(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 141 155 A1

(12) EUROPEAN PATENT APPLICATION
published in accordance with Art. 153(4) EPC

(43) Date of publication:
01.03.2023 Bulletin 2023/09

(21) Application number: **21792845.6**

(22) Date of filing: **25.03.2021**

(51) International Patent Classification (IPC):
D02G 3/38 *(2006.01)* ***D02G 3/04*** *(2006.01)*
D02G 3/28 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
D02G 3/04; D02G 3/28; D02G 3/38

(86) International application number:
PCT/JP2021/012739

(87) International publication number:
WO 2021/215190 (28.10.2021 Gazette 2021/43)

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(30) Priority: **23.04.2020 JP 2020076690**

(71) Applicant: **Seiren Co., Ltd.**
Fukui-shi
Fukui 918-8560 (JP)

(72) Inventors:
- **UESUGI Takashi**
  Fukui-shi, Fukui 918-8560 (JP)
- **HAYASHI Hiroyuki**
  Fukui-shi, Fukui 918-8560 (JP)
- **TSUJIMOTO Kazuhisa**
  Fukui-shi, Fukui 918-8560 (JP)

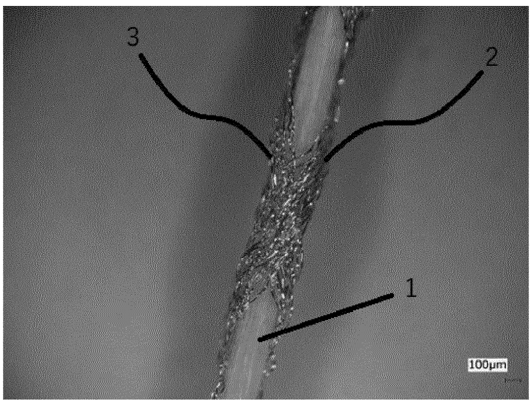
(74) Representative: **Hoffmann Eitle**
Patent- und Rechtsanwälte PartmbB
Arabellastraße 30
81925 München (DE)

(54) CONDUCTIVE YARN AND ARTICLE HAVING WIRING LINE THAT IS FORMED OF CONDUCTIVE YARN

(57) [Problem] To provide a conductive yarn which has conductivity that exhibits durability in terms of deformation and tensile force, while being free from the occurrence of twisting or slacking during sewing. The present invention is capable of providing an article that is provided with a flexible wiring line having a free shape by means of an easy method of sewing.

[Solution] A conductive yarn which is characterized by comprising a non-twisted high-strength filament yarn, a first conductive filament yarn that covers the high-strength filament yarn with a Z twist, and a second conductive filament yarn that covers the high-strength filament yarn with an S twist. In addition, an article which has a wiring line that is formed of this conductive yarn.

[Fig. 1]



Description

Technical Field

[0001] The present invention relates to a conductive yarn and an article having a wiring line that is formed of said conductive yarn.

Background Art

[0002] Today, many ideas regarding wearable devices equipped with various electric devices on a garment are proposed. Electric devices having various functions such as a sensor for measuring a body temperature and/or a heart rate, an electrode used for a low frequency therapy by electrical stimulation or EMS (electrical Muscle Stimulation) and LED for decoration are applied on a garment. In addition, wiring lines for connecting with a power supply for driving the electric devices and for input/output signals are also applied on the garment at the same time.
[0003] Means for preparing a wiring line on a wearable device include a method of cutting a metal foil out in the wiring shape to stick on the device and a method of printing conductive paste on the device.
[0004] However, the wiring line prepared by these methods required to be protected by covering with a resin film or the like in order to prevent disconnection accompanying deformation of the garment. There is a significant problem in using the resin film, because the resin film might impair flexibility of clothing.
[0005] In order to avoid the problem, there has been proposed a method of forming a conductive wire by incorporating a metal wire and/or a conductive fiber into the fiber structure of a fabric as the base material of the garment at the time of weaving or knitting the fabric. However, this method has a problem that the degree of freedom in the wiring shape is low.
[0006] The Patent Document 1 discloses a sewing machine yarn wherein a conductive filament and a flame-retardant fiber having a limiting oxygen index LOI of 26 or more are twisted together. Using the flame-retardant fiber having a limiting oxygen index LOI of 26 or more enables to resist abrasion and wear of the sewing needle and to form conductive patterns freely on a fabric by a sewing machine sewing.

Prior Art Documents

[Patent Document]

[0007] Patent Document 1: Jpn. Pat. Laid-Open Publication No.2018-154944

Disclosure of the Invention

Problems to be Solved by the Invention

[0008] The Patent document 1 illustrates a sewing machine yarn obtained by twisting a conductive filament and a twistable flame-retardant fiber spinning yarn together, according to which thread breakage while sewing machine sewing can be prevented.
[0009] The flame-retardant fiber spinning yarn has high strength and has moderate extensibility against tension in a length direction. While it can exhibit an effect of relaxing the tension during sewing machine sewing, there is a risk of breaking since the conductive filament is weak against elongation.
[0010] The sewing machine yarn wherein two kinds of fibers having different physical properties such as a flame-retardant fiber spinning yarn and a conductive filament are twisted together is unbalanced in stress caused by twisting. For that reason, twisting and slacking of the sewing machine yarn on a stitch during sewing may easily occur. Twisting and slacking of the sewing machine yarn on a stitch may cause the decrease in conductivity. There also arises a problem that electrical short circuit between the wiring lines adjacent to each other may occur.

