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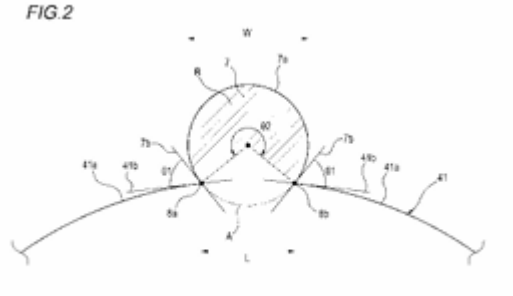
(54) [Title of Invention] FIBER OPTIC CABLE

(57) [Abstract] (Including Modifications)
[Problem] To provide a fiber optic cable for pneumatic feeding, wherein a pneumatic feeding distance can be extended by providing a protrusion on a cable outer cover, and the protrusion on the cable outer cover can be easily removed.
[Resolution Means] A fiber optic cable 1A includes a plurality of fiber optic cores and a cable outer cover that encloses the plurality of fiber optic cores and includes a protrusion 7 on an outer peripheral portion 41, wherein, in a cross section in the cable radial direction, an angle θ1 formed by tangent lines 7b and 41b between surfaces at intersections 8a and 8b between a surface 7a of the protrusion 7 and a surface 41a of the outer peripheral portion 41 that is not the protrusion 7 is 90 degrees or less.
[Selected Drawing] FIG. 2

FIG.2



[Scope of Patent Claims]
[Claim 1]
A fiber optic cable comprising:
a plurality of fiber optic cores; and
a cable outer cover that encloses the plurality of fiber optic cores and comprises a protrusion on an outer peripheral portion,
wherein, in a cross section in the cable radial direction, an angle formed by tangent lines between the surfaces at intersections between a surface of the protrusion and a surface of the outer peripheral portion that is not the protrusion is 90 degrees or less.
[Claim 2]
The fiber optic cable according to claim 1, wherein the shape of the protrusion is a shape wherein a portion of a circle protrudes from the outer peripheral portion when viewed in a cross section in the cable radial direction, and the portion in which the circle protrudes from the outer peripheral portion includes a circular sector part, and a center angle of the circular sector is 180 degrees or more.
[Claim 3]
The fiber optic cable according to claim 1 or claim 2, wherein the angle of the protrusion 30 degrees or less.
[Claim 4]
The fiber optic cable according to any one of claims 1 to 3, wherein a maximum width of the protrusion in the cable circumferential direction in a cross section in the cable radial direction is 5 mm or less.
[Detailed Description of Invention]
[Technical Field]
[0001]
The present disclosure relates to a fiber optic cable provided with a plurality of fiber optic cores.
[Background Art]
[0002]
Patent Document 1 teaches a fiber optic cable wherein protrusions are formed along the longitudinal direction of a peripheral surface of an outer sheath, and, when adding notches on the outer sheath, the protrusions are used for alignment.
Patent Document 2 teaches an optical cable having a configuration in which a protruding portion is provided on a cable outer cover and the protruding portion indicates a position of an outer cover tear string.
[Prior Art Documents]
[Patent Documents]
[0003]
[Patent Document 1] JP 2018-189962 A
[Patent Document 2] JP 2019-040090 A
[Summary of Invention]
[Problem to Be Solved by Invention]
[0004]
A fiber optic cable for pneumatic feeding is required to perform pneumatic feeding over a large distance in a duct. For example, if friction between a cable outer cover and an inner surface of the duct is reduced, the pneumatic feeding distance can be extended. Thus, it is conceivable to reduce the friction between the cable outer cover and the inner surface of the duct by providing protrusions on the surface of the cable outer cover and reducing the contact area with the inner surface of the duct.
However, if there are protrusions on the cable outer cover, there is a risk that airtightness may not be maintained when the fiber optic cable is housed in a closure. In such cases, in order to remove the protrusions, the laborious task of shaving off the protrusions using a paper file or the like is required.
[0005]
The object of the present disclosure is to provide a fiber optic cable for pneumatic feeding, wherein a pneumatic feeding distance can be extended, and airtightness can be maintained when the fiber optic cable is housed in a closure.
[Means For Solving Problem]
[0006]
A fiber optic cable according to one embodiment of the present disclosure includes: a plurality of fiber optic cores; and a cable outer cover that encloses the plurality of fiber optic cores and includes a protrusion on an outer peripheral portion, wherein, in a cross section in the cable radial direction, an angle formed by tangent lines between the surfaces at intersections between a surface of the protrusion and a surface of the outer peripheral portion that is not the protrusion is 90 degrees or less.
[Effect of Invention]
[0007]
According to the present disclosure, it is possible to provide a fiber optic cable for pneumatic feeding, wherein a pneumatic feeding distance can be extended, and airtightness can be maintained when the fiber optic cable is housed in a closure.
[Brief Description of Drawings]
[0008]
[FIG.1] A cross-sectional view illustrating a configuration of a fiber optic cable of a first embodiment.
[FIG. 2] An enlarged view schematically illustrating a cross section in the cable radial direction of a protrusion and an outer peripheral portion of the fiber optic cable illustrated in FIG. 1.
[FIG. 3] An enlarged view schematically illustrating a cross section in the cable radial direction of the protrusion and the outer

