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Takasu et al.

(54) **CABLE CONNECTION MEMBER AND CABLE CONNECTION STRUCTURE**

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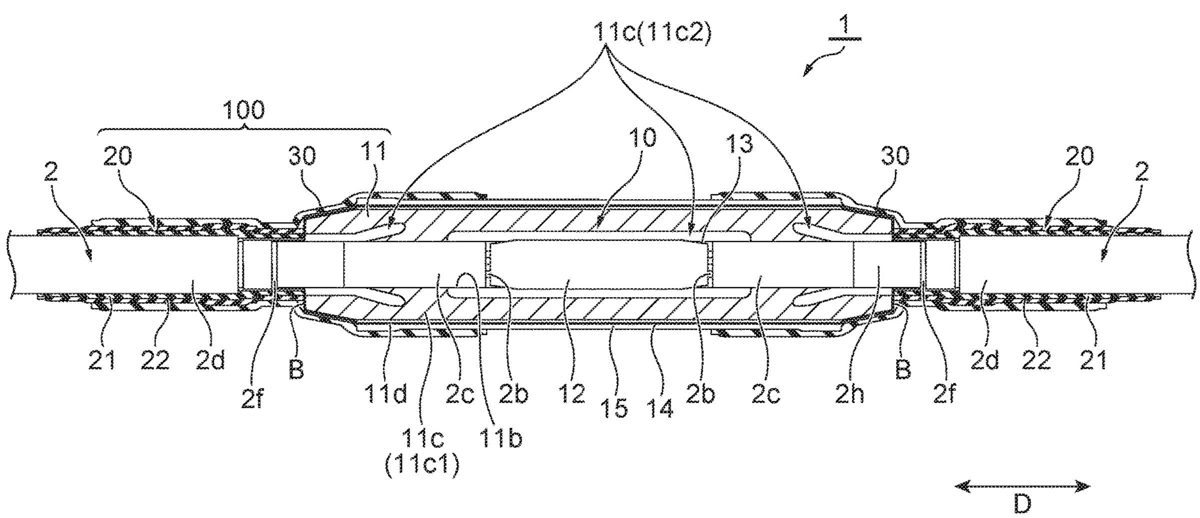
(57) **ABSTRACT**

A cable connection member comprises a cold shrink tube, an impervious layer provided inside the cold shrink tube, and a cushion layer provided inside the cold shrink tube and bonded to an entire surface of the impervious layer.



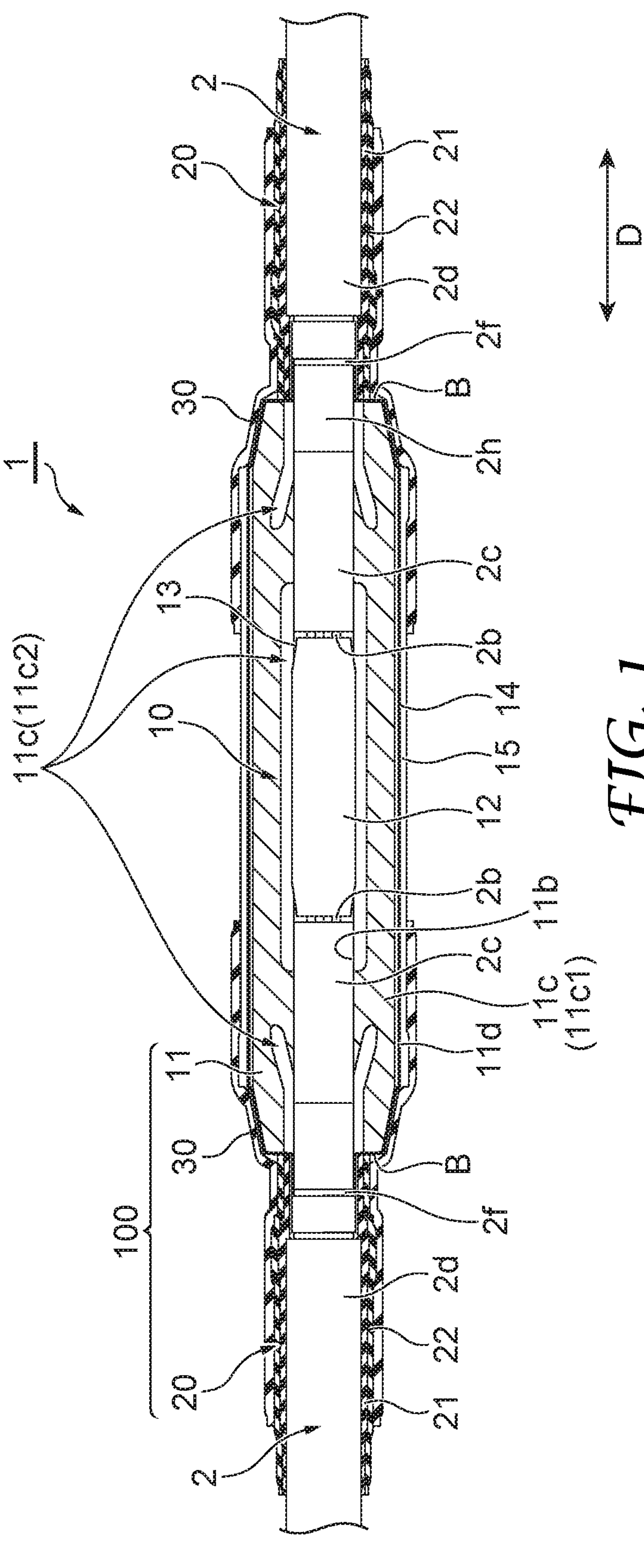

1
2
20
21
22
2d
2f
30
B
2h
2c
13
2b
11c(11c2)
10
14
15
12
11b
11c
(11c1)
11d
11
100
D

