



(12) **DEMANDE DE BREVET CANADIEN**
CANADIAN PATENT APPLICATION

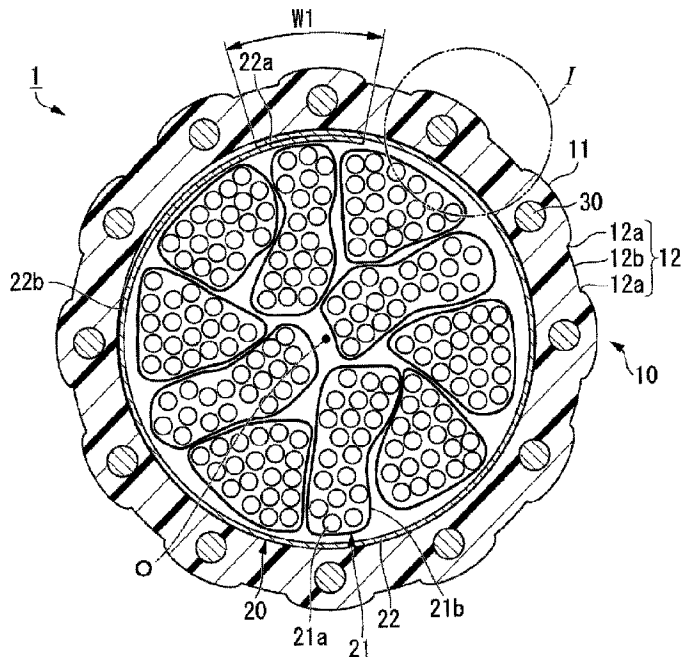
(13) **A1**

(86) Date de dépôt PCT/PCT Filing Date: 2019/10/09
(87) Date publication PCT/PCT Publication Date: 2020/04/16
(85) Entrée phase nationale/National Entry: 2021/01/04
(86) N° demande PCT/PCT Application No.: JP 2019/039740
(87) N° publication PCT/PCT Publication No.: 2020/075734
(30) Priorité/Priority: 2018/10/11 (JP2018-192706)

(51) Cl.Int./Int.Cl. *G02B 6/44* (2006.01)
(71) Demandeur/Applicant:
FUJIKURA LTD., JP
(72) Inventeurs/Inventors:
SHIMIZU, SHOGO, JP;
NAMAZUE, AKIRA, JP;
OSATO, KEN, JP
(74) Agent: BCF LLP

(54) Titre : CABLE A FIBRES OPTIQUES
(54) Title: OPTICAL FIBER CABLE

[FIG. 1A]



(57) **Abrégé/Abstract:**

This optical fiber cable comprises: a sheath; and a core that is accommodated in the sheath and that has an intermittent adhesive-type tape core wire which includes a plurality of optical fibers and a plurality of adhesive parts for intermittently adhering the plurality of optical fibers in the length direction. Recesses and protrusions are formed so as to be disposed alternately in the circumferential direction on the outer circumferential surface of the sheath. The recesses each include: two connection sections respectively connected to the radial inner edges of two adjacent protrusions; and a bottom surface positioned between the two connection sections.

(12) 特許協力条約に基づいて公開された国際出願

(19) 世界知的所有権機関
国際事務局(43) 国際公開日
2020年4月16日(16.04.2020)

(10) 国際公開番号

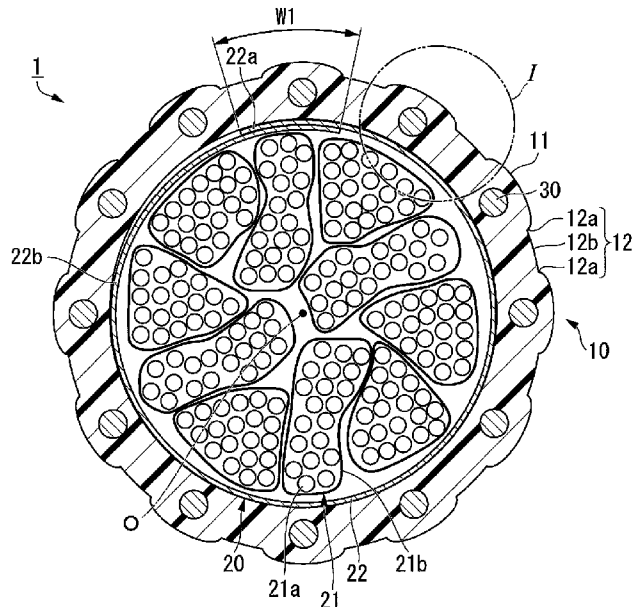
WO 2020/075734 A1

- (51) 国際特許分類:
G02B 6/44 (2006.01)
- (21) 国際出願番号: PCT/JP2019/039740
- (22) 国際出願日: 2019年10月9日(09.10.2019)
- (25) 国際出願の言語: 日本語
- (26) 国際公開の言語: 日本語
- (30) 優先権データ:
特願 2018-192706 2018年10月11日(11.10.2018) JP
- (71) 出願人: 株式会社フジクラ (FUJIKURA LTD.)
[JP/JP]; 〒1358512 東京都江東区木場 1
- 5 - 1 Tokyo (JP).
- (72) 発明者: 清水 正砂 (SHIMIZU Shogo); 〒2858550
千葉県佐倉市六崎 1 4 4 0 番地 株式会社
フジクラ 佐倉事業所内 Chiba (JP). 鯨江 彰
(NAMAZUE Akira); 〒2858550 千葉県佐倉市
六崎 1 4 4 0 番地 株式会社フジクラ 佐倉
事業所内 Chiba (JP). 大里 健 (OSATO Ken);
〒2858550 千葉県佐倉市六崎 1 4 4 0 番地 株式
会社フジクラ 佐倉事業所内 Chiba (JP).
- (74) 代理人: 棚井 澄雄, 外 (TANAI Sumio et al.);
〒1006620 東京都千代田区丸の内一丁
目9番2号 Tokyo (JP).
- (81) 指定国(表示のない限り、全ての種類の国内保
護が可能): AE, AG, AL, AM, AO, AT, AU, AZ,
BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH,

(54) Title: OPTICAL FIBER CABLE

(54) 発明の名称: 光ファイバケーブル

[図1A]



(57) **Abstract:** This optical fiber cable comprises: a sheath; and a core that is accommodated in the sheath and that has an intermittent adhesive-type tape core wire which includes a plurality of optical fibers and a plurality of adhesive parts for intermittently adhering the plurality of optical fibers in the length direction. Recesses and protrusions are formed so as to be disposed alternately in the circumferential direction on the outer circumferential surface of the sheath. The recesses each include: two connection sections respectively connected to the radial inner edges of two adjacent protrusions; and a



WO 2020/075734 A1

WO 2020/075734 A1 

CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO,
DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT,
HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH,
KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY,
MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ,
NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT,
QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL,
SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA,
UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) 指定国(表示のない限り、全ての種類の広域保護が可能): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), ユーラシア (AM, AZ, BY, KG, KZ, RU, TJ, TM), ヨーロッパ (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

添付公開書類:

- 一 国際調査報告 (条約第21条(3))

bottom surface positioned between the two connection sections.

(57) 要約: 光ファイバケーブルは、シースと、複数の光ファイバおよび前記複数の光ファイバを長手方向において間欠的に接着する複数の接着部を含む間欠接着型テープ心線を有し、前記シース内に収容されたコアと、を備える。前記シースの外周面には周方向に交互に配置された凹部および凸部が形成され、前記凹部は、隣接する2つの前記凸部の径方向内端にそれぞれ接続された2つの接続部と、2つの前記接続部の間に位置する底面と、を有している。

[DESCRIPTION]

[TITLE OF INVENTION]

OPTICAL FIBER CABLE

[Technical Field]

5 [0001]

The present invention relates to an optical fiber cable.

Priority is claimed on Japanese Patent Application No. 2018-192706, filed October 11, 2018, the content of which is incorporated herein by reference.

[Background Art]

10 [0002]

In the related art, an optical fiber cable as illustrated in Patent Document 1 has been known. This optical fiber cable includes a sheath and a plurality of optical fibers housed in the sheath. The outer circumferential surface of the sheath is formed with recesses and protrusions alternately disposed in the circumferential direction. The plurality of optical fibers in Patent Document 1 are housed in a tube in a twisted state. Alternatively, the plurality of optical fibers are collectively coated with a UV curable resin to form a tape core wire.

[Citation List]

[Patent Literature]

20 [0003]

[Patent Document 1]

US Patent No. 6963686

[Summary of Invention]

[Technical Problem]

25 [0004]

In the optical fiber cable of Patent Document 1, the recess is a V-shaped groove. Therefore, for example, when a force in the circumferential direction is applied to the protrusion, the stress tends to concentrate on the inner end portion of the groove, and the sheath tends to crack.

5 Further, it has been found that the configuration in which a plurality of optical fibers are simply twisted and housed in the tube lacks the rigidity of the optical fiber cable and is disadvantageous in terms of air-blowing characteristics. On the other hand, in a configuration in which a plurality of optical fibers are collectively coated with a resin, the rigidity of the optical fiber cable can be obtained. However, when the optical
10 fiber is collectively coated with resin, the core becomes large, which is disadvantageous in terms of reducing the diameter of the cable, and the strain applied to the optical fiber also becomes large, which is disadvantageous in terms of transmission loss.

[0005]

The present invention has been made in consideration of such circumstances,
15 and an object of the present invention is to provide an optical fiber cable which is advantageous in terms of air-blowing characteristics, diameter reduction, and transmission loss while increasing the strength of the sheath.

[Solution to Problem]

[0006]

20 In order to solve the above problems, an optical fiber cable according to a first aspect of the present invention includes a sheath and a core which is housed in the sheath and which has an intermittently-adhered optical fiber ribbon including a plurality of optical fibers and a plurality of adhesive portions for intermittently adhering the plurality of optical fibers in a longitudinal direction, in which recesses and protrusions are formed
25 so as to be disposed alternately in a circumferential direction on an outer circumferential

surface of the sheath, and the recesses each include two connecting portions respectively connected to radial inner ends of two adjacent protrusions, and a bottom surface positioned between the two connecting portions.

[Advantageous Effects of Invention]

5 [0007]

According to the above aspect of the present invention, it is possible to provide an optical fiber cable which is advantageous in terms of air-blowing characteristics, diameter reduction, and transmission loss while increasing the strength of the sheath.

[Brief Description of Drawings]

10 [0008]

Fig. 1A is a transverse cross-sectional view of an optical fiber cable according to a present embodiment.

Fig. 1B is an enlarged view of a part I of Fig. 1A.

Fig. 2 is a schematic view of an intermittently-adhered optical fiber ribbon.

15 Fig. 3 is a schematic view illustrating a method of air-blowing.

Fig. 4 is a schematic view of a truck used for an air-blowing test.

Fig. 5 is a transverse cross-sectional view of a deformed optical fiber cable.

Fig. 6 is an explanatory view of a cross-sectional area of a recess.

20 Fig. 7A is a diagram illustrating a case where a protrusion and a tensile strength member extend linearly.

Fig. 7B is a diagram illustrating a case where the protrusion and the tensile strength member are twisted in a spiral shape.

Fig. 8 is a graph illustrating the effect of the spiral twist of the protrusion and the tensile strength member on the flexural rigidity of the optical fiber cable.

25 Fig. 9 is a diagram illustrating a measurement angle X, which is the horizontal

axis of Fig. 8.

Fig. 10 is a transverse cross-sectional view of an optical fiber cable in which a plurality of tensile strength members are disposed inside one protrusion.

Fig. 11 is a graph illustrating the effect of the SZ-shaped twist of the protrusion and the tensile strength member on the flexural rigidity of the optical fiber cable.

Fig. 12A is a transverse cross-sectional view of an optical fiber cable in which a low friction material is disposed on the top of a protrusion.

Fig. 12B is a transverse cross-sectional view of an optical fiber cable in which a layer of a low friction material is disposed on the entire surface of the sheath.

Fig. 12C is a transverse cross-sectional view of an optical fiber cable having a protrusion formed of a low friction material.

Fig. 13A is a transverse cross-sectional view of an optical fiber cable in which a ripcord is disposed inside a part of the protrusion and a tensile strength member is disposed inside the other protrusion.

Fig. 13B is a transverse cross-sectional view of an optical fiber cable in which a protrusion in which a ripcord is embedded is projected larger than the other protrusions.

Fig. 13C is a transverse cross-sectional view of an optical fiber cable in which the width of a protrusion in which a ripcord is embedded is smaller than that of other protrusions.

Fig. 13D is a transverse cross-sectional view of an optical fiber cable in which tensile strength members are disposed at equal intervals and ripcords are disposed between the tensile strength members in the circumferential direction.

Fig. 14A is a transverse cross-sectional view of an optical fiber cable according to a modification example of the present embodiment.

Fig. 14B is a transverse cross-sectional view of an optical fiber cable according

to another modification example of the present embodiment.

[Description of Embodiments]

[0009]

Hereinafter, an optical fiber cable of the present embodiment will be described
5 with reference to the drawings.

As illustrated in Fig. 1A, the optical fiber cable 1 includes a sheath 10, a core 20
housed in the sheath 10, and a plurality of tensile strength members 30 embedded in the
sheath 10.

The core 20 has a plurality of optical fiber units 21, and a wrapping tube 22 that
10 wraps these optical fiber units 21. Each of the optical fiber units 21 has a plurality of
optical fibers 21a and a binding material 21b that binds the optical fibers 21a.

[0010]

(Direction Definition)

In the present embodiment, the central axis of the optical fiber cable 1 is referred
15 to as the central axis O. Further, the longitudinal direction of the optical fiber cable 1
(longitudinal direction of the optical fiber 21a) is simply referred to as the longitudinal
direction. The cross-section orthogonal to the longitudinal direction is referred to as a
transverse cross-section. In the transverse cross-sectional view (Fig. 1A), a direction
intersecting the central axis O is referred to as a radial direction, and a direction
20 revolving around the central axis O is referred to as a circumferential direction.

When the optical fiber cable 1 is non-circular in the transverse cross-sectional
view, the central axis O is positioned at the center of the optical fiber cable 1.

[0011]

As illustrated in Fig. 2, the optical fiber unit 21 of the present embodiment is a
25 so-called intermittently-adhered optical fiber ribbon. That is, the optical fiber unit 21

has a plurality of optical fibers 21a, and a plurality of adhesive portions 21c for adhering adjacent optical fibers 21a to each other. In the intermittently-adhered optical fiber ribbon, when a plurality of optical fibers 21a are pulled in a direction orthogonal to the longitudinal direction, the optical fibers 21a spread in a mesh shape (spider web shape).

5 Specifically, one optical fiber 21a is adhered to the adjacent optical fibers 21a at different positions in the longitudinal direction by the adhesive portions 21c. Further, the adjacent optical fibers 21a are adhered to each other by the adhesive portion 21c at a certain interval in the longitudinal direction.

[0012]

10 As the adhesive portion 21c, a thermosetting resin, a UV curable resin, or the like can be used.

The plurality of optical fiber units 21 are twisted together about the central axis O. The aspect of twisting may be spiral or SZ.

