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(54) **Electrically conductive, elastic composite yarn, corresponding device and manufacturing method**

(57) The electrically conductive elastic composite yarn comprises a first elastic, non-conductive core (1a), and at least one conductive yarn (3). Also the composite yarn comprises at least a second elastic, non-conductive

core (1b), and said conductive yarn (3) is wrapped in spirals alternatively around said first and second cores (1a,1b). The invention also considers a manufacturing method and a device for implementing the manufacturing method of the composite yarn.

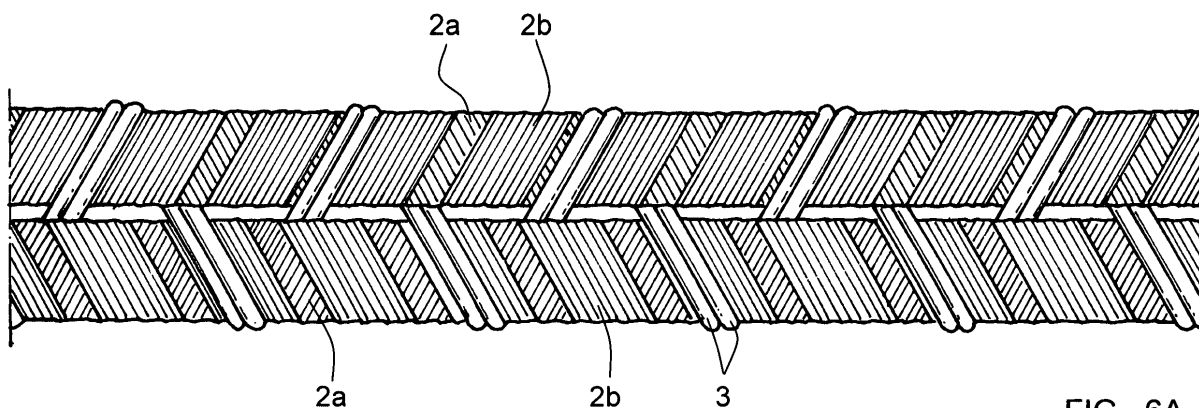


FIG. 6A

Description

Field of the invention

[0001] The invention relates to an electrically conductive elastic composite yarn comprising a first non-conductive elastic core, and at least one conductive yarn. Also the invention relates to a method for manufacturing an electrically conductive elastic composite yarn according to the invention, and a device for implementing the method.

[0002] In the invention, the concept of an electrically conductive elastic compound refers to a yarn or industrial wire made up of more than one component, one of which is electrically conductive. This composite yarn allows electricity to be conducted between two points located at a variable distance. The composite yarn according to the invention can be applied in the industrial sector and preferably in the textile sector, so that fabrics can be manufactured from this composite yarn.

State of the art

[0003] At present, ways are known in the market for solving the problem of the lack of elasticity in electrically conductive metallic materials, both in textile and industrial applications.

[0004] Document EP 1537264 A1 discloses an electrically conductive composite yarn comprising at least one elastic core, at least one wrapping yarn wrapped around the core and at least one electrically conductive yarn wrapped around the core on top of the wrapping yarn, whereby drafting of the composite yarn is limited by the wrapping yarn. In one embodiment, this yarn has a double layer of wrapping yarn on the core, particularly one layer wrapped in an S direction (also called right hand wrapping) and one layer wrapped in a Z direction (also called left hand wrapping). The resulting covered core is known in the art as DCY (Double covered yarn), and it is intended to prevent the yarn from twisting on itself. Nevertheless, in practice, the composite yarn, with the electrically conductive yarn wrapped on the DCY, tends to twist because it is unbalanced. Moreover, after repeated elastic drafting, pulling the yarn from two separate ends, non-desired shifts occur in the loops of the electrically conductive yarn with respect to the covered core. Neither does the yarn easily withstand localised elastic drafting in a short section of yarn, because when this localised stress is applied, shifts also occur in the loops of the electrically conductive yarn. In the invention, localised elastic drafting is understood to be an elastic deformation applied to a relatively short, intermediate section of the yarn; in other words, that the traction force is not applied from both ends of the yarn. The shift produced in the loops has a very negative effect on the yarn, because it causes non-desirable localised twists in it and consequently, the useful life of the composite yarn is extremely reduced due to fatigue; in other words, repeated

loads that end up reducing the yarn's breaking strength. Finally, it is also worth mentioning that with this yarn, after drafting it over 100%, its recovery is not really elastic, because when the yarn recovers it is permanently deformed more than 5%; in other words, its length after drafting is 5% greater than the original length of the new yarn at rest.

[0005] Document WO2006/128633 A1, on which the preamble of claim 1 is based, discloses an electrically conductive elastic composite yarn comprising a central elastic core, on which at least two electrically conductive yarns twisted together are wrapped in spirals. In practice, neither does this arrangement eliminate the localised shifts in the electrically conductive yarn with respect to the core, and neither does it improve the fatigue resistance of the composite yarn. Moreover, in a preferable embodiment, document WO2006/128633 A1 also discloses another electrically conductive elastic composite yarn with an elastic multi-threaded core in which the elastic yarns are twisted together. A double layer of electrically conductive yarns are wrapped spirally on said twisted multi-threaded core. The core has a first layer of two electrically conductive yarns twisted together wrapped in the S direction, and a second layer of two electrically conductive yarns twisted together wrapped in the Z direction; in other words, in the opposite direction to the layer that is directly in contact with the central core. The twist caused by the elastic multi-threaded core unbalances the yarn, and causes it to twine. Also, after numerous drafting from both ends of the composite yarn, localised shifts of the electrically conductive yarn are produced. Neither does the yarn easily withstand localised elastic drafting. Both types of stress end up limiting the yarn's real recovery and reduce its fatigue resistance. Moreover, the double layer of electrically conductive yarns wrapped in the S and Z direction, which is necessary to balance the yarn, makes the composite yarn very rigid. In order to correct the non-desired shifts in the conductive yarn, the document considers the possibility of covering the composite yarn with a double covering of wrapping yarn in the S and Z direction, which is complicated and not very desirable.

[0006] Document PCT/CH 2008/000041 describes an electrically conductive elastic composite yarn with a maximum elastic limit of 40% for manufacturing RFID (Radio Frequency Identification) antennae. The yarn is made up of two cores with a different function; the first is a stress relaxation yarn, whereas the second one is a loose yarn for tying. An electrically conductive yarn is wrapped loosely and alternatively on these two cores. According to this document, the production process is carried out using a swivel shuttle loom with the electrically conductive yarn inside the shuttle. This manufacturing system impedes the use of elastic cores and lacks the accuracy required to produce composite yarns with such small dimensions. On the other hand, the yarn has very low elasticity and its fatigue resistance is very low.

Disclosure of the invention

[0007] The aim of the invention is to overcome these drawbacks. This purpose is achieved by means of an electrically conductive elastic composite yarn of the type indicated at the beginning, **characterized in that** it also comprises at least one second non-conductive elastic core, and in that said conductive yarn is wrapped in spirals alternatively around said first and second cores. In the invention, the term non-conductive yarn is understood to mean that the yarn is electrically passive.

[0008] These novel characteristics reveal beneficial effects that noticeably improve the yarns known in the state of the art. As the electrically conductive yarn is wrapped alternatively on the separate elastic cores, each spiral is formed individually, manufacturing an alternative rotation which makes two consecutive spirals between both cores adopt a shape like an eight. This arrangement exactly determines the diameters of the spirals corresponding to each of the two cores. Thus, this shape can be elastically deformed, but after this deformation it is difficult for the geometry of the spirals to be modified, because the deformation of a spiral is compensated by the previous and subsequent spirals located on the contiguous core, and which are wrapped in the opposite direction. When the composite yarn has been drafted numerous times, the original geometry of each spiral at rest is recovered. The way the conductive material is wrapped prevents a permanent radial shift and any longitudinal shift tends to balance itself given the difficulty of modifying the length of material used in each spiral. So, the shape of the spirals of the electrically conductive yarn with the composite yarn at rest is determined and balanced both in the diameter and in the pitch, that is, the distance between the spirals.

[0009] In comparison, in the state of the art composite yarns on a single core, the spiral is not fixed individually, and after numerous drafting there is nothing to prevent a spiral from varying its original diameter or at rest. The variation of the diameter facilitates the variation of the pitch, or distance between the spirals, this being an irreversible effect that worsens when the composite yarn is drafted again.

[0010] As will be seen later, both the first and the second cores are drafted inside the composite yarn. Therefore, the yarn can be subjected to repeated drafting from its ends and, nevertheless, the shape of the double helix of the electrically conductive yarn remains constant, which further facilitates the yarn's real elastic recovery.

[0011] Another particularly beneficial effect with respect to the state of the art is that the composite yarn can be subjected to a repeated localised drafting without causing the conductive yarn to shift with respect to the elastic cores. As already mentioned, the accumulation of conductive yarn in local areas of the elastic core has a very negative effect on the geometry and useful life of an electrically conductive elastic composite yarn due to tension accumulation in these points.

[0012] On the other hand, another additional beneficial

effect is that the electrically conductive elastic composite yarn balances itself. For example, if the double helix of the conductor yarns is forced to shift locally, owing to the localised drag of a reduced number of conductive yarn spirals, this shift is corrected by the composite yarn itself after a few drafts. In other words, surprisingly the actual geometrical distribution of the electrically conductive yarn causes the yarn to rebalance the local tensions caused in the area, where the spirals have moved, and automatically reorganises the original distance between the conductive yarn spirals.