FIG. 1

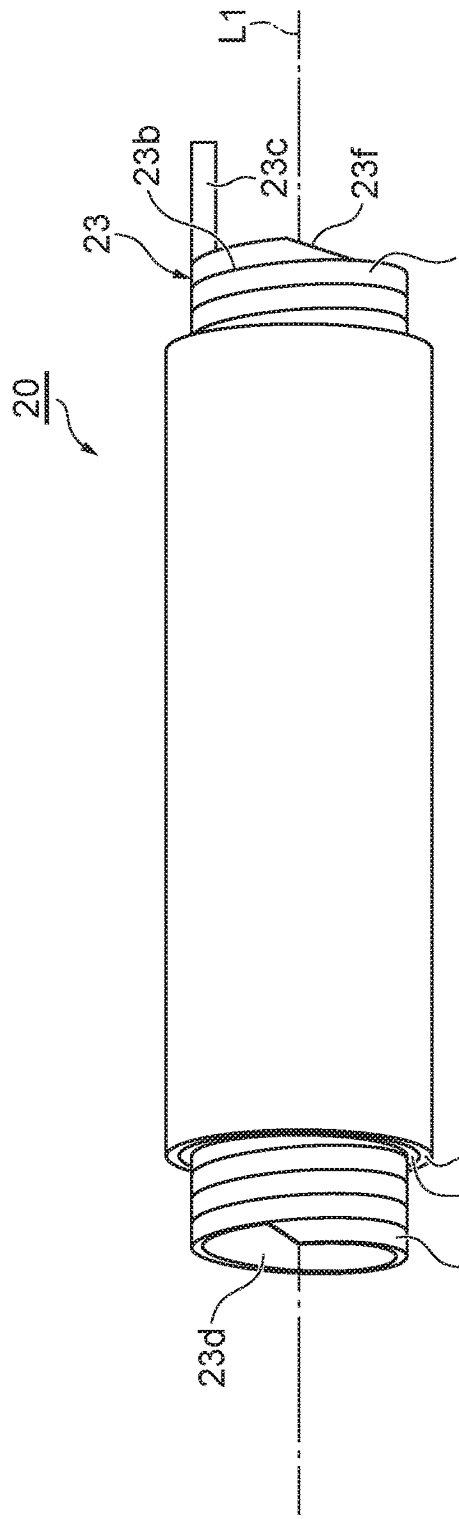

20
23
23b
23c
23f
23g
L1
22
21
23g
23d

FIG. 2A

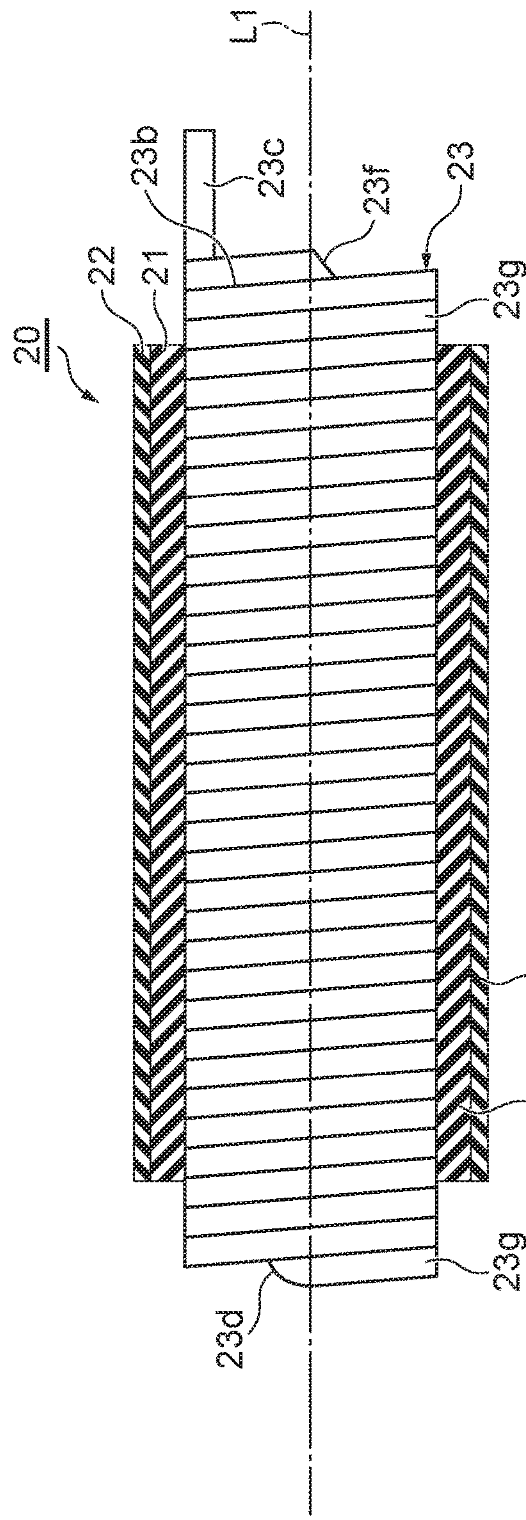

20
22
21
23b
23c
23f
23
23g
L1
22
21
23g
23d

FIG. 2B

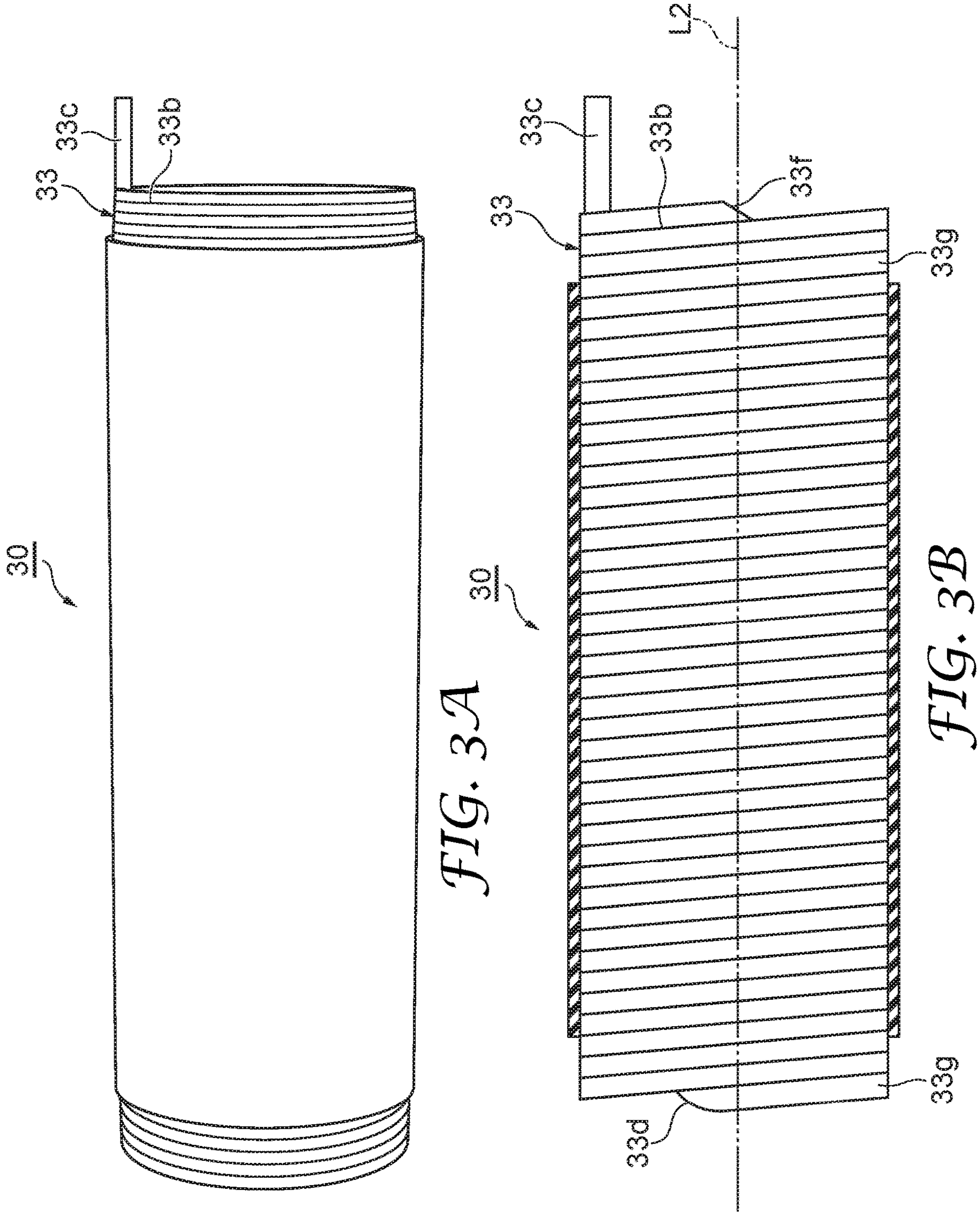


FIG. 3A

FIG. 3B

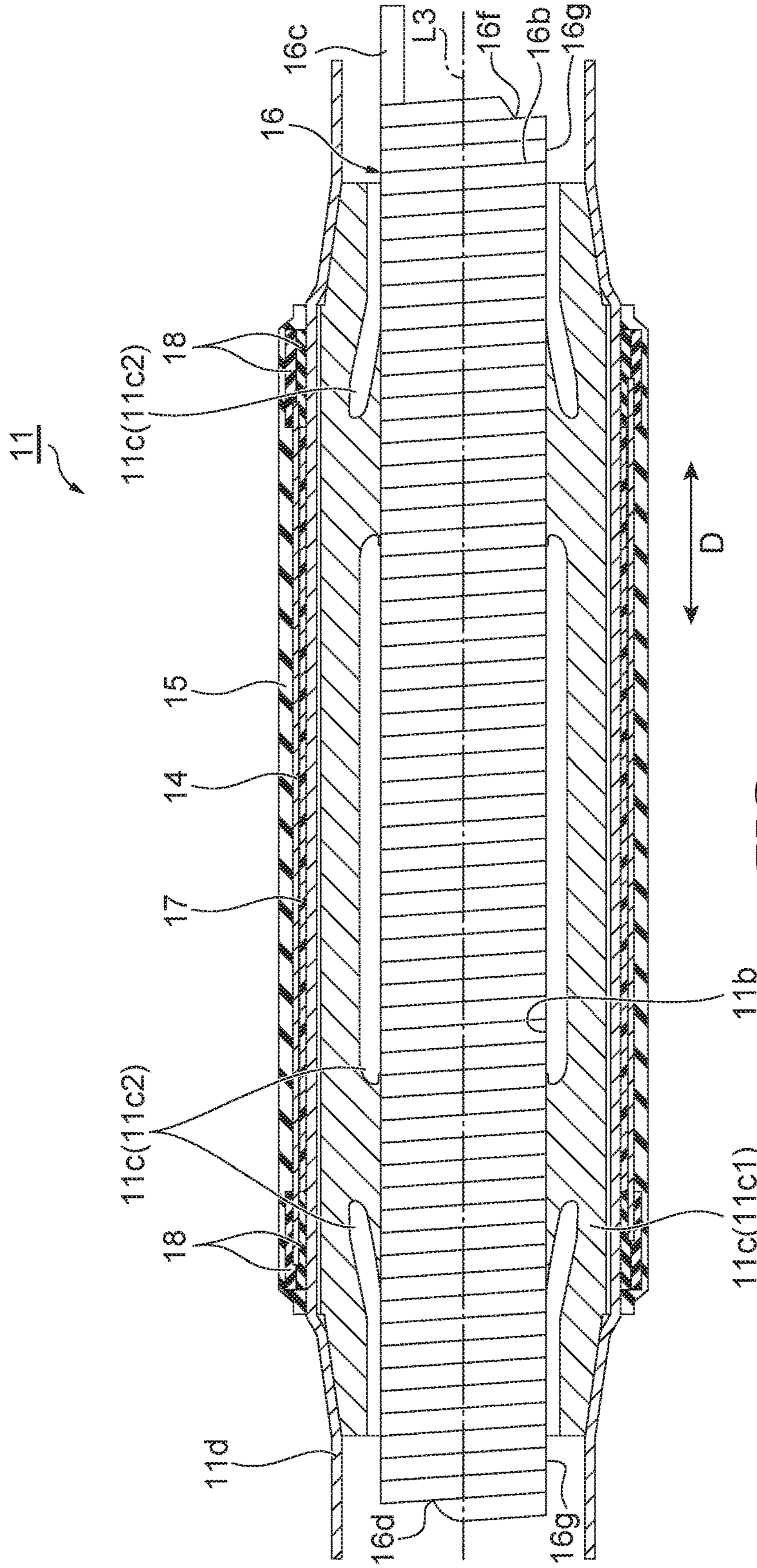

11
16c
L3
16f
16b
16g
16
18
11c(11c2)
D
15
14
17
11b
11c(11c2)
18
11c(11c1)
11d
16d
16g

