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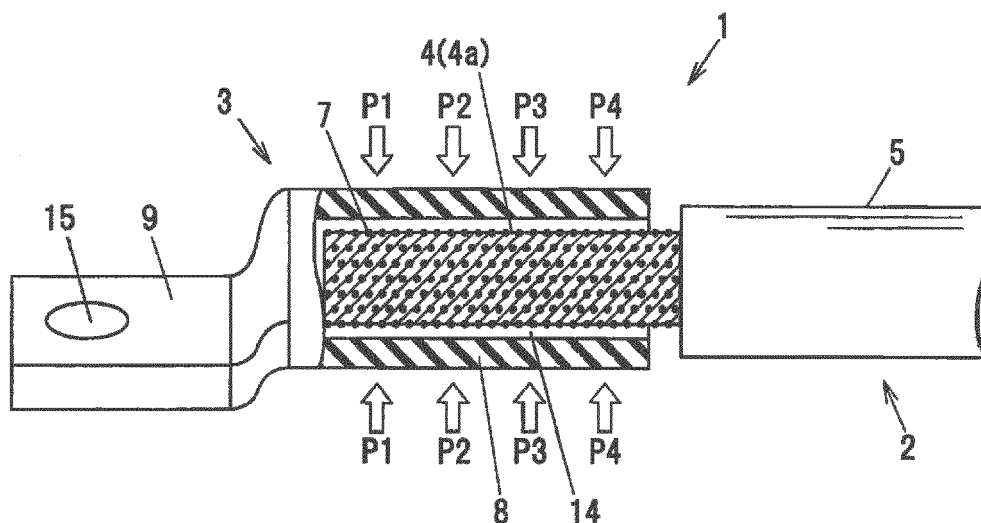
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(54) **ELECTRIC WIRE WITH TERMINAL**

(57) An electric wire with terminal comprises: an electric wire comprising a conductor comprising an aluminum or an aluminum alloy, an insulating cover covering the conductor and a conductor exposed portion that the conductor is exposed without being covered with the insulating cover at an end of the electric wire; a compression terminal comprising a compression section compres-

sion-crimped onto the conductor exposed portion; and a conductive particle-containing compound attached to the conductor exposed portion. The conductive particle-containing compound comprises conductive particles comprising a NiP or a Ni-B. The conductive particles included in the conductive particle-containing compound are not more than 20 wt%.

FIG.1



Description

Field of Invention

5 **[0001]** The invention relates to an electric wire with terminal.

Description of Related Art

10 **[0002]** An electric wire with terminal is known which is configured such that a compression terminal is crimped onto a conductor of an electric wire which is used for vehicle, etc., and the conductor is formed of aluminum or an aluminum alloy for the purpose of weight reduction, etc. (see, e.g., JP H08/321331 A)

[0003] In this type of electric wire with terminal, when a conductor **100** formed of aluminum or an aluminum alloy makes contact with oxygen **101** present in the air, etc., as shown in **FIG. 3A**, an oxide film **102** is formed on a surface of the conductor **100** as shown in **FIG. 3B**. Therefore, when a compression terminal **103** is crimped onto the conductor **100** of the electric wire as shown in **FIG. 3C**, electric resistance between the conductor **100** and the compression terminal **103** is increased due to the interposition of the oxide film **102**. **FIG. 3C** shows the state before the compression terminal **103** is compressed.

15 **[0004]** JP H08/321331 A discloses a technique in which conductive particles (metal particles) applied to the conductor of the electric wire before crimping the compression terminal onto the conductor of the electric wire break through the oxide film on the surface of the conductor by using pressure applied when crimping the compression terminal. In this technique, when the conductor is formed by twisting metal strands made of aluminum, the oxide film covering the metal strands is broken by the conductive particles.

