, G.657 fibres.

[0070] Preferably, the sensor element 100 comprises a number of fibres 101 ranging from 1 to 24, even more preferably from 2 to 24, buried in the filling material 102. For example, as shown in Figures 8 and 9, the sensor element 100 comprises three optical fibres 101 placed substantially in the centre of the filling material 102.

[0071] The optical fibres 101 may be either closely grouped, e.g. in the centre of the filling material 102, or, alternatively, mutually spaced apart.

[0072] According to one embodiment of the present invention, as shown in Figures 9 and 10, the filling material 102 fills the inner volume of the tube 103 by at least 80% by volume, leaving a gap G between the outer lateral surface of the filling material 102 and the inner lateral surface of the tube 103. In other words, the gap G has, preferably, a volume ranging between 1% and 20%, even more preferably between 1% and 10%, in particular between 3% and 8%.

[0073] It should be noted that, in a sectional view, the gap G may have a half-moon shape, when the filling material 102 is in contact with a portion of the inner lateral surface of the tube 103. In particular, the filling material 102 (and hence the at least one fibre 101) can move freely within the tube 103.

[0074] Preferably, as shown in Figures 3-7, the sensor element 100 further comprises an outer covering 104. The outer covering 104 envelops the outer lateral surface of the tube 103. In particular, the covering 104 may be made of a metallic material, e.g. aluminium.

[0075] Preferably, the covering 104 has a thickness in the range of 2 to 6 mm. For example, the covering 104 is made of a material selected among: aluminium, aluminium alloys, zirconium, copper.

[0076] Preferably, the outer covering 104 may have a substantially circular or triangular or trapezoidal or Z-shaped cross-section. In particular, the cross-section of the covering 104 is selected as a function of the cross-section of the conductor wires used, together with the sensor element 100, for making up a skirt 210, 220 of the conductor 200. As mentioned above, the sensor element 100 has a shape and/or size which are substantially similar to the shape and/or size of a conductor wire stranded with the sensor element 100 and with a plurality of conductor wires to form a respective skirt 210, 220 of the conductor 200.

[0077] The Applicant observes that, in a sectional view, the tube 103 of the sensor element 100 is preferably positioned in the centre of the covering 104. Considering a Z-shaped covering, the tube 103 may be positioned in one half-part of the covering.

[0078] Still with reference to Figures 1 and 2, a conductor 200 is positioned between two substations 320 of a power line 400. In the following, the term "power line 400" will refer to an overhead power line, preferably a bare overhead power line. As shown in Figure 2, one end of at least one optical fibre 101 of the sensor element 100 is coupled to an optical interrogator 320.

[0079] The optical interrogator 320 is configured for detecting the operating conditions of said conductor 200 by means of the at least one optical fibre 101 of the sensor element 100.

[0080] For example, in order to detect the operating conditions of the conductor 200 (such as: temperature, deformation, or failure of the line), the optical interrogator 320 is a Brillouin, or Rayleigh, or Raman, or polarization, or frequency-analysis, or acoustic optical interrogator.

[0081] The Applicant observes that the above-mentioned optical interrogators are known in the art and will not therefore be described in detail hereinafter.

[0082] Preferably, when the sensor element 100 comprises at least two optical fibres 101, such optical fibres 101 may be connected either to respective interrogators of different types or to a single interrogator.

[0083] According to the present invention, a respective end of the conductor 200 is engaged with a respective substation by means of a clamp 311. For example, the end of the conductor 200 is engaged with an electric pylon 300 by means of the clamp 311, and a tract of the sensor element 100 is extracted, whether before or past the clamp 311, from the respective skirt of the conductor wire 100 and coupled to the interrogator 320.

[0084] For example, the conductor 200 can be installed in an overhead power line 400 as follows:

- extracting, at a clamp 311 associated with a pylon 300, a linear portion of the sensor element 100 from the conductor 200;
- inserting through the clamp 311 (for example, the clamp may be a tension clamp or any known type of clamp) the conductor wires of the skirts 210, 220 and the central core 201 of the conductor 200, and tightening the clamp 311, thereby fastening the conductor wires of the skirts 210, 220 and the central core 201 to the pylon 300. When the clamp 311 is in the middle of the line, the optical connection between two successive conductors 200 is achieved through a further cable equipped with optical fibre running parallel to the electric "dead neck";
- coupling the optical fibre 101 of the sensor element 100 to the interrogator 320. This coupling is made, for example, by means of a junction box containing a first end of a reading optical fibre connected, at its second end, to the interrogator 320, the optical fibre 101 of the sensor element 100 being coupled in a known manner to the reading optical fibre within said junction box.