Means for Solving the Problems

[0011] In order to solve the above problems, the present inventors studied the structure of a double covering yarn having a high-strength filament yarn as a core yarn and two conductive filament yarns as a sheath yarn. As a result, they have found that a conductive yarn comprising a non-twisted high-strength filament yarn covered by one conductive filament yarn with a Z-twist and the other conductive filament yarn with an S-twist can exhibit highly durable conductivity and excellent sewability.
[0012] The present invention provides a conductive yarn characterized by comprising a non-twisted high-strength filament yarn formed of a high-strength fiber having tensile strength of 10 cN/dtex or more, a first conductive filament

yarn that covers the high-strength filament yarn with a Z-twist and a second conductive filament yarn that covers the high-strength filament yarn with an S-twist.

[0013] According to the above configuration, it is possible to obtain a wiring line without occurring twisting and slacking of the conductive yarn at the time of forming the wiring line by sewing. Since a high-strength filament yarn is used as a core yarn, disconnection of the first conductive filament yarn and the second conductive filament yarn consisting a sheath yarn can be suppressed.

[0014] Regarding the conductive filament yarns covering the above-mentioned high-strength filament yarn, the ratio of the twist number of Z-twists of the first conductive filament yarn (Tz) and the twist number of S-twists of the second conductive filament yarn (Ts) is preferably Tz : Ts = 1 : 0.8 - 1.2. More preferably, Tz is equal to Ts. According to this configuration, occurrence of twisting and slacking of the conductive yarn at the time of forming the wiring line can be suppressed more effectively.

[0015] It is preferable that the high-strength fiber forming the high-strength filament yarn has tensile strength of 20 cN/dtex or more. It is preferable that the high-strength fiber is formed of an ultra-high molecular weight polyethylene fiber. According to this configuration, it is possible to prevent disconnection of the first conductive filament yarn and the second conductive filament yarn even when tension is applied to the wiring part at the time of wearing after sewing, and to keep high conductivity.

[0016] It is preferable that both the first conductive filament yarn and the second conductive filament yarn are a copper-coated polyester filament yarn or a silver-coated polyester filament yarn. According to this configuration, it is possible to form a low-resistance wiring line capable of imparting reduction of power consumption and improvement of accuracy in input/output signals.

[0017] The present invention also relates to an article which has a wiring line that is formed of the above-mentioned conductive yarn. According to the present invention, an article having a flexible wiring line that exhibits high durability in terms of tensile force can be produced by means of an easy method of sewing or the like.

Effect of the Invention

[0018] The present invention is capable of providing a conductive yarn which has excellent sewability and conductivity that exhibits high durability in terms of tensile force in a length direction. Using the conductive yarn according to the present invention, a flexible wiring line having the high degree of freedom of shape can be formed by means of an easy method of sewing.

Brief Description of Drawings

[0019] [Fig.1]
Figure 1 shows an enlarged photograph which exhibits one embodiment of the conductive yarn of the present invention.

Modes for Carrying Out the Invention

[0020] The conductive yarn of the present invention comprises a high-strength filament yarn formed of a high-strength fiber having tensile strength of 10 cN/dtex or more, which has a structure of a double covering yarn covered by a first conductive filament yarn and a second conductive filament yarn. The high-strength filament yarn is a non-twisted yarn constituting a core yarn in the conductive yarn of the present invention having a structure of a double covering yarn consisting of a core yarn and a sheath yarn.

[0021] The high-strength filament yarn of the present invention is formed by using a high-strength fiber having tensile strength of 10 cN/dtex or more. Tensile strength in the present invention is measured in the length direction of the filament according to JIS L 1013. The high-strength fiber forming the high-strength filament yarn of the present invention has tensile strength of 10 cN/dtex or more, preferably 20 cN/dtex or more, more preferably 20 cN/dtex to 50 cN/dtex, most preferably 30 cN/dtex to 40 cN/dtex.

[0022] The high-strength fiber having tensile strength of 10 cN/dtex or more enables to suppress reduction in conductivity during sewing and/or wearing. The single yarn fineness of the high-strength fiber is preferably 0.5 to 10 dtex.

[0023] Examples of the high-strength filament yarns formed of the high-strength fiber having tensile strength in the length direction of 10 cN/dtex or more include a para-aramid fiber filament yarn, an ultra-high molecular weight polyethylene filament yarn, a liquid crystal polyester filament yarn and a polyarylate filament yarn. Among them, an ultra-high molecular weight polyethylene filament yarn formed of an ultra-high molecular weight polyethylene fiber is preferable in terms of high abrasion resistance and being light-weight. The ultra-high molecular weight polyethylene fiber is preferably made of an ultra-high molecular weight polyethylene having an average molecular weight of 1,000,000 to 7,000,000.

[0024] The high-strength filament fiber is preferably a multi-filament fiber, more preferably having a total fineness of 50 dtex to 2,000 dtex. Further preferably, it has a total fineness in the range of 200 dtex to 900 dtex. Tensile strength of the high-strength filament yarn is preferably 1,500 cN or more.

[0025] It is important that the above-mentioned high-strength filament yarn is a non-twisted yarn. Sine the high-strength filament yarn is a non-twisted yarn, the conductive yarn of the present invention has an effect of being free from occurrence of twisting or slacking during forming the wiring line by sewing.