FIG. 4

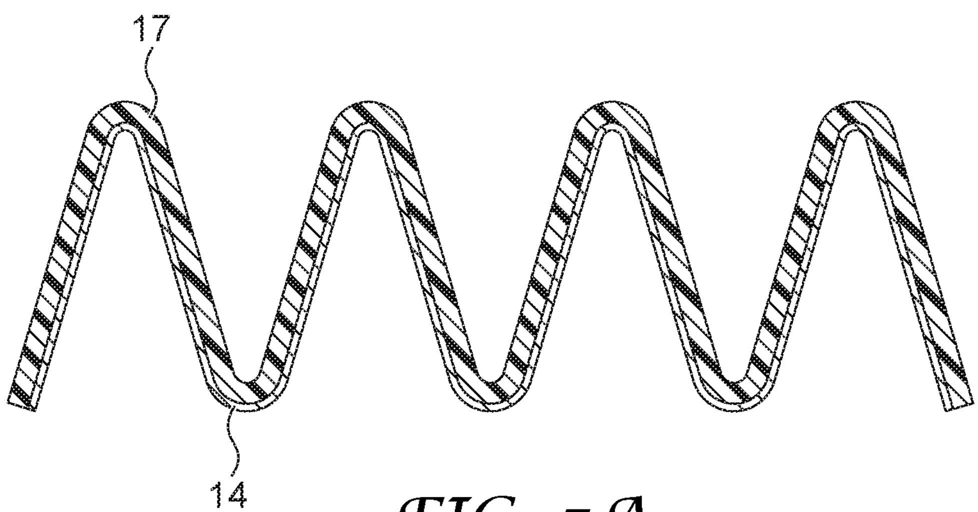


FIG. 5A

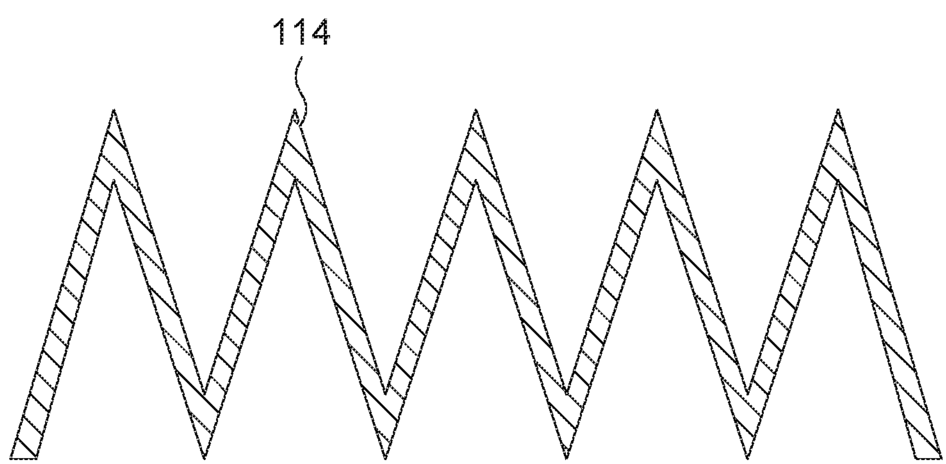


FIG. 5B

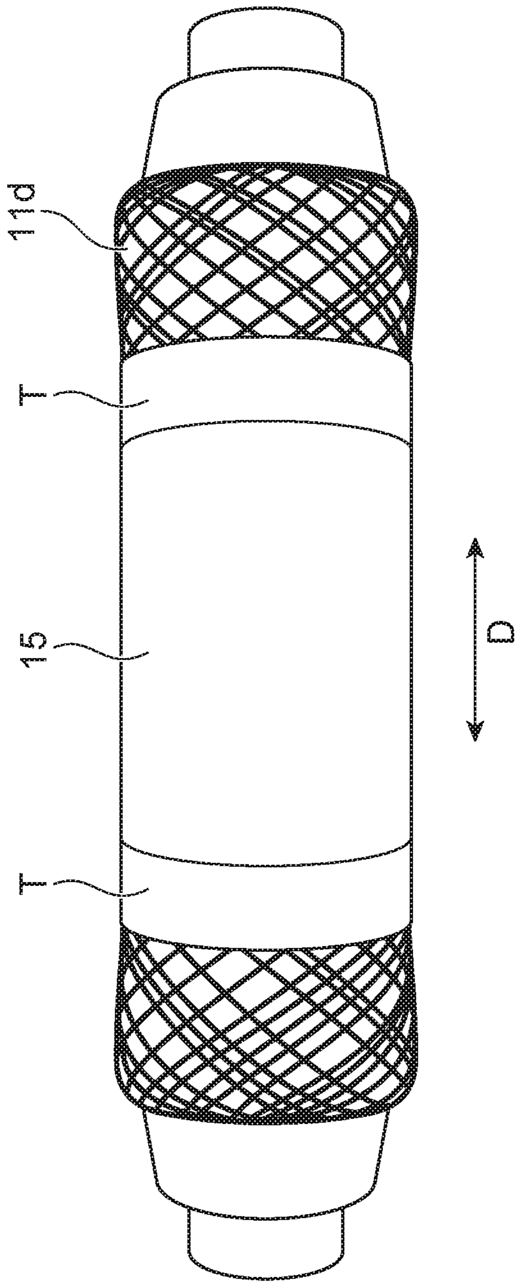


FIG. 6

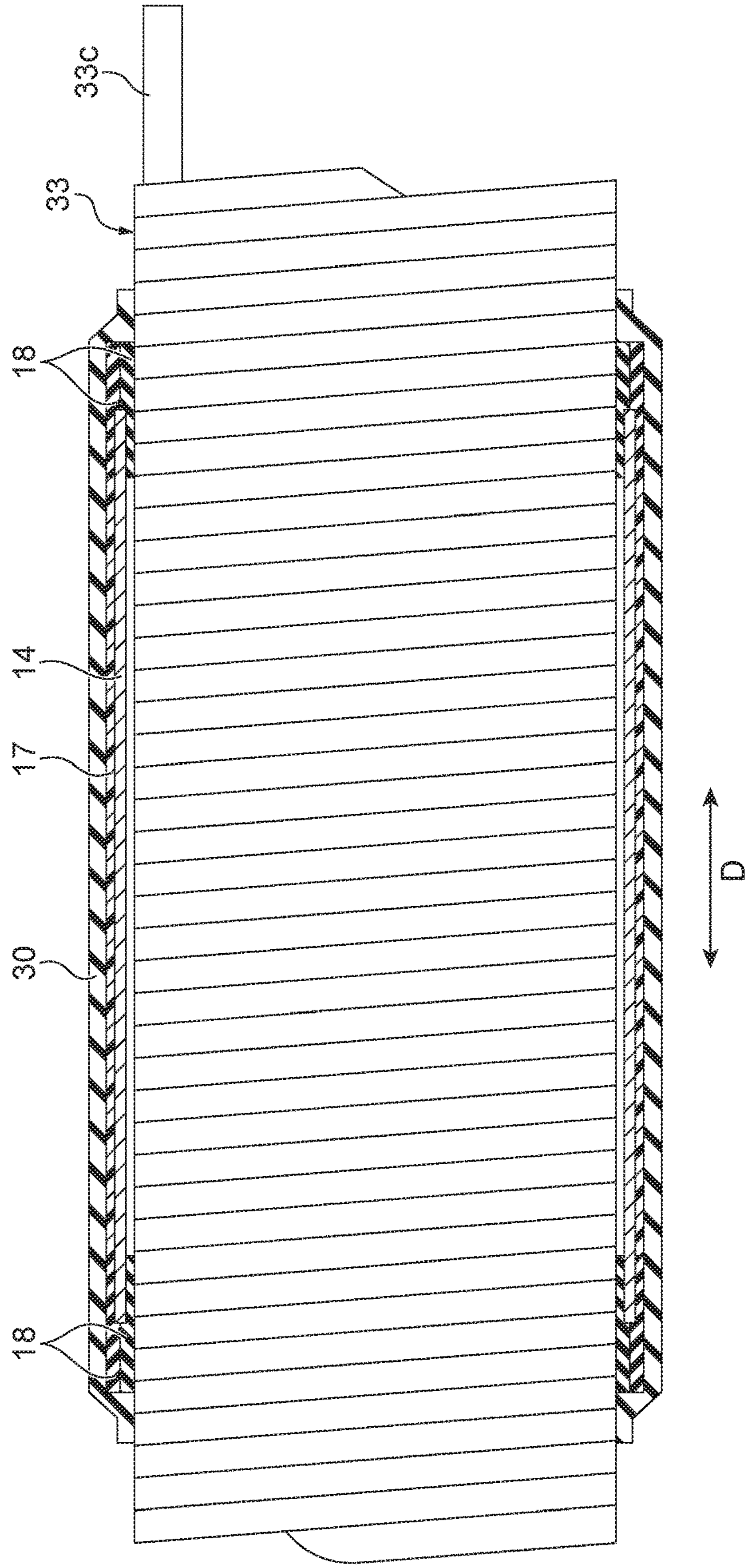


FIG. 7

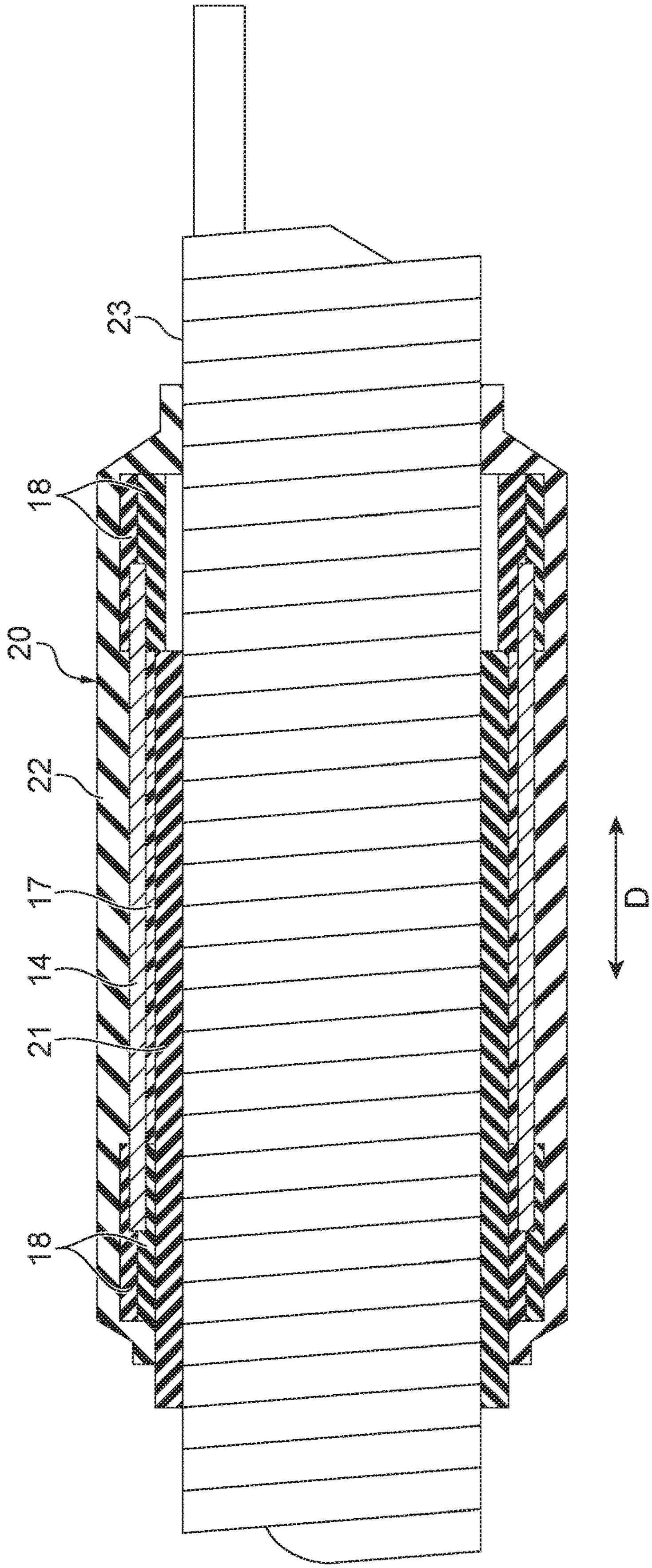


FIG. 8

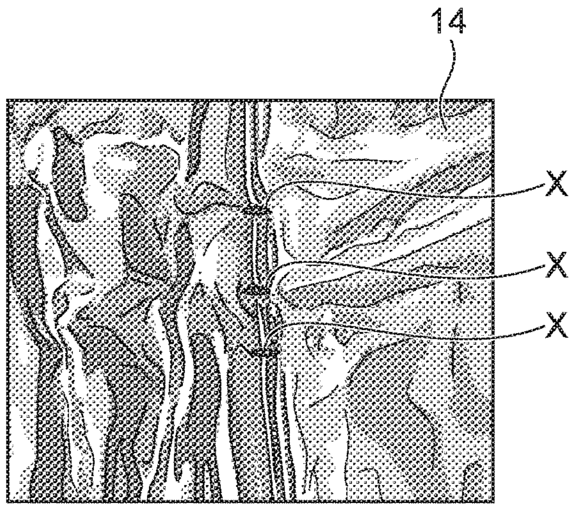


FIG. 9A

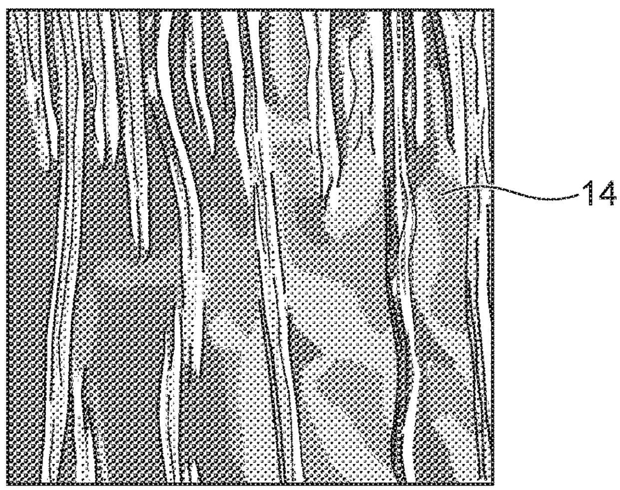


FIG. 9B

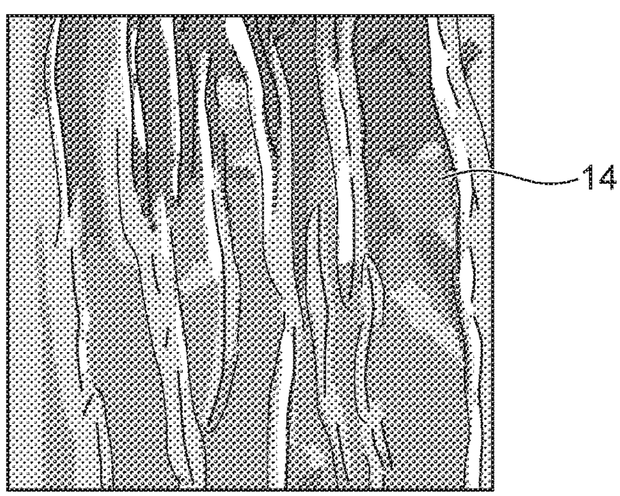


FIG. 9C

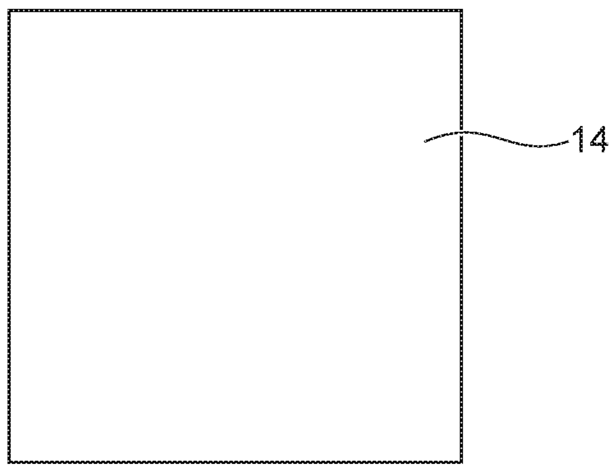


FIG. 10A

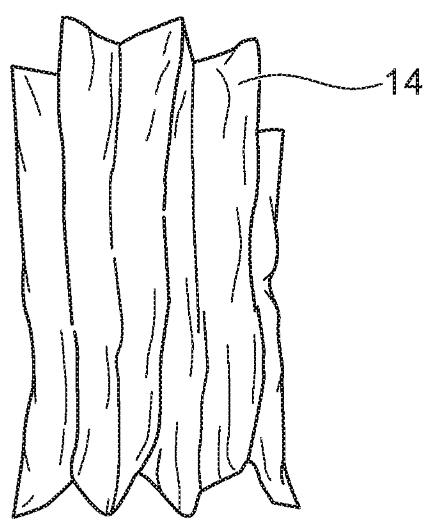


FIG. 10B

FIG. 11A

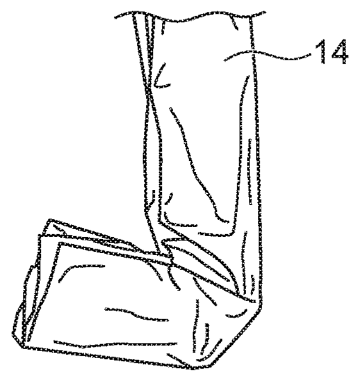


FIG. 11B

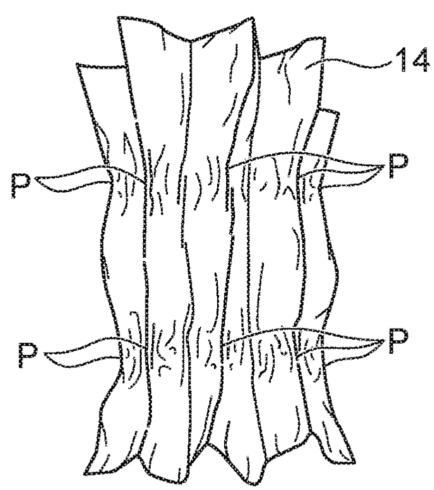


FIG. 11C

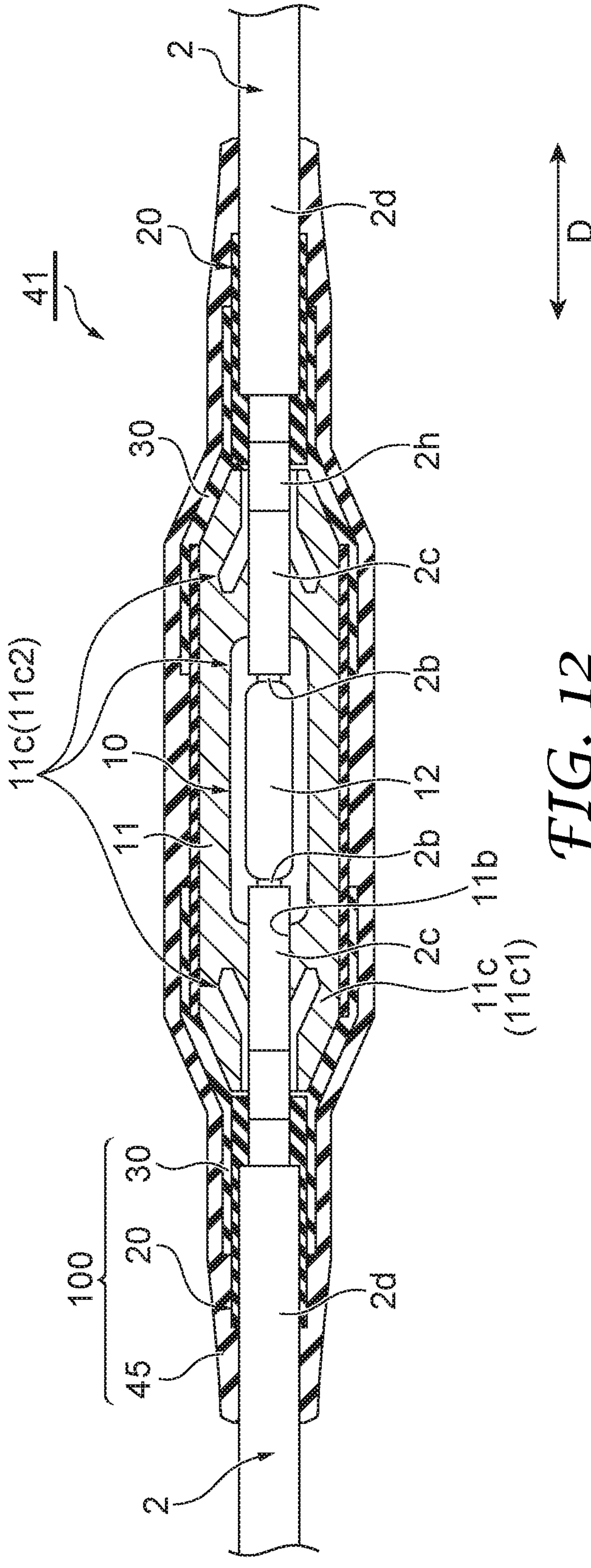

2
2d
20
D
41
30
2h
2c
11c(11c2)
2b
10
12
11
2b
11b
2c
11c
(11c1)
30
100
20
2d
45
2