Claims

1. A conductor (200) for overhead power lines, comprising a sensor element (100);

said sensor element (100) comprising:

- a tube (103),
- a solid filling material (102), partially filling the inner volume of said tube (103);
- at least one optical fibre (101), arranged within said tube (103) and buried in said filling material (102);

wherein said filling material (102) fills said inner

volume of said tube (103) by at least 80% by volume;
wherein said filling material (102) has a density in the range of 0.8 g/cm^3 to 2 g/cm^3.

2. The conductor (200) according to the preceding claim, wherein said filling material (102) has a hardness in the range of 0 to 80 Shore A.

3. The conductor (200) according to the preceding claim, wherein said filling material (102) fills said inner volume of said tube (103) leaving a gap (G) between the outer lateral surface of said filling material (102) and the inner lateral surface of said tube (103).

4. The conductor (200) according to any one of the preceding claims, wherein said sensor element (100) comprises an outer covering (104) that envelops the outer lateral surface of said tube (103).

5. The conductor (200) according to the preceding claim, wherein said outer covering (104) has a substantially circular or triangular or trapezoidal or Z-shaped cross-section.

6. The conductor (200) according to any one of claims 1-5, wherein said conductor (200) further comprises:

a central core (201) and a plurality of concentrical skirts (210, 220), disposed around said central core (201);
each skirt (210, 220) being formed by a plurality of mutually stranded conductor wires;
wherein said sensor element (100) has an outer covering (104) having a cross-section substantially similar to the cross-section of a conductor wire;
wherein said sensor element (100) is stranded with a respective plurality of conductor wires, thus forming a skirt (210, 220);
preferably, said sensor element (100) is stranded with a respective plurality of conductor wires to form the radially external skirt (220) of said conductor (200).

7. An overhead power line (400) comprising:

- a conductor (200) according to any one of the preceding claims, positioned between two substations (320) of said overhead power line (400);
wherein one end of at least one optical fibre (101) of said sensor element (100) is connected to an optical interrogator (320) ;
said optical interrogator (320) being configured for detecting operating conditions of said conductor (200).

8. The overhead power line (400) according to the preceding claim, wherein said conductor (200) comprises at least two optical fibres (101);
wherein said two optical fibres (101) are connected to respective interrogators, preferably of different types.

9. The overhead power line (400) according to any one of claims 7-8, wherein said end of said conductor (200) is engaged with a respective substation by means of a clamp (311);
wherein a tract of said sensor element (100) is extracted from said conductor (200) at said clamp (311), and said at least one optical fibre (101) is coupled to said interrogator (320).

10. Method for installing a conductor (200) in an overhead power line (400), said method comprising:

- providing a conductor (200) according to claim 6;
- at a clamp (311) associated with a pylon (300), extracting a linear portion of the sensor element (100) from the conductor (200);
- inserting the conductor wires forming the skirts (210, 220) and the central core (201) of said conductor (200) into said clamp (311) and tightening said clamp (311);
- coupling said at least one optical fibre (101) of said sensor element (100) to said interrogator (320).