[0013]

15 The wrapping tube 22 wraps a plurality of optical fiber units 21 and is formed into a cylindrical shape. Both end portions (first end portion and second end portion) of the wrapping tube 22 in the circumferential direction are overlapped with each other to form a wrap portion 22a. The portion of the wrapping tube 22 excluding the wrap portion 22a is referred to as a non-wrap portion 22b. The non-wrap portion 22b is
20 positioned between the first end portion and the second end portion forming the wrap portion 22a.

[0014]

As the material of the wrapping tube 22, a non-woven fabric, a plastic tape member, or the like can be used. When the wrapping tube 22 is made of plastic,
25 polyethylene terephthalate, polyester or the like can be used as the material. Further, as

the wrapping tube 22, a water-absorbing tape obtained by imparting water absorbency to the above-described non-woven fabric or tape member may be used. In this case, the waterproof performance of the optical fiber cable 1 can be improved. When a plastic tape member is used as the wrapping tube 22, water absorbency may be imparted by
 5 applying a water absorbing powder to the surface of the tape member.

[0015]

The plurality of tensile strength members 30 are embedded in the sheath 10 at equal intervals in the circumferential direction. The intervals at which the plurality of tensile strength members 30 are embedded may not be equal. The number of tensile
 10 strength members 30 can be changed as appropriate. As the material of the tensile strength member 30, for example, metal wire (steel wire or the like), tensile strength fiber (aramid fiber or the like), Fiber Reinforced Plastics (FRP) or the like can be used. As specific examples of FRP, KFRP using Kevlar fiber and PBO-FRP using poly-
 paraphenylene benzobisoxazole (PBO) can be used.

15 In addition to the tensile strength member 30, for example, a ripcord or the like may be embedded in the sheath 10.

[0016]

The sheath 10 is formed into a cylindrical shape centered on the central axis O. As the material of the sheath 10, polyolefin (PO) resin such as polyethylene (PE),
 20 polypropylene (PP), ethylene ethyl acrylate copolymer (EEA), ethylene vinyl acetate copolymer (EVA), and ethylene propylene copolymer (EP), polyvinyl chloride (PVC), or the like can be used.

[0017]

A plurality of recesses 12 and protrusions 11 are formed on the outer
 25 circumferential surface of the sheath 10. The recesses (concavities) 12 and the

protrusions (convexities) 11 are disposed alternately in the circumferential direction. In this way, an uneven shape is formed on the outer circumferential surface of the sheath 10. The recesses 12 and the protrusions 11 extend along the longitudinal direction.

[0018]

5 The protrusion 11 is disposed at the same position as the tensile strength member 30 in the circumferential direction. In other words, the protrusion 11 is positioned on a straight line extending from the central axis O toward the center of the tensile strength member 30 in the transverse cross-sectional view. The recess 12 is disposed at a position different from that of the tensile strength member 30 in the
10 circumferential direction. In other words, the recess 12 is not positioned on a straight line extending from the central axis O toward the center of the tensile strength member 30 in the transverse cross-sectional view.

[0019]

15 The recess 12 has two connecting portions 12a and a bottom surface 12b. The connecting portion 12a is connected to the radial inner end of the protrusion 11 adjacent in the circumferential direction. The bottom surface 12b is positioned between the two connecting portions 12a in each recess 12. As illustrated in Fig. 1B, the connecting portions 12a are formed in a curved surface shape that is radially inward convex.

[0020]

20 The bottom surface 12b has a curved surface centered on the central axis O, and has an arc shape centered on the central axis O in a transverse cross-sectional view. However, the shape of the bottom surface 12b is not limited to a curved surface centered on the central axis O. For example, the bottom surface 12b may have a shape in which two connecting portions 12a are connected in a straight line.

25 [0021]

As described above, since each of the recesses 12 has the two connecting portions 12a and the bottom surface 12b positioned between the connecting portions 12a, even if a force in the circumferential direction acts on the protrusion 11, a stress is hardly concentrated in the recess 12. Therefore, cracks and the like are suppressed in the recess 12, and the strength of the sheath 10 is increased.

Further, the core 20 of the present embodiment has an intermittently-adhered optical fiber ribbon (optical fiber unit 21) including a plurality of optical fibers 21a and a plurality of adhesive portions 21c for intermittently adhering the plurality of optical fibers 21a in the longitudinal direction. Thus, the rigidity of the optical fiber cable 1 is ensured as compared with the case where a plurality of optical fibers, which are not adhered, are simply twisted, and the structure is advantageous in buckling resistance and air-blowing characteristics. Further, as compared with the case where a plurality of optical fibers are collectively coated with a resin, the diameter of the optical fiber cable 1 can be reduced, and an increase in transmission loss can be suppressed.

[0022]

Further, the connecting portion 12a is formed into a curved surface shape that is radially inward convex. Thus, the concentration of stress on the connecting portion 12a is more reliably suppressed, and the strength of the sheath 10 can be further increased.

[0023]

Further, since the wrapping tube 22 has the wrap portion 22a, it is possible to prevent the sheath 10 from coming into contact with the constituent members inside the wrapping tube 22. Thus, when the sheath 10 is extruded and molded, it is possible to prevent the optical fiber 21a from being taken into the softened sheath 10 and the extra-length ratio of the optical fiber 21a to the optical fiber cable from becoming unstable. Further, it is possible to suppress an increase in transmission loss due to the optical fiber

21a being sandwiched between the wrapping tube 22 and the sheath 10.

[0024]

The radius of curvature of the outer circumferential surface of the protrusion 11 may be smaller than the radius of the sheath 10 (the radius of the optical fiber cable 1).

- 5 According to this configuration, the contact area between the protrusion 11 and the micro-duct (details will be described later) becomes smaller. Therefore, the workability when the optical fiber cable 1 is inserted into the micro-duct can be improved. In the present embodiment, the "radius of the sheath 10" is the maximum value of the distance between the outer circumferential surface of the protrusion 11 and the central axis O.
- 10 When the maximum value is different for each protrusion 11, the average value of each maximum value is defined as the "radius of the sheath 10".

[0025]

Next, a specific example of the optical fiber cable 1 of the present embodiment will be described. The present invention is not limited to the examples below.

15 [0026]

(Maximum Compressive Stress)

In the present embodiment, as illustrated in Fig. 3, the workability when the optical fiber cable is inserted into the micro-duct D by air-blow has been examined.

The micro-duct D is a pipe installed in advance in the ground or the like. In the air-

- 20 blowing, a seal S is attached to the end of the micro-duct D, and an optical fiber cable is introduced into the micro-duct D through the opening of the seal S. Further, a pump P is connected to the seal S to allow air to flow from the seal S into the micro-duct D.

Thus, an air layer can be formed between the optical fiber cable and the micro-duct D to reduce friction.

25 [0027]

Here, when installing the optical fiber cable, the optical fiber cable may be inserted into the micro-duct D over a long distance of, for example, 2000 m or more. When the optical fiber cable is inserted into the micro-duct D over such a long distance, the force needs to be efficiently transmitted from the upstream side (-X side) to the downstream side (+X side) in the longitudinal direction of the optical fiber cable.

[0028]

As a result of careful examination by the inventors of the present application, it has been found that the compressive strength (maximum compressive stress) of the optical fiber cable is preferably within a predetermined range, in order to appropriately transmit the force from the upstream side to the downstream side of the optical fiber cable.

Hereinafter, the results of checking the workability of air-blowing by preparing a plurality of optical fiber cables (Test Examples 1-1 to 1-7) having different compressive strengths will be described with reference to Table 1. Test Example 1-8 is a loose tube type optical fiber cable. Details of Test Example 1-8 will be described later.

[0029]

[Table 1]

Test Example	1-1	1-2	1-3	1-4	1-5	1-6	1-7	1-8
Diameter d (mm)	9.2	10.5	10.0	6.1	6.3	8.0	9.4	6.5
Cross-sectional area a (mm ²)	66.5	86.6	78.5	29.2	31.2	50.3	69.4	33.2
Cross-sectional secondary moment I	351.7	596.7	490.9	68.0	77.3	201.1	383.2	87.6
Cross-sectional secondary radius i	2.3	2.6	2.5	1.5	1.6	2.0	2.4	1.6
Sample length L' (mm)	11.5	13.1	12.5	7.6	7.9	10.0	11.8	8.1
Edge surface support condition and buckling length	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Slenderness ratio λ	5	5	5	5	5	5	5	5
d/L'	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8
Compressive strength (N/mm ²)	11.6	9.3	12.8	19.2	19.4	16.4	14.4	32.4
Air-blowing test	NG	NG	OK	OK	OK	OK	OK	OK

[0030]

- 5 The results of the air-blowing test of optical fiber cables are illustrated in the field of "Air-blowing test" shown in Table 1. More specifically, when each optical fiber cable is air-blown into the micro-duct D and can be blown 2000 m, the result is good (OK), and when 2000 m cannot be blown, the result is not good (NG).

[0031]

- 10 The micro-duct D used in the air-blowing test is formed into a figure eight shape as illustrated in Fig. 4. The inner width of the curved portion is 18.33 m, and the length of one circumference of the figure eight shape illustrated in Fig. 4 is 125 m. Although not illustrated, a truck having a total length of 2000 m is constructed by making the figure eight shape continuous 16 times. The pump P (see Fig. 3) is disposed in a
- 15 substantially straight line portion having a figure eight shape, and air-blows the optical fiber cable into the micro-duct D in the direction indicated by the arrow F in Fig. 4.

[0032]

"Compressive strength" in Table 1 refers to a value obtained by dividing the maximum compressive load (N), which measured by compressing a sample with the length of "Sample length L'(mm)" in Table 1 with a compression tester for each test
 5 example, by "Cross-sectional area a (mm²)". The compressive strength is calculated according to JIS K7181: 2011.

More specifically, a general-purpose universal material testing machine is used as the compression tester. Both ends of each sample are fitted into a metal cylinder, which is attached to a compression tester. That is, both ends of the sample are fixedly
 10 supported as a boundary condition during the compression test. Each sample is compressed in the longitudinal direction at a rate of 1 mm/min. Then, the compressive load immediately before each sample buckles is measured as the "Maximum compressive load".

The sample length L' of each sample is set such that the value of d/L' is constant
 15 (0.8).

[0033]

As shown in Table 1, in Test Examples (1-1, 1-2) having a compressive strength of 11.6 N/mm² or less, the air-blowing test results are not good. This is because the compressive strength of the optical fiber cable is not good, and buckling of the optical
 20 fiber cable occurs while traveling in the micro-duct D. When the optical fiber cable buckles in the micro-duct D, the force transmitted from the upstream side to the downstream side of the optical fiber cable is converted into a force that presses the optical fiber cable against the inner surface of the micro-duct D at the buckled portion. As a result, it becomes difficult for the force to be transmitted to the downstream end of
 25 the optical fiber cable, and the progress of the optical fiber cable is stopped. As a result,

it is considered that 2000 m of air-blowing is not possible.

[0034]

On the other hand, good air-blowing test results can be obtained in Test Examples (1-3 to 1-7) having a compressive strength of 12.8 N/mm^2 or more. This is because the compressive strength, that is, the difficulty of deformation with respect to the force in the direction (longitudinal direction) along the central axis O of the optical fiber cable is within a predetermined amount or more, so that buckling of the optical fiber cable in the micro-duct D is suppressed. It is considered that by suppressing the buckling of the optical fiber cable in this way, the force is reliably transmitted to the downstream end of the optical fiber cable, and 2000 m of air-blowing is possible.

[0035]

From the above results, the compressive strength of the optical fiber cable is preferably 12.8 N/mm^2 or more. With this configuration, buckling of the optical fiber cable in the micro-duct D is suppressed, and the installation workability of the optical fiber cable can be improved.

Further, as shown in Test Example 1-8 of Table 1, the air-blowing test result is also good for the optical fiber cable having a compressive strength of 32.4 N/mm^2 . Therefore, it is considered that good air-blowing test results can be obtained by setting the compressive strength to 32.4 N/mm^2 or less.

From the above, the compressive strength of the optical fiber cable is preferably 12.8 N/mm^2 or more and 32.4 N/mm^2 or less.

[0036]

(Wrap Rate)

As illustrated in Fig. 1A, a wrap portion 22a is formed on the wrapping tube of the present embodiment. As a result of examination by the inventors of the present

application, it is found that when the ratio of the circumference length of the wrap portion 22a to the total circumference length of the wrapping tube 22 is large, the optical fiber cable is likely to be deformed into a substantially elliptical shape as illustrated in Fig. 5. More specifically, it tends to have an elliptical shape such that the direction in which the wrap portion 22a extends has a major axis of the elliptical shape. When such deformation occurs, the sealability at the opening (see Fig. 3) of the sealing portion S may decrease. Further, the protrusion 11 positioned on the major axis in the elliptical shape may be strongly pressed against the inner circumferential surface of the micro-duct D to increase the friction.

That is, it has been found that the ratio of the wrap portion 22a to the total circumference length of the wrapping tube 22 affects the workability when air-blowing the optical fiber cable.

[0037]

Therefore, the result of examining the preferable ratio of the wrap portion 22a will be described below.

As illustrated in Fig. 1A, the circumference length of the wrap portion 22a in the transverse cross-sectional view is W1. Further, the circumference length of the non-wrap portion 22b is W2 (not illustrated). At this time, the wrap rate R is defined by the following Equation (1).

$$R = W1 \div (W1 + W2) \times 100 \dots (1)$$

The wrap rate R indicates the ratio of the circumference length of the wrap portion 22a to the total circumference length of the wrapping tube 22.

[0038]

In the present example, as shown in Table 2, a plurality of optical fiber cables (Test Examples 2-1 to 2-6) having different wrap rates R are prepared.

The measurement result of the transmission loss of each optical fiber cable is shown in the field of "Transmission loss" in Table 2. More specifically, at a wavelength of 1550 nm, the result is good (OK) when the transmission loss is 0.30 dB/km or less, and the result is not good (NG) when the transmission loss is greater than 0.30 dB/km.

5 The significance of the field of "Air-blowing test" in Table 2 is the same as in Table 1.

[0039]

[Table 2]

Test Example	2-1	2-2	2-3	2-4	2-5	2-6
wrap rate R	27%	20%	13%	9%	5%	3%
Transmission loss	OK	OK	OK	OK	OK	NG
Air-blowing test	NG	OK	OK	OK	OK	OK

10 [0040]

As shown in Table 2, in Test Examples (2-1 to 2-5) having a wrap rate R of 5% or more, the transmission loss results are good. On the other hand, in Test Example (2-6) having a wrap rate R of 3%, the result of transmission loss is not good. It is considered that this is because when the wrap rate R is significantly small, the optical fiber protrudes from the wrap portion 22a to the outside of the wrapping tube 22, local bending is applied to the optical fiber, and the transmission loss increases.

15

[0041]

Further, in Test Examples (2-2 to 2-6) having a wrap rate R of 20% or less, the results of the air-blowing test are good. On the other hand, in Test Example (2-1)

20 having a wrap rate R of 27%, the result of the air-blowing test is not good. The reason for this is that the wrap rate R is significantly large, and as described above, the optical fiber cable is deformed into an elliptical shape, so that the workability during air-blowing

has decreased.

[0042]

From the above results, the wrap rate R is preferably 5% or more and 20% or less. With this configuration, it is possible to improve the workability of air-blowing
5 while suppressing an increase in transmission loss due to local bending of the optical fiber.