[0026] The number of filaments of the multi-filament yarn is preferably 10 to 1,000, more preferably 10 to 300, although not particularly limited.

[0027] The first conductive filament yarn and the second conductive filament yarn are a sheath yarn in a double covering yarn structure of the conductive yarn of the present invention.

[0028] A covering yarn has a structure consisting of a core yarn and a sheath yarn wound around the core yarn. The double covering yarn has a double sheath-yarn layer structure consisting of a lower sheath yarn wound around the core yarn side (inside) and an upper sheath yarn wound around the outside of the lower sheath yarn. In the present invention, the first conductive filament yarn and the second conductive filament yarn can be used to form either a lower sheath yarn or an upper sheath yarn. They may be a lower sheath yarn or an upper sheath yarn alternately.

[0029] The first conductive filament yarn covers the high-strength filament yarn with a Z-twist. The second conductive filament yarn covers the high-strength filament yarn with an S-twist. Prior to covering the high-strength filament yarn, a primary twist can be applied to the first conductive filament yarn and/or the second conductive filament yarn each individually.

[0030] It is preferable that the first conductive filament yarn and the second conductive filament yarn are a metal-coated filament yarn formed by coating a metal film on a synthetic fiber filament yarn.

[0031] Examples of the synthetic fiber filament yarns include a polyester filament yarn, a nylon filament yarn, an acryl filament yarn, a polyolefin filament yarn, a vinylidene chloride filament yarn, and an aramid filament yarn. Among them, a polyester filament yarn is preferable in terms of versatility, chemical resistance, and strength.

[0032] It is preferable that the synthetic fiber filament yarn is a multi-filament yarn. The synthetic fiber filament yarn has a total fineness of preferably 20 dtex to 120 dtex, more preferably 30 dtex to 80 dtex.

[0033] The number of filaments of the synthetic fiber filament yarn is preferably 10 or more, more preferably 10 to 50 from the viewpoint of bending durability. A single yarn fineness of the synthetic fiber filament yarn is preferably 0.5 dtex to 10 dtex.

[0034] The conductive filament yarn of the present invention can be obtained by coating a metal film on the synthetic fiber filament yarn. The synthetic fiber filament yarn may be primarily twisted prior to forming the metal film thereon.

[0035] Examples of the metals constituting the metal film include silver, gold, copper, nickel, tin, zinc, and palladium. Alloys containing these metals can also be included. Among them, silver and copper are preferable in terms of excellent conductivity, and silver is more desirable.

[0036] Examples of means for forming the metal film include a dry process such as vapor deposition and sputtering and a wet process. It is preferable to employ a wet plating process. Examples of the wet plating processes include an electroplating method and an electroless plating method. The wet plating process enables to form a uniform metal film on each filament yarn even in the case of the synthetic fiber filament yarn.

[0037] The thickness of the metal film is preferably 0.075μm to 0.50um, more preferably 0.1μm to 0.3um. The thickness of the metal film within the range of 0.075μm - 0.50um allows to achieve both of excellent conductivity and flexibility.

[0038] The conductive filament yarn thus obtained has a total fineness of preferably 20 dtex to 200 dtex, more preferably 40 dtex to 150 dtex. It has a single yarn fineness of preferably 0.5 dtex to 20 dtex.

[0039] The conductive filament yarn thus obtained has a resistance value of preferably 10,000 Ω/m or less, more preferably 1,000 Ω/m or less. The resistance value in the present invention is measured according to JIS C 2525.

[0040] It is preferable that both the first conductive filament yarn and the second conductive filament yarn are a copper-coated polyester filament yarn or a silver-coated polyester filament yarn. More preferably, they are both a silver-coated polyester filament yarn.

[0041] It is preferable that a single yarn fineness, a total fineness, the number of filaments and the like are substantially the same for the first conductive filament yarn and the second conductive filament yarn. Since the properties of the first conductive filament yarn and the second conductive filament yarn constituting the sheath yarn of the conductive yarn are substantially the same, stress caused by twisting two sheath yarns can be cancelled each other. As a result, a conductive yarn excellent in sewability can be obtained.

[0042] The conductive yarn of the present invention employs the structure of a double covering yarn having a core yarn formed of the non-twisted high-strength filament yarn and a sheath yarn formed of the first conductive filament yarn and the second conductive filament yarn. The first conductive filament yarn covers the high-strength filament yarn with a Z-twist. The second conductive yarn covers the high-strength filament yarn with an S-twist.

[0043] The twist number of Z-twists of the first conductive filament yarn and the twist number of S-twists of the second conductive filament yarn are preferably each within the range of 100 T/m to 1,000 T/m. When the twist number is each within the range of 100 T/m to 1,000 T/m, a conductive yarn having excellent conductivity and high sewability can be obtained. The twist number of each conductive filament yarn is more preferably within the range of 100 T/m to 400 T/m.

[0044] It is preferable that the ratio of the twist number of Z-twists of the first conductive filament yarn (Tz) and the twist number of S-twists of the second conductive filament yarn (Ts) is preferably Tz : Ts = 1 : 0.8 - 1.2, more preferably Tz : Ts = 1 : 0.9 - 1.1, further preferably Tz = Ts.

[0045] Accordingly, the conductive yarn can be improved in balance of stress caused by twisting and in suppression of twisting and slacking of the conductive yarn during sewing.