Summary of Invention

25 **[0005]** If Zn particles are used as the conductive particles, the Zn particles break the oxide film on the surfaces of the metal strands and it is thus possible to reduce initial electrical resistance (hereinafter, also referred to as "initial resistance") between the compression terminal and the electric wire. However, if both the compression terminal and the conductor are formed of aluminum or an aluminum alloy and if a connecting portion therebetween is exposed to high temperature for a long period of time due to, e.g., temperature rise caused by large-current conduction, compressive stress acting between the metal strands and compressive stress acting between the metal strand and the compression terminal are reduced due to stress relaxation. In this case, at the connecting portion between the compression terminal and the conductor, an oxide film is formed again on the surfaces of the metal strands or a gap is formed between the metal strands. This may result in that electrical resistance between the compression terminal and the electric wire becomes larger than the initial resistance.

30 **[0006]** It is an object of the invention to provide an electric wire with terminal that prevents the electrical resistance between the conductor of the electric wire and the terminal compression-crimped thereto from increasing even when exposed to the high temperature.

35 **[0007]** According to an embodiment of the invention, an electric wire with terminal comprises:

40 an electric wire comprising a conductor comprising an aluminum or an aluminum alloy, an insulating cover covering the conductor and a conductor exposed portion that the conductor is exposed without being covered with the insulating cover at an end of the electric wire;
a compression terminal comprising a compression section compression-crimped onto the conductor exposed portion;
45 and
a conductive particle-containing compound attached to the conductor exposed portion,
wherein the conductive particle-containing compound comprises conductive particles comprising a Ni-P or a Ni-B, and
wherein the conductive particles included in the conductive particle-containing compound are not more than 20 wt%.

50 (Effects of the invention)

[0008] According to an embodiment of the invention, an electric wire with terminal can be provided that prevents the electrical resistance between the conductor of the electric wire and the terminal compression-crimped thereto from increasing even when exposed to the high temperature.

55 Brief Description of Drawings

[0009] Next, the present invention will be explained in more detail in conjunction with appended drawings, wherein:

FIG. 1 is a schematic explanatory diagram illustrating a configuration of an electric wire with terminal in an embodiment of the present invention;

FIG. 2 is a cross sectional view showing a configuration of an electric wire in the embodiment of the invention; and

FIGS. 3A to 3C are explanatory diagrams illustrating the problem which occurs in electric wires with terminal.

Description of Embodiment

[0010] An embodiment of the invention will be described in detail below in reference to the drawings.

Configuration of electric wire with terminal

[0011] **FIG. 1** is a schematic explanatory diagram illustrating a configuration of an electric wire with terminal in an embodiment of the invention.

[0012] An electric wire with terminal **1** in the embodiment of the invention is provided with an electric wire **2** and a compression terminal **3**. The electric wire with terminal **1** is used as, e.g., a wiring installed in a vehicle such as railroad car or automobile. Obviously, the electric wire with terminal **1** can be also used for a purpose other than for vehicle and can be used in, e.g., electrical and electronic equipment, etc.

Electric wire

[0013] The electric wire **2** is provided with a conductor **4** and an insulating cover **5** covering the conductor **4**. In addition, the electric wire **2** has a conductor exposed portion **4a** which is formed at an end portion and is a portion at which the conductor **4** is exposed without being covered with the insulating cover **5**. The conductor exposed portion **4a** is a portion onto which the compression terminal **3** is compression-cripped.

Conductor

[0014] The conductor **4** forms a core of the electric wire **2**. The conductor **4** is constructed from, e.g., a concentric-stranded wire, a bunch-stranded wire or a composite twisted wire formed by twisting plural metal strands **11**. The composite twisted wire here is a wire formed by twisting plural bunch-stranded wires **12** each of which is formed by twisting the plural metal strands **11**, as shown in **FIG. 2**. In this case, the total number of the metal strands **11** constituting one conductor (composite twisted wire) **4** is "m x n", where "m" is the number of the metal strands **11** constituting one bunch-stranded wire **12** and "n" is the number of the bunch-stranded wires **12** constituting one composite twisted wire. The metal strand **11** is formed of, e.g., aluminum or an aluminum alloy. The cross-sectional shape of the conductor **4** is generally a circle.