peripheral portion in a comparative example.
[FIG. 4] A cross-sectional view illustrating a configuration of a fiber optic cable according to a second embodiment.
[FIG. 5] A schematic diagram illustrating a cable pneumatic feeding evaluation device.
[Embodiments of Invention]
[0009]
(Description of Embodiments of Present Disclosure)
First, embodiments of the present disclosure will be described in a list.
A fiber optic unit according to one embodiment of the present disclosure includes:

(1) a plurality of fiber optic cores; and

a cable outer cover that encloses the plurality of fiber optic cores and includes a protrusion on an outer peripheral portion,

wherein, in a cross section in the cable radial direction, an angle formed by tangent lines between the surfaces at intersections between a surface of the protrusion and a surface of the outer peripheral portion that is not the protrusion is 90 degrees or less.

According to the fiber optic cable of this configuration, the protrusion is provided on the outer peripheral portion of the cable outer cover, and thus a contact area with an inner surface of a duct can be reduced when performing pneumatic feeding. Thus, friction with the inner surface of the duct is reduced during pneumatic feeding, and a pneumatic feeding distance can be extended.
Furthermore, 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 nippers can be easily fixed to a portion of the intersection. Thus, slipping of nippers 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.
[0010]

(2) The shape of the protrusion is a shape wherein a portion of a circle protrudes from the outer peripheral portion when viewed in a cross section in the cable radial direction, and the portion in which the circle protrudes from the outer peripheral portion includes a circular sector part, and a center angle of the circular sector may be 180 degrees or more.

According to the fiber optic cable of this configuration, the center angle of the circular sector is 180 degrees or more, and thus the angle formed by the tangent lines is 90 degrees or less, and blades such as nippers can be easily fixed to a portion of the intersection.
[0011]

(3) The angle of the protrusion may be 30 degrees or less.

According to the fiber optic cable of this configuration, the angle is 30 degrees or less, and thus blades such as nippers can be securely fixed to a portion of the intersection. Therefore, the protrusion can be removed more easily.
[0012]

(4) A maximum width of the protrusion in the cable circumferential direction in a cross section in the cable radial direction may be 5 mm or less.

