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(71) Applicant: **Hitachi Metals, Ltd.**
Minato-ku
Tokyo 108-8224 (JP)

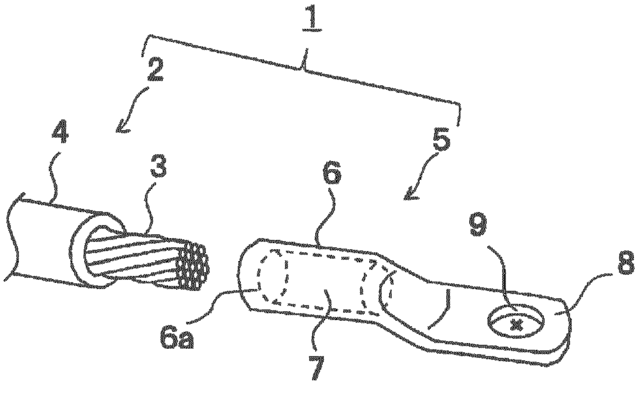
(72) Inventors:
- **INOUE, Ryo**
  Tokyo, 108-8224 (JP)
- **SATO, Tetsuro**
  Tokyo, 108-8224 (JP)
- **ENDO, Yuju**
  Tokyo, 108-8224 (JP)

(74) Representative: **Betten & Resch**
Patent- und Rechtsanwälte PartGmbB
Maximiliansplatz 14
80333 München (DE)

(54) **ELECTRIC WIRE WITH TERMINAL, METHOD FOR MANUFACTURING THE SAME, AND TERMINAL FOR ELECTRIC WIRE WITH TERMINAL**

(57) An electric wire with terminal **1** is provided with a conductor **3** made of an aluminum material, an electric wire **2,** and a terminal **5** made of an aluminum material which is configured to be connected to the conductor **3.** The terminal **5** includes three or more compressed portions along a longitudinal direction of the conductor **3.** A resistance ratio growth rate (%) obtained by a formula ((R**2**-R**1**)/R**1**)×**100** is not more than **19%** wherein R**1** represents an electric resistance ratio between the conductor **3** and the terminal **5** before performing a test that keeps the electric wire with terminal **1** at **150°C** in air for **50** hours, and R**2** represents an electric resistance ratio between the conductor **3** and the terminal **5** after performing the test.

FIG. 1



EP 3 687 000 A1

Description

BACKGROUND OF THE INVENTION

1. FIELD OF THE INVENTION

[0001] The present invention relates to an electric wire with terminal, a method for manufacturing the same, and a terminal for the electric wire with terminal.

2. DESCRIPTION OF THE RELATED ART

[0002] Conventionally, for an electric wire with terminal which is formed by connecting a terminal and a conductor of the electric wire, a conductor and a terminal each being made of copper or copper alloy has been used in view of electrical conductivity. Recently, it is considered to use a conductor and a terminal each being made of an aluminum material in view of weight reducing. For example, Japanese Patent No. 6410163 discloses connecting a terminal made of aluminum or aluminum alloy to a conductor made of aluminum or aluminum alloy.

[0003] [Patent Document **1**] Japanese Patent No. 6410163

SUMMARY OF THE INVENTION

[0004] However, aluminum tends to cause stress relaxation in comparison to copper. Thus, when the terminal made of an aluminum material is connected to the conductor made of an aluminum material, the stress caused at a connection between the conductor and the terminal decreases as time advances. In accordance with this, contact force between the conductor and the terminal may decrease and electric resistance between the conductor and the terminal may increase. When electric current flows through the conductor while the electric resistance between the conductor and the terminal is large, the electric wire with terminal generates heat so that the heat may cause electric wire breaking or loose connection.

[0005] It is an object of the invention to provide an electric wire with terminal that maintains low electric resistance between the conductor made of an aluminum material and the terminal made of an aluminum material and ensures enough electric connection, the method for manufacturing the same, and a terminal for the electric wire with terminal.

[0006] According to the first embodiment of the invention, an electric wire with terminal comprises: an electric wire comprising a conductor comprising an aluminum material and an insulation layer coating the conductor; and a terminal comprising an aluminum material and including a hollow portion into which the conductor exposed from an end of the electric wire is inserted, which is connected to the conductor by compressing the hollow portion while the conductor is inserted into the hollow portion, wherein the terminal comprises three or more compressed portions along a longitudinal direction of the conductor, and wherein a resistance ratio growth rate (%) obtained by a formula $((R2-R1)/R1)\times 100$ is not more than **19**% wherein R**1** represents an electric resistance ratio between the conductor and the terminal before performing a test that keeps the electric wire with terminal at **150**°C in air for **50** hours, and R**2** represents an electric resistance ratio between the conductor and the terminal after performing the test.

[0007] According to the second embodiment of the invention, a method for manufacturing an electric wire with terminal comprises: preparing an electric wire comprising a conductor comprising an aluminum material and an insulation layer coating the conductor, and a terminal comprising an aluminum material and including a hollow portion; and connecting the terminal to the conductor by forming a plurality of compressed portions on the terminal by compressing the terminal three or more times while the conductor exposed from an end of the electric wire is inserted into the hollow portion, wherein said connecting the terminal to the conductor comprises forming a further compressed portion between adjacent compressed portions which are already formed.

[0008] According to the third embodiment of the invention, a terminal comprises a hollow portion into which a conductor is inserted, wherein the terminal is configured to be connected to the conductor by compressing the terminal while the conductor is inserted into the hollow portion, and wherein information as to a terminal compression order is given on the terminal.

<u>Points of the invention</u>

[0009] According to an embodiment of the invention, an electric wire with terminal, the method for manufacturing the same, and a terminal of the electric wire with terminal can be provided that maintain low electric resistance between the conductor made of an aluminum material and the terminal made of an aluminum material and ensure enough electric connection.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010]

FIG. 1 is a perspective view showing a terminal and a conductor of an electric wire with terminal according to the embodiment, which shows a state before the conductor is inserted into a hollow portion of the terminal;

FIG. 2 is a cross-sectional view showing an electric wire with terminal according to the embodiment, which shows a state after the conductor is inserted into the hollow portion of the terminal and before the hollow portion is compressed;

FIGS. 3A to **3**C are cross-sectional views showing an electric wire with terminal according to the embodiment of which the terminal is compressed three times, wherein **FIG. 3**A shows a cross-sectional view showing an electric wire with terminal when the first compression is finished, **FIG. 3**B shows a cross-sectional view showing the electric wire with terminal when the second compression is finished, and **FIG. 3**C shows a cross-sectional view showing the electric wire with terminal when the third compression is finished;

FIG. 4 is a block diagram showing a terminal according to the embodiment; and

FIGS. 5A and **5**B are cross-sectional views showing an electric wire with terminal which is compressed two times, wherein **FIG. 5**A shows a cross-sectional view showing an electric wire with terminal when the first compression is finished, and **FIG. 5**B shows a cross-sectional view showing the electric wire with terminal when the second compression is finished;

FIGS. 6A to **6**C are cross-sectional views showing an electric wire with terminal according to the embodiment of which the terminal is compressed three times, wherein **FIG. 6**A shows a cross-sectional view showing an electric wire with terminal when the first compression is finished, **FIG. 6**B shows a cross-sectional view showing the electric wire with terminal when the second compression is finished, and **FIG. 6**C shows a cross-sectional view showing the electric wire with terminal when the third compression is finished;

FIG. 7 is a cross-sectional view showing portions where compressed portions are formed when a terminal of an electric wire with terminal according to the embodiment is compressed four times;

FIG. 8 is a cross-sectional view showing portions where compressed portions are formed when a terminal of an electric wire with terminal according to the embodiment is compressed five times;

FIG. 9 is a diagram showing a summary of high temperature exposure test; and

FIG. 10 is a diagram showing a measuring method of electric resistance ratio.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0011] Next, an electric wire with terminal, a method for manufacturing the same, and a terminal of the electric wire with terminal according to the present invention will be described in reference to the appended drawings.

<**1**. Example of an electric wire with terminal>

[0012] An example of an electric wire with terminal will be explained as follows.

[0013] Referring to **FIG. 1,** an electric wire with terminal **1** according to the present embodiment comprises an electric wire **2** and a terminal **5.** For example, the electric wire with terminal **1** may be used as a wiring member to be used for buildings, aero generators, railroad cars, and automobiles.