[0015] The main reason for using the composite twisted wire as the conductor **4** of the electric wire **2** is to achieve both a large current flow and high flexibility of the electric wire **2**. In detail, increasing an effective cross-sectional area (sq value: sq stands for square millimeter) of the conductor **4** is effective to allow the electric wire **2** to carry a larger current. However, if thick metal strands **11** are used for this purpose, flexibility decreases. Meanwhile, use of thin metal strands **11** (e.g., not more than 1 mm in diameter) is effective to increase flexibility. However, thickness which can be provided by twisting a bunch of thin metal strands **11** is limited. Unlike these cases, in the present embodiment, since the conductor **4** is a composite twisted wire formed by twisting plural metal strands **11** to form each bunch-stranded wire **12** and then twisting plural bunch-stranded wires **12**, the conductor **4** can have a large effective cross-sectional area even when formed of thin metal strands **11**. Thus, it is possible to achieve both a large current flow and high flexibility of the electric wire **2**.

[0016] A conductive particle-containing compound containing particles having electrical conductivity (conductive particles) **7** is attached to each of the plural metal strands **11** constituting the conductor exposed portion **4a** onto which the compression terminal **3** is compression-cripped. The conductive particle-containing compound is, e.g., a grease such as lubricating oil or thickener containing particles having electrical conductivity. The lubricating oil constituting the conductive particle-containing compound is, e.g., a fluorine-based oil, a silicone-based oil, an ester-based oil, or a hydrocarbon-based synthetic oil, etc. Among these lubricating oils, the fluorine-based oil or the silicone-based oil is preferably used so that electrical resistance between the compression terminal **3** and the conductor **4** of the electric wire **2** is less likely to increase even in a high-temperature environment. The conductive particles **7** act to break an oxide film covering the surface of the metal strand **11** constituting the conductor exposed portion **4a** when a compression section **8** of the compression terminal **3** is compression-cripped onto the conductor exposed portion **4a** of the conductor **4**. Therefore, the conductive particles **7** are preferably attached to the surfaces of the plural metal strands **11** constituting the conductor exposed portion **4a**. It is possible to attach the conductive particles **7** to the surfaces of the plural metal strands **11** along the longitudinal direction of the conductor exposed portion **4a** by applying the conductive particle-containing compound

to the surfaces of the plural metal strands **11** constituting the conductor exposed portion **4a**, or by inserting the conductor exposed portion **4a** into the compression section **8** inside which the conductive particle-containing compound is preliminarily attached. The conductive particles **7** are preferably provided in the entire cross-sectional region of the conductor **4**, including the inside and the outer peripheral portion of the conductor **4**. The inside of the conductor **4** means a portion on the inner side with respect to the outer peripheral portion of the conductor **4** (the center side in the radial direction of the conductor **4**), and the outer peripheral portion of the conductor **4** means a portion around the periphery of the conductor **4** which is visible from the outside when the conductor **4** is a bare wire (is exposed). In addition, the cross-sectional region of the conductor **4** means a substantially circle region formed by a group of the cross sections of the plural bunch-stranded wires **12** constituting the conductor **4** in a cross section of the conductor **4** taken along a direction orthogonal to the length direction of the electric wire **2**. In FIG. 2, a region inside a wound binding tape **6** is the cross-sectional region of the conductor **4**.

[0017] The conductive particles **7** are desirably uniformly dispersed in the entire cross-sectional region of the conductor **4**. In the present embodiment, the conductive particles **7** are attached to the surface of each of the metal strands **11** constituting the bunch-stranded wire **12** at the conductor exposed portion **4a**. Therefore, many conductive particles **7** are dispersed in the entire cross-sectional region of the bunch-stranded wire **12**, including the inside and the outer peripheral portion of the bunch-stranded wire **12**. Then, such bunch-stranded wires **12** are twisted together into one conductor **4** as a composite twisted wire. In the present embodiment, it is thereby possible to uniformly disperse the conductive particles **7** in the entire cross-sectional region of the conductor exposed portion **4a** of the conductor **4**. The meanings of the inside, the outer peripheral portion and the cross-sectional region of the bunch-stranded wire **12** are respectively the same as for those of the conductor **4**.