FIG. 12

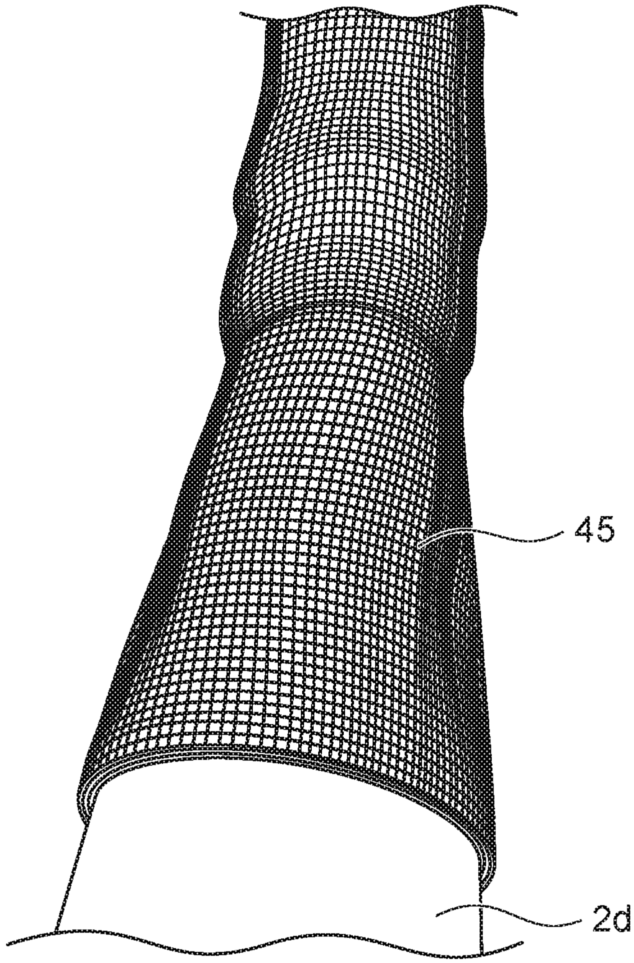


FIG. 13

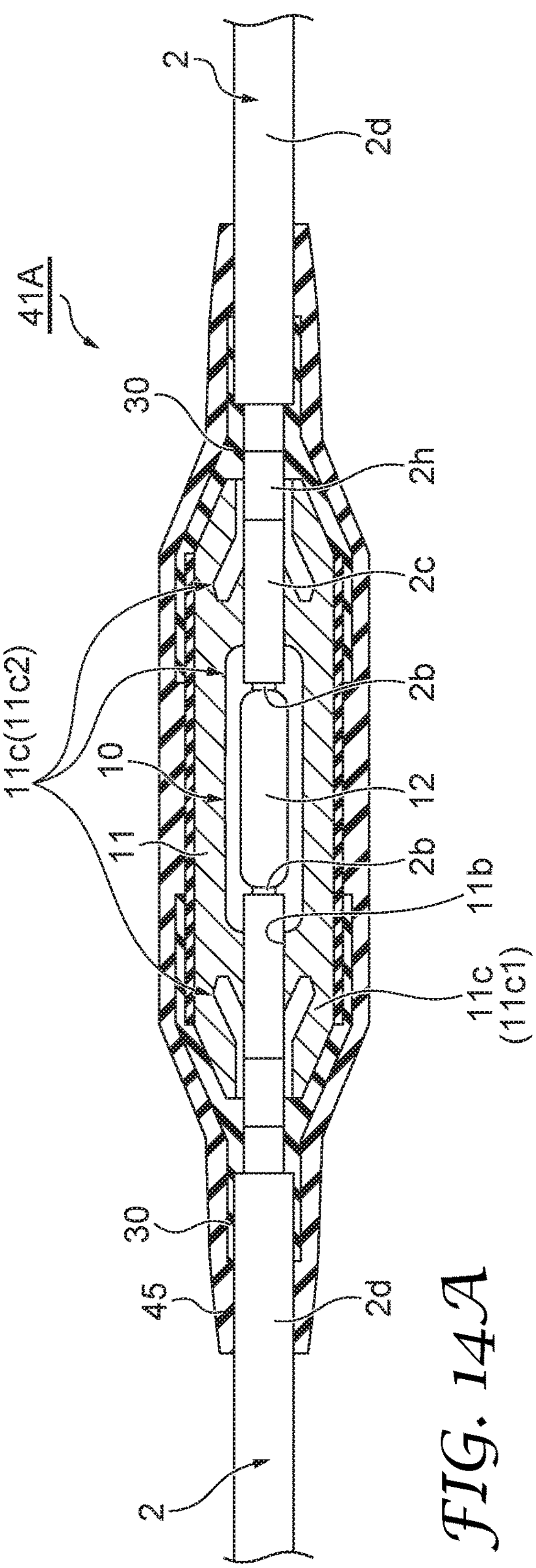


FIG. 14A

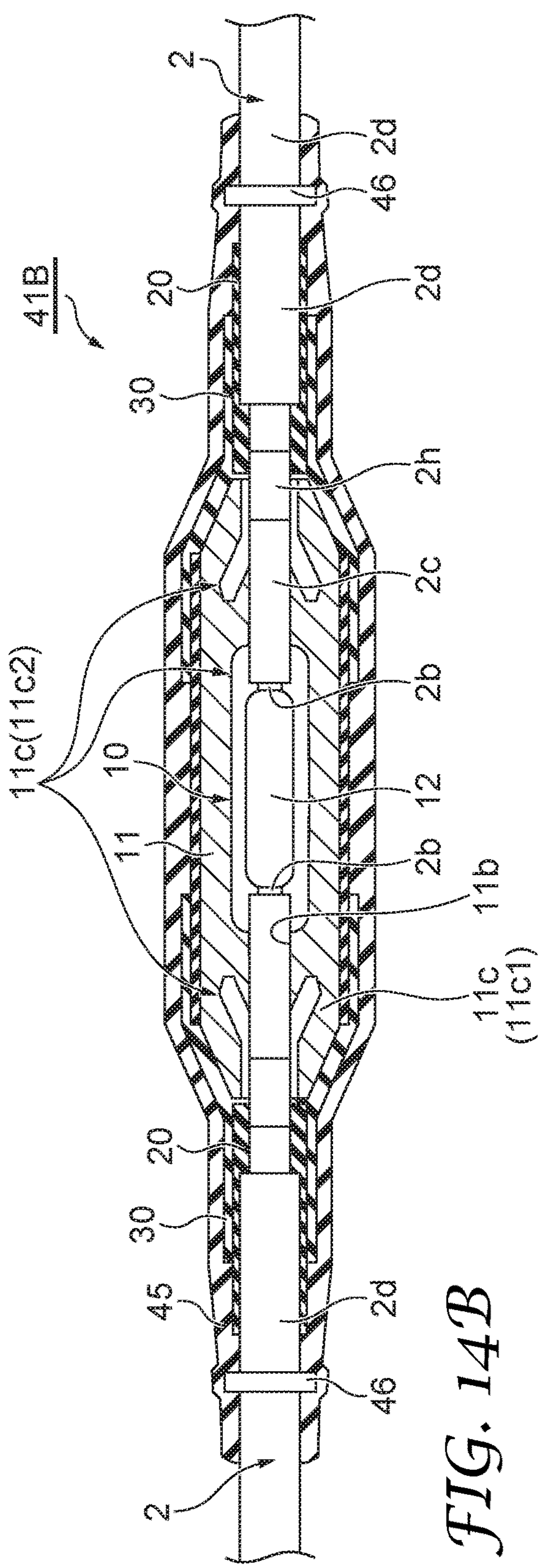


FIG. 14B

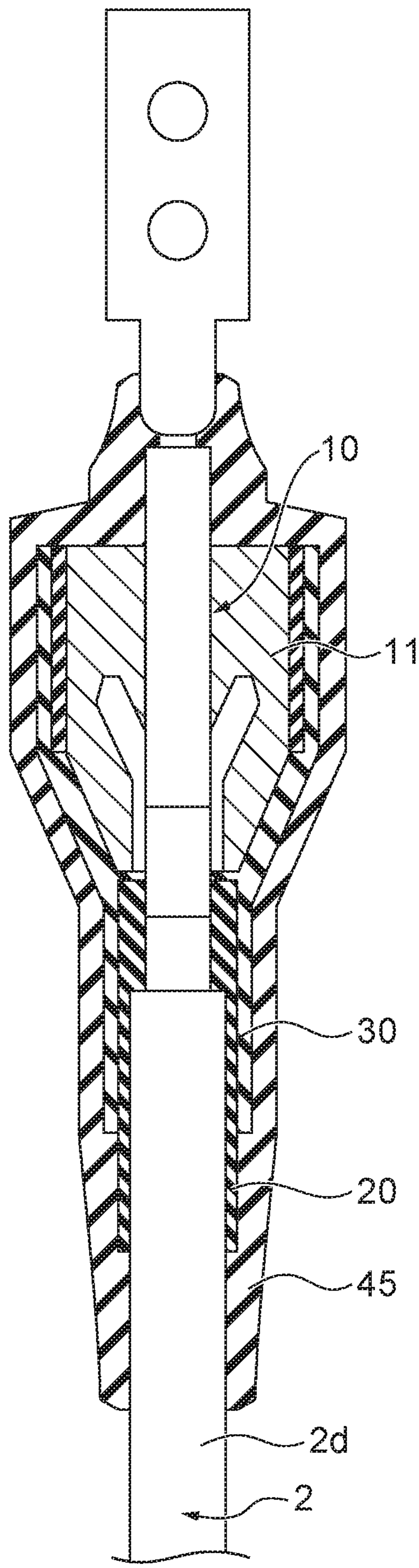


FIG. 15

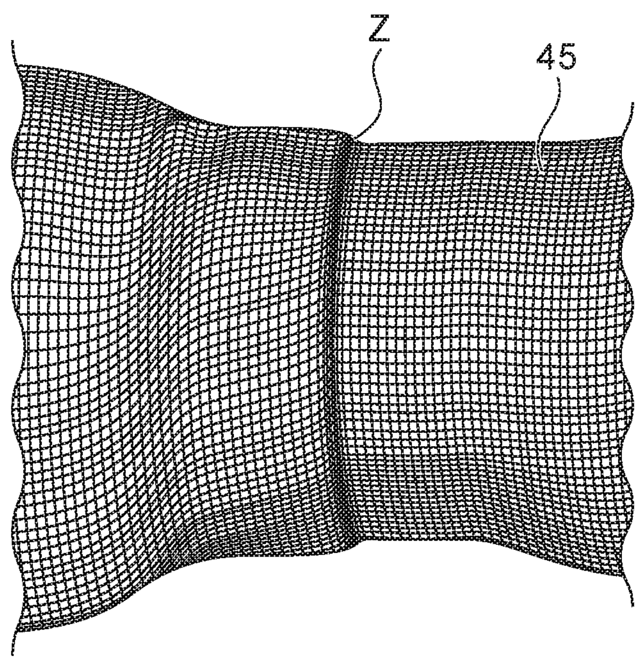


FIG. 16

CABLE CONNECTION MEMBER AND CABLE CONNECTION STRUCTURE

TECHNICAL FIELD

[0001] The present disclosure relates to a cable connection member and a cable connection structure.

BACKGROUND

[0002] Patent Document 1 describes an impervious cold shrinkable tube. The impervious cold shrinkable tube includes a disassemblable tubular core, two layers of cold shrinkable tube layers supported on the tubular core with diameters elastically expanded, an impervious layer, and an adhesive layer. The impervious layer is formed by wrapping a metal foil in a tubular shape in a circumferential direction and overlapping both side edges that are opposed of the metal foil, and is interposed between the two layers of the cold shrinkable tube layers. The adhesive layer is formed by adhering to inner and outer peripheral surfaces of the impervious layer, and brings the impervious layer into close contact with the cold shrinkable tube layers.

[0003] Patent Document 2 describes an impervious tube. The impervious tube is an impervious tube provided with an impervious layer formed by forming a metal foil on which a rubber or a plastic film is layered in a cylindrical shape such that both side edges overlap and fusing or bonding the overlapping portions. A non-permeable cushion layer made of an olefin-based foam material is layered on the inner surface of the impervious layer. An adhesive seal layer is provided on the inner surface of the cushion layer at the end portion of the impervious tube, and is attached to an outer periphery of a cable connection portion for use.

CITATION LIST

Patent Literature

[0004] Patent Document 1: JP 2001-231150 A

[0005] Patent Document 2: JP 2004-201378 A

SUMMARY

Technical Problem

[0006] In the case of a cable connection member including a cold shrink tube and an impervious layer made of a metal foil, there is a concern that when the cold shrink tube is shrunk, the impervious layer bends and a hole is formed in the impervious layer. The hole in the impervious layer fails to obtain desired moisture-proof performance. In the impervious tube described above, the cushion layer is layered on the inner surface of the impervious layer. However, even in the impervious tube provided with the cushion layer, there is still a concern that when the tube is shrunk, the impervious layer bends and a hole is formed in the impervious layer. Therefore, reducing the bending of the impervious layer is requested.

Solution to Problem

[0007] A cable connection member according to the present disclosure includes a cold shrink tube, an impervious layer, and a cushion layer. The impervious layer is provided inside the cold shrink tube. The cushion layer is provided inside the cold shrink tube and bonded to an entire surface of the impervious layer.

[0008] The cable connection member can increase impermeability. Since the cushion layer is bonded to the impervious layer, bending of the impervious layer that possibly occurs when the cold shrink tube shrinks can be reduced with the cushion layer. That is, even when the impervious layer bends, a decrease in functionality of the impervious layer due to, for example, formation of a hole in the impervious layer can be suppressed.

[0009] The cushion layer may have a thickness of 1 mm or more and 5 mm or less.

[0010] The cushion layer may have a 25% compressive stress of 30 N/cm^2 or less.

[0011] A base material of the cushion layer may have a shear strength of 150 N/cm^2 or more.

[0012] The cushion layer may have a compression set of 80% or less.

[0013] The cushion layer may be configured by a foam tape.

[0014] The impervious layer may be configured by a layered body of a metal and a resin.

[0015] The cold shrink tube may constitute an insulating tube of a cable connection portion attached to an end portion of a cable.

[0016] The cushion layer may be provided inside the cold shrink tube. The impervious layer may be provided inside the cushion layer.

[0017] The cold shrink tube may include an inner layer and an outer layer located outside the inner layer. The cushion layer and the impervious layer may be provided between the inner layer and the outer layer.

[0018] A cable connection structure according to the present disclosure includes a cold shrink tube, an impervious layer, and a cushion layer. The cold shrink tube of an insulating tube of a cable connection portion is attached to an end portion of a cable. The impervious layer is provided inside the cold shrink tube. The cushion layer is provided inside the cold shrink tube and bonded to an entire surface of the impervious layer.

[0019] In this cable connection structure, the impervious layer is provided inside the cold shrink tube of the insulating tube, and thus impermeability in the insulating tube can be enhanced. Since the cushion layer is bonded to the impervious layer, bending of the impervious layer can be reduced with the cushion layer. That is, even when the impervious layer bends, a decrease in functionality of the impervious layer due to, for example, formation of a hole in the impervious layer can be suppressed.

[0020] The cable connection structure described above may include an outer cold shrink tube, a cushion layer, and an impervious layer. The outer cold shrink tube may cover at least a portion of the cable connection portion. The cushion layer may be provided inside the outer cold shrink tube. The impervious layer may be provided inside the cushion layer.