(Electric wire)

[0014] The electric wire **2** is configured as so-called insulated electric wire. The electric wire **2** comprises a conductor **3** and an insulation layer **4** that coats the conductor **3.** An exposed part of the conductor **3** exposed at an end of the electric wire **2** is inserted into a hollow portion **7** of the terminal **5.**

[0015] The conductor **3** constitutes a core wire of the electric wire **2.** A stranded wire stranding metal wires or a plurality of metal strands may be used as the conductor **3.** As a metal material for the conductor **3,** e.g., pure aluminum or aluminum alloy (hereinafter, these materials are collectively referred to as "aluminum material") are used. Pure aluminum is a material comprising Al and inevitable impurities or consisting of Al and inevitable impurities. As the pure aluminum, e.g., electric conductor grade aluminum (ECA1) may be used. As the aluminum alloy, e.g., Al-Zr, Al-Fe-Zr and the like as below may be used. Al-Zr is aluminum alloy having a chemical composition comprising or consisting of **0.03** to **1.5**% by mass of Zr, **0.1** to **1.0**% by mass of Fe and Si, and the balance being Al and inevitable impurities. Al-Fe-Zr is aluminum alloy having a chemical composition comprising or consisting of **0.01** to **0.10**% by mass of Zr, not more than **0.1**% by mass of Si, **0.2** to **1.0**% by mass of Fe, not more than **0.01**% by mass of Cu, not more than **0.01**% by mass of Mn, not more than **0.01**% by of Mg, not more than **0.01**% by mass of Zn, not more than **0.01**% by mass of Ti, and not more than

0.01% by mass of V, and the balance being Al and inevitable impurities.

[0016] In Al-Zn, "**0.1** to **1.0**% by mass of Fe and Si" means as follows. If Al-Zn includes both of Fe and Si, a total concentration of Fe and Si is **0.1** to **1.0**% by mass. If Al-Zn includes Fe and does not include Si, a concentration of Fe is **0.1** to **1.0**% by mass. If Al-Zn includes Si and does not include Fe, a concentration of Si is **0.1** to **1.0**% by mass. In this case, e.g., "does not include" means the concentration is not more than the detection limit of the high frequency inductively coupled plasma emission spectroscopy.

[0017] The insulation layer **4** is made of an electrically insulating material. The insulation layer **4** is provided to coat the conductor **3.** Resin such as fluorine resins, olefin resins, and silicone resins may be used as the material of the insulation layer **4.** Although the insulation layer **4** is arranged over a whole length in the longitudinal direction of the electric wire **2,** in the present embodiment, the insulation layer **4** is removed in a predetermined length from the end of the electric wire **2.** Thus, a portion of the end of the conductor **3** is exposed.

(Terminal)

[0018] The terminal **5** comprises a cylindrical portion **6** and an extended portion **8,** which are integrally, i.e. as one piece, formed. For example, the terminal **5** is formed by pressing one end side of a pipe. The one end side corresponds to the extended portion **8.** Alternatively, the terminal **5** is e.g., formed by drilling one end side of a cylindrical base material and pressing the other end. Drilled one end side corresponds to the hollow portion **7.** Further, the pressed another end side corresponds to the extended portion **8.** The hollow portion **7** has a cylindrical shape that is opened at the one end side. The terminal **5** is made of e.g. an aluminum material. More specifically, the terminal **5** is preferably made of e.g., pure aluminum or aluminum alloy. As the pure aluminum, e.g., electric conductor grade aluminum (ECAl) may be used. As the aluminum alloy, e.g., Al-Fe-Zr and the like as below may be used. Al-Fe-Zr is aluminum alloy having a chemical composition comprising or consisting of **0.01** to **0.10**% by mass of Zr, not more than **0.1**% by mass of Si, **0.2** to **1.0**% by mass of Fe, not more than **0.01**% by mass of Cu, not more than **0.01**% by mass of Mn, not more than **0.01**% by of Mg, not more than **0.01**% by mass of Zn, not more than **0.01**% by mass of Ti, and not more than **0.01**% by mass of V, and the balance being A1 and inevitable impurities.

[0019] The cylindrical portion **6** is configured as a portion to be connected to the terminal **3** which is exposed from the end of electric wire **2.** In the present embodiment, the cylindrical portion **6** is formed in a cylindrical shape having a cross section in a circular shape. Inside of the cylindrical portion **6** forms the hollow portion **7** into which the conductor **3** exposed from the end of electric wire **2** can be inserted. The conductor **3** is inserted from one end portion **6**a (entrance) of the cylindrical portion **6.** The one end portion **6**a has an opening having an inner diameter not less than an outside diameter of the conductor **3.** Further, a surface of the terminal **5** and an inner surface of the cylindrical portion **6** may be plated with Sn or Ag. Furthermore, the exposed conductor **3** may be inserted into the hollow portion **7** after applying a compound including electrically conductive particles. Furthermore, the exposed conductor **3** may be inserted into the hollow portion **7** after applying or filling the compound including electrically conductive particles on the hollow portion **7** of the cylindrical portion **6.** For example, electrically conductive particles made of Ni-P or Ni-B, or fluorine-based oil including electrically conductive particles of a mixture of Ni-P and Ni-B may be used as the compound with electrically conductive particles.

[0020] The extended portion **8** is configured as a portion connected to a terminal or a bolt or the like of an external connection counterpart. In the present embodiment, the extended portion **8** is formed in plate shape and provided with a bolt hole **9** into which e.g., the terminal or the bolt of the external connection counterpart is inserted.

<**2**. Example of the method for manufacturing an electric wire with terminal>

[0021] Next, the method for manufacturing the electric wire with terminal **1** according to the present embodiment will be explained as follows.

[0022] The electric wire with terminal **1** according to the present embodiment can be manufactured by sequentially performing preparing the electric wire **2** and the terminal **5,** connecting the terminal **5** with the conductor **3** by pressing the terminal **5** while the conductor **3** is inserted into the terminal **5.** Each step will be explained as follows with referring to **FIGS. 1, 2** and **3**A to **3**C.

(Preparation step)

[0023] Firstly, the electric wire **2** having the conductor **3** and the terminal **5** is prepared. Each of the conductor **3** and the terminal **5** is made of the aluminum material. As shown in **FIG. 1,** the insulation layer **4** configuring the electric wire **2** is removed at a predetermined length from an end of the electric wire **2** in the longitudinal direction, and a part of the conductor **3** is exposed. Thereafter, as shown in **FIG. 2,** the exposed part of the conductor **3** of the electric wire **2** is inserted into the hollow portion **7** formed in the cylindrical portion **6** of the terminal **5.**

(Compression and Connection step)

[0024] Next, as shown in **FIG. 3**A, a compressed portion **10** is formed by compressing a compression part P**1** while the exposed part of the conductor **3** of the electric wire **2** is inserted into the hollow portion **7** of the terminal **5.** Then, as shown in **FIG. 3**B, a compressed portion **12** is formed by compressing a compression part P**3**. Finally, as shown in **FIG. 3**C, the terminal **3** is connected to the terminal **5** by forming a compressed portion **11** by compressing a compression part P**2** formed between the compression part P**1** and compression part P**3**.

[0025] This compression is achieved by compression deforming (plastic deforming) the cylindrical portion **6** by compressing along the entire circumference of the cylindrical portion **6** in a circumference direction at the compression parts P**1** to P**3** of the cylindrical portion **6** by using e.g., a compression jig. In the present embodiment, the compressed portions **10** to **12** have hexagonal cross-sectional shapes in cross-section perpendicular to the longitudinal direction (axial direction) of the conductor **3.** Further, the compressed portions **10** to **12** are formed to be shifted in an axial direction of the cylindrical portion **6** (the longitudinal direction of the conductor **3** which is inserted into the hollow portion **7**), i.e., so as not to overlap respectively. As described above, the electric wire with terminal **1** can be obtained by compressively connecting the terminal **5** to the conductor **3.**

<**3**. Effect of the present embodiment>

[0026] According to the present embodiment, one or more effects described below can be achieved.

(a) In the present embodiment, it is possible to suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by stress relaxation between the conductor **3** and the terminal **5,** so that low electric resistance between the conductor **3** and the terminal **5** can be maintained. Thus, it is possible to suppress the increase of an electric resistance ratio of the electric wire with terminal 1 under a predetermined level and to ensure enough electric connection. Specifically, an electric resistance ratio growth rate that is obtained by the formula $((R2-R1)/R1)\times 100$ can be controlled to be not more than **19**%, wherein R**1** represents the electric resistance ratio between the conductor **3** and the terminal **5** before performing a test that keeps the electric wire with terminal **1** in a constant temperature at **150**°C in air (the high temperature exposure test), and R**2** represents the electric resistance ratio between the conductor **3** and the terminal **5** after performing the test. Here, the electric resistance ratio is measured by the four-terminal sensing described below. The electric resistance ratio is substantially the same as the electric resistance between the terminal **5** and the conductor **3.** A calculation method of the electric resistance ratio will be described below.