[0018] Regarding the size of the conductive particle **7**, when the diameter (the outer diameter) of the metal strand **11** is, e.g., **0.45 mm** (not more than **1 mm**), fine particles having an average particle size of not less than **1.0 μm** and not more than **10.0 μm** can be used as the conductive particle **7**. When the conductive particle **7** has an average particle size within such a range, the conductive particle-containing compound can easily enter the inside of the conductor exposed portion **4a** composed of twisted wires each formed by twisting plural metal strands **11** together, and the conductive particles **7** are likely to be uniformly attached to the surfaces of the metal strands **11** constituting the conductor exposed portion **4a**. The average particle size of the conductive particle **7** can be appropriately changed according to the outer diameter of the metal strand **11**. The average particle size of the conductive particle **7** here is a particle size represented by **D50** (the median diameter) in a cumulative particle size distribution obtained by a laser diffraction scattering method.

[0019] Hardness of the conductive particle **7** only needs to be enough to break through an oxide film on the surfaces of the metal strands **11** and to bite into the surfaces of the metal strands **11** when the compression terminal **3** is compression-crippled onto the conductor exposed portion **4a** of the conductor **4** (e.g., Vickers hardness **Hv** of not less than **400**). In addition, the conductive particle **7** is desirably formed of a material having a small standard redox potential difference with that of a material of the metal strand **11** (i.e., aluminum or an aluminum alloy). In the present embodiment, to reduce change in electrical resistance of the electric wire with terminal **1** (electrical resistance between the terminal and the electric wire) in a high-temperature environment, the conductive particle **7** is desirably formed of a less oxidizable material and is, e.g., Ni-P or Ni-B particle. By using such material to form the conductive particle **7**, it is possible to reduce change in electrical resistance of the electric wire with terminal **1** used in a high-temperature environment for a long period of time.

[0020] In detail, when the electric wire with terminal **1** has the compression terminal **3** and the conductor **4** both formed of aluminum or an aluminum alloy and a connecting portion between the compression terminal **3** and the conductor exposed portion **4a** of the conductor **4** is exposed to high temperature for a long period of time due to, e.g., temperature rise caused by large-current conduction, compressive stress acting between the metal strands **11** and compressive stress acting between the metal strand **11** and the compression terminal **3** would be reduced due to stress relaxation. However, since the electric wire with terminal **1** of the present embodiment is configured that the conductive particle-containing compound containing the conductive particles **7** formed of Ni-P or NiB is attached to the conductor exposed portion **4a**, it is possible to prevent an oxide film from being formed again on the surfaces of the metal strands **11** and also to prevent a gap from being formed between the metal strands **11**. As a result, in the electric wire with terminal **1** of the present embodiment, electrical resistance between the compression terminal **3** and the electric wire **2** (i.e., electrical resistance between the compression section **8** and the conductor exposed portion **4a**) is less likely to become greater than the initial resistance even when exposed to a high-temperature environment. In the electric wire with terminal **1** of the present embodiment, the content of the Ni-P or Ni-B conductive particles **7** in the conductive particle-containing compound is preferably not more than **20 wt%**, more preferably not less than **2 wt%** and not more than **20 wt%**, so that the above-mentioned effects can be easily obtained.

