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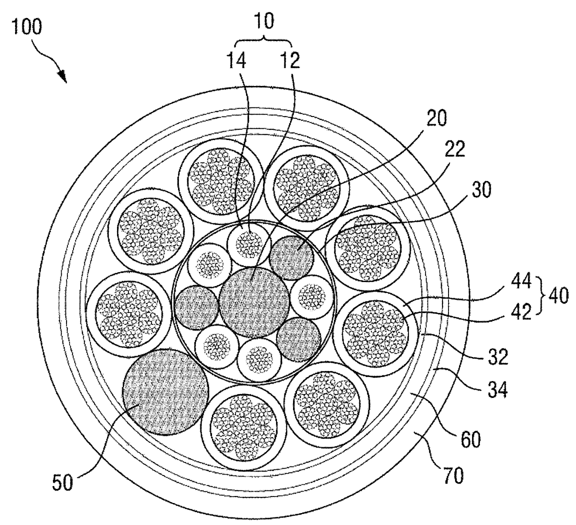
(54) **CABLE FOR ROBOT**

(57) The present invention relates to a cable, for a robot, which has significantly improved durability against repeated torsion and a long bending life and thus is applicable as an industrial robot.

Fig. 1



EP 3 633 692 A1

Description

TECHNICAL FIELD

[0001] The present invention relates to a cable for a robot, and more particularly, to a cable, for a robot, which has significantly improved durability against repeated torsion and a long bending life and thus is applicable as an industrial robot.

BACKGCIRCULAR ART

[0002] In general, an industrial robot performs various tasks such as welding, painting, and conveying in a machine part production line. Such an industrial robot is connected to a central control unit or the like via a cable for a robot, and is supplied with necessary power and transmit or receive information necessary for various tasks via the cable.

[0003] However, during the tasks, the industrial robot is continuously moving or making actions and thus fatigue load such as tension, torsion, bending or the like is repeatedly applied to the cable, for a robot, connected to the industrial robot.

[0004] In this case, a conductor of the cable for a robot may be broken, and thus, considerable time and cost losses may occur for replacement of cables when the production line is stopped due to the broken of the conductor. Therefore, there is a need for a cable, for a robot, which ensures high durability.

DETAILED DESCRIPTION OF THE INVENTION

TECHNICAL PROBLEM

[0005] In order to address the above problem, the present invention is directed to providing a cable for a robot, which is capable of significantly increasing durability and a fatigue life even when used in an environment where torsion or bending frequently occurs.

TECHNICAL SOLUTION

[0006] According to an aspect of the present invention, there is provided a cable for a robot, comprising: a center insert; at least one inner core surrounding the center insert; at least one first insert surrounding the center insert and disposed between the at least one inner core; an inner binding tape surrounding the inner core and the first insert to bind the inner core and the first insert, the inner binding tape being formed of an unsintered fluororesin; at least one outer core surrounding an outer side of the inner binding tape; at least one second insert on an outer side of the inner binding tape; an outer binding tape for binding the outer core and the second insert, the outer binding tape being formed of an unsintered fluororesin; a shielding layer on an outer side of the outer binding tape; and a sheath on an outer side of the shielding layer.

[0007] And the inner core may comprise a first conductor with a plurality of first wire rods twisted at a predetermined first pitch; and a first insulating layer on an outer side of the first conductor, wherein the first pitch is 15 to 30 times an outer diameter of the first conductor.

[0008] And the outer core may comprise a second conductor with a plurality of second wire rods twisted at a predetermined second pitch; a core part with a plurality of second conductors twisted at a predetermined third pitch; and a second insulating layer on an outer side of the core part, wherein the second pitch is 15 to 50 times an outer diameter of the second conductor, and the third pitch is 10 to 30 times an outer diameter of the core part.

[0009] And an increase rate of yield strength of the first wire rods of the inner core and the second wire rods of the outer core may be in a range of 1% to 30%.

[0010] And the unsintered fluororesin may comprise an unsintered polytetrafluoroethylene (PTFE) resin.

[0011] And a coefficient of friction of each of the inner binding tape and the outer binding tape may be in a range of 0.05 to 0.2.

[0012] And an outer diameter of the first insert and an outer diameter of the second insert respectively correspond to an outer diameter of the inner core and an outer diameter of the outer core.

[0013] And the outer diameter of the first insert may be 80% to 120% of that of the inner core, and the outer diameter of the second insert may be 80% to 120% of that of the outer core.

[0014] And at least one of the center insert, the first insert, or the second insert may be formed by twisting elastic yarn.

[0015] And the elastic yarn may comprise polyester yarn.

[0016] And the cable may further comprise an additional binding tape between the shielding layer and the sheath.

[0017] And the additional binding tape may comprise an unsintered polytetrafluoroethylene (PTFE) resin.

[0018] And the sheath may be formed by tube type extrusion.

[0019] According to an aspect of the present invention, there is a cable, for a robot, which is formed of an unsintered fluororesin, comprising: a plurality of inner cores on an outer circumferential surface of a center insert having a round cross-section; an inner binding tape for binding outsides of the inner cores; a plurality of outer cores on an outer circumferential surface of the inner binding tape; an outer binding tape for binding outsides of the outer cores; a shielding layer on an outer side of the outer binding tape; and a sheath on an outer side of the shielding layer, wherein a coefficient of friction of each of the inner binding tape and the outer binding tape is in a range of 0.05 to 0.2.

ADVANTAGEOUS EFFECTS

[0020] According to a cable for a robot according to the present invention, the durability and fatigue life thereof can be remarkably increased even when used in an environment in which torsion or bending frequently occurs.
[0021] In addition, according to the cable for a robot according to the present invention, the durability thereof is improved to minimize process interruptions at an industrial site, thereby minimizing losses due to the process interruptions.