[0013] It is also worth highlighting as a particularly important advantage that in comparison with the state of the art yarns, the yarn is balanced by means of a single electrically conductive yarn, so that in order to produce a simple, perfectly balanced composite yarn, it is not necessary to wrap additional layers of conductive or wrapping yarn. As already mentioned, in the known state of the art yarns, additional layers of wrapping or conductive yarn are wrapped in opposite directions to counteract the twist caused by the first wrapping of conductive yarn.

[0014] It is also worth mentioning as an advantage that the yarn according to the invention is flat, so that it can be processed subsequently in a comfortable manner for manufacturing textiles. Therefore, the yarn according to the invention has multiple applications. The yarn is used for making fabrics with elastic properties such as low voltage heatable bandages, wherein high elasticity is required, at least 100%, high electrical conductivity, as well as an easy connection for the various elastic yarns. In the case of heatable bandages, the electrically conductive yarn will be covered with one layer of insulating material. Alternatively, the composite yarn can be used as an antenna in RFID applications. Moreover, if the conductive yarn is not insulated, the composite yarn according to the invention makes it possible to incorporate biometric sensors in highly elastic sport textiles or applications such as pulse monitor. For this type of sport textiles very elastic composite yarns are required, which are unaffected by fatigue and are effective conductors. Also, in certain applications, it is necessary that the composite yarns can transmit various electrical signals through a single composite yarn that has high elasticity, flexibility and resistance.

[0015] The composite yarn according to the invention is also applicable to industrial environments that require power supply connections between two points at a variable distance, such as for example the case of truck trailers, power cables of mobile mechanisms such as robot, machine tools or the like.

[0016] Preferably, and for textile applications, the electrically conductive yarns have a diameter smaller than 100 microns because small section metallic yarns are more flexible. Moreover, in order to obtain high electrical conductivity, various parallel yarns are used to obtain the appropriate electrical resistance according to the application.

[0017] Finally, the composite yarn according to the in-

vention has very high electrically conductivity, which is very beneficial both in the textile and industrial sectors.

[0018] The elastic cores can be any elastic material, such as for example, an elastic polymer, natural or synthetic rubber. The conductive yarn can be made of any conductive material, such as for example copper or its alloys. Nevertheless, other solutions of conductive materials are applicable such as aluminium, iron, silver, nickel, gold, or the like, as well as the alloys thereof. Alternatively, natural or synthetic fibres can be used, coated with a conductive material.

[0019] Preferably, each of said first and second cores comprises a first non-conductive wrapping yarn.

[0020] In other words, an individual layer of wrapping yarn is wrapped on to each core before wrapping the conductive yarn. This layer of wrapping yarn has several advantages. First of all, and particularly in the case of small section composite yarns, it affords the core certain rigidity, which provides better working conditions when the conductive yarn is wrapped. Another important function of this wrapping layer is to accurately determine the elastic limit that is to be given to the composite yarn. Therefore, the elastic core is drafted to the desired drafting percentage and the wrapping yarn which will determine the elastic limit of the ensemble allowing large dimensional and production tolerances, is wrapped in a drafted state. The thus produced composite yarn is highly elastic, allowing drafting over 200%, highly flexible, fatigue resistant and has very high elastic recovery.

[0021] Also, in a particularly preferable way, the wrapping direction of said first wrapping yarn on said first core is opposite the wrapping direction of said first wrapping yarn on said second core. This way a perfect balance of the set of cores is obtained, provided that there is an even number of cores.

[0022] In a particularly preferable way, each of said first and second cores comprises a second, non-conductive wrapping yarn, superimposed on said first wrapping yarn and the wrapping direction of said second wrapping yarn is opposite the wrapping direction of said first wrapping yarn.

[0023] This introduces a particular advantage in that when the composite yarn is subject to traction, the conductive yarn remains hidden between both sheaths of wrapping yarns, which noticeably improves the touch of the composite yarn. This characteristic is particularly important for applications such as heatable bandages or biometric sensors. Particularly in this type of applications, the composite yarn is subject to elongations over 100% to guarantee uniform contact with the user's skin. By virtue of this characteristic, the user will not notice the presence of the conductive yarn in the composite yarn and not only will it feel pleasant, it will also prevent injuries through the yarn rubbing continuously on the skin. The wrapping yarns can be natural or synthetic fibres, as well as mixtures thereof. For example, any type of natural fibres such as cotton, wool, silk, or synthetic fibres such as, carbon, polyester, rayon, polyamide fibres or others

are considered suitable as wrapping yarns for implementing the invention.

[0024] Preferably in the composite yarn according to the invention, said first and second cores are multi-threaded. This characteristic affords the composite yarn greater flexibility, which is particularly convenient in textile applications.

[0025] Preferably the electrically conductive yarn of the composite yarn according to the invention is multi-threaded. This improves the flexibility of the whole composite yarn even more. Moreover, and depending on the arrangement of the conductive yarn, further additional advantages are obtained. Preferably the surface of said conductive yarn is covered with an insulating sheathing. If the conductive yarn is multi-threaded, but with a single insulating sheathing, high yarn conductivity is obtained and it is guaranteed that even though some of its threads may break, the conductivity of the composite yarn is not affected. Also the insulated conductive yarn can be applied to heatable bandages. Alternatively, if the conductive yarn is multi-threaded with each filament being individually insulated, it is possible to transmit a large number of signals through one single composite yarn, which is particularly interesting in the case of biomedical applications. Alternatively the surface of the conductive yarn is not covered with an insulating sheathing.

[0026] Moreover, the more yarns there are making up the wrapping yarns, the easier it is for the conductive yarn to remain hidden among them so that the feel of the composite yarn is noticeable improved. Therefore, in the composite yarn preferably said first and second wrapping yarns are multi-threaded.

[0027] In a particularly preferable way the invention envisages a fabric comprising the electrically conductive elastic composite yarn. So, the fabric of the composite yarn can also have other electronic applications such as the electronic identification of people or goods. So, preferably, the conductive yarn can be an RFID antenna. This way, by joining the ends of the conductive yarn to the corresponding chip, identification clothing can be developed, such as bracelets, shirts or the like.

[0028] The invention also relates to a device for manufacturing an electrically conductive elastic composite yarn, **characterized in that** it comprises at least static support means for conductive yarn, first rotatable drafting means for said first and second cores, upstream of said support means and second drafting means for said first and second cores downstream of said support means, said second drafting means being rotatable at a drafting speed greater than the drafting speed of said first drafting means to advance and draft said first and second cores in a feeding direction, and first and second guiding means arranged between said first and second drafting means capable of guiding respectively said first and second cores around said support means, with said first and second guiding means eccentrically rotatable with respect to said support means in a simultaneous and synchronised fashion and in opposite directions of rotation, so

that said conductive yarn is wrapped in spirals alternatively around said first and second cores, downstream of said support means, dragged by said first and second cores in said feeding direction.

[0029] This considerably simplifies the production of the yarn, since the conductive yarn support means, for example a coil, are static and it is the elastic cores that rotate around the core of the conductive yarn. This reduces the inertia of the device because a large conductive yarn coil is considerably heavy and also it would be extremely difficult to perform the wrapping movement of the conductive yarn on the cores because the movements would never be balanced. On the contrary, in the device according to the invention, the elastic core guiding means rotate eccentrically with respect to the conductive yarn coil but perform a simple circular movement.

[0030] Preferably, the device comprises a first guiding ring between said first drafting means and said first and second guiding means for guiding said first and second cores. In a particularly preferably way, the machine also comprises a second guiding ring between said first and second guiding means and said second drafting means intended for guiding said first and second cores.

[0031] This provides a reliability increase of the machine because it prevents the composite yarn from coming out of the drafting means in a non-desirable way. Moreover, in the case of the second guiding ring, the conductive yarn is wrapped more compactly on the set of two cores.

[0032] Finally, the invention also proposes a method for manufacturing an electrically conductive elastic comprising the steps of main simultaneous draft of said first and second cores between first rotatable drafting means arranged upstream of support means of conductive yarn and second rotatable drafting means provided downstream of said support means, with said second drafting means rotating at a speed greater than the speed of said first drafting means, to drag and draft said first and second cores in a feeding direction, guiding said first core through first guiding means and said second core through second guiding means, with said first and second guiding means being arranged between said first and second drafting means and arranged eccentrically with respect to said support means, rotatable in a simultaneous and synchronised fashion and in opposite directions of rotation, and wrapping said conductive yarn in spirals alternatively around said first and second cores downstream of said support means being dragged by said first and second cores in said feeding direction.

[0033] Preferably, the manufacturing method also comprises a previous drafting step of said first and second cores between third and fourth drafting means, and a covering step wherein each of said first and second cores are led through a first and second consecutive, rotatable hollow spindles, arranged between said third and fourth drafting means and which comprises respectively a coil of first and second, non-conductive wrapping yarns, and in that said first and second hollow spindles

rotate in opposite directions, so that upon exiting said second hollow spindle, each of said first and second cores are covered with two layers of wrapping yarn wrapped in opposite directions.

[0034] Preferably said covering step of said first and second cores is carried out simultaneously and in that the first hollow spindle associated with said first core and the first hollow spindle associated with said second core rotate in opposite directions and the second hollow spindle associated with said first core and the second hollow spindle associated with said second core rotate in opposite directions and opposite to the rotation direction of their respective first hollow spindles.