[0043]

(Cross-sectional Area of Recesses)

When the optical fiber cable is inserted into the micro-duct D by air-blowing, at
10 least a part of the air flows through the recess 12 as a flow path. Then, a part of the air flowing through the recess 12 flows between the protrusion 11 and the micro-duct D, and an air layer is formed therebetween to reduce the friction. Here, as a result of examination by the inventors of the present application, it has been found that in order for the above air layer to be properly formed, it is preferable that the cross-sectional area
15 of the recesses 12 functioning as an air flow path is within a predetermined range. The results of the examination will be described below.

[0044]

In the present example, a plurality of optical fiber cables (Test Examples 3-1 to 3-6) having different cross-sectional areas A of the recesses illustrated in Fig. 6 are
20 prepared. The cross-sectional area A of the recesses is the cross-sectional area of the space defined by the closed curve L and all the recesses 12 when the closed curve L in contact with the radial outer end of each protrusion 11 is drawn, in the transverse cross-sectional view. In other words, the cross-sectional area A of the recesses is the difference in the cross-sectional area of the optical fiber cable of the present example
25 with respect to the cross-sectional area of the virtual optical fiber cable having the closed

curve L as the outer circumferential surface.

The closed curve L is usually circular with the central axis O as the center.

However, due to the deformation of the optical fiber cable, the closed curve L may have an elliptical shape.

5 [0045]

[Table 3]

Test Example	3-1	3-2	3-3	3-4	3-5	3-6
Cross-sectional area A of recesses (mm ²)	5.2	4.8	3.4	2.8	1.3	0.0
Air-blowing test	NG	OK	OK	OK	OK	NG

[0046]

As shown in Table 3, the results of the air-blowing test are not good, in Test
 10 Example (3-1) having a cross-sectional area A of the recesses of 5.2 mm². The reason
 for this is that when the cross-sectional area A of the recesses is significantly large, the
 scalability between the seal S and the optical fiber cable is deteriorated, and the backflow
 of air from the inside of the micro-duct D is likely to occur. When the amount of air
 flowing back from the inside of the micro-duct D is large, the amount of air intervening
 15 between the inner surface of the micro-duct D and the optical fiber cable is reduced, and
 friction increases. It is considered that this friction made it difficult for the force to be
 transmitted from the upstream side to the downstream side of the optical fiber cable, and
 the progress of the optical fiber cable stopped.

[0047]

20 In contrast, in Test Examples (3-2 to 3-5) in which the cross-sectional area A of
 the recesses is 1.3 mm² or more and 4.8 mm² or less, the results of the air-blowing test is
 good. This is because the cross-sectional area A of the recesses is sufficiently small, the

sealability between the seal S and the optical fiber cable is good, and the backflow of air from the inside of the micro-duct D is suppressed. That is, it is considered that the friction is reduced by the sufficient air intervening between the inner surface of the micro-duct D and the optical fiber cable, and the force can be transmitted from the upstream side to the downstream side of the optical fiber cable.

[0048]

Further, in Test Example 3-6, since the sheath 10 is not formed with an uneven shape, the friction between the inner surface of the micro-duct D and the optical fiber cable is large, and the progress of the optical fiber cable is stopped.

10 [0049]

From the above results, it is preferable that the cross-sectional area A of the recesses is in the range of 1.3 mm² or more and 4.8 mm² or less. With this configuration, the sealability between the seal S and the optical fiber cable can be ensured, and the workability of air-blowing can be improved.

15 [0050]

(Twisted Shape of Sheath)

The recess 12 serves as an air flow path when the optical fiber cable is air-blown. Here, for example, when the recesses 12 extend linearly along the longitudinal direction (see Fig. 7A) and when the recesses 12 are spirally twisted along the longitudinal direction (see Fig. 7B), the air flow state changes. It is considered that the difference in the air flow state affects the workability when the optical fiber cable is air-blown.

[0051]

Therefore, the results of examining the relationship between the twisted shape of the sheath 10 and the workability of air-blowing will be described with reference to

Table 4. Here, a plurality of optical fiber cables (Test Examples 4-1 to 4-5) having different twist angles θ are prepared. The twist angle θ is the amount of twist around the central axis O of the sheath 10 (protrusion 11) per 1 m in the longitudinal direction. For example, when $\theta = 90$ ($^{\circ}/\text{m}$), it means that the positions of the protrusions 11 differ by 90° around the central axis O when comparing the portions separated by 1 m along the longitudinal direction in the cable. In Test Examples 4-2 to 4-5, the tensile strength members 30 are twisted around the central axis O at a twist angle θ similar to that of the protrusions 11. Therefore, the optical fiber cables of Test Examples 4-2 to 4-5 have substantially the same transverse cross-sectional shape at any position in the longitudinal direction.

[0052]

[Table 4]

Test Example	4-1	4-2	4-3	4-4	4-5
Twist angle θ ($^{\circ}/\text{m}$)	0	5	10	120	180
Air-blowing test	NG	NG	OK	OK	OK

[0053]

As shown in Table 4, in Test Examples (4-3 to 4-5) in which the twist angle is $10 \leq \theta$ ($^{\circ}/\text{m}$) ≤ 180 , results of the air-blowing test are good. It is considered that this is because the pressure of the air flowing in the recesses 12 can be effectively converted into the thrust that propels the optical fiber cable to the downstream side. That is, the air flowing in the recesses 12 exerts a pressure in the direction perpendicular to the side surface of the protrusion 11. Therefore, the larger the value of θ , the more the side surface of the protrusion 11 is inclined with respect to the longitudinal direction, and the pressure of air is converted into the force in the longitudinal direction.

[0054]

On the other hand, in Test Examples (4-1, 4-2) in which the twist angle θ is $5^\circ/\text{m}$ or less, the results of the air-blowing test are not good. It is considered that this is because the pressure of the air flowing in the recesses 12 cannot be effectively used for the thrust of the optical fiber cable.

5 [0055]

From the above, the twist angle of the sheath 10 is preferably $10 \leq \theta$ ($^\circ/\text{m}$) ≤ 180 . With this configuration, the pressure of the air flowing in the recesses 12 can be effectively converted into a force for propelling the optical fiber cable to the downstream side, and the workability of air-blowing can be improved.

10 [0056]

When molding the sheath 10 such that $10 \leq \theta$ ($^\circ/\text{m}$) ≤ 180 , a twisted shape may be positively provided on the sheath 10. Alternatively, the sheath 10 may be twisted by utilizing the force that the optical fiber unit 21 twisted in a spiral shape tries to untwist.

[0057]

15 Next, the result of examining the influence of the twisted shape of the sheath 10 and the tensile strength members 30 on the flexural rigidity of the optical fiber cable will be described. In the present example, two optical fiber cables of Test Examples 5-1 and 5-2 (see Fig. 8) are prepared. The optical fiber cable of Test Example 5-1 is an optical fiber cable similar to that of Test Example 4-1. As illustrated in Fig. 7A, the sheath 10
20 and the tensile strength members 30 are not twisted. In the optical fiber cable of Test Example 5-2, the sheath 10 and the tensile strength members 30 are twisted in a spiral shape as illustrated in Fig. 7B, and the pitch in the longitudinal direction is 700 mm. In both Test Examples 5-1 and 5-2, a core 20 in which a plurality of optical fiber units 21 are twisted in an SZ shape is adopted. In both Test Examples 5-1 and 5-2, the number
25 of protrusions 11 and tensile strength members 30 is 12.

[0058]

Fig. 8 is a graph illustrating the flexural rigidity values for each measurement angle X, for the optical fiber cables of Test Examples 5-1 and 5-2. As illustrated in Fig. 9, the measurement angle X indicates an angle at which a force is applied when measuring the flexural rigidity. In the present example, since a force is applied to each of the central portions of the 12 protrusions 11 and the 12 recesses 12, the measurement angle X is in increments of $15^\circ (= 360^\circ \div 24)$.

[0059]

As illustrated in Fig. 8, the optical fiber cable of Test Example 5-1 has a large variation in the flexural rigidity value for each measurement angle X. On the other hand, in the optical fiber cable of Test Example 5-2, the variation in the flexural rigidity value for each measurement angle X is smaller than that of Test Example 5-1. This difference is due to whether or not the tensile strength members 30 are twisted in a spiral shape and disposed. In Test Example 5-2, since the tensile strength members 30 are disposed in a spiral shape, it is considered that the flexural rigidity is made uniform in the circumferential direction.

[0060]

As described above, the tensile strength members 30 are embedded inside the protrusions 11 of the sheath 10, and the protrusions 11 and the tensile strength members 30 are formed into a spirally twisted shape centered on the central axis O, so that the flexural rigidity of the optical fiber cable can be made uniform in the circumferential direction. This makes it possible to provide an optical fiber cable that is easier to handle and easier to install in a micro-duct.

[0061]

(Material of Tensile Strength Member)

Next, the results of examining the material of the tensile strength member 30 will be described with reference to Tables 5 and 6. Test Examples 6-1 to 6-3 shown in Table 5 are optical fiber cables having 288 optical fibers. Test Examples 7-1 and 7-2 shown in Table 6 are optical fiber cables having 144 optical fibers.

5 [0062]

[Table 5]

	TM material	Tensile elastic modulus (kg/mm ²)	TM diameter (mm)	TM cross-sectional area (mm ²)	Number of TMs (pieces)	Tensile strength index	Outer diameter ratio
Test Example 6-1	KFRP	5000	0.5	0.196	12	1.00	1.00
Test Example 6-2	PBO-FRP	25000	0.25	0.049	12	1.25	0.94
Test Example 6-3	PBO-FRP	25000	0.3	0.071	8	1.20	0.95

[0063]

[Table 6]

	TM material	Tensile elastic modulus (kg/mm ²)	TM diameter (mm)	TM cross-sectional area (mm ²)	Number of TMs (pieces)	Tensile strength index	Outer diameter ratio
Test Example 7-1	KFRP	5000	0.5	0.196	10	1.00	1.00
Test Example 7-2	PBO-FRP	25000	0.25	0.049	10	1.25	0.92

10

[0064]

In Tables 5 and 6, "TM material", "Tensile elastic modulus", "TM diameter", and "TM cross-sectional area" indicate the material, tensile elastic modulus, diameter, and cross-sectional area of the tensile strength member 30, respectively. "Number of

TMs" indicates the number of tensile strength members 30 included in the test example. The surface of the sheath 10 in each test example is provided with the same number of protrusions 11 as the tensile strength members 30, and the tensile strength member 30 is disposed inside each protrusion 11.

5 [0065]

The "Tensile strength index" shown in Table 5 indicates the ratio of the tensile force, when the tensile force in the longitudinal direction is applied to the optical fiber cables of Test Examples 6-1 to 6-3 to reach a predetermined elongation rate α (%), based on Test Example 6-1. For example, since Test Example 6-2 has a tensile strength index
10 of 1.25, a tensile force which is 1.25 times greater than the tensile force of Test Example 6-1 is required before the elongation rate reaches α . The tensile strength index shown in Table 6 is also the same as the tensile strength index in Table 5 except that the tensile force of Test Example 7-1 is used as a reference.

The elongation rate α is set in a range in which the optical fiber cable elongates
15 in proportion to the tensile force. Therefore, the tensile strength index of Test Examples 6-2, 6-3, and 7-2 is not affected by the value of the elongation rate α .

[0066]

The "Outer diameter ratio" shown in Table 5 represents the size of the outer diameter of the optical fiber cables of Test Examples 6-2 and 6-3 with respect to the
20 outer diameter of the optical fiber cable of Test Example 6-1. For example, the outer diameter of the optical fiber cable of Test Example 6-2 is 0.94 times the outer diameter of the optical fiber cable of Test Example 6-1. The same applies to the "Outer diameter ratio" in Table 6, which represents the size of the outer diameter of the optical fiber cables of Test Example 7-2 with respect to the outer diameter of the optical fiber cable of
25 Test Example 7-1. Since the sheath 10 of each test example is designed to have the

same minimum thickness, the smaller the diameter of the tensile strength member 30, the smaller the outer diameter ratio.

[0067]

As shown in Table 5, the tensile strength indices of Test Examples 6-2 and 6-3
 5 are 1.25 and 1.20, respectively, which are more difficult to elongate in the longitudinal direction than Test Example 6-1 and effectively protect the optical fiber from tension. Further, the TM diameters of Test Examples 6-2 and 6-3 are 0.25 mm and 0.30 mm, respectively, which are significantly smaller than the TM diameter of Test Example 6-1. Thus, the outer diameter of the optical fiber cables of Test Examples 6-2 and 6-3 is
 10 smaller than that of Test Example 6-1.

As shown in Table 6, the same results as in Table 5 are also obtained in Test Examples 7-1 and 7-2 having 144 optical fibers.

[0068]

As described above, by using PBO-FRP having a large tensile elastic modulus
 15 as the material of the tensile strength member 30, it is possible to provide an optical fiber cable that is difficult to elongate with respect to tension in the longitudinal direction and has a small outer diameter.

[0069]

(Number of Tensile Strength Members for protrusions)

20 The number of tensile strength members 30 disposed inside the protrusions 11 can be appropriately changed. For example, an optical fiber cable having a transverse cross-sectional shape as illustrated in Fig. 10 may be adopted. In the optical fiber cable illustrated in Fig. 10, two tensile strength members 30 are embedded inside one protrusion 11, in a transverse cross-sectional view. In this way, two or more tensile
 25 strength members 30 may be disposed inside one protrusion 11.

[0070]

(Set Twist Angle)

Next, the effect of twisting the plurality of optical fiber units 21 in an SZ shape will be described with reference to Table 7.

5 [0071]

[Table 7]

	Set angle (°)	Twist angle of sheath (°)	Air-blowing test	Transmission loss	Determination
Test Example 9-1	0	0	1500 m	NG	NG
Test Example 9-2	±350	±30	2000 m or more	OK	OK
Test Example 9-3	±500	±50	2000 m or more	OK	OK
Test Example 9-4	±700	±70	2000 m or more	OK	OK

[0072]

The optical fiber cables of Test Examples 9-1 to 9-4 have a transverse cross-sectional shape as illustrated in Fig. 1A. The number of protrusions 11 and tensile strength members 30 is 12. An intermittently-adhered optical fiber ribbon is used as the optical fiber unit 21. The "Set angle" in Table 7 indicates a set angle when the plurality of optical fiber units 21 are twisted in an SZ shape. For example, in a case where the set angle is ±350°, when the core 20 is housed in the sheath 10, an operation of rotating the bundle of the optical fiber units 21 by 350° in the CW direction and then rotating the bundle by 350° in the CCW direction is repeatedly performed. Thus, the bundle of the optical fiber units 21 is housed in the sheath 10 in a state of being twisted in an SZ shape.

[0073]

When the bundle of the optical fiber units 21 is twisted in an SZ shape, the bundle of the optical fiber units 21 tries to untwist back to the shape before being twisted. By wrapping the bundle of the optical fiber units 21 with the wrapping tube 22 and the sheath 10 before the untwisting occurs, the state in which the bundle of the optical fiber units 21 is twisted in an SZ shape inside the optical fiber cable is maintained.