(b) In the present embodiment, since a predetermined pressure is applied over the entire circumference in the circumference direction of the cylindrical portion **6** at the time of forming the compressed portions **10** to **12,** it is possible to compressively connect the terminal **5** to the entire circumference of the conductor **3** equally and to maintain high contact force between the terminal **5** and the conductor **3.**

<**4**. Variations>

[0027] As described above, although the embodiment of the present invention is 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.

[0028] In the present embodiment, although the compression part P**1** is compressed firstly and the compression part P**3** is compressed after the compression part P**1** is compressed when the compressed portions **10** to **12** are formed, the present invention is not limited thereto, and the compression part P**3** may be compressed firstly and the compression part P**1** is compressed after the compression part P**3** is compressed if the compression part P**2** arranged between the compression part P**1** and the compression part P**3** is compressed finally. Such a compression order can control the electric resistance ratio under to be not more than **19**%.

[0029] In the present embodiment, although the terminal **5** having three compressed portions (having three compression parts) is described as an example, the present invention is not limited thereto, and the terminal **5** may be compressed at four points as shown in **FIG. 7** or at five points as shown in **FIG. 8.** When the terminal **5** is compressed at the four points, it is preferable to locate the compressed portion to be formed by the fourth compression between adjacent two ones of the compressed portions which have been already formed. For example, it is preferable to compress the terminal **5** in order of the compression parts P**1**, P**4**, P**2**, and P**3**. Since such a compression order can suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by the stress relaxation between the conductor **3** and the terminal **5,** it is possible to suppress the increase in electric resistance ratio of the electric wire with terminal **1.**

[0030] Moreover, even if the compressed portion formed by the fourth compression (final compression) is not located between the adjacent compressed portions which have been already formed, the compressed portion formed by the third compression may be located between the adjacent compressed portions which have been already formed such that the compressed portions are compressed in order of the compression parts e.g., P**1**, P**3**, P**2**, and P**4**. Meanwhile, it is preferable to locate the compressed portion to be formed by the final compression between the adjacent compressed portions which have been already formed.

[0031] When the terminal **5** is compressed at the five points, it is preferable to form the compressed portion between the adjacent two compressed portions from a plurality of compressed portions which was already formed. Especially, it is preferable to locate the compressed portion which is formed by the fifth compression between adjacent two ones of the compressed portions which have been already formed. Furthermore, it is preferable to locate all the compressed portions to be formed by or after the third compression between the adjacent two ones of the compressed portions which have been already formed. For example, it is preferable to compress the terminal **5** in order of the compression parts P**1**, P**5**, P**3**, P**2**, and P**4**. Since such a compression order can suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by the stress relaxation between the conductor **3** and the terminal **5,** it is possible to suppress the increase in the electric resistance ratio of the electric wire with terminal **1.**

[0032] The aluminum material constituting the terminal **5** may comprise pure aluminum or aluminum alloy. The aluminum material constituting the conductor **3** may comprise pure aluminum or aluminum alloy. The pure aluminum is comprising or consisting of A1 and inevitable impurities. As the pure aluminum, e.g., electric conductor grade aluminum (ECA1) may be used. As the aluminum alloy for the terminal **5,** e.g., Al-Fe-Zr and the like as below may be used. As the aluminum alloy for the conductor **3,** e.g., Al-Fe-Zr, Al-Zr and the like as below may be used. Al-Fe-Zr is aluminum alloy having a chemical composition comprising or consisting essentially of **0.01** to **0.10**% by mass of Zr, not more than **0.1**% by mass of Si, **0.2** to **1.0**% by mass of Fe, not more than **0.01**% by mass of Cu, not more than **0.01**% by mass of Mn, not more than **0.01**% by of Mg, not more than **0.01**% by mass of Zn, not more than **0.01**% by mass of Ti, and not more than **0.01**% by mass of V, and the balance being A1 and inevitable impurities. Al-Zr is aluminum alloy having a chemical composition comprising or consisting of **0.03** to **1.5**% by mass of Zr, **0.1** to **1.0**% by mass of Fe and Si, and the balance being Al and inevitable impurities. Since such a combination of the aluminum materials for the terminal **5** and the conductor **3** can suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by the stress relaxation between the conductor **3** and the terminal **5,** it is possible to suppress the increase in the electric resistance ratio of the electric wire with terminal **1.**

[0033] A compression ratio of the conductor **3** is preferably not less than **50**% and not more than **95**%, although it is not limited in the present embodiment. Herein, the compression ratio is defined as a ratio of a cross-sectional area of the conductor **3** corresponding to a compressed portion of the terminal **5** to a cross-sectional area of the conductor **3** corresponding to a non-compressed portion of the terminal **5** in cross section perpendicular to a longitudinal direction of the conductor **3** when the terminal **5** with the hollow portion **7** into which the conductor **3** is inserted is compressed. The compression ratio is obtained by a formula $(C\mathbf{2}/C\mathbf{1})\times\mathbf{100}$ wherein C**1** (mm^2) represents the cross-sectional area of the conductor **3** corresponding to the non-compressed portion of the terminal **5** and C**2** (mm^2) represents the cross-sectional area of the conductor **3** corresponding to the compressed portion of the terminal **5.** When the compression ratio falls within the above range, it is possible to suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by the stress relaxation between the conductor **3** and the terminal **5,** it is possible to suppress the increase in the electric resistance ratio of the electric wire with terminal **1.**

[0034] Further, the width of the compressed portions **10** to **12** is preferably not more than **7** mm. When the width falls within the above range, it is possible to suppress the decrease in contact force between the conductor **3** and the terminal **5** caused by the stress relaxation between the conductor **3** and the terminal **5,** so that it is possible to suppress the increase in the electric resistance ratio of the electric wire with terminal **1.** Furthermore, the width of the compressed portion is more preferably not less than **2** mm and not more than **5** mm. Further, when the width of the compressed portion is more preferably not less than **2** mm and not more than **5** mm, the electric resistance ratio can be controlled to be not more than **19**%. Furthermore, the width of the compressed portion is more preferably not less than **3** mm and not more than **4** mm. When the width of the compressed portion is not less than **3** mm and not more than **4** mm, it is possible to further suppress the increase in the electric resistance ratio.

[0035] Furthermore, although the present invention is not limited thereto, it is preferable to arrange the compressed portions **10** to **12** respectively at a regular interval. Arrangement of the compressed portions **10** to **12** at the regular interval can suppress the increase in the electric resistance ratio.

[0036] In the present embodiment, although the example in which the compressed portions **10** to **12** are formed so as not to be overlapped respectively is explained, the present invention is not limited thereto, and the compressed portions may be provided to be partially overlapped respectively.

[0037] In the present embodiment, although the example in which the compressed portions **10** to **12** have hexagonal cross sections in a cross section perpendicular to the longitudinal direction (axial direction) of the conductor **3** is explained, the present invention is not limited thereto, and the compressed portions **10** to **12** may have cross sections having the other polygonal shape or the circular shape.

[0038] In the present embodiment, although the present invention is not limited thereto, it is preferable to provide the information as to the compression order on the terminal **5.** For example, as shown in **FIG. 4,** although it is preferable to respectively arrange characters (letters) "first", "third", or "second" at points corresponding to the compression parts P**1**, P**2**, and P**3** of the cylindrical portion **6,** the present invention is not limited thereto, and the character "first" may be provided at the compression part P**3** and the character "second" may be provided at the compression part P**1**, if the character "third" is provided at the compression part P**2** arranged between the compression part P**1** and the compression part P**3**. Meanwhile, the information as to the compression order is not limited to the characters such as "first", "second", or "third". Any information may be provided if the compression order can be identified. Further, the characters may be punched or described. As the information as to the compression order is provided at the terminal **5,** the compressed portion to be formed lastly can be securely formed between the adjacent two ones of the compressed portions which have been already formed.

[0039] In the present embodiment, although the electric wire with terminal is explained as the example, the present invention is not limited thereto. For example, the present invention can be applied to a cable with a terminal.

[Experimental examples]

[0040] Next, the present invention will be explained in more detail based on experimental examples. However, the present invention is not limited to the experimental examples.