Insulating cover

[0021] The insulating cover **5** is formed of an insulating material. The material which can be used to form the insulating cover **5** is, e.g., a fluorine-based resin, an olefin-based resin or a silicone-based resin, etc. The insulating cover **5** is formed to surround the outer peripheral portion of the conductor **4** and has a circular cross-sectional shape. The insulating cover **5** covers over the conductor **4** in a longitudinal direction of the electric wire **2**. However, a portion not covered with the insulating cover **5** is provided at a longitudinal end of the electric wire **2** as shown in **FIG. 1**, and the conductor **4** thereby has a partially exposed portion (hereinafter, referred to as "conductor exposed portion") **4a**. To obtain the conductor exposed portion **4a**, the insulating cover **5** covering the entire length of the conductor **4** is stripped only at an end portion of the electric wire **2**. Alternatively, the conductor exposed portion **4a** can be obtained by applying the insulating cover **5** around the conductor **4** except an end portion so that the conductor **4** is preliminarily exposed only at an end portion of the electric wire **2**.

[0022] The binding tape **6** is interposed between the conductor **4** and the insulating cover **5** in a radial direction of the electric wire **2**. The binding tape **6** is wound around the conductor **4** and physically separates the conductor **4** from the insulating cover **5**. The reason for winding the binding tape **6** around the conductor **4** is to prevent a material of the insulating cover **5** from adversely affecting the metal strands **11** when the insulating cover **5** is formed around the conductor **4** by extrusion molding. At the conductor exposed portion **4a** of the conductor **4**, the binding tape **6** is removed together with the insulating cover **5**.

Compression terminal

[0023] The compression terminal **3** integrally has the compression section **8** and a connecting portion **9**. The compression terminal **3** is formed by, e.g., plating tin, etc., onto a terminal material formed of aluminum or an aluminum alloy. Alternatively, another plating (e.g., silver plating) may be used in place of the tin plating.

[0024] The compression section **8** is a portion connected to the conductor **4** (the conductor exposed portion **4a**) of the electric wire **2**. The compression section **8** is formed into a barrel shape (cylindrical shape) having a circular cross section. The inside of the compression section **8** is a hollow portion **14** into which the conductor exposed portion **4a** of the conductor **4** of the electric wire **2** can be inserted. An end portion (entry portion) of the hollow portion **14** is an opening which is larger than the outer diameter of the conductor **4** of the electric wire **2**. As shown in **FIG. 1**, predetermined portions of the compression section **8** are compressed in a state in which the conductor **4** (the conductor exposed portion **4a**) of the electric wire **2** is inserted thereinto from the end portion of the hollow portion **14**. Thus, the compression section **8** in contact with the surface of the conductor **4** (the conductor exposed portion **4a**) is compression-crimped. Preferably, the compression section **8** is compression-crimped onto the conductor **4** (the conductor exposed portion **4a**) by compressing plural compression points (**P1**, **P2**, **P3** and **P4** in **FIG. 1**) along the longitudinal direction of the conductor **4** (the conductor exposed portion **4a**). The plural compression points are spaced apart from each other at predetermined intervals. In addition, the compression section **8** is compressed all around the circumference at each of the plural compression points. Due to having such plural compression points along the longitudinal direction of the conductor **4** (the conductor exposed portion **4a**), the compression section **8** is effective to make electrical resistance between the compression terminal **3** and the conductor **4** less likely to increase particularly when both the compression terminal **3** and the conductor **4** are formed of aluminum or an aluminum alloy.

[0025] The connecting portion **9** is formed into a plate shape. The connecting portion **9** has a connecting hole **15** for connection to another terminal (not shown). The connecting hole **15** penetrates the connecting portion **9** in a thickness direction and has a circular shape in a plan view. The shape, etc., of the connecting portion **9** can be arbitrarily changed according to the form of the other terminal.

[0026] The invention will be described in more detail below in reference to Examples. However, the invention is not limited to only these Examples.

Examples

[0027] The configurations of samples in Examples **1** to **4** and Comparative Examples **1** to **3** are shown in Tables **1** and **2**. The results for the evaluation item (described later) are also shown in Tables **1** and **2**.