DESCRIPTION OF THE DRAWINGS

[0022]

FIG. 1 is a cross-sectional view of an inner structure of a cable for a robot according to an embodiment of the present invention,
FIGS. 2 and 3 are graphs each showing a resistance change rate according to the number of times of torsion of an example of the present invention and comparative examples,
FIG. 4 is a graph showing the difference between a coefficient of friction when a binding tape according to the present invention is applied and a coefficient of friction when a binding tape of a related art is applied,
FIG. 5 is a graph comparing a change of a pull-out force of an example of the present invention with that of a pull-out force of a comparative example, and
FIG. 6 is a graph showing a resistance change rate (%) according to the number of times of torsion of each of an example of the present invention and a comparative example.

MODE OF THE INVENTION

[0023] Hereinafter, a cable for a robot according to an embodiment of the present invention will be described in detail with reference to the accompanying drawings.
[0024] FIG. 1 is a cross-sectional view of an inner structure of a cable 100 for a robot according to an embodiment of the present invention.
[0025] Referring to FIG. 1, the cable 100 for a robot includes a center insert 20, at least one inner core 10 surrounding the center insert 20, at least one first insert 22 surrounding the center insert 20 and disposed between the at least one inner core 10, an inner binding tape 30 surrounding the at least one inner core 10 and the at least one first insert 22 to bind them, and formed of an unsintered fluororesin, at least one outer core 40 surrounding an outer side of the inner binding tape 30, at least one second insert 50 disposed on an outer side of the inner binding tape 30, an outer binding tape 32 for binding the outer core 40 and the second insert 50 and formed of an unsintered fluororesin, a shielding layer 60 disposed on an outer side of the outer binding tape 32, and a sheath 70 disposed on an outer side of the shielding layer 60.
[0026] In the cable 100 for a robot, the inner core 10 may be configured for communication to exchange information with the outside, and the outer core 40 may be configured for power supply.
[0027] In detail, the inner core 10 may include a first conductor 13 with a plurality of first wire rods 12 twisted at a predetermined first pitch, and a first insulating layer 14 provided on an outer side of the first conductor.
[0028] The first wire rod 12 may be formed of a material such as copper, and the first insulating layer 14 covering the first conductor 13 with the first wire rods 12 may be formed of polyethylene (PE), high-density polyethylene (HDPE), or the like.
[0029] However, when the above-described process is performed on the first wire rods 12 to form the inner core 10, tensile stress may remain in the first wire rods 12. As such, the tensile stress remaining in the first wire rods 12 after the formation of the inner core 10 indicates that tensile pre-strain is high. In this case, yield strength of the first wire rods 12 may be increased, for example, by 30% or more.
[0030] As such, when the yield strength of the first wire rods 12 is increased, the fatigue life of the first wire rods 12 decreases and thus damage such as cracks may occur in the first wire rods 12. The damage caused to the first wire rods 12 may be represented by a resistance change rate (%) which changes a resistance.
[0031] That is, when the resistance change rate (%) is relatively high, it means that damage such as cracks occurred

in the first wire rods 12 to a large degree and may lead to breaking of wires in severe cases.

[0032] FIG. 2 is a graph showing resistance change rates according to the number of times of torsion of an example of the present invention and a comparative example. The example refers to a wire rod, an increase rate of yield strength of which was in a range 1% to 30% after the formation of the inner core 10. The comparative example refers to a wire rod, an increase rate of yield strength of which was greater than 30% after the formation of the inner core 10. In the graph of FIG. 2, the horizontal axis represents the number of times of torsion (x1000 times) and the vertical axis represents a resistance change rate (%).

[0033] As illustrates in FIG. 2, even when the number of times of torsion exceeds 10,000, the resistance change rate of the example was approximately 7%, i.e., it was very low. In the case of the wire rod of the example, damage such as cracks occurred to a relatively very small degree, and an increase rate of yield strength was 30% or less, i.e., in a range of 1% to 30%, due to relatively low tensile pre-strain.

[0034] In contrast, in the case of the comparative example, when the number of times of torsion exceeded 10,000, a resistance change rate was approximately 13% or more and thus was relatively very large. This means that in the case of the wire rod of the comparative example, damage such as cracks occurred to a relatively very large degree, and an increase rate of yield strength was greater than 30% or less due to relatively high tensile pre-strain.

[0035] Accordingly, it can be seen that a fatigue life increases as tensile pre-strain is relatively smaller after processing of a wire rod and may be predicted indirectly by an increase rate of yield strength or a resistance change rate after the processing of the wire rod.

[0036] Therefore, the fatigue life may be increased by determining the increase rate of yield strength or the resistance change rate according to a predetermined threshold after the processing of the wire rod. For example, in the present invention, an increase rate of yield strength of 1% to 30%, i.e., 30% or less, or a resistance change rate of 1% to 25%, i.e., 25% or less, after the processing of the wire rod may be set as a threshold.

[0037] The present inventors conducted an experiment to identify factors affecting a resistance change rate of a wire rod. The result of the experiment is illustrated in FIG. 3.

[0038] FIG. 3 is a graph showing resistance change rates according to the number of times of torsion of an example of the present invention and comparative examples. The example refers to wire rods obtained by forming each of conductors by twisting a plurality of wire rods at a predetermined pitch ('aggregate type') and forming a core part by twisting the conductors at a predetermined pitch ('composite type'). The comparative examples were each obtained by forming each conductor by twisting a plurality of wire rods at a predetermined pitch ('aggregate type'). The total outer diameters of the example and the comparative examples were the same.