Brief description of the drawings

[0035] Other advantages and characteristics of the invention are appreciated from the following description, wherein, some preferable embodiments of the invention are explained, in a non-limiting way, with reference to the figures, in which:

Figs. 1A to 1C are schematic views of electrically conductive elastic composite yarns according to the invention, without wrapping covering.

Fig. 2 is a schematic view of a yarn with a double covered core.

Figs. 3A and 3B are schematic view of an electrically conductive, elastic composite yarn according to the invention with a single-thread wrapping covering, in a relaxed and drafted state.

Fig. 4 is a schematic view of a device for wrapping a wrapping yarn on top of an elastic core.

Fig. 5 is a schematic view of a device for manufacturing an electrically conductive elastic composite yarn according to the invention.

Figs. 6A and 6B are schematic views of an electrically conductive elastic composite yarn conductor with a multi-threaded wrapping covering for a textile application, in a relaxed and drafted state.

Fig. 7 is a strength/strain diagram of the composite yarn according to Figures 6a, 6b.

Figs. 8A and 8B are views of an electrically conductive elastic composite yarn for industrial application, in a relaxed and drafted state.

Fig. 9 is a schematic view of a fabric produced from a yarn according to the invention.

Detailed description of some embodiments of the invention

[0036] The drafting can be defined in two ways. For example if a non-drafted yarn measures 1 meter and when drafted it measures 1,3 meters, the drafting will be 30% or a relative draft that is 1,3 times the original length. When the non-elastic yarns of the composite yarn are drafted, the average distance between their spirals increases proportionally with respect to the relative draft,

and the elastic yarns reduce their diameter in the inverse ratio of the square root of the relative draft, whereby drafting 1,3 times the diameter would increase from 1 to 0,877. This phenomenon conditions the design of composite yarns.

[0037] In the invention, fatigue resistance is measured by the number of respective drafting cycles the yarn is able to withstand before breaking.

[0038] In Figures 1A to 1C, first schematic embodiments of the electrically conductive elastic composite yarn according to the invention are observed, wherein the composite yarn is made up of a first and second elastic cores 1a, 1b. A conductive yarn 3 is wrapped in alternatively in spirals on said first and second core 1a, 1b, so that the wrapping on the first core 1a is in the S direction, whereas on the second core 1b, it is in the Z direction. In Figure 1A a single conductive yarn 3 is wrapped on the first and second cores 1a, 1b. In Figure 1B, two conductive yarns 3 are wrapped. Thanks to this, for example, if conductive yarns 3 are insulated two signals can be transmitted by a single composite yarn. Finally, in Figure 1C, conductive yarn 3 is multi-threaded. If each conductive yarn 3 is coated with an individual insulating sheathing, a plurality of different signals can be transmitted. In the event they do not have an insulating sheathing, good conductivity is guaranteed because if some of the yarns break, the passage of the current is not interrupted.

[0039] In Figures 2, 3A and 3B the structure of a composite yarn according to the invention is shown in detail, which comprises a double covering of single-threaded wrapping yarn. In Figure 2, a generic, elastic core 1a is covered with a first wrapping yarn 2a wrapped in the Z direction. On top of this Z-shaped layer a second wrapping yarn 2b is wrapped in the S direction, to consequently balance the composite yarn. In the interest of clarity in the figures, first wrapping yarn 2a is shown in white, whereas the second wrapping yarn 2b is shown in black. Nevertheless, this does not necessarily imply that the first and the second wrapping yarns 2a, 2b are different fibres. As will be seen in greater detail later, wrapping yarn 2a, 2b is wrapped with core 1a drafted to the elastic limit that it is to be conferred to the finished composite yarn. In the same way as explained here, a second core 1b is formed, wherein the layers of wrapping yarn 2a, 2b are arranged in reverse order; in other words, on the second core 1b, the first wrapping yarn 2a is wrapped in the S direction, whereas the second wrapping yarn 2b is wrapped in the Z direction on first wrapping yarn 2a.

[0040] Finally, a first core 1a with wrapping yarns 2a, 2b wrapped in the Z and S directions respectively, is used and a second core 1b, with wrapping yarns 2a, 2b, wrapped in the S and Z directions respectively, according to the arrangement shown in Figures 3A and 3B. This assembly is drafted to a value near the elastic limit predetermined by wrapping yarns 2a, 2b. On first and second cores 1a, 1b a conductive yarn 3 is wrapped alternatively with a pitch greater than that of wrapping yarns 2a, 2b. Since it is a composite yarn, its elastic drafting limit is

understood to be the traction force applied to the yarn after which proportional elongation does not occur. If the yarn continues to be drafted after this point, any deformation caused is irreversible. In the composite yarn according to the invention, the elastic limit is determined by the wrapping of wrapping yarns 2a, 2b on elastic cores 1a, 1b, which withstand the largest part of the force, thereby unloading the tension of conductive yarns 3. The finished and relaxed composite yarn, produced in this way, therefore has the structure shown in Figures 3A and 3B. As can be seen, in the final ensemble on first core 1a, conductive yarn 3 is wrapped in the S direction, whereas on second core 1b, the conductive yarn is wrapped in the Z direction and by virtue of this, the composite yarn is perfectly balanced.

[0041] Continuing with Figures 4 and 5, the method and device for manufacturing the composite yarn according to the invention are described in detail.

[0042] The first operation consists in covering the first and second elastic cores 1a, 1b with first and second wrapping yarns 2a, 2b. The device in Figure 4 shows the case of covering first core 1a to obtain a DCY yarn. Core 1a is dragged and drafted longitudinally by third and fourth drafting means 11, 12 which, in this case, are two roller systems driven for example by a motor. The third drafting means 11 move core 1a at a tangential speed v_1 , whereas the fourth drafting means 12 move core 1a in a drafted and recovered state at a speed v_2 . The relationship between speeds v_1 , v_2 corresponds to the drafting E in a percentage, this being defined by the formula $E [\%] = (v_2 - v_1) / v_1 \times 100$. The drafting percentage will depend on the drafting limit that is desirable for the final composite yarn, which can vary from 30% to 400%, and preferably from 100% to 300%.

[0043] Drafted core 1a passes through the inside of a first and a second hollow spindle 13, 14, with said spindles being supported by a coil that contains first and second non-conductive wrapping yarns 2a, 2b. The coils, via the spindles, rotate in opposite directions to form S and Z direction wrappings, or vice versa, as explained before. In the example shown in Figure 4, a first wrapping yarn 2a is wrapped in the S direction and subsequently a second wrapping yarn 2b is wrapped in the Z direction. In order to create an inverted wrapping, it is simply a question of inverting the rotation of hollow spindles 13, 14.

[0044] First and second wrapping yarns 2a, 2b are wrapped on core 1a, 1b, but the following formula is used to calculate the turns applied: $T (\text{turns/m}) = v_1 / G$, is the turns on core 1a in a relaxed state, with v_1 being the drafting speed in m/min of the third drafting means 11, and G the rotation speed of the coils in revolutions per minute (rpm).

[0045] Preferably first and second wrapping yarns 2a, 2b are multi-threaded and by adapting the helix on elastic core 1a they adopt a flat shape so that they virtually cover the whole of core 1a.

[0046] Upon exiting fourth drafting means 12, core 1a

is not drafted any more and after relaxing it is coiled, and the coils obtained are used in the following operation shown in Figure 5. To produce a perfectly balanced composite yarn, preferably the wrapping direction of the first wrapping yarn 1b on the first and second cores 1a, 1b will be in opposite directions. This way, in order to cover second core 1b, the same method described herein will be applied, but hollow spindles 13, 14 are driven in reverse directions to the preceding description regarding Figure 4, so that on first core 1a the final wrapping of second wrapping yarn 2b will be in the S direction, and on second core 1b it will be in the Z direction. Optionally, the device described for manufacturing the cores could have been assembled in a machine so that both cores 1a and 1b covered with wrapping yarns 2a, 2b were produced in parallel, and these DCY yarns were fed to the following processing step, upon exiting the respective fourth drafting means 12.

[0047] In the device in Figure 5, the operation of alternatively wrapping conductive yarn 3 on each core 1a, 1b is performed. To carry out this operation, first and second cores 1a, 1b are drafted to the maximum with wrapping to obtain maximum rigidity, without reaching the elastic limit of the DCY yarns fed into the device. This operation is carried out by drafting first and second cores 1a, 1b in parallel with wrapping yarns 2a, 2b between first and second drafting means 5, 6, in the form of dragging rollers. Although DCY yarns are shown in the figure, the device in Figure 5 is also applicable to uncovered elastic cores.

[0048] Covered first core 1a, fully drafted, is guided through first guiding means 7, whereas covered second core 1b, drafted, is guided through second guiding means 8, so that the first and second cores 1a, 1b surround static support means 4. In this embodiment, said first and second guiding means 7, 8 are rotatable axes which by means of a cam movement rotate in a circular direction around central support means 4 of conductive yarn 3, in the form of a static coil 4, in other words one that does not rotate. This is achieved by two pins that support coil 4 alternatively moving away so as to allow the passage of axes 7, 8 and cores 1a and 1b. Axes 7, 8 arranged eccentrically with respect to coil 4, rotate in simultaneous, synchronised fashion and in opposite rotation directions, which prevents axes 7, 8 from colliding with one another as they cross.