(Experimental example 1)

[0041] As shown in **FIGS. 3**A to **3**C, in the experimental example **1,** the terminal **5** of the conductor **3** which was inserted into the hollow portion **7** was compressed three times in order of the compression parts P**1**, P**3**, and P**2**. The electric wire with terminal **1** was obtained by setting the width of the compressed portion along the longitudinal direction of the conductor **3** at **3** mm and forming three compressed portions at a regular interval. The interval between the adjacent compressed portions (a width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **9** mm. Al-Fe-Zr having the same composition was used as the aluminum materials for the terminal **5** and the conductor **3.** Al-Fe-Zr is aluminum alloy having a chemical composition comprising or consisting of **0.6**% by mass of Fe, **0.02**% by mass of Zr, **0.06**% by mass of Si, **0.002**% by mass of Cu, **0.002**% by mass of Mn and **0.006**% by mass of total of Ti and V, and the balance being A1 and inevitable impurities. A cross-sectional area of the conductor **3** was **50** mm^2. All metal strands for forming the conductor was the same material. A diameter of the metal strand forming the conductor was **0.45** mm. The number of the metal strands was **309.** As shown in **FIG. 9,** in the high temperature exposure test, the electric wire with terminal **1** after compressing the terminal 5 and connecting with the terminal **3** was placed and kept in a thermostatic chamber **14** at **150**°C in the air for **50** hours. The high temperature exposed test simulated the current test environment. Further, an aluminum plate **13** was fixed on the extended portion **8** by a bolt (not shown) with assuming as if the extended portion **8** was connected to a terminal or a bolt of the external connection counterpart. **FIG. 9** shows the case in which the aluminum plate is fixed on a lower side of the extended portion **8.** Even if the aluminum plate is fixed on an upper side of the extended portion **8,** the same effect as the case in which the aluminum plate is fixed on a lower side of the extended portion **8** can be obtained. According to the experimental examples **2** to **9** shown in Table **1,** the high temperature exposure test was performed under the same condition.

(Experimental example **2**)

[0042] As shown in Table **1,** in the experimental example **2,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the width of the compressed portion was **5** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **7** mm.

(Experimental example **3**)

[0043] As shown in Table **1,** in the experimental example **3,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the order of the compression parts was P**3**, P**1**, and P**2**, the width of the compressed portion was **5** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **7** mm.

(Experimental example **4**)

[0044] As shown in Table **1,** in the experimental example **4,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the width of the compressed portion was **7** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **4** mm.

(Experimental example **5**)

[0045] As shown in **FIGS. 5**A and **5**B, in the experimental example **5,** the terminal **5** of the conductor **3** which was inserted into the hollow portion **7** was compressed two times in order of the compression parts P**1** and P**2**. The electric wire with terminal **1** was obtained by setting the width of the compressed portion along the longitudinal direction of the conductor **3** at **10** mm.

(Experimental example **6**)

[0046] As shown in Table **1,** in the experimental example **6,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the order of the compression parts was P**1**, P**2**, and P**3**.

(Experimental example **7**)

[0047] As shown in **FIGS. 6**A to **6**C, in the experimental example **1,** the terminal **5** of the conductor **3** which was inserted into the hollow portion **7** was compressed three times in order of the compression parts P**1**, P**2**, and P**3**. The electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the order of the compression parts was P**1**, P**2**, and P**3**, the width of the compressed portion was set at **5** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was set at approximately **7** mm.

(Experimental example **8**)

[0048] As shown in Table **1,** in the experimental example **8,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the order of the compression parts was P**2**, P**1**, and P**3**, the width of the compressed portion was **5** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **7** mm.

(Experimental example **9**)

[0049] As shown in Table **1,** in the experimental example **9,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **1,** except that the order of the compression parts was P**1**, P**2**, and P**3**, the width of the compressed portion was **7** mm, and the interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **4** mm.

[0050] The resistance ratio growth rate and the like of the electric wire with terminal **1** in the above experimental examples **1** to **9** is summarized in Table **1.**

[Table **1**]

Items	Number of times of compressions	Compression order	Width of compressed portion (mm)	Compression ratio (%)	Resistance ratio growth rate (%)
Experimental example **1**	**3**	P**1**→P**3**→P**2**	**3**	**90**	**9**
Experimental example **2**	**3**	P**1**→P**3**→P**2**	**5**	**86**	**17**
Experimental example **3**	**3**	P**3**→P**1**→P**2**	**5**	**86**	**19**
Experimental example **4**	**3**	P**1**→P**3**→P**2**	**7**	**82**	**18**

(continued)

Items	Number of times of compressions	Compression order	Width of compressed portion (mm)	Compression ratio (%)	Resistance ratio growth rate (%)
Experimental example **5**	**2**	P**1**→P**2**	**10**	**75**	**60**
Experimental example **6**	**3**	P**1**→P**2**→P**3**	**3**	**90**	**45**
Experimental example **7**	**3**	P**1**→P**2**→P**3**	**5**	**86**	**37**
Experimental example **8**	**3**	P**2**→P**1**→P**3**	**5**	**86**	**43**
Experimental example **9**	**3**	P**1**→P**2**→P**3**	**7**	**82**	**28**

(Measuring the resistance ratio growth rate)

[0051] The resistance ratio growth rate herein is defined by a change rate of the electric resistance ratio (initial resistance ratio) before the electric wire with terminal **1** was placed and kept in a thermostatic chamber **14** at **150**°C in the air for **50** hours (the high temperature exposure test) to the electric resistance ratio after performing the high temperature exposure test. The resistance ratio growth rate is obtained by a formula ((R**2**-R**1**)/R**1**)×**100** wherein R**1** represents the electric resistance ratio between the conductor **3** and the conductor **5** before performing the high temperature exposure test, and R**2** represents the electric resistance ratio between the conductor **3** and the conductor **5** after performing the high temperature exposure test.

(Measuring the electric resistance ratio)

[0052] In this case, the electric resistance ratio R**1** (the initial resistance ratio) of the electric wire with terminal **1** before performing the high temperature exposure test was measured by so-called four-terminal sensing. The four-terminal sensing method will be explained as follows with referring to **FIG. 10.**

[0053] Firstly, constant current of **1**A is fed to the whole of the electric wire with terminal **1** and an electric resistance value R**0** between the point P and the point Q is measured. In this case, the point P is a part which is an end of the cylindrical portion **6** of the terminal **5** and corresponds to a tip end of the conductor **3** inserted into the hollow portion **7.** The point Q is a part of the conductor **3** which does not contact the terminal **5.** The point S is an entrance of the terminal **5** that is the other end of the cylindrical portion **6** into which the conductor **3** is inserted. The initial resistance ratio R**1** is obtained by a formula (R**0** - L**2**×α)/(L**1** ×α) wherein L**1** represents the distance between the point P and the point S, L**2** represents the distance between the point Q and the point S, and α represents an electric resistance value of the conductor **3** per unit length. The electric resistance value of the conductor **3** per unit length may be previously measured. Alternatively, the electric resistance value of the conductor **3** per unit length may be defined by measuring the electric resistance value in the length L**2** and dividing the measured value by the length L**2**.

[0054] The electric resistance ratio R**2** after performing the high temperature exposure test was measured by the four-terminal sensing after cooling down the electric wire with terminal **1** to a room temperature, in the same manner as measuring the electric resistance ratio before performing the high temperature exposure test (initial electric resistance ratio). Specifically, the constant current of **1**A is fed to the whole of the electric wire with terminal 1 and the electric resistance value R between the point P and the point Q is measured. The electric resistance value α of the conductor **3** per unit length is constant and the same value before and after performing the high temperature exposure test. The electric resistance ratio R**2** is obtained by a formula (R-L**2**×α)/(L**1**×α). The resistance value will be measured by the resistance meter made by HIOKI E.E. Corporation.

(Measuring compression ratio)

[0055] As described above, the compression ratio is defined by a ratio of a cross-sectional area of the conductor **3** corresponding to a compressed portion of the terminal **5** to a cross-sectional area of the conductor **3** corresponding to a non-compressed portion of the terminal **5** in cross section perpendicular to a longitudinal direction of the conductor **3** when the terminal **5** with the hollow portion **7** into which the conductor **3** is inserted is compressed. The compression ratio is obtained by a formula (C2/C1)×100 wherein C1 (mm^2) represents the cross-sectional area of the conductor **3** corresponding to the non-compressed portion of the terminal **5,** and C2 (mm^2) represents the cross-sectional area of the conductor **3** corresponding to the compressed portion of the terminal **5.**

[0056] From the results described above, it was confirmed that the resistance ratio growth rate can be controlled by forming three compressed portions of which the compressed portion formed for the last time is located between the adjacent two ones which have been already formed.