[0074]

Here, inside the optical fiber cable, the sheath 10 receives the force that the optical fiber unit 21 tries to untwist, through the wrapping tube 22. Since the sheath 10 is deformed by this force, an SZ-shaped twist also appears on the surface of the sheath 10. In this case, the tensile strength members 30 embedded in the sheath 10 are also twisted in an SZ shape. The SZ-shaped twist angle that appears on the surface of the sheath 10 in this way is shown in "Twist angle of sheath" in Table 7. In the optical fiber cable of Test Example 9-1, since the optical fiber unit 21 is not twisted in an SZ shape, no SZ-shaped twist appears on the surface of the sheath 10. On the other hand, in the optical fiber cables of Test Examples 9-2 to 9-4, since the optical fiber unit 21 is twisted in an SZ shape, an SZ-shaped twist appears on the surface of the sheath 10.

[0075]

The larger the set angle, the greater the force that the optical fiber unit 21 tries to untwist. Therefore, as shown in Table 7, the larger the set angle, the larger the "Twist angle of sheath".

[0076]

In the field of "Air-blowing test" shown in Table 7, the results of the air-blowing test performed on the optical fiber cables of Test Examples 9-1 to 9-4 are shown. The details of the air-blowing test are the same as those in Table 1. For example, in Test Example 9-1, it is possible to blow 1500 m in the air-blowing test, but it is difficult to

blow more than that. On the other hand, in Test Examples 9-2 to 9-4, air-blowing of 2000 m or more is possible in the air-blowing test. The details of "Transmission loss" in Table 7 are the same as those in Table 2.

[0077]

5 As shown in Table 7, with respect to the optical fiber units of Test Examples 9-2 to 9-4, better results are obtained than Test Example 9-1 in the air-blowing test. This is because the protrusions 11 and the recesses 12 are twisted in an SZ shape, so that the pressure of the air flowing in the recesses 12 can be effectively converted into the thrust that propels the optical fiber cable to the downstream side. That is, the air flowing in
 10 the recesses 12 exerts a pressure in the direction perpendicular to the side surface of the protrusion 11. Therefore, it is considered that the air pressure is converted into the force in the longitudinal direction and the result of the air-blowing test is improved as compared with Test Example 9-1 in which the sheath 10 is not twisted. Further, in Test Examples 9-2 to 9-4, when SZ-shaped twist is applied to the sheath 10, the tensile
 15 strength members 30 embedded in the sheath 10 are also twisted in an SZ shape, and the flexural rigidity of the optical fiber cable is homogenized in the circumferential direction. This point is also considered to have been a factor in improving the results of the air-blowing test.

[0078]

20 The flexural rigidity values of the optical fiber cables of Test Examples 9-1 and 9-2 for each measurement angle X are illustrated in Fig. 11. The method for measuring the flexural rigidity value is the same as in Test Examples 5-1 and 5-2. From Fig. 11, it can be seen that the optical fiber cable of Test Example 9-2 has a smaller variation in the flexural rigidity value for each measurement angle X than the optical fiber cable of Test
 25 Example 9-1.

From the above, by twisting a plurality of optical fiber units 21 in an SZ shape, and applying an SZ-shaped twist to the sheath 10 by the force of untwisting, it is possible to provide an optical fiber cable in which flexural rigidity is made uniform in the circumferential direction and is more suitable for air-blowing. In the present example, the optical fiber unit 21 is twisted in an SZ shape. However, it is considered that the same result can be obtained when a plurality of optical fibers 21a are twisted in an SZ shape without being unitized. That is, by twisting the plurality of optical fibers 21a in an SZ shape, the above-described action and effect can be obtained when an SZ-shaped twist is applied to the sheath 10.

10 [0079]

Further, as shown in Table 7, it has been found that in Test Examples 9-2, 9-3, and 9-4, in addition to the air-blowing test, the transmission loss is also good. Therefore, by setting the SZ twist angle of the optical fiber unit 21 such that the twist angle of the sheath 10 is $\pm 30^\circ$ to $\pm 70^\circ$, it is possible to provide an optical fiber cable having good transmission loss characteristics.

[0080]

(Low Friction Material)

Since the sheath 10 comes into contact with the micro-duct D (see Fig. 3) when the optical fiber cable is air-blown, the sheath 10 is preferably made of a material having a low friction coefficient (hereinafter referred to as a low friction material). On the other hand, when the entire sheath 10 is made of a low friction material, it is considered that the strength of the sheath 10 cannot be ensured or the cost increases. Therefore, an examination is performed in which a portion of the sheath 10 in contact with the micro-duct is formed of a low friction material. Hereinafter, a description will be made with reference to Table 8.

[0081]

[Table 8]

	Transverse cross-sectional shape	Cable outer diameter	Air-blowing test result
Test Example 10-1	Fig. 1A	12 mm	2000 m
Test Example 10-2	Fig. 1A	8 mm	2000 m or more
Test Example 10-3	Fig. 12A	12 mm	2000 m or more
Test Example 10-4	Fig. 12A	8 mm	2000 m or more
Test Example 10-5	Fig. 12B	12 mm	2000 m or more
Test Example 10-6	Fig. 12B	8 mm	2000 m or more
Test Example 10-7	Fig. 12C	12 mm	2000 m or more
Test Example 10-8	Fig. 12C	8 mm	2000 m or more

[0082]

5 As shown in Table 8, the optical fiber cables of Test Examples 10-1 to 10-8 are prepared. In the optical fiber cables of Test Examples 10-1 and 10-2, the sheath 10 is formed of a single base material B (average dynamic friction coefficient: 0.27). In the optical fiber cables of Test Examples 10-3 and 10-4, as illustrated in Fig. 12A, the top of the protrusion 11 is formed of a low friction material M (average dynamic friction

10 coefficient is 0.20), and the rest part of the sheath 10 is formed of the base material B. That is, the low friction material M is a material having a smaller friction coefficient than the base material B. The average dynamic friction coefficient is measured according to JIS K7125.

[0083]

In the optical fiber cables of Test Examples 10-5 and 10-6, as illustrated in Fig. 12B, a layer of the low friction material M is provided on the entire surface of the sheath 10 formed of the base material B. In the optical fiber cables of Test Examples 10-7 and 5 10-8, as illustrated in Fig. 12C, the protrusions 11 and the recesses 12 are formed of the low friction material M on the outer circumferential surface of the cylindrical base material B.

The optical fiber cables of Test Examples 10-3 to 10-8 are common in that the sheath 10 is formed of the base material B and the low friction material M, and the low 10 friction material M is disposed at least on the top of the protrusion 11. In the present specification, the "top" of the protrusion 11 refers to a portion curved so as to be convex radially outward.

[0084]

An air-blowing test is performed on the optical fiber cables of Test Examples 15 10-1 to 10-8. The speed of blowing the optical fiber cable (blowing speed) is about 60 m/min at the start of the test. In all of Test Examples 10-1 to 10-8, the blowing speed decreases as the blowing distance increases. In Test Example 10-1, the blowing speed is almost zero when the blowing distance is 2000 m. On the other hand, in Test Examples 10-2 to 10-8, it is confirmed that the blowing speed is 30 m/min or more when 20 the blowing distance is 2000 m, and that blowing of 2000 m or more is sufficiently possible. As described above, in the optical fiber cables of Test Examples 10-2 to 10-8, better results are obtained than the results of Test Example 10-1. Since Test Examples 10-2 and 10-1 have the same transverse cross-sectional shape, but Test Example 10-1 has a large outer diameter and a large contact area with a micro-duct, it is considered that 25 friction increases and the air-blowing property is lower than that of Test Example 10-2.

On the other hand, in Test Examples 10-3, 10-5, and 10-7, the friction is reduced by forming the portion in contact with the micro-duct with the low friction material M, and the air-blowing property can be improved even in the optical fiber cable having an outer diameter of 12 mm or more.

5 [0085]

As described above, since the low friction material M is disposed at least on the top of the protrusion 11, it is possible to provide an optical fiber cable having good air-blowing property. Further, by forming the sheath 10 with the base material B and the low friction material M, it is possible to improve the strength of the sheath 10 and reduce
10 the cost, as compared with the case where the entire sheath 10 is formed of the low friction material M.

However, in consideration of the air-blowing property and cost required for the optical fiber cable 1, the entire sheath 10 may be formed of the low friction material M.

[0086]

15 (Ripcord)

In the optical fiber cable connection work and disassembly work, it is necessary to take out the core 20 from the inside of the sheath 10. The structures of Figs. 13A to 13C are proposed as the arrangement of the ripcord for facilitating the operation of accessing to the core 20.

20 [0087]

In the optical fiber cable 1 illustrated in Fig. 13A, a part of the tensile strength member 30 is replaced with the ripcord 40 as compared with Fig. 1A. More specifically, two ripcords 40 are embedded inside the protrusions 11 of the sheath 10, and are disposed so as to sandwich the core 20 therebetween.

25 [0088]

As the ripcord 40, a yarn obtained by twisting fibers such as polypropylene (PP) and polyester can be used. The tensile strength member 30 has a role of protecting the optical fiber 21a from tension, while the ripcord 40 has a role of tearing the sheath 10. Therefore, the materials of the ripcord 40 and the tensile strength member 30 are
5 different. Specifically, the tensile elastic modulus of the tensile strength member 30 is larger than that of the ripcord 40. Further, the ripcord 40 is more flexible than the tensile strength member 30.

[0089]

As illustrated in Fig. 13A, by embedding the ripcord 40 inside the protrusion 11
10 of the sheath 10, the ripcord 40 can be disposed while preventing the sheath 10 from becoming thin. When the core 20 is taken out from the inside of the sheath 10, a part of the protrusion 11 is incised to take out the ripcord 40, and the ripcord 40 is pulled in the longitudinal direction of the optical fiber cable. Thus, the sheath 10 is torn and the core 20 can be taken out.

15 [0090]

As illustrated in Fig. 13A, when an optical fiber cable in which a pair of ripcords 40 are disposed so as to sandwich the core 20 is fabricated, the operation of accessing to the core 20 can be performed satisfactorily. The number of ripcords 40 included in the optical fiber cable may be one or three or more.

20 [0091]

As described above, in the transverse cross-sectional view, among the plurality of protrusions, the ripcords 40 are positioned inside some of the plurality of protrusions 11 and the tensile strength members 30 are positioned inside the other protrusions 11, which facilitates the operation of accessing to the core 20 in the optical fiber cable while
25 protecting the optical fiber 21a from tension.

[0092]

In order to identify the position where the ripcord 40 is embedded, a marking portion (coloring or the like) may be provided on the protrusion 11 where the ripcord 40 is embedded. Alternatively, as illustrated in Figs. 13B, 13C, and 13D, the shape of the protrusion 11 in which the ripcord 40 is embedded may be different from the shape of the other protrusions 11. In the example of Fig. 13B, the protrusions 11 in which the ripcords 40 are embedded are projected radially outward more than the other protrusions 11. In the example of Fig. 13C, the width of the protrusions 11 in which the ripcord 40 is embedded in the circumferential direction is smaller than that of the other protrusions 11.

[0093]

In the example of Fig. 13D, the ripcord 40 is disposed so as to be in contact with the core 20. Further, the tensile strength members 30 are disposed at equal intervals in the circumferential direction, and the ripcords 40 are positioned between adjacent tensile strength members 30 in the circumferential direction. Then, two tensile strength members 30 sandwiching the ripcord 40 are positioned inside one protrusion 11.

By adopting the forms illustrated in Figs. 13B, 13C, and 13D, the position of the ripcord 40 can be easily recognized from the outside of the optical fiber cable.

[0094]

It should be noted that the technical scope of the present invention is not limited to the above-described embodiments, and various modifications can be made without departing from the spirit of the present invention.

[0095]

For example, as illustrated in Fig. 14A, the inner surface of the recess 12 may be a curved surface that is radially inward convex.

Further, as illustrated in Fig. 14B, the number of the protrusions 11 needs not to match the number of the tensile strength members 30. Further, as illustrated in Fig. 14B, the tensile strength member 30 may be disposed at a position closer to the inner circumferential surface than the outer circumferential surface of the sheath 10.

5 [0096]

In addition, without departing from the spirit of the present invention, it is possible to appropriately replace the constituent elements in the above-described embodiment with well-known constituent elements, and the above-described embodiment and modification examples may be appropriately combined.

10 [Reference Signs List]

[0097]

1 Optical fiber cable

10 Sheath

11 Protrusion

15 12 Recess

12a Connecting portion

12b Bottom surface

20 Core

21 Optical fiber unit (intermittently-adhered optical fiber ribbon)

20 21a Optical fiber

21c Adhesive portion

22 Wrapping tube

22a Wrap portion

22b Non-wrap portion

25 30 Tensile strength member

40 Ripcord

B Base material

M Low friction material

[CLAIMS]

What is claimed is:

[Claim 1]

An optical fiber cable comprising:

5 a sheath; and

a core which is housed in the sheath and which has an intermittently-adhered optical fiber ribbon including a plurality of optical fibers and a plurality of adhesive portions for intermittently adhering the plurality of optical fibers in a longitudinal direction,

10 wherein recesses and protrusions are formed so as to be disposed alternately in a circumferential direction on an outer circumferential surface of the sheath, and

the recesses each include two connecting portions respectively connected to radial inner ends of two adjacent protrusions, and a bottom surface positioned between the two connecting portions.

15

[Claim 2]

The optical fiber cable according to claim 1,

wherein the connecting portions are formed in a curved surface shape that is radially inward convex.

20

[Claim 3]

The optical fiber cable according to claim 1 or 2,

wherein the optical cable has a compressive strength of 12.8 N/mm² or more and 32.4 N/mm² or less.

25

[Claim 4]

The optical fiber cable according to any one of claims 1 to 3,
 wherein the core has a wrapping tube that wraps the intermittently-adhered
 optical fiber ribbon.

5

[Claim 5]

The optical fiber cable according to claim 4,
 wherein the wrapping tube has a first end portion and a second end portion that
 overlap each other to form a wrap portion, and a non-wrap portion positioned between
 10 the first end portion and the second end portion.

[Claim 6]

The optical fiber cable according to claim 5,
 wherein when a circumferential length of the wrap portion is $W1$ and a
 15 circumferential length of the non-wrap portion is $W2$, a wrap rate R obtained by $R = W1$
 $\div (W1 + W2) \times 100$ is within a range of 5% or more and 20% or less.

[Claim 7]

The optical fiber cable according to any one of claims 1 to 6,
 20 wherein in a transverse cross-sectional view, a cross-sectional area A of the
 recesses, which is a cross-sectional area of a space defined by closed curves tangent to
 radial outer ends of the plurality of protrusions and all the recesses, is within a range of
 1.3 mm^2 or more and 4.8 mm^2 or less.

25 [Claim 8]

The optical fiber cable according to any one of claims 1 to 7,
wherein when a twist angle of the sheath per 1 m along the longitudinal
direction of the optical fiber cable is θ ($^{\circ}/\text{m}$), $10 \leq \theta \leq 180$.

5 [Claim 9]

The optical fiber cable according to any one of claims 1 to 8,
wherein a radius of curvature of each outer circumferential surface of the
protrusions is smaller than a radius of the sheath.

10 [Claim 10]

The optical fiber cable according to any one of claims 1 to 9, further comprising:
tensile strength members embedded inside the protrusions in the sheath,
wherein the protrusions and the tensile strength members have a spirally twisted
shape centered on a central axis of the optical fiber cable.