[0049] In addition, the device comprises a first guiding ring 9 between first rollers 5 and axes 7, 8 and a second guiding ring 10 between said axes 7, 8 and said second rollers 6 to guide said first and second cores 1a, 1b. In second ring 10 conductive yarn 3 is wrapped on central coil 4, with conductive yarn 3 being dragged by first and second cores 1a, 1b during the feeding movement. In the event of using various conductive yarns 3, coil 4 can be a multiple coil. Also, conductive yarn 3 from central coil 4 is passed through a braking mechanism, not shown in the figure, which allows the developing tension of conductive yarn 3 to be adjusted.

[0050] The circular, simultaneous and synchronised

movement of first and second cores 1a, 1b with wrapping, drafted to the limit by exit rollers 6, drags conductive yarn 3 downwards and due to the tension of the braking mechanism, it is deformed to adapt helical and alternatively on each core 1a, 1b. Upon exiting rollers 6, the finished composite yarn relaxes. This guarantees that conductive yarn 3 remains positioned on the composite yarn without any relative play between cores 1a, 1b and conductive yarn 3, which is important for preventing subsequent movement of spirals with respect to the cores.

[0051] The size of the wrapping device of conductive yarn 3 is conditioned by the balance between the size of central coil 4 and the production speed. It is desirable to have the maximum quantity of conductive yarn 3 in central coil 4, but by increasing the diameter of coil 4, axes 7, 8 increase the rotation ratio and the centrifugal forces produced limit the rotation speed.

[0052] Finally, it is worth mentioning that in a particularly preferable way, the wrapping direction of second wrapping yarn 2b, is the same as the wrapping direction of conductive yarn 3 on each core 1a, 1b. So, if second wrapping yarn 2b of core 1a is wrapped in the Z direction, it is advisable that conductive yarn 3 also be wrapped in the Z direction on this core, whereas if second wrapping yarn 2b of core 1b is in the S direction, the conductive yarn is also wrapped in the S direction on this core, as shown in Figures 3A and 3B. Also, preferably the distance between the spirals of first and second wrapping yarns 2a, 2b, will be smaller than the distance between the spirals of conductive yarn 3. The wrapping direction applied will not affect or introduce tension on core 1a and the wrapping directions of wrapping yarns 2a, 2b compensate one another. This way neutral, fully balanced cores 1a, 1b are obtained, which hugely facilitate the following handling operations of this yarn.

[0053] Below, based on Figures 6A, 6B and 7, an embodiment of an electrically conductive elastic composite yarn is shown, intended for a textile application. The composite yarn is made up of two single-threaded, elastic Spandex cores 1a, 1b measuring 0,4 mm in diameter, covered with first and second wrapping yarns 2a, 2b made up of 30 nylon filaments measuring 12 microns, and finally two conductive yarns 3 made of insulation covered copper and with a 65 micron diameter. In this case, the composite yarn has an elasticity higher than 200%. In the interest of simplicity, the filaments are shown schematically as if they were parallel, although in reality these filaments are twisted together so that when viewed under a microscope they make up a mass of interlaced yarns.

[0054] In a first step, the wrapping is placed on elastic Spandex core 1a, 1b according to the method explained in Figure 4. To do this, the coils of wrapping yarn 2a, 2b are loaded and the drafting between drafting rollers 11, 12 is adjusted to obtain a 300% draft. Core 1a, 1b is passed through hollow spindles 13, 14. The device is adjusted so that when drafting rollers 11, 12 advance one meter, first and second hollow spindles 13, 14 rotate 1900

turns in opposite directions. To do this, in the device in Figure 4, hollow spindles 13, 14 rotate at a speed of 9000 rpm (revolutions per minute), so that the production speed of the device will be 9000 rpm / 1900 turns/m = 4.73 meters/minute of yarn.

[0055] The result will be a first core 1a covered by a first wrapping yarn 2a wrapped in the Z direction at 1900 turns/m and a second wrapping yarn 2b wrapped in the S direction at 1900 turns/m. When the core covered with the wrapping yarns is drafted, upon reaching a 300% draft, overload is noticed and this point is considered to be the drafting limit for the finished composite yarn.

[0056] For second core 1b, the same operation is repeated but the rotation of first and second hollow spindles 13, 14 is inverted, so that the result will be a second core 1b covered by first wrapping yarn 2a twisted in the S direction at 1900 turns/m and a second wrapping layer twisted in the Z direction at 1900 turns/m.

[0057] In the second step, carried out in the device in Figure 5, two electrically conductive yarns 3 are placed between first and second elastic cores 1a, 1b covered by wrapping yarns 2a, 2b. Initially central coil 4 is prepared by loading it with the two conductive yarns 3. First core 1a passes between rollers 5, first ring 9, axis 7, second ring 10 and finally between rollers 6. The same operation is carried out for second core 1b, but it is passed through axis 8, instead of axis 7. Next, in the device the drafting is adjusted to 300%. Then, the device is adjusted so that drafting rollers 5 advance one meter, guide axes 7, 8 rotate 1900 turns/m in opposite directions. When the device operates, the result is an electrically conductive elastic composite yarn drafted to the limit, which relaxes upon exiting rollers 6.

[0058] It is worth mentioning that during production, after the composite yarn relaxes, it does fully recover, because the elastic recovery is affected by conductive yarns 3, whereby in the relaxed composite yarn, cores 1a, 1b are drafted. So, drafting the resulting composite yarn at the exit of the conductive yarn 3 wrapping device, a 230% draft will be reached, instead of a 300% draft.

[0059] Figure 6A shows the composite yarn in a relaxed state, whereas Figure 6B shows the composite yarn drafted 200%.

[0060] In the figures, it is also shown that by drafting the composite yarn the elastic elements, in other words, first and second cores 1a, 1b, reduce their diameter, whereas the non-elastic elements, first and second wrapping yarns 2a, 2b and conductive yarns 3, increase the distance between their spirals.

[0061] If a meter of relaxed composite yarn is used, joining the two yarns at both ends, the electrical resistance of the connection will be 10.5 ohms (each conductive yarn has a resistance of 21 ohms)

[0062] Analysing 1000 mm of electrically conductive elastic composite yarn according to this example, the lengths corresponding to each component of said composite yarn are as follows:

Elastic Spandex	2 x 740 mm.
Non-elastic wrapping	4 x 3450 mm.
65 micron copper yarn	2 x 3750 mm.

[0063] The Strength/strain diagram in Figure 7 shows the characteristics of the composite yarn, as well as of the cores, with and without a wrapping covering. The first curve to the left in the diagram corresponds to the finished composite yarn; in other words 2DCY+Conductive Cu. The composite yarn behaves elastically up to 200% and has a breaking limit at 290% deformation under a force of 10.5 N. The central curve represents the behaviour of the two cores 1a and 1b covered with two layers of wrapping yarn 2a, 2b, 2xDCY as described in the first step of the manufacturing method. While the curve to the right of the diagram represents the traction test of two single-threaded Spandex yarns without wrapping.

[0064] It is important to highlight that the 65 micron diameter copper yarns have virtually no elasticity, although two conductive yarns 3 in parallel can resist a plastic drafting without breaking up to 20% under a breaking force of 1.7 N. Nevertheless, this figure shows the surprising effect that the invention achieves, because the composite yarn manages 290% linear drafting until the assembly breaks.

[0065] Moreover, it is also worth mentioning that this same composite yarn has been subjected to repetitive drafting from 0% to 100%, withstanding 450 cycles until definitive breakage owing to fatigue. It is considered that such a high number of cycles allows this type of yarn to be applied in the textile sector without any problems, since drafting on this scale and with so many cycles is not very frequent if it occurs at all, including the case of medical bandages.

[0066] Figures 8A and 8B show another embodiment of an electrically conductive elastic composite yarn intended for an industrial application. The composite yarn is made up of elastic cores 1a, 1b made from natural rubber and measuring 4 mm in diameter, and two conductive yarns 3 of 0.5 mm², provided with 500 V insulation and a nominal current of 10 A. Each conductive yarn 3 is made up of 129 copper filaments measuring 70 microns in diameter, with the whole assembly of filaments being covered with a single PVC insulation. In this case, the yarn has an elastic limit of 130%.

[0067] In this case, there is not a step for covering cores 1a, 1b, whereby the method proceeds directly to wrapping conductive yarns 3 using the device in Figure 5. In this case, cores 1a, 1b are drafted to 180%. The rotation speed of guide axes 7, 8 will be 85 turns per meter advanced by the pulling feeding rollers.

[0068] In order to overcome the wear of the electrically conductive elastic yarn, once finished it is covered with an outer protection 15 in the form of netting with crossed yarns using a braiding machine like the ones used to cover elastic ropes. In this case, the elastic limit of the

composite yarn is determined by the braiding of the covering.

[0069] Finally, Figure 9 schematically shows a fabric produced from a composite yarn with two elastic cores 1a, 1b, covered with a double layer of wrapping yarn and with a conductive yarn 3 wrapped alternatively according to the invention. In the figure, in the warp, parallel series of three elastic yarns covered with natural fibres 17, such as for example cotton, and a composite yarn 16 according to the invention, are arranged. In the weft tying yarns 18 are arranged. This way it is possible to create a fabric of a certain width. In order to create, for example, a heatable bandage, the fabric is cut to the necessary size and the composite yarns are joined to conductive bridges 19 leaving the free ends 20, 21 prepared for their connection to a battery responsible for supplying electricity to the fabric. Alternatively, if the conductive yarn 3 is not insulated, the fabric can be used as a biometric sensor.