In the fiber optic cable of the above configuration, a maximum width of the protrusion in the cable circumferential direction in a cross section in the cable radial direction is 5 mm or less, and therefore, it is easy to open blades of nippers or the like and insert blades of nippers or the like in a portion of the intersection.
[0013]
(Details of Embodiments of Present Disclosure)

Specific examples of the fiber optic cable according to the embodiments 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.
[0014]
(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 cross-sectional view in the cable radial direction perpendicular to the length direction of the fiber optic cable 1A. As illustrated in FIG. 1, a fiber optic cable 1A is provided with a plurality of fiber optic tape cores 2, a water absorption tape 3 that covers the circumference of the fiber optic tape cores 2, a cable outer cover 4 that covers 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. The diameter of the fiber optic cable 1A is about 5 mm to 20 mm.
[0015]

The fiber optic tape cores 2 are housed, for example, in the fiber optic cable 1A in a rounded and aggregated state. Alternatively, a 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. In order to mount the fiber optic tape cores 2 within the fiber optic cable 1A at a high density, the fiber optic tape cores 2 are preferably, for example, intermittently connected fiber optic tape cores. 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. Furthermore, the form of the fiber optic housed in the fiber optic cable 1A is not limited to a fiber optic tape core, and, for example, may be a plurality of fiber optic cores not formed in a tape shape.
[0016]

The water absorption tape 3 is wound around the circumference of 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.

[0017]

The cable outer cover 4 is formed of, for example, a resin such as polyethylene (PE). The resin of the cable outer cover 4 preferably has a Young's modulus of 500 Pa or more. The cable outer cover 4 contains, for example, a silicon-based lubricant. The silicon-based lubricant is preferably contained, for example, at 2 wt% or more. 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.

[0018]

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 using, for example, fiber reinforced plastic (FRP), and is, for example, aramid FRP, glass FRP, carbon FRP, or the like. The tensile strength body 5 is formed in a circular shape in a cross-sectional view. A plurality (four in the present example) of the tensile strength body 5 (four in the present example) is provided. The four respective tensile strength bodies 5 are provided as two pairs of two paired tensioning bodies 5 at opposing positions across the center of the fiber optic cable in a cross-sectional view. The positions of the four tensile strength bodies 5 in the cross-sectional view are such that two straight lines connecting each of the two paired tensioning bodies 5 are orthogonal. The respective tensile strength bodies 5 are provided within the cable outer cover 4 along the longitudinal direction of the fiber optic cable 1A.

[0019]

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 bodies 5. The cable outer cover 4 is torn in the longitudinal direction by pulling out the tear strings 6, which allows the fiber optic tape cores 2 to be pulled out. The tear strings 6 are formed, for example, of a plastic material (for example, polyester) that has a high tensile strength.

[0020]

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 1A. The protrusions 7 are formed so as to be of a shape that configures a part of the circle in the cross-sectional view. 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. Eight protrusions 7 are provided at substantially equal intervals on the outer peripheral portion 41 of the cable outer cover 4 in the cross-sectional view.

[0021]

Furthermore, the respective eight protrusions 7 are provided along the longitudinal direction of the fiber optic cable 1A. The respective protrusions 7 may be provided continuously along 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 1A 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.

[0022]

FIG. 2 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. 2, the protrusions 7 are formed such that a part of a circle A protrudes from the outer peripheral portion 41 in a cross-sectional view in the cable radial direction. For 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. 2) 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.

[0023]

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 1A of the protrusion 7. Furthermore, the maximum width W is preferably 5 mm or less.

[0024]

As described above, the fiber optic cable 1A according to the first 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 cable radial direction, 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 cable radial direction, 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 nippers can be easily fixed to the intersections 8a and 8b. Thus, slipping of nippers 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 nippers 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.

[0025]

Incidentally, when attaching the fiber optic cable 1A to the closure, for example, the fiber optic cable 1A 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 1A must be removed. In order to remove the protrusion 7, first, blades such as nippers are brought close to the protrusion 7 from the radial direction of the fiber optic cable 1A, 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 nippers that go over the protrusion 7 into the intersections 8a and 8b. In contrast to this, according to the fiber optic cable 1A, 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 1A. On the other hand, for example, the end portion of the fiber optic cable 1A 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 1A may be cut, and blades such as nippers 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 1A. Accordingly, it is sufficient if blades such as nippers 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.