15

[Claim 11]

The optical fiber cable according to any one of claims 1 to 10, further
comprising:

tensile strength members embedded inside the protrusions in the sheath,
20 wherein the tensile strength members are formed of PBO-FRP.

[Claim 12]

The optical fiber cable according to any one of claims 1 to 11, further
comprising:

25 a plurality of tensile strength members embedded in the sheath,

wherein in a transverse cross-sectional view, the plurality of tensile strength members are positioned inside each of the protrusions in the sheath.

[Claim 13]

5 The optical fiber cable according to any one of claims 1 to 12, wherein a plurality of intermittently-adhered optical fiber ribbons including the intermittently-adhered optical fiber ribbon are provided, and an SZ-shaped twist is applied to the sheath by twisting the plurality of intermittently-adhered optical fiber ribbons in an SZ shape.

10

[Claim 14]

The optical fiber cable according to any one of claims 1 to 13, wherein the sheath is formed of a base material and a low friction material having a friction coefficient smaller than a friction coefficient of the base material, and
15 the low friction material is disposed at least on tops of the protrusions.

[Claim 15]

The optical fiber cable according to any one of claims 1 to 14, further comprising:
20 tensile strength members and ripcords embedded in the sheath, wherein in a transverse cross-sectional view, among the plurality of protrusions, the ripcords are positioned inside some of the protrusions, and the tensile strength members are positioned inside the other protrusions.

FIG. 1A

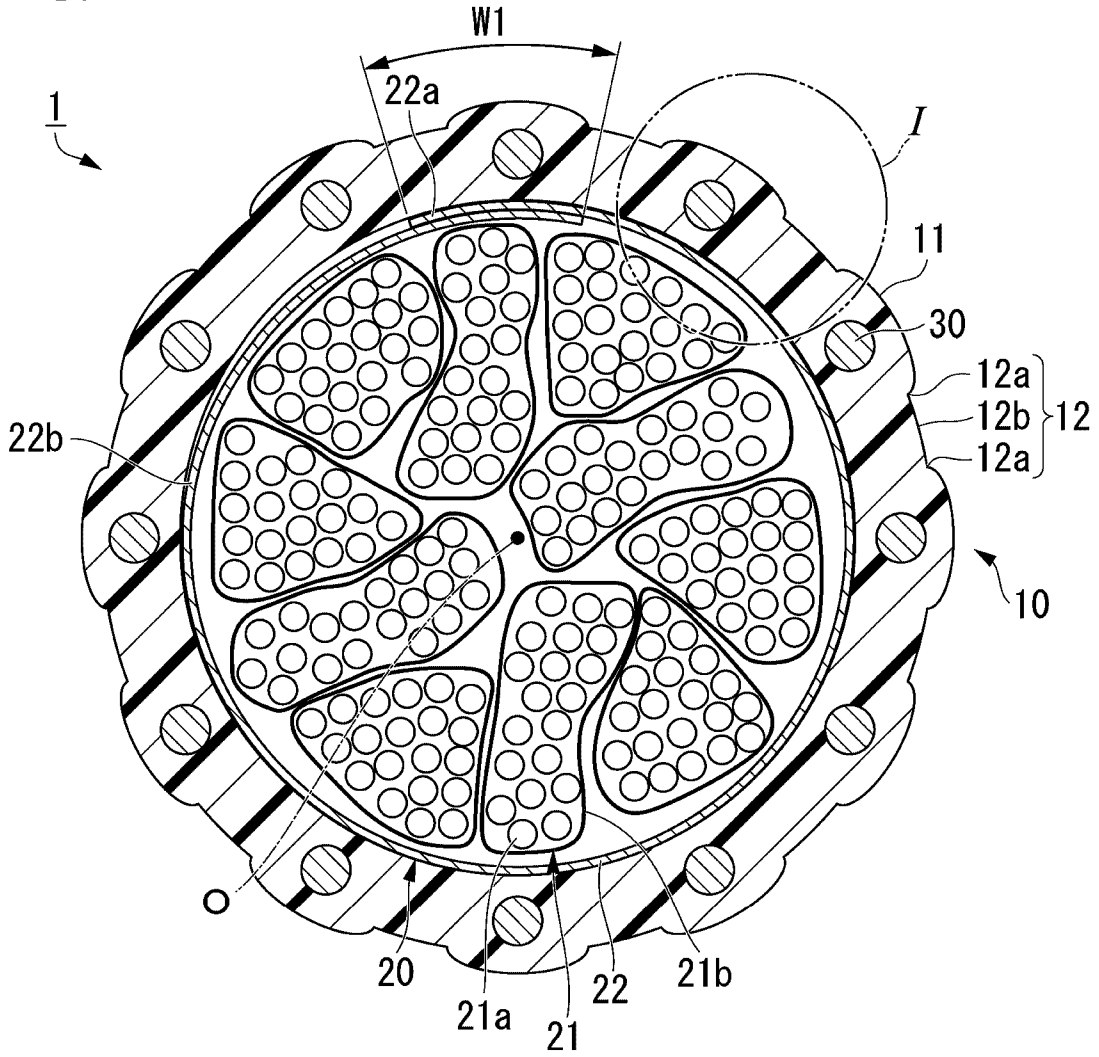


FIG. 1B

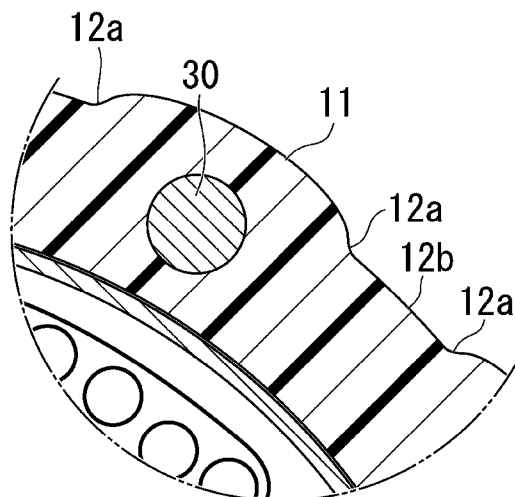
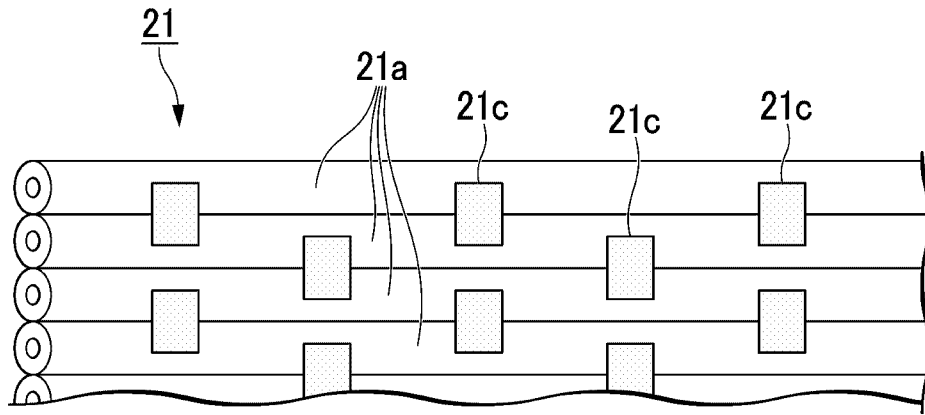