Claims

1. Electrically conductive elastic composite yarn comprising a first non-conductive elastic core (1a), and at least one conductive yarn (3), **characterized in that** it also comprises at least one second non-conductive elastic core (1b), and **in that** said conductive yarn (3) is wrapped in spirals alternatively around said first and second cores (1a, 1b).
2. Electrically conductive elastic composite yarn according to claim 1, **characterized in that** each of said first and second cores (1a, 1b) comprises a first non-conductive wrapping yarn (2a).
3. Electrically conductive elastic composite yarn according to claim 2, **characterized in that** the wrapping direction of said first wrapping yarn (2a) on said first core (1a) is opposite the wrapping direction of said first wrapping yarn (2a) on said second core (1b).
4. Electrically conductive elastic composite yarn according to claim 2 or 3, **characterized in that** each of said first and second cores (1a, 1b) comprises a second, non-conductive wrapping yarn (2b), superimposed on said first wrapping yarn (2a) and **in that** the wrapping direction of said second wrapping yarn (2b) is opposite the wrapping direction of said first wrapping yarn (2a).
5. Electrically conductive elastic composite yarn according to any of the claims 1 to 4, **characterized in that** said first and second cores (1a, 1b) are multi-threaded.
6. Electrically conductive elastic composite yarn according to any of the claims 1 to 5, **characterized**

in that the surface of said conductive yarn (3) is covered with an insulating sheathing.

7. Electrically conductive elastic composite yarn according to any of the claims 1 to 5, **characterized in that** the surface of said conductive yarn (3) is not covered with an insulating sheathing.
8. Electrically conductive elastic composite yarn according to any of the claims 1 to 6, **characterized in that** said conductive yarn (3) is multi-threaded.
9. Fabric **characterized in that** it comprises an electrically conductive elastic composite yarn according to any of the claims 1 to 8.
10. Device for manufacturing an electrically conductive elastic composite yarn according to any of the claims 1 to 8, **characterized in that** it comprises

[a] at least static support means (4) for conductive yarn (3),

[b] first rotatable drafting means (5) for said first and second cores (1a, 1b), upstream of said support means (4) and second drafting means (6) for said first and second cores (1a, 1b) downstream of said support means (4), said second drafting means (6) being rotatable at a drafting speed greater than the drafting speed of said first drafting means (5) to advance and draft said first and second cores (1a, 1b) in a feeding direction, and

[c] first and second guiding means (7, 8) arranged between said first and second drafting means (5, 6) capable of guiding respectively said first and second cores (1a, 1b) around said support means (4), with said first and second guiding means (7, 8) eccentrically rotatable with respect to said support means (4) in a simultaneous and synchronised fashion and in opposite directions of rotation, so that said conductive yarn (3) is wrapped in spirals alternatively around said first and second cores (1a, 1b), downstream of said support means (4), dragged by said first and second cores (1a, 1b) in said feeding direction.

11. Device for manufacturing an electrically conductive elastic composite yarn according to claim 7, **characterized in that** it comprises a first guiding ring (9) between said first drafting means (5) and said first and second guiding means (7, 8) for guiding said first and second cores (1a, 1b).
12. Device for manufacturing an electrically conductive elastic composite yarn according to claim 7 or 8, **characterized in that** it comprises a second guiding ring (10) between said first and second guiding

means (7, 8) and said second drafting means (6) for guiding said first and second cores (1a, 1b).

13. Method for manufacturing an electrically conductive elastic composite yarn according to any of the claims 1 to 8, **characterized in that** it comprises the following steps:

[a] main simultaneous draft of said first and second cores (1a, 1b) between first rotatable drafting means (5) arranged upstream of support means (4) of conductive yarn (3) and second rotatable drafting means (6) provided downstream of said support means (4), with said second drafting means (6) rotating at a speed greater than the speed of said first drafting means (5), to drag and draft said first and second cores (1a, 1b) in a feeding direction ,
 [b] guiding said first core (1a) through first guiding means (7) and said second core (1b) through second guiding means (8), with said first and second guiding means (7, 8) being arranged between said first and second drafting means (5, 6) and arranged eccentrically with respect to said support means (4), rotatable in a simultaneous and synchronised fashion and in opposite directions of rotation, and
 [c] wrapping said conductive yarn (3) in spirals alternatively around said first and second cores (1a, 1b) downstream of said support means (4) being dragged by said first and second cores (1a, 1b) in said feeding direction.

14. Method for manufacturing an electrically conductive elastic composite yarn according to claim 13, **characterized in that** it also comprises a previous drafting step of said first and second cores (1a, 1b) between third and fourth drafting means (11, 12), and a covering step wherein each of said first and second cores (1a, 1b) are led through a first and second consecutive, rotatable hollow spindles (13, 14), arranged between said third and fourth drafting means (11, 12) and which comprises respectively a coil of first and second, non-conductive wrapping yarns (2a, 2b), and **in that** said first and second hollow spindles (13, 14) rotate in opposite directions, so that upon exiting said second hollow spindle (14), each of said first and second cores (1a, 1b) are covered with two layers of wrapping yarn (2a, 2b) wrapped in opposite directions.

15. Method for manufacturing an electrically conductive elastic composite yarn according to claim 14, **characterized in that** said covering step of said first and second cores (1a, 1b) is carried out simultaneously and **in that** the first hollow spindle (13) associated with said first core (1a) and the first hollow spindle (13) associated with said second core (1b) rotate in

opposite directions and the second hollow spindle (14) associated with said first core (1a) and the second hollow spindle (13) associated with said second core (1b) rotate in opposite directions and opposite to the rotation direction of their respective first hollow spindles (13).