[0026]

Next, differences between a comparative example of a protrusion and the protrusion 7 of the present embodiment will be described with reference to FIG. 3. FIG. 3 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. 3, the protrusion 107 of the comparative example is of a shape wherein a part of the circle A protrudes from the outer peripheral portion 41 in a sectional view. The protrusion 107 of the comparative example is different from the protrusion 7 of the present 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. 3).

[0027]

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 nippers to a portion of the intersections 8a and 8b on both sides of the protrusion 107, and the blades such as nippers slide when cutting the protrusion 107, which makes cutting difficult.

[0028]

(Second Embodiment)

A fiber optic cable 1B according to a second embodiment will be described with reference to 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 description thereof is omitted. Note that the diameter of the fiber optic cable 1B is also the same as that of the fiber optic cable 1A.

[0029]

FIG. 4 is a cross-sectional view perpendicular to the length direction of the fiber optic cable 1B. As illustrated in FIG. 4, the top portion 171 of the protrusion 17 is formed substantially flat, and the protrusion 17 is formed in a shape such that the maximum width (length in the cable circumferential direction) W of the protrusion 17 is longer than the height (length in the cable radial direction) H of the protrusion 17. That is, the protrusion 17 is formed in a long oblong shape in the cable circumferential direction, wherein the maximum width W is greater than the height H. Curved surface portions 172 and 172 that are curved in the center direction of the fiber optic cable 1B are formed at both ends of the top portion 171. Additionally, following the curved surface portions 172 and 172, straight line portions 173 and 173 facing the inside direction of the protrusion 17 are formed. Note that as long as the height H of the protrusion 17 is a height at which the blades such as nippers can be inserted into the intersections 18a and 18b that will be described below (length in the cable radial direction), the shape thereof may be such that the maximum width W is shorter than the height H.

[0030]

The straight line portion 173 intersects the surface 41a of the outer peripheral portion 41 that is not the protrusion 17 at intersections 18a and 18b, respectively. The angle $\theta 3$ formed by the tangent line 173a of the surface of the straight line portion 173 and the tangent line 41b of the surface 41a of the outer peripheral portion 41 that is not the protrusion 17 at the intersections 18a and 18b is formed to be 90 degrees or less. $\theta 3$ is preferably 30 degrees or less, and for example, in the example in FIG. 4, $\theta 3$ is approximately 15 degrees. The protrusion 17 has a shape such that a notch (notch) is formed between itself and the surface 41a of the outer peripheral portion 41 that is not the protrusion 17.

[0031]

In the fiber optic cable 1B, the distance L between the intersections 18a and 18b is smaller than the maximum width W

in the circumferential direction of the fiber optic cable 1B of the protrusion 17.
Note that it is preferable that the maximum width W in the circumferential direction of the fiber optic cable 1B of the protrusion 17 is also 5 mm or less. When the maximum width W is 5 mm or less, it is easy to bring blades such as nippers close to the protrusion 17 from the radial direction of the fiber optic cable 1B and go over the protrusion17 by opening the blades to the maximum width W or more of the protrusion 17.
[0032]
According to the fiber optic cable 1B according to the second embodiment, blades such as nippers can be inserted between the straight line portion 173 and the surface 41a, and the blades such as nippers can be easily fixed to the intersections18a and 18b. Thus, slipping of nippers and the like during cutting of the protrusion 17, which makes cutting difficult, can be suppressed. Therefore, the protrusion 17 can be easily removed, and airtightness can be maintained when the fiber optic cable is housed in the closure.
[0033]
Additionally, as in the example in FIG. 4, when $\theta 3$ is 30 degrees or less, the protrusion 17 is shaped such that a notch (notch) is formed between itself and the surface 41a of the outer peripheral portion 41 that is not the protrusion 17. By inserting blades such as nippers into this notch, the blades such as nippers can be more securely fixed. Therefore, the protrusion 17 can be removed more easily. Furthermore, even in the fiber optic cable 1A according to the first embodiment, if θ1 is 30 degrees or less, the same effect is exhibited.
[0034]
As above, in the fiber optic cable 1B according to the second embodiment, the protrusion 17 can be easily removed, and thus airtightness can be maintained when the fiber optic cable 1B is housed in the closure.
[0035]
Note that, in the fiber optic cable 1B of the second embodiment, the straight line portion 173 does not need to be formed strictly by a straight line. For example, the curved surface portion 172 of the protrusion 17 may be formed so as to curve gently toward the intersections 18a and 18b. Even in this case, it is sufficient as long as the angle formed by the tangent line of the curved surface portion 172 at the intersection 18a (18b) and the tangent line 41b of the surface 41a of the outer peripheral portion 41 that is not the protrusion 17 is 90 degrees or less.
[0036]
(Examples)
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 first 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 1 below.