[0039] In this case, the pitch of the wire rods of comparative example 1 was greater than that of the wire rods of comparative example 2. For example, the pitch of the wire rods of comparative example 1 was approximately 18 mm, and the pitch of the wire rods of comparative example 2 was approximately 12 mm. In the graph of FIG. 3, the horizontal axis represents the number of times of torsion (x1000 times) and the vertical axis represents a resistance change rate (%).

[0040] As illustrated in FIG. 3, the resistance change rate (%) of the wire rods of the example, which was obtained by aggregate type and composite type processings, versus an increase in the number of times or torsion is remarkably greater than those of the comparative examples.

[0041] That is, in the case of the wire rods of the example, even when the number of times of torsion exceeded 10,000, the resistance change rate (%) was about 12% and thus was very small.

[0042] In contrast, by only the aggregate type processing, the resistance change rate (%) exceeded about 25% when the number of times of torsion exceeded 2,000.

[0043] In the case of the wire rods of comparative example 1, when the number of times of torsion exceeded 10,000, the resistance change rate (%) was approximately 23% and thus was less than that of comparative example 2 but was higher than that of the example.

[0044] As a result, when the wire rods were manufactured by forming by the aggregate type and composite type processings, the resistance change rate thereof was relatively smallest. When only the aggregate type processing was performed, the resistance change rate decreased as the pitch of the wire rod was relatively higher.

[0045] As illustrated in FIG. 1, the first conductor 13 of the inner core 10 may be formed by the aggregate type processing. In this case, the first pitch of the first wire rod 12 may be 15 to 30 times the outer diameter of the first conductor 13. When the first pitch of the first wire rod 12 is less than 15 times the outer diameter of the first conductor 13, a resistance change rate of the first wire rod 12 is greater than 25% or an increase rate of yield strength is greater than 30%. In contrast, when the first pitch of the first wire rod 12 is greater than 30 times the outer diameter of the first conductor 13, the first pitch is extremely long and prevents the first conductor 13 from being appropriately formed in a round shape.

[0046] That is, when the first pitch of the first wire 12 is in the above-described range, the increase rate of the yield strength of the first wire 12 of the inner core 10 is in a range of 1% to 30% and thus the resistance change rate (%) is in a range of 1% to 25%.

[0047] The center insert 20 is provided in a center of the inner core 10. The center insert 20 maintains a round shape of the cable 100 for a robot, together with the first insert 22 and the second insert 50 to be described later.

[0048] An insert of a cable of a related art is formed of a PVC string, polyethylene (PE), ethylene propylene diene monomer (EPDM), or the like.

[0049] When bending or torsion is applied to the cable of the related art, friction occurs between an insulator of a core and the insert other than a slip. In this case, stress is more strongly applied to the core and thus a conductor is damaged or broken.

[0050] Table 1 below shows a result of measuring a resistance of the inner core 10 after a torsion test was conducted 500,000 times on an example and a comparative example having the same structure. The center insert 20, the first insert 22, and the second insert 50 of the example were each manufactured by twisting elastic yarn, i.e.., polyester yarn, and those of the comparative example were each formed of an EPDM. Inner cores 1 to 5 represent the at least one inner core 10 of FIG. 1, to which arbitrary numbers are assigned.

[Table 1]

	resistance (mΩ) of comparative example	resistance (mΩ) of example
inner core 1	18.27	7.1
inner core 2	18.05	7.6
inner core 3	37.5	8.2
inner core 4	16.06	7.1
inner core 5	28.07	7.5

[0051] In Table 1 above, a threshold may vary depending on a place where a cable was installed, a work process, a customer request, or the like but was set to about 8.25 mΩ.

[0052] In this case, resistance values of all the inner cores of the comparative example were greater than or equal to the threshold and thus did not satisfy a reference value.

[0053] In contrast, a maximum resistance value of the example was 8.2 mΩ and thus all resistance values satisfied the reference value. In the case of the example, the inserts were formed of highly elastic yarn to deliver only relatively low stress to the inner cores even when torsion or the like was applied, thereby preventing an increase of a resistance value due to internal stress damage.

[0054] Therefore, in the present invention, at least one of the center insert 20, the first insert 22, or the second insert 50 may be formed by twisting elastic yarn. The elastic yarn may be polyester yarn.

[0055] As illustrated in FIG. 1, the center insert 20 was located at a center, and at least one inner core 10 and the first insert 22 were disposed along the outer side of the center insert 20.

[0056] Although five inner cores 10 and three first inserts 22 are illustrated in the drawing, the numbers of inner cores 10 and first inserts 22 are merely examples and may be appropriately changed.

[0057] Because the inner core 10 and the first insert 22 are formed in a round shape, the first insert 22 preferably has an outer diameter corresponding to that of the inner core 10.

[0058] Because the outer diameter of the inner core 10 may be determined according to a working environment to which the cable 100 for a robot is applied, the outer diameter of the first insert 22 is preferably determined to correspond to that of the inner core 10.

[0059] For example, the outer diameter of the first insert 22 may be 80% to 120% of that of the inner core 10.

[0060] When the outer diameter of the first insert 22 is relatively extremely large, pressure may be applied to the inner core 10 when torsion is applied thereto and thus the first conductor 13 of the inner core 10 may be damaged, e.g., broken. When the outer diameter of the first insert 22 is relatively extremely small, the round shape may not be achieved.

[0061] The inner binding tape 30 surrounds the inner core 10 and the first insert 22 to bind them and maintains the round shape.

[0062] In a cable of a related art, nonwoven fabric or a sintered fluororesin is used as a binding tape. However, the strength and coefficient of friction of the sintered fluororesin are relatively high and thus stress cannot be absorbed and is transferred to an inner core when torsion or the like is applied to the cable. In addition, when torsion or the like is applied to the cable, the inner core may be damaged by friction between the binding tape and the inner core.