[0021] The cable connection structure described above may include an inner cold shrink tube provided inside the outer cold shrink tube. The inner cold shrink tube may include an inner layer and an outer layer located outside the inner layer. The inner cold shrink tube may include an impervious layer provided between the inner layer and the outer layer and a cushion layer provided between the outer layer and the impervious layer.

[0022] The cable connection structure described above may include a sheath cover member that covers the outer cold shrink tube and a cable sheath of the cable.

[0023] A cable connection structure according to another aspect of the present disclosure includes a cable connection portion attached to an end portion of a cable. The cable connection structure includes a sheath cover member that covers a cable sheath of the cable and the cable connection portion. This cable connection structure includes the sheath cover member that covers the cable sheath and the cable connection portion. Accordingly, the sheath cover member covering the cable sheath allows suppressing shrink back as a phenomenon in which the cable sheath shrinks in a longitudinal direction of the cable.

[0024] The cable connection structure described above may include a band member attached to the cable sheath and located inside the sheath cover member.

Advantageous Effects of Invention

[0025] According to the present disclosure, a cold shrink tube, for example, that have an impervious layer built-in and suppresses a decrease in functionality can be provided.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** is a cross-sectional view illustrating an example of a cable connection structure according to an embodiment.

[0027] FIG. **2**A is a drawing illustrating an example of an inner cold shrink tube according to an embodiment. FIG. **2**B is a cross-sectional view illustrating an example of the inner cold shrink tube according to an embodiment.

[0028] FIG. **3**A is a drawing illustrating an example of an outer cold shrink tube according to an embodiment. FIG. **3**B is a cross-sectional view illustrating an example of the outer cold shrink tube according to an embodiment.

[0029] FIG. **4** is a cross-sectional view illustrating an insulating tube of a cable connection portion according to an embodiment as an example.

[0030] FIG. **5**A is a drawing schematically illustrating a behavior of an impervious layer when a cushion layer is provided. FIG. **5**B is a drawing schematically illustrating a behavior of the impervious layer in a case where the cushion layer is not provided.

[0031] FIG. **6** is a drawing illustrating the insulating tube according to an embodiment.

[0032] FIG. **7** is a cross-sectional view illustrating the outer cold shrink tube according to an embodiment.

[0033] FIG. **8** is a cross-sectional view illustrating the inner cold shrink tube according to an embodiment.

[0034] FIG. **9**A is a drawing illustrating an experimental result of an impervious layer according to a comparative example. FIG. **9**B and FIG. **9**C are drawings illustrating experimental results of impervious layers according to examples.

[0035] FIGS. **10**A and **10**B are drawings for describing a method of experiment of the impervious layer.

[0036] FIG. **11**A, FIG. **11**B, and FIG. **11**C are drawings for describing the method of experiment of the impervious layer.

[0037] FIG. **12** is a cross-sectional view illustrating an example of a cable connection structure according to another embodiment.

[0038] FIG. **13** is a perspective view illustrating a sheath cover member of the cable connection structure in FIG. **12**.

[0039] FIG. **14**A and FIG. **14**B are cross-sectional views illustrating cable connection structures according to modified examples.

[0040] FIG. **15** is a drawing for describing an experiment of a cable connection structure according to another embodiment.

[0041] FIG. **16** is a drawing illustrating experimental results of a sheath cover member.

DETAILED DESCRIPTION

[0042] The following will describe details of embodiments of a cable connection structure, a cable connection member, an inner cold shrink tube (Inner Pre-Stretched Tube, Inner Cold Shrink PST Tube), and an outer cold shrink tube (Outer Pre-Stretched Tube, Outer Cold Shrink PST Tube) according to the present embodiment with reference to the drawings. In the description of the drawings, the same or corresponding elements are denoted by the same reference signs, and redundant description will be appropriately omitted. In addition, the drawings may be simplified or exaggerated in part for ease of understanding, and the dimensional ratios, etc. are not limited to those illustrated in the drawings.

[0043] First, the term “cable” used herein includes a power cable such as a CVT cable, an insulated wire, and a communication cable, and encompasses a wide variety of cables. “Cable Connection Portion” includes a connection portion that connects a plurality of cables one another, and the periphery of the connection portion, a connection portion that connects each of the cables and a connector, and the periphery of the connection portion, and a connection portion that connects the cable and equipment other than the connector, and the periphery of the connection portion. The term “inside” according to the present disclosure refers to a cable side in a member covering the cable, that is, the inside of the cable in the radial direction. The “outside” refers to an opposite side of the cable in the member covering the cable, that is, the outside of the cable in the radial direction.

[0044] As illustrated in FIG. **1**, a cable connection structure **1** according to the present embodiment includes a pair of cables **2**, a cable connection portion **10** connecting the pair of cables **2** together, a pair of inner cold shrink tubes **20** covering the cables **2**, and a pair of outer cold shrink tubes **30** covering the cable connection portion **10** and the inner cold shrink tubes **20**. The cable **2** is, as an example, a power cable of rated 66 kV. However, the cable **2** may be a power cable of 6 kV, 22 kV, or 33 kV. The cable **2** includes, for example, a conductor **2***b*, an insulating layer **2***c* covering the conductor **2***b*, an external semi-conductive layer **2***h* covering the insulating layer **2***c*, a shielding copper tape **2***f* covering the external semi-conductive layer **2***h*, and a cable sheath **2***d* covering the shielding copper tape **2***f*. The conductor **2***b* has a cross-sectional area of, as an example, 80 (mm^2) or more and 600 (mm^2) or less, and the cable connection portion **10** has an outer diameter (diameter) of 90 (mm) or more. The cable connection portion **10** has, for example, a larger outer diameter than the cable **2**.

[0045] The outer diameter of the cable connection portion **10** may have a lower limit of 100 (mm), 110 (mm), 120 (mm), or 130 (mm). The outer diameter of the cable connection portion **10** may have an upper limit of 200 (mm), 170 (mm), or 150 (mm). For example, the outer diameter of the cable connection portion **10** is 135 (mm) or more and 145 (mm) or less. However, the outer diameter of the cable connection portion **10** is not limited to the values described above, and is not particularly limited.

[0046] The cable connection portion **10** is provided at the end portions of the cables **2**, and, for example, connects the end portions of the pair of cables **2** to one another. One of the cables **2**, the cable connection portion **10**, and the other cable **2** are disposed in alignment along a longitudinal direction D of the cable connection structure **1**. A cable connection member **100** according to the present embodiment includes, for example, an insulating tube **11** constituting the cable connection portion **10**, the inner cold shrink tubes **20** covering portions adjacent to the cable connection portion **10**, and the outer cold shrink tubes **30** covering the cable connection portion **10** and the inner cold shrink tubes **20**. However, the cable connection member **100** may include one or two of the insulating tube **11**, the inner cold shrink tubes **20**, and the outer cold shrink tubes **30**.

[0047] FIG. **2**A is a perspective view illustrating an appearance of the inner cold shrink tube **20** as an example. FIG. **2**B is a schematic cross-sectional view of the inner cold shrink tube **20**. As illustrated in FIG. **2**A and FIG. **2**B, the inner cold shrink tube **20** includes an inner layer **21** and an outer layer **22** covering the inner layer **21**. The inner layer **21** and the outer layer **22** are separable from one another, for example.

[0048] The inner cold shrink tube **20** may include an expanded diameter holding member **23** that holds the inner layer **21** and the outer layer **22** with diameters expanded. The expanded diameter holding member **23** includes a disassembly line **23***b* formed in a direction in which the axis L**1** of the expanded diameter holding member **23** extends (hereinafter, also referred to as an axial direction). The expanded diameter holding member **23** is, for example, a cylindrical, tubular hollow member. The disassembly line **23***b* is formed such that the line advances gradually in the axial direction while revolving or revolving and reversing around the axis L**1** of the expanded diameter holding member **23**.

[0049] As a material of the expanded diameter holding member **23**, a resin material, such as polyethylene or polypropylene, is used, for example. The expanded diameter holding member **23** can be pulled out along the disassembly line **23***b* as a core ribbon **23***c* that has a string-like body. The portion where the disassembly line **23***b* is formed is thinner than the remaining surrounding portion, and is easily ruptured.

[0050] The disassembly line is not limited to an aspect in which the disassembly line is spirally formed like the disassembly line **23***b*, and, for example, may be formed in an SZ shape, or can have any shape as long as the expanded diameter holding member **23** can be pulled out. Pulling the core ribbon **23***c* sequentially ruptures the expanded diameter holding member **23** along the disassembly line **23***b*, and is continuously pulled out as the new core ribbon **23***c*. The disassembly line **23***b* is formed, for example, with a constant pitch, and in this case, the width of the core ribbon **23***c* pulled out is constant. However, the width of the core ribbon **23***c* need not be constant.

[0051] The disassembly line **23***b* may be formed only on an inner circumferential surface of the expanded diameter holding member **23**, or may be formed only on an outer circumferential surface of the expanded diameter holding member **23**, or may be formed on both the inner circumferential surface and the outer circumferential surface of the expanded diameter holding member **23**. The expanded diameter holding member **23** with the disassembly line **23***b* may be manufactured, for example, by spirally turning the disassembly line **23***b*, while fixing adjacent portions of the disassembly line **23***b* one another by bonding, welding, engagement, or a combination thereof, or may be manufactured by directly forming the disassembly line **23***b* in a cylindrical member.

[0052] As described above, the tubular, hollow expanded diameter holding member that can be pulled out may be in an aspect in which the core ribbon **23***c* is pulled to sequentially shrink the inner cold shrink tube as is the case with the expanded diameter holding member **23**, or in an aspect in which the expanded diameter holding member slides relative to the inner cold shrink tube and is pulled out from the inner cold shrink tube to be separated. The expanded diameter holding member **23** includes a first end portion **23***d* corresponding to a start point side for pulling out the expanded diameter holding member **23** as the core ribbon **23***c*, and a second end portion **23***f* corresponding to an end point side for pulling out the expanded diameter holding member **23** as the core ribbon **23***c*. In the vicinity of the first end portion **23***d*, an exposed portion **23***g* is formed in which the inner cold shrink tube **20** is not installed, with the outer circumferential surface of the expanded diameter holding member **23** exposed, and the exposed portion **23***g* is also formed in the vicinity of the second end portion **23***f*.

[0053] The core ribbon **23***c* disassembled from the first end portion **23***d* is passed through the inside of the expanded diameter holding member **23** and pulled out from the second end portion **23***f* side. The core ribbon **23***c* is pulled out on the second end portion **23***f* side, and thus the expanded diameter holding member **23** is sequentially disassembled from the first end portion **23***d* toward the second end portion **23***f*. In the present embodiment, the core ribbon **23***c* is formed all over the length in the axial direction, and thus the expanded diameter holding member **23** can be completely disassembled from the first end portion **23***d* to the second end portion **23***f*. However, the disassembly line **23***b* only needs to be formed in at least a portion of the expanded diameter holding member **23** in which the inner cold shrink tube **20** is held with an expanded diameter, and, for example, a portion where the disassembly line **23***b* is not formed may be present in a predetermined region on the second end portion **23***f* side.

[0054] For example, the inner cold shrink tube **20** is a member held with an expanded diameter on the outer circumference side of the expanded diameter holding member **23**. The inner cold shrink tube **20** covers a portion of the cable **2** located adjacent to the cable connection portion **10**. For example, the inner peripheral surface of the inner layer **21**, the outer peripheral surface of the inner layer **21**, the inner peripheral surface of the outer layer **22**, and the outer peripheral surface of the outer layer **22** have smooth surfaces. The "smooth surface" refers to a smooth surface that does not have a pointed portion or an unevenness portion.

[0055] Each of the inner layer **21** and the outer layer **22** is formed of, for example, a rubber that shrinks at normal temperature and has excellent stretching properties. Each of the inner layer **21** and the outer layer **22** is made of, for example, a material having waterproof properties. In this regard, "has waterproof properties" refers to a state in which an external liquid can be prevented from entering to inside with the inner cold shrink tube **20** being shrunk. "Has waterproof properties" refers to, for example, IPX7 specified in JIS C 0920 "degree of protection (IP code) provided by enclosure of electrical machinery and equipment" (when the article is immersed in water at a water depth of 1 m for 30 minutes, no water enters inside). The material of the inner layer **21** and the outer layer **22** is, for example, Ethylene Propylene Diene rubber (EPDM). The material of the inner layer **21** and the material of the outer layer **22** may be the same as or different from one another.

[0056] The thickness of the inner layer **21** is, for example, 4.5 (mm) or more and 8.5 (mm) or less. The thickness of the inner layer **21** may have a lower limit of 5 (mm), 5.5 (mm), 6 (mm), or 6.5 (mm). The thickness of the inner layer **21** may have an upper limit of 8 (mm), 7.5 (mm), or 7 (mm). Note that the value of the thickness of the inner layer **21** and the value of the thickness of the outer layer **22** are not limited to the respective examples described above, and are not particularly limited.

[0057] The inner layer **21** covers a portion of the cable **2** adjacent to the cable connection portion **10**. For example, the inner layer **21** tightens the adjacent portion. As a result, a high tightening force can be exerted in the portion of the cable **2** adjacent to the cable connection portion **10**. The outer layer **22** approaches the outer diameter of the inner cold shrink tube **20** to the outer diameter of the cable connection portion **10**. "Approaches the outer diameter" means that the outer diameter of the inner cold shrink tube is set such that the outer diameter of the inner cold shrink tube becomes the same extent of the outer diameter of the cable connection portion, that is, the size of the outer diameter of the inner cold shrink tube is set so as to be the same extent of the outer diameter of the cable connection portion.