Table 1

	Conductive particle	Particle content (wt%)	Rate of increase in resistance (%)
Example 1	Ni-P	2	11
Example 2	Ni-P	5	10

(continued)

	Conductive particle	Particle content (wt%)	Rate of increase in resistance (%)
Example 3	Ni-P	10	15
Comparative Example 1	-	-	20
Comparative Example 2	Zn	5	25

Table 2

	Conductive particle	Particle content (wt%)	Rate of increase in resistance (%)
Example 4	Ni-P	20	14
Comparative Example 3	Ni-P	40	22

Example 1

[0028] In Example 1, a sample of an electric wire with terminal was made by the following procedure. In detail, a composite twisted wire formed using plural metal strands of aluminum and having a cross-sectional area of **200** SQ (square millimeter) was prepared as a conductor (the outer diameter of metal strand: ϕ **0.45** mm, the total number of metal strands: **37x34**), and an electric wire was made by covering the conductor with an insulating cover. The insulating cover at an end of the electric wire was stripped and a conductor exposed portion was thereby formed at an end of the conductor. A conductive particle-containing compound formed of a fluorine-based oil and containing Ni-P conductive particles with an average particle size of **3** μ m was applied to the conductor exposed portion. Next, the conductor exposed portion to which the conductive particle-containing compound was applied was inserted into a compression section of an aluminum compression terminal, and the conductor exposed portion formed of aluminum was electrically connected to the compression section of the aluminum compression terminal by swaging (compressing) the inserted portion, thereby obtaining a sample of the electric wire with terminal. The content of the NiP conductive particle was 2 wt%.

Example 2

[0029] A sample of the electric wire with terminal in Example 2 was made in the same manner as Example 1, except that a conductive particle-containing compound formed of a fluorine-based oil containing **5** wt% of Ni-P conductive particles was used.

Example 3

[0030] A sample of the electric wire with terminal in Example 3 was made in the same manner as Example 1, except that a conductive particle-containing compound formed of a fluorine-based oil containing **10** wt% of Ni-P conductive particles was used.

Example 4

[0031] A sample of the electric wire with terminal in Example 4 was made in the same manner as Example 1, except that a conductive particle-containing compound formed of a fluorine-based oil containing **20** wt% of Ni-P conductive particles was used.

Comparative Example 1

[0032] In Comparative Example 1, the conductor exposed portion was inserted into the compression section of the aluminum compression terminal without applying the conductive particle-containing compound formed of a fluorine-based oil containing conductive particles to the conductor exposed portion, and the conductor exposed portion formed of aluminum was electrically connected to the compression section of the aluminum compression terminal by swaging (compressing) the inserted portion, thereby obtaining a sample of the electric wire with terminal.

Comparative Example 2

[0033] A sample of the electric wire with terminal in Comparative Example 2 was made in the same manner as Example 1, except that a conductive particle-containing compound containing Zn conductive particles (the content: 5 wt%) in place of Ni-P conductive particles was used.

Comparative Example 3

[0034] A sample of the electric wire with terminal in Comparative Example 3 was made in the same manner as Example 1, except that a conductive particle-containing compound formed of a fluorine-based oil containing 40 wt% of Ni-P conductive particles was used.

Rate of increase in resistance

[0035] The rate of increase in resistance is a rate of change of the resistance value after the high-temperature exposure test from the initial resistance ((the resistance value after the high-temperature exposure test/the initial resistance value) x 100).

[0036] The initial resistance value here was obtained by measuring resistance between the aluminum compression terminal and the other end of the aluminum conductor in the obtained electric wire with terminal.

[0037] Meanwhile, in the high-temperature exposure test, the electric wire with terminal after measuring the initial resistance value was placed and kept in a constant-temperature oven at 200°C in the air for 200 hours. Then, after cooling the sample to room temperature, the resistance value after the high-temperature exposure test was measured by the same method as for the measurement of the initial resistance value.

[0038] The samples were regarded as acceptable when the rate of increase in resistance was not more than 15%.

[0039] From the results, it was confirmed that an increase in the rate of increase in resistance was reduced more when using the conductive particle-containing compound containing Ni-P conductive particles than when using the conductive particle-containing compound containing Zn conductive particles. It was confirmed that the rate of increase in resistance can be reduced to not more than 15% particularly when the particle content is not less than 2 wt% and not more than 20 wt%.