[0046] Regarding the means for double-covering the high-strength filament yarn with the first conductive filament yarn and the second conductive filament yarn, any methods using a known double-covering apparatus can be employed. Examples of the methods using a double-covering apparatus include a method wherein a core yarn formed of the non-twisted high-strength filament yarn is fed from a feed roller, then the first conductive filament yarn as a lower sheath yarn is fed from the first spindle to cover the high-strength filament yarn in Z-twisting, and then the second conductive filament yarn as an upper sheath yarn is fed from the second spindle to cover them in S-twisting. The double covering yarn thus obtained is wound up on a winder via a delivery roller.

[0047] Although, the above-mentioned example of the double covering method is carried out by firstly covering by the first conductive filament yarn and secondly covering by the second conductive filament yarn, this order may be reversed. For example, the double covering method can be carried out by firstly covering the second conductive filament yarn as a lower sheath yarn in S-twisting and secondly covering the first conductive filament yarn as an upper sheath yarn in Z-twisting.

[0048] The conductive yarn thus obtained has a total fineness of preferably 50 dtex to 2,500 dtex, more preferably 200 dtex to 1,500 dtex.

[0049] A resistance value of the conductive yarn thus obtained is not particularly limited, but is preferably 1,000 Ω/m or less, more preferably 500 Ω/m or less.

[0050] The conductive yarn of the present invention thus obtained which has the structure of a double covering yarn enables to suppress twisting and slacking thereof during sewing by balancing stress in an S-twisting direction and that in a Z-twisting direction.

[0051] Since a non-twisted high-strength filament yarn is used as a core yarn, in addition, elongation in a length direction of the conductive yarn can be restricted to have an effect of reducing the risk of a change in a resistance value and disconnection.

[0052] The elongation rate in a length direction of the conductive yarn according to the present invention is preferably 5% or less. When the elongation rate in a length direction of the conductive yarn is 5% or less, it is possible to form a wiring line wherein deterioration of conductivity against tensile force in a length direction is suppressed. As a result, increase of a resistance value can be prevented even when a force in a length direction is applied at the time of using such as wearing. The elongation rate in the present invention is measured according to JIS L 1095 (Testing Methods for Spun Yarn; 9.5; a single yarn tensile strength and an elongation rate).

[0053] The conductive yarn of the present invention having highly durable conductivity can be used for a wiring line for various electric devices and the like. Since it also has excellent sewability, it is suitable to use for a wiring line provided especially on a fabric such as a garment.

[0054] Examples of the article having the wiring line of the present invention include an article having a wiring line formed as a stitch using the conductive yarn on a flexible base material such as a fabric. Since said wiring line is formed of the conductive yarn, it has high strength and low elongation in a length direction. Further, because of excellent flexibility of said wiring line using the above-mentioned conductive yarn, it does not inhibit flexibility that the base material inherently has.

[0055] Examples of means for forming a wiring line on the base material include sewing. Sewing may be hand sewing or sewing by using a sewing machine such as a home sewing machine or an industrial sewing machine. The conductive yarn of the present invention can be used for a sewing machine yarn. Since the conductive yarn of the present invention allows to equalize the twist stress, it exhibits excellent sewability during sewing using a sewing machine. Even in the case of forming a wiring line having a complex shape, occurrence of twisting and slacking of the conductive yarn can be suppressed. Suppression of occurrence of twisting and slacking of the conductive yarn enables preventing of causing a short circuit even between the two adjacent wirings, which allows to form a precise and fine wiring pattern.

[0056] Examples of stitches forming a wiring line formed of a conductive yarn of the present invention include a single chain stitch, a hand-sewing stitch, a lock stitch and a double ring sewing stitch, although it is not particularly limited. They can be selected properly according to the position and/or the purpose of forming the wiring line.

[0057] Examples of the articles having the wiring line formed of a conductive yarn of the present invention, which are the base materials on which the wiring line is formed, include a fabric such as a woven fabric, a knitted fabric and a non-woven fabric made of various kinds of fibers, a sheet or a film made of a resin such as a synthetic resin or a natural resin, paper, and natural leather.

[0058] Composite base materials wherein two or more base materials selected from the above materials are laminated each other can also be used. Examples of the composite base materials include a resin-coated fabric and a synthetic leather.

[0059] Examples of various kinds of fibers capable of forming a fabric include a synthetic fiber such as polyester, polyamide, polyurethane, and polyethylene; a natural fiber such as cotton, hemp, and silk; a mixed spinning fiber thereof; and a mixed fiber thereof.

[0060] Examples of the synthetic resins capable of forming the sheet or film include polyethylene, polyester, polyamide, polyurethane, and polyvinyl chloride. Examples of the natural resins capable of forming the sheet or film include a natural rubber.

[0061] Examples of the resin-coated fabric include a laminate of a fabric and a film or sheet made of a synthetic resin and a fabric obtained by coating a synthetic resin thereon and drying. Examples of the synthetic leathers include a laminate of a fabric and a polyurethane resin.

Examples

[0062] The present invention will be described in more detail below referring to examples. Note that the scope of the present invention is not limited by the following examples. Evaluations in the examples are carried out according to the following methods.

[Evaluation of Conductivity]

[0063] A resistance value per 1 m of the length of the conductive yarn was measured while pinching both ends in the longitudinal direction of the yarn by a clip-type probe of a digital multimeter named "PM3", manufactured by Sanwa Electric Instrument Co., Ltd. The measurement of the resistance value was carried out according to JIS C 2525.