[0037]
[Table 1]

Table 1

| Sample No. | Maximum Width of Protrusion W | Angle $\theta 1$ | Pneumatic Feeding Distance | Ease of Removing Protrusions | Airtightness |
|---|---|---|---|---|---|
| 1 | 6mm | 90 degrees or less | B | B | A (after removing protrusions) |
| 2 | 6mm | Greater than 90 degrees | B | C | B (without removing protrusions) |
| 3 | 5mm | 90 degrees or less | A | A | A (after removing protrusions) |
| 4 | 5mm | Greater than 90 degrees | A | C | C (without removing protrusions) |
| 5 | 4mm | 90 degrees or less | A | A | A (after removing protrusions) |
| 6 | 4mm | Greater than 90 degrees | A | C | C (without removing protrusions) |

[0038]
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 1A of an example 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.
[0039]
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 air pressure was 1.3 MPa to 1.5 MPa.

[0040]

The ease of the removing protrusions was evaluated by cutting the protrusions using a cutting tool such as nippers. The airtightness of the closure was evaluated when the fiber optic cable was housed in the closure.

[0041]

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

[0042]

For evaluation of the ease of removing protrusions, those for which removal was easy were given an evaluation A, those for which removal was possible but for which it was difficult to insert blades such as nippers were given an evaluation B, and those for which removal was difficult were given an evaluation C.

[0043]

For evaluation of airtightness, for samples for which an evaluation A or evaluation B was given for the for the ease of removing the protrusions, the airtightness was evaluated by housing the samples in the closure after the protrusions were removed. Furthermore, for samples for which an evaluation C was given for the ease of the removing the protrusions, 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 given an evaluation A, those for which the airtightness could be maintained by the deformation of a grommet were given an evaluation B, and those which were unfavorable were given an evaluation C.

[0044]

According to the evaluation results of Table 1, 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 understood 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.

[0045]

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 nippers 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 understood 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 understood 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 nippers into the protrusion is difficult, removal is possible. On the other hand, it was understood 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.

[0046]

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 understood 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 nippers or the like, and thus it is necessary that the maximum width W be up to several tens of mm at most.

On the other hand, it was understood 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 understood 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.

[0047]

Additionally, it was understood 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.

[0048]

Note that even for the protrusion 17 of the fiber optic cable 1B of the second embodiment, evaluation results similar to those of the examples above can be obtained.

[0049]

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 to an appropriate number, position, shape, and the like when implementing the present invention.

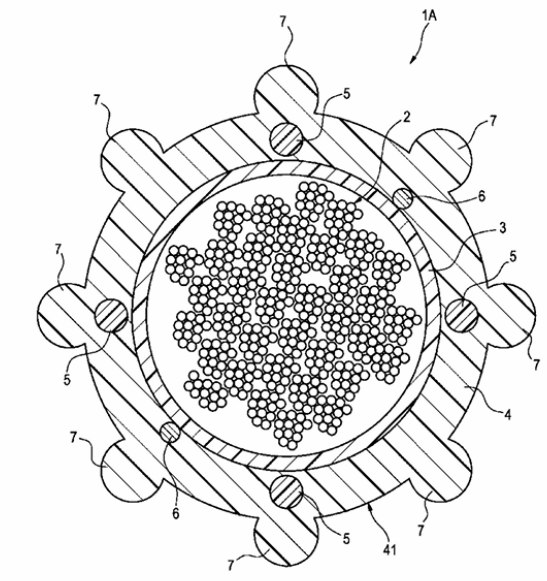
[Description of Reference Numerals]