[0058] In the example of FIG. **1**, the outer layer **22** thickens the inner cold shrink tube **20** such that the outer diameter of the inner cold shrink tube **20** is close to the outer diameter of the cable connection portion **10**. That is, the portion of the outer layer **22** of the inner cold shrink tube **20** of the plurality of layers is thicker than the inner cold shrink tube of the single layer. Note that the single-layer inner cold shrink tube is equivalent to the inner cold shrink tube including only the inner layer **21** without the outer layer **22**, for example. For the purpose of only approaching the outer diameter to the outer diameter of the cable connection portion **10**, which has the large diameter, it is only necessary to use an inner cold shrink tube including only the further thick inner layer **21**. However, the outer diameter of the cable connection portion **10** is not always limited to the large diameter, and is changed as appropriate.

[0059] Therefore, as in the present embodiment, in the case of the inner cold shrink tube **20** having the two-layer structure of the inner layer **21** and the outer layer **22**, the outer layer **22** is attachable/removable in accordance with the outer diameter of the cable connection portion **10**. This allows more reliably approaching the outer diameter of the inner cold shrink tube **20** to the outer diameter of the cable connection portion **10** by attachment/removal of the outer layer **22**. The method of "approaching the outer diameter to the outer diameter of the cable connection portion," as illustrated in FIG. **1** as an example, the outer diameter may be approached to the outer diameter of the cable connection portion by providing the outer layer **22** or by removing the outer layer **22**. In the example of FIG. **1**, the outer diameter of the inner cold shrink tube **20** can be approached to the size of the outer diameter of the cable connection portion **10** with the outer layer **22**, thus contributing to suppression of shrink back.

[0060] FIG. **3**A is a drawing illustrating the outer cold shrink tube **30** according to an embodiment as an example. FIG. **3**B is a cross-sectional view of the outer cold shrink tube **30** as an example. As illustrated in FIGS. **1**, **3**A and **3**B, the outer cold shrink tube **30** covers the cable connection portion **10** and the inner cold shrink tube **20**. The outer cold shrink tube **30** has a larger diameter (outer diameter and inner diameter) than that of the inner cold shrink tube **20**. For example, the outer cold shrink tube **30** has a larger length in the axial direction (longitudinal direction) than that of the inner cold shrink tube **20**.

[0061] For example, the outer cold shrink tube **30** covers at least a portion of the cable connection portion **10** and at least a portion of the inner cold shrink tube **20**. The outer cold shrink tube **30** covers a region that includes a boundary portion B between the cable connection portion **10** and the inner cold shrink tube **20**. For example, like the inner cold shrink tube **20**, the outer cold shrink tube **30** is formed of a material having waterproof properties. The material of the outer cold shrink tube **30** is, for example, EPDM.

[0062] For example, before the outer cold shrink tube **30** covers the cable connection portion **10** and the inner cold shrink tube **20** (before installation and before use), the outer cold shrink tube **30** may be held around an outer circumference of an expanded diameter holding member **33** in a state in which the outer cold shrink tube **30** has an expanded diameter. Similar to the expanded diameter holding member **23** described above, the expanded diameter holding member **33** includes a disassembly line **33*b*** formed in the direction in which the axis L**2** extends, and can be pulled out along the disassembly line **33*b*** as a core ribbon **33*c*** that has a string-like body. Similar to the expanded diameter holding member **23** described above, the expanded diameter holding member **33** includes a first end portion **33*d*** corresponding to a start point side for pulling out the expanded diameter holding member **33** as the core ribbon **33*c***, and a second end portion **33*f*** corresponding to an end point side for pulling out the expanded diameter holding member **33** as the core ribbon **33*c***. In the vicinity of the first end portion **33*d***, an exposed portion **33*g*** is formed in which the outer cold shrink tube **30** is not installed, with the outer surface of the expanded diameter holding member **33** exposed, and the exposed portion **33*g*** is also formed in the vicinity of the second end portion **33*f***. Thus, the shape and material of the expanded diameter holding member **33** can, for example, be same as the shape and material of the expanded diameter holding member **23**.

[0063] For example, the cable connection portion **10** includes the insulating tube **11**, a connector **12**, and a semi-conductive tape **13**. The insulating tube **11** is configured as a tubular body including a hollow portion **11*b*** that penetrates the cable **2** in the longitudinal direction D. The insulating tube **11** includes, for example, an insulating tube body **11*c*** including the hollow portion **11*b***, a shield mesh **11*d***, an impervious layer **14**, and a cold shrink tube **15**. The insulating tube body **11*c*** is, for example, an integrally molded article of rubber.

[0064] The insulating tube body **11***c* as an example may include insulating rubber, for example, ethylene propylene rubber or silicone rubber. For example, the insulating tube body **11***c* includes insulating rubber **11***cl* and conductive rubber **11***c***2**. The conductive rubber **11***c***2** is provided, for example, at three locations including respective both end portions of the insulating tube body **11***c* in the longitudinal direction D and the center of the insulating tube body **11***c* in the longitudinal direction D. The shield mesh **11***d* covers at least a portion of the insulating tube body **11***c*. The impervious layer **14** covers the shield mesh **11***d*. For example, at least a portion of the shield mesh **11***d* is covered with the outer cold shrink tube **30**.

[0065] FIG. **4** is a cross-sectional view illustrating the insulating tube **11** as an example. For example, before installation (before use), the insulating tube **11** is held around the outer circumference of an expanded diameter holding member **16** in a state in which the insulating tube **11** has an expanded diameter. Similar to the expanded diameter holding member **23** described above, the expanded diameter holding member **16** includes a disassembly line **16***b* formed in the direction in which an axis L**3** extends, and can be pulled out along the disassembly line **16***b* as a core ribbon **16***c* that has a string-like body.

[0066] The expanded diameter holding member **16** includes a first end portion **16***d* corresponding to a start point side for pulling out the expanded diameter holding member **23** as the core ribbon **16***c*, and a second end portion **16***f* corresponding to an end point side for pulling out the expanded diameter holding member **23** as the core ribbon **16***c*. In the vicinity of the first end portion **16***d*, an exposed portion **16***g* where the insulating tube **11** is not installed but the outer surface of the expanded diameter holding member **16** is exposed is formed, and the exposed portion **16***g* is also formed in the vicinity of the second end portion **16***f*. Thus, the shape and material of the expanded diameter holding member **16** can be same as the shape and material of the expanded diameter holding member **23**.

[0067] The impervious layer **14** is provided inside the cold shrink tube **15**. The material of the cold shrink tube **15** is, for example, EPDM. The impervious layer **14** is formed of, for example, a layered body of a metal and a resin. The impervious layer **14** contains aluminum as a metal, for example. However, the metal constituting the impervious layer **14** may contain nickel or copper, and is not particularly limited. When the impervious layer **14** includes a resin layer, corrosion of the metal constituting the impervious layer **14** is more reliably suppressed.

[0068] The impervious layer **14** has a function to prevent water infiltration from the outside to the inside (the insulating tube **11** side) of the cold shrink tube **15**. When water infiltrates, for example, an adverse effect, such as causing a phenomenon referred to as a Water Tree, possibly occurs in the insulating layer **2***c*. The impervious layer **14** suppresses the adverse effect. The impervious layer **14** is formed of, for example, a layered body (also referred to as a metal laminated film) of a resin film and a metal foil. As an example, the impervious layer **14** may contain aluminum, and may be constituted by an aluminum laminated film. The impervious layer **14** may be formed by laminating a metal layer and a resin on the main surface of the metal layer. In the impervious layer **14**, the resins may be laminated on both surfaces of the metal layer, or the resin may be laminated on one surface of the metal layer. However, laminating the resins on both surfaces of the metal layer of the impervious layer **14** allows providing satisfactory handleability of the impervious layer **14**.

[0069] For example, the insulating tube **11** includes a cushion layer **17** provided inside (as an example, between the shield mesh **11***d* and the impervious layer **14**) of the impervious layer **14**, and putty materials **18** provided on respective both ends of the cushion layer **17** in the longitudinal direction D. The cushion layer **17** as an example is provided to reduce bending of the impervious layer **14** (for example, to avoid the bending angle to be an excessively steep angle or to avoid the curvature of the bending to be excessively large) that possibly occurs when the cold shrink tube **15** is shrunk. The putty material **18** is made of butyl, as an example.

[0070] The cushion layer **17** has a cushion property that deforms while having stress when a force is applied. The deformation is, for example, compression. For example, this allows reducing bending of creases due to shrinkage by partial deformation. For example, the cushion layer **17** may be made of a putty material. The cushion layer **17** may also be a foam tape made of a foamable material. As an example, the cushion layer **17** is made of butyl. The cushion layer **17** may be a strong adhesive foam tape. As an example, the cushion layer **17** is an acrylic foam tape. The foam tape of the cushion layer **17** may be constituted by a foam base material having a tackiness of a single layer, or a gluing agent layer may be provided on the main surface (for example, both surfaces) of the foam base material. The gluing agent layer of the cushion layer **17** may be, for example, a silicone-based gluing agent, in addition to an acrylic-based gluing agent.

[0071] Additionally, the cushion layer **17** is more preferably made of a material, such as a foam tape, that does not have excessively high flowability (does not easily flow when, for example, a shear force is applied due to, for example, flexure and can hold a positional relationship). In this case, since the cushion layer **17** does not flow by bending of the impervious layer **14**, the cushion property can be exhibited in the positional relationship, and bending of the impervious layer **14** can be more reliably reduced.

[0072] The thickness of the cushion layer **17** is, for example, 1 mm or more and 5 mm or less. The thickness of the cushion layer **17** may be 1.1 mm or more or 1.2 mm or more. The thickness of the cushion layer **17** may be 4 mm or less or 3 mm or less. The cushion layer **17** having the thickness of a predetermined value or more allows reducing bending of the impervious layer **14**. The cushion layer **17** having the thickness of the predetermined value or less allows providing satisfactory workability and cost reduction.

[0073] The 25% compressive stress of the cushion layer **17** is, for example, 30 N/cm^2 or less. The 25% compressive stress of the cushion layer **17** may be 20 N/cm^2 or less or may be 15 N/cm^2 or less. This makes it possible to exhibit the cushion property of deformation while having stress when a force is applied, thus ensuring reducing bending of the impervious layer **14**. Here, the cushion layer **17** made of acrylic foam at 1.2 mm in thickness and the cushion layer **17** made of putty material at 1.5 mm in thickness were prepared. The 25% compressive stresses of the cushion layers **17** were measured from loads when the sizes of the respective cushion layers **17** were configured to be 25 mm×25 mm and at 25% compression.

[0074] The shear strength of the base material of the cushion layer **17** is, for example, 150 N/cm^2 or more. The shear strength may be 200 N/cm^2 or more or 300 N/cm^2 or more. It is preferable in that the shear strength being the predetermined value or more allows suppressing the flow of the cushion layer **17** by bending of the impervious layer **14** and holding the cushion layer **17**. Here, the shear strength of the cushion layer indicates a value when the shear force is measured in the following method. 25 mm×50 mm (1.5 mm in thickness) of the cushion layers **17** (the putty materials) were stuck on both surfaces of 25 mm×50 mm (122 μm in thickness) of an aluminum laminated film (the impervious layer **14**), it was sandwiched between stainless plates, a steel roller having a weight of 2 kg was moved back and forth on it once for pressure bonding, and it was cured for 24 hours at room temperature. After that, the force of the maximum stress when the base material stretched (at the time point of elongation at several %) when the stainless plates were pulled at a tensile speed of 30 mm/minute was measured as the shear strength.

[0075] The compression set of the cushion layer **17** is, for example, 80% or less. The compression set of the cushion layer **17** may be 70% or less or may be 60% or less. It is preferable in that the compression set being the predetermined value or less allows suppressing the flow of the cushion layer **17** by bending of the impervious layer **14** and holding the cushion layer **17**. Here, for the compression set of the cushion layer **17**, the cushion layer **17** having the diameter of 29 mm (each of the cushion layer **17** made of acrylic foam at 1.2 mm in thickness and the cushion layer **17** made of putty material at 1.5 mm in thickness) in a 25% compression state was left at room temperature for 24 hours, the thicknesses before and after the compression were measured, and the compression set was calculated from the following equation (1).

[Equation 1]

$$CS = \frac{h_o - h_1}{h_0 - s} \times 100 \quad (1)$$

[0076] In Formula (1), CS indicates a compression set (%), h_0 indicates a thickness of a test specimen before compression (mm), h_1 indicates the thickness of the test specimen after removal from a compression device (mm), and h_s indicates a thickness of a spacer (mm).

[0077] The cushion layer **17** is bonded to the entire surface of the impervious layer **14**. In the present disclosure, "bonding" is bonding when an article itself is an adhesive (for example, a putty), bonding when an article itself includes a gluing agent (for example, a tape), or bonding when an adhesive is separately applied to an article, and "bonding" includes an aspect without using an adhesive, such as welding. In the present disclosure, first of all, "the entire surface of the impervious layer" only needs to be an entire surface of a region that functions as the impervious layer (for example, when a region includes a surplus region generated at, for example, an end portion due to a production reason, the region excluding the surplus region). Additionally, "bonding to the entire surface" also includes substantially the entire surface of the impervious layer and practically the entire surface of the impervious layer, in addition to 100%. For example, "bonding to the entire surface" includes a state in which portions where bonding is not performed are sparsely present in a small dot shape. Conversely, "bonding to the entire surface" does not include a case in which a portion in a large dot shape or a stripe shape where bonding is not performed is present and stress concentration caused by, for example, bending of the impervious layer occurs. For example, a state in which the region functioning as the impervious layer is bonded by the area 95% or more may also be "bonding to the entire surface."