[0057] When the terminal **5** is compressed, the force is generated not only in a radial direction of the conductor **3** but also in the axial direction of the conductor **3.** Thus, the extending force of the conductor **3** in the axial direction, which is caused at the time of forming the third compressed portion, may be suppressed by the two compressed portions which have been already formed. Therefore, as the third compressed portion is compressed, in addition to the increase in a contact force between the conductor **3** and the terminal **5** in the third compressed portion, there may be the increase in a contact force between the conductor **3** and the terminal **5** in a portion between the first compressed portion and the third compressed portion as well as a contact force between the conductor **3** and the terminal **5** in a portion between the second compressed portion and the third compressed portion. Thus, the increase in the resistance ratio of the electric wire with terminal **1** may be suppressed.

[0058] Furthermore, it was confirmed that the resistance ratio growth rate decreases in accordance with the decrease in the width of the compressed portion in the experimental examples **1** and **2.** Meanwhile, it was confirmed that the resistance ratio growth rate decreases in accordance with the increase in the width of the compressed portion in the experimental examples **6** and **7.**

[0059] Furthermore, it was confirmed that the resistance ratio growth rate of the experimental example **5** is **60**%, which is the highest rate. It was confirmed that the resistance ratio growth rates in the experimental examples **6** to **9** is higher than the resistance ratio growth rates in the experimental examples **1** to **4.** In the experimental examples **6** to **9,** three compressed portions of which the last compressed portion is not located between the adjacent two ones which have been already formed.

[0060] Next, the electric wire with terminal **1** of which the number of times for compressing the terminal **5** is four or five will be explained based on the experimental examples as follows.

(Experimental example **10**)

[0061] As shown in **FIG. 7,** in the experimental example **10,** the terminal **5** of the conductor **3** inserted into the hollow portion **7** was compressed for four times in order of the compression parts P**1**, P**4**, P**2**, and P**3**. The electric wire with terminal **1** was obtained by setting the width of the compressed portion along the longitudinal direction of the conductor **3** at **3** mm, and forming four compressed portions at a regular interval. The interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **6** mm. Al-Fe-Zr having the same composition was used as the aluminum material for the terminal **5** and the conductor **3.** Al-Fe-Zr is aluminum alloy having a chemical composition consisting of **0.6**% by mass of Fe, **0.02**% by mass of Zr, **0.06**% by mass of Si, **0.002**% by mass of Cu, **0.002**% by mass of Mn and **0.006**% by mass of total of Ti and V, and the balance being Al and inevitable impurities. A cross-sectional area of the conductor **3** was **50** mm^2. All metal strands for forming the conductor were made of the same material. A diameter of the metal strand for forming the conductor was **0.45** mm. The number of the metal strands was **309.** In the high temperature exposure test, the electric wire with terminal **1** after compressing the terminal **5** and connecting to the terminal **3** was placed and kept in a thermostatic chamber **14** at **150**°C in the air for **50** hours. In the experimental examples **11** to **22** shown in Table **2,** the high temperature exposure test was performed under the same condition. The high temperature exposure test was performed in the same method as in the experimental examples **1** to **9.** Further, the electric resistance ratio and the compression ratio were measured by the same methods as in the experimental examples **1** to **9.**

(Experimental example **11**)

[0062] As shown in Table **2,** in the experimental example **11,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**1**, P**2**, P**4**, and P**3**.

(Experimental example **12**)

[0063] As shown in Table **2,** in the experimental example **12,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**1**, P**4**, P**3**, and P**2**.

(Experimental example **13**)

[0064] As shown in Table **2,** in the experimental example **13,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**2**, P**1**, P**4**, and P**3**.

(Experimental example **14**)

[0065] As shown in Table **2,** in the experimental example **14,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**4**, P**1**, P**2**, and P**3**.

(Experimental example **15**)

[0066] As shown in Table **2,** in the experimental example **15,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**3**, P**1**, P**4**, and P**2**.

(Experimental example **16**)

[0067] As shown in Table **2,** in the experimental example **16,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**3**, P**4**, P**1**, and P**2**.

(Experimental example **17**)

[0068] As shown in **FIG. 8,** in the experimental example **17,** the terminal **5** of the conductor **3** which was inserted into the hollow portion **7** was compressed for five times in order of the compression parts P**1**, P**5**, P**3**, P**2**, and P**4**. The width of the compressed portion along the longitudinal direction of the conductor **3** was **3** mm. The interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **4** mm. The electric wire with terminal **1** was obtained by forming five compressed portions at a regular interval.

(Experimental example **18**)

[0069] As shown in Table **2,** in the experimental example **18,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **17,** except that the order of the compression parts was P**1**, P**4**, P**3**, P**5**, and P**2**.

(Experimental example **19**)

[0070] As shown in **FIGS. 5**A and **5**B, in the experimental example **5,** the terminal **5** of the conductor **3** inserted into the hollow portion **7** was compressed for two times in order of the compression parts P**1** and P**2**. The electric wire with terminal **1** was obtained by setting the width of the compressed portion along the longitudinal direction of the conductor **3** at **10** mm. The experimental example **19** was in same with the experimental example **5** shown in Table **1.**

(Experimental example **20**)

[0071] As shown in Table **2,** in the experimental example **20,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**1**, P**2**, P**3**, and P**4**.

(Experimental example **21**)

[0072] As shown in Table **2,** in the experimental example **21,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**1**, P**3**, P**2**, and P**4**.

(Experimental example **22**)

[0073] As shown in Table **2,** in the experimental example **22,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **10,** except that the order of the compression parts was P**3**, P**1**, P**2**, and P**4**.

[0074] The resistance ratio growth rate and the like of the electric wire with terminal **1** in the above experimental examples **10** to **22** is summarized in Table **2.**

[Table **2**]

Items	Number of times of Compression	Compression order	Width of compressed portion (mm)	Compression ratio (%)	Resistance ratio growth rate (%)
Experimental example **10**	**4**	P**1**→P**4**→P**2** →P**3**	**3**	**90**	**7**
Experimental example **11**	**4**	P**1**→P**2**→P**4** →P**3**	**3**	**90**	**8**
Experimental example **12**	**4**	P**1**→P**4**→P**3** →P**2**	**3**	**90**	**8**
Experimental example **13**	**4**	P**2**→P**1**→P**4** →P**3**	**3**	**90**	**7**
Experimental example **14**	**4**	P**4**→P**1**→P**2** →P**3**	**3**	**90**	**10**
Experimental example **15**	**4**	P**3**→P**1**→P**4** →P**2**	**3**	**90**	**13**
Experimental example **16**	**4**	P**3**→P**4**→P**1** →P**2**	**3**	**90**	**12**
Experimental example **17**	**5**	P**1**→P**5**→P**3** →P**2** →P**4**	**3**	**90**	**4**
Experimental example **18**	**5**	P**1**→P**4**→P**3** →P**5** →P**2**	**3**	**90**	**7**
Experimental example **19**	**2**	P**1**→P**2**	**10**	**75**	**60**
Experimental example **20**	**4**	P**1**→P**2**→P**3** →P**4**	**3**	**90**	**21**
Experimental example **21**	**4**	P**1**→P**3**→P**2** →P**4**	**3**	**90**	**15**
Experimental example **22**	**4**	P**3**→P**1**→P**2** →P**4**	**3**	**90**	**16**

[0075] As described above, in the experimental examples **10** to **16,** it was confirmed that the resistance ratio growth rate can be controlled to be not more than **13**% by forming the four compressed portions and forming the last compressed portion between the adjacent two ones of the compressed portions which have been already formed. In the experimental examples **17** and **18,** it was confirmed that the resistance ratio growth rate can be controlled to be not more than **7**% by forming the five compressed portions and forming the last compressed portion between the adjacent two ones of the compressed portions which have been already formed.

[0076] In the experimental examples **10** to **18,** it was confirmed that the resistance ratio growth rate when the terminal **5** is compressed for five times is lower than the resistance ratio growth rate when the terminal **5** is compressed for four times. In the experimental examples **21** and **22,** it was confirmed that the resistance ratio growth rate can be controlled to be not more than **16**% by forming the four compressed portions and forming the third compressed portion between the adjacent two ones of the compressed portions which have been already formed, although the last compressed portion is not formed between the adjacent two ones of the compressed portions which have been already formed and.