FIG. 2



3/17

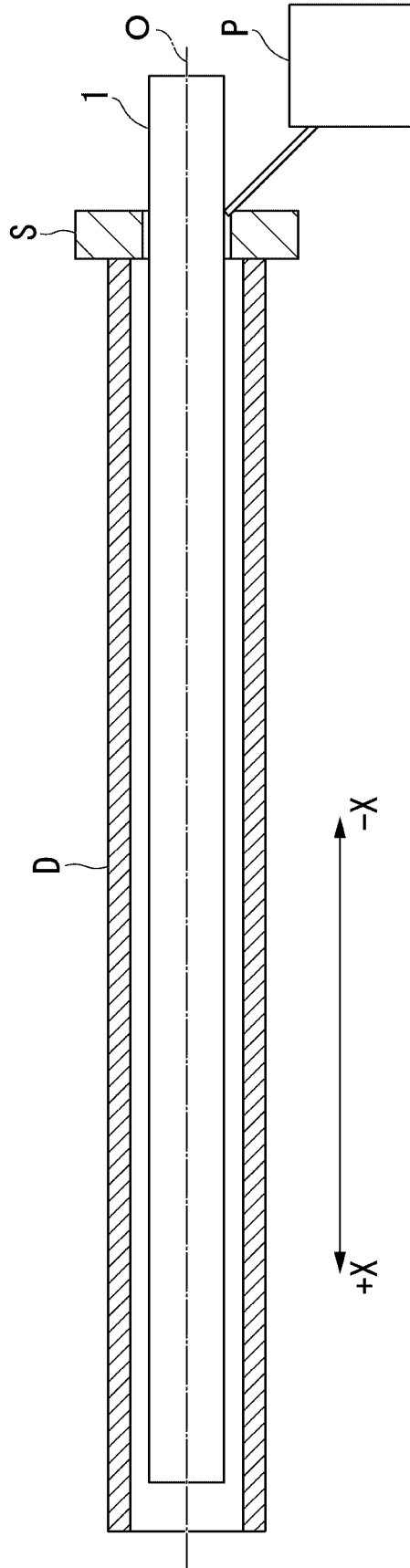


FIG. 3

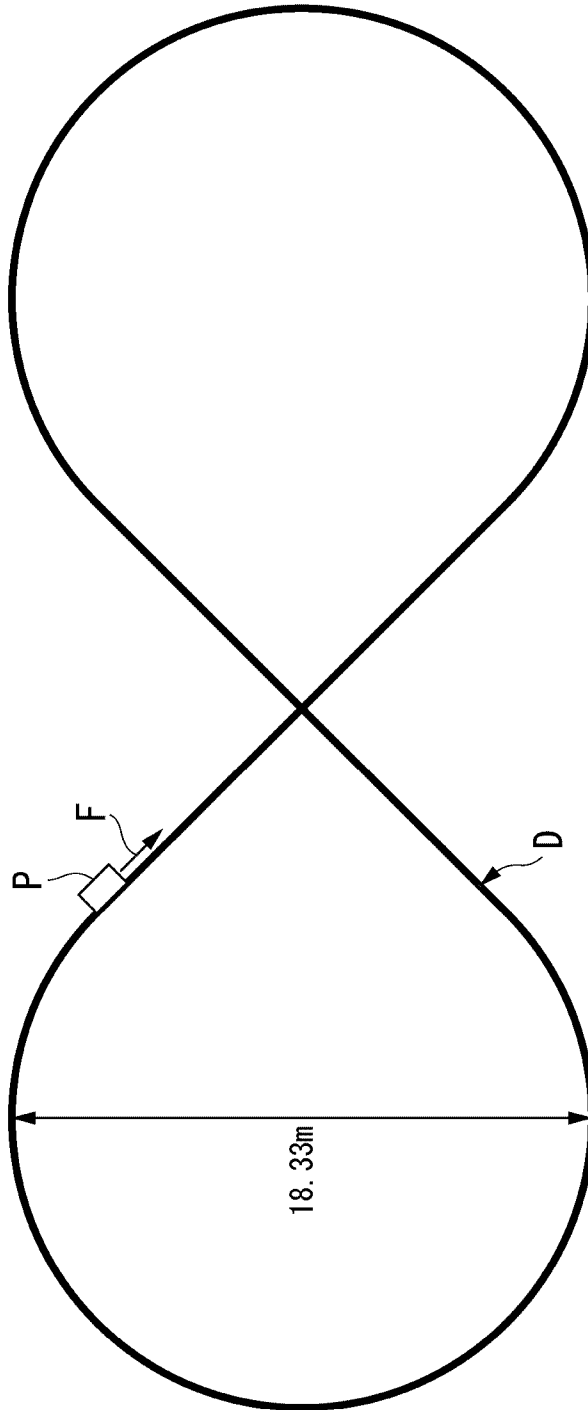


FIG. 4

FIG. 5

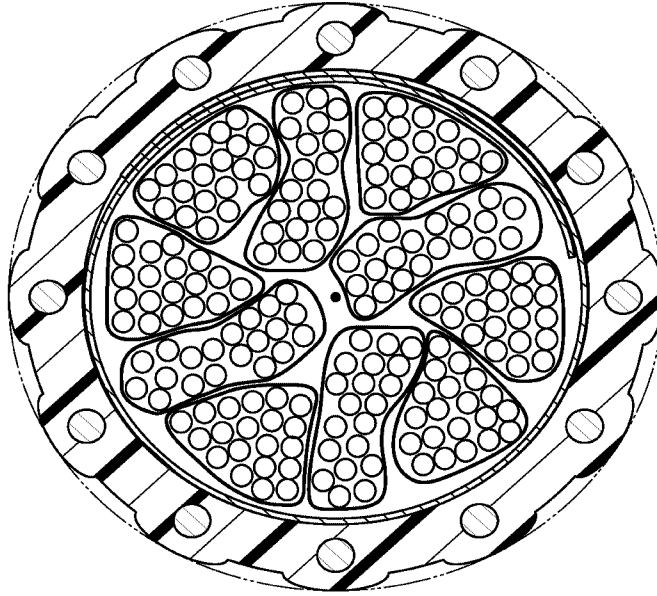
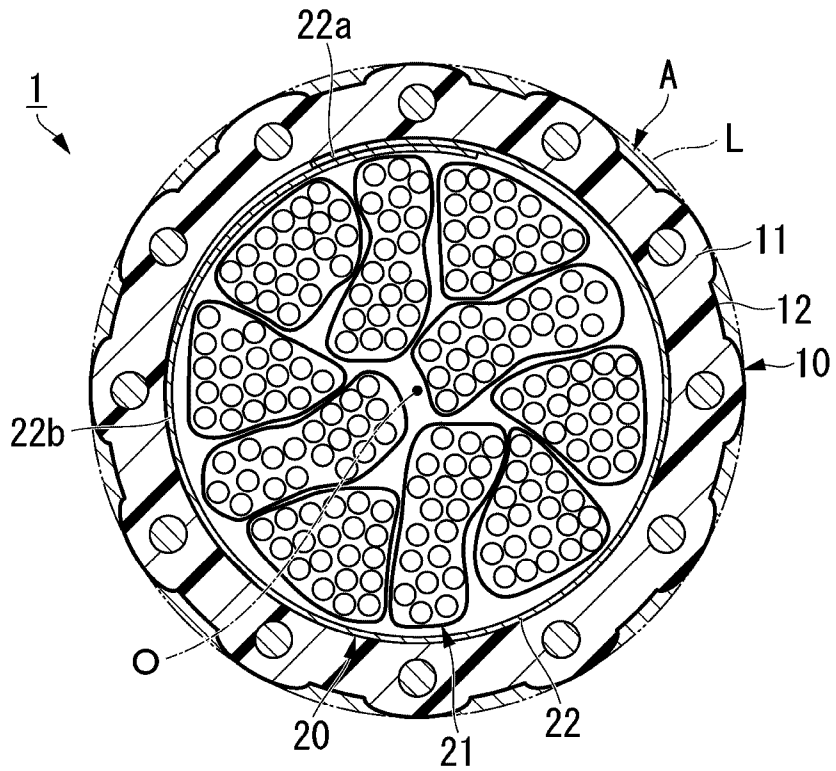
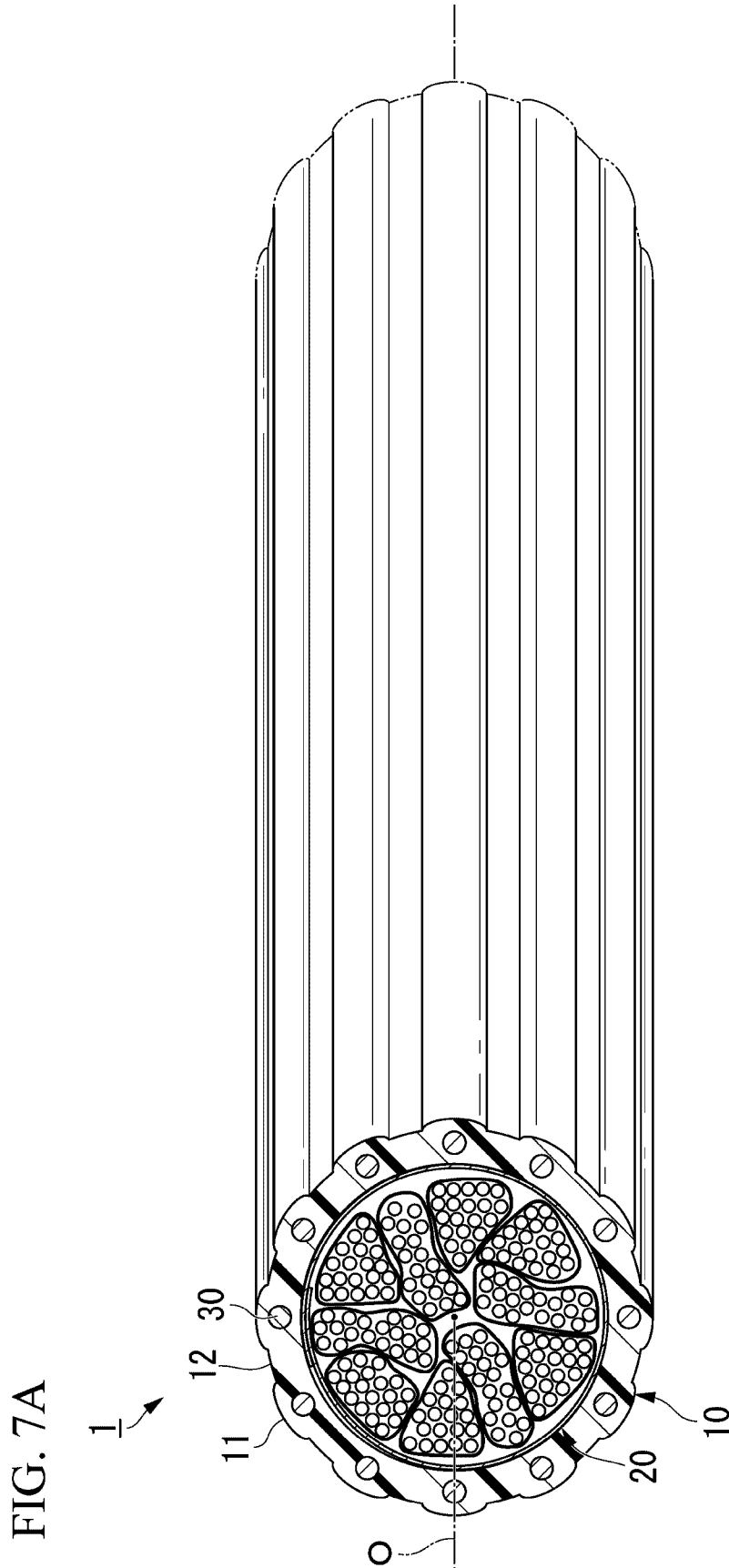