[0078] FIG. **5**A is a drawing schematically illustrating a bending state of the impervious layer **14** when the cushion layer **17** is bonded to the entire surface of the impervious layer **14**. FIG. **5**B is a drawing schematically illustrating a bending state of an impervious layer **114** in a case where the cushion layer **17** is not bonded to the impervious layer **114**. As illustrated in FIG. **5**B, with the impervious layer **114** to which the cushion layer **17** is not bonded, there is a concern that the impervious layer **114** is bent during shrinkage of the cold shrink tube located outside the impervious layer **114**, and a hole is formed in the impervious layer **114** in the bent portion of the impervious layer **114**. As illustrated in FIG. **5**A, when the cushion layer **17** is bonded to the entire surface of the impervious layer **14**, bending of the impervious layer **14** during shrinkage of the cold shrink tube **15** located outside the impervious layer **14** is reduced. In other words, by bonding the cushion layer **17** to the entire surface of the impervious layer **14**, the bending angle of the impervious layer **14** becomes gradual. Accordingly, when the cushion layer **17** is bonded to the entire surface of the impervious layer **14**, bending of the impervious layer **14** can be reduced, and thus formation of a hole in the impervious layer **14** can be suppressed.

[0079] FIG. **6** is a perspective view illustrating the insulating tube **11** of FIG. **4**. As illustrated in FIG. **6**, the insulating tube **11** includes the shield meshes **11***d*, which extend from the cold shrink tube **15** attached to the outside of the impervious layer **14** to both sides in the longitudinal direction D, formed by being folded back to the center side of the longitudinal direction D. Each of the shield meshes **11***d* folded back to the center side of the longitudinal direction D is fixed by winding with a tape T. Various tapes can be used as the tape T as long as the tape can fix the shield mesh **11***d* and can be peeled.

[0080] Next, effects obtained from the cable connection member **100** and the cable connection structure **1** according to the present embodiment will be described. The cable connection member **100** includes the impervious layer **14** inside the cold shrink tube **15**, and thus impermeability can be enhanced. The cable connection member **100** includes the cushion layer **17** bonded to the impervious layer **14**. The cushion layer **17** bonded to the impervious layer **14** can protect the impervious layer **14**. Additionally, since the cushion layer **17** is bonded to the entire surface of the impervious layer **14**, bending of the impervious layer **14** that possibly occurs when the cold shrink tube **15** shrinks can be reduced with the cushion layer **17**. That is, even when the impervious layer **14** bends, the cushion layer **17** bonded to the entire surface of the impervious layer **14** can suppress formation of a hole in the impervious layer **14**.

[0081] The thickness of the cushion layer **17** may be 1 mm or more and 5 mm or less. In this case, the thickness of the cushion layer **17** being 1 mm or more allows reducing bending of the impervious layer **14**. The thickness of the cushion layer **17** being 5 mm or less allows avoiding the cushion layer **17** to be excessively thick.

[0082] The shear strength of the cushion layer **17** may be 150 N/cm^2 or more. In this case, the shear strength of the cushion layer **17** being 150 N/cm^2 or more allows increasing the strength of the cushion layer **17** and reducing bending of the impervious layer.

[0083] The cushion layer **17** may be configured by a foam tape. In this case, a foam tape having high shape maintainability in which flowability of the cushion layer **17** is low is used as the cushion layer **17**. Accordingly, the change in shape of the cushion layer **17** due to the bending of the impervious layer **14** can be suppressed, thereby ensuring suppressing formation of a hole in the impervious layer **14** more reliably.

[0084] The impervious layer **14** may be configured by a layered body of a metal and a resin. In this case, protection of the metal of the impervious layer **14** by the resin allows providing the satisfactory handleability of the impervious layer **14**.

[0085] The cold shrink tube **15** may constitute the insulating tube **11** of the cable connection portion **10** attached to the end portions of the cables **2**. In this case, since the impervious layer **14** provided on the cold shrink tube **15** of the insulating tube **11** is protected by the cushion layer **17** to ensure suppressing formation of a hole in the impervious layer **14** of the insulating tube **11**, the impermeability of the insulating tube **11** can be enhanced.

[0086] The impervious layer **14** and the cushion layer **17** described above can be built in each of the outer cold shrink tube **30** and the inner cold shrink tube **20** described above. FIG. **7** is a cross-sectional view of the outer cold shrink tube **30** illustrating a state in which the impervious layer **14** and cushion layer **17** are built in the outer cold shrink tube **30** in FIG. **3**. As illustrated in FIG. **7**, the impervious layer **14** is provided inside the cushion layer **17**. The cushion layer **17** is bonded to the entire surface of the impervious layer **14**. The present embodiment shows an example of the outer cold shrink tube **30** as the single-layer outer cold shrink tube, and an example of the inner cold shrink tube **20** as the cold shrink tube of a plurality of layers. The single-layer cold shrink tube can be in a simple configuration. However, in the cold shrink tube having the plurality of layers, the impervious layer does contact a bonded matter, and therefore is, for example, advantageous of ensuring suppressing shrink back due to a slip of the aluminum laminated film.

[0087] The cushion layer **17** is disposed between the outer cold shrink tube **30** and the impervious layer **14**. For example, when viewed from the impervious layer **14**, the cushion layer **17** is disposed on the opposite side to the expanded diameter holding member **33**. This allows suppressing that the cushion layer **17** adheres to the expanded diameter holding member **33** and the core ribbon **33***c* is less likely to be pulled. The putty materials **18** are provided on both ends of the cushion layer **17** in the longitudinal direction D.

[0088] As described above, in the cable connection member **100** according to the present embodiment, the cushion layer **17** may be provided inside the outer cold shrink tube **30**, and the impervious layer **14** may be provided inside the cushion layer **17**. In other words, the cable connection structure may include the outer cold shrink tube **30** covering at least a portion of the cable connection portion **10**, the cushion layer **17** provided inside the outer cold shrink tube **30**, and the impervious layer **14** provided inside the cushion layer **17**.

[0089] In the example described above, the cushion layer **17** and the impervious layer **14** are provided inside the outer cold shrink tube **30**, and thus bending of the impervious layer **14** located inside the outer cold shrink tube **30** can be reduced with the cushion layer **17**, and impermeability can be further enhanced. An example in which the cushion layer **17** is provided outside the impervious layer **14** inside the outer cold shrink tube **30** has been described above. Note that the cushion layer **17** may be provided outside the impervious layer **14** inside the cold shrink tube other than the outer cold shrink tube **30** (for example, the cold shrink tube **15** or the inner cold shrink tube **20** described above).

[0090] Next, an example in which the impervious layer **14** and the cushion layer **17** are built in the inner cold shrink tube **20** will be described with reference to FIG. **8**. FIG. **8** is a cross-sectional view of an inner cold shrink tube illustrating a state in which the impervious layer **14** and the cushion layer **17** are built in the inner cold shrink tube **20** of FIG. **2**. As illustrated in FIG. **8**, the impervious layer **14** is provided between the cushion layer **17** and the outer layer **22**. The cushion layer **17** is provided between the inner layer **21** and the impervious layer **14**. In other words, the inner layer **21**, the cushion layer **17**, the impervious layer **14**, and the outer layer **22** are arranged in this order from the inside in the radial direction to the outside in the radial direction of the inner cold shrink tube **20**. The putty materials **18** are provided on respective both end sides of the cushion layer **17** in the longitudinal direction D, and the putty materials **18** are provided on the outer surfaces and the inner surfaces of the respective both ends of the impervious layer **14** in the longitudinal direction D.

[0091] An example in which the impervious layer **14** and the cushion layer **17** are built in the cold shrink tube (the cold shrink tube **15**, the inner cold shrink tubes **20**, or the outer cold shrink tubes **30**) has been described above. In this way, when the impervious layer **14** and the cushion layer **17** are built in the cold shrink tube, the impervious layer **14** can be formed together with attachment of the cold shrink tube. The impervious layer **14** can be formed together with the attachment of the cold shrink tube, and this allows eliminating the need for separately preparing an impervious layer or separately attaching an impervious layer, thereby allowing improving attachment of the cold shrink tube and workability of forming the impervious layer **14**.

[0092] As described above, in the cable connection member **100** according to the present embodiment, the inner cold shrink tube **20** may include the inner layer **21** and the outer layer **22** located outside the inner layer **21**. The cable connection structure **1** according to the present embodiment may include the inner cold shrink tubes **20** provided inside the outer cold shrink tubes **30**. The inner cold shrink tube **20** may include the inner layer **21** and the outer layer **22** located outside the inner layer **21**. The impervious layer **14** provided between the inner layer **21** and the outer layer **22**, and the cushion layer **17** provided between the outer layer **22** and the impervious layer **14** may be provided.

[0093] In this case, the cushion layer **17** and the impervious layer **14** may be provided between the inner layer **21** and the outer layer **22**. In this case, the inner cold shrink tube **20** has two layers, and the cushion layer **17** and the impervious layer **14** are provided between the two layers. Accordingly, it is possible to increase the strength of the cable connection portion **10** and enhance impermeability. In this case, the inner cold shrink tube **20** is provided inside the outer cold shrink tube **30**, and the impervious layer **14** and the cushion layer **17** are provided between the inner layers **21** and the outer layers **22** of the inner cold shrink tubes **20**. Accordingly, bending of the impervious layer **14** of the inner cold shrink tube **20** is reduced with the cushion layer **17**, and thus impermeability can be further enhanced. Note that the inner cold shrink tube may have a single layer.

EXAMPLES

[0094] Next, the examples of the present embodiment will be described. Note that the present disclosure is not limited to the examples given below.

Heat Expansion/Shrinkage Test

[0095] The cable connection structure **1** was manufactured using the insulating tube **11** including the impervious layer **14**, the inner cold shrink tubes **20** including the impervious layer **14**, and the outer cold shrink tubes **30** including the impervious layer **14** described above. An aluminum laminated film was used as the impervious layer **14**. A heat cycle test was conducted on the cable connection structure **1**. The contents of heat cycle test are as follows.

- **[0096]** Conductor cross-sectional area of the cable **2** to: 100 mm^2 be connected
- **[0097]** Conductor temperature: 90° ° C.
- **[0098]** Energization time: 3 hours
- **[0099]** Stop time: 3 hours
- **[0100]** Number of cycles: 365 cycles (equivalent to 1 year)

[0101] The cable connection structure **1** was disassembled after completion of the test described above to confirm the situation of the impervious layer **14**.

[0102] In addition, in the present test, the cushion layer **17** was not provided in the insulating tube **11**, and the cushion layer **17** was bonded to the entire surface of the impervious layer **14** in the respective inner cold shrink tubes **20** and outer cold shrink tubes **30**. The cushion layer **17** provided in the inner cold shrink tube **20** was an acrylic foam tape having a thickness of 1.2 mm, and the cushion layer **17** provided in the outer cold shrink tube **30** was a butyl putty having a thickness of 1.5 mm. The acrylic foam tape having the 25% compressive stress of about 10 N/cm^2 and the compression set of about 52% was used. The butyl putty having the 25% compressive stress of about 10 N/cm^2, the shear strength of about 95 N/cm^2, and the compression set of about 100% was used.

[0103] The cable connection structure **1** was manufactured by shrinking each of the above-described insulating tube **11**, inner cold shrink tube **20**, and outer cold shrink tube **30**. The shrink ratio of the insulating tube **11** (the cold shrink tube **15**) (the inner diameter after shrink/the inner diameter before shrink) was 90%, the shrink ratio of the inner cold shrink tube **20** was 80%, and the shrink ratio of the outer cold shrink tube **30** was 85% (on the insulating tube **11**). In addition, by observing presence of a hole in each of the impervious layer **14** of the insulating tube **11**, the impervious layer **14** of the inner cold shrink tube **20**, and the impervious layer **14** of the outer cold shrink tube **30**, presence of the effect of the cushion layer **17** was confirmed. FIG. **9**A, FIG. **9**B, and FIG. **9**C illustrate the results.

[0104] FIG. **9**A schematically illustrates a photograph of the impervious layer **14** of the insulating tube **11** without the cushion layer **17**, FIG. **9**B schematically illustrates a photograph of the impervious layer **14** of the inner cold shrink tube **20** including the cushion layer **17** as the acrylic foam tape, and FIG. **9**C schematically illustrates a photograph of the impervious layer **14** of the outer cold shrink tube **30** including the cushion layer **17** as the butyl putty. The photographs in FIG. **9**A, FIG. **9**B, and FIG. **9**C each illustrate the result of causing light to pass through the impervious layer **14**. Furthermore, the portion of the impervious layer **14** shown in the photograph indicates a flat portion of the impervious layer **14** of no step difference.

[0105] As illustrated in FIG. **9**A, it has been found that the impervious layer **14** of the insulating tube **11** without the cushion layer **17** generated creases in the vertical direction and creases in the lateral direction, and formed holes X at the intersection portions of the creases in the vertical direction and the creases in the lateral direction. On the other hand, as illustrated in FIG. **9**B and FIG. **9**C, when the cushion layer **17** as the acrylic foam tape was provided, and when the cushion layer **17** as the butyl putty was provided, creases were generated only in the vertical direction but were not generated in the two directions, and holes were not formed. Therefore, it has been found that with the impervious layer **14** to which the cushion layer **17** was bonded over the entire surface, formation of holes was able to be suppressed.

Bending Test

[0106] The bending test that bended the impervious layer **14** as the aluminum laminated film to confirm whether a hole was formed was conducted. The bending test was conducted on each of the impervious layer **14** without the cushion layer **17**, the impervious layer **14** to which the cushion layer **17** as the acrylic foam was bonded, and the impervious layer **14** to which the cushion layer **17** as the butyl putty was bonded. FIG. **10**A, FIG. **10**B, FIG. **11**A, FIG. **11**B, and FIG. **11**C illustrate the contents of bending test.

[0107] First, as illustrated in FIG. **10**A and FIG. **10**B, the impervious layer **14** having a rectangular shape at 90 mm×90 mm (and the impervious layer **14** to which the cushion layer **17** was bonded) were prepared, and each of the impervious layers **14** was bent such that five folding lines extending in the vertical direction were put on each of the impervious layers **14**. As illustrated in FIG. **11**A and FIG. **11**B, a mountain fold was made in the lateral direction on one end (the upper end in FIG. **11**A) of each of the impervious layers **14** in the vertical direction, and a mountain fold was made in the direction reverse to the above-described lateral direction (the left direction in FIG. **11**B) on the other end (the lower end in FIG. **11**B) of the impervious layer **14** in the vertical direction.