Other embodiments of the invention

[0040] Although the embodiment of the invention has been described in detail, the invention is not intended to be limited to the embodiment, and the various kinds of modifications can be implemented without departing from the gist of the invention.

[0041] For example, although the conductive particle-containing compound formed of a fluorine-based oil and containing Ni-P conductive particles was used in Examples specifically implementing the embodiment, it is possible to use a conductive particle-containing compound formed using a silicone-based oil. In addition, the conductive particle-containing compound used in Examples specifically implementing the embodiment can contain Ni-B conductive particles (the particle content: not less than 2 wt% and not more than 20 wt%) in place of the Ni-P conductive particles.

Claims

1. An electric wire with terminal, comprising:

an electric wire comprising a conductor comprising an aluminum or an aluminum alloy, an insulating cover covering the conductor and a conductor exposed portion that the conductor is exposed without being covered with the insulating cover at an end of the electric wire;

a compression terminal comprising a compression section compression-crimped onto the conductor exposed portion; and

a conductive particle-containing compound attached to the conductor exposed portion, wherein the conductive particle-containing compound comprises conductive particles comprising a Ni-P or a Ni-B, and

wherein the conductive particles included in the conductive particle-containing compound are not more than 20 wt%.

2. The electric wire with terminal according to claim 1, wherein the compression terminal comprises aluminum or an

aluminum alloy.

3. The electric wire with terminal according to claim 1 or 2, wherein the compression section comprises a plurality of compression points along a longitudinal direction of the conductor exposed portion.

4. The electric wire with terminal according to any one of claims 1 to 3, wherein the plurality of compression points of the compression section are spaced apart from each other.

5. The electric wire with terminal according to claim 3 or 4, wherein the compression section is compressed all around the circumference at each of the plurality of compression points.