[0063] Therefore, in the present invention, the inner binding tape 30 may be formed of an unsintered fluorine resin having a relatively low coefficient of friction and strong lubricity.

[0064] For example, the unsintered fluororesin may be an unsintered polytetrafluoroethylene (PTFE) resin. In this case, it was confirmed that the inner binding tape 30 may be configured to have a coefficient of friction between 0.05 and 0.2. The binding tape 30 of the coefficient of friction may slip softly when torsion is applied to the cable and thus frictional damage between the binding tape 30 and the outer core 40 may be minimized, thereby greatly improving the durability of the cable.

[0065] FIG. 4 is a graph showing the difference between a coefficient of friction when a binding tape B according to the present invention was applied and a coefficient of friction when a binding tape A of a related art was applied,

[0066] In FIG. 4, the binding tape B of the present invention was formed of an unsintered polytetrafluoroethylene (PTFE) resin, and the binding tape A of the related art was formed of a sintered fluororesin.

[0067] As illustrated in FIG. 4, a coefficient of friction was approximately 0.146 μ when the binding tape A of the related art was applied, whereas a coefficient of friction was approximately 0.092 μ and decreased by about 37% when the binding tape B of the present invention was applied.

[0068] FIG. 5 is a graph comparing a change of a pull-out force of an example of the present invention with that of a pull-out force of a comparative example.

[0069] In FIG. 5, an example represents a case in which the inner binding tape 30 was formed of an unsintered polytetrafluoroethylene (PTFE) resin, and a comparative example represents a case in which a sintered fluororesin was used as a binding tape. A pull-out force is defined as a force N required due to friction with an outer core when an inner core was pulled out. That is, a friction force between an inner core and the outer core due to the inner binding tape 30 increases as the pull-out force is relatively large but decreases as the pull-out force decreases as the pull-out force is relatively small. In FIG. 5, the horizontal axis represents a length (mm) by which the inner core was pulled out, and the vertical axis represents a required force N.

[0070] Referring to FIG. 5, in the case of the comparative example, a required force decreases as a length by which the inner core is pulled out increases. For example, the required force was 30 to 35 N when the length by which the inner core was pulled out was about 100 mm.

[0071] In contrast, in the case of the example, the required force was lower than that of the comparative example. For example, when the length by which the inner core was pulled out was about 100 mm, the required force was about 15 N and decreased to about 50% to 57% of that of the comparative example.

[0072] In the case of the the cable 100 for a robot 100 according to the present invention, torsion, bending, etc. are frequently applied thereto due to frequent movement and thus as a pull-out force is smaller, a frictional force between the inner core and the outer core decreases due to the inner binding tape 30, thereby improving durability and a fatigue life.

[0073] Referring to FIG. 1, at least one outer core 40 and at least one second insert 50 are provided on an outer side of the inner binding tape 30.

[0074] In this case, the outer core 40 may be formed by the aggregate type and complex type processings.

[0075] For example, the outer core 40 may include a second conductor 43 with a plurality of second wire rods 42 twisted at a predetermined second pitch, a core part 45 with a plurality of second conductors 43 twisted at a predetermined third pitch, and a second insulating layer 44 provided on an outer side of the core part 45.

[0076] In this case, the second pitch is 15 to 50 times an outer diameter of the second conductor 43, and the third pitch is 10 to 30 times an outer diameter of the core part 45.

[0077] That is, when the second pitch and the third pitch of the second wire 42 are in the above-described ranges, an increase rate of the yield strength of the second wire 42 of the outer core 40 is in a range of 1% to 30% and a resistance change rate (%) is in a range of 1% to 25%.

[0078] The second insert 50 has an outer diameter corresponding to that of the outer core 40. For example, the outer diameter of the second insert 50 may be 80 to 120% of that of the outer core 40.

[0079] In addition, the second insert 50 may be formed by twisting elastic yarn, and the elastic yarn may be polyester yarn.

[0080] The second insert 50 is substantially the same as the first insert 22 described above and thus a redundant description thereof will be omitted.

[0081] Although eight outer cores 40 and one second insert 50 are illustrated in the drawing, the numbers of outer cores 40 and second inserts 50 are merely examples and may be appropriately changed.

[0082] The outer binding tape 32 binds the outer core 40 and the second insert 50 and is formed of an unsintered fluororesin. In this case, the unsintered fluororesin may an unsintered polytetrafluoroethylene (PTFE) resin, and a coefficient of friction of the outer binding tape 32 may be in a range of 0.05 and 0.2.

[0083] The outer binding tape 32 is substantially the same as the inner binding tape 30 described above and thus a redundant description thereof will be omitted.

[0084] The shielding layer 60 is provided on an outer side of the outer binding tape 32. The shielding layer 60 may be in the form of a metal tape or braid formed of a material such as copper, aluminum, a copper alloy, or an aluminum alloy. The shielding layer 60 maintains communication characteristics of a communication cable by electromagnetic shielding or protects the cable from external impacts.

[0085] The sheath 70 is provided on an outer side of the shielding layer 60. The sheath 70 may be an outermost layer of the cable 100 for a robot, and prevents the above-described inner components from being exposed to the outside and protects the inner components from external impacts.

[0086] In the case of a cable of a related art, a sheath is molded by fully filled type extrusion but in this case, pressure marks may be caused on an inner conductor or a shielding layer due to the sheath after the extrusion.

[0087] Therefore, in the present invention, the sheath 70 is extrusion molded by tube type extrusion. The tube type extrusion is a process of inserting the inner components into the sheath 70 prepared in advance in the form of a tube and thus pressure marks may be prevented from occurring on the inner conductor or the shielding layer due to the sheath 70 after extrusion.