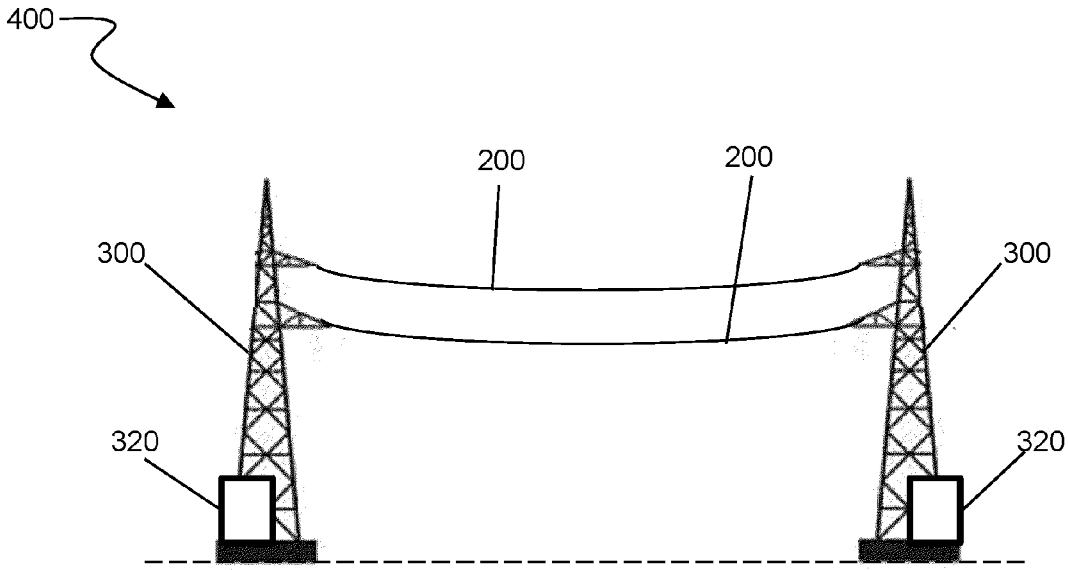

FIG. 1

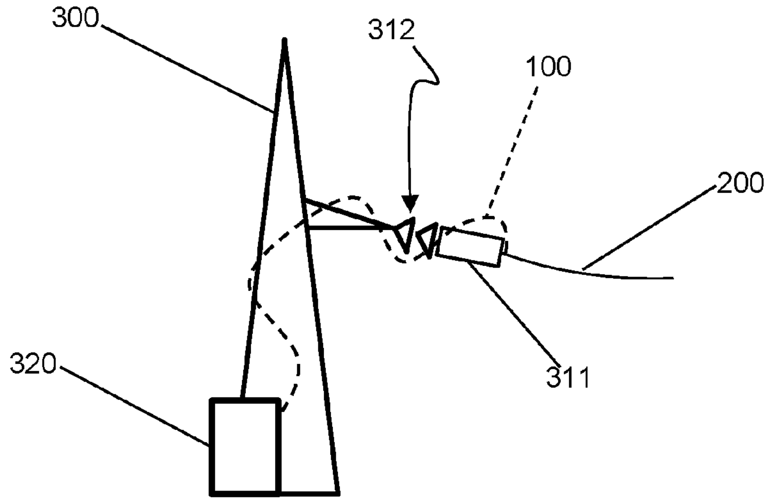

FIG. 2

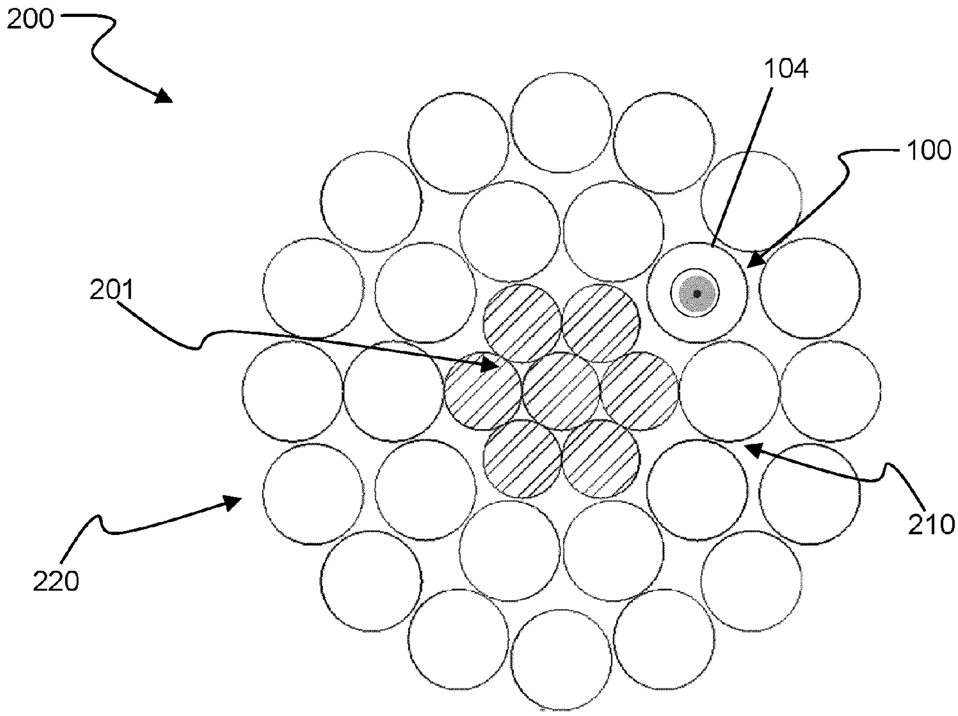

FIG. 3

