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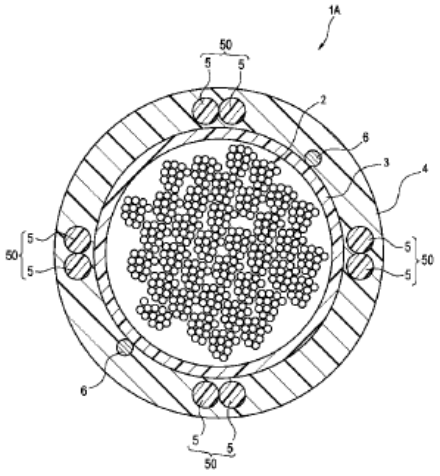
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(54) Title: OPTICAL FIBER CABLE

(54) Title of Invention: FIBER OPTIC CABLE

[FIG. 1]

FIG. 1



(57) **Abstract:** This optical fiber cable comprises a plurality of coated optical fibers or a plurality of coated optical fiber ribbons, a cable jacket which encloses the plurality of coated optical fibers or the plurality of coated optical fiber ribbons, and at least four tensile body units which are provided embedded inside the cable jacket and in which at least two tensile bodies are paired, wherein: the at least four tensile body units are provided to opposing positions in a cross section of the optical fiber cable in the radial direction, with the center of the optical fiber cable therebetween; and the outer cable diameter of the optical fiber cable is 6-16 mm.

(57) **Abstract:** A fiber optic cable, having: a plurality of fiber optic cores or a plurality of fiber optic tape cores; a cable outer cover enclosing the plurality of fiber optic cores or the plurality of fiber optic tape cores; and four or more tensile strength body units which are provided so as to be embedded within the cable outer cover, and which have two or more tensile strength bodies as pairs; wherein the four or more tensile strength body units are respectively provided at positions facing each other across the center of the fiber optic cable in a cross-section in a radial direction of the fiber optic cable, and the cable outer diameter of the fiber optic cable is 6 mm to 16 mm.

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Attached Publications:
- International Search Report (Treaty Article 21(3))

SPECIFICATION

Title of Invention: FIBER OPTIC CABLE

Technical Field

[0001] The present disclosure relates to a fiber optic cable.

The present application asserts the priority of Japanese Patent Application No. 2019-113810 filed on June 19, 2019, Japanese Patent Application No. 2019-176737 filed on September 27, 2019, Japanese Patent Application No. 2019-134351 filed on July 22, 2019, and Japanese Patent Application No. 2019-182643 filed on October 3, 2019, and incorporates by reference all of the contents of the above applications.

Background Art

[0002] Patent Document 1 describes a fiber optic cable provided with an intermittently connected fiber optic tape core in a pipe.

Patent Document 2 describes a fiber optic cable wherein a unit configured by winding identification threads around an outer periphery of a fiber optic bundle that aggregates a plurality of single core coated fiber optics that configure an intermittently coupled fiber optic tape core is mounted.

Patent Document 3 describes a slot rod type fiber optic cable.

Prior Art Literature

Patent Documents

[0003] Patent Document 1: JP 2015-517679 A (Translation of PCT Application)

Patent Document 2: JP 2010-8923 A

Patent Document 3: JP 2014-71441 A

Summary of Invention

[0004] A fiber optic cable according to one embodiment of the present invention has:

a plurality of fiber optic cores or a plurality of fiber optic tape cores;

a cable outer cover enclosing the plurality of fiber optic cores or the plurality of fiber optic tape cores;

and four or more tensile strength body units which are provided so as to be embedded within the cable outer cover, and which have two or more tensile strength bodies as pairs;

wherein the four or more tensile strength body units are respectively provided at positions facing each other across the center of the fiber optic cable in the cross-section in the radial direction of the fiber optic cable, and the cable outer diameter of the fiber optic cable is 6 mm to 16 mm.

Brief Description of Drawings

[0005] [FIG. 1] is a cross-sectional view illustrating a configuration of a fiber optic cable according to the first embodiment.

[FIG. 2] is a plan view illustrating an example of a fiber optic tape core housed in a fiber optic cable.

[FIG. 3] is a cross-sectional view illustrating a configuration of a fiber optic cable according to the second embodiment.

[FIG. 4] is a side view of the fiber optic cable illustrated in FIG. 3.

[FIG. 5] is a schematic diagram illustrating a cable pneumatic feeding evaluation device.

[FIG. 6] is a cross-sectional view illustrating a configuration of a fiber optic cable according to a third embodiment.

[FIG. 7] is an enlarged view schematically illustrating a protrusion of the fiber optic cable and a cross-section in the cable radial direction of the outer peripheral portion according to the third embodiment.

[FIG. 8] is an enlarged view schematically illustrating

the protrusions of the comparative example of the fiber optic cable according to the third embodiment and the cross-section in the cable radial direction of the outer peripheral portion.

[FIG. 9] is a cross-sectional view illustrating a configuration of a fiber optic cable according to the fourth embodiment.

[FIG. 10] is a cross-sectional view illustrating a configuration of a fiber optic cable according to a fifth embodiment.

[FIG. 11] is a table describing the specifications and evaluation results for each sample of the fiber optic cable

according to the fifth embodiment.
[FIG. 12] is a diagram describing a relationship between a low temperature loss change amount and a HDPE area ratio in an evaluation result of FIG. 11.
[FIG. 13] is a diagram describing a relationship between a low temperature loss change amount and an ES product in an evaluation result of FIG. 11.
[FIG. 14] is a diagram describing a relationship between the bending rigidity and the HDPE area ratio in the evaluation result of FIG. 11.
[FIG. 15] is a cross-sectional view illustrating a configuration of a fiber optic cable according to a sixth embodiment.
[FIG. 16] is a cross-sectional view illustrating a configuration of a fiber optic cable according to the seventh embodiment.

Embodiments of Invention

[0006] [Problem to Be Solved by the Present Disclosure]
When the fiber optic cable has a structure having tensile strength bodies on both sides of the outer covering, it tends to bend easily in the direction of 90 degrees with respect to the line connecting the tensile strength bodies in the cross-section in the radial direction, and the bending rigidity in that direction tends to be low. Conversely, it is difficult to bend in the direction in which the tensile strength body is located, and the bending rigidity tends to be large in that direction. In other words, fiber optic cables of the above structure have anisotropic bending.
When the structure of the fiber optic cable for pneumatic feeding is used, there is anisotropic bending, and therefore, when pneumatic feeding or pushing in a duct, the cable tends to bend in a direction with a low bending rigidity, and there is a risk of buckling in the middle of the duct. Thus, it is difficult to obtain favorable pneumatic feeding characteristics for fiber optic cables for pneumatic feeding having a structure such as the foregoing.

[0007] Furthermore, in many cases, the thickness of the cable outer cover is made thin for the fiber optic cable for pneumatic feeding in order to reduce the diameter and weight, and a hard cable outer cover is used. In this case, only a thin tensile strength body can be put in the cable outer cover, so that it is difficult to suppress lowering of rigidity and linear expansion of the cable outer cover. On the other hand, when the structure is arranged around a large diameter tensile strength body or a plurality of tensile strength bodies bundled together, such as a fiber optic cable of the loose tube type or a slot rod type, the inner space is reduced by the volume of the tensile strength body, and thus it is difficult to increase the core density of the fiber optic cable.

[0008] An object of the present invention is to provide a fiber optic cable having favorable pneumatic feeding characteristics.

[0009] [Effect of Present Disclosure]
According to the present disclosure, it is possible to provide a fiber optic cable having favorable pneumatic feeding characteristics.

[0010] (Description of Embodiments of Present Disclosure)
First, the embodiments of the present disclosure will be described in a list.
A fiber optic cable according to one embodiment of the present invention is provided with:
(1) a plurality of fiber optic cores or a plurality of fiber optic tape cores;
a cable outer cover enclosing the plurality of fiber optic cores or the plurality of fiber optic tape cores; and
four or more tensile strength body units which are provided so as to be embedded within the cable outer cover, and which have two or more tensile strength bodies as pairs; wherein
the four or more tensile strength body units are respectively provided at positions facing each other across the center of the fiber optic cable in the cross-section in the radial direction of the fiber optic cable, and
the cable outer diameter of the fiber optic cable is 6 mm to 16 mm.
According to the fiber optic cable of the above configuration, there are tensile strength body units in which two or more of them are paired in a balanced manner, and thus anisotropic bending of the fiber optic cable

(bias in the direction of bending ease) can be suppressed. Accordingly, it is possible to suppress buckling within the duct, for example, when the fiber optic cable is pneumatically fed or pushed in the duct. Therefore, the fiber optic cable of the aforementioned configuration can obtain favorable pneumatic feeding characteristics. Furthermore, because the cable outer diameter is 16 mm or less, it can be housed in a small diameter micro duct having a general inner diameter of 20 mm or less. When the outer diameter of the cable is less than 6 mm, the occurrence of buckling during pneumatic feeding is more likely when the microduct is laid while bent at a small diameter, but the fiber optic cable of the above configuration has an outer diameter of 6 mm or more, and thus the occurrence of buckling during pneumatic feeding can be suppressed.

[0011] (2) At least four tensile strength body units among the four or more tensile strength body units of the fiber optic cable may be arranged in positions where straight lines connecting the respective pairs of tensile strength body units are orthogonal in the cross-section in the radial direction of the fiber optic cable.

According to the fiber optic cable of the aforementioned configuration, because the tensile strength body units are present in a further well-balanced manner, the anisotropic bending (bias in the direction in which bending is easy) of the fiber optic cable can be further suppressed.

[0012] (3) The bending rigidity in the radial direction of the fiber optic cable may be 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in all directions.

According to the fiber optic cable of the above configuration, a moderate bending rigidity suitable for pneumatic feeding can be obtained due to being within the above bending rigidity range. In addition, because the bending rigidity in the radial direction is 0.35 $N \cdot m^2$ or more in the full circumferential direction, buckling when the fiber optic cable is fed pneumatically can be suppressed, and because the bending rigidity in the radial direction is 1.3 $N \cdot m^2$ or less in the full circumferential direction, the retractability when storing the excess length of the fiber optic cable is favorable.

[0013] (4) The tensile strength body may be an aramid FRP.

(5) The tensile strength body may be a liquid crystal polymer.

Aramid FRPs and liquid crystal polymers have relatively high elastic moduli, and thus the cable stiffness can be reasonably high. Furthermore, aramid FRPs and liquid crystal polymers have relatively low coefficients of linear expansion, which can reduce the shrinkage of fiber optic cables under low temperature conditions. In addition, aramid FRPs and liquid crystal polymers are non-inductive, and thus there is no need to provide grounding for lightning protection.

[0014] (6) The cable outer cover may contain a silicon-based lubricant.

According to the fiber optic cable of the above configuration, the cable outer cover contains a silicon-based lubricant, and thus the coefficient of friction of the cable outer cover can be lowered. As a result, friction between the cable outer cover and the duct is reduced when the fiber optic cable is pneumatically fed in the duct, and the pneumatic feeding distance can be increased.

[0015] (7) The silicon-based lubricant contained in the cable outer cover may be 1.5% by mass or more.

According to the fiber optic cable of the above configuration, the cable outer cover contains 1.5% by mass or more of the silicon-based lubricant, and thus the coefficient of friction of the cable outer cover can be lowered more reliably.

[0016] (8) The cable outer cover may have protrusions protruding in a radial direction of the fiber optic cable at the outer peripheral portion.

According to the fiber optic cable of the above configuration, there are protrusions protruding in the radial direction of the fiber optic cable on the outer peripheral portion of the cable outer cover, and thus the contact area between the cable outer cover and the duct can be reduced when the fiber optic cable is fed pneumatically in the duct. This reduces the friction between the cable outer cover and the duct and increases the pneumatic feeding distance.

[0017] (9) In a cross-section in the radial direction of the fiber optic cable, the angle formed by tangential lines on both surfaces at an intersection point between the surface of the protrusion and the surface of the outer peripheral portion that is not the protrusion may be 90 degrees or less.

In the fiber optic cable, an angle formed by the tangent lines between the surfaces at the intersections is 90 degrees or less, and thus blades such as diagonal pliers can be easily fixed to a portion of the intersection. Thus, slipping of diagonal pliers and the like during cutting of the protrusion, which makes cutting difficult, can be suppressed. Therefore, the protrusion can be easily removed, and airtightness can be maintained when the fiber optic cable is housed in a closure.

[0018] (10) The protrusion may be formed in a helical shape in a longitudinal direction of the fiber optic cable.

According to the fiber optic cable of the above configuration, the above protrusion is formed in a helical shape in the longitudinal direction of the fiber optic cable, and thus the contact resistance can be further reduced because the inner wall of the duct and the fiber optic cable are in point contact.

[0019] (11) The cable outer cover has a concave portion on the surface thereof, and an identification display may be applied only to the recessed part.

According to a fiber optic cable having this configuration, because the concave portion and the inner surface of a duct carry a low risk of rubbing together during pneumatic feeding, the identification display applied only to the concave portion has a low risk of being scraped off. Therefore, the identification display applied to the cable outer cover is readily visible. In addition, because the surface is uneven due to the provision of the concave portion on the surface of the cable outer cover, an area of contact with the inner surface of the duct decreases, and friction between the surface of the cable outer cover and the inner surface of the duct during pneumatic feeding is reduced. As a result, a pneumatic feeding distance when conducting pneumatic feeding within a duct can be extended.

[0020] (12) The cable outer cover may have an inner layer provided on the outer side of an assembly core of a plurality of the fiber optic cores or a plurality of the fiber optic tape cores, and an outer layer provided on the outer side of the inner layer, wherein the density of the material used in the outer layer is 0.942 (g/cm^3) or more, and the density of the material used in the inner layer may be less than 0.942 (g/cm^3).

According to the fiber optic cable of the above configuration, the cable outer cover is composed of two layers, an inner layer and an outer layer, and the density of the material used in the outer layer is higher than that in the inner layer, therefore, the coefficient of friction is lower than when only the material of the inner layer is used, and it is easier to pass through the inside of the duct. Moreover, even when the air pressure supplied into the duct is high or pushed into the duct, the pneumatic feeding is sufficiently resilient because the outer layer is hard.

[0021] (13) The cable outer cover may include flame retardant PVC or flame retardant polyethylene having an oxygen index of 50 or more.

Although it is difficult to improve the flame retardancy of the fiber optic cable for pneumatic feeding because the cable outer cover has a thin structure, the flame retardancy can be improved by using flame retardant PVC or flame retardant polyethylene having an oxygen index of 50 or more for the cable outer cover according to the fiber optic cable of the above configuration.

[0022] (14) The fiber optic core or the fiber optic tape core may have a glass fiber and a coating covering an outer periphery of the glass fiber, the coating including two layers, the outer coating layer being a cured resin composition containing a base resin having a urethane acrylate oligomer or urethane methacrylate oligomer, a monomer having a phenoxy group, a photoinitiator, and a silane coupling agent, and hydrophobic inorganic oxide particles, and the content of the inorganic oxide particles being from 1% to 45% by mass based on the total amount of the resin composition.

According to the fiber optic cable of the above configuration, the lateral pressure resistance of the fiber optic core becomes stronger due to using the above resin composition as the outer coating layer constituting the coating in the fiber optic core. This reduces increase in transmission loss of fiber optic cables.

[0023] (15) The fiber optic core or the fiber optic tape core constituting the fiber optic tape core may have a bending loss of 1550 nm in a wavelength of 0.5 dB or less for a bending diameter of φ15 mm x 1 turn and 0.1 dB or less for a bending diameter of φ20 mm x 1 turn.

According to the fiber optic cable of the above configuration, the side pressure characteristic can be improved and the low temperature loss characteristic improved.

[0024] (16) The fiber optic core or the fiber optic core that configures the fiber optic tape core may include a multi-core fiber where a per core count is 4 or more.

According to the fiber optic cable of the above configuration, transmission capacity per fiber optic core wire can be increased because separate information can be sent for each core.

[0025] (Details of Embodiments of the Present Disclosure)

Specific examples of the fiber optic cable according to embodiment of the present disclosure will be described below with reference to the drawings.

Note that the present invention is not limited to these examples, but is indicated by the Scope of Patent Claims and is intended to include all modifications within the meanings and scope equivalent to the Scope of Patent Claims.

[0026] (First Embodiment)

A fiber optic cable 1A according to a first embodiment will be described with reference to FIG. 1 and FIG. 2.

FIG. 1 is a sectional view perpendicular to the length direction of the fiber optic cable 1A. As illustrated in FIG. 1, the fiber optic cable 1A is provided with a plurality of fiber optic tape cores 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, an cable outer cover 4 containing the fiber optic tape cores 2 covered by the water absorption tape 3, and a tensile strength body 5 and a tear string 6 provided inside the cable outer cover 4.

[0027] The water absorption tape 3 is wound around the entirety of the plurality of fiber optic tape cores 2, for example, vertically or horizontally. The water absorption tape 3 is subjected to water absorbing treatment by adhering water absorbing powder to a base fabric made of, for example, polyester or the like.