[0088] As illustrated in FIG. 1, an additional binding tape 34 may be further provided between the shielding layer 60 and the sheath 70. By providing the additional binding tape 34, an internal frictional force may be further reduced when torsion, bending, or the like is applied to the cable 100 for a robot.

[0089] In this case, the additional binding tape 34 is formed of an unsintered polytetrafluoroethylene (PTFE) resin and has a coefficient of friction between 0.05 and 0.2. The additional binding tape 34 is substantially the same as the inner binding tape 30 and the outer binding tape 32 described above and thus a redundant description thereof will be omitted.

[0090] FIG. 6 is a graph showing resistance change rates (%) according to the number of times of torsion of an example of the present invention and a comparative example.

[0091] In FIG. 6, the example refers to a cable having the same configuration as that of FIG. 1 described above, and the comparative example refers to a cable in which high-density polyethylene (HDPE) or an EPDM was applied as an insert, a sintered fluororesin was applied as a binding tape, and a sheath was formed by fully filled type extrusion. In FIG. 6, the horizontal axis represents the number of times of torsion (x1000 times) and the vertical axis represents a resistance change rate (%).

[0092] As illustrated in FIG. 6, in the case of the cable of the comparative example, the resistance change rate exceeded 25% which was a reference value when the number of times of torsion reached approximately 20,000 to 25,000.

[0093] In contrast, in the case of the cable of the example of the present invention, the resistance change rate did not exceed 5.0% and was far less than 25% which was the reference value even when the number of times of torsion was greater than 50,000.

[0094] While the present invention has been described above with respect to exemplary embodiments thereof, it would be understood by those of ordinary skilled in the art that various changes and modifications may be made without departing from the technical conception and scope of the present invention defined in the following claims. Thus, it is clear that all modifications are included in the technical scope of the present invention as long as they include the components as claimed in the claims of the present invention.

Claims

1. A cable for a robot, comprising:

a center insert;
at least one inner core surrounding the center insert;
at least one first insert surrounding the center insert and disposed between the at least one inner core;
an inner binding tape surrounding the inner core and the first insert to bind the inner core and the first insert, the inner binding tape being formed of an unsintered fluororesin;
at least one outer core surrounding an outer side of the inner binding tape;
at least one second insert on an outer side of the inner binding tape;
an outer binding tape for binding the outer core and the second insert, the outer binding tape being formed of an unsintered fluororesin;
a shielding layer on an outer side of the outer binding tape; and
a sheath on an outer side of the shielding layer.

2. The cable of claim 1, wherein the inner core comprises:

a first conductor with a plurality of first wire rods twisted at a predetermined first pitch; and
a first insulating layer on an outer side of the first conductor, wherein the first pitch is 15 to 30 times an outer diameter of the first conductor.

3. The cable of claim 1, wherein the outer core comprises:

a second conductor with a plurality of second wire rods twisted at a predetermined second pitch;
a core part with a plurality of second conductors twisted at a predetermined third pitch; and
a second insulating layer on an outer side of the core part, wherein the second pitch is 15 to 50 times an outer

diameter of the second conductor, and
the third pitch is 10 to 30 times an outer diameter of the core part.

4. The cable of claim 2 or 3, wherein an increase rate of yield strength of the first wire rods of the inner core and the second wire rods of the outer core is in a range of 1% to 30%.

5. The cable of claim 1, wherein the unsintered fluororesin comprises an unsintered polytetrafluoroethylene (PTFE) resin.

6. The cable of claim 1, wherein a coefficient of friction of each of the inner binding tape and the outer binding tape is in a range of 0.05 to 0.2.

7. The cable of claim 1, wherein an outer diameter of the first insert and an outer diameter of the second insert respectively correspond to an outer diameter of the inner core and an outer diameter of the outer core.

8. The cable of claim 7, wherein the outer diameter of the first insert is 80% to 120% of that of the inner core, and the outer diameter of the second insert is 80% to 120% of that of the outer core.

9. The cable of claim 1, wherein at least one of the center insert, the first insert, or the second insert is formed by twisting elastic yarn.

10. The cable of claim 9, wherein the elastic yarn comprises polyester yarn.

11. The cable of claim 1, further comprising an additional binding tape between the shielding layer and the sheath.

12. The cable of claim 11, wherein the additional binding tape comprises an unsintered polytetrafluoroethylene (PTFE) resin.

13. The cable of claim 1, wherein the sheath is formed by tube type extrusion.

14. A cable, for a robot, which is formed of an unsintered fluororesin, comprising:

a plurality of inner cores on an outer circumferential surface of a center insert having a round cross-section;
an inner binding tape for binding outsides of the inner cores;
a plurality of outer cores on an outer circumferential surface of the inner binding tape;
an outer binding tape for binding outsides of the outer cores;
a shielding layer on an outer side of the outer binding tape; and
a sheath on an outer side of the shielding layer,
wherein a coefficient of friction of each of the inner binding tape and the outer binding tape is in a range of 0.05 to 0.2.