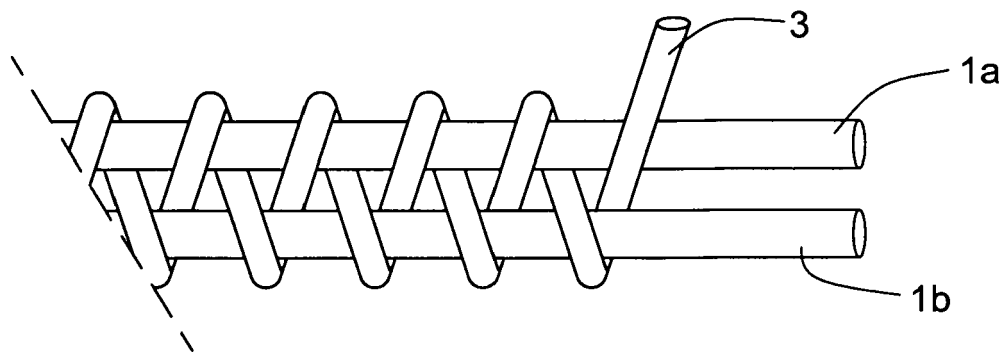


FIG. 1A

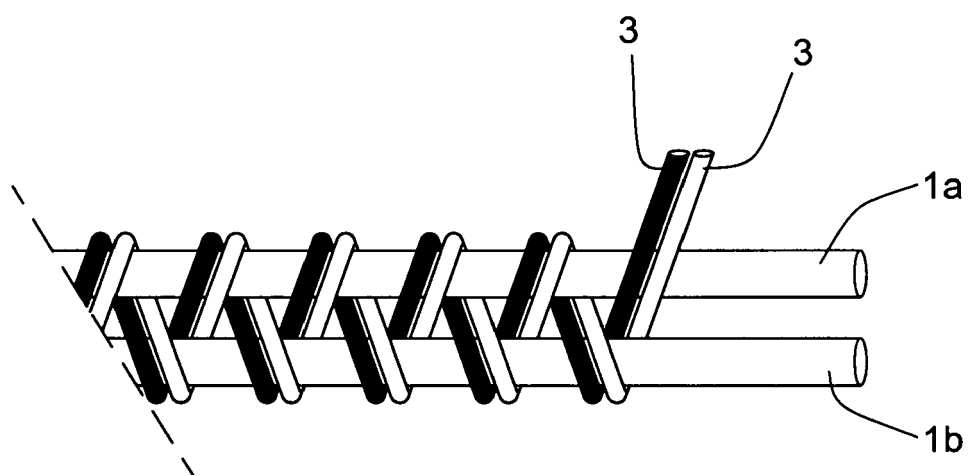


FIG. 1B

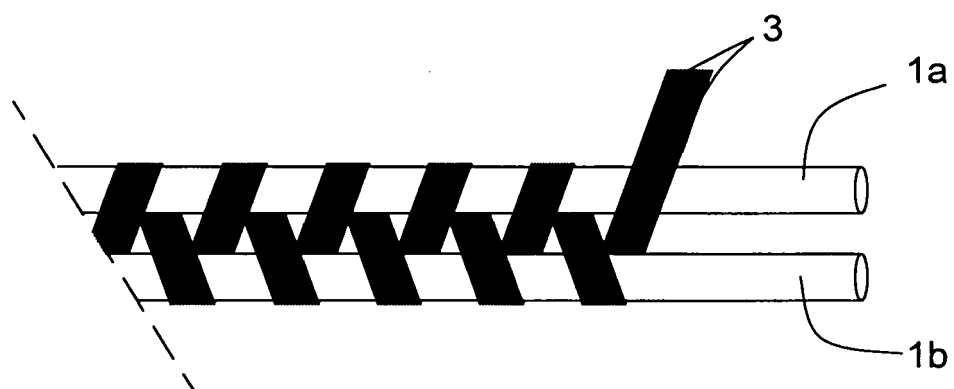


FIG. 1C

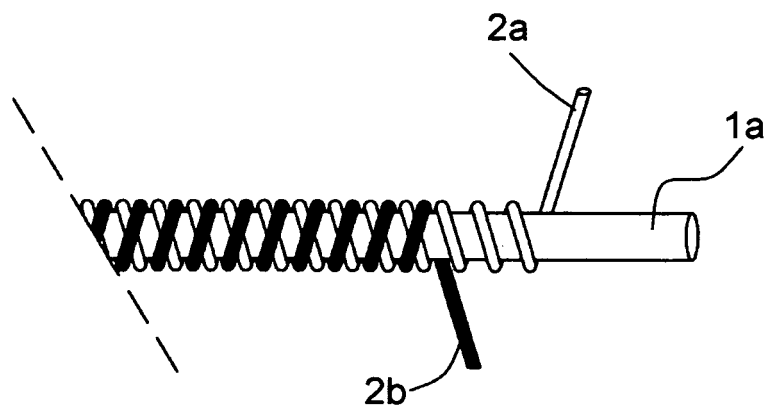


FIG. 2

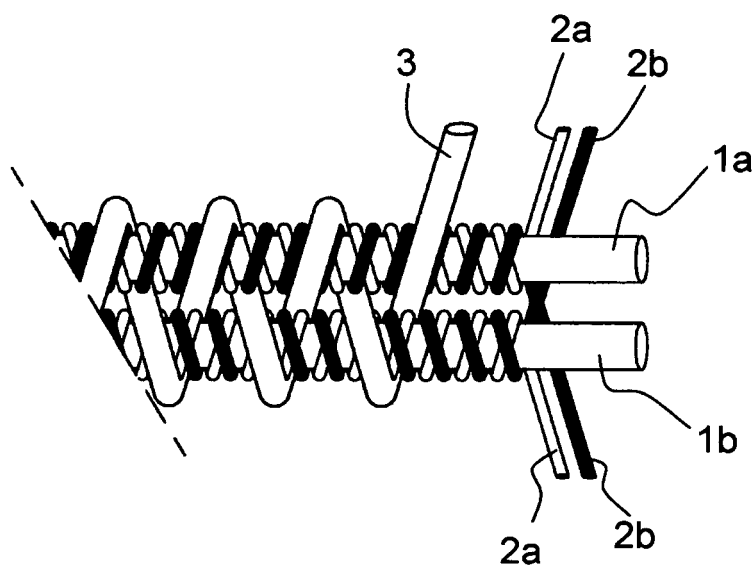


FIG. 3A

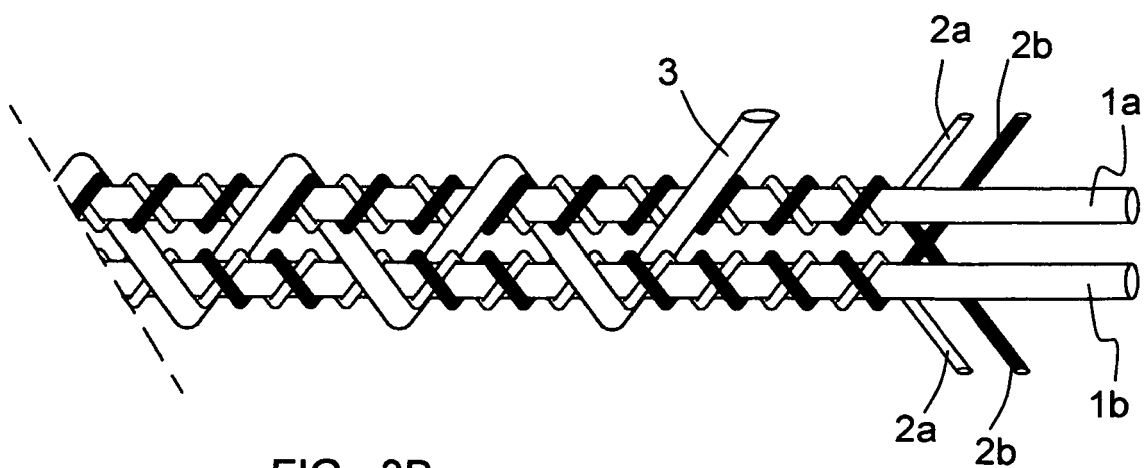
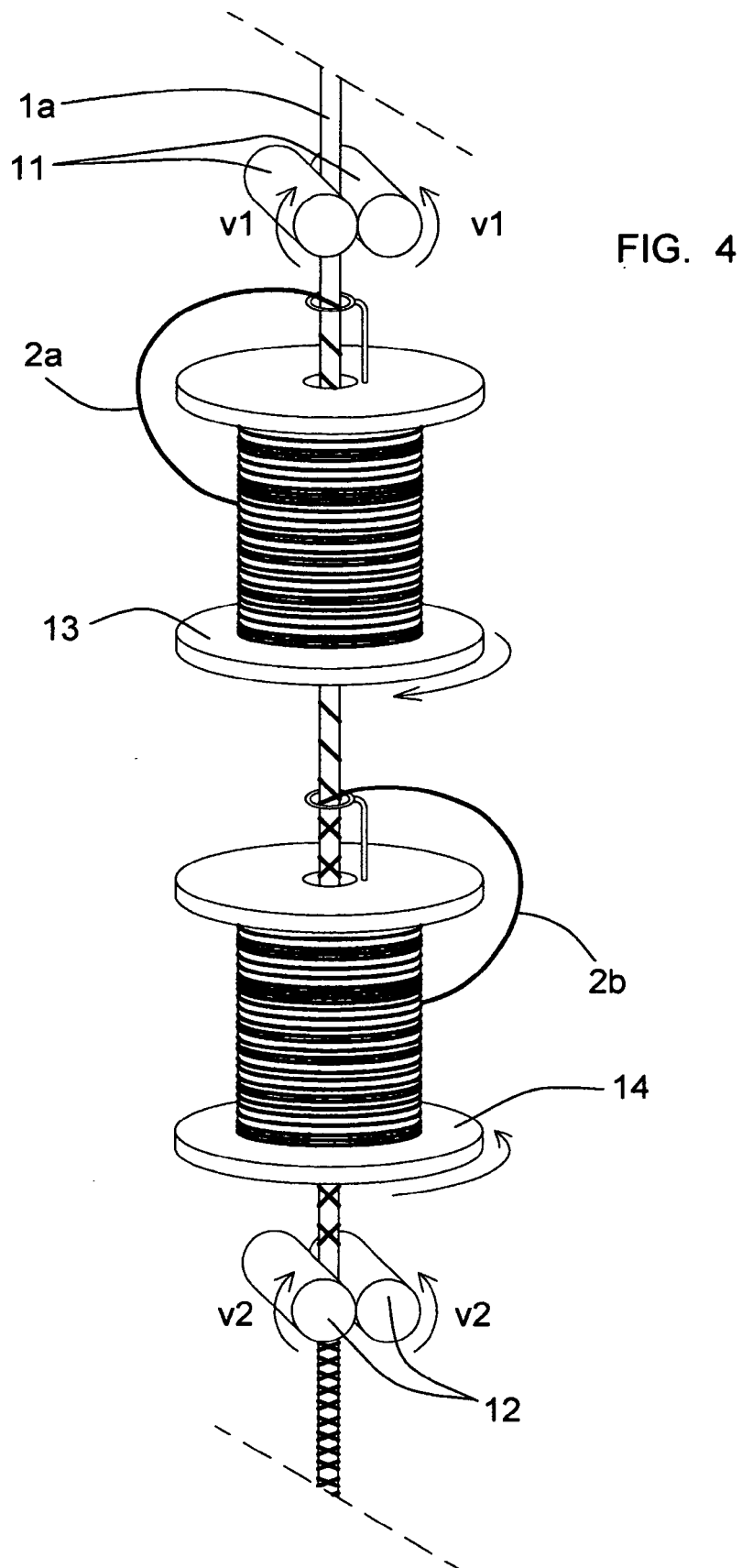