[Evaluation of Elongation Rate]

[0064] The elongation rate of the conductive yarn was measured by pinching both ends in the longitudinal direction of the yarn and extending until it was broken using a compact tabletop tester named "EZ-Test", manufactured by Shimadzu Corporation. The elongation rate is measured according to JIS L 1095 (Testing Methods for Spun Yarn; 9.5; a single yarn tensile strength and an elongation rate) .

[Evaluation of Sewability]

[0065] Using the conductive yarn obtained, 5 linear wiring lines having the number of stitches of 50/100 mm were formed at an interval of 10 mm each other by sewing at the sewing speed of 600 rpm on a polyester twill fabric having the warp density of 120 yarns/inch and the weft density of 70 yarns/inch as a base material.

[0066] Sewing was carried out by using an embroidery sewing machine named "Innovis VF1", manufactured by Brother Industries, Ltd. A distance between each linear wiring line was measured at arbitrary 10 points to obtain an average value thereof. Then a maximum dispersion thereof was calculated by the following numerical formula. Based on the maximum dispersion (%) thus obtained and a result of confirming the presence/non-presence of slackening of a yarn by visually inspecting the sewing portion, sewability was evaluated according to the following evaluation standard.

(Numerical Formula)

[Maximum Dispersion (%) = |Lm - La| ÷ La × 100]

[Formula 1]

$$\text{Maximum Dispersion (\%)} = \frac{|Lm - La|}{La} \times 100$$

[0067] In the above numerical formula, "La" indicates an average value of the distance between each wiring line measured at arbitrary 10 points and "Lm" indicates either the maximum value or the minimum value of the distance between each wiring line which is larger than the other in the difference from the average value.

(Evaluation Standard)

[0068]

○: Maximum Dispersion is less than 10% with no slack
△: Maximum Dispersion is less than 10% with a slack observed
×: Maximum Dispersion is 10% or more

[Evaluation of Wiring Strength]

[0069] On the center of the width direction of a polyester twill fabric having the width of 10 mm and the length of 120 mm as a base material, a wiring line was formed by sewing linearly with the number of stitches of 50/100 mm using the conductive yarn to prepare an article having a wiring line formed as a stitch in the same manner as in the above-described case of evaluation of sewability.

[0070] The article thus obtained was subjected to an expansion operation repeating for 20 times in the length direction of the base material under a tensile load of 1.0 N/mm using a compact tabletop tester named "EZ-Test", manufactured by Shimadzu Corporation. The increasing rate of the resistance value after the expansion operation against the resistance value before the expansion operation was calculated according to the following numerical formula 2. Evaluation was carried out according to the following evaluation standard.

$$[\text{Resistance Increasing Rate } (\%)] = (Ra - Rb) \div Rb \times 100$$

[Formula 2]

$$[\text{Resistance Increasing Rate } (\%)] = \frac{(Ra - Rb)}{Rb} \times 100$$

[0071] In the above numerical formula, Ra indicates a resistance value after the expansion operation and Rb indicates a resistance value before the expansion operation.

(Evaluation Standard)

[0072]

○: Resistance Increasing Rate is less than 5%
△: Resistance Increasing Rate is 5% or more and less than 10%
×: Resistance Increasing Rate is 10% or more

[Example 1]

[0073] A non-twisted ultra-high molecular weight polyethylene filament yarn having a total fineness of 275 dtex/the number of filaments of 192f and a single yarn fineness of 1.4 dtex was used as a core yarn. It was a filament yarn named "IZANAS (registered trademark) SK60", manufactured by TOYOBO CO., LTD., using an ultra-high molecular weight polyethylene fiber having tensile strength of 32 cN/dtex as a high-strength fiber. The ultra-high molecular weight polyethylene filament yarn had tensile strength of 8800 cN.

[0074] Two silver-plated polyester filament yarns having a total fineness after plating of 75 dtex/the number of filaments of 24f and a single yarn fineness of 3.1 dtex, manufactured by SEIREN Co., LTD. , were used as two sheath yarns . This silver-plated polyester filament yarn had been formed by preliminary subjecting a polyester filament yarn having a total fineness of 50 dtex/the number of filaments of 24f and a single yarn fineness of 2.1 dtex to a first twisting process, and then subjecting to an electroless plating process to form a silver coating film having the thickness of 0.19 um. The resistance value of the silver-plated polyester filament yarn was 240 Ω/m.

[0075] The above-described non-twisted core yarn was covered with one of the two sheath yarns as a lower sheath yarn with a Z-twist at the twist number of 450 T/m, and then was covered with the other of the two sheath yarns as an upper sheath yarn with an S-twist at the twist number of 450 T/m, to obtain a conductive yarn.

[0076] The conductive yarn thus obtained had a total fineness of 436 dtex, a resistance value of 129 Ω/m, and the elongation rate of 4.5%. As a result of a sewability test using the conductive yarn thus obtained, the maximum dispersion of the distance between each wiring line was 3.7%, exhibiting excellent sewability with no slack observed.

[0077] As a result of evaluation of wiring strength, the increasing rate of the resistance value was 4.0%, exhibiting excellent durability against tension.