[0050]

1A, 1B: Fiber optic cable
2: Fiber optic tape core
3: Water absorption tape
4: Cable outer cover
41: Outer peripheral portion
41a: Surface of outer peripheral portion
41b, 7b, 107b, 173a: Tangent line
5: Tensile strength body
7, 17, 107: Protrusion
7a, 107a: Surface
8a, 8b, 18a, 18b: Intersection
20: Pipe
21, 22: Opening
171: Top portion
172: Curved surface portion
173: Straight line portion
A: Circle
B: Circular sector
H: Height of protrusion (length in the cable radial direction)
W: Maximum width of protrusion
L: Distance between intersections
θ1,θ3: Angle formed by tangent lines between surfaces at intersections
θ2: Center angle of circular sector

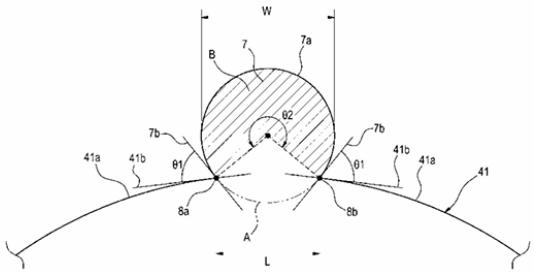
[FIG. 1]

FIG.1



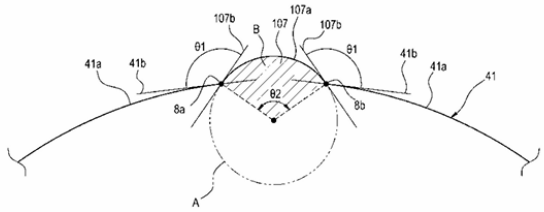

[FIG. 2]

FIG.2



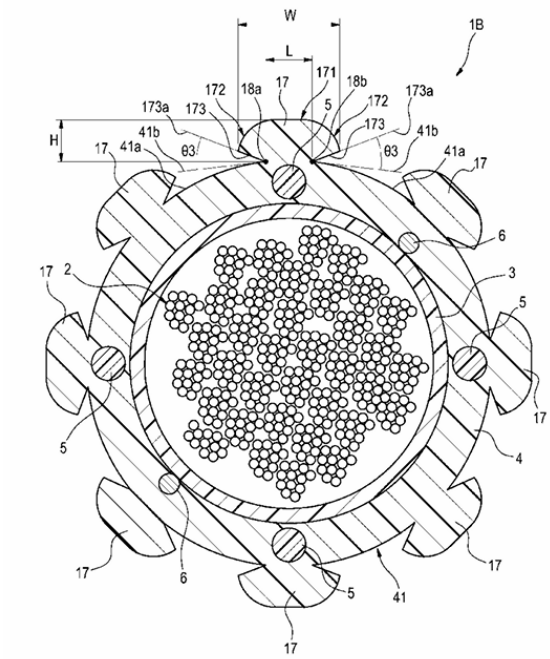

[FIG. 3]

FIG.3



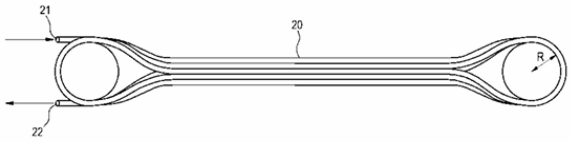
[FIG. 4]

FIG.4




[FIG. 5]

FIG.5



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2H038 CA38 CA69

**CERTIFICATE OF TRANSLATION**

I, Seongweon Park, 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: JP 2021-56281 A 2021. 4. 8**

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.

Park Seongweon

Signature

Seongweon Park

Printed Name

Sworn to before me this

30th day of October, 2024

Debbie Musgrave Bevins

Signature, Notary Public

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