[0077] Furthermore, it was confirmed that the resistance ratio growth rate is the highest in the experimental example **19** in which the compression ratio and the number of times of compression of the conductor **3** are the lowest. Furthermore, it was confirmed that the resistance ratio growth rate in the experimental example **20** is the highest among the experimental examples **20** to **22.**

(Experimental example **23**)

[0078] As shown in **FIGS.** 3A to 3C, in the experimental example **23,** the terminal **5** of the conductor **3** inserted into the hollow portion **7** was compressed for three times in order of the compression parts P**1**, P**3**, and P**2**. The electric wire with terminal **1** was obtained by setting the width of the compressed portion along the longitudinal direction of the conductor **3** at **5** mm, and forming three compressed portions at a regular interval. The interval between the adjacent compressed portions (the width of the non-compressed portion along the longitudinal direction of the conductor **3**) was approximately **7** mm. ECA1 was used for the aluminum material of the terminal **5**. Al-Fe-Zr was used for the aluminum material of the conductor **3**. ECA1 is a pure aluminum satisfying standard A**1070.** Al-Fe-Zr is aluminum alloy having a chemical composition consisting of **0.6**% by mass of Fe, **0.02**% by mass of Zr, **0.06**% by mass of Si, **0.002**% by mass of Cu, **0.002**% by mass of Mn and **0.006**% by mass of total of Ti and V, and the balance being A1 and inevitable impurities. A cross-sectional area of the conductor **3** was **50** mm^2. In the high temperature exposure test, the electric wire with terminal **1** after compressing the terminal **5** and connecting to the terminal **3** was placed and kept in a thermostatic chamber **14** at **150**°C in the air for **50** hours. In the experimental example **24** shown in Table **3,** the high temperature exposure test was performed under the same condition. The high temperature exposure test was performed in the same method as in the experimental examples **1** to **22.** Further, the electric resistance ratio and the compression ratio were measured by the same methods as in the experimental examples **1** to **22.** Furthermore, the experimental example **25** was in the same manner as the electric wire with terminal **1** in the experimental example **2** shown in Table **1.**

(Experimental example **24**)

[0079] As shown in Table **3,** in the experimental example **24,** the electric wire with terminal **1** was made in the same manner as the electric wire with terminal **1** in the experimental example **23,** except that the aluminum material for the conductor **3** was Al-Zr. Al-Zr is aluminum alloy having a chemical composition consisting of **0.34**% by mass of Zr, **0.15**% by mass of Fe, **0.1**% by mass of Si, **0.03**% by mass of total of Ti and V, and the balance being Al and inevitable impurities. The electric resistance ratio and the compression ratio were measured by the same methods as in the experimental examples **1** to **22.**

[0080] From the results described above, in the experimental examples **23** and **24,** it was confirmed that the increase in the electric resistance ratio can be further controlled as compared with the case in the experimental example **25,** by forming three compressed portions of which the last compressed portion is formed between the adjacent two ones of the compressed portions which have been already formed, and changing the combination of the aluminum materials for the terminal **5** and the conductor **3.**

[0081] The terminal **5** and the conductor **3** are compressed by loading a compressive load on the terminal **5** of which the conductor **3** is inserted into the hollow portion **7.** The terminal **5** and the conductor **3** spring back (i.e. the stress is relaxed) in accordance with the Young's modulus after the compressive load is completely moved away. Thus, the load that compresses the conductor **3** and the terminal **5** each other occurs between an outer circumferential surface of the conductor **3** and an inner circumferential surface of the terminal **5** when the compressive load is completely moved away. The amount of spring back increases in accordance with an increase in tensile strength of the aluminum material for forming the conductor **3,** and tensile strength of the aluminum material for forming the terminal **5** that is lower than the tensile strength of the aluminum material forming the conductor **3.** The amount of spring back in the experimental example **23** is higher than the amount of spring back in the experimental example **25.** Further, the amount of spring back in the experimental example **24** is higher than the amount of spring back in the experimental example **23.** As the amount of spring back increases, the load to compress the conductor **3** and the terminal **5** each other occurred between the outer circumferential surface of the conductor **3** and the inner circumferential surface of the terminal **5** increase. As a result, it was confirmed that the resistance ratio growth rate could be additionally controlled by increasing the amount of spring back.

[0082] The resistance ratio growth rate and the like of the electric wire with terminal **1** in the above experimental examples **23** to **25** is summarized in Table **3.**

[Table **3**]

Items	Number of times of Compression	Compression order	Width of compressed portion (mm)	Compression ratio (%)	Aluminum material of terminal	Aluminum material of conductor	Resistance ratio growth rate (%)
Experimental example **23**	**3**	P**1**→P**3**→P**2**	**5**	**86**	ECA1	Al-Fe-Zr	**11**
Experimental example **24**	**3**	P**1**→P**3**→P**2**	**5**	**86**	ECA1	Al-Zr	**6**
Experimental example **25**	**3**	P**1**→P**3**→P**2**	**5**	**86**	Al-Fe-Zr	Al-Fe-Zr	**17**

[0083] Although the cross-sectional area of the conductor **3** was set at **50** mm^2 in the present experimental examples, the present invention is not limited thereto. The effect of the present invention can be obtained regardless of the cross-sectional area of the conductor **3.** For example, it is significant to maintain the low resistance ratio growth rate although the conductor has a cross-sectional area of **50** to **400** mm^2 which cannot ignore the effect of stress relaxation.

[**5**. Preferred embodiment of the present invention]

[0084] The preferred embodiment of the present invention will be noted as follows.

(Note **1**)

[0085] According to an embodiment of the invention, an electric wire with terminal comprises:

an electric wire comprising a conductor comprising an aluminum material and an insulation layer coating the conductor; and
a terminal comprising an aluminum material and including a hollow portion into which the conductor exposed from an end of the electric wire is inserted, which is connected to the conductor by compressing the hollow portion while the conductor is inserted into the hollow portion,
wherein the terminal comprises three or more compressed portions along a longitudinal direction of the conductor, and wherein a resistance ratio growth rate (%) obtained by a formula ((R**2**-R**1**)/R**1**)×**100** is not more than **19**% wherein R**1** represents an electric resistance ratio between the conductor and the terminal before performing a test that keeps the electric wire with terminal at **150**°C in air for **50** hours, and R**2** represents an electric resistance ratio between the conductor and the terminal after performing the test.

(Note **2**)

[0086] Preferably, in the electric wire with terminal according to Note **1,** a tensile strength of the aluminum material for the conductor is higher than a tensile strength of the aluminum material for the terminal.

(Note **3**)

[0087] Preferably, in the electric wire with terminal according to Notes **1** or **2,** the conductor is aluminum alloy comprising or consisting of **0.03** to **1.5**% by mass of Zr, **0.1** to **1.0**% by mass of Fe and Si, and the balance being Al and inevitable impurities.

(Note **4**)

[0088] Preferably, in the electric wire with terminal according to any one of Notes **1** to **3,** the conductor is aluminum alloy comprising or consisting of **0.01** to **0.10**% by mass of Zr, not more than **0.1**% by mass of Si, **0.2** to **1.0**% by mass of Fe, not more than **0.01**% by mass of Cu, not more than **0.01**% by mass of Mn, not more than **0.01**% by of Mg, not more than **0.01**% by mass of Zn, not more than **0.01**% by mass of Ti and not more than **0.01**% by mass of V, and the balance being Al and inevitable impurities, and the terminal comprising pure aluminum composed of A1 arid inevitable impurities.

(Note **5**)

[0089] Preferably, in the electric wire with terminal according to any one of Notes **1** to **4,** a width of the compressed portion of the conductor along the longitudinal direction is not more than **7** mm.

(Note **6**)

[0090] Preferably, in the electric wire with terminal according to any one of Notes **1** to **5,** the compressed portions are respectively arranged at a regular interval.

(Note **7**)

[0091] Preferably, in the electric wire with terminal according to any one of Notes **1** to **6,** a cross-sectional area of the conductor is not less than **50** mm^2.

(Note **8**)

[0092] According to the other embodiment of the invention, a method for manufacturing an electric wire with terminal comprises:

preparing an electric wire comprising a conductor made of an aluminum material and an insulation layer coating the conductor and a terminal made of an aluminum material having a hollow portion; and
connecting the terminal to the conductor by forming a plurality of compressed portions on the terminal by compressing the terminal three or more times while the conductor exposed from an end of the electric wire is inserted into the hollow portion,
wherein said connecting the terminal to the conductor comprises forming a further compressed portion between adjacent compressed portions which are already formed.