[Example 2]

[0078] A conductive yarn was prepared and each evaluation was carried out in the same manner as in Example 1, except for using a non-twisted liquid crystal polyester yarn having a total fineness of 280 dtex/the number of filaments of 48f and a single yarn fineness of 5.8 dtex as a core yarn. This core yarn was a yarn named "Zxion" (registered trademark), manufactured KB SEIREN LTD. , using a liquid crystal polyester fiber having tensile strength of 30 cN/dtex as a high-strength fiber. The liquid crystal polyester filament yarn had tensile strength of 8400 cN.

[0079] The conductive yarn thus obtained had a total fineness of 448 dtex, a resistance value of 134 Ω/m, and the elongation rate of 4.8%. As a result of a sewability test by using the conductive yarn thus obtained, the maximum dispersion of the distance between each wiring line was 5.8%, exhibiting excellent sewability with no slack observed. As a result of evaluation of wiring strength, the increasing rate of the resistance value was 4.7%, exhibiting excellent durability against tension.

[Comparative Example 1]

[0080] A conductive yarn was prepared in the same manner as in Example 1, except for using a silver-plated polyester filament yarn manufactured by SEIREN Co., LTD., which was the same yarn as the sheath yarn used in Example 1, as a core yarn. This silver-plated polyester filament yarn had been prepared by a preliminary first twisting process of primarily twisting a polyester filament yarn having a total fineness of 50 dtex/the number of filaments of 24f and a single yarn fineness of 2.1 dtex, formed of a polyester fiber having tensile strength of 4.1 cN/dtex, followed by an electroless plating process of plating the yarn to form a silver coating film having the thickness of 0.19 um thereon.

[0081] The silver-plated polyester filament yarn after a silver plating process had a total fineness of 75 dtex/the number of filaments of 24f and a single yarn fineness of 3.1 dtex. The silver-plated polyester filament yarn itself had tensile strength of roughly 300 cN.

[0082] The conductive yarn thus obtained had a total fineness of 250 dtex, a resistance value of 89 Ω/m and the elongation rate of 15.4%. As a result of a sewability test using the conductive yarn thus obtained, the maximum dispersion of the distance between each wiring line was 2.7% with no slack observed.

[0083] As a result of evaluation of wiring strength, the increasing rate of the resistance value was 14.0%, exhibiting poor durability against tension.

[Comparative Example 2]

[0084] Two silver-plated polyester filament yarns having a total fineness of 75 dtex/the number of filaments of 24f, manufactured by SEIREN CO., LTD., which were the same yarns used in Comparative Example 1, were single twisted in S-twist at the twist number of 297 T/m. A liquid crystal polyester yarn having a total fineness of 280 dtex/the number of filaments of 48f, named "Zxion" (registered trademark) , manufactured KB SEIREN LTD., which was the same yarn used in Example 2, was single twisted in S-twist at the twist number of 297 T/m. These twisted yarns were twisted together in Z-twist at the twist number of 207 T/m to obtain a conductive yarn.

[0085] The conductive yarn thus obtained had a total fineness of 434 dtex, a resistance value of 121 Ω/m and the elongation rate of 5.3%.

[0086] As a result of a sewability test using the conductive yarn thus obtained, the maximum dispersion of the distance between each wiring line was 6.3% with a larger number of slack observed.

[0087] As a result of evaluation of wiring strength, the increasing rate of the resistance value was 9.1%, exhibiting insufficient durability against tension.

[Table 1]

		Example 1	Example 2	Comparative Example 1	Comparative Example 2
Core Yarn	Yarn Kinds	Ultra-high Molecular Weight Polyethylene 275dtex/192f	Liquid Crystal Polyester 280dtex/48f	Silver-plated Polyester 75dtex/24f	Liquid Crystal Polyester 280dtex/48f
	Tensile Strength (cN/dtex)	32.0	30.0	4.1	30.0
	Twist	Non-twisted (0 T/m)			S-twist at 297 T/m
Sheath Yarn	First Conductive Filament Yarn (Lower Sheath Yarn)	Silver-plated Polyester 75 dtex/24f			Silver-plated Polyester 75 dtex/ 24f × 2 yarns single twist of 2 yarns S-twist at 297 T/m
	Second Conductive Filament Yarn (Upper Sheath Yarn)	Silver-plated Polyester 75 dtex/24f			
Process for Preparing Yarn		Double Covering First Conductive Filament Yarn: Z-twist at 450 T/m Second Conductive Filament Yarn: S-twist at 450 T/m			Twisted together in Z-twist at 207 T/m
Resistance Value (Ω/m)		129	134	89	121
Elongation Rate of Conductive Yarn (%)		4.5	4.8	15.4	5.3
Evaluation of Sewability (Maximum Dispersion, Slack)		○ (3.7%, No Slack)	○ (5.8%, No Slack)	○ (2.7%, No Slack)	Δ (6.3%, Slack Observed)
Wiring Strength	Increasing Rate of Resistance Value	4.0%	4.7%	14.0%	9.1%
	Evaluation	○	○	×	Δ

Industrial Applicability

[0088] The conductive yarn of the present invention is flexible and excellent in strength in the length direction and has an effect of maintaining high conductivity against modification and tension. Therefore, a flexible electric wiring can be formed on not only a wearable device such as a garment, but also a flexible and insulating sheet-like base material such as sheets used for a sofa or a seat of vehicle, curtains, and bedclothes.