Fig. 1

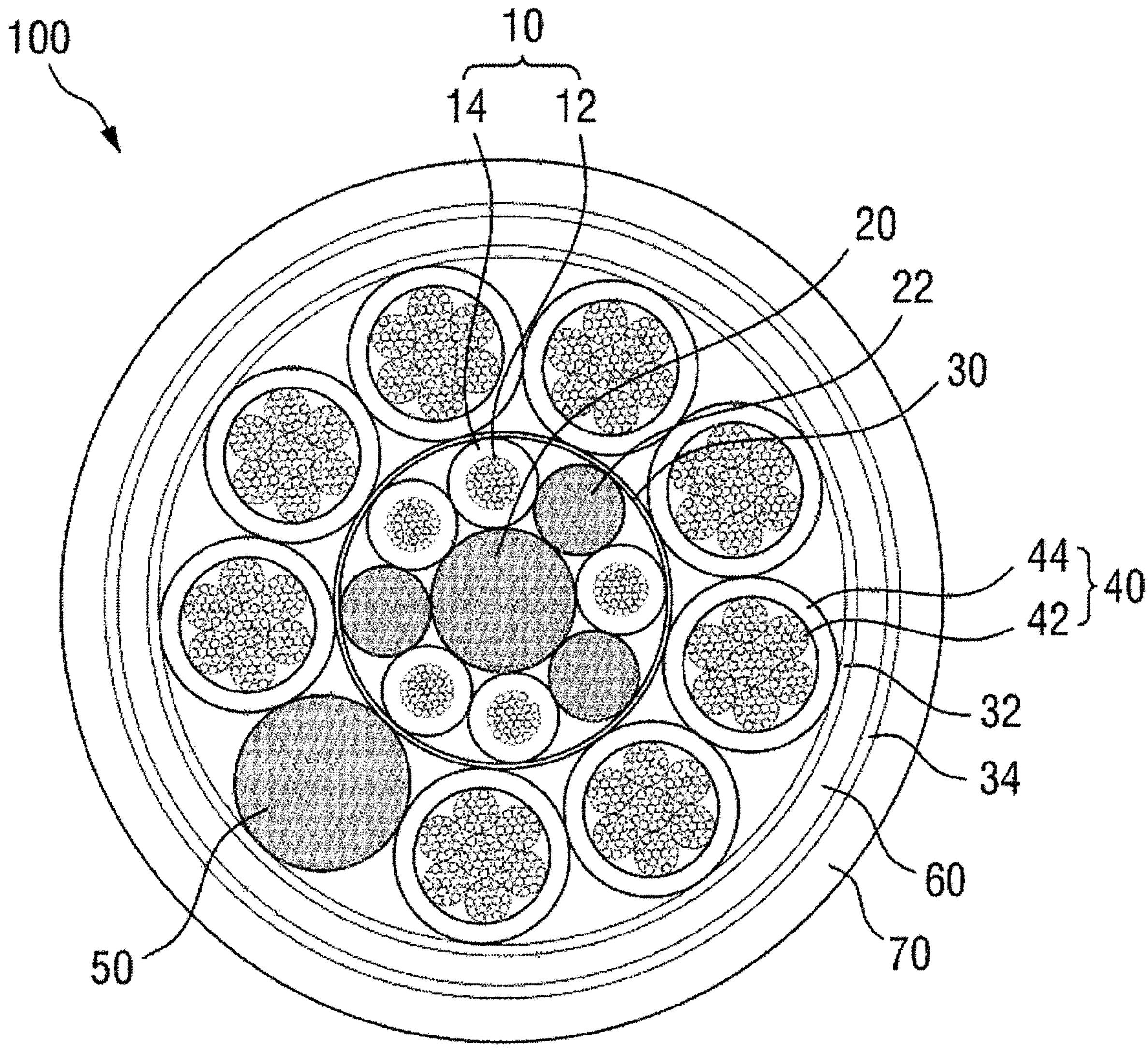


Fig. 2

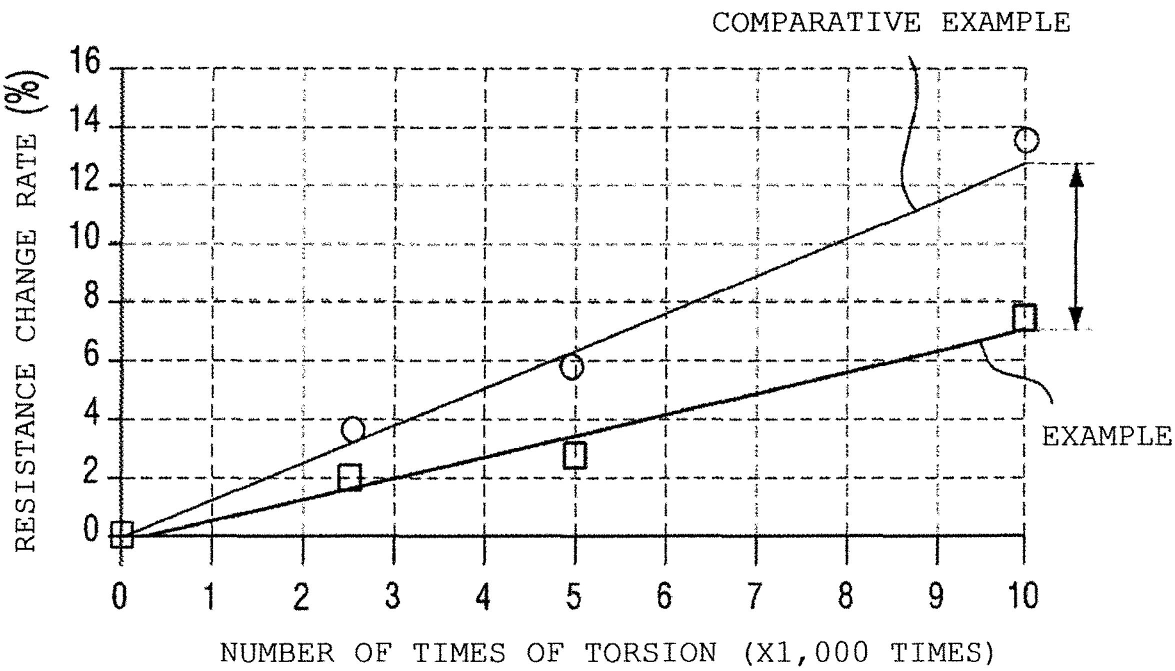

COMPARATIVE EXAMPLE
EXAMPLE
RESISTANCE CHANGE RATE (%)
0
2
4
6
8
10
12
14
16
0 1 2 3 4 5 6 7 8 9 10
NUMBER OF TIMES OF TORSION (X1,000 TIMES)