FIG.1

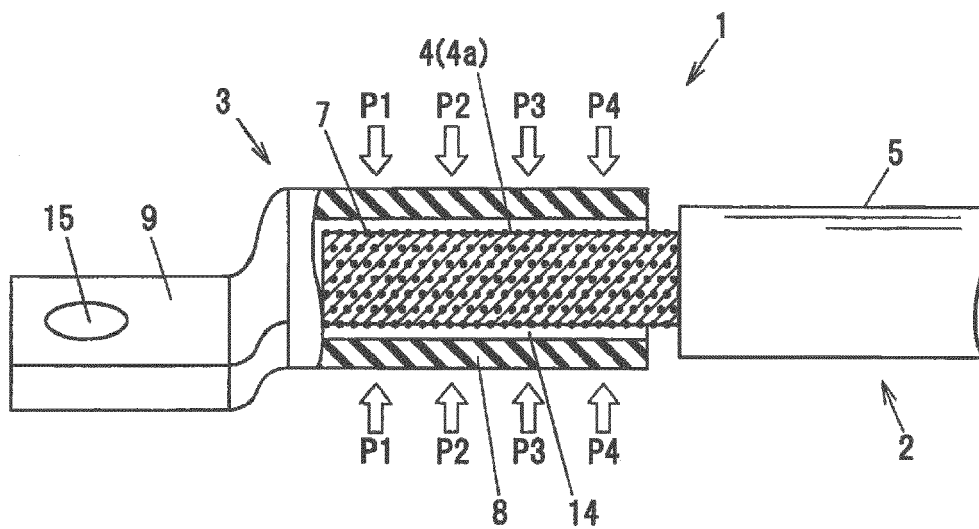


FIG.2

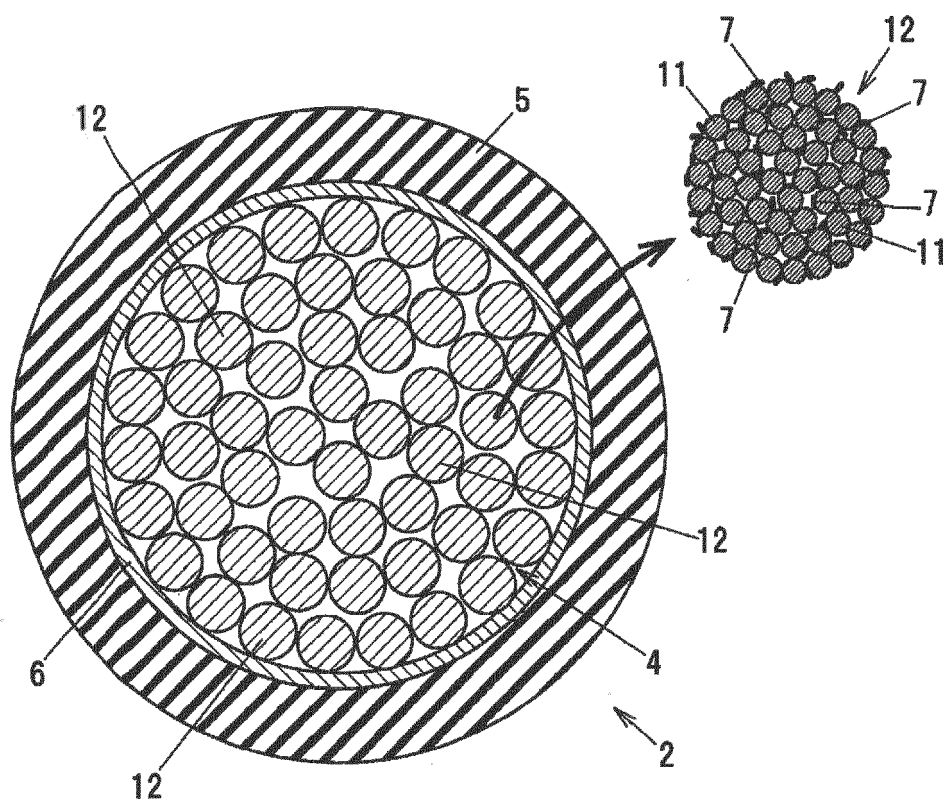


FIG.3A

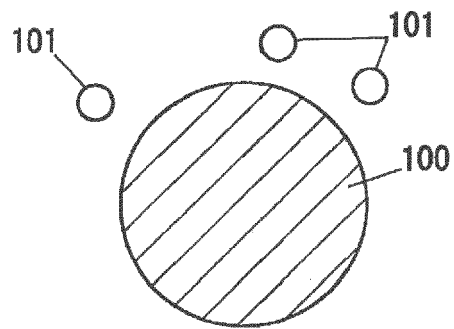


FIG.3B

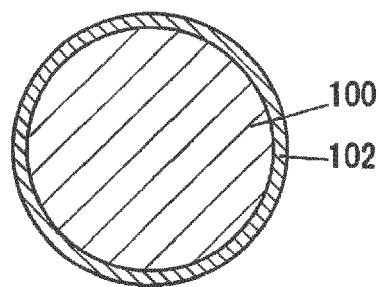
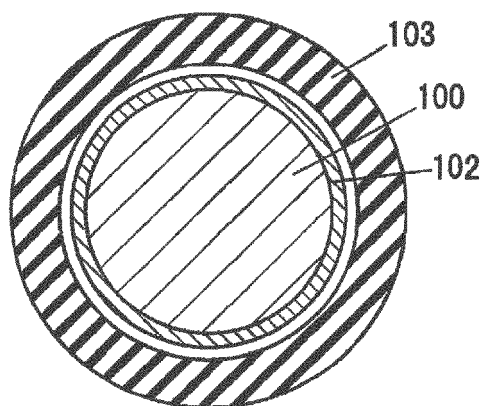


FIG.3C





EUROPEAN SEARCH REPORT

Application Number
EP 18 17 5004

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 13 November 2018	Examiner Oliveira Braga K., A
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03/82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 18 17 5004

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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