FIG. 3B



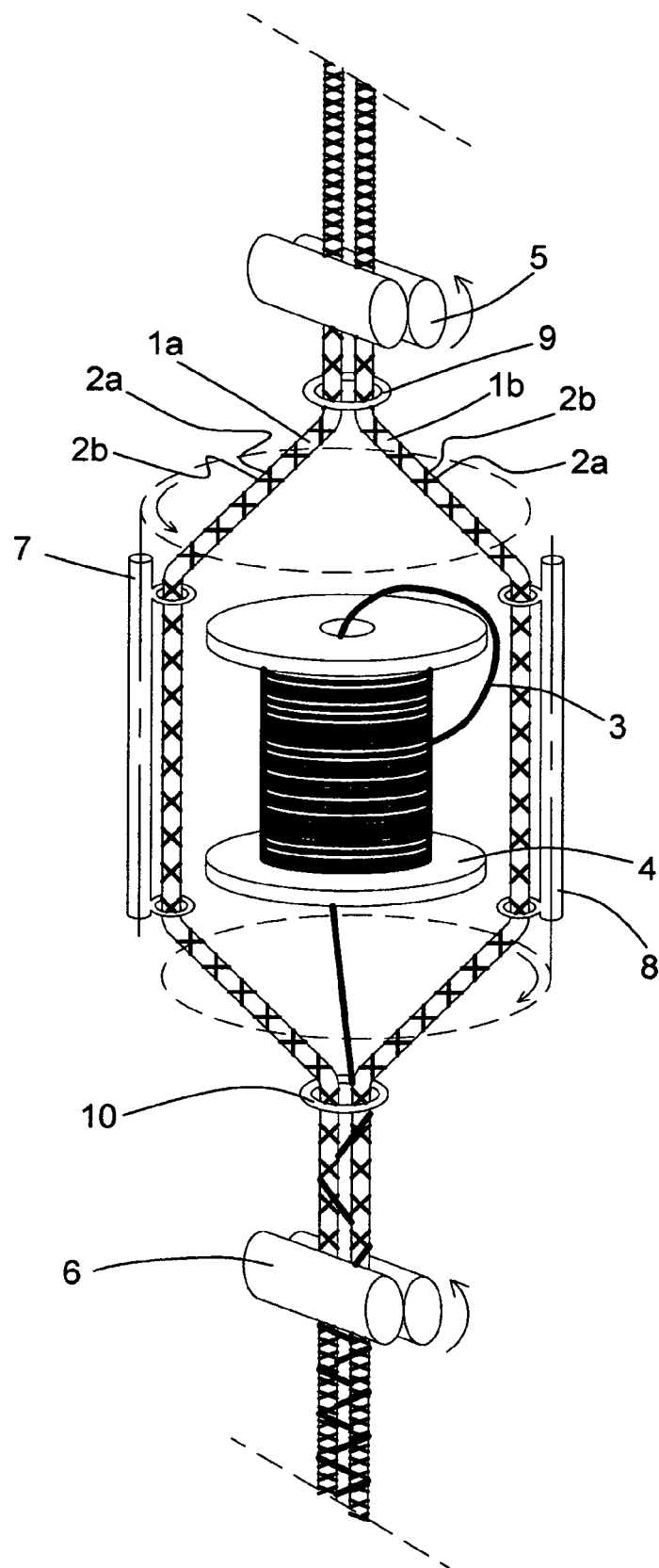
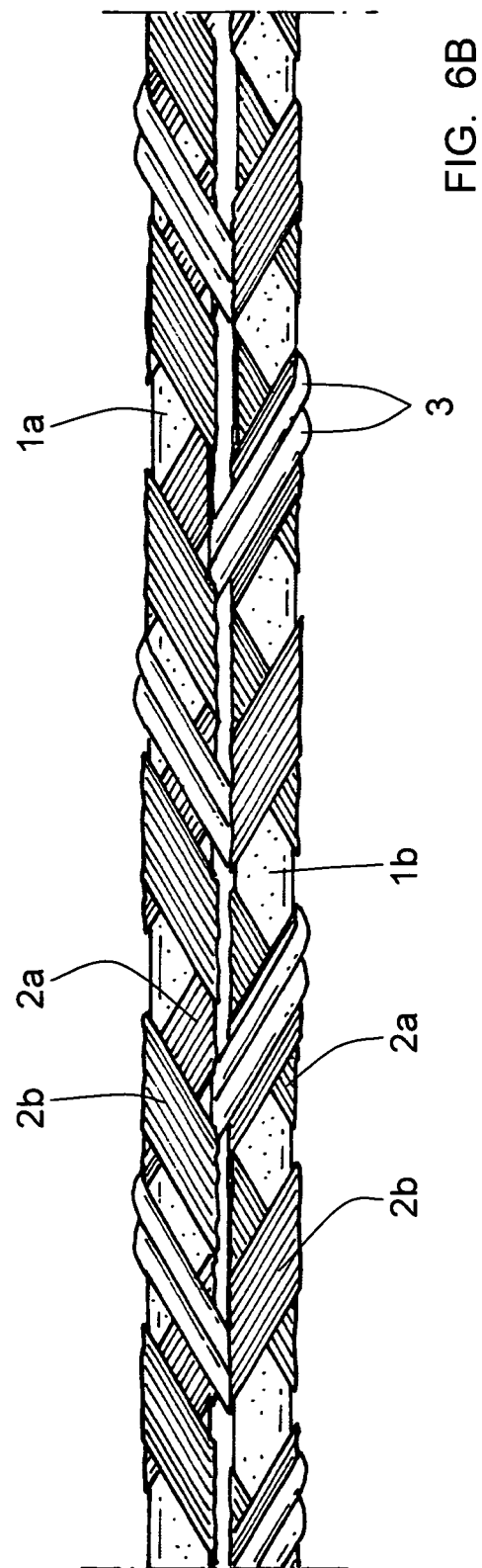
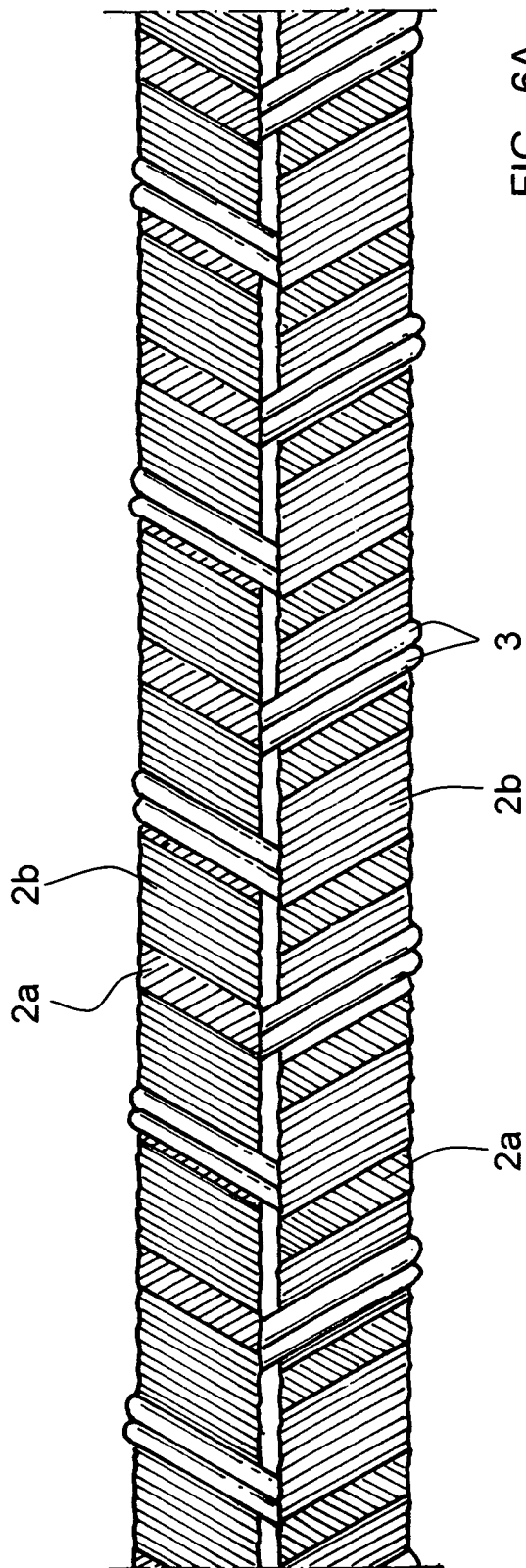