Fig. 3

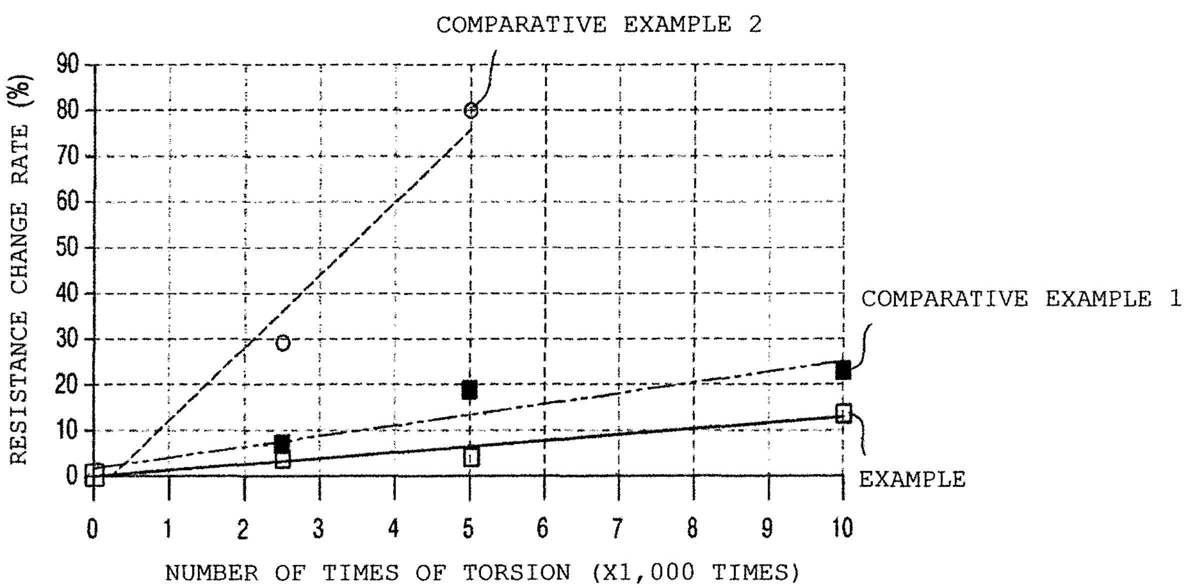

COMPARATIVE EXAMPLE 2
COMPARATIVE EXAMPLE 1
EXAMPLE
RESISTANCE CHANGE RATE (%)
0
10
20
30
40
50
60
70
80
90
0 1 2 3 4 5 6 7 8 9 10
NUMBER OF TIMES OF TORSION (X1,000 TIMES)