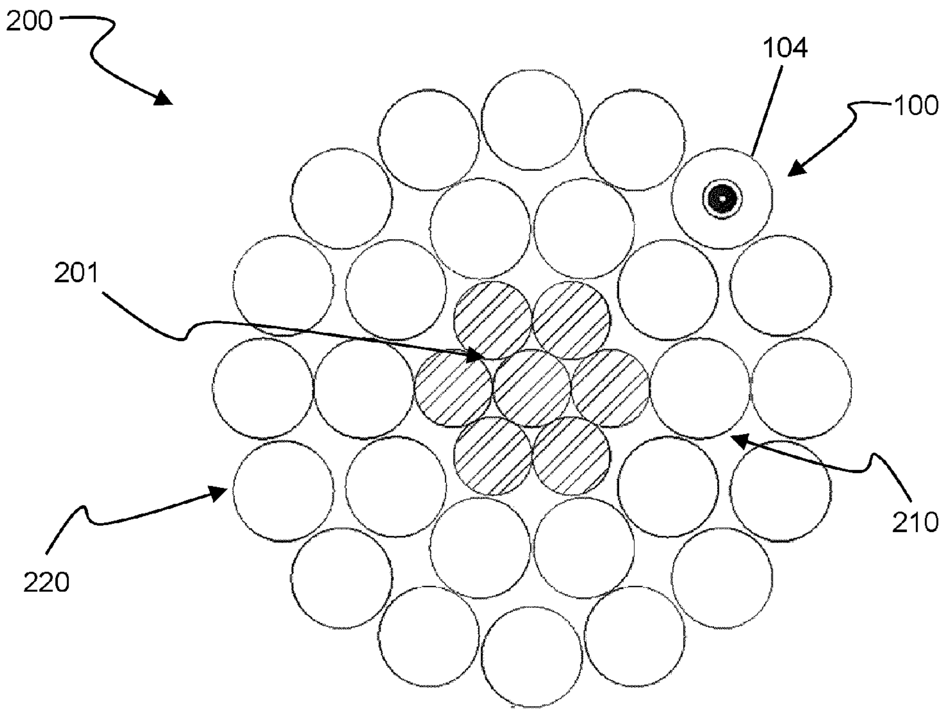

FIG. 4

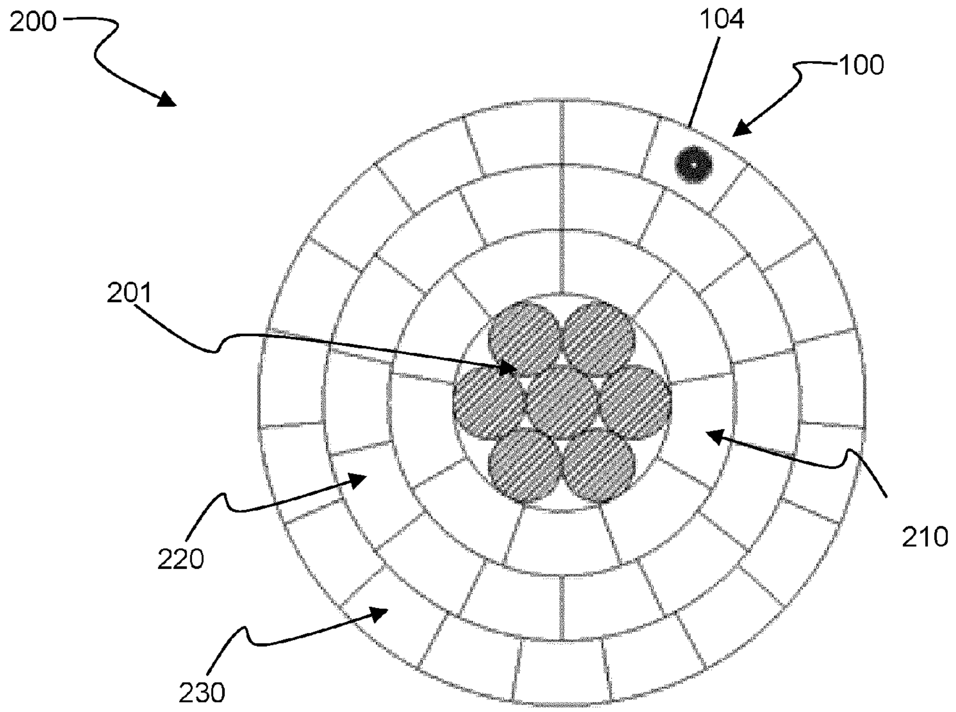

FIG. 5

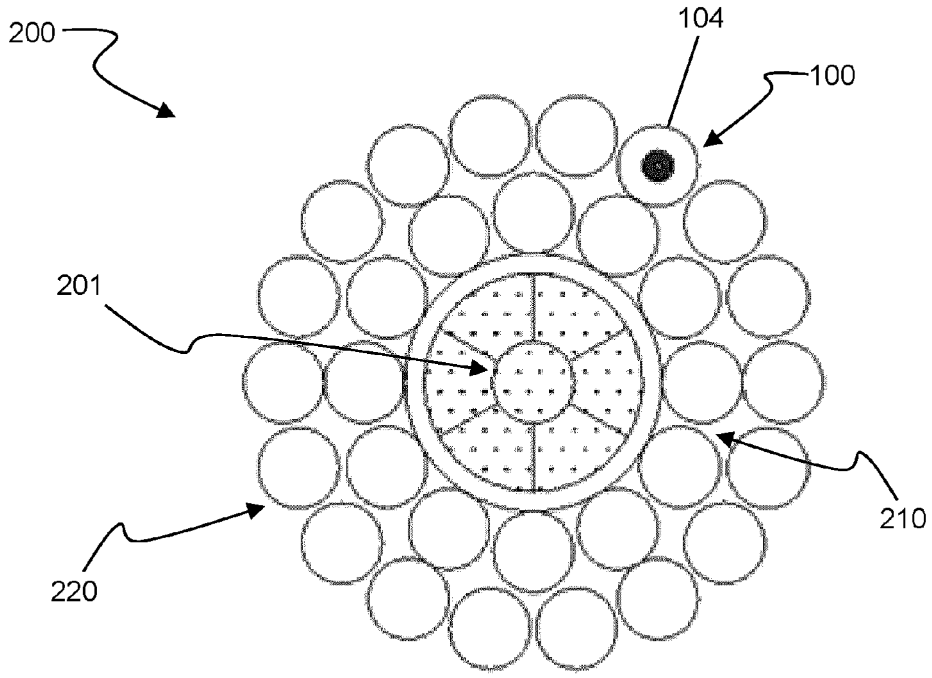

FIG. 6

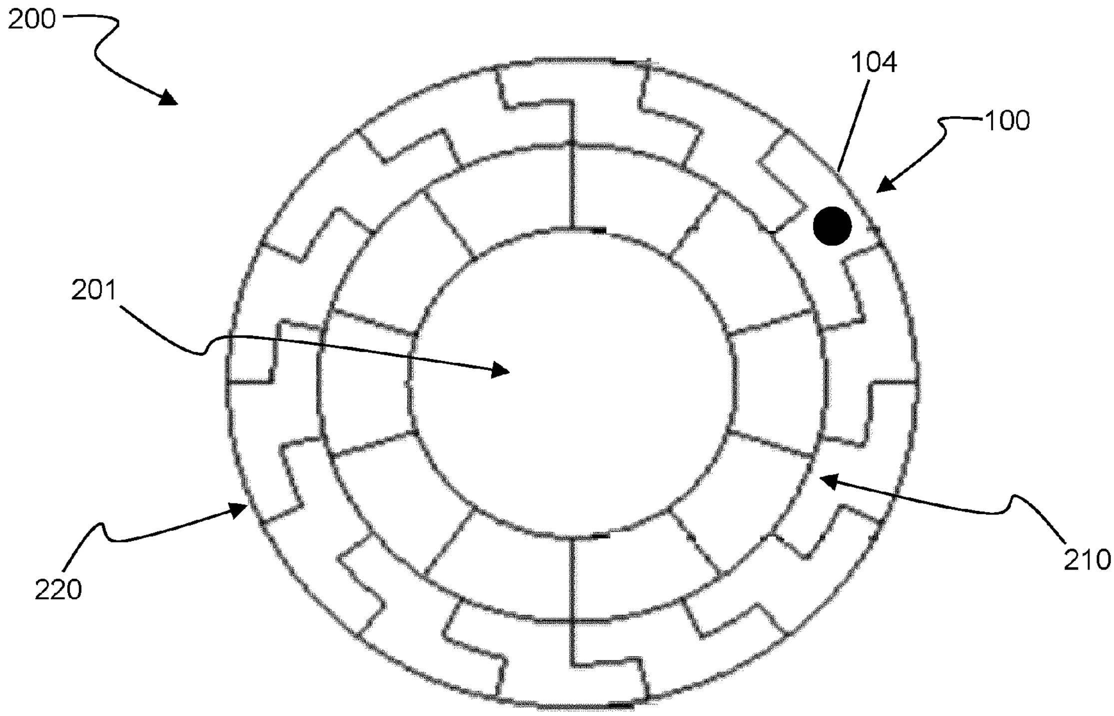