(Note **9**)

[0093] In the method for manufacturing the electric wire with terminal according to Note **8,** said forming of the further compressed portion between the adjacent compressed portions which are already formed may be performed as a last step in said connecting the terminal to the conductor.

(Note **10**)

[0094] According to another embodiment of the invention, a terminal comprises a hollow portion into which a conductor is inserted,
wherein the terminal is configured to be connected to the conductor by compressing the terminal while the conductor is inserted into the hollow portion, and
wherein information as to an order for compression is given on the terminal.

(Note **11**)

[0095] Preferably, in the terminal according to Note **10,** the order for compression is given at a part to be compressed of the terminal.

(Note **12**)

[0096] According to the other embodiment of the invention, a jig for connecting a terminal to a conductor by compressing the terminal at three or more parts while the conductor is inserted into a hollow portion of the terminal is provided in which the jig is configured to compress the terminal to form three or more compressed portions at the terminal along the longitudinal direction of the conductor, and to form at least one of the compressed portions formed on after a third compression between adjacent ones of the compressed portions which are already formed.

(Note **13**)

[0097] Preferably, in the electric wire with terminal according to any one of Notes **1** to **7,** the number of the compressed portions is four or more.

(Note **14**)

[0098] Preferably, in the electric wire with terminal according to any one of Notes **1** to **7,** the number of the compressed portions is four or more, and the resistance ratio growth rate (%) is not more than **13**%.

(Note **15**)

[0099] Preferably, in the electric wire with terminal according to any one of Notes **1** to **7,** the number of the compressed portions is five or more.

(Note **16**)

[0100] Preferably, in the electric wire with terminal according to any one of Notes **1** to **7,** the number of the compressed portions is five or more, and the resistance ratio growth rate (%) is not more than **7**%.

(Note **17**)

[0101] Preferably, in the method for manufacturing the electric wire with terminal according to Note **8** or **9,** the terminal is compressed four or more times.

(Note **18**)

[0102] Preferably, in the method for manufacturing the electric wire with terminal according to Note **8,** the terminal is compressed four or more times, and forming a compressed portion by or after a third compression is performed between adjacent compressed portions which are already formed.

(Note **19**)

[0103] Preferably, in the terminal according to Note **10** or **11,** the number of the order for compression is four or more.

(Note **20**)

[0104] Preferably, in the jig according to Note **12,** the number of the compressed portions is four or more.

(Note **21**)

[0105] Preferably, in the jig according to Note **12,** the number of the compressed portions is four or more, and all compressed portions formed by or after a third compression are located between adjacent ones of the compressed portions which are already formed.

[0106] Although the invention has been described with respect to the specific embodiments for complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art which fairly fall within the basic teaching herein set forth.

Claims

1. An electric wire with terminal **(1),** comprising:

   an electric wire **(2)** comprising a conductor **(3)** comprising an aluminum material and an insulation layer **(4)** coating the conductor **(3);** and
   a terminal **(5)** comprising an aluminum material and including a hollow portion **(7)** into which the conductor **(3)** exposed from an end of the electric wire **(2)** is inserted, which is connected to the conductor **(3)** by compressing the hollow portion **(7)** while the conductor **(3)** is inserted into the hollow portion **(7),**
   wherein the terminal **(5)** comprises three or more compressed portions (**10,11,12**) along a longitudinal direction of the conductor **(3),** and wherein a resistance ratio growth rate (%) obtained by a formula ((R**2**-R**1**)/R**1**)×**100** is not more than **19**% wherein R**1** represents an electric resistance ratio between the conductor **(3)** and the terminal **(5)** before performing a test that keeps the electric wire with terminal **(1)** at **150**°C in air for **50** hours, and R**2** represents an electric resistance ratio between the conductor **(3)** and the terminal **(5)** after performing the test.

2. The electric wire with terminal **(1)** according to claim **1,** wherein a tensile strength of the aluminum material for the conductor **(3)** is higher than a tensile strength of the aluminum material for the terminal **(5).**

3. The electric wire with terminal **(1)** according to claim **1** or **2,** wherein a width of the compressed portions (**10,11,12**) along the longitudinal direction of the conductor **(3)** is not more than **7** mm.

4. The electric wire with terminal **(1)** according to any one of claims **1** to **3,** wherein the compressed portions **(10,11,12)** are respectively arranged at a regular interval.

5. A method for manufacturing an electric wire with terminal **(1),** comprising:

preparing an electric wire **(2)** comprising a conductor **(3)** comprising an aluminum material and an insulation layer **(4)** coating the conductor **(3),** and a terminal **(5)** comprising an aluminum material and including a hollow portion **(7);** and

connecting the terminal **(5)** to the conductor **(3)** by forming a plurality of compressed portions (**10,11,12**) on the terminal **(5)** by compressing the terminal **(5)** three or more times while the conductor **(3)** exposed from an end of the electric wire **(2)** is inserted into the hollow portion **(7),**

wherein said connecting the terminal **(5)** to the conductor **(3)** comprises forming a further compressed portion **(11)** between adjacent compressed portions (**10,12**) which are already formed.

6. The manufacturing method according to claim **5,** wherein said forming of the further compressed portion **(11)** between the adjacent compressed portions **(10,12)** which are already formed is performed as a last step in said connecting the terminal **(5)** to the conductor **(3).**

7. A terminal **(5)** comprising:

a hollow portion **(7)** into which a conductor **(3)** is inserted,

wherein the terminal **(5)** is configured to be connected to the conductor **(3)** by compressing the terminal **(5)** while the conductor **(3)** is inserted into the hollow portion **(7),** and

wherein information as to an order for compression is given on the terminal **(5).**

8. The terminal **(5)** according to claim **7,** wherein the order for compression is given at a part to be compressed of the terminal **(5).**

9. The electric wire with terminal **(1)** according to any one of claims **1** to **4,** wherein the number of the compressed portions **(10,11,12)** is four or more.

10. The manufacturing method according to any one of claims **5** to **6,** wherein the number of the compressed portions (**10, 11, 12**) is four or more.