[0089] The wiring line formed of the conductive yarn of the present invention can be utilized as a signal line and a power supply line, and may also function as a heat-generating unit of a sheet-like heater.

Explanation of Reference Letters

[0090]

1: High-strength filament yarn
2: First conductive filament yarn
3: Second conductive filament yarn

Claims

1. A conductive yarn which is **characterized by** comprising a non-twisted high-strength filament yarn formed of a high-strength fiber having tensile strength of 10 cN/dtex or more, a first conductive filament yarn that covers the high-strength filament yarn with a Z-twist, and a second conductive filament yarn that covers the high-strength filament yarn with an S-twist.

2. The conductive yarn according to claim 1 or 2, wherein tensile strength of said high-strength fiber is 20 cN/dtex or more.

3. The conductive yarn according to claim 1, wherein the ratio of the twist number of Z twists of the first conductive filament yarn (Tz) and the twist number of S twists of the second conductive filament yarn (Ts), each covering said high-strength filament yarn, is in the range of Tz : Ts = 1 : 0.8 - 1.2.

4. The conductive yarn according to any one of claims 1 to 3, wherein said high-strength fiber is an ultra-high molecular weight polyethylene fiber.

5. The conductive yarn according to any one of claims 1 to 4, wherein both said first conductive filament yarn and said second conductive filament yarn are a copper-coated polyester filament yarn or a silver-coated polyester filament yarn.

6. An article which has a wiring line that is formed of the conductive yarn according to any one of claims 1 to 5.

Amended claims under Art. 19.1 PCT

1. (Amended) A conductive yarn which is **characterized by** comprising a non-twisted high-strength filament yarn formed of a high-strength fiber having tensile strength of 20 cN/dtex or more, a first conductive filament yarn that covers the high-strength filament yarn with a Z-twist, and a second conductive filament yarn that covers the high-strength filament yarn with an S-twist.

2. (Amended) The conductive yarn according to claim 1, wherein a resistance value is 1,000 Ω/m or less.

3. (Amended) The conductive yarn according to claim 1 or 2, wherein the ratio of the twist number of Z twists of the first conductive filament yarn (Tz) and the twist number of S twists of the second conductive filament yarn (Ts), each covering said high-strength filament yarn, is in the range of Tz : Ts = 1 : 0.8 - 1.2.

4. The conductive yarn according to any one of claims 1 to 3, wherein said high-strength fiber is an ultra-high molecular weight polyethylene fiber.

5. The conductive yarn according to any one of claims 1 to 4, wherein both said first conductive filament yarn and said second conductive filament yarn are a copper-coated polyester filament yarn or a silver-coated polyester filament yarn.

6. An article which has a wiring line that is formed of the conductive yarn according to any one of claims 1 to 5.

Statement under Art. 19.1 PCT

According to the invention set forth in claim 1, a conductive yarn having excellent sewability and durable conductivity can be obtained by double covering a non-twisted filament yarn formed of a high-strength fiber with conductive filament yarns.

The amendment of claim 1 is intended to clarify the features of the present invention where a high-strength fiber having high tensile strength of 20 cN/dtex or more is used.

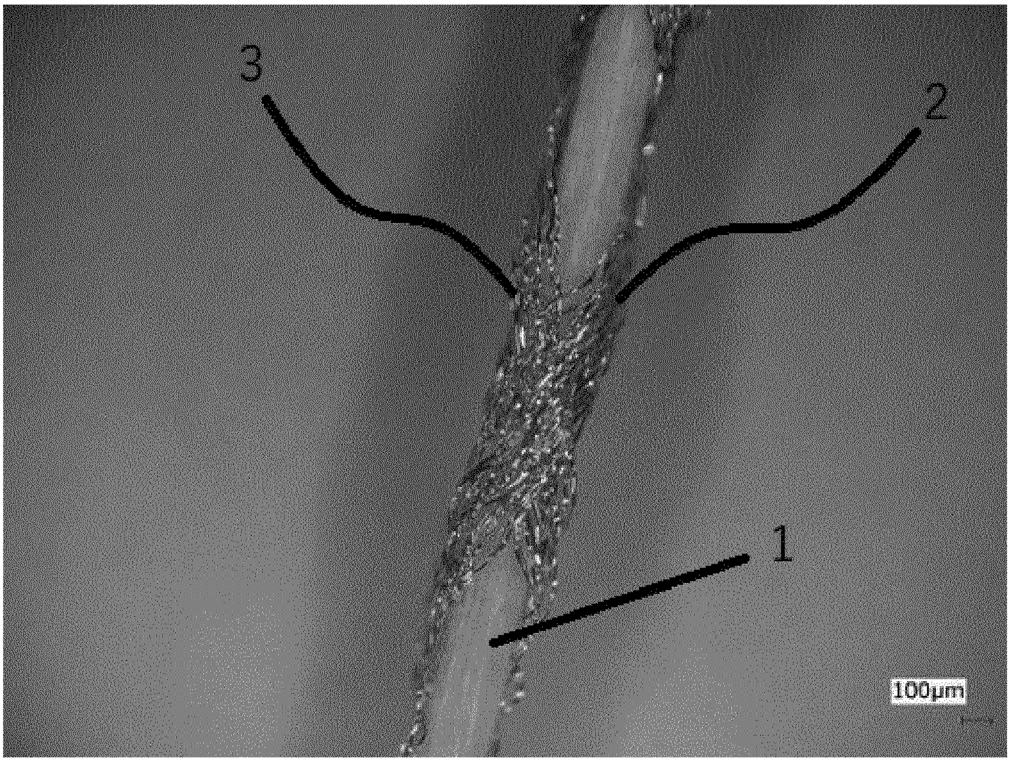
A conductive yarn obtained by double covering a non-twisted high-strength filament yarn formed of a high-strength fiber having tensile strength of 20 cN/dtex or more with conductive filament yarns is not disclosed in any of the documents 1-11 cited in the International Search Report Written Opinion.