[0108] Thereafter, as illustrated in FIG. **11**C, each of the mountain folds described above was restored, and whether a hole was formed in peaks P of the ten portions where the mountain folds were made was confirmed. Each of the three impervious layers **14** that did not include the cushion layers **17**, the three impervious layers **14** to which the cushion layers **17** as the acrylic foam tapes were bonded, and the three impervious layers **14** to which the cushion layers **17** as the butyl putties were bonded were prepared to conduct the bending test described above on each of the impervious layers **14**. The results are shown in Table 1 below.

TABLE 1

	No.	Number of holes	Occurrence percentage of hole
No cushion layer (impervious layer only)	1	3	30%
	2	4	40%
	3	3	30%
Cushion layer as acrylic foam tape	1	1	10%
	2	1	10%
	3	0	0%
Cushion layer as butyl putty	1	4	40%
	2	4	40%
	3	4	40%

[0109] As shown in Table 1, it has been found that, in the bending test of the impervious layers **14**, the number of holes and the occurrence percentage of hole were able to be reduced in the impervious layer **14** to which the cushion layer **17** as the acrylic foam tape was bonded, compared with the impervious layers **14** without the cushion layers **17**. Specifically, among the ten peaks P, the portion where the hole was formed was able to be reduced to one or less and the occurrence percentage of hole was able to be reduced to 10% or less. Also, it has been found that the impervious layer **14** to which the cushion layer **17** as the acrylic foam tape was bonded was able to reduce the number of holes and the occurrence percentage of hole compared with the impervious layer **14** to which the cushion layer **17** as the butyl putty was bonded. It is considered because the butyl putty whose shear strength is not sufficiently high has high flowability, and when strong stress is applied, the butyl putty moves and the concentration of stress cannot be reduced.

[0110] Next, a cable connection structure **41** and a cable connection member **101** according to another embodiment will be described with reference to FIG. **12**. A portion of the configuration of the cable connection structure **41** overlaps with a portion of the configuration of the cable connection structure **1** described above, and thus, the description that overlaps with the description described above will be omitted as appropriate. As illustrated in FIG. **12**, the cable connection structure **41** and the cable connection member **101** include a sheath cover member **45** covering the outer cold shrink tubes **30** and the cable sheaths **2***d* of the cables **2**.

[0111] FIG. **13** is a drawing schematically illustrating a portion of the sheath cover member **45**. As illustrated in FIG. **12** and FIG. **13**, the sheath cover member **45** is netlike, for example. The sheath cover member **45** is provided to suppress a phenomenon referred to as shrink back in which the cable sheath **2***d* shrinks. As an example, the sheath cover member **45** includes a glass cloth. For example, the sheath cover member **45** is constituted by a glass cloth impregnated with a resin (as an example, a polyurethane resin). The sheath cover member **45** may contain a polyurethane resin that cures with moisture. However, the material of the sheath cover member **45** is not particularly limited.

[0112] The sheath cover member **45**, for example, is wrapped around the cable sheath **2***d* located on one side of the pair of cables **2** until the outer diameter of the sheath cover member **45** becomes approximately the same as the outer diameter of the outer cold shrink tube **30**. After that, the sheath cover member **45** is wrapped around the inner cold shrink tubes **20** and the outer cold shrink tubes **30**. The sheath cover member **45** is wrapped around the cable sheath **2***d* located on the other side of the pair of cables **2** until the outer diameter of the sheath cover member **45** becomes approximately the same as the outer diameter of the outer cold shrink tube **30**. After that, the sheath cover member **45** is wrapped around the inner cold shrink tubes **20** and the outer cold shrink tubes **30**.

[0113] FIG. **14**A is a cross-sectional view illustrating a cable connection structure **41**A according to a modified example that includes the sheath cover member **45**. As illustrated in FIG. **14**A, as long as the outer cold shrink tubes **30** sufficiently grips the cable sheaths **2***d*, even without the inner cold shrink tubes **20**, shrink back can be more reliably suppressed using the sheath cover member **45**.

[0114] FIG. **14**B is a cross-sectional view illustrating a cable connection structure **41**B according to another modified example that includes the sheath cover member **45**. As illustrated in FIG. **14**B, the cable connection structure **41**B includes band members **46** attached to the cable sheaths **2***d*. As an example, the cable connection structure **41**B includes a pair of the band members **46** attached to the respective pair of cable sheaths **2***d*. For example, each band member **46** tightens the cable sheath **2***d* at the adjacent position of the inner cold shrink tube **20**.

[0115] The band member **46** is attached to the cable sheath **2***d* inside the sheath cover member **45**. Shrink back of the cable sheath **2***d* is more reliably suppressed with the band member **46**. The band member **46** is a metallic metal band as an example. However, the band member **46** may be made of resin, and the material of the band member **46** is not particularly limited. For example, the band member **46** is elastically deformable and has a C-shape. In this case, the band member **46** can be easily attached to the cable sheath **2***d* from outside the cable sheath **2***d*. However, the band member **46** may have a shape other than the C-shape (for example, an O-shape), and the shape of the band member **46** is not particularly limited.

EXAMPLES

[0116] Next, the examples of the present embodiment will be described. Note that the present disclosure is not limited to the examples given below.

Verification of Shrink Back

[0117] As illustrated in FIG. **15**, the cable **2** was tightened with the inner cold shrink tube **20**, and the cable connection portion **10** and the inner cold shrink tube **20** were tightened with the outer cold shrink tube **30**. Then, with the inner cold shrink tube **20** facing downward, a weight was attached to the portion of the cable sheath **2***d* in the cable **2** extending downward from the inner cold shrink tube **20**. In this state, a heat cycle test that performed cycles at 70° C. for 2 hours and at −20° ° C. for 2 hours by 30 times was conducted. An amount of positional deviation of the cable sheath **2***d* between before and after the heat cycle test was measured as an amount of extension of the length of the inner cold shrink tube **20** and the outer cold shrink tube **30**. This measurement was performed on each of the following Examples 1 to 3. Specifications of each of Examples 1 to 3 will be described below.

Example 1

[0118] The conductor cross-sectional area of the cable **2** was configured to be 100 mm^2, and polyvinyl chloride

(PVC) was used as the material of the cable sheath **2***d*. The weight of the weight described above was set to be 15 kg.

Example 2

[0119] The conductor cross-sectional area of the cable **2** was configured to be 100 mm^2, and polyethylene (PE) was used as the material of the cable sheath **2***d*. The weight of the weight described above was set to be 25 kg. The weight of the weight of Example 2 set to be larger than the weight of the weight of Example 1 is to reflect that the shrinkage force of PE is larger than the shrinkage force of PVC. The shrinkage force of PVC is 33.5 g/mm^2, and the shrinkage force of PE is approximately 1.5 times the shrinkage force of PVC. As described above, the PE had the shrinkage force of approximately 1.5 times the PVC, and thus the weight of the weight of Example 2 was approximately 1.5 times the weight of the weight of Example 1.

Example 3

[0120] The sheath cover member **45** was further wrapped around the outer cold shrink tube **30** and the cable sheath **2***d*. The conductor cross-sectional area of the cable **2** was configured to be 100 mm^2, and polyethylene (PE) was used as the material of the cable sheath **2***d*. The weight of the weight described above was set to be 25 kg.

[0121] The following Table 2 shows the results of measuring the amount of positional deviation of the cable sheath **2***d* in each of Examples 1 to 3 described above.

TABLE 2

	Cross-sectional area of cable (mm^2)	Material of cable sheath	Weight of weight (kg)	Presence of sea wrap	Amount of positional deviation of cable sheath (mm)
Example 1	100	PVC	15	No	8
Example 2	100	PE	25	No	19
Example 3	100	PE	25	Yes	4

[0122] As shown in Table 2, in Example 1 in which the material of the cable sheath **2***d* was PVC, the amount of positional deviation of the cable sheath **2***d* was suppressed to 8 (mm) even in the absence of the sheath cover member **45**. Note that since there is a concern that the amount of positional deviation of 20 (mm) or more breaks the shielding copper tape **2***f* of the cable **2** and causes a burning accident, the amount of positional deviation is required to be less than 20 (mm).

[0123] In Example 2 in which the material of the cable sheath **2***d* was the PE, in the absence of the sheath cover member **45**, the amount of positional deviation of the cable sheath **2***d* was 19 mm, which was the value close to 20 mm. In contrast, it has been found that in Example 3 in which the sheath cover member **45** was wrapped around the cable sheath **2***d*, the amount of positional deviation of the cable sheath **2***d* was 4 mm. The deviation of the cable sheath **2***d* was able to be significantly reduced by the sheath cover member **45** and shrink back was able to be suppressed. Note that, in terms of environmental consideration, PE is preferably used for the material of the cable sheath **2***d* rather than the PVC. In Example 3, even when the cable **2** made of the environmentally friendly PE is used, shrink back can be more reliably suppressed by the sheath cover member **45**.

[0124] FIG. **16** is a drawing schematically illustrating the state of the sheath cover member **45** in Example 3. As illustrated in FIG. **16**, it has been found that, in Example 3, the sheath cover member **45** bites into a step difference Z of the cable. Thus, by the sheath cover member **45** biting into the step difference Z to suppress deviation of the cable sheath **2***d*, shrink back of cable sheath **2***d* can be more reliably suppressed.

[0125] As described above, the cable connection structures **41**, **41**A, and **41**B include the outer cold shrink tubes **30** and the sheath cover members **45** covering the cable sheaths **2***d* of the cables **2**. Providing the sheath cover member **45** covering the cable sheaths **2***d* allows suppressing shrink back in which the cable sheath **2***d* shrinks.

[0126] The cable connection structure **41**B includes the band members **46** attached to the cable sheaths **2***d* and located inside the sheath cover member **45**. In this case, since the cable sheath **2***d* is held by the band member **46**, shrink back of the cable sheath **2***d* can be more reliably suppressed. In addition, when the band member **46** holds the cable sheath **2***d*, one other than the cold shrink tube can be used as the cable connection portion **10**, for example, a heat shrink tube can be used.

[0127] The various embodiments of the cable connection structure and the cable connection member according to the present disclosure have been described above. However, the present disclosure can be variously modified without departing from the subject matter recited in the claims. That is, the shape, size, number, and arrangement aspect of each portion of the cable connection structure and the cable connection member can be changed as appropriate within the scope not changing the gist described above. For example, in the embodiments described above, the impervious layer **14** in which the resins are laminated on both surfaces of the metal layer has been exemplified. However, the configuration of the impervious layer is not limited to this example, and, for example, an impervious layer in which a resin is laminated on one surface of a metal layer and a cushion layer (such as an acrylic foam tape) is stuck to the other one surface may be used, and the impervious layer is not particularly limited. Additionally, in the embodiments described above, the cable connection portion **10** including the insulating tube **11**, the connector **12**, and the semi-conductive tape **13** has been exemplified. However, the configuration of the cable connection portion is not limited to the examples described above, and can be changed as appropriate.

[0128] For example, in the above-described embodiments, the example in which the cable connection structure **1** includes the cable connection portion **10** that connects the pair of cables **2** together has been described. However, the cable connection structure may include a cable connection portion that connects a cable to a plurality of cables, or may include a cable connection portion that connects a cable to another device. Thus, the object to which the cable connection portion provided at the end portion of the cable is connected is not particularly limited.

1. A cable connection member comprising:

a cold shrink tube;

an impervious layer provided inside the cold shrink tube; and

a cushion layer provided inside the cold shrink tube and bonded to an entire surface of the impervious layer.

2. The cable connection member according to claim **1**, wherein the cushion layer has a thickness of 1 mm or more and 5 mm or less.

3. The cable connection member according to claim **1**, wherein the cushion layer has a 25% compressive stress of 30 N/cm^2 or less.

4. The cable connection member according to claim **1**, wherein a base material of the cushion layer has a shear strength of 150 N/cm^2 or more.

5. The cable connection member according to claim **1**, wherein the cushion layer has a compression set of 80% or less.

6. The cable connection member according to claim **1**, wherein the cushion layer is configured by a foam tape.

7. The cable connection member according to claim **1**, wherein the impervious layer is configured by a layered body of a metal and a resin.

8. The cable connection member according to claim **1**, wherein the cold shrink tube constitutes an insulating tube of a cable connection portion attached to an end portion of a cable.

9. The cable connection member according to claim **1**, wherein:

the cushion layer is provided inside the cold shrink tube; and

the impervious layer is provided inside the cushion layer.

10. The cable connection member according to claim **1**, wherein:

the cold shrink tube includes an inner layer and an outer layer located outside the inner layer; and

the cushion layer and the impervious layer are provided between the inner layer and the outer layer.

11. A cable connection structure comprising:

a cold shrink tube of an insulating tube of a cable connection portion attached to an end portion of a cable;

an impervious layer provided inside the cold shrink tube; and

a cushion layer provided inside the cold shrink tube and bonded to an entire surface of the impervious layer.

12. The cable connection structure according to claim **11**, comprising:

an outer cold shrink tube covering at least a portion of the cable connection portion;

a cushion layer provided inside the outer cold shrink tube; and

an impervious layer provided inside the cushion layer.

13. The cable connection structure according to claim **12**, comprising an inner cold shrink tube provided inside the outer cold shrink tube, wherein the inner cold shrink tube includes:

an inner layer and an outer layer located outside the inner layer;

an impervious layer provided between the inner layer and the outer layer; and

a cushion layer provided between the outer layer and the impervious layer.

14. The cable connection structure according to claim **12**, comprising a sheath cover member that covers the outer cold shrink tube and a cable sheath of the cable.

15. A cable connection structure that includes a cable connection portion attached to an end portion of a cable, the cable connection structure comprising a sheath cover member that covers a cable sheath of the cable and the cable connection portion.

16. The cable connection structure according to claim **15**, comprising a band member attached to the cable sheath and located inside the sheath cover member.

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