FIG. 7

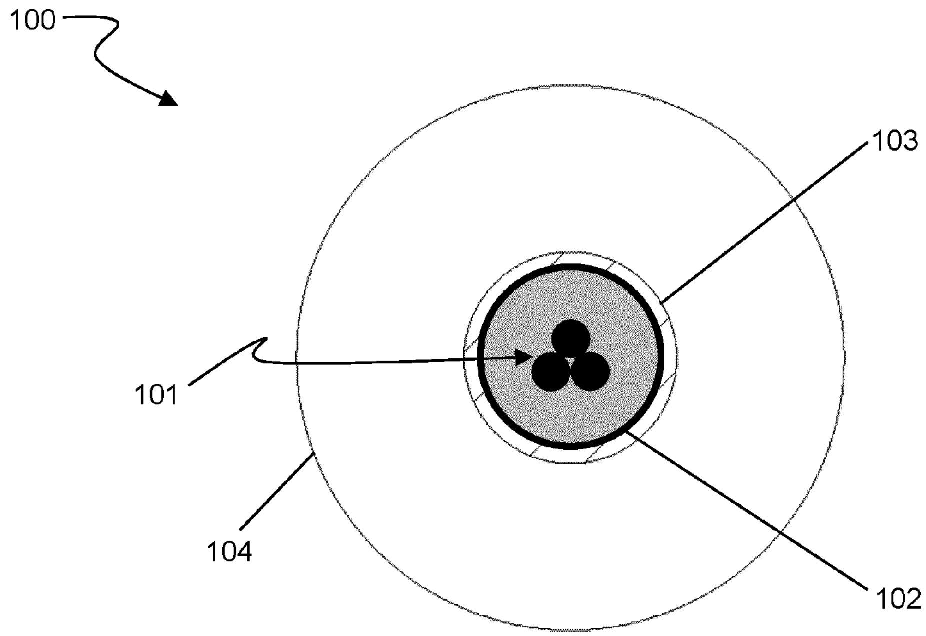

FIG. 8

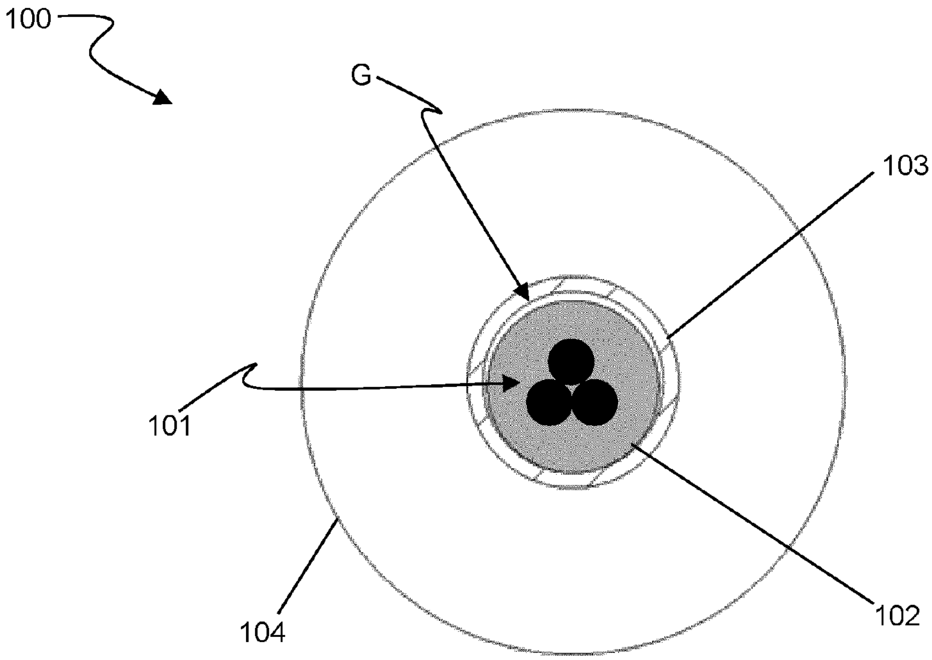

FIG. 9

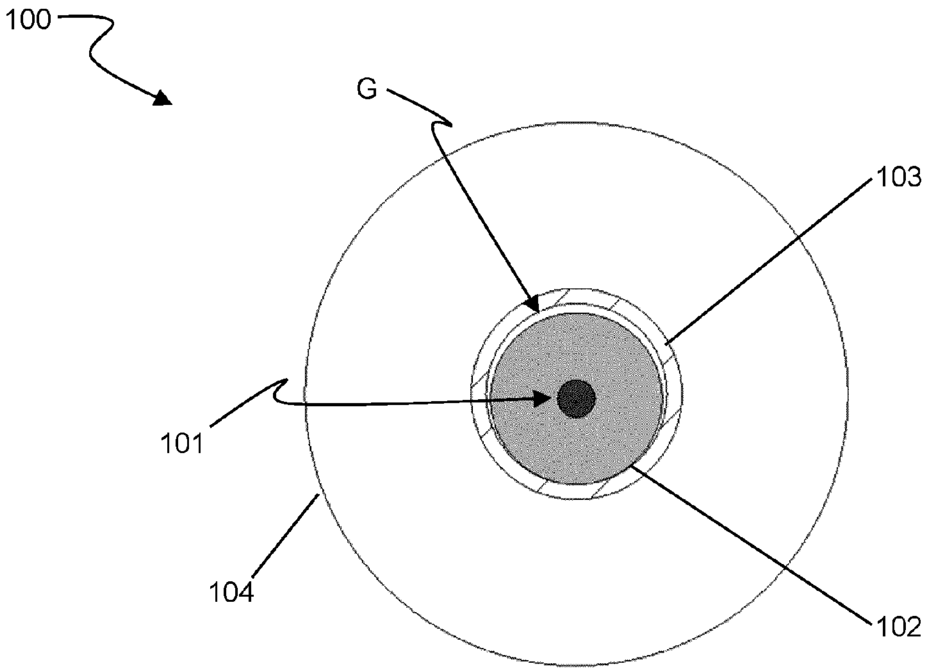

FIG. 10

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EUROPEAN SEARCH REPORT

Application Number
EP 23 18 3265

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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
The Hague	6 November 2023	Alberti, Michele

CATEGORY OF CITED DOCUMENTS

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