FIG. 5



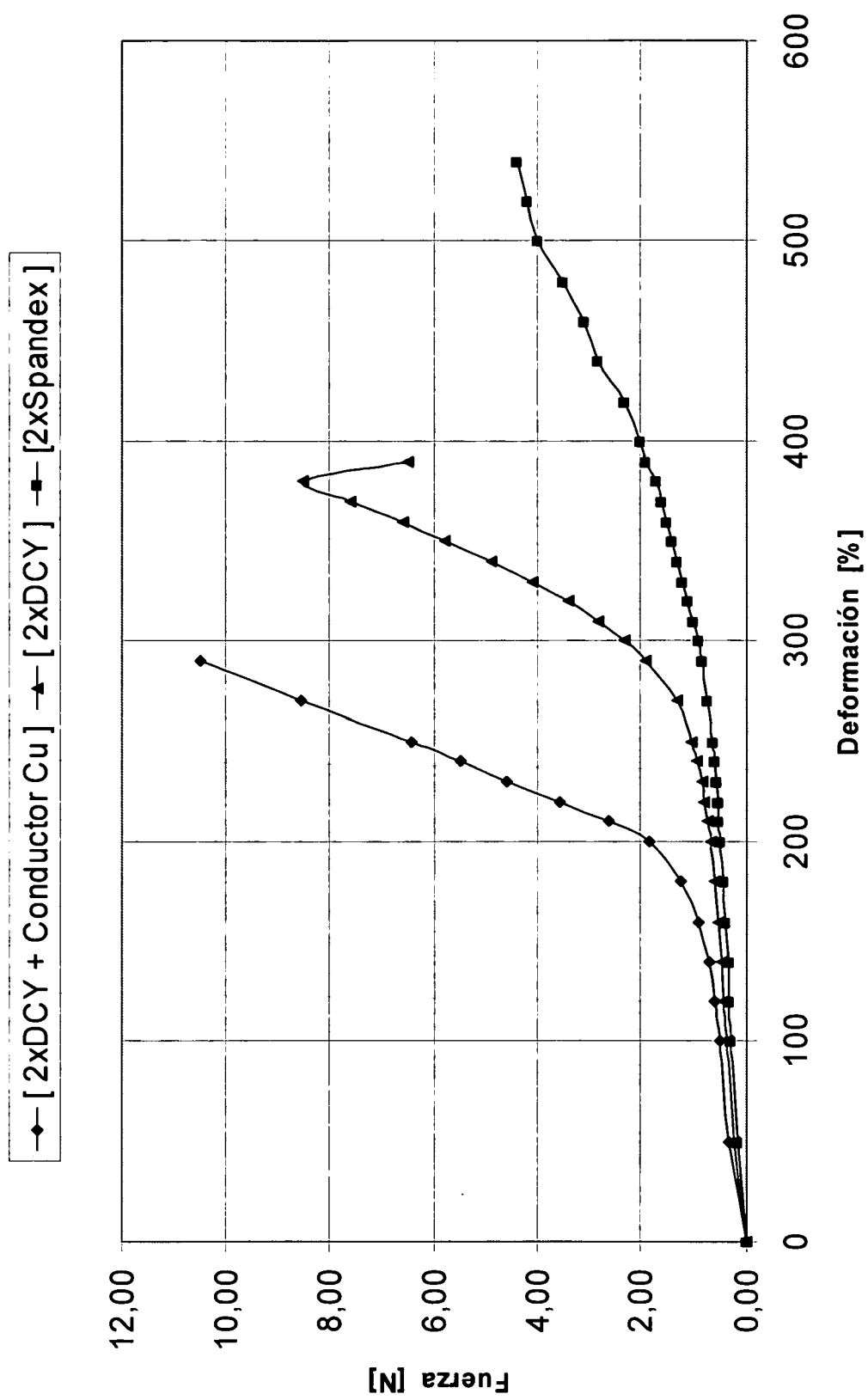


FIG. 7

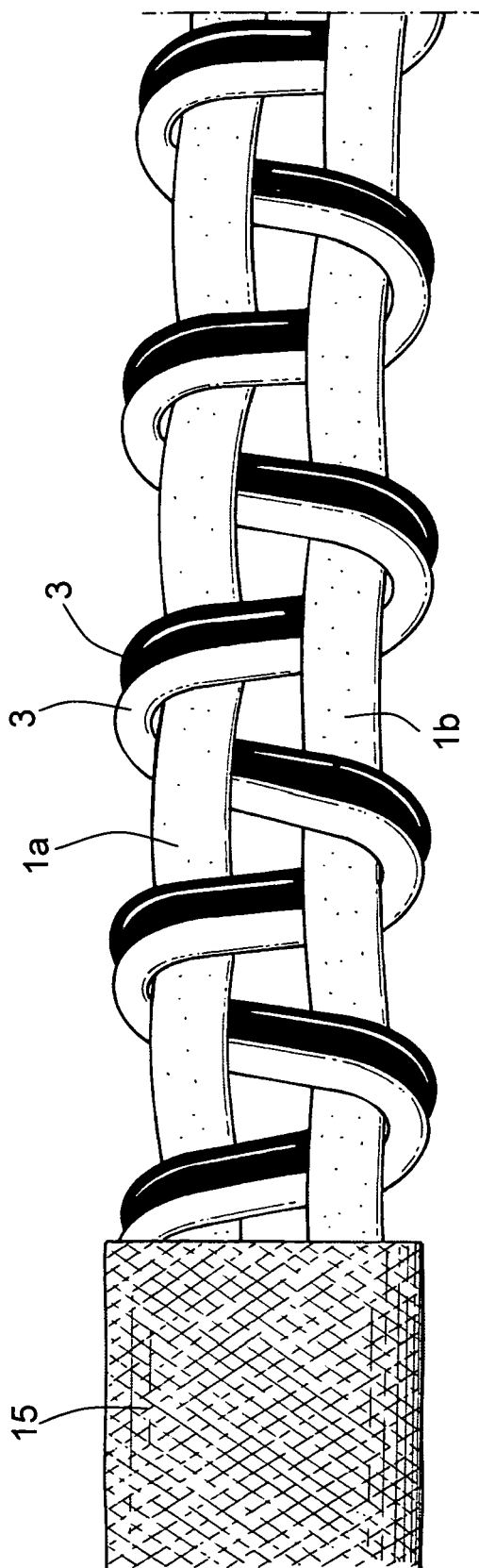


FIG. 8A

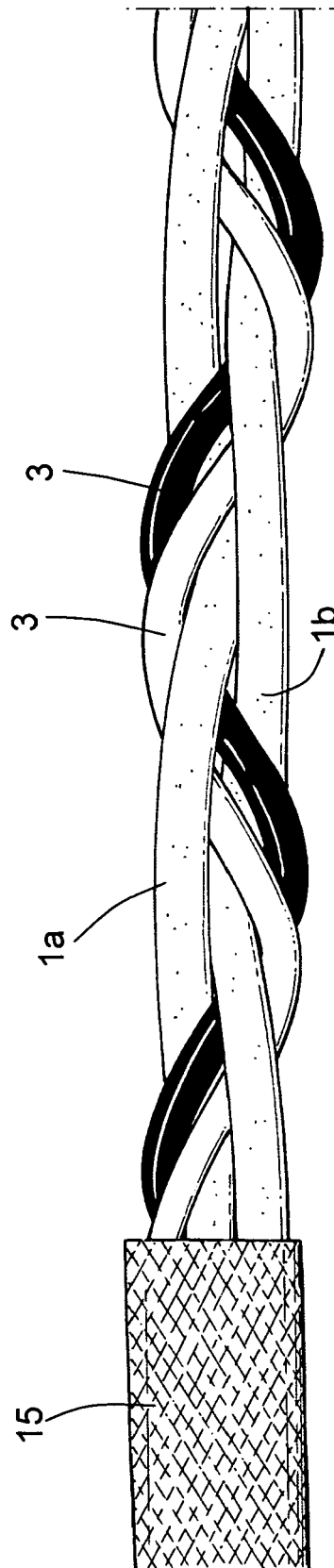


FIG. 8A

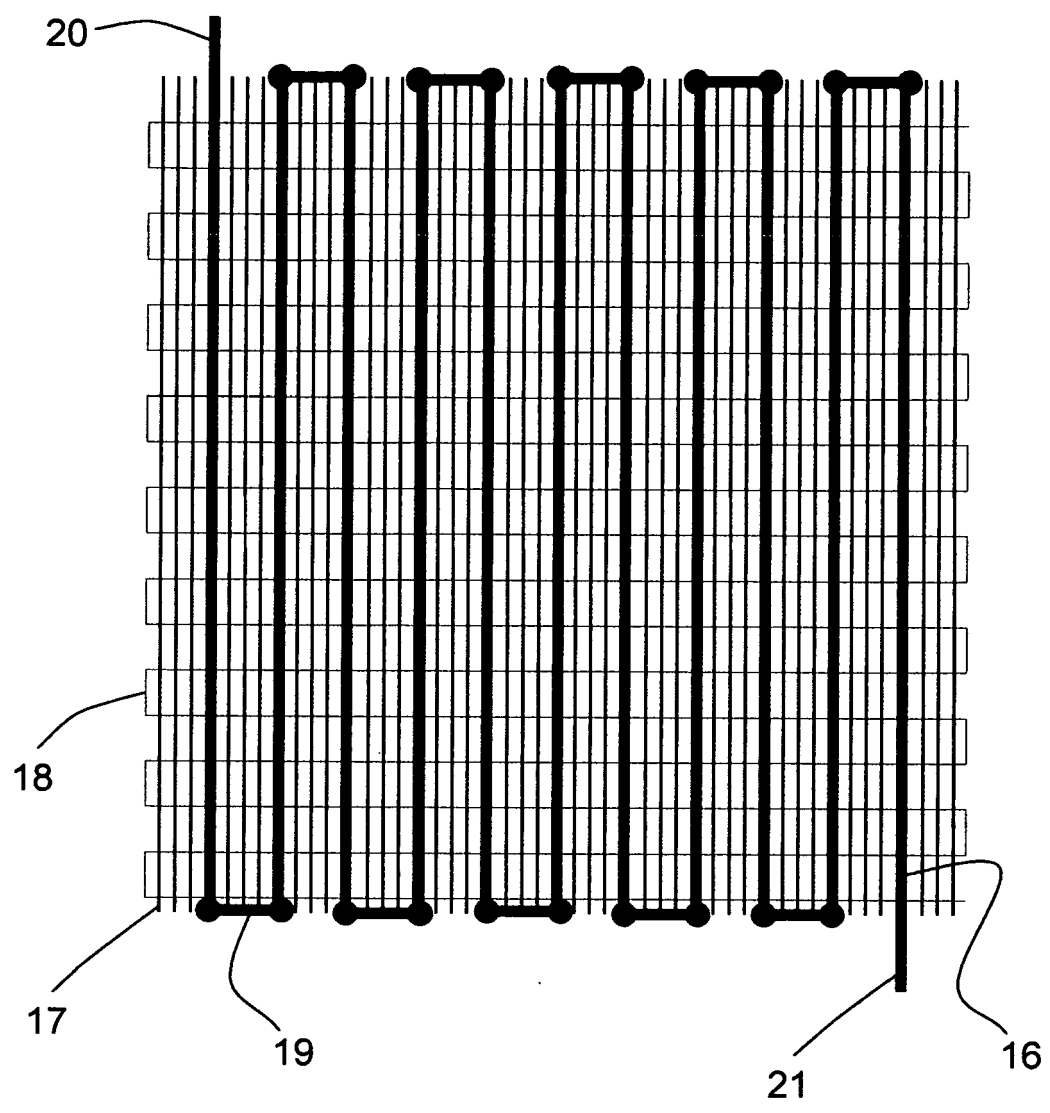


FIG. 9



EUROPEAN SEARCH REPORT

Application Number
EP 09 38 0068

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			D02G D03D D04B H01B H05B D07B A41D
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 21 October 2009	Examiner Pollet, Didier
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21-10-2009

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