Fig. 4

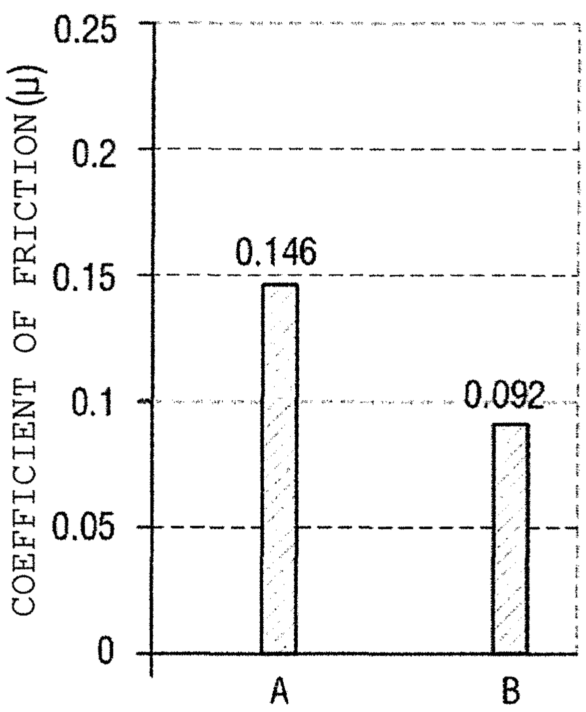

COEFFICIENT OF FRICTION (μ)
0.25
0.2
0.15
0.1
0.05
0
0.146
0.092
A
B

Fig. 5

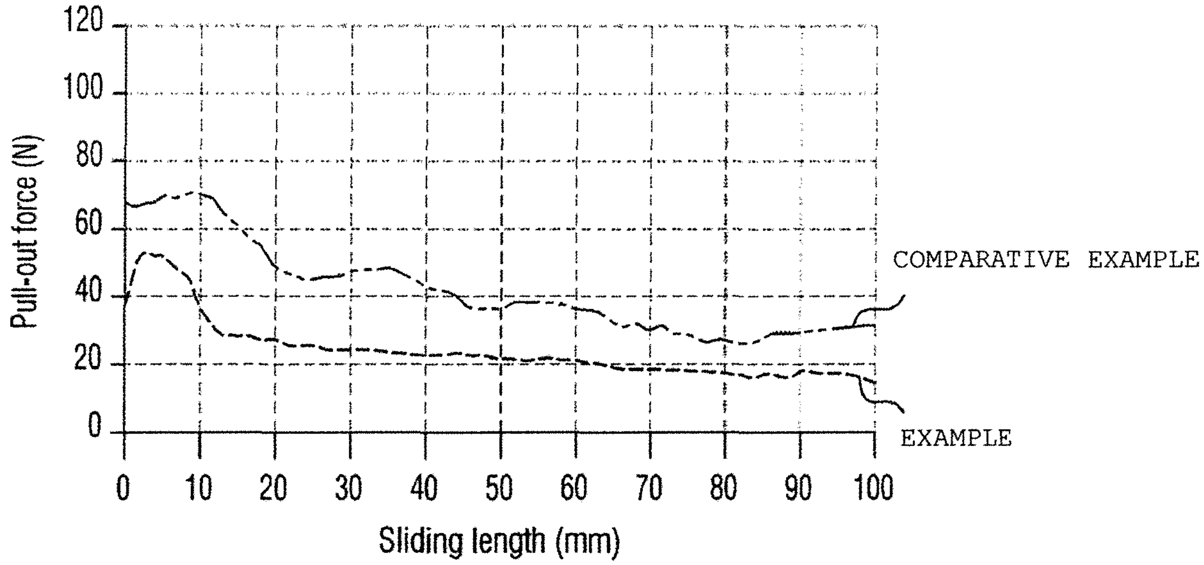
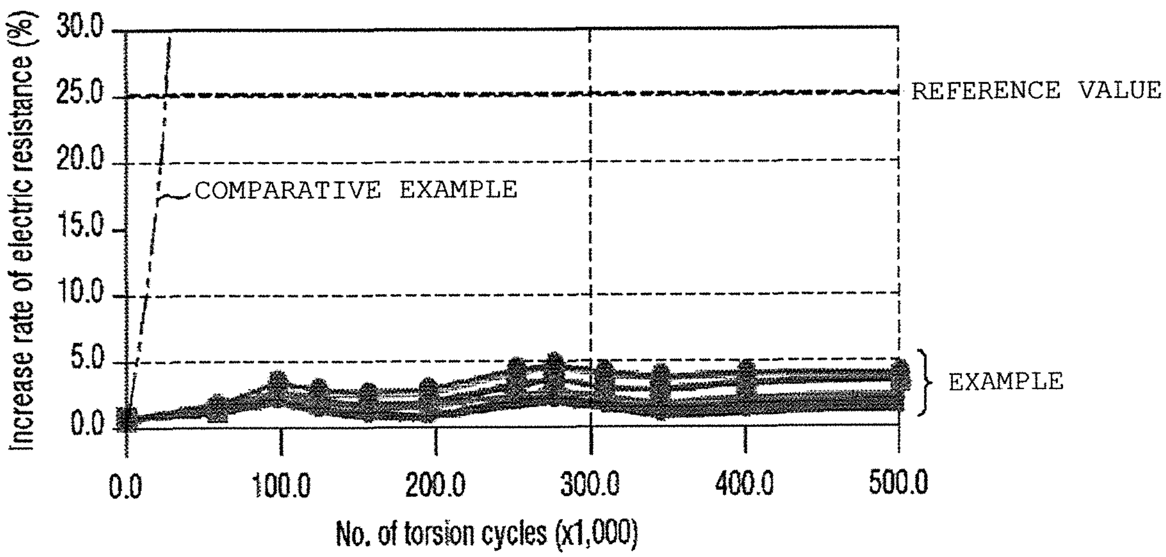

Pull-out force (N)
120
100
80
60
40
20
0
0
10
20
30
40
50
60
70
80
90
100
Sliding length (mm)
COMPARATIVE EXAMPLE
EXAMPLE

Fig. 6


30.0
25.0
20.0
15.0
10.0
5.0
0.0
Increase rate of electric resistance (%)
REFERENCE VALUE
COMPARATIVE EXAMPLE
EXAMPLE
0.0
100.0
200.0
300.0
400.0
500.0
No. of torsion cycles (x1,000)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/KR2017/011830

A. CLASSIFICATION OF SUBJECT MATTER

H01B 9/02(2006.01)i, H01B 7/17(2006.01)i, H01B 9/00(2006.01)i, H01B 7/02(2006.01)i

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)
H01B 9/02; H01B 11/18; H04R 17/00; A61B 8/00; H01B 11/02; H01B 11/20; H01B 11/00; H01B 3/00; H01B 7/17; H01B 9/00; H01B 7/02

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean Utility models and applications for Utility models: IPC as above
Japanese Utility models and applications for Utility models: IPC as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS (KIPO internal) & Keywords: robot cable, torsion, core, unsintered fluororesin, binding tape

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	JP 11-243594 A (THE WHITAKER CORP.) 07 September 1999 See paragraphs [23]-[35]; claims 1-2; and figure 4.	1-14
Y	JP 2003-007145 A (MITSUBISHI CABLE IND., LTD.) 10 January 2003 See paragraphs [13]-[18]; claims 1-3; and figure 1.	1-14
Y	JP 2016-207658 A (SUMITOMO ELECTRIC IND., LTD.) 08 December 2016 See paragraphs [19]-[31]; claim 1; and figures 1-2.	9-10,13
A	JP 2015-230836 A (HITACHI METALS LTD.) 21 December 2015 See paragraphs [19]-[29]; claims 1-3; and figure 1.	1-14
A	KR 10-2008-0080148 A (JUNKOSHA INC.) 02 September 2008 See paragraphs [16]-[21]; and figure 1.	1-14

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

* Special categories of cited documents:
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"E" earlier application or patent but published on or after the international filing date
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"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
12 FEBRUARY 2018 (12.02.2018)	**13 FEBRUARY 2018 (13.02.2018)**

Name and mailing address of the ISA/KR	Authorized officer
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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/KR2017/011830

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