FIG. 1

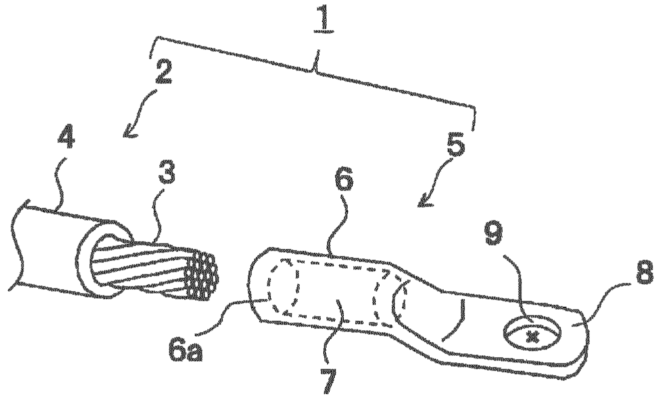


FIG. 2

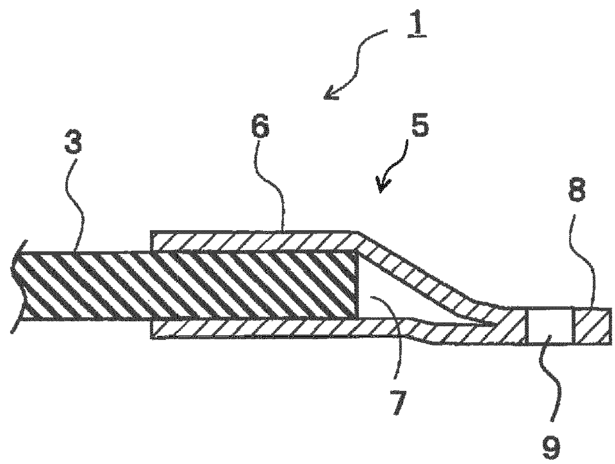


FIG. 3A

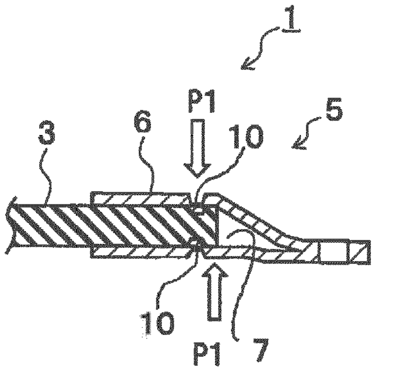


FIG. 3B

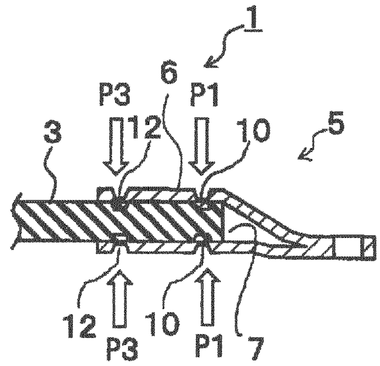


FIG. 3C

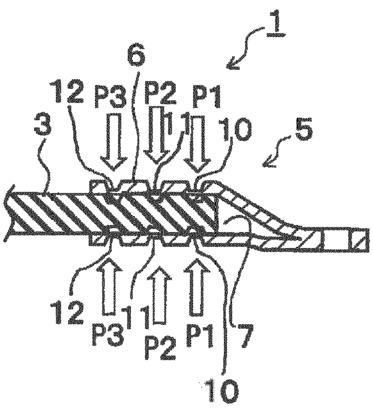


FIG. 4

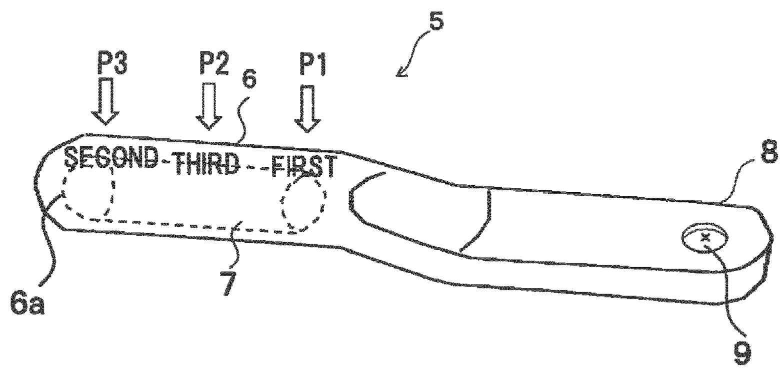


FIG. 5A

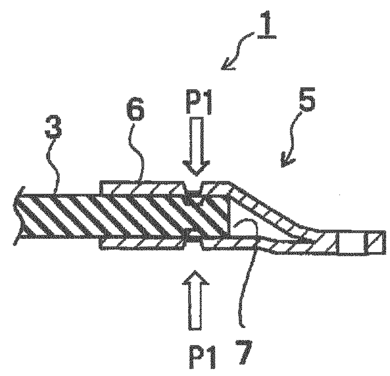


FIG. 5B

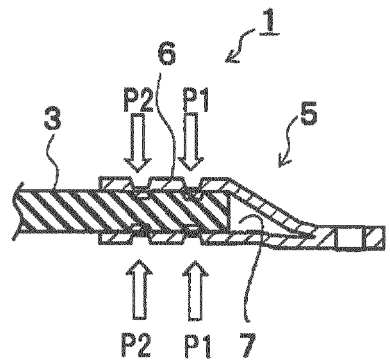


FIG. 6A

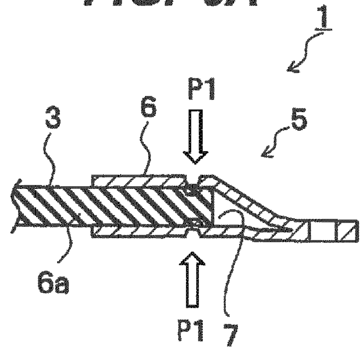


FIG. 6B

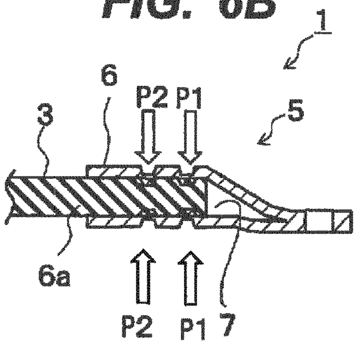


FIG. 6C

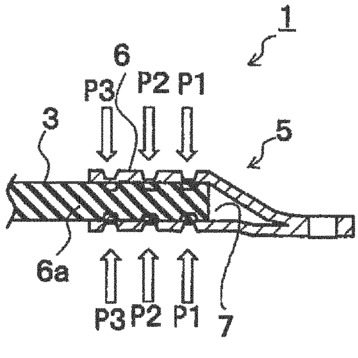


FIG. 7

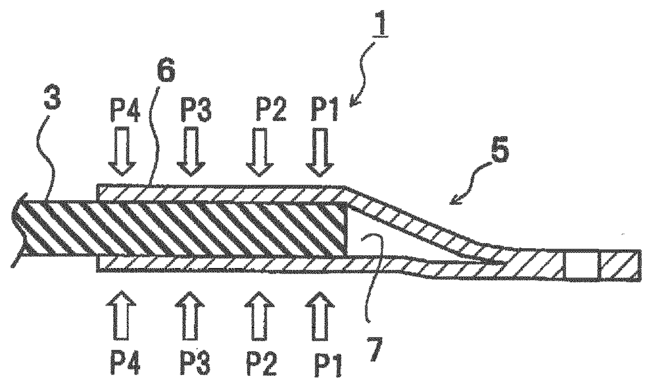


FIG. 8

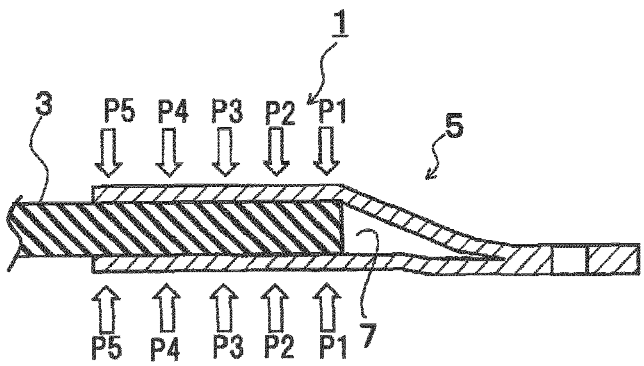


FIG. 9

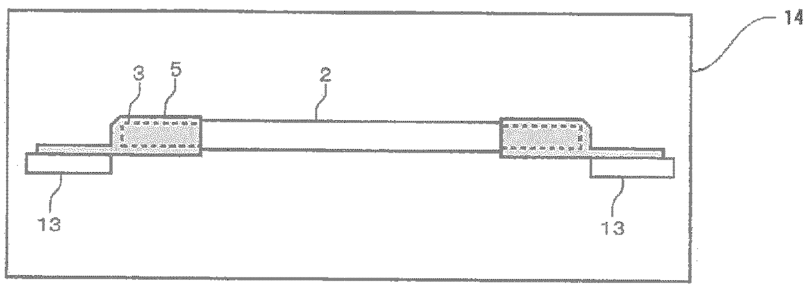
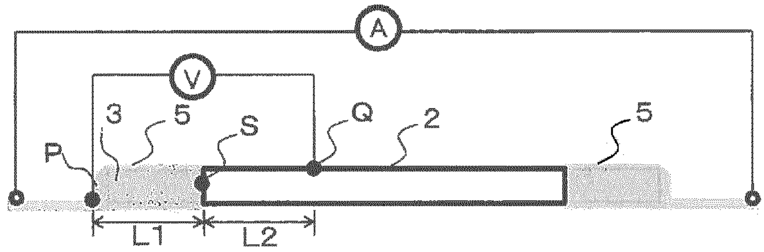


FIG. 10



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EUROPEAN SEARCH REPORT

Application Number
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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	EP 3 419 118 A1 (HITACHI METALS LTD [JP]) 26 December 2018 (2018-12-26) * paragraphs [0020] - [0025]; figure 1 *	1-4 5,6	INV. H01R4/20 H01R43/048
Y	US 9 196 971 B2 (MECATRACTION [FR]) 24 November 2015 (2015-11-24) * column 11, lines 16-45, figures 7-10 *	5,6	
X	US 2 587 095 A (BERGAN MARTIN D) 26 February 1952 (1952-02-26) * column 6, line 42- column 7, line 66 , figures 1-7 *	7-10	

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H01R
F21V

The present search report has been drawn up for all claims

3

Place of search	Date of completion of the search	Examiner
The Hague	2 June 2020	López García, Raquel

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02-06-2020

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