FIG. 6





7/17

FIG. 7B

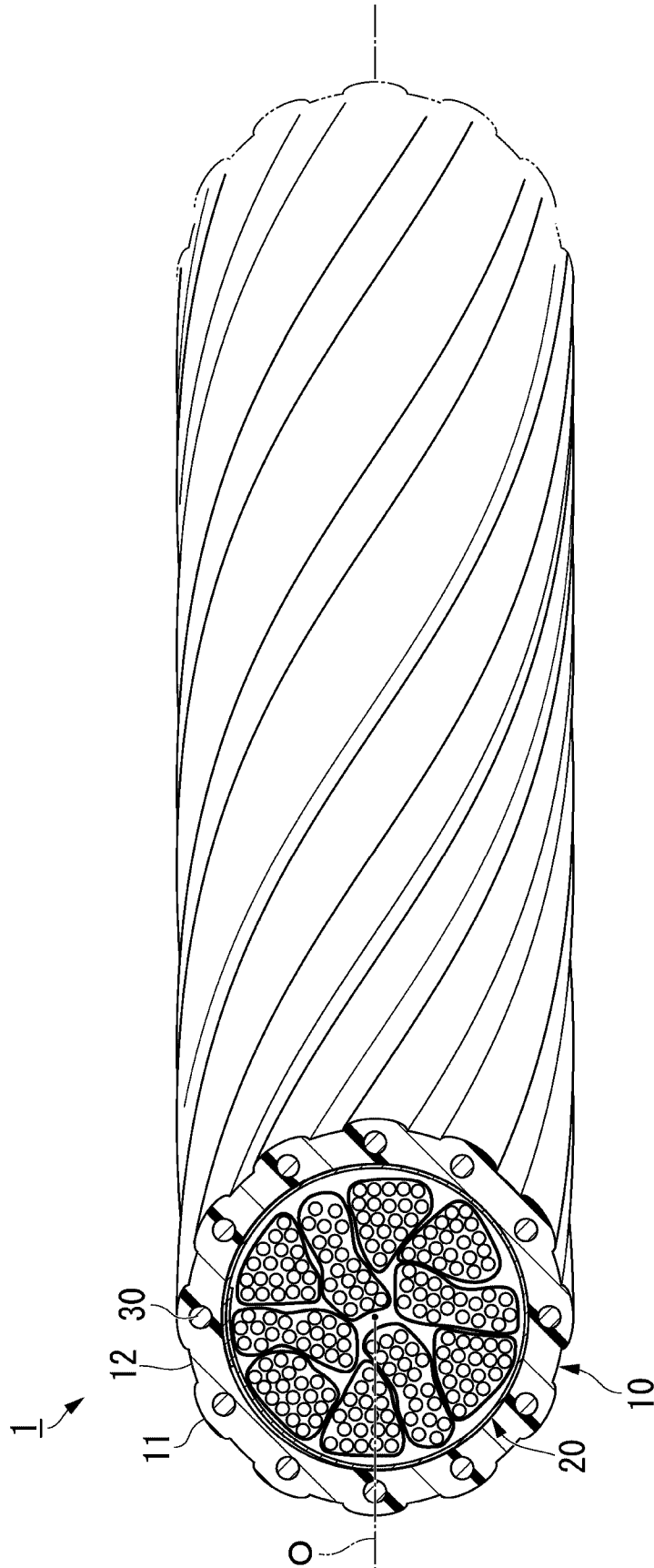


FIG. 8

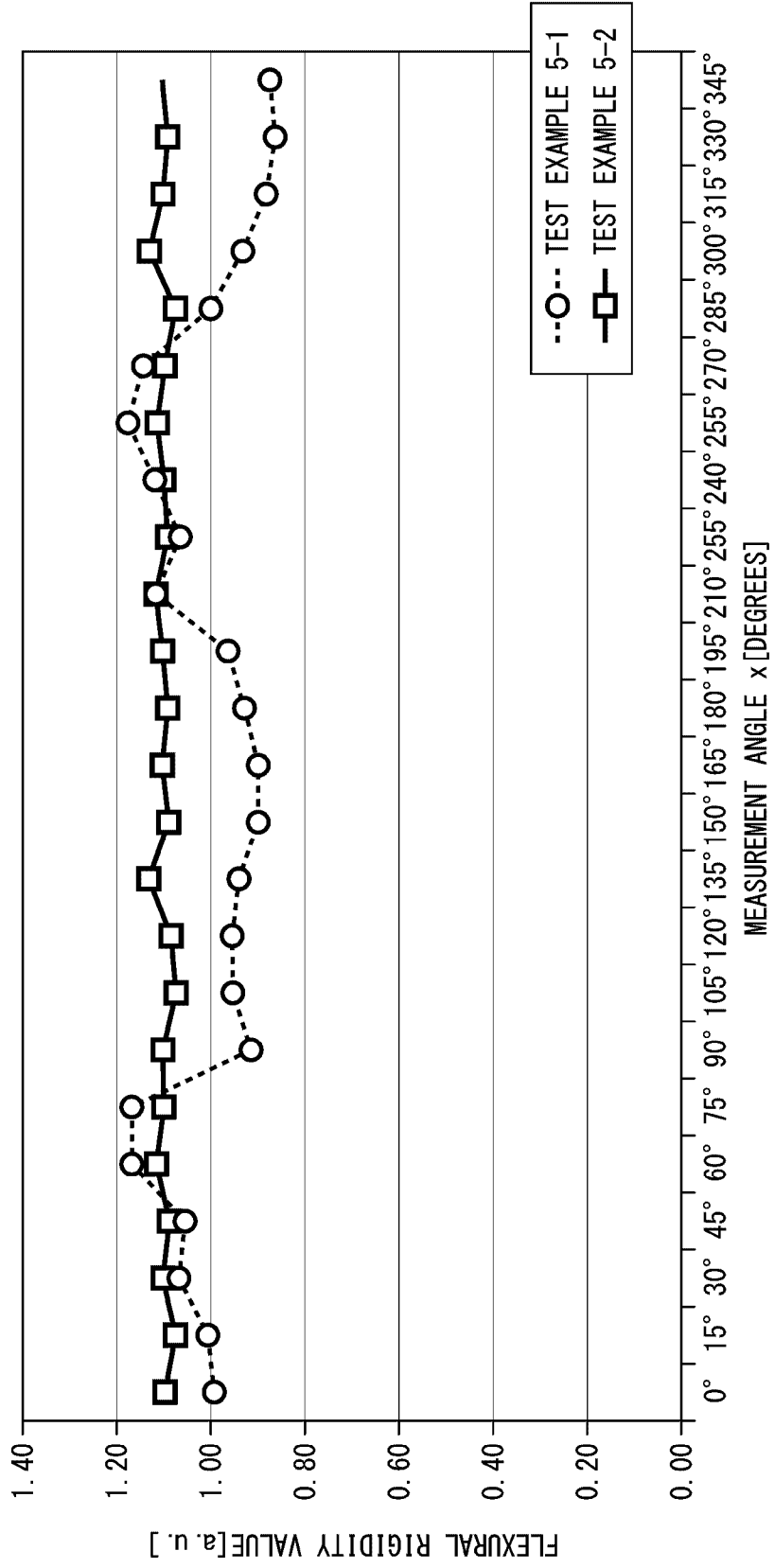


FIG. 9

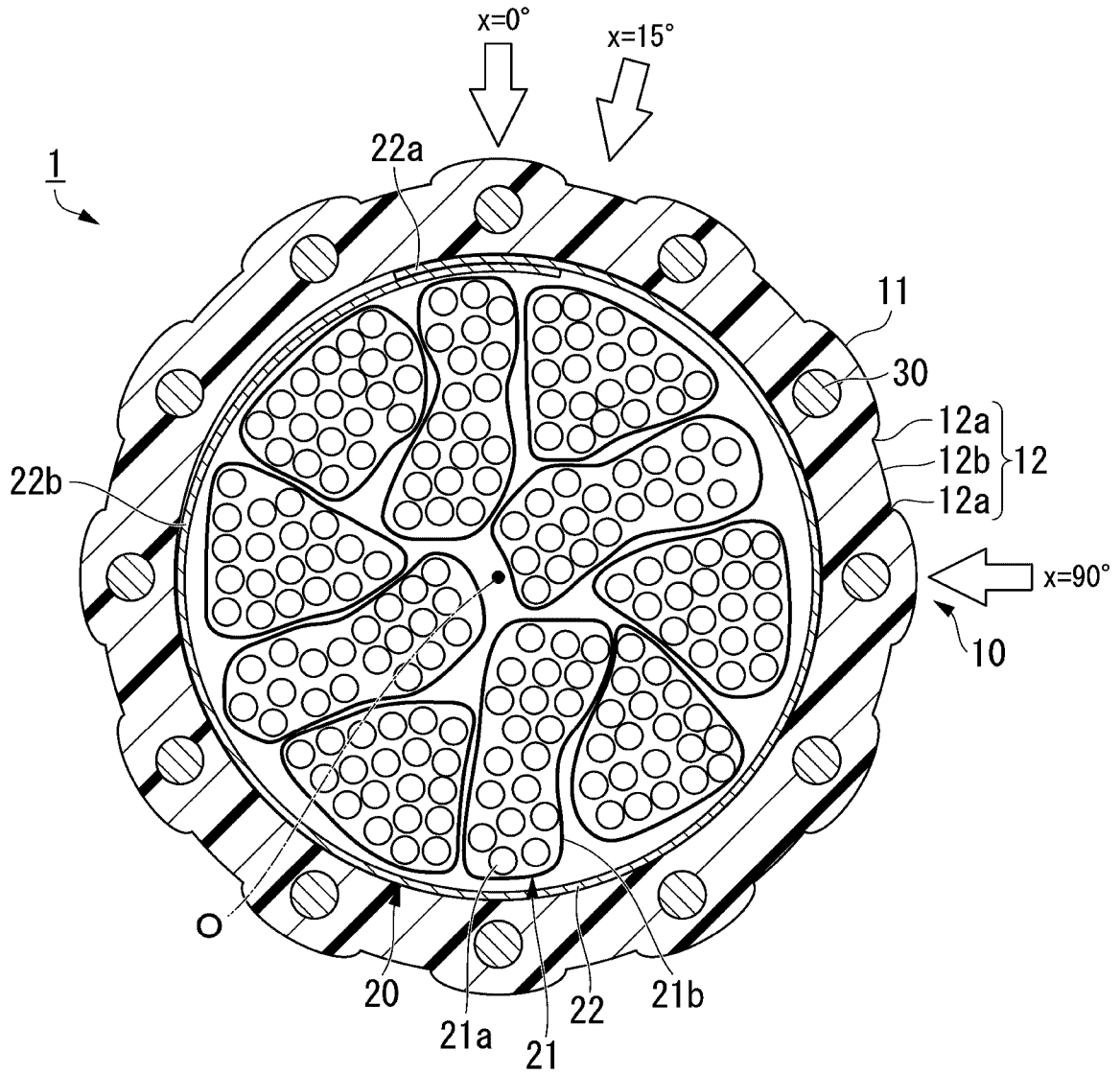


FIG. 10

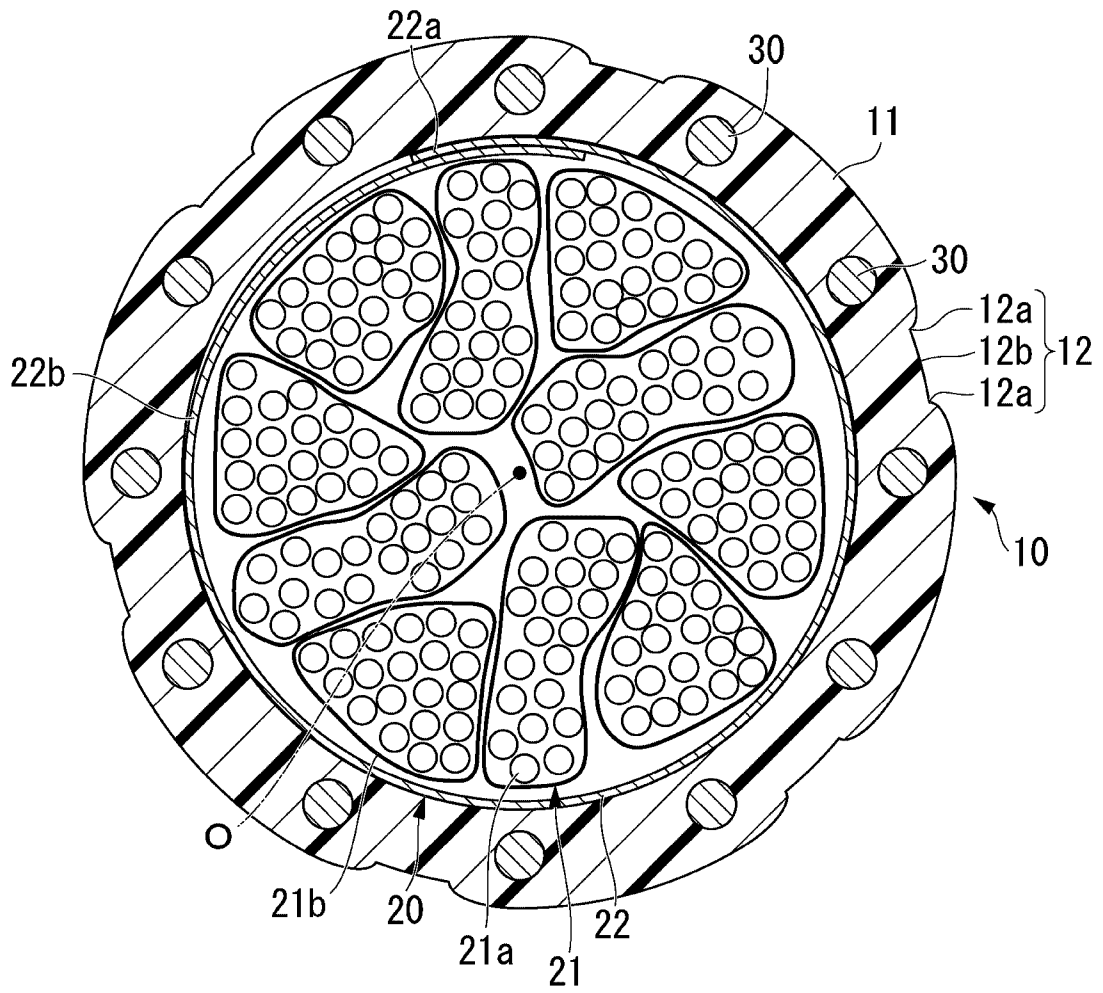


FIG. 11

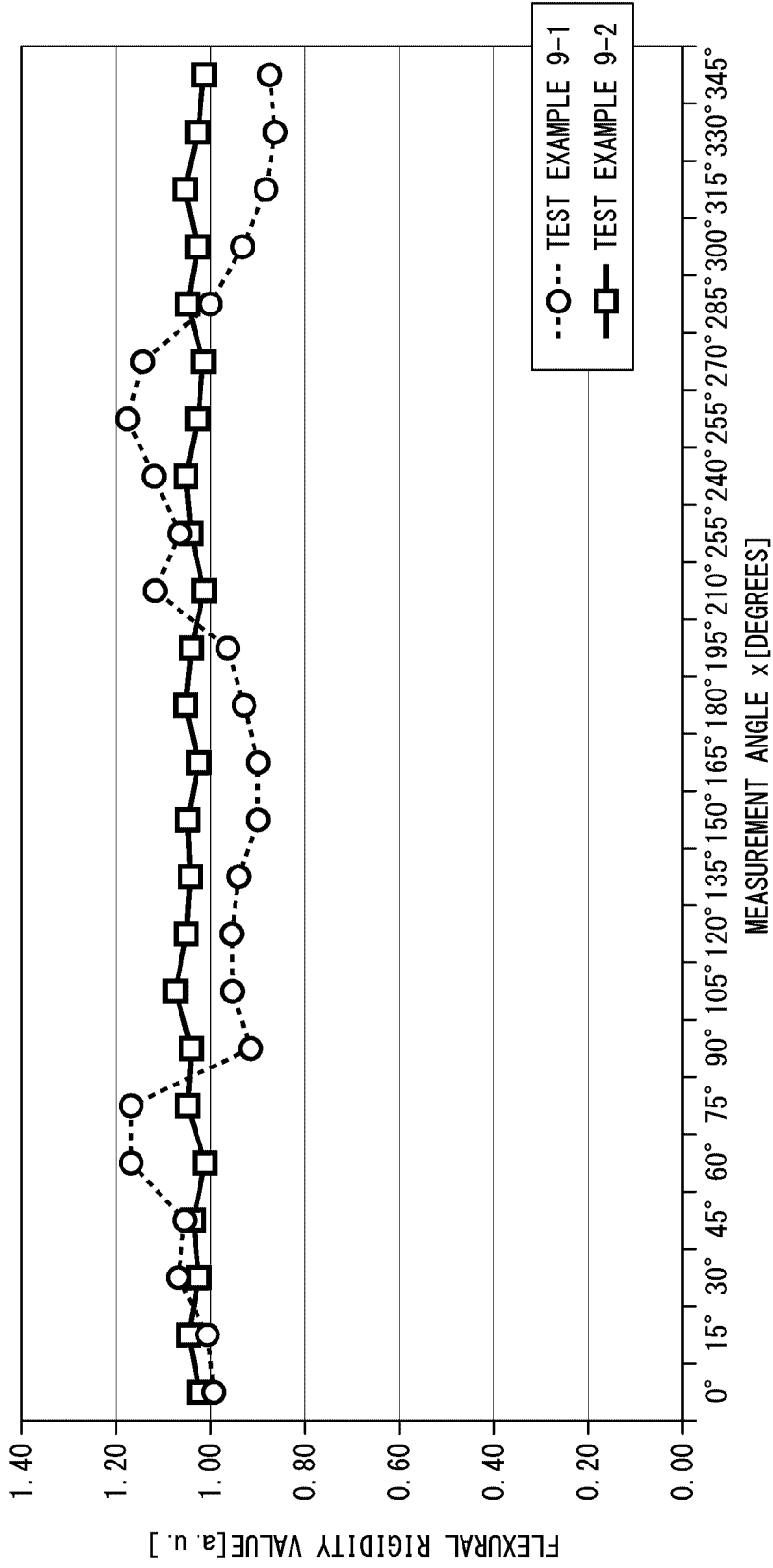


FIG. 12A

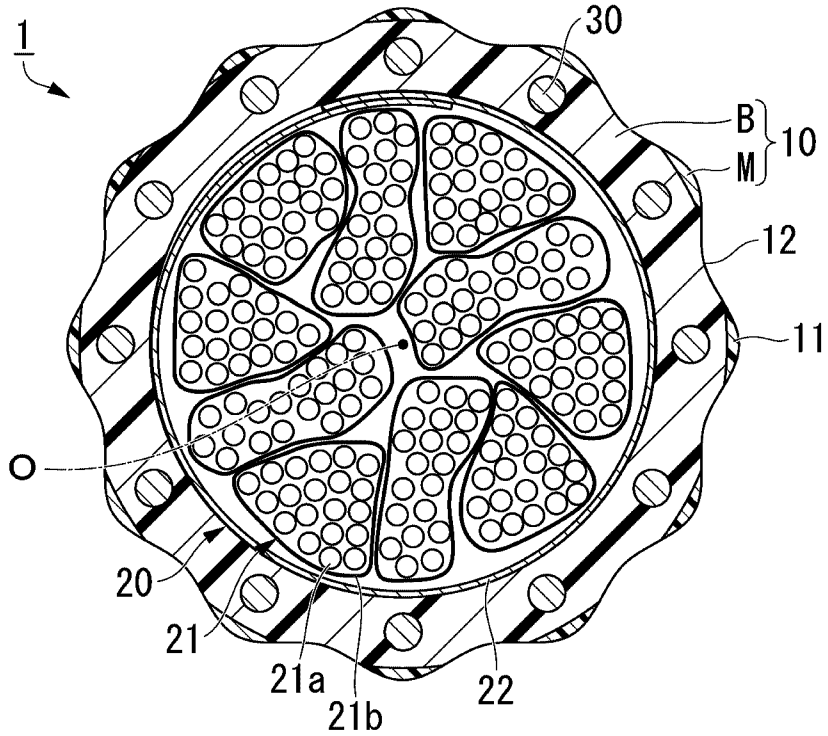


FIG. 12B

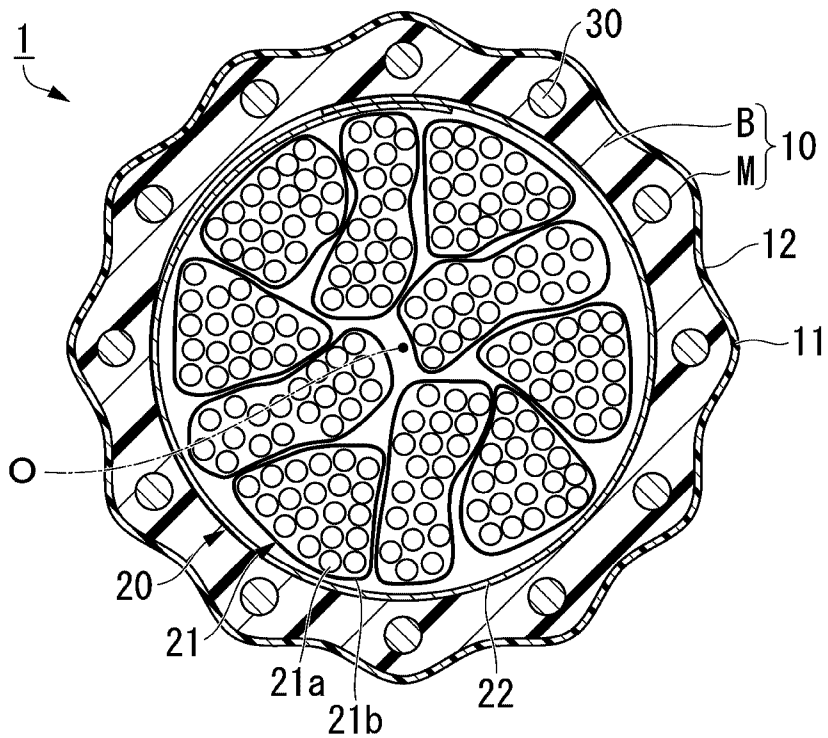