The amendment of claim 2 is intended to clarify the features of the present invention where said conductive yarn has high conductivity (low resistance).

A conductive yarn obtained by double covering a non-twisted high-strength filament yarn formed of a high-strength fiber having tensile strength of 20 cN/dtex or more with conductive filament yarns and further having a resistance value of 1,000 Ω/m or less is not disclosed in any of the above-described documents 1 - 11.

The amendment of claim 3 is intended to correct the error in claim dependency and to clarify that the claim 3 refers to preceding claims 1 or 2.

[Fig. 1]



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/012739

A. CLASSIFICATION OF SUBJECT MATTER
D02G 3/38(2006.01)i; D02G 3/04(2006.01)i; D02G 3/28(2006.01)i
FI: D02G3/38; D02G3/04; D02G3/28

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
D02G1/00-3/48; D02J1/00-13/00

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan	1922-1996
Published unexamined utility model applications of Japan	1971-2021
Registered utility model specifications of Japan	1996-2021
Published registered utility model applications of Japan	1994-2021

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	JP 2016-37680 A (TOYOTA BOSHOKU CORP.) 22 March 2016 (2016-03-22) claims, paragraphs [0014], [0015], examples examples	1-3, 5-6 1-6
Y A	JP 2018-80413 A (PANASONIC IP MANAGEMENT CO., LTD.) 24 May 2018 (2018-05-24) claims, paragraphs [0022], [0026]	4-6 1-3
Y A	JP 2019-522738 A (NV BEKAERT SA) 15 August 2019 (2019-08-15) paragraph [0003]	4-6 1-3
Y	JP 61-245334 A (SHIOTANI KIRIYOU KK) 31 October 1986 (1986-10-31) claims, page 1, right column, lines 3-5, page 2, lower right column, lines 2-8, 16 to page 3, upper left column, line 4, page 4, upper left column, lines 9-19, examples	1-6

☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
04 June 2021 (04.06.2021)	22 June 2021 (22.06.2021)

Name and mailing address of the ISA/	Authorized officer
Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Telephone No.

Form PCT/ISA/210 (second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2021/012739

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-350296 A (SEIREN CO., LTD.) 21 December 1999 (1999-12-21) claims	1-6
Y	JP 2000-170046 A (SCALAR HIGH TOUCH KK) 20 June 2000 (2000-06-20) claims, drawings	1-6
Y	JP 2008-75193 A (TORAY INDUSTRIES, INC.) 03 April 2008 (2008-04-03) claims, drawings	1-6
Y	JP 2010-255157 A (UNITIKA TRADING CO., LTD.) 11 November 2010 (2010-11-11) claims, paragraph [0066], examples	1-6
X	WO 2011/021494 A1 (SHOWA GLOVE CO.) 24 February 2011 (2011-02-24) claims, paragraphs [0015], [0035], examples, fig. 3	1-4, 6
Y	claims, paragraphs [0015], [0035], examples, fig. 3	5-6
Y A	JP 2018-521501 A (SANKO TEKSTIL ISLETMELERI SAN. VE TIC. A.S.) 02 August 2018 (2018-08-02) claims, paragraph [0037]	5-6 1-4
Y A	JP 2011-23495 A (TEIJIN FIBERS LTD.) 03 February 2011 (2011-02-03) claims, examples	5-6 1-4

Form PCT/ISA/210 (continuation of second sheet) (January 2015)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2021/012739

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2016-37680 A	22 Mar. 2016	(Family: none)	
JP 2018-80413 A	24 May 2018	US 2018/0135211 A1 claims, paragraphs [0027], [0032] CN 207567406 U	
JP 2019-522738 A	15 Aug. 2019	WO 2018/011001 A1 paragraph [0003] US 2019/0344629 A1 EP 3484730 A1 CN 109476192 A	
JP 61-245334 A	31 Oct. 1986	(Family: none)	
JP 11-350296 A	21 Dec. 1999	US 2003/0054719 A1 claims	
JP 2000-170046 A	20 Jun. 2000	(Family: none)	
JP 2008-75193 A	03 Apr. 2008	(Family: none)	
JP 2010-255157 A	11 Nov. 2010	(Family: none)	
WO 2011/021494 A1	24 Feb. 2011	EP 2468120 A1 claims, paragraphs [0015], [0035], examples, fig. 3 CN 102469838 A KR 10-2012-0052195 A	
JP 2018-521501 A	02 Aug. 2018	WO 2016/188853 A1 claims, page 8 US 2018/0151795 A1 EP 3096368 A1 CN 107896497 A	
JP 2011-23495 A	03 Feb. 2011	(Family: none)	

Form PCT/ISA/210 (patent family annex) (January 2015)

REFERENCES CITED IN THE DESCRIPTION

Patent documents cited in the description

- JP 2018154944 A **[0007]**