[0028] The cable outer cover 4 is provided to cover around the water absorption tape 3. The cable outer cover 4 is formed from, for example, a resin such as polyvinyl chloride (PVC) or polyethylene (PE). The resin of the cable outer cover 4 preferably has a Young's modulus of 500 Pa or more. Also, a silicon-based lubricant is preferably contained in the cable outer cover 4. The silicon-based lubricant content is, for example, 1 wt% or more, preferably 1.5 wt% or more to 2.5 wt% or less.

[0029] Furthermore, the cable outer cover 4 is preferably formed from a resin having high flame retardancy. The cable outer cover 4 is formed from, for example, flame retardant PVC, flame retardant polyethylene, or the like having an oxygen index of 50 or more. As a result, the fiber optic cable 1A conforms to the UL 1666 riser grade of the NEC (National Electronic Code) standard in North America, and to the Cca class of the CPR (Construction Products Regulation) standard in Europe. The cable outer cover 4 is, for example, a thermoplastic resin and is formed by extrusion molding a resin on the plurality of fiber optic tape cores 2 having the water absorption tape 3 wound thereon.

[0030] The tensile strength body 5 is provided so as to be embedded inside the cable outer cover 4. The tensile strength body 5 is formed from, for example, a fiber reinforced plastic (FRP) such as an aramid FRP, a glass FRP, or a carbon FRP. In addition, the tensile strength body 5 may be formed from a liquid crystal polymer. It is preferable that the tensile strength body 5 is non-inductive.

[0031] The tensile strength body (5) has a cross-section in the radial direction formed in a circular shape. Eight or more tensile strength bodies 5 (eight in this example) are provided. The eight tensile strength bodies 5 in this example are provided in pairs of two each. The two paired tensile strength bodies 5 are provided, for example, close to each to each other or in contact with at least a part of each other. Each

tension in body 5 is provided in the cable outer cover 4 in the longitudinal direction of the fiber optic cable 1A. In the following description, the two paired tensile strength bodies 5 are collectively referred to as a tensile strength body unit 50.

[0032] In this example, four tensile strength body units 50 are provided. The four tensile strength body units 50 are provided as two pairs of two tensile strength body units 50 at opposing positions across the center of the fiber optic cable 1A in a cross-section in the radial direction of the fiber optic cable 1A. The positions of the four tensile strength body units 50 in the cross-section in the radial direction of the fiber optic cable 1A are, for example, positions so that two straight lines respectively connecting the two tensile strength body units 50 forming a pair are orthogonal to each other.

[0033] Note that, for example, when the number of tensile strength bodies 5 is more than 8 and the number of tensile strength body units 50 is more than 4, each tensile strength body unit 50 is provided in the cable outer cover 4 so that the spacing between adjacent tensile strength body units 50 is equal.

[0034] The tear string 6 is for tearing the cable outer cover 4 and is embedded within the cable outer cover 4 in the longitudinal direction of the fiber optic cable 1A. In the present example, two tear strings 6 are provided. The two tearing strings 6 are provided to face each other at approximately the center position of adjacent tensile strength body units 50. By pulling out the tear string 6, the cable outer cover 4 can be torn in the longitudinal direction and the fiber optic tape core 2 pulled out. The tear strings 6 are formed, for example, of a plastic material (for example, polyester) that has a high tensile strength.

[0035] FIG. 2 illustrates one example of the fiber optic tape core 2 housed in the fiber optic cable 1A. As illustrated in FIG. 2, the fiber optic tape core 2 is an intermittently connected fiber optic tape core having a connected part 12 connected between adjacent fiber optic cores and a unconnected part 13 not connected between adjacent fiber optic cores in the longitudinal direction, a plurality of fiber optic cores 11A to 11L being disposed in parallel.

[0036] The fiber optic tape core 2 of the present example has 12 fiber optic cores 11A to 11L disposed in parallel. FIG. 2 illustrates a plan view of the intermittently connected fiber optic tape core 2 with the fiber optic cores 11A to 11L open in the array direction and a cross-sectional view of the fiber optic core 11A. Where the connecting portion 12 and the disjoint portion 13 are intermittently provided may be between some fiber optic cores (intermittent per two cores) as shown in FIG. 2, or between all fiber optic cores (intermittent per one core). In the example illustrated in FIG. 2, there is no unconnected part 13 between the fiber optic cores 11A and 11B, 11C and 11D, 11E and 11F, 11G and 11H, 11I and 11J, 11K and 11L.

[0037] The connected part 12 in the fiber optic tape core 2 is formed by applying a connecting resin 14 composed of, for example, ultraviolet curing resin or thermosetting resin between the fiber optic cores. By applying the connecting resin 14 between the predetermined fiber optic cores, the connected part 12 and the unconnected part 13 are intermittently provided, and each of the fiber optic cores 11A to 11L is integrated in a parallel state. The connecting resin 14 may be applied to only one side of the parallel faces formed by parallel fiber optic cores 11A to 11L or may be applied to both sides. In addition, the fiber optic tape core 2 may be fabricated so that, for example, a tape resin is applied to one side or to the entirety of both sides of the parallel fiber optic cores 11A to 11L, and all fiber optic cores 11A to 11L are connected together, and then a portion is cut using a rotary blade or the like to form the unconnected part 13.

[0038] The fiber optic cores 11A to 11L have a glass fiber 15 configured from, for example, a core and a cladding, and two coating layers 16 and 17 covering the periphery of the glass fiber 15. The inner coating layer 16 among the two layers is formed from a primary resin. Also, the outer coating layer 17 of the two layers is formed from a secondary resin. The fiber optic cores 11A to 11L are so-called small diameter cores, and an outer diameter A thereof is, for example, 165 μm or more and 220 μm or less. Note that the fiber optic cores 11A to 11L may be multicore fibers where the number of cores per core is 4 or more. Since the multicore fibers can send separate information for each core, the transmission capacity per coated fiber optic core can be increased.

[0039] For the primary resin constituting the inner coating layer 16 in contact with the glass fiber 15, a flexible resin having a relatively low Young's modulus is used as a buffer layer. Also, for the secondary resin comprising the outer coating layer 17, a hard resin having a relatively high Young's modulus is used as a protection layer. The secondary resin has, for example, a Young's modulus of 900 MPa or more at 23°C, preferably 1,000 MPa or more, and more preferably 1,500 MPa or more.

[0040] The secondary resin that will constitute the coating layer 17 is preferably a resin composition including: a base resin containing a urethane acrylate oligomer or a urethane methacrylate oligomer, a monomer having a phenoxy group, a photoinitiator, and a silane coupling agent; and hydrophobic inorganic oxide particles. The content of inorganic oxide particles in the resin composition is 1% by mass or more to 45% by mass or less based on the total amount of the resin composition.

[0041] Hereinafter, acrylates or their corresponding methacrylates are referred to as (meth)acrylates.

[0042] Oligomers obtained by reacting polyol compounds, polyisocyanate compounds, and hydroxyl-containing (meth)acrylate compounds may be used as the urethane (meth)acrylate oligomer. This oligomer is obtained, for example, by reacting polypropylene glycol having a molecular weight of 4000, isophorone diisocyanate, hydroxyethyl acrylate, and methanol.

[0043] (Meth)acrylate compounds having phenoxy groups can be used as monomers having phenoxy groups. For example, the monomer having phenoxy groups is nonylphenol EO modified acrylate (trade name "Aronix M-113" from Toagosei Co., Ltd.) or the like.

[0044] The photoinitiator can be used by suitably selecting from publicly known radical photoinitiators, for example, 2,4,6-trimethylbenzoyldiphenylphosphine oxide.

[0045] The silane coupling agent is not particularly limited unless it interferes with the curing of the resin composition. For example, the silane coupling agent is 3-mercaptopropyltrimethoxysilane or the like.

[0046] Hydrophobic inorganic oxide particles have hydrophobic groups introduced on the surface of inorganic oxide particles. The inorganic oxide particles are, for example, silica particles. The hydrophobic group may be a reactive group such as a (meth)acryloyl group or a vinyl group, or a non-reactive group such as a hydrocarbon group (for example, an alkyl group) or an aryl group (for example, a phenyl group).

[0047] Lateral pressure characteristics of the fiber optic cores 11A to 11L are improved by blending inorganic particles with the secondary resin that will constitute the coating layer 17. The primary resin constituting the coating layer 16 and the secondary resin are formed from, for example, ultraviolet curing resin, thermosetting resin, or the like.

[0048] The fiber optic tape cores 2 are rounded and aggregated when they are housed within the fiber optic cable 1A. Alternatively, the plurality of fiber optic tape cores 2 may be twisted together to form a unit, and a plurality of units may be housed in an aggregated state. Note that the plurality of fiber optic tape cores 2 in the aggregated state may be bundled by a bundle material or the like, or may be bundled by a bundle material or the like by the unit.

[0049] In the fiber optic cable 1A having the above configuration, it is preferable that the ratio of the total cross-sectional area of the eight tensile strength bodies 5 (four tensile strength body units 50) to the cross-sectional area of the cable outer cover 4 is 5.4% or more. The outer diameter of the fiber optic cable 1A is 6 mm or more and 16 mm or less; for example, when the outer diameter of the fiber optic cable 1A is 10 mm, the thickness of the cable outer cover 4 is 1.0 mm, and eight tensile strength bodies 5 of the outer diameter 0.5 mm are provided in the cable outer cover 4, the ratio of the total cross-sectional area is 5.6%. In addition, it is desirable that the bending rigidity in the radial direction in the fiber optic cable 1A is 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in the full circumferential direction.

[0050] In addition, it is preferable that a core density obtained by dividing the total number of fiber optic cores constituting the plurality of fiber optic tape cores 2 by the cable cross-sectional area of the fiber optic cable 1A be 5.0 cores/mm^2 or more. For example, when an outer diameter of the fiber optic cable 1A is 10 mm, the thickness of the cable outer cover 4 is 1.0 mm, and the outer diameter A of the fiber optic core is 200 μm, if the number of the 12-core fiber optic tape cores 2 housed within the cable outer cover 4 of the fiber optic cable 1A is 36, the total number of fiber optic cores at that time is 432, making for a core density of 5.5 cores/mm^2. Note that, considering that this will be fed pneumatically, it is desirable that the unit weight of the fiber optic cable 1A is 100 kg/km or less.

[0051] Note that although a 12-core fiber optic tape core 2 is used in this example, for example, a fiber optic tape core such as 16-core or 24-core may be used. In addition, although the fiber optic tape cores are housed within the fiber optic cable 1A in the present example, such may be housed as-is as a fiber optic core without a taped form. Furthermore, it is preferable that the fiber optic cores 11A to 11L have a bending loss equivalent to ITU-TG.657A2, wherein the bending loss of the wavelength 1550 nm is 0.5 dB or less for a bending diameter φ15 mm x 1 turn and 0.1 dB or less for a bending diameter φ20 mm x 1 turn. By using such fiber optic cores, the lateral pressure characteristic can be improved and the low temperature loss characteristic improved.

[0052] As described above, according to the fiber optic cable 1A according to the first embodiment, the tensile strength body units 50, each of which is configured from two pairs of tensile strength bodies 5, are disposed in a balanced manner inside the cable outer cover 4, and thus anisotropic bending of the fiber optic cable 1A (deviation in the direction of easy bending) can be suppressed.
Thus, it is possible to suppress buckling within the duct, for example, when the fiber optic cable 1A is pneumatically fed or pushed in the duct. Therefore, the fiber optic cable 1A can be provided with favorable pneumatic feeding characteristics.

[0053] In addition, the outer diameter of the fiber optic cable 1A is 16 mm or less, and thus the fiber optic cable 1A can be pneumatically fed into a microduct having an inner diameter of 20 mm or less and can be housed in the microduct.

[0054] When the outer diameter of the fiber optic cable is less than 6 mm, once the duct is bent to a small diameter and laid, it is likely that buckling will occur in the fiber optic cable during pneumatic feeding. In contrast, the fiber optic cable 1A has an outer diameter of 6 mm or more, and thus the occurrence of buckling during pneumatic feeding can be suppressed.

[0055] Furthermore, the fiber optic cable 1A can be provided with a moderate bending rigidity suitable for pneumatic feeding by setting the bending rigidity of the radial direction thereof to a range of 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in the full circumferential direction. For example, the bending rigidity in the radial direction is 0.35 $N \cdot m^2$ or more in the full circumferential direction, and thus the occurrence of buckling when the fiber optic cable 1A is fed pneumatically can be suppressed. Moreover, the bending rigidity in the radial direction is 1.3 $N \cdot m^2$ or less in the full circumferential direction, and thus it is possible to bundle the fiber optic cable 1A to a reasonable size, for example, when storing the extra length of the fiber optic cable 1A in a hand hole, and storability is favorable.

[0056] In addition, it is preferable that the tensile strength bodies 5 of the fiber optic cable 1A are formed from, for example, aramid FRP or liquid crystal polymer. According to this configuration, aramid FRPs, liquid crystal polymers, and the like have relatively high elastic modulus, and thus the rigidity of the fiber optic cable 1A can be reasonably high. Furthermore, aramid FRPs, liquid crystal polymers, and the like have relatively low coefficients of linear expansion, and thus it is possible to suppress shrinkage of the fiber optic cable 1A due to shrinkage of the cable outer cover 4 under low temperature conditions. In addition, aramid FRPs, liquid crystal polymers, and the like are non-inductive, and thus there is no need to provide grounding for lightning protection.

[0057] Also, the fiber optic cable 1A preferably contains a silicon-based lubricant in the resin of the cable outer cover 4. According to this configuration, the coefficient of friction of the cable outer cover 4 can be lowered. Also, by setting the silicon-based lubricant contained in the cable outer cover 4 to 1.5% by mass or more, it is possible to more reliably lower the coefficient of friction of the cable outer cover 4. As a result, friction between the cable outer cover 4 and the duct inner wall can be reduced when the fiber optic cable 1A is pneumatically fed in the duct, and the pneumatic feeding distance can be increased.

[0058] By way of mention, it is difficult to improve the flame retardancy of fiber optic cables for pneumatic feeding because the cable outer cover is thin. In contrast, the flame retardancy of the fiber optic cable 1A can increased by forming the cable outer cover 4 from flame retardant PVC or flame retardant polyethylene having an oxygen index of 50 or more.

[0059] In addition, according to the fiber optic cable 1A, the lateral pressure resistance of the fiber optic cores 11A to 11L can be strengthened by using the curing material of the above resin composition as the outer coating layer 17 constituting the coating of the fiber optic cores 11A to 11L. Therefore, when the fiber optic tape core 2 is configured using such fiber optic cores 11A to 11L, increase in transmission loss when housed in the fiber optic cable 1A can be suppressed.

[0060] (Second Embodiment)

A fiber optic cable 1B according to a second embodiment will be described with reference to FIG. 3 and FIG. 4. Note that configurations similar to those of the fiber optic cable 1A according to the first embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0061] FIG. 3 is a sectional view perpendicular to the longitudinal direction of the fiber optic cable 1B. FIG. 4 is a side view of the fiber optic cable 1B illustrated in FIG. 3.

As illustrated in FIG. 3, the fiber optic cable 1B is provided with a plurality of intermittently connected fiber optic tape cores 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, a cable outer cover 4 containing the fiber optic tape cores 2 covered by the water absorption tape 3, and a tensile strength body 5 and a tear string 6 provided inside the cable outer cover 4. Furthermore, the fiber optic cable 1B has protrusions 7 on the outer peripheral portion of the cable outer cover 4.

[0062] A plurality of protrusions 7 (eight in this example) are provided. As illustrated in FIG. 4, the eight protrusions 7 are provided in a spiral shape in the longitudinal direction of the fiber optic cable 1B. Each protrusion 7 may be provided continuously in the longitudinal direction or may be provided intermittently. In addition, the eight protrusions 7 are provided in the circumferential direction of the outer peripheral portion of the cable outer cover 4 at approximately equal intervals in a cross-section in the radial direction of fiber optic cable 1B. The protrusions 7 are formed protruding in the radial direction of the fiber optic cable 1B on the outer peripheral portion of the cable outer cover 4. The protrusions 7 are formed such that surfaces 7a in the protruding direction are composed of a curved surface, and the radius of curvature of the curved surface is 2.5 mm or more. The protrusions 7 are formed integrally with the cable outer cover 4 by extrusion. Note that although the eight protrusions 7 are provided in a spiral shape in this example, they may be provided in a linear shape in the longitudinal direction of the fiber optic cable 1B, for example.

[0063] According to the fiber optic cable 1B of the second embodiment, the plurality of protrusions 7 protruding in the radial direction of the fiber optic cable 1B are provided in the outer peripheral portion of the cable outer cover 4. Therefore, when the fiber optic cable 1B is fed pneumatically in the duct, the protrusion 7 comes into contact with the inner wall of the duct, and thus the contact area between the cable outer cover 4 and the duct can be reduced. This reduces the friction between the cable outer cover 4 and the duct and increases the pneumatic feeding distance.

[0064] Also, according to the fiber optic cable 1B, the protrusions 7 of the cable outer cover 4 are formed in a helical shape in the longitudinal direction of the fiber optic cable 1B. As a result, the inner wall of the

duct and the cable outer cover 4 of the fiber optic cable 1B are close to point contact when pneumatically feeding in the duct. Therefore, friction between the two can be further reduced and the pneumatic feeding distance can be increased.

[0065] (Example 1)

In the fiber optic cable 1A of the first embodiment and fiber optic cable 1B of the second embodiment, the pneumatic feeding distance was evaluated for samples of the fiber optic cables of each example in which the type, number, and structure of the cable outer cover 4 of the tensile strength body 5 are different, and for samples of the fiber optic cables of each comparative example of conventional structures. The evaluation results are shown in Table 1.

[0066] [Table 1]

Table 1

Sample No.	Tensioning Body Configuration	Bending Rigidity ($N \cdot m^2$)	Outer Cover Structure	Coefficient of Dynamic Friction	Pneumatic Feeding Distance (m) (Evaluation)
1	Outer diameter 0.5 mm glass FRP 2 strands	Max 1.0, min 0.1	HDPE No protrusions	0.3	600 m (C)
2	Outer diameter 0.5 mm glass FRP 4 strands	Max 1.0, min 0.8	HDPE No protrusions	0.3	1,100 m (B)
3	Outer diameter 0.5 mm aramid FRP 4 strands	Max 0.8, min 0.3	HDPE No protrusions	0.3	1,000 m (B)
4	Outer diameter 0.5 mm glass FRP 8 strands	Max 2.5, min 1.2	HDPE No protrusions	0.3	1,500 m (A)
5	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.2, min 0.4	HDPE No protrusions	0.3	1,300 m (A)
6	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.2, min 0.4	HDPE 1 wt% silicon added No protrusions	0.15	1,500 m (A)
7	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.2, min 0.4	HDPE 1.5 wt% silicon added No protrusions	0.12	1,800 m (S)
8	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.0, min 0.35	HDPE 2.5 wt% silicon added No protrusions	0.11	1,850 m (S)
9	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.2, min 0.4	HDPE 1.5 wt% silicon added Linear protrusions	0.11	1,900 m (S)
10	Outer diameter 0.5 mm aramid FRP 8 strands	Max 1.2, min 0.4	HDPE 1.5 wt% silicon added Spiral protrusions	0.1	2,000 m (S)
11	Outer diameter 0.5 mm liquid crystal polymer 8 strands	Max 1.3, min 0.5	HDPE 2.5 wt% silicon added No protrusions	0.11	1,930 m (S)

[0067] In Table 1, samples No. 1 to 3 are comparative examples. Sample No. 1 is a fiber optic cable having a structure in which two tensile strength bodies are embedded in the cable outer cover, and samples No. 2 and 3 are fiber optic cables having a structure in which four tensile strength bodies are embedded in the cable outer cover. Samples No. 4 to 8 and 11 have eight tension bodies embedded in the cable outer cover, each two forming pairs, which corresponds to the first embodiment. Samples No. 9 and 10 have eight tensile strength bodies embedded in the cable outer cover in such a way that two of each are paired, and protrusions are provided on the outer peripheral portion of the cable outer cover, which corresponds to the second embodiment. Note that in sample No. 9, the protrusions 7 is formed in a straight line in the longitudinal direction of the fiber optic cable 1B. In sample No. 10, the protrusions 7 are formed in a spiral in the longitudinal direction of the fiber optic cable 1B as illustrated in FIG. 4.

In addition, the tensile strength bodies of samples No. 1, 2, and 4 is are a glass FRP having an outer diameter of 0.5 mm. The tensile strength bodies of samples No. 3 and 5 to 10 are an aramid FRP having an outer diameter of 0.5 mm. The tensile strength bodies of sample No. 11 are a liquid crystal polymer having an outer diameter of 0.5 mm.

In addition, sample No. 6 was made by adding 1 wt% silicon-based lubricant to the cable outer cover, samples No. 7, 9, and 10 were made by adding 1.5 wt%, and samples No. 8 and 11 were made by adding 2.5 wt%.

In addition, the cable outer diameter of each sample is 10 mm.

[0068] Maximum and minimum bending rigidity indicates the bending rigidity value in the direction of maximum bending rigidity when bending each fiber optic cable in the radial direction and the bending rigidity value in the direction of minimum bending rigidity. The method for measuring bending rigidity is in accordance with IEC60794 Stiffness (MethodE17A). Note that the bending rigidity is the maximum value when bent in the direction of the tensile strength body 5, for example, for the structure of FIG. 1, and the minimum value when bent in a direction shifted by 45 degrees from the direction of the tensile strength bodies 5.

The coefficient of dynamic friction indicates the coefficient of friction between a fiber optic cable pneumatically fed through the duct and the inner wall of the duct.

For the pneumatic feeding distance, a pneumatic feeding test in compliance with IEC was performed using the pneumatic feeding device illustrated in FIG. 5. A pipe 20 is 1,000 m long and is folded back every 100 m. Bending (R) of the pipe 20 is 40 times the outer diameter of the pipe, and the inner diameter of the pipe 20 is 14 mm. An opening 21 is a entry feed port for air and a fiber optic cable, and an opening 22 is an exit feed port for air and a fiber optic cable. The pneumatic pressure was 1.3 MPa to 1.5 MPa.

[0069] For evaluation of the pneumatic feeding distance, those for which the pneumatic feeding distance was 1,800 m or more were set to an evaluation S, those for which the pneumatic feeding distance was 1,300 m or more and less than 1,800 m were set to an evaluation A, those for which the pneumatic feeding distance was 800 m or more and less than 1,300 m were set to an evaluation B, and those for which the pneumatic feeding distance was less than 800 m were set to an evaluation C.

[0070] According to the evaluation results of Table 1, samples having a pneumatic feeding distance of 1,800 m or more (samples evaluated as S) were No. 7 to 11, and samples having a pneumatic feeding distance of 1,300 m or more but less than 1,800 m (samples evaluated as A) were No. 4 to 6. Conversely, samples having a pneumatic feeding distance of 800 m or more and less than 1,300 m (samples evaluated as B) were No. 2 and 3, and the samples having a pneumatic feeding distance of less than 800 m (samples evaluated as C) was No. 1. It was found that the pneumatic feeding distance can be increased to more than 1,300 m in fiber optic cables by embedding a total of eight tensile strength bodies in the cable outer cover, each two forming a pair.

[0071] Also, the samples having a pneumatic feeding distance of 1,800 m or more (samples evaluated as S) were No. 7 to 11, and thus it was found that the dynamic friction coefficient can be reduced to about 1/3 when 1.5 wt% of a silicon-based lubricant is added to the cable outer cover compared to when a silicon-based lubricant is not added, and the pneumatic feeding distance can be greatly extended. However, it was found that when 2.5 wt% of the silicon-based lubricant was added, the cable outer cover became

slightly softer, resulting in a smaller bending rigidity and there was a slower rate of extension of the pneumatic feeding distance than when 1.5 wt% of the silicon-based lubricant was added. Furthermore, when a silicon-based lubricant is added in excess of 2.5 wt%, the fiber optic cable collapses and handling worsens. This showed that the ratio of addition of silicon-based lubricants is preferably 1.5 wt% or more and 2.5 wt% or less.

[0072] It was also found that the pneumatic feeding distance can be made 1,900 m or more by providing protrusions on the cable outer cover, as in samples No. 9 and 10. Furthermore, it was found that the pneumatic feeding distance could even be extended to 2,000 m by making the protrusions spiral in the longitudinal direction of the fiber optic cable.

[0073] Moreover, in order to further improve the characteristics of the fiber optic cable, secondary resins of the fiber optic cores 11A to 11L were examined. As a result, it was found that by combining inorganic oxide particles in the secondary resin, the lateral pressure characteristics of the fiber optic tape core could be improved, and the core density could be increased by about 1.0 to 1.5 cores/mm^2.

[0074] (Third Embodiment)

A fiber optic cable 1C according to a third embodiment will be described with reference to FIG. 6. Note that configurations similar to those of the fiber optic cable 1A according to the first embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0075] FIG. 6 is a cross-sectional view perpendicular to the longitudinal direction of the fiber optic cable 1C.

As illustrated in FIG. 6, the fiber optic cable 1C is provided with a plurality of a fiber optic tape core 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, a cable outer cover 4 covering the circumference of the water absorption tape 3, and a tensile strength body 5 and a tear string 6 provided inside the cable outer cover 4. Furthermore, the fiber optic cable 1C has protrusions 7 on the outer peripheral portion of the cable outer cover 4. The diameter of the fiber optic cable 1C is about 6 mm to 16 mm.

[0076] Four tension strength body units 50 each having a pair of two tension strength bodies 5 are provided. The four tensile strength body units 50 are provided as two pairs of two tensile strength body units 50 at opposing positions across the center of the fiber optic cable 1C in a cross-section in the radial direction of the fiber optic cable 1C.

[0077] A plurality (eight in the present example) of protrusions 7 are provided on a part of the outer peripheral portion 41 of the cable outer cover 4. The respective protrusions 7 are provided so as to protrude from the cable outer cover 4 toward the outside in the radial direction of the fiber optic cable 1C. The protrusions 7 are formed so as to form a shape that partially configures a circle in a cross-section in the radial direction of the fiber optic cable 1C. The protrusions 7 are formed so as to be of, for example, a shape having an outer circumference of at least a semicircle of the circle configuring the protrusion 7. The eight protrusions 7 are provided at almost equal intervals on the outer peripheral portion 41 of the cable outer cover 4 in the cross-section in the radial direction of the fiber optic cable 1C.

[0078] The protrusions 7 are provided in eight, and are each provided along the longitudinal direction of the fiber optic cable 1C. Each protrusion 7 may be provided continuously in the longitudinal direction or may be provided intermittently. Furthermore, the respective protrusions 7 may be provided in a straight line along the longitudinal direction of the fiber optic cable 1C or may be provided in a spiral shape. The protrusions 7 are formed integrally with the cable outer cover 4. The protrusions 7 are formed by extrusion molding together with the cable outer cover 4, for example.

[0079] FIG. 7 is an enlarged view schematically illustrating a cross section in the cable radial direction of the protrusion 7 and the outer peripheral portion 41.

As illustrated in FIG. 7, the protrusion 7 is formed such that a part of the circle A protrudes from the outer peripheral portion 41 in a cross-section of the radial direction of the fiber optic cable 1C. The portion

in which the circle A protrudes from the outer peripheral portion 41, a portion indicated by diagonal lines forms a circular sector B, and a center angle $\theta 2$ of the circular sector B is 180 degrees or more.

For the protrusions 7 provided in this manner, intersections 8a and 8b of a surface 7a of the protrusion 7 and a surface 41a of the outer peripheral portion 41 that is not a protrusion 7 are formed on both side portions (left and right side portions in FIG. 7) of the protrusion 7 in a cross section in the cable radial direction. The angle $\theta 1$ formed by the tangent line 7b of the surface 7a and the tangent line 41b of the surface 41a at the intersections 8a and 8b is 90 degrees or less.

[0080] The angle $\theta 1$ is 90 degrees or less, and thus a distance L between the intersections 8a and 8b of the protrusion 7 is smaller than a maximum width W (diameter of the circle A on the protrusion 7) in the circumferential direction of the fiber optic cable 1C of the protrusion 7. Furthermore, the maximum width W is preferably 5 mm or less.

[0081] As described above, the fiber optic cable 1C according to the third embodiment is provided with the protrusion 7 on the outer peripheral portion 41 of the cable outer cover 4, and thus the contact area with the inner surface of the duct when performing pneumatic feeding can be reduced. Thus, friction with the inner surface of the duct is reduced during pneumatic feeding, and a pneumatic feeding distance can be extended.

Furthermore, the shape of the protrusion 7 is such that a portion of the circle A protrudes from the outer peripheral portion 41 in a cross-sectional view in the radial direction of the fiber optic cable 1C, and the portion in which the circle A protrudes from the outer peripheral portion 41 includes a portion of the circular sector B. For the protrusion 7, the center angle $\theta 2$ of the circular sector B is formed to be 180 degrees or more.

Thus, in a cross section in the radial direction of fiber optic cable 1C, the angle $\theta 1$ formed by the tangent lines 7b and 41b between the surfaces at the intersections 8a and 8b of the surface 7a of the protrusion 7 and the surface 41a of the outer peripheral portion 41 that is not the protrusion 7 is 90 degrees or less.

Accordingly, blades such as diagonal pliers can be easily fixed to the intersections 8a and 8b. Thus, slipping of diagonal pliers and the like during cutting of the protrusion 7, which makes cutting difficult, can be suppressed. Therefore, the protrusion 7 can be easily removed, and airtightness can be maintained when the fiber optic cable is housed in a closure.

Note that as long as there is a gap between the surface 7a of the protrusion 7 and the surface 41a of the outer peripheral portion 41, blades such as diagonal pliers can be inserted in this gap, and therefore, it is sufficient as long as the angle $\theta 1$ formed by the tangent lines 7b and 41b is greater than 0 degrees so that the gap may be formed.

[0082] Incidentally, when attaching the fiber optic cable 1C to the closure, for example, the fiber optic cable 1C may be attached by being passed from an entrance to an exit of the closure. In this case, the protrusions 7 of the middle portion passing through the entrance portion and the exit portion of the closure from among the protrusions 7 of the fiber optic cable 1C must be removed. In order to remove the protrusion 7, first, blades such as diagonal pliers are brought close to the protrusion 7 from the radial direction of the fiber optic cable 1C, and the blades are opened to the maximum width W or more of the protrusion 7 to go over the protrusion 7. It is conceivable to cut the protrusion 7 by inserting blades such as diagonal pliers that go over the protrusion 7 into the intersections 8a and 8b. In contrast to this, according to the fiber optic cable 1C, by setting the maximum width W of the protrusion 7 in the cable circumferential direction to 5 mm or less, the protrusion 7 can be cut by going over the protrusion 7 from the radial direction of the fiber optic cable 1C. On the other hand, for example, the end portion of the fiber optic cable 1C may be inserted and attached only to the entrance of the closure. In this case, only the protrusion 7 of the end portion from among the protrusions 7 of the fiber optic cable 1C may be cut, and blades such as diagonal pliers may be inserted into portions of the intersections 8a and 8b from the end portion side in the longitudinal direction of the fiber optic cable 1C. Accordingly, it is sufficient if blades such as diagonal pliers can open at or above the distance L between the intersections 8a and 8b, and thus, even when, for example, the maximum width W of the protrusion 7 is greater than 5 mm, if the width of the root of the protrusion 7 is 5 mm or less, the protrusion 7 can be easily cut.

[0083] Next, differences between a comparative example of a protrusion and the protrusion 7 of the third embodiment will be described with reference to FIG. 8. FIG. 8 is an enlarged view schematically illustrating a cross section in the cable radial direction of a protrusion 107 and the outer peripheral portion 41 in the comparative example.

As illustrated in FIG. 8, the protrusion 107 is formed such that a part of the circle A protrudes from the outer peripheral portion 41 in a cross-section of the radial direction of the fiber optic cable. The protrusion 107 of the comparative example is different from the protrusion 7 of the third embodiment in that the center angle $\theta 2$ of the circular sector B that forms the arc of the surface 107a is formed to be less than 180 degrees (approximately 100 degrees in the example in FIG. 8).

[0084] In the comparative example, the angle $\theta 1$ formed by the tangent lines 107b and 41b between the surfaces at the intersections 8a and 8b of the surface 107a of the protrusion 107 and the surface 41a of the outer peripheral portion 41 that is not the protrusion 107 is greater than 90 degrees (approximately 135 degrees in the example in FIG. 3). For such a protrusion 107, it is difficult to fix blades such as diagonal pliers to a portion of the intersections 8a and 8b on both sides of the protrusion 107, and the blades such as diagonal pliers slide when cutting the protrusion 107, which makes cutting difficult.

[0085] (Example 2)

Samples No. 1 to 6 of a fiber optic cable, in which the maximum width W of the protrusion and angle $\theta 1$ in the protrusion 7 of the fiber optic cable 1A according to the third embodiment or the protrusion 107 of the comparative example differed, were prepared. The diameter of the fiber optic cable of samples No. 1 to 6 was set to be 12 mm. The pneumatic feeding distance, ease of removing protrusions, and airtightness were evaluated for samples No. 1 to 6. The evaluation results thereof are shown in Table 2 below.

[0086]

[Table 2]

Table 2

Sample No.	Maximum Width W of Protrusion	Angle θ1	Pneumatic Feeding Distance	Ease of Removing Protrusions	Airtightness
1	6 mm	90° or less	B	B	A (after removing protrusions)
2	6 mm	Greater than 90°	B	C	B (protrusions not removed)
3	5 mm	90° or less	A	A	A (after removing protrusions)
4	5 mm	Greater than 90°	A	C	C (protrusions not removed)
5	4 mm	90° or less	A	A	A (after removing protrusions)
6	4 mm	Greater than 90°	A	C	C (protrusions not removed)

[0087] The maximum width W of the protrusion was 6 mm for samples No. 1 and 2, 5 mm for samples No. 3 and 4, and 4 mm for samples No. 5 and 6. Furthermore, samples No. 1, 3, and 5 were fiber optic cables 1C of example 2 wherein the angle $\theta 1$ was 90 degrees or less. Samples No. 2, 4, and 6 were fiber optic cables of a comparative example wherein the angle $\theta 1$ was greater than 90 degrees.

[0088] For the pneumatic feeding distance, a micro duct pneumatic feeding test in compliance with IEC was performed using the pneumatic feeding device illustrated in FIG. 5. A pipe 20 is 1,000 m long and is folded back every 100 m. Bending (R) of the pipe 20 is 40 times the outer diameter of the pipe, and the inner diameter of the pipe 20 is 14 mm. An opening 21 is a entry feed port for air and a fiber optic cable, and an opening 22 is an exit feed port for air and a fiber optic cable. The pneumatic pressure was 1.3 MPa to 1.5 MPa.

[0089] The ease of removing the protrusions was evaluated by cutting the protrusions using a cutting tool such as diagonal pliers.

The airtightness of the closure was evaluated when the fiber optic cable was housed in the closure.

[0090] For evaluation of the pneumatic feeding distance, those for which the pneumatic feeding distance was over 1,000 m were set to an evaluation A, those for which the pneumatic feeding distance was 1,000 m were set to an evaluation B, and those for which the pneumatic feeding distance was less than 1,000 m were set to an evaluation C.

[0091] For evaluation of the ease of removing protrusions, those for which removal was easy were set to be evaluation A, those for which removal was possible but for which it was difficult to insert blades such as diagonal pliers were set to be evaluation B, and those for which removal was difficult were set to be evaluation C.

[0092] For evaluation of airtightness, for samples for which the for the ease of removing the protrusions was evaluation A or evaluation B, the airtightness was evaluated by housing the samples in the closure after the protrusions were removed. Furthermore, for samples for which the ease of the removing the protrusions was evaluation C, the airtightness of the closure was evaluated by housing the sample in the closure without removing the protrusions. For evaluation of airtightness, those which were favorable were set to be evaluation A, those for which the airtightness could be maintained by the deformation of a grommet were set to be evaluation B, and those which were unfavorable were set to be evaluation C.

[0093] According to the evaluation results of Table 2, samples for which the pneumatic feeding distance exceeded 1,000 m (evaluation A samples) were Nos. 3, 4, 5, and 6. On the other hand, samples for which the pneumatic feeding distance was 1,000 m (evaluation B samples) were Nos. 1 and 2. Thus, it was found that in a fiber optic cable having a diameter of 12 mm, pneumatic feeding exceeding 1,000 m is possible when the maximum width W of the protrusion is 5 mm or less.

[0094] Furthermore, samples for which removal was easy (evaluation A samples) in terms of the ease of removing the protrusion were Nos. 3 and 5. The sample (evaluation B sample) for which, while removal was possible, insertion of the blades of the diagonal pliers into the protrusion was difficult, was No. 1. On the other hand, samples for which removal was difficult (evaluation C samples) were Nos. 2, 4, and 6. Thus, it was found that removal of a protrusion of a fiber optic cable is easy when the angle $\theta 1$ is 90 degrees or less and the maximum width W of the protrusion is 5 mm or less. Furthermore, it was found that, when the angle $\theta 1$ is 90 degrees or less and the maximum width W of the protrusion is greater than 5 mm, while inserting blades such as diagonal pliers into the protrusion is difficult, removal is possible. On the other hand, it was found that, when the angle $\theta 1$ is greater than 90 degrees, removal is difficult regardless of the size of the maximum width W of the protrusion.

[0095] Furthermore, samples for which the airtightness was favorable (evaluation A samples) were Nos.1, 3, and 5. The sample for which airtightness could be maintained by deformation of the grommet (evaluation B sample) was No. 2. On the other hand, samples having poor airtightness (evaluation C samples) were Nos. 4 and 6. Thus, it was found that, in a fiber optic cable, when an angle $\theta 1$ is 90 degrees or less, a protrusion can be removed even if the maximum width W of the protrusion is 5 mm or less or greater than 5 mm, and airtightness can be made to be favorable by removing the protrusion. However, when the maximum width W becomes much greater than 5 mm, it becomes difficult to remove the protrusion using diagonal pliers or the like, and thus it is necessary that the maximum width W be up to several dozen mm

at most.

On the other hand, it was found that, when the angle $\theta 1$ is greater than 90 degrees and removal of the protrusion is difficult, when the maximum width W of the protrusion is 5 mm or less, it is difficult to close a gap resulting from unevenness of the protrusion by deformation of the grommet, and airtightness cannot be maintained. However, it was found that, even when the angle $\theta 1$ is greater than 90 degrees and removal of the protrusion is difficult, when the maximum width W of the protrusion is greater than 5 mm, airtightness can be maintained by deformation of the grommet even when the protrusion is not removed.

[0096] Additionally, it was found that even when the maximum width W of the protrusion is greater than 5 mm, when the angle $\theta 1$ is 90 degrees or less, it is difficult to close the gap by deformation of the grommet in a state wherein the protrusion is not removed, and airtightness cannot be maintained.

[0097] (Fourth Embodiment)

A fiber optic cable 1D according to a fourth embodiment will be described with reference to FIG. 9. Note that configurations similar to those of the fiber optic cable 1A according to the first embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0098] FIG. 9 is a perspective view illustrating a configuration of an fiber optic cable 1D according to the fourth embodiment. As illustrated in FIG. 9, the fiber optic cable 1D is provided with a plurality of a fiber optic tape core 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, a cable outer cover 4 covering the circumference of the water absorption tape 3, and the tensile strength body unit 50 made up of two tension body 5 and a tear string 6 inside the cable outer cover 4.

[0099] The cable outer cover 4 has the concave portions 42 on the surface thereof. The convex portions 43 are provided on the surface of the cable outer cover 4 other than that of the concave portions 42. The concave portions 42 and the convex portions 43 are alternately provided on the surface of the cable outer cover 4 so as to be adjacent in a cross-sectional view of the radial direction of fiber optic cable 1D. In the present example, four each of the concave portion 42 and the convex portion 43 are provided in a radial direction of the fiber optic cable 1D. The four concave portions 42 and convex portions 43 are provided at substantially equal intervals on the surface of the cable outer cover 4 in a cross-sectional view of the radial direction of fiber optic cable 1D. Note that the number of the concave portion 42 and the convex portion 43 are not limited to four.

[0100] The concave portions 42 are parts, in a radial direction of the cable outer cover 4, having a smaller fiber optic cable 1D diameter than that of the convex portions 43. The concave portions 42 are provided continuously along the longitudinal direction of the fiber optic cable 1D in a straight line. The convex portions 43 are also provided along the longitudinal direction of the fiber optic cable 1, however, the convex portions 43 may be provided continuously or discontinuously along the longitudinal direction.

In addition, the concave portions 42 and the convex portions 43 may be provided in a straight line or in a spiral along the longitudinal direction of the fiber optic cable 1D. The concave portions 42 and the convex portions 43 of the present example are provided continuously along the longitudinal direction of the fiber optic cable 1D in a straight line. The concave portions 42 and the convex portions 43 are, for example, integrally formed by extrusion molding. Note that in the example in FIG. 9, although the convex portions 43 are formed such that an end surface 43a, whose direction is that in which the convex portions 43 protrude, forms a curved surface of a constant curvature, the invention is not limited thereto. For example, curved surfaces of different curvatures or flat surfaces may also be incorporated. In addition, the concave portions 42 may likewise have a surface other than a curved, arc-shaped surface, for example, curved surfaces of different curvatures or flat surfaces may also be incorporated.

[0101] A width Wc of the concave portions 42 in the circumferential direction of the cable outer cover 4, and a width Wv of the convex portions 43 in the circumferential direction of the cable outer cover 4 are formed such that the ratio thereof is less than 2:1. That is, the width Wc of the concave portions 42 and the width Wv of the convex portions 43 are formed so as to satisfy the relationship: $Wc < 2Wv$.

In addition, the width Wc of the concave portions 42 is formed to be 3 mm or more. The width Wc

may be changed, for example, according to an outer diameter of the fiber optic cable 1D.

[0102] In addition, the surface of the cable outer cover 4 has the identification display (marking) 9 for identifying the fiber optic cable 1D applied thereto. The identification display 9 is only applied to the concave portions 42 of the cable outer cover 4. The identification display 9 contains information such as a product name, company name, number of fiber optic cores housed within the fiber optic cable 1D, cable length (position), and year of manufacture. A size of the characters, numbers, and the like included in the identification display 9 is, for example 2 mm or more, as far as the size in the vertical direction. The size of the identification display 9 can be varied according to the size of the width Wc of the concave portions 42. The identification display 9 is printed, for example, by spraying ink on the concave portions 42 using an inkjet printer. Alternatively, the identification display 9 is printed by transferring a toner onto the concave portions 42 using a laser printer.

[0103] In addition, the identification display 9 may be formed, for example, via a hot stamping method in which a stamp is pressed onto the concave portions 42, and characters, numbers, and the like are engraved.

In addition, the identification display 9 may, for example, be a colored band that extends along the surface of the concave portions 42 in the longitudinal direction of the cable. In addition, the colored band may be provided along with the characters, numbers, and the like. The colored band is formed, for example, by simultaneously pressing a material of a different color than that of the outer cover main body part during the pressure extrusion of the cable outer cover 4.

[0104] In the fiber optic cable 1D described above, the outer diameter of the fiber optic cable 1D is, for example, 16 mm or less when the inner diameter of a micro-duct through which the fiber optic cable 1D is pneumatically fed is 20 mm or less. In addition, for example, when the inner diameter of a micro-duct through which the fiber optic cable 1 is pneumatically fed is 14 mm or less, the outer diameter of the fiber optic cable 1D is 11 mm or less.

[0105] In addition, it is preferable that a core density obtained by dividing the total number of fiber optic cores constituting the plurality of fiber optic tape cores 2 by the cable cross-sectional area of the fiber optic cable 1D be 5.0 cores/mm^2 or more. For example, when the outer diameter of the fiber optic cable 1D is 10 mm, the thickness of the cable outer cover 4 is 1.0 mm, and the outer diameter of the fiber optic core is 200 μm, if the number of the 12-core fiber optic tape cores 2 housed within the cable outer cover 4 of the fiber optic cable 1 is 36, the total number of fiber optic cores at that time is 432, making for a core density of 5.5 cores/mm^2. In addition, it is preferable that a bending rigidity of the fiber optic cable 1D in the radial direction be 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in the full circumferential direction. In addition, in the case that the tensile strength body 5 is formed of an aramid FRP, when, for example, the outer diameter of the fiber optic cable 1D is 10 mm and the thickness of the cable outer cover 4 is 1.0 mm, the outer diameter of the aramid FRP is preferably 0.5 mm or more.

[0106] As described above, the fiber optic cable 1D according to the fourth embodiment is provided with the plurality of fiber optic tape cores 2, as well as the cable outer cover 4 that contains these fiber optic tape cores 2 and has the concave portions 42 on the surface. Furthermore, the identification display 9 is applied only to the concave portion 42. According to this configuration, when the fiber optic cable 1D is pneumatically fed, the concave portions 42 do not readily make contact with the inner surface of the duct, which carries little risk of the identification display 9 applied to the concave portions 42 being scraped off by rubbing against the inner surface of the duct. Therefore, the identification display applied 9 to the cable outer cover 4 can maintain a high visibility. In addition, because the surface has an uneven structure due to the provision of the concave portions 42 on the surface of the cable outer cover 4, an area of contact between the fiber optic cable 1D and the inner surface of the duct decreases, and friction between the surface of the cable outer cover 4 and the inner surface of the duct during pneumatic feeding is reduced. As a result, a pneumatic feeding distance when conducting pneumatic feeding of the fiber optic cable 1D within a duct can be extended. In addition, because the identification display 9 is applied only to the concave portions 42 of the surface of the cable outer cover 4, the identification display 9 does not overlap a boundary of the concave portions 42 and the convex portions 43, which allows for favorable visibility

of the characters, numbers, and the like included in the identification display 9.

[0107] In addition, the fiber optic cable 1D has the numbers, characters, and the like of the identification display 9 printed by an inkjet printer or a laser printer, which are generally regarded as having a high printing speed. Thus, the time required for the process of forming the identification display 9 can be shortened, so the manufacturing efficiency of the fiber optic cable 1D can be increased.

[0108] In addition, the fiber optic cable 1D is formed such that the width Wc of the concave portions 42 on the surface of the cable outer cover 4 is 3 mm or more. As such, the identification display 9 of characters and numbers of 2 mm or more, which in general is readily visible with the naked eye, can be applied to the concave portions 42 of the cable outer cover 4. Therefore, this allows for favorable visibility of the identification display 9 in the fiber optic cable 1D.

[0109] However, when the concave portion 42 width Wc is overly widened, the concave portions 42 come into contact with the inner surface of the duct, which carries the risk of the identification display 9 applied to the concave portions 42 being scraped off. In addition, when the concave portions 42 come into contact with the inner surface of the duct, friction between the surface of the cable outer cover 4 and the inner surface of the duct increases. In contrast, according to the fiber optic cable 1D, the ratio between the concave portion 42 width Wc and the convex portion 43 width Wv is formed so as to be smaller than 2:1. This allows for contact between the concave portions 42 and the inner surface of the duct to be suppressed, and allows for scraping off of the identification display 9 to be suppressed. In addition, because the convex portions 43 can be made to contact the inner surface of the duct, friction between the surface of the cable outer cover 4 and the inner surface of the duct can be suppressed from increasing, and can ensure a sufficiently long pneumatic feeding distance.

[0110] (Example 3)
In the fiber optic cable according to the fourth embodiment, visibility of the identification display as well as pneumatic feeding distance were evaluated for a plurality of samples in which the ratio of the concave portion width to the convex portion width was different. The evaluation results are shown in Table 3.

[0111] [Table 3]

Table 3

Sample No.	1	2	3	4	5	6	7
Concave Portion Width (Convex Portion Width) [mm]	2.5 (5.3)	3.0 (4.8)	3.5 (4.3)	4.0 (3.8)	4.5 (3.3)	5.0 (2.8)	5.5 (2.3)
Visibility of the Identification Display	B	A	A	A	A	A	A
Pneumatic Feeding Distance [m]	A	A	A	A	A	A	B

[0112] In Table 3, the outer diameter of the fiber optic cable is 10 mm. The number of concave portions (convex portions) of the cable outer cover was the same as the number of concave portions (convex portions) of the fiber optic cable 1D illustrated in FIG. 9, which was four. The identification display of the cable outer cover had 2 mm characters and numbers printed on the concave portions using an ink jet printer.

[0113] The visibility of the identification display in terms of whether the printed characters and numbers were visible, and whether such might be identified as other characters and numbers (for example, whether a

printed number could be identified as an “8” or a “0”) was determined visually.

For the pneumatic feeding distance, a micro duct pneumatic feeding test in compliance with IEC was performed using the pneumatic feeding device illustrated in FIG. 5. A pipe 20 is 1,000 m long and is folded back every 100 m. Bending (R) of the pipe 20 is 40 times the outer diameter of the pipe, and the inner diameter of the pipe 20 is 14 mm. An opening 21 is a entry feed port for air and a fiber optic cable, and an opening 22 is an exit feed port for air and a fiber optic cable. The pneumatic pressure was 1.3 MPa to 1.5 MPa.

[0114] Evaluation of the visibility of the identification display was as such: those for which visibility was favorable were given an evaluation A, those which were visible were given an evaluation B, and those for which visibility was difficult were given an evaluation C.

For evaluation of the pneumatic feeding distance, those for which the pneumatic feeding distance was 1,000 m or more were given an evaluation A, those for which the pneumatic feeding distance was 600 m or more and less than 1,000 m were given an evaluation B, and those for which the pneumatic feeding distance was less than 600 m were given an evaluation C.

[0115] According to the evaluation results in Table 3, the samples having favorable visibility in the visibility of the identification display (evaluation A samples) were nos. 2 to 7. In addition, the sample which was visible (evaluation B sample) was no. 1. Thereby, it was found that when the concave portion width was 3 mm or more, visibility of the identification display was favorable. Meanwhile, it was found that when the concave portion width was 2.5 mm, although printing of 2 mm characters and the like within the concave portions was possible, the identification display overlapped a boundary of the concave portion and the convex portion due to variations in manufacturing. Thus in this case, despite being visible, visibility could not be said to be favorable.

[0116] In addition, the samples for which the pneumatic feeding distance was 1,000 m or more (evaluation A samples) were Nos. 1 to 6. In addition, the sample for which the pneumatic feeding distance was 600 m or more and less than 1,000 m (evaluation B sample) was No. 7. Accordingly, it was found that when the ratio of the concave portion width to the convex portion width is less than 2:1 in the fiber optic cable, the pneumatic feeding distance is favorable.

[0117] (Fifth Embodiment)

A fiber optic cable 1E according to a fifth embodiment will be described with reference to FIG. 10. Note that configurations similar to those of the fiber optic cable 1A according to the first embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0118] The fiber optic cable 1E illustrated in FIG. 10 is slotless and has, for example, a round assembly core 111 and a cable outer cover 113 formed around the assembly core 111. The assembly core 111 houses, for example, a plurality of twelve-core intermittent fiber optic tape core 2. Note that in addition to intermittent fiber optic tape core, it is also possible to house a plurality of single-core fiber optic cores bundled together.

[0119] The assembly core 111 of the fiber optic cable 1E is vertically attached or horizontally wound with, for example, a water absorption tape 3 to form a round shape. The outer side of the water absorption tape 3 is covered by a cable outer cover 113 configured by two types of polyethylene (PE). In the cable outer cover 113 (inner layer 114 described hereafter), for example, tensile strength body (tension member) 5 for maintaining strength in the longitudinal direction and for example, four tension member units 50 configured by two tension members, two tear strings 6 for tearing the cable outer cover 113 in the cable longitudinal direction are longitudinally attached and embedded during extrusion molding of the cable outer cover 113 (inner layer 114).

[0120] For the tensile strength body 5, a wire material having a bearing capacity against tension and compression, for example, steel wire or FRP (Fiber Reinforced Plastics), or the like is used. Two tensile strength body units 50 to be a pair among the four tensile strength body units 50 are provided on both

sides across the assembly core 111, for example. The positions of the tensile strength body units 50 in the cross-sectional view are such that two straight lines connecting each of the two tensile strength body units 50 are orthogonal. The tear string 6 is provided one by one on both sides of the assembly core 111. The tear strings 6 are cross-sectionally circular string-shaped members in which, for example, a resin material such as nylon or polyester is used, and is aligned along the radial direction of the assembly core 111, for example, on the same straight line.

[0121] As illustrated in FIG. 10, the cable outer cover 113 is formed of two layers, an inner layer 114 and an outer layer 115. The inner layer 114 contacts the assembly core 111, and the outer layer 115 is provided outside the inner layer 114 and covers the outside of the tensile strength body 5.

[0122] Because the microduct cable is pneumatically fed in a duct, it is desirable to reduce the coefficient of friction of the cable surface in order to extend the pneumatic feeding distance in the duct. Therefore, the material used for the outer layer 115 has a density 0.942 (g/cm^3) or greater and 0.98 (g/cm^3) or less (4 for example, 0.95 (g/cm^3)) and a tensile elastic modulus between 700 and 1,200 (MPa). It should be noted that those having a density of 0.942 (g/cm^3) or greater are also referred to as high-density polyethylene (HDPE).

[0123] In this manner, the outer layer 115 of the cable outer cover 113 is configured by HDPE, and the coefficient of friction is low, so the cable is easy to pass through the duct. Moreover, when the outer layer 115 is configured by HDPE, even when the air pressure supplied into the duct is high or the cable is pushed into the duct, the outer layer is firm enough to withstand pneumatic feeding. However, when the cable outer cover 113 is configured only by HDPE, the tensile elastic modulus is high, so the material contracts at low temperatures, the fiber optic tape core 2 in the assembly core 111 are compressed, causing bending, and loss increases. In this case, with the type of tensile strength body 5 that is embedded in the cable outer cover 113 as illustrated in FIG. 10, it is also difficult to make the tensile strength body thicker, and it is not possible to counter the contracting of the cover. Therefore, the material used for the inner layer 114 has a density of 0.91 (g/cm^3) or greater and less than 0.942 (g/cm^3) (for example, 0.93 (g/cm^3)) and a tensile elastic modulus of 100 to 600 (MPa), which is less likely to contract at low temperatures and prevents an increase in loss at low temperatures. It should be noted that when the density is less than 0.942 (g/cm^3), these are referred to as low density polyethylene (LDPE) for convenience to distinguish them from HDPE.

[0124] FIG. 11 is a table describing the specifications and evaluation results of each sample. For the fiber optic cable 1E having an outer diameter of ϕ12 (mm) or φ16 (mm), the outer cover thickness of the LDPE (tensile elastic modulus of 300 (MPa)) of the inner layer 114 and the outer cover thickness of the HDPE (tensile elastic modulus of 1,050 (MPa)) of the outer layer 115 were respectively changed, and the surface friction coefficient, the change in loss at low temperatures, the synthetic tensile elastic modulus, and the synthetic tensile elastic modulus × outer covering total cross-sectional area value (also referred to the ES product) were found, and an evaluation was performed as to whether the various conditions are suitable for the fiber optic cable for pneumatic feeding (A if suitable, B if not).

[0125] The surface friction coefficient is the friction coefficient of the cable surface of the fiber optic cable 1E. The change in loss at low temperatures (dB/km) is the change in loss when the fiber optic cable 1E is left under low temperatures (-40°C). The synthetic tensile elastic modulus (MPa) is the tensile elastic modulus of a material having the inner layer 114 and the outer layer 115 combined and converted into one member, and is obtained using the cross-sectional area ratio of the inner layer 114 and the outer layer 115. The ES product (N) is the product of the synthetic tensile elastic modulus (MPa) and the outer covering total cross-sectional area value (mm^2), and is one of the indicators of the strength of the cable outer cover 113. The synthetic tensile elastic modulus corresponds to "the synthetic tensile modulus of the cable outer cover" according to the present disclosure, and the outer covering total cross-sectional area value corresponds to "the total cross-sectional area of the cable outer cover" according to the present disclosure.

[0126] When the outer diameter of the cable (the outer diameter of the fiber optic cable 1E) is φ12 (mm), the inner diameter of the cable (the outer diameter of the assembly core 111) is φ8 (mm), the LDPE outer cover thickness is 2 (mm), and the HDPE outer cover thickness is 0 (mm) (referred to as sample 1), the LDPE cross-sectional area is 62.8 (mm^2), the HDPE cross-sectional area is 0 (mm^2), and the HDPE area ratio is 0 (%). Note that the HDPE area ratio corresponds to "the ratio of the cross-sectional area of the outer layer to the total cross-sectional area of the cable outer cover" according to the present disclosure. In sample 1, the ES product was 18,850 (N) and the change in loss at low temperatures was low at 0.05 (dB/km), but the surface friction coefficient was large at 0.5 and it was difficult for the cable to pass through the duct, so it was determined as not suitable for a fiber optic cable for pneumatic feeding (evaluation B). It should be noted that in sample 1, the bending rigidity was 0.1 ($N \cdot m^2$), and even at this point, it was insufficient to pass through.

[0127] Meanwhile, when the cable outer diameter is φ12 (mm), the inner diameter of the cable is φ8 (mm), the LDPE outer cover thickness is 1 (mm), and the HDPE outer cover thickness is 1 (mm) (referred to as sample 2), the LDPE cross-sectional area is 28.3 (mm^2), the HDPE cross-sectional area is 34.6 (mm^2), and the HDPE area ratio is 55 (%). In sample 2, the surface friction coefficient was 0.15, the ES product was 44,768 (N), and the change in loss at low temperatures was 0.15 (dB/km). In this case, the surface friction coefficient became small, and the change in loss at low temperatures was at a prescribed reference value of 0.2 (dB/km) or less, so it was determined as suitable for a fiber optic cable for pneumatic feeding (evaluation A). It should be noted that in sample 2, the bending rigidity was 0.85 ($N \cdot m^2$) and was insufficient to pass through.

[0128] Next, when the cable outer diameter is φ12 (mm), the inner diameter of the cable is φ8 (mm), the LDPE outer cover thickness is 0 (mm), and the HDPE outer cover thickness is 2 (mm) (referred to as sample 3), the LDPE cross-sectional area is 0.0 (mm^2), the HDPE cross-sectional area is 62.8 (mm^2), and the HDPE area ratio is 100 (%). In sample 3, the surface friction coefficient was 0.15, the ES product was larger than 60,000 (N) at 65,973 (N). Therefore, because the change in loss at low temperatures was 0.22 (dB/km) and did not meet the condition of being at the prescribed reference value of 0.2 (dB/km) or less, increased loss at low temperatures could not be avoided, and it was therefore determined as unsuitable for a fiber optic cable for pneumatic feeding (evaluation B). It should be noted that in sample 3, the bending rigidity was 1.5 ($N \cdot m^2$).

[0129] When the cable outer diameter is φ16 (mm), the cable inner diameter is φ12 (mm), the LDPE outer cover thickness is 2 (mm), and the HDPE outer cover thickness is 0 (mm) (referred to as sample 4), the LDPE cross-sectional area is 88.0 (mm^2), the HDPE cross-sectional area is 0 (mm^2), and the HDPE area ratio is 0 (%). In sample 4, the ES product was 26,389 (N) and the change in loss at low temperatures was 0.05 (dB/km), but the surface friction coefficient became large at 0.5 and it was difficult for the cable to pass through the duct, so it was determined as not suitable for a fiber optic cable for pneumatic feeding (evaluation B). It should be noted that in sample 4, the bending rigidity was 0.1 ($N \cdot m^2$), and even at this point, it was insufficient to conduct the wire.

[0130] Meanwhile, when the cable outer diameter is φ16 (mm), the inner diameter of the cable is φ12 (mm), the LDPE outer cover thickness is 1.1 (mm), and the HDPE outer cover thickness is 0.9 (mm) (referred to as sample 5), the LDPE cross-sectional area is 45.3 (mm^2), the HDPE cross-sectional area is 42.7 (mm^2), and the HDPE area ratio is 49 (%). In sample 5, the surface friction coefficient was 0.15, the ES product was 58,410 (N), and the change in loss at low temperatures was 0.18 (dB/km). In this case, the surface friction coefficient became small, and the change in loss at low temperatures was at a prescribed reference value of 0.2 (dB/km) or less, so it was determined as suitable for a fiber optic cable for pneumatic feeding (evaluation A). It should be noted that in sample 5, the bending rigidity was 0.7 ($N \cdot m^2$).

[0131] Next, when the cable outer diameter is φ16 (mm), the inner diameter of the cable is φ12 (mm), the LDPE outer cover thickness is 0 (mm), and the HDPE outer cover thickness is 2 (mm) (referred to as

sample 6), the LDPE cross-sectional area is 0 (mm^2), the HDPE cross-sectional area is 88.0 (mm^2), and the HDPE area ratio is 100 (%). In sample 6, the surface friction coefficient was 0.15, the ES product was larger than 60,000 (N) at 92,363 (N). Therefore, because the change in loss at low temperatures was 0.25 (dB/km) and did not meet the condition of being at the prescribed reference value of 0.2 (dB/km) or less, increased loss at low temperatures could not be avoided, and it was therefore determined as unsuitable for a fiber optic cable for pneumatic feeding (evaluation B). It should be noted that in sample 6, the bending rigidity was 1.5 ($N \cdot m^2$).

[0132] FIG. 12 is a diagram describing the relationship between the change in loss at low temperatures and the HDPE area ratio. As the HDPE area ratio decreases, the change in loss at low temperatures also gradually decreases. It is understood that when the HDPE area ratio is 60 (%) or less, the change in loss at low temperatures is kept at or below the predetermined reference value (0.2 (dB/km). When the HDPE area ratio is 60 (%) or less in this manner, even when the outer layer 115 is configured by HDPE, it is possible to prevent an increase in loss at low temperatures.

[0133] FIG. 13 is a diagram describing the relationship between the change in loss at low temperatures and the ES product. As the ES product decreases, the change in loss at low temperatures also gradually decreases. It is understood that when the ES product is 60,000 (N) or less, the change in loss at low temperatures is kept at or below the predetermined reference value (0.2 (dB/km). When the ES product is 60,000 (N) or less in this manner, even when the outer layer 115 is configured by HDPE, it is possible to prevent an increase in loss at low temperatures.

[0134] FIG. 14 is a diagram describing the relationship between bending rigidity and HDPE area ratio. As the HDPE area ratio increases, the bending rigidity also gradually increases. It is understood that when the HDPE area ratio is 20 (%) or greater, the bending rigidity is at or greater than the predetermined reference value of 0.3 ($N \cdot m^2$). Therefore, when the HDPE area ratio is 20 (%) or greater, it becomes easier to pass the cable through the duct and the cable can sufficiently withstand pneumatic feeding.

[0135] (Sixth Embodiment)

A fiber optic cable 1F according to a sixth embodiment will be described with reference to FIG. 15. Note that configurations similar to those of the fiber optic cable 1B according to the second embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0136] FIG. 15 is a cross-sectional view illustrating a configuration of a fiber optic cable 1F according to a sixth embodiment. As illustrated in FIG. 15, the fiber optic cable 1F is provided with a plurality of a fiber optic tape core 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores 2, a cable outer cover 4 covering the circumference of the water absorption tape 3, and a tensile strength body 5 and a tear string 6 provided inside the cable outer cover 4, and a protrusion 7 provided in the outer peripheral portion of the cable outer cover 4.

[0137] The fiber optic cable 1F differs from the fiber optic cable 1B in that the tensile strength body unit 50 is composed of three tensile strength body 5. The fiber optic cable 1F differs from the fiber optic cable 1B in that the protrusion 7 are provided in only two lines at positions opposed to the circumferential direction of the outer peripheral portion of the cable outer cover 4 in a radial direction of the fiber optic cable 1F.

[0138] (Seventh Embodiment)

A fiber optic cable 1G according to a seventh embodiment will be described with reference to FIG. 16. Note that configurations similar to those of the fiber optic cable 1B according to the second embodiment are labelled using the same reference numerals and that the description thereof is omitted.

[0139] FIG. 16 is a cross-sectional view illustrating a configuration of a fiber optic cable 1G according to a seventh embodiment. As illustrated in FIG. 16, the fiber optic cable 1G is provided with a plurality of a fiber optic tape core 2, a water absorption tape 3 covering the circumference of the fiber optic tape cores

2, a cable outer cover 4 covering the circumference of the water absorption tape 3, and a tensile strength body 5 and a tear string 6 provided inside the cable outer cover 4, and a protrusion 7 provided in the outer peripheral portion of the cable outer cover 4.

[0140] The fiber optic cable 1G differs from the fiber optic cable 1B in that the tensile strength body unit 50 are provided more than the fiber optic cable1B. The fiber optic cable 1G differs from the fiber optic cable 1B in that the protrusion 7 are provided in only two lines at positions opposed to the circumferential direction of the outer peripheral portion of the cable outer cover 4 in a radial direction of the fiber optic cable 1G.

[0141] So far, the present invention has been described in detail with reference to specific embodiments, but it is clear to a person skilled in the art that various changes and modifications can be made without departing from the spirit and scope of the present invention. Furthermore, the number, position, shape, and the like of the constituent members described above are not limited to the embodiments described above, and the number, position, shape, and the like can be changed as appropriate in implementing the present invention.

Description of Reference Numerals

[0142] 1A to 1G: Fiber optic cable
2: Fiber optic tape core
3: Water absorption tape
4, 113: Cable outer cover
5: Tensile strength body
6: Tear string
7, 107: Protrusion
7a : Surface
8a, 8b: Intersection
9: Identification display
11A to 11L: Fiber optic core
12: Connected part
13: Unconnected part
14: Connection resin
15: Glass fiber
16: Inner coating layer
17: Outer coating layer
20: Pipe
21, 22: Opening
41: Outer peripheral portion
41a, 107a: Surface
41b, 107b: Tangent line
42: Concave portion
43: Convex portion
43a: End surface
50: Tensile strength body unit
111: Assembly core
114: Inner layer
115: Outer layer

Scope of Claims

[Claim 1] A fiber optic cable, comprising:

a plurality of fiber optic cores or a plurality of fiber optic tape cores;

a cable outer cover enclosing the plurality of fiber optic cores or the plurality of fiber optic tape cores; and four or more tensile strength body units which are provided so as to be embedded within the cable outer cover, and which have two or more tensile strength bodies as pairs;

wherein the four or more tensile strength body units are respectively provided at positions facing each other across the center of the fiber optic cable in a cross-section in a radial direction of the fiber optic cable, and the cable outer diameter of the fiber optic cable is 6 mm to 16 mm.

[Claim 2] The fiber optic cable according to claim 1, wherein at least four tensile strength body units among the four or more tensile strength body units of the fiber optic cable is arranged in positions where straight lines connecting the respective pairs of tensile strength body units are orthogonal in the cross-section in the radial direction of the fiber optic cable.

[Claim 3] The fiber optic cable according to claim 1 or claim 2, wherein the bending rigidity in the radial direction of the fiber optic cable is 0.35 $N \cdot m^2$ or more and 1.3 $N \cdot m^2$ or less in all directions.

[Claim 4] The fiber optic cable according to any one of claims 1 to 3, wherein the tensile strength body is an aramid FRP.

[Claim 5] The fiber optic cable according to any one of claims 1 to 3, wherein the tensile strength body is a liquid crystal polymer.

[Claim 6] The fiber optic cable according to any one of claims 1 to 5, wherein the cable outer cover includes a silicon-based lubricant.

[Claim 7] The fiber optic cable according to claim 6, wherein the silicon-based lubricant contained in the cable outer cover is 1.5% by mass or more.

[Claim 8] The fiber optic cable according to any one of claims 1 to 7, wherein the cable outer cover has protrusions protruding in a radial direction of the fiber optic cable in an outer peripheral portion.

[Claim 9] The fiber optic cable according to claim 8, wherein a cross-section in the radial direction of the fiber optic cable, the angle formed by tangential lines on both surfaces at an intersection point between the surface of the protrusion and the surface of the outer peripheral portion that is not the protrusion is 90 degrees or less.

[Claim 10] The fiber optic cable according to claim 8 and 9, wherein the protrusion is formed in a helical shape in a longitudinal direction of the fiber optic cable.

[Claim 11] The fiber optic cable according to any one of claims 1 to 10, wherein the cable outer cover has a concave portion on the surface, and an identification display is applied only to the concave portion.

[Claim 12] The fiber optic cable according to any of claims 1 to 11, wherein the cable outer cover has an inner layer provided on the outer side of an assembly core of a plurality of the fiber optic cores or a plurality of the fiber optic tape cores, and an outer layer provided on the outer side of the inner layer, wherein the density of the material used in the outer layer is 0.942 (g/cm^3) or more, and the density of the material used in the inner layer is less than 0.942 (g/cm^3).

[Claim 13] The fiber optic cable according to any one of claims 1 to 12, wherein the cable outer cover includes flame retardant PVC or flame retardant polyethylene having an oxygen index of 50 or more.

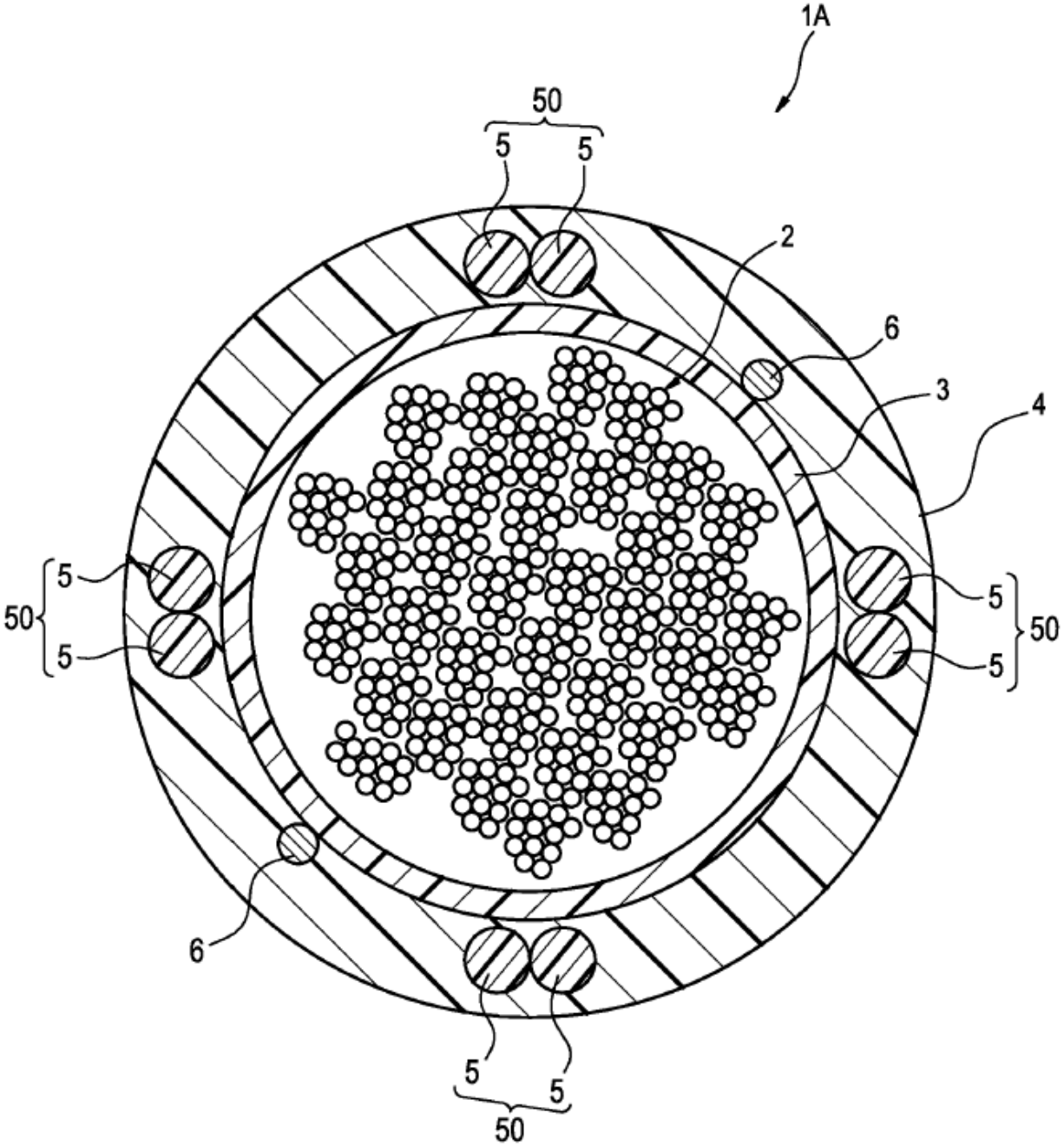
[Claim 14] The fiber optic cable according to any one of claims 1 to 13, wherein the fiber optic core or the fiber optic tape core has a glass fiber and a coating covering an outer periphery of the glass fiber, the coating includes two layers, the outer coating layer is a cured resin composition containing a base resin having a urethane acrylate oligomer or urethane methacrylate oligomer, a monomer having a phenoxy group, a photoinitiator, and a silane coupling agent, and hydrophobic inorganic oxide particles, and the content of the inorganic oxide particles is from 1% to 45% by mass based on the total amount of the resin composition.

[Claim 15] The fiber optic cable according to any one of claims 1 to 14, wherein the fiber optic core or the fiber optic tape core constituting the fiber optic tape core has a bending loss of 1550 nm in a wavelength of 0.5 dB or less for a bending diameter of φ15 mm x 1 turn and 0.1 dB or less for a bending diameter of φ20 mm x 1 turn.

[Claim 16] The fiber optic cable according to any one of claims 1 to 14, wherein the fiber optic core or the fiber optic core that configures the fiber optic tape core includes a multi-core fiber where a per core count is 4 or more.

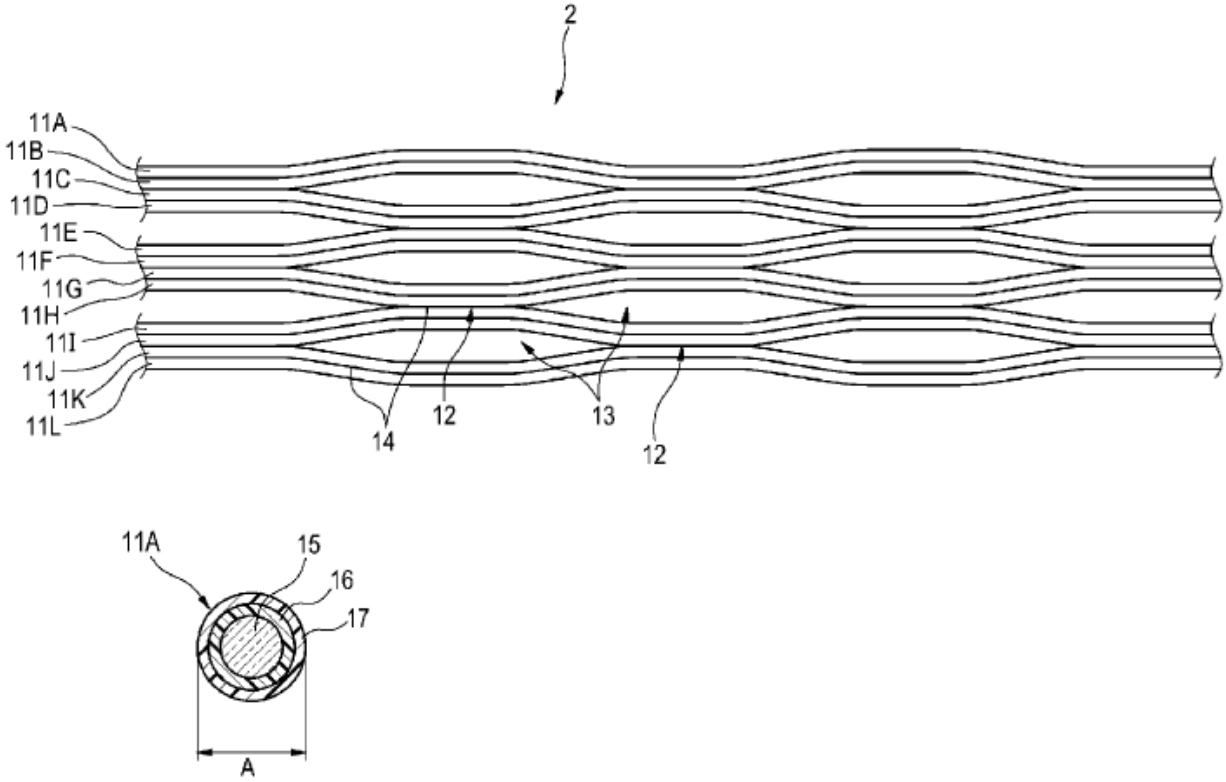
[FIG. 1]

FIG. 1



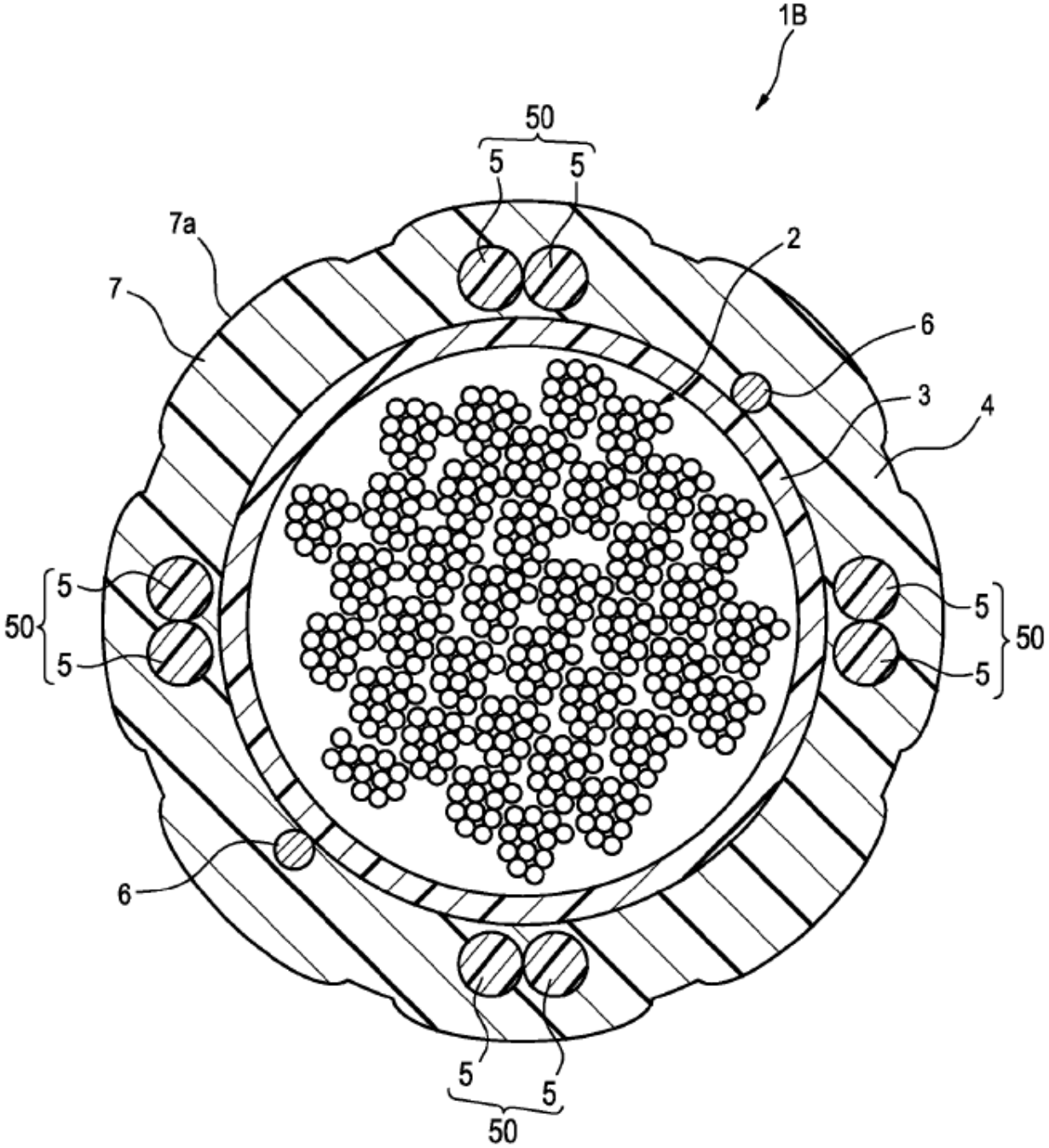
[FIG. 2]

FIG. 2


2
11A
11B
11C
11D
11E
11F
11G
11H
11I
11J
11K
11L
14
12
13
12
11A
15
16
17
A

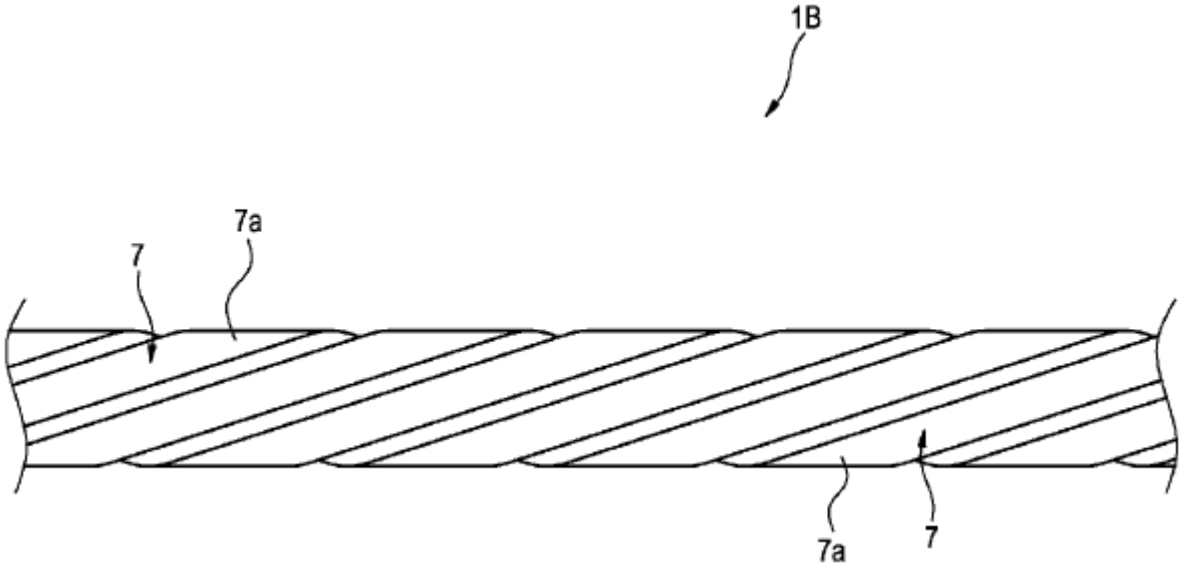
[FIG. 3]

FIG. 3



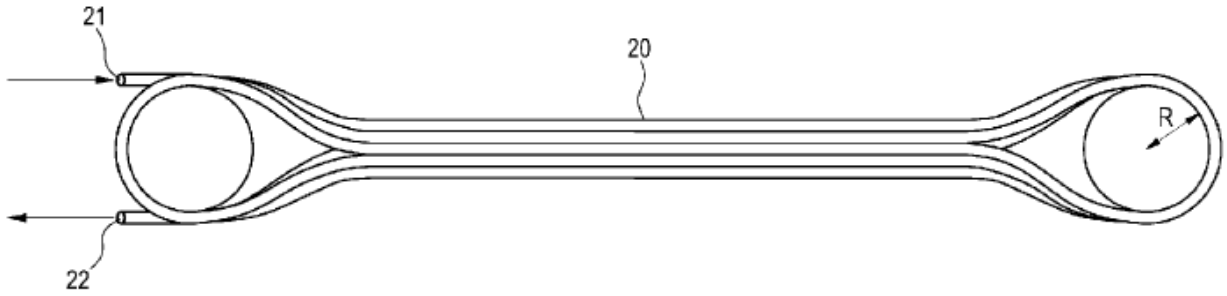
[FIG. 4]

FIG. 4



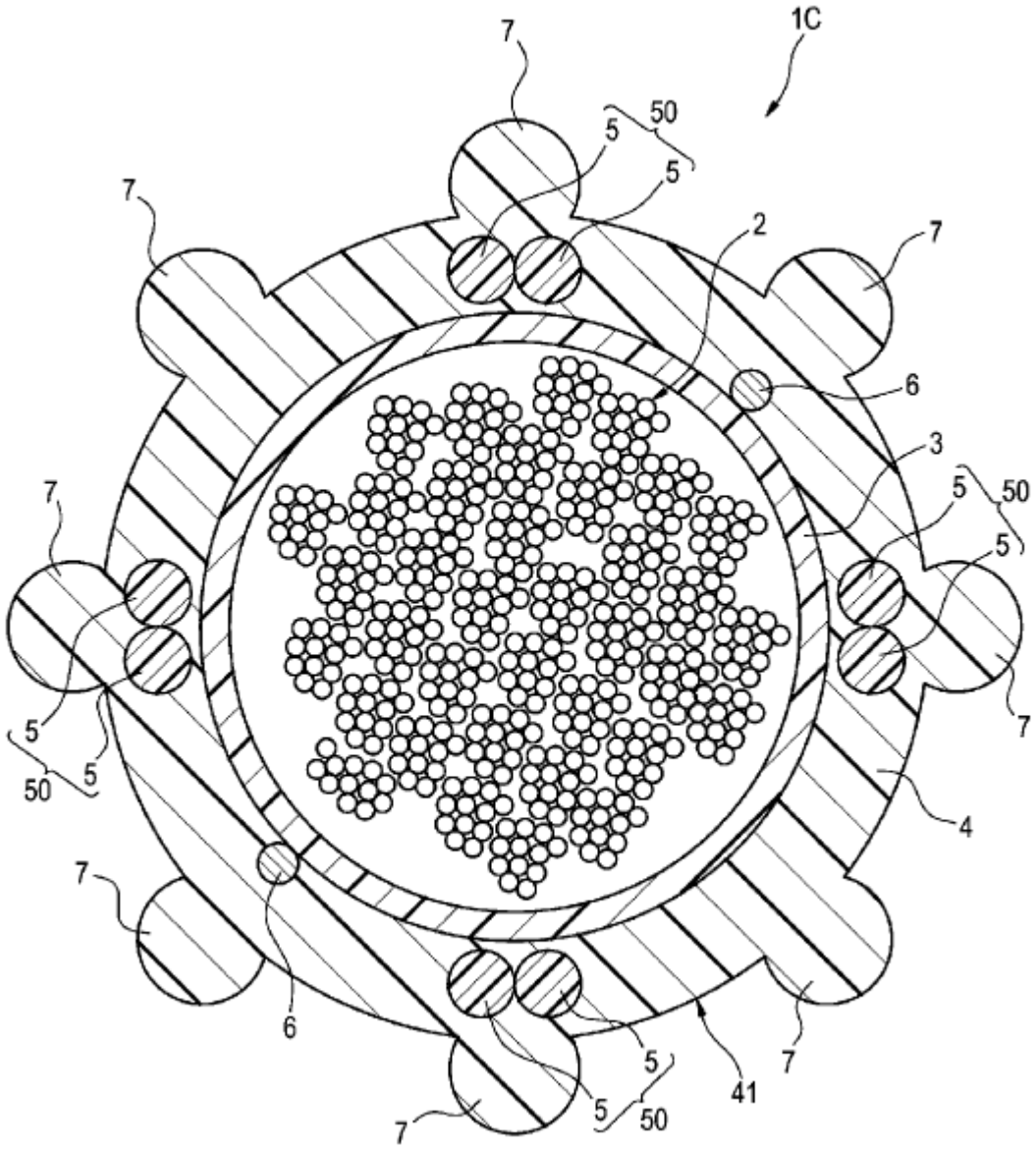
[FIG. 5]

FIG. 5



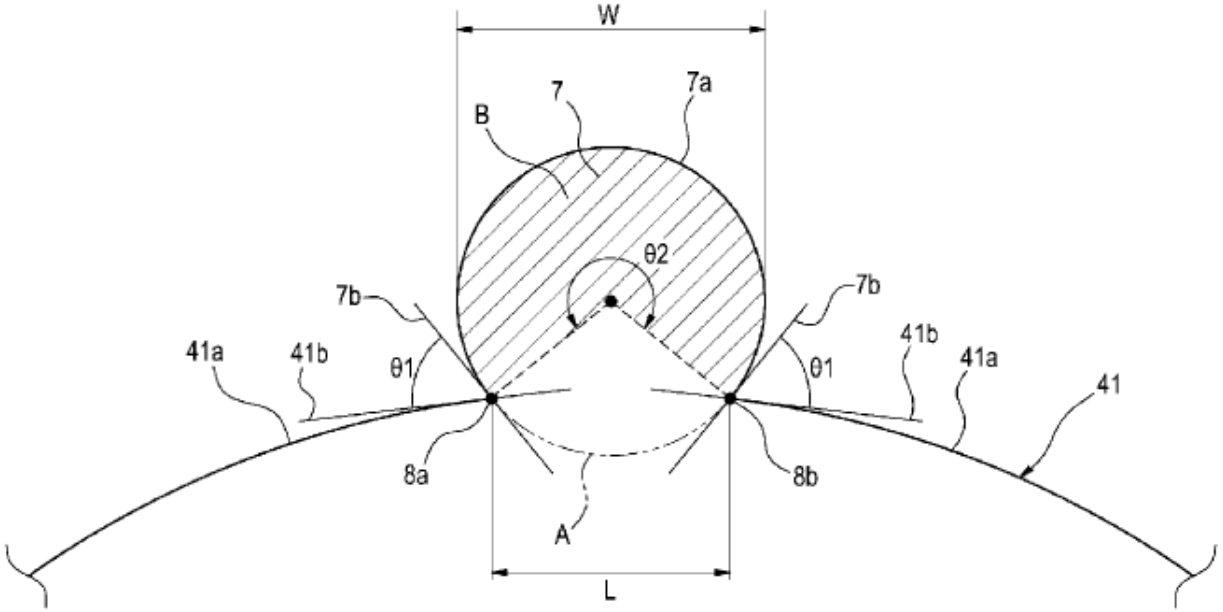
[FIG. 6]

FIG. 6



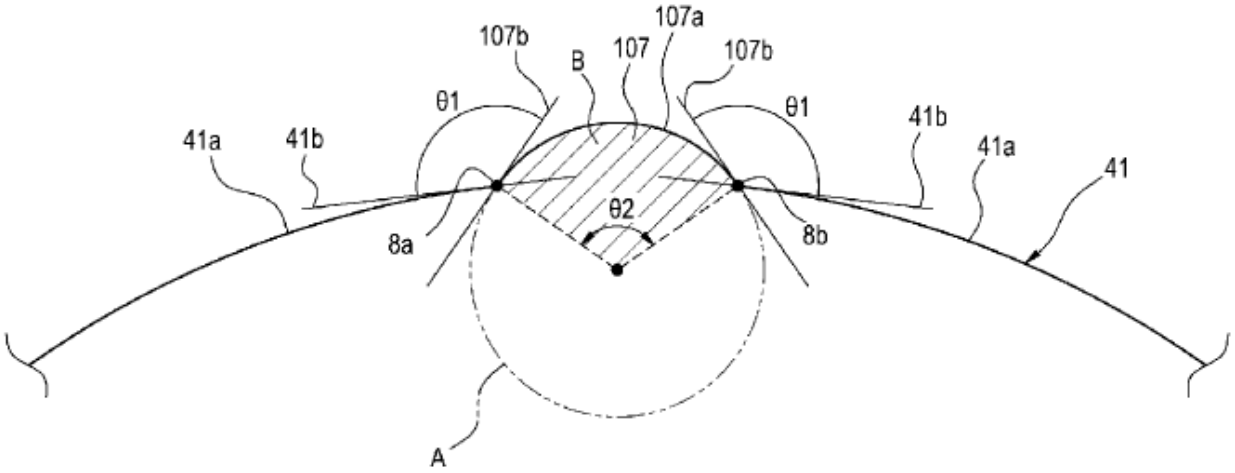
[FIG. 7]

FIG. 7



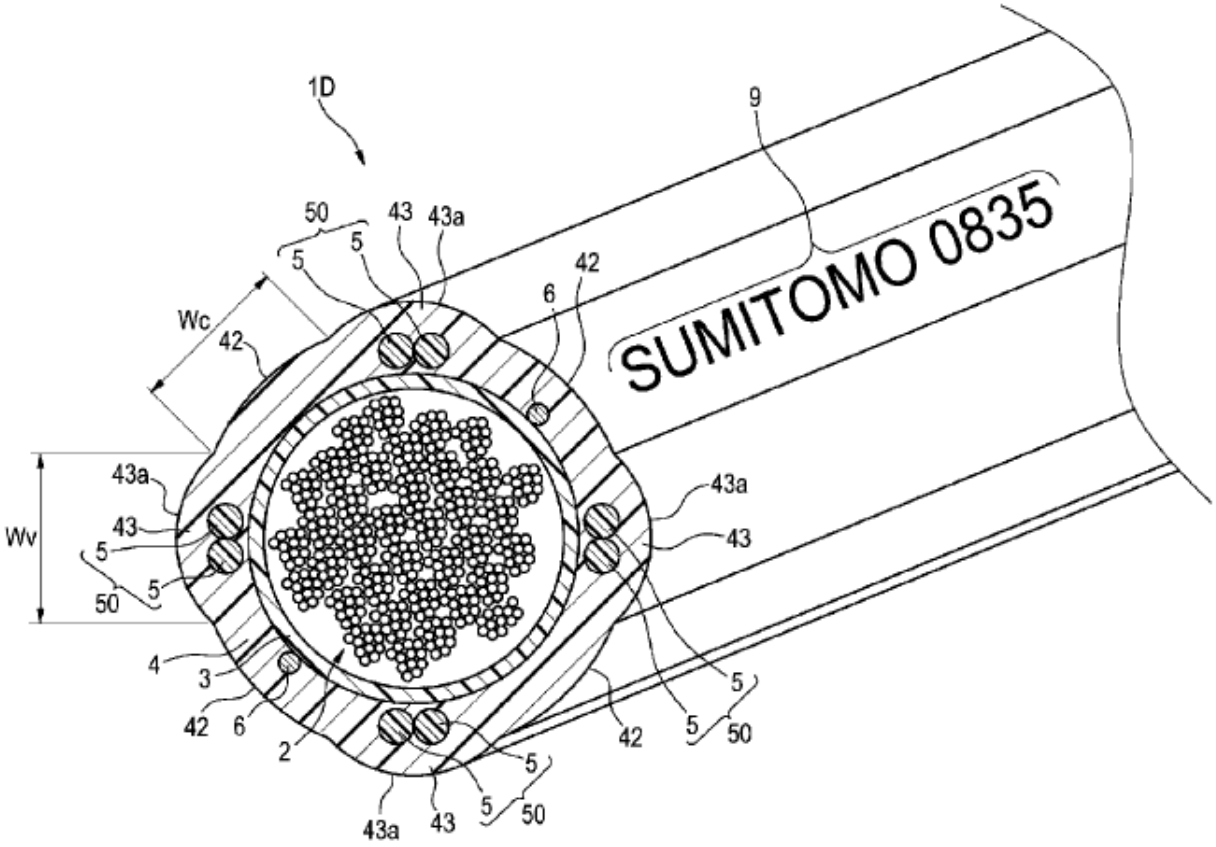
[FIG. 8]

FIG. 8



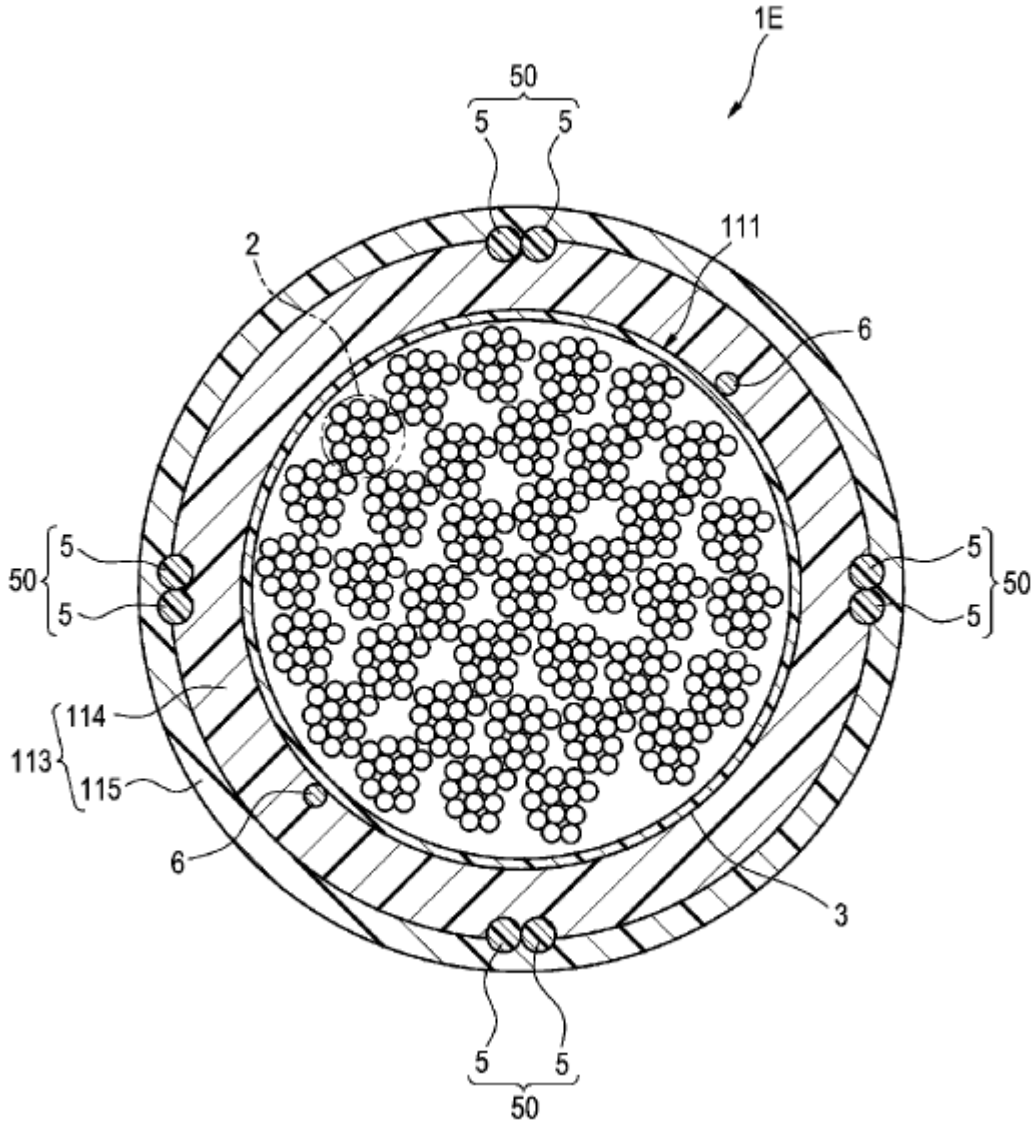
[FIG. 9]

FIG. 9


1D
9
SUMITOMO 0835
50
43
43a
5
5
42
6
Wc
42
43a
43
5
5
50
Wv
43a
43
5
5
50
4
3
42
6
2
42
5
50
5
5
50
43a
43

[FIG. 10]

FIG. 10



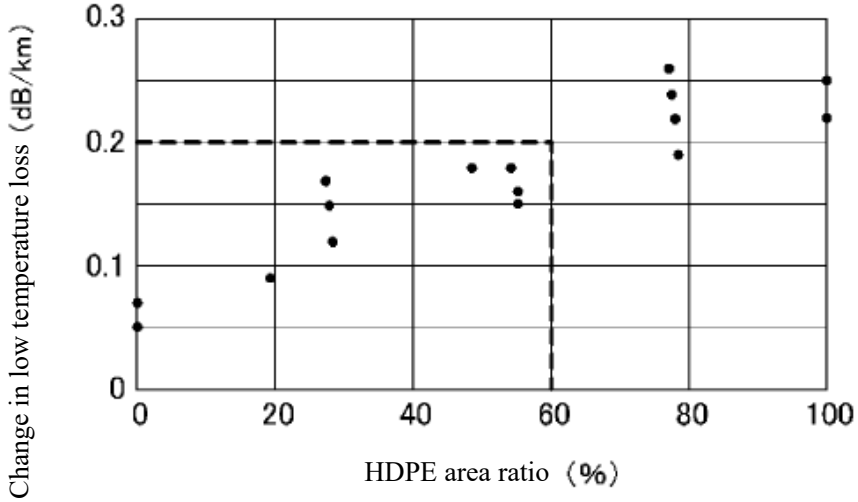
[FIG. 11]

FIG. 11

	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Sample 6
Cable inner diameter (mm)	8	8	8	12	12	12
LDPE outer cover thickness (mm)	2	1	0	2	1.1	0
LDPE cross-sectional area (mm^2)	62.8	28.3	0	88.0	45.3	0
LDPE tensile elastic modulus (MPa)	300	300	300	300	300	300
HDPE outer cover thickness (mm)	0	1	2	0	0.9	2
HDPE cross-sectional area (mm^2)	0	34.6	62.8	0	42.7	88.0
HDPE area ratio (%)	0	55	100	0	49	100
HDPE tensile elastic modulus (MPa)	1,050	1,050	1,050	1,050	1,050	1,050
Cable outer diameter (mm)	12	12	12	16	16	16
Surface friction coefficient	0.5	0.15	0.15	0.5	0.15	0.15
Change in low temperature loss (dB/km)	0.05	0.15	0.22	0.05	0.18	0.25
Synthetic tensile elastic modulus (MPa)	300	713	1,050	300	664	1,050
Synthetic tensile elastic modulus × Outer cover total cross-sectional area value (N)	18,850	44,768	65,973	26,389	58,410	92,363
Evaluation	B	A	B	B	A	B

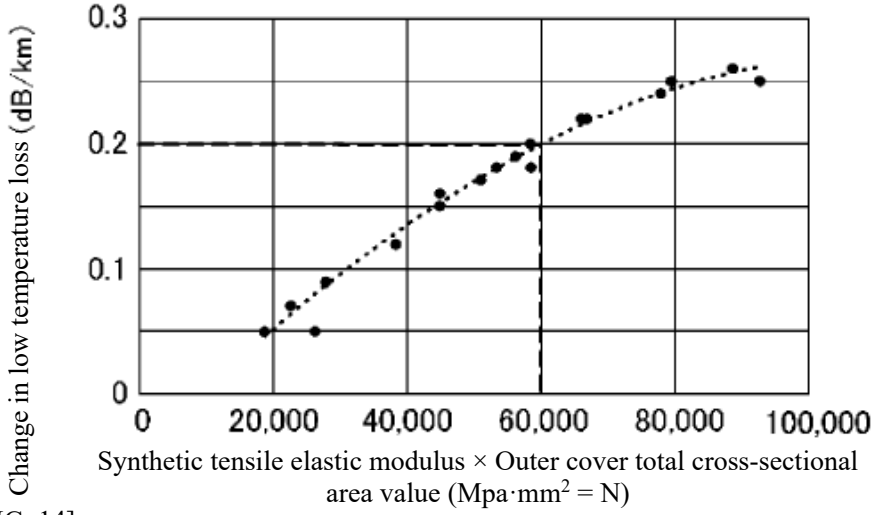
[FIG. 12]

FIG. 12



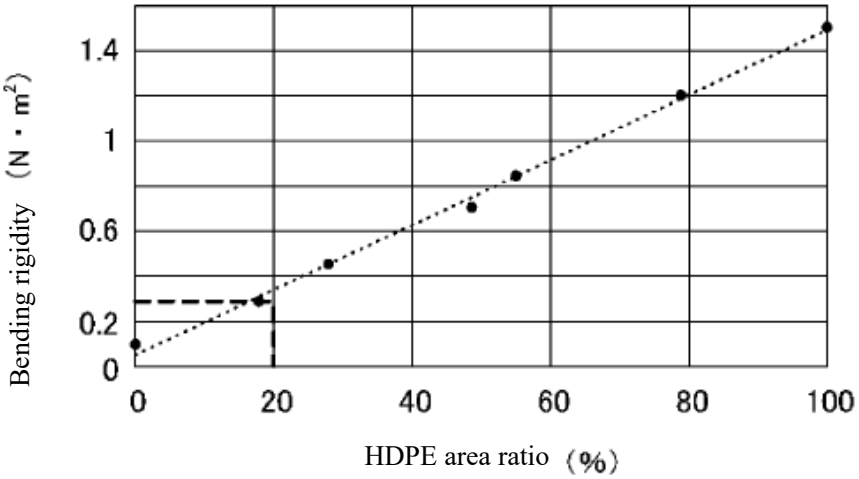
[FIG. 13]

FIG. 13



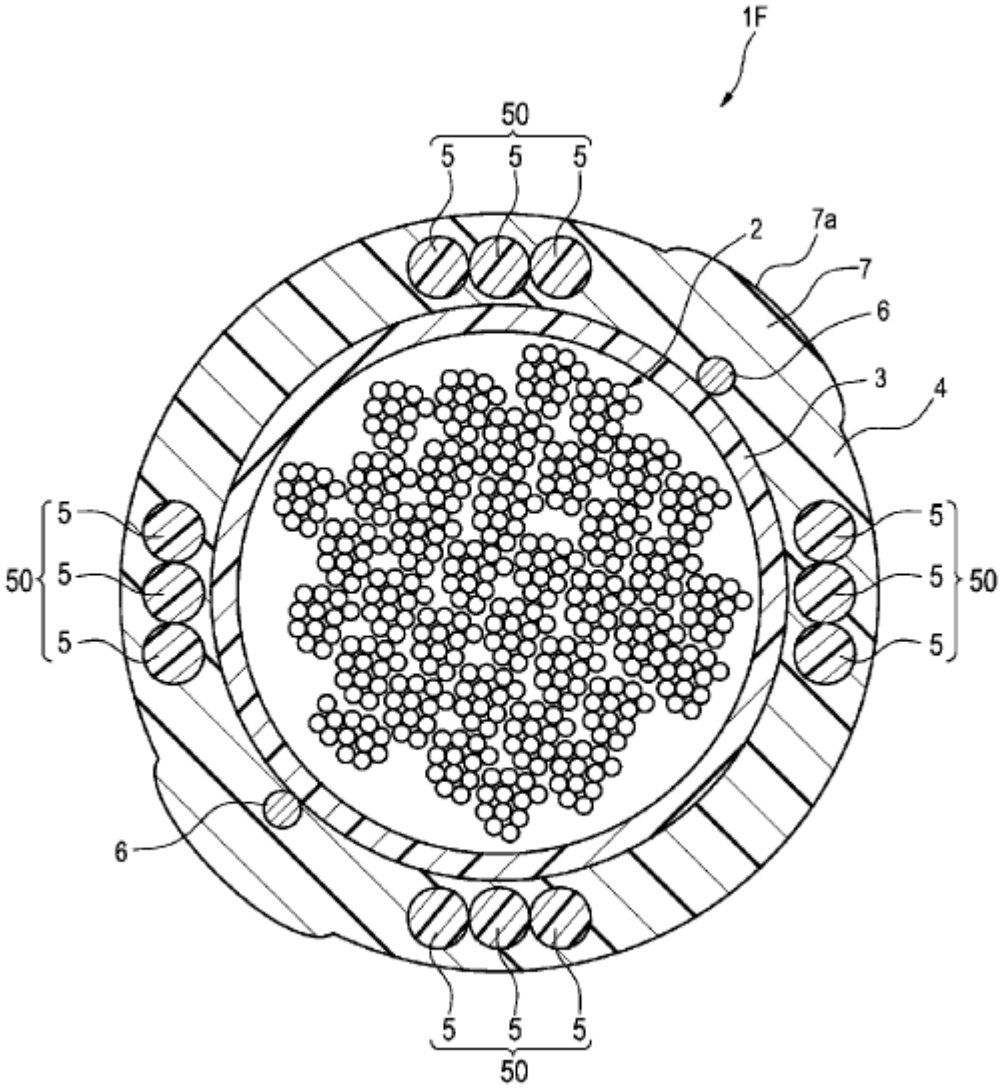
[FIG. 14]

FIG. 14

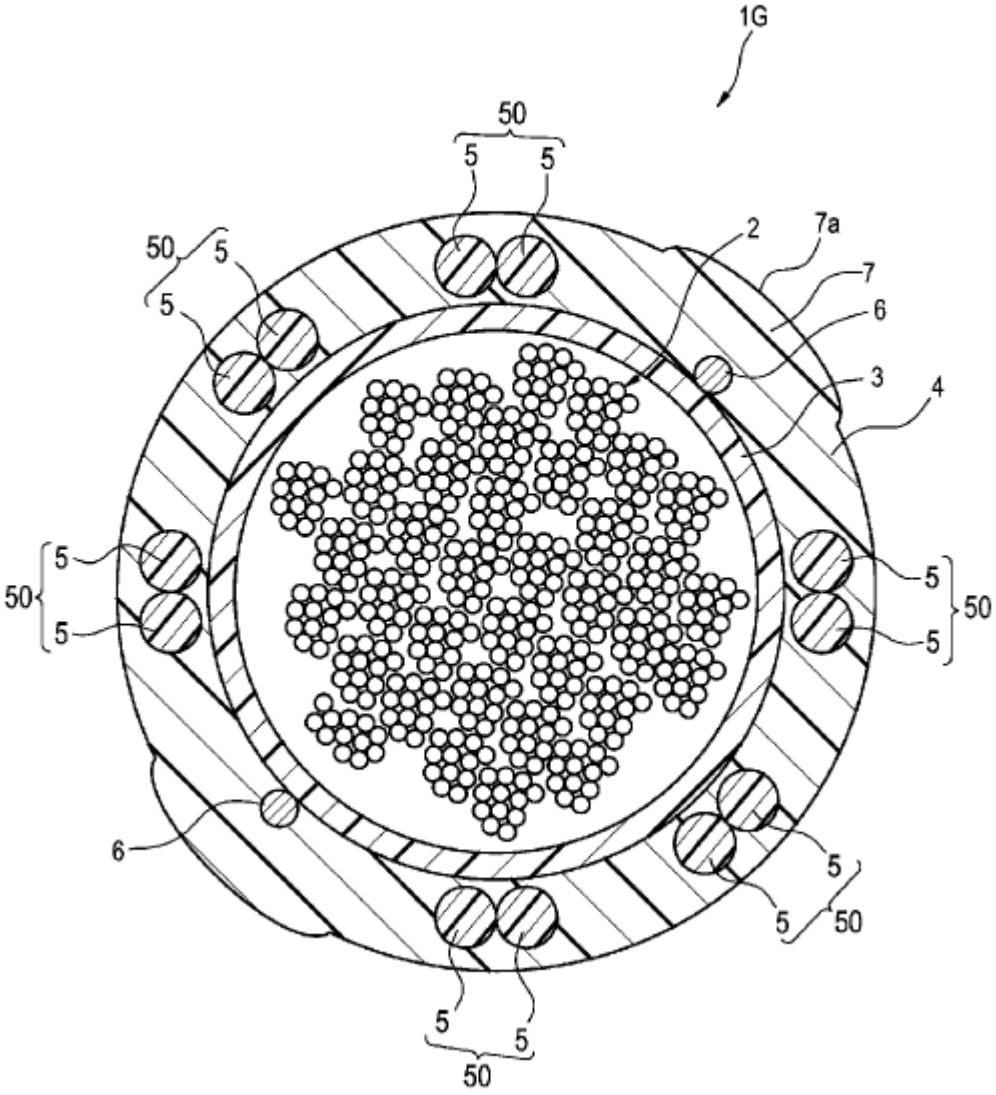


[FIG. 15]

FIG. 15



[FIG. 16]
FIG. 16



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/023810

A. CLASSIFICATION OF SUBJECT MATTER
G02B 6/44(2006.01)i; G02B 6/52(2006.01)i
FI: G02B6/44 376; G02B6/44 366; G02B6/44 331; G02B6/44 301A; G02B6/52; G02B6/44 371; G02B6/44 381
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)
G02B6/44; G02B6/52

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	1971-2020
Registered utility model specifications of Japan	1996-2020
Published registered utility model applications of Japan	1994-2020

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 2000-89068 A (SIECOR OPERATIONS, LLC) 31.03.2000 (2000-03-31) paragraphs [0007]-[0012], fig. 3	1-2, 15-16 3-14
Y	WO 2018/101041 A1 (FUJIKURA LTD.) 07.06.2018 (2018-06-07) paragraphs [0030]-[0033], [0059], [0064]-[0065], fig. 8	1-16
Y	JP 2002-98870 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 05.04.2002 (2002-04-05) paragraph [0051], fig. 11	1-16
Y	WO 2011/014452 A2 (CORNING CABLE SYSTEMS LLC) 03.02.2011 (2011-02-03) paragraphs [0014]-[0017], fig. 1	1-16

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"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
21 August 2020 (21.08.2020)	08 September 2020 (08.09.2020)
Name and mailing address of the ISA/ Japan Patent Office 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Telephone No.

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/023810

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Y	JP 2017-142285 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 17.08.2017 (2017-08-17) paragraphs [0021]-[0024], fig. 6	3
Y	JP 2002-357750 A (MITSUBISHI CABLE INDUSTRIES, LTD.) 13.12.2002 (2002-12-13) paragraphs [0006]-[0018]	3, 12
Y	JP 10-170778 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 26.06.1998 (1998-06-26) paragraph [0026]	4-5
Y	JP 2001-264601 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 26.09.2001 (2001-09-26) paragraphs [0032]-[0034]	6-7
Y	JP 2000-19366 A (FUJIKURA LTD.) 21.01.2000 (2000-01-21) paragraphs [0007]-[0015], fig. 1-4	8-10
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Y	JP 2002-231066 A (NIPPON UNICAR CO., LTD.) 16.08.2002 (2002-08-16) paragraphs [0010]-[0045]	12
Y	WO 2016/067611 A1 (MITSUBISHI CABLE INDUSTRIES, LTD.) 06.05.2016 (2016-05-06) paragraph [0053]	13
Y	JP 2-69706 A (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 08.03.1990 (1990-03-08) page 2, lower right column, line 15 to page 3, lower right column, line 20, fig. 1	14
P, Y	WO 2019/116967 A1 (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 20.06.2019 (2019-06-20) paragraphs [0016]-[0043]	14

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/023810

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
JP 2000-89068 A	31 Mar. 2000	US 6259844 B1 column 3, line 14 to column 4, line 51, fig. 3 EP 985946 A1 CA 2255175 A1	
WO 2018/101041 A1	07 Jun. 2018	US 2019/0310437 A1 paragraphs [0040]-[0043], [0071], [0076]-[0077], fig. 8 EP 3546999 A1 KR 10-2019-0030751 A CA 3045786 A1 AU 2017369091 A1 CN 109844596 A1	
JP 2002-98870 A	05 Apr. 2002	(Family: none)	
WO 2011/014452 A2	03 Feb. 2011	US 2012/0121225 A1 EP 2460044 A2 AU 2010276527 A1 CA 2769324 A1 CN 102483502 A	
WO 2006/051898 A1	18 May 2006	US 2007/0104429 A1 paragraph [0038]	
JP 2017-142285 A	17 Aug. 2017	US 2019/0064462 A1 paragraphs [0042]-[0046], fig. 6 WO 2017/138572 A1 CN 108603991 A	
JP 2002-357750 A	13 Dec. 2002	(Family: none)	
JP 10-170778 A	26 Jun. 1998	(Family: none)	
JP 2001-264601 A	26 Sep. 2001	(Family: none)	
JP 2000-19366 A	21 Jan. 2000	(Family: none)	
JP 2001-21781 A	26 Jan. 2001	(Family: none)	
JP 2011-23274 A	03 Feb. 2011	(Family: none)	
JP 2002-231066 A	16 Aug. 2002	(Family: none)	
WO 2016/067611 A1	06 May 2016	JP 6359115 B2	
JP 2-69706 A	08 Mar. 1990	(Family: none)	
WO 2019/116967 A1	20 Jun. 2019	FR 3076556 A1 NL 2022158 A TW 201932554 A CN 111433242 A KR 20200088904 A	

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/023810

A. CLASSIFICATION OF SUBJECT MATTER
G02B 6/44(2006.01)i; G02B 6/52(2006.01)i
FI: G02B6/44 376; G02B6/44 366; G02B6/44 331; G02B6/44 301A; G02B6/52; G02B6/44 371; G02B6/44 381

B. FIELDS SEARCHED

Minimum documentation searched (International Patent Classification (IPC))
G02B6/44; G02B6/52

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

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Registered utility model specifications of Japan	1996-2020
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Y	WO 2011/014452 A2 (CORNING CABLE SYSTEMS LLC) 03.02.2011 (2011-02-03) paragraphs [0014]-[0017], fig. 1	1-16

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
21 August 2020 (21.08.2020)	08 September 2020 (08.09.2020)

Name and mailing address	Authorized officer
Japan Patent Office(ISA/JP) 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Motohiko Yamamoto 2L 3914 Telephone No. 03-3581-1101 Ext. 3295

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2020/023810

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

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P, Y	WO 2019/116967 A1 (SUMITOMO ELECTRIC INDUSTRIES, LTD.) 20.06.2019 (2019-06-20) paragraphs [0016]-[0043]	14

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INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.
PCT/JP2020/023810

Patent Documents referred in the Report	Publication Date	Patent Family	Publication Date
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WO 2018/101041 A1	07 Jun. 2018	US 2019/0310437 A1 paragraphs [0040]-[0043], [0071], [0076]-[0077], fig. 8 EP 3546999 A1 KR 10-2019-0030751 A CA 3045786 A1 AU 2017369091 A1 CN 109844596 A	
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WO 2006/051898 A1	18 May 2006	US 2007/0104429 A1 paragraph [0038]	
JP 2017-142285 A	17 Aug. 2017	US 2019/0064462 A1 paragraphs [0042]-[0046], fig. 6 WO 2017/138572 A1 CN 108603991 A	
JP 2002-357750 A	13 Dec. 2002	(Family: none)	
JP 10-170778 A	26 Jun. 1998	(Family: none)	
JP 2001-264601 A	26 Sep. 2001	(Family: none)	
JP 2000-19366 A	21 Jan. 2000	(Family: none)	
JP 2001-21781 A	26 Jan. 2001	(Family: none)	
JP 2011-23274 A	03 Feb. 2011	(Family: none)	
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WO 2019/116967 A1	20 Jun. 2019	FR 3076556 A1 NL 2022158 A TW 201932554 A CN 111433242 A KR 20200088904 A	

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CERTIFICATE OF TRANSLATION

I, Eric Vance, hereby certify that the document identified below, translated from Japanese into English, is true and accurate to the best of my knowledge and belief.

Reference: WO 2020/256019 A1

I declare under penalty of perjury under the laws of the United States of America that the foregoing is true and correct. I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Eric Vance

Signature

Eric Vance

Printed Name

Sworn to before me this

31 day of October, 2024

Becky Watson

Signature, Notary Public

BECKY WATSON
Notary Public - State of Utah
Comm. No. 725401
My Commission Expires on
Jun 24, 2026

Stamp, Notary Public