FIG. 12C

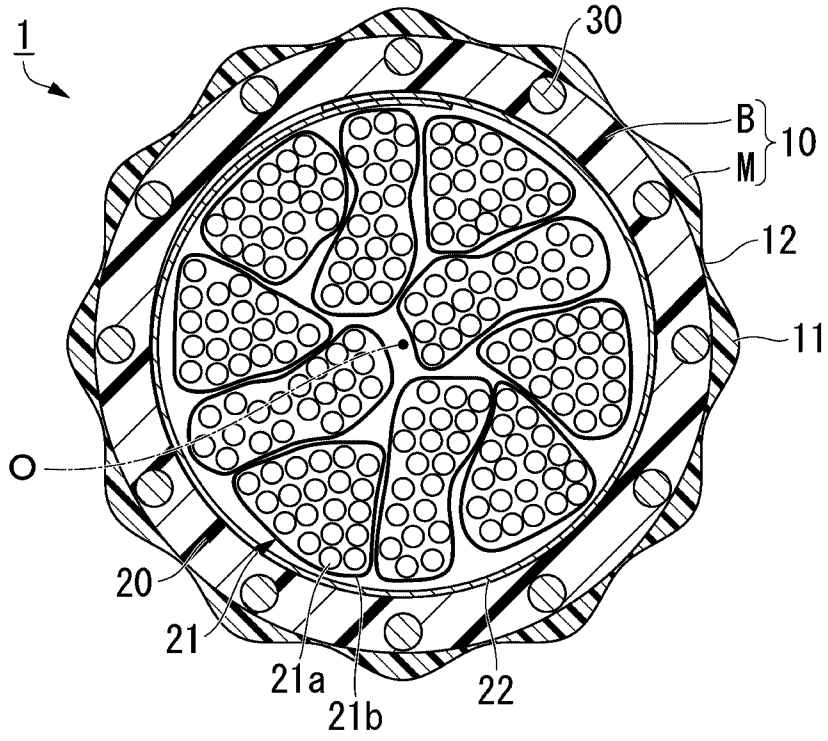


FIG. 13A

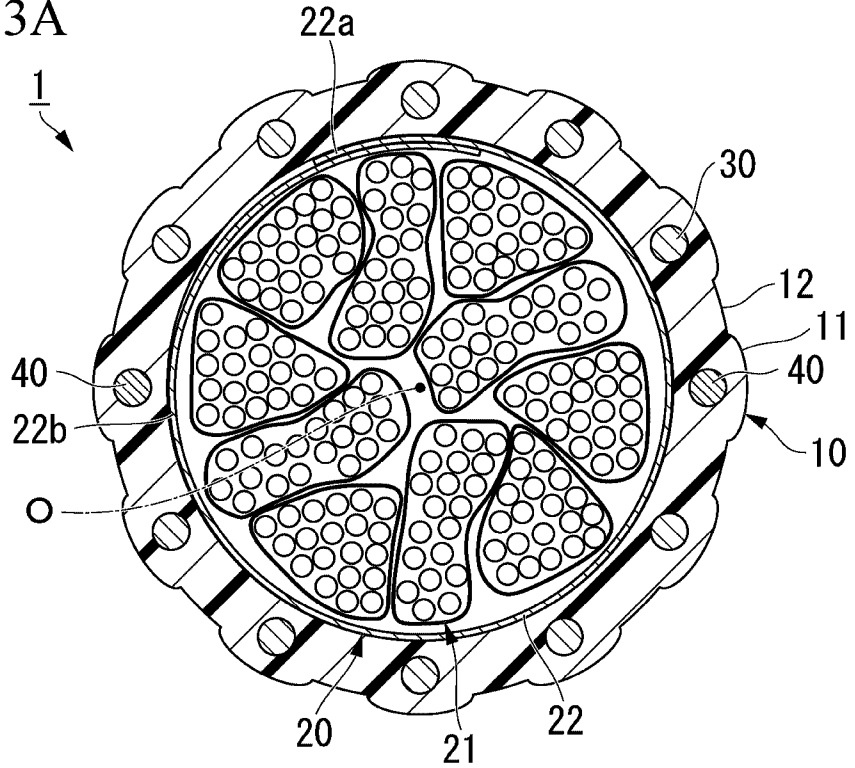


FIG. 13B

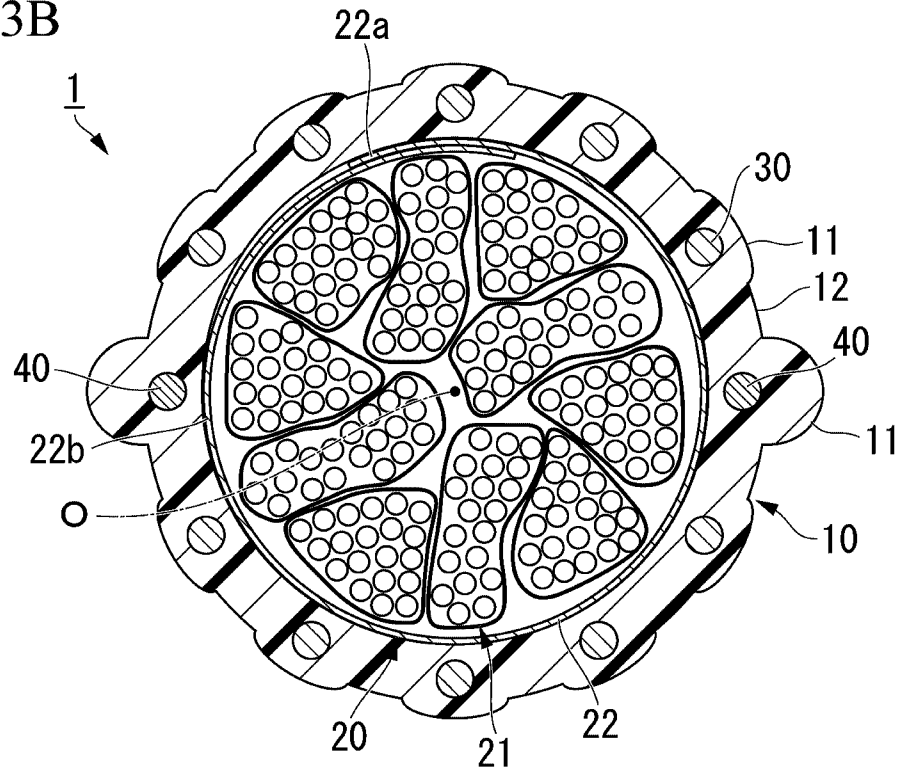


FIG. 13C

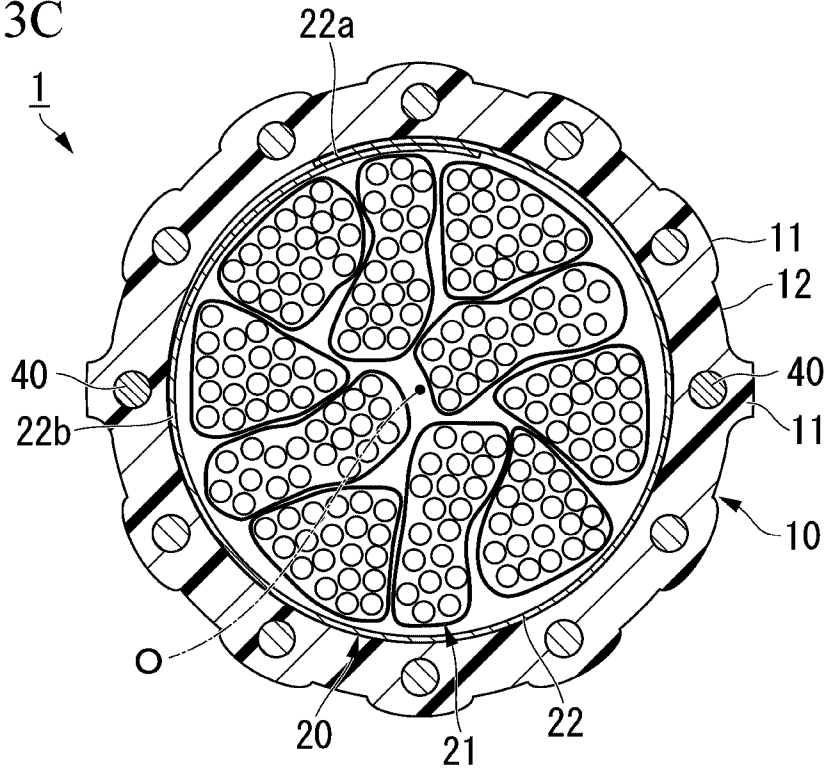


FIG. 13D

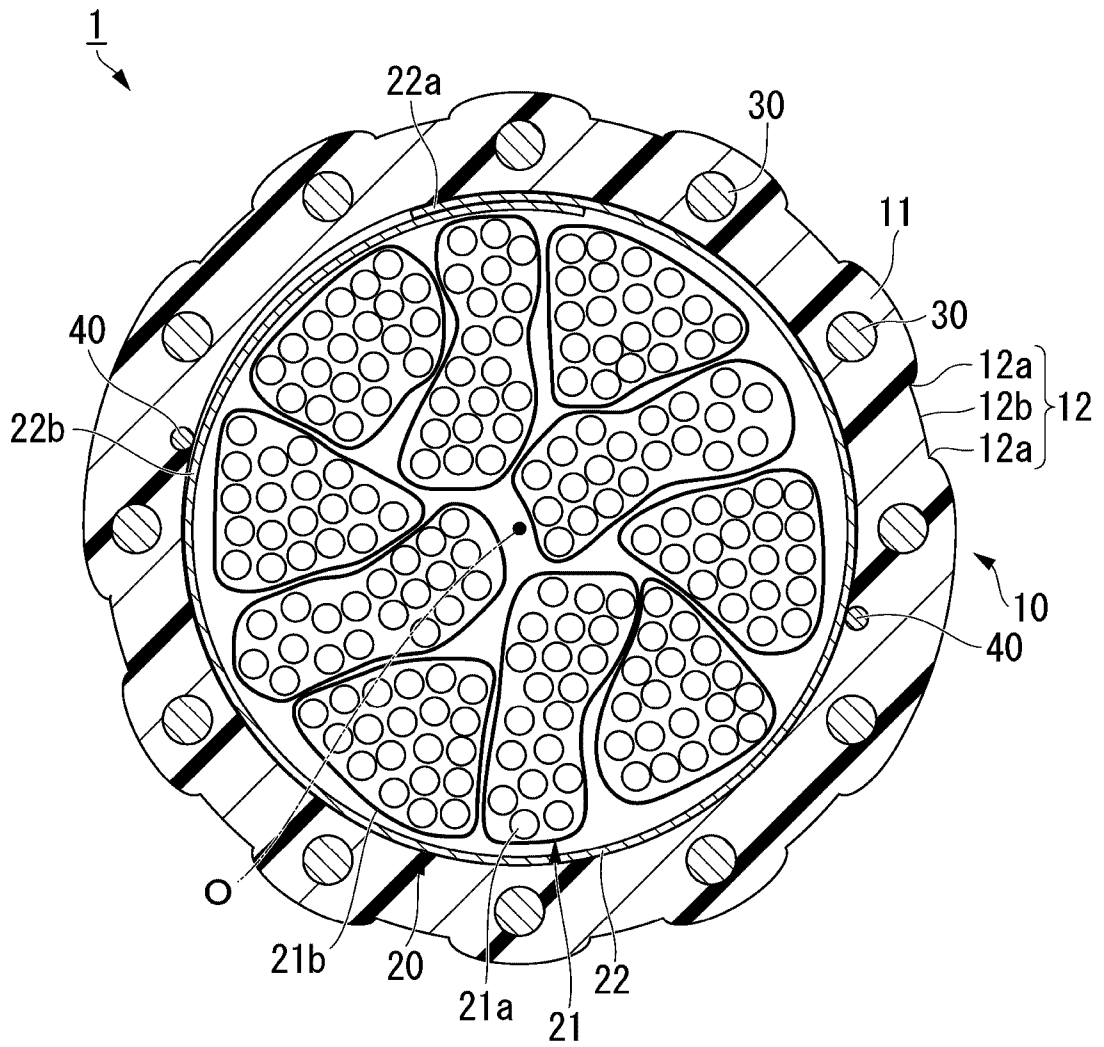


FIG. 14A

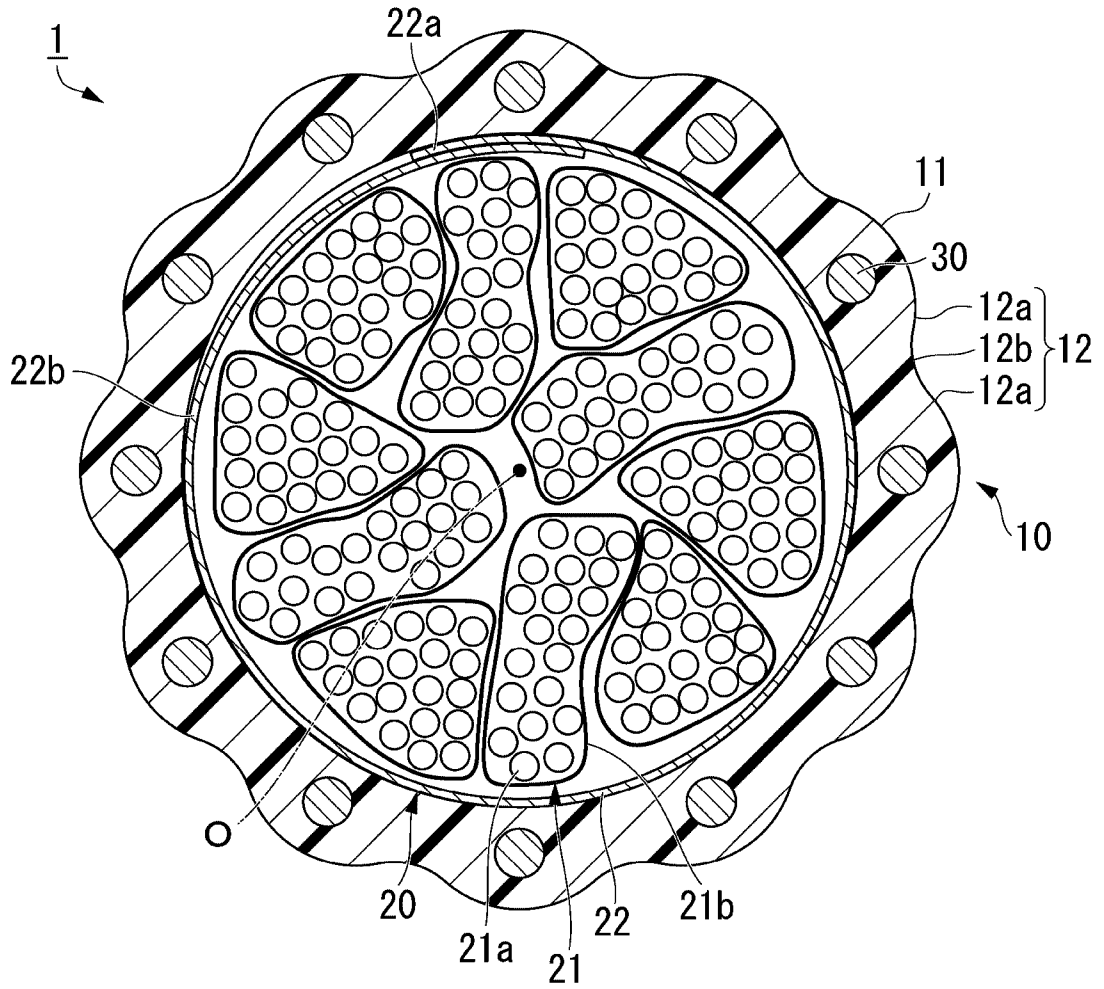
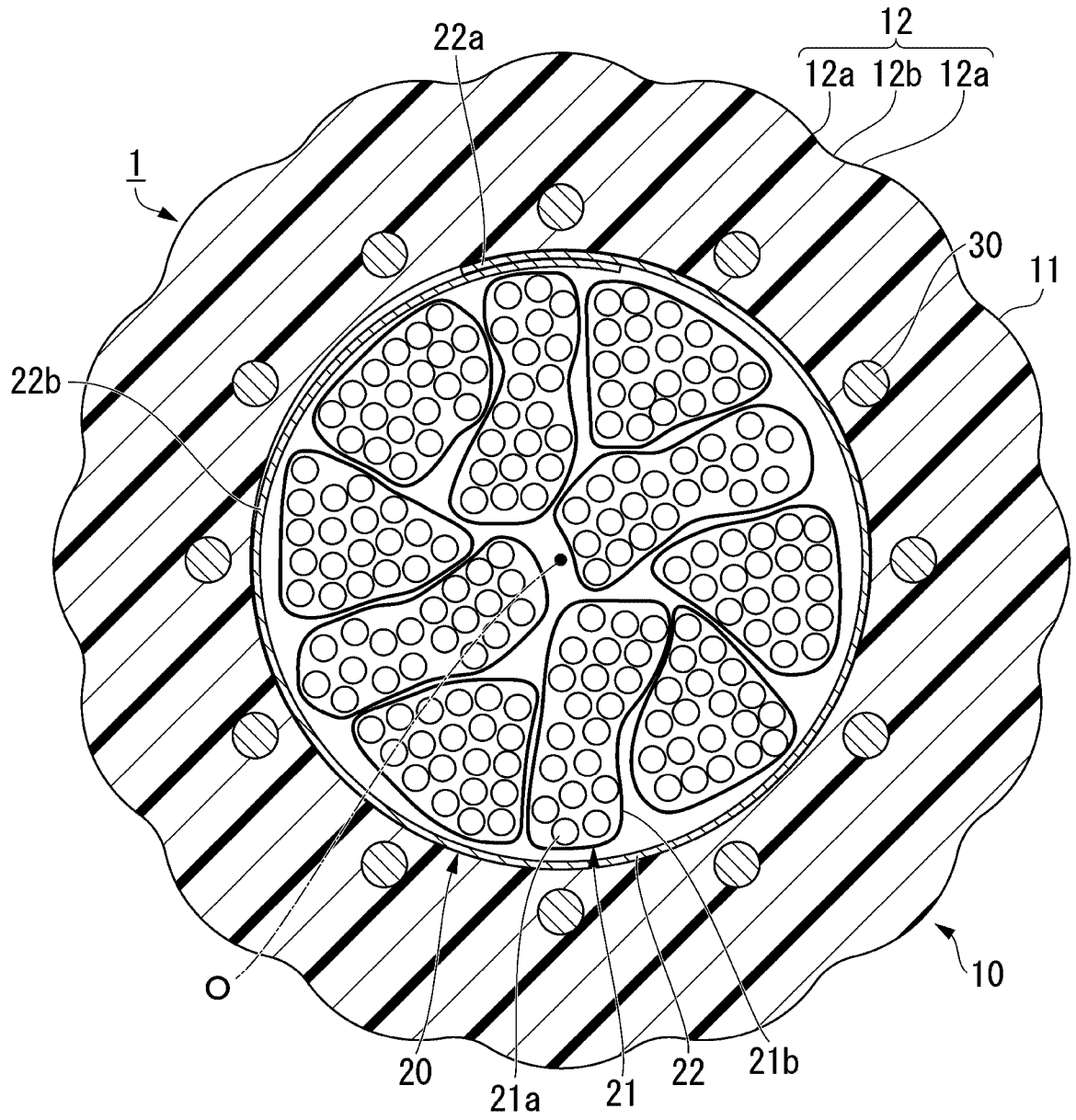


FIG. 